CEINT/NIST PROTOCOL FOR

PREPARATION OF A NANOSCALE TiO_2 AQUEOUS DISPERSION FOR TOXICOLOGICAL OR ENVIRONMENTAL TESTING

Ver. 1

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1. Introduction

Toxicity and fate assessments are key elements in the evaluation of the environmental, health and safety risks of engineered nanomaterials (ENMs). While significant efforts and resources have been devoted to the toxicological evaluation of many ENMs, and in particular nanoscale TiO_2 [1-4], obtaining conclusive and reproducible results remains a challenge [5]. This can be traced in part to the lack of standardized dispersion protocols and the inconsistent application of dispersion procedures in relevant biological and environmental matrices [6, 7].

This protocol was developed and validated using National Institute of Standards and Technology (NIST) Standard Reference Material (SRM) 1898,[a] which consists of an industrially relevant and widely studied commercial TiO_2 nanomaterial with a production history dating back several decades [3, 8-10]. The protocol provides a validated method for the preparation of aTiO_2 nanoparticle dispersion in high purity de-ionized water, as a stock preparation compatible with biological and environmental matrices. Furthermore, this protocol can be used in combination with matrix-specific protocols for the preparation of dispersions in more complex biological or environmental media. Matrix-specific protocols are currently under preparation and will be issued in the near future.

While the procedures detailed in this document focus on the dispersion of SRM 1898 in high purity water, it is believed that the adopted characterization, validation and optimization approaches can be more generally applied to the preparation of aqueous dispersions for a wide range of ENMs that are available in the *dry powder form*. For this reason, and to allow for a broader applicability of this work, experimental details and discussions regarding the characterization, validation and process optimization adopted for the development of the dispersion method are offered as appendices to this protocol.

2. Principles and Scope

In this protocol, an aqueous TiO_2 nanoscale dispersion is produced, starting with a dry powder and by application of ultrasound (a process referred to here as sonication). For guidelines on reporting relevant conditions and critical parameters relating to the ultrasonic dispersion of ENMs, consult reference [11]. For additional relevant and general considerations on the application of ultrasound to prepare ENP dispersions, refer to [7, 12].

The feedstock for the test material, SRM 1898, is a commercial TiO_2 nanomaterial commonly referred to in the literature and within the scientific community as "Degussa P25" or simply "P25".[b] This product is used in a variety of applications, such as a surrogate for the class of untreated TiO_2 products used in sunscreen formulations, in food formulations and personal care products, and as an additive to protect cosmetics and medicinal formulations from sunlight [13].

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[a] SRM 1898 was in production as of the publication of this protocol, with a target date for release in 2011. The NIST SRM inventory can be accessed at http://www.nist.gov/srm/.

[b] Certain commercial equipment, instruments, or materials are identified in this document in order to specify the experimental procedure adequately. Such identification is not intended to imply recommendation or endorsement by the National Institute of Standards and Technology or the Center for the Environmental Implications of Nanotechnology, nor is it intended to imply that the materials or equipment identified are necessarily the best available for the purpose.

It has also served as a benchmark in photocatalysis research and development [14] and, more recently, P25 has been utilized as a test material and benchmark for the toxicological assessment of ENMs, including the Organization for Economic Cooperation and Development (OECD) Sponsorship Program for the Testing of Manufactured Nanomaterials [3, 9, 10].

The method described herein, if applied correctly, yields a monomodal P25 dispersion in water, characterized by a mean particle diameter of ≈ 70 nm and a pH between 3.7 and 4.9. The method is validated for the preparation of dispersions in the (0.5 to 20) mg/mL concentration range. Dispersions prepared following this protocol should be stored so as to minimize exposure to light (e.g., in amber vials), at room temperature, and used within 24 h of preparation.

3. Terminology

This protocol complies with definitions relevant to nanotechnology as set forth in the ASTM standard E2456 [15] and is consistent with the draft standard ISO TS 80004-1 [16]. Additional guidance is derived from recommendations of the International Union of Pure and Applied Chemistry [17].

nanoparticle - sub-classification of ultrafine particle that is characterized by dimensions in the nanoscale (i.e., between 1 nm and 100 nm) in at least two dimensions; also referred to as "nano-object" in ISO TS 80004-1 [16].

primary particle - the smallest discrete identifiable entity associated with a particle system; in this context, larger particle structures (e.g., aggregates and agglomerates) may be composed of primary particles.

aggregate - a discrete assemblage of primary particles strongly bonded together (i.e., fused, sintered, or metallically bonded), which are not easily broken apart.

> *Note—The adjective "primary", when used in conjunction with the term aggregate, is employed in the present context to indicate the smallest achievable aggregate.*

agglomerate - assemblages of particles (including primary particles and/or smaller aggregates) held together by relatively weak forces (e.g., van der Waals, capillary, or electrostatic), that may break apart into smaller particles upon further processing.

> *Note—Although we define them as distinct entities, the terms aggregate and agglomerate are often used interchangeably to denote particle assemblies.*

dispersion - used in the present context to denote a liquid (aqueous) in which particles are suspended, or the process of creating a suspension in which discrete particles are homogeneously distributed throughout a continuous fluid phase; implies the intention to break down agglomerates into their principal components (i.e., primary particles and/or aggregates).

4. Reagents, materials and equipment

4.1. Reagents

4.1.1. AEROXIDE® TiO_2 P25 (Evonik Degussa GmbH, Germany); available from distributors world-wide or obtained as a certified reference material from NIST (SRM 1898; in production, not yet available at time of publication).

4.1.2. 18.2 MΩ·cm resistivity Type I biological grade de-ionized (DI) water; biological grade implies sterility and absence of endotoxin contamination.

Note: Sterility and absence of endotoxin contamination should be verified for all materials in contact with the dispersion.

4.2. Materials [c]

4.2.1. 100 mL, ≈ 5 cm diameter cylindrical glass beaker

4.2.2. 125 mm wide x 65 mm deep crystallizing glass dish

4.2.3. 50 mL borosilicate volumetric flask or pipette

4.2.4. Aluminum or polystyrene weighing dish

4.2.5. Clamps or other locking device for holding beaker in place

4.2.6. Chopped ice

4.3. Equipment

For the preparation of the aqueous dispersion:

4.3.1. Analytical balance

4.3.2. Probe-type sonicator with a standard ½ inch (1.3 cm) diameter titanium horn fitted with a removable flat tip (or similar ultrasonic device)

For verification of acceptance criteria:

4.3.3. pH meter and electrode

4.3.4. Laser diffraction spectrometer (LDS), ***or***

4.3.5. Dynamic light scattering (DLS) instrument, ***or***

4.3.6. X-ray disc centrifuge (XDC) particle size analyzer

5. Preparation of aqueous TiO_2 nanoparticle dispersion

5.1. Using an analytical balance and an aluminum or polystyrene weighing dish, weigh an adequate mass of dry TiO_2 powder to achieve the desired concentration in a 50 mL water volume. For guidance on mass-concentration relationships, refer to the table below.

Mass (g)	Concentration in 50 mL volume (mg/mL)
0.025	0.5
0.05	1
0.5	10
1	20

[c] Glassware in contact with liquids or samples should be cleaned, sterilized, and dried prior to use. Avoid detergents if possible; if detergents are used, rinse with copious quantities of DI water before drying. Glassware can be sterilized using an autoclave, by exposure to hot dry air (130 °C-170 °C) for 2-4 h in an oven, or by prolonged contact with alcohol. Containers should be capped or sealed (e.g., with thermoplastic such as Parafilm) or stored in a HEPA filtered clean bench.

Note: This protocol has been validated for SRM 1898 mass quantities in the range of (0.05 to 1) g in 50 mL of water, yielding concentrations in the (0.5 to 20) mg/mL range, respectively. If other concentrations or volumes are used, the reader is advised to verify the applicability of this protocol. For greater accuracy and reproducibility with respect to mass concentration, the TiO_2 powder should be dried overnight at an elevated temperature between (105 and 150) ºC and then allowed to cool to room temperature in a desiccator prior to use.

5.2. Add the weighed mass of powder to a 100 mL, ≈ 5 cm diameter cylindrical glass beaker. Add 50 mL of DI water to the beaker with the powder.

5.3. Place the beaker inside the 125 x 65 mm glass dish and secure the beaker in the center of the dish by use of clamps or other locking device to ensure that the beaker remains in place during sonication.

5.4. Fill the 125 x 65 mm glass dish with enough water and chopped ice to allow for the ice water bath level to encase the beaker to approximately the level of the water contained in the beaker.

5.5. Immerse the sonicator horn into the liquid in the beaker down to about 2.5 cm below the liquid level in the beaker. Center the horn in the beaker; the horn should not touch the sides or the bottom of the beaker, as this could cause the beaker to shatter during sonication.

5.6. Select a sonicator setting that yields a <u>delivered power</u> of approximately 50 W.

Note: Refer to [12] for details on the recommended calibration procedure for the determination of the sonicator's delivered power.

5.7. Operate the sonicator at this delivered power level for 15 min, using an 80 % pulsed operation mode (e.g., 80 % on / 20 % off during each second of operation time), or similar on/off time sequence.

Note: Refer to Appendix C for details on the optimization of the sonication sequence.

5.8. After sonication, transfer the aqueous dispersion to an amber borosilicate glass container and store at ambient temperature until further use. Do not refrigerate.

Note: If an amber glass container is not used, store the stock dispersion in a cabinet or other container such that exposure to light is minimized. It is not established whether or not exposure to typical laboratory light levels is consequential with respect to dispersion properties or biological behavior of the TiO_2 nanoparticles.

Note: The stability of dispersions prepared according to this protocol has been validated up to 48 h; however, since this protocol is intended as a preliminary step for the preparation of dispersions in relevant media, the resulting dispersions should be used as soon as possible following preparation and in accordance with directions prescribed in medium-specific protocols (currently under preparation).

6. Acceptance criteria

6.1. The obtained TiO_2 aqueous dispersion should have an opaque white appearance if prepared using P25.

Note: If source powders other than P25 are used, the appearance may vary depending on the final particle size, particle concentration and other factors. Refer to section A.3 for further details on the applicability and repeatability of the procedure for different P25 sources.

6.2. The particle size distribution (PSD) of P25 dispersions prepared following this protocol should be monomodal, with a volume-based mean particle diameter of:

≈ 75 nm, if measured using XDC;

≈ 70 nm, if measured using LDS;

≈ 110 nm, if measured using DLS.

The volume-based mean particle diameter, as well as the D_{10} and D_{90} values,[d] for aqueous P25 dispersions prepared following the protocol should be reported by the user to allow for comparison with the values specified herein. Refer to Appendix A for details on PSD characterization and validation criteria, as well as the determination of the mean diameter, D_{10} and D_{90} values.

6.3. The pH of P25 aqueous dispersions prepared using this protocol should be between 3.7 and 4.9, with lower pH values obtained for higher P25 concentrations. Refer to Appendix B for details on pH and stability measurements for P25 dispersions at varying concentrations.

Note: The successful implementation of this protocol for ENMs other than P25, including other sources of TiO_2 or other metal oxide ENMs, is dependent on knowing the isoelectric point (IEP) or zero point of charge of the ENM; in order to obtain a stable dispersion for ENMs that are electrostatically stabilized (i.e., that do not contain a sterically stabilizing capping agent), the final pH should be at least 2 to 3 pH units below or above the IEP. This may require the addition of a compatible acid or base, and should be evaluated as part of the optimization process (see Appendix C). Multiple test or practice runs may be required in order to determine the required quantity and concentration of acid or base to add; pH adjustment should, optimally, be performed after step 5.2 and prior to sonication. If dispersions are to be used for toxicological or environmental tests, additives for adjusting the pH should be selected based on their biocompatibility and relevance to the test matrix, and considering potential sonication-induced physicochemical changes[7].

[d] D10 and D90 refer to characteristic percentile size values associated with the cumulative volume or mass less than 10 % and 90 %, respectively, of the total volume or mass within the distribution. These parameters are routinely reported by LDS and XDC instruments. They may or may not be obtainable directly from commercial DLS instruments, depending on the manufacturer.

APPENDICES

Appendix A. Procedure to Validate Dispersion State

A.1 Characterization of the Particle Size Distribution (PSD)

Laser diffraction spectrometry (LDS), dynamic light scattering (DLS), and X-ray disc centrifugation (XDC) were used as size characterization techniques for the validation of the protocol with respect to producing a monomodal dispersion in the nanoscale size range. These techniques were selected as they allowed for *in situ* measurements with minimal sample transformations, ensuring that the measured PSD profiles reflected the actual state of the "as produced" dispersions rather than technique specific or sample preparation induced artifacts in size (e.g., drying induced agglomeration or probe-sample interaction artifacts commonly observed when using SEM, TEM or AFM). Furthermore, while LDS and DLS allowed for the measurement of PSD profiles based on light scattering properties, XDC provided an additional degree of validation as an orthogonal technique that relies on fundamentally different principles to determine size (i.e., centrifugal sedimentation and X-ray absorption).

To validate the size distribution of dispersions obtained by the prescribed protocol, a triplicate set of 10 mg/mL SRM 1898 aqueous dispersions were prepared following the procedure prescribed in the protocol, and their PSDs measured using LDS, DLS and XDC. In addition to SRM 1898, the procedure was validated across several different P25 commercial lots (section A.3).

LDS measurements were performed using a Partica LA-950 V2 (Horiba Instruments Inc., Irvine CA, USA), equipped with an 87 detector, high-resolution silicon photodiode array (75 detectors for forward/low-angle light scattering and 12 detectors for high-angle and backscatter light scattering); operating with a 5 mW 650 nm red laser and a 3 mW 405 nm blue light emitting diode. Measurements were conducted by introducing the sample into a stirred 15 mL glass cell containing DI water, until an adequate blue line transmittance level was attained (between 70 % and 90 % transmittance). For all LDS measurements, the instrument was zeroed using DI water as a blank. Volumetric PSDs were determined by application of the Mie scattering model, with a particle refractive index of 2.5.

DLS measurements were performed using a Zetasizer Nano ZS (Malvern Instruments Inc., Westborough MA, USA) in backscatter configuration (θ = 173°) at a laser wavelength of λ_0 = 633 nm. Samples were measured in 1.5 mL disposable cuvettes by dilution in DI water (up to 1 mL total volume) to achieve an appropriate light attenuation level. Measurement protocols used in this method are described elsewhere [18]. For each sample, measurements were performed in triplicate, with the number and duration of sub-measurements for each run determined automatically by the instrument's software. A non-negatively constrained least squares inversion algorithm was used to generate the PSD. A regularization parameter of 0.01 was selected, with data parsed over 70 bins. For conversion from intensity-weighted to volumetric PSDs, the Mie scattering model was applied using a particle refractive index of 2.5.

XDC measurements were performed using a BI-XDCW X-ray disc centrifuge system (Brookhaven Instruments Corp, Holtsville NY, USA) equipped with a standard PMMA 10 cm disc. For XDC measurements, 25 mL of a 10 mg/mL sample was loaded into the disc and spun at 3500 rpm (58.3 Hz) for 32 min. The particle size distribution was calculated using the radial scanning mode and the Stokes equation for laminar flow particle settling under a centrifugal field.

Unless otherwise noted, all PSD profiles are shown on a volume basis, and are thus equivalent to a mass weighted distribution. To allow for a quantitative and normalized comparison between different PSD profiles, the following two characteristic size parameters were used:

Mean Diameter (D_m): The arithmetic mean diameter of the sample's PSD, obtained by:

$$D_m = \frac{\sum q(j)X(j)}{\sum q(j)} \qquad (1)$$

Where *j* is the particle diameter division of the *volume (%) vs. diameter* frequency distribution, *q(j)* is the frequency value (%) for diameter division *j*, and *X(j)* is the central particle diameter for the diameter division *j*.

Mode Diameter (D_M): The size corresponding to the peak maximum in a PSD profile.

Diameters representing cumulative 10th (D_{10}) and 90th (D_{90}) percentiles: These diameters are used as a measure of the polydispersity or *spread* of a given size distribution; the parameters indicate that 10 % or 90 % (by mass or volume) of the particles in the evaluated size fraction have a diameter equal to or less than the D_{10} or D_{90} values, respectively. Percentile diameters can be obtained directly from a cumulative plot of the volumetric PSD (see e.g., [19]), and are usually available as output from commercial LDS and XDC instruments.

Uncertainties associated with reported characteristic size values are based on a Type A uncertainty analysis. The sample standard deviation (or standard uncertainty) was first calculated for replicate measurement results obtained under repeatability conditions. The standard deviation was then multiplied by *k*, where *k*=2 is the coverage factor approximating a 95 % confidence interval. The resulting uncertainty interval is referred to as the expanded uncertainty. [20]

Representative PSD profiles and characteristic dimensions for the prepared 10 mg/mL SRM 1898 dispersions, measured using the three selected techniques are shown in Figure A1 and Table A1.

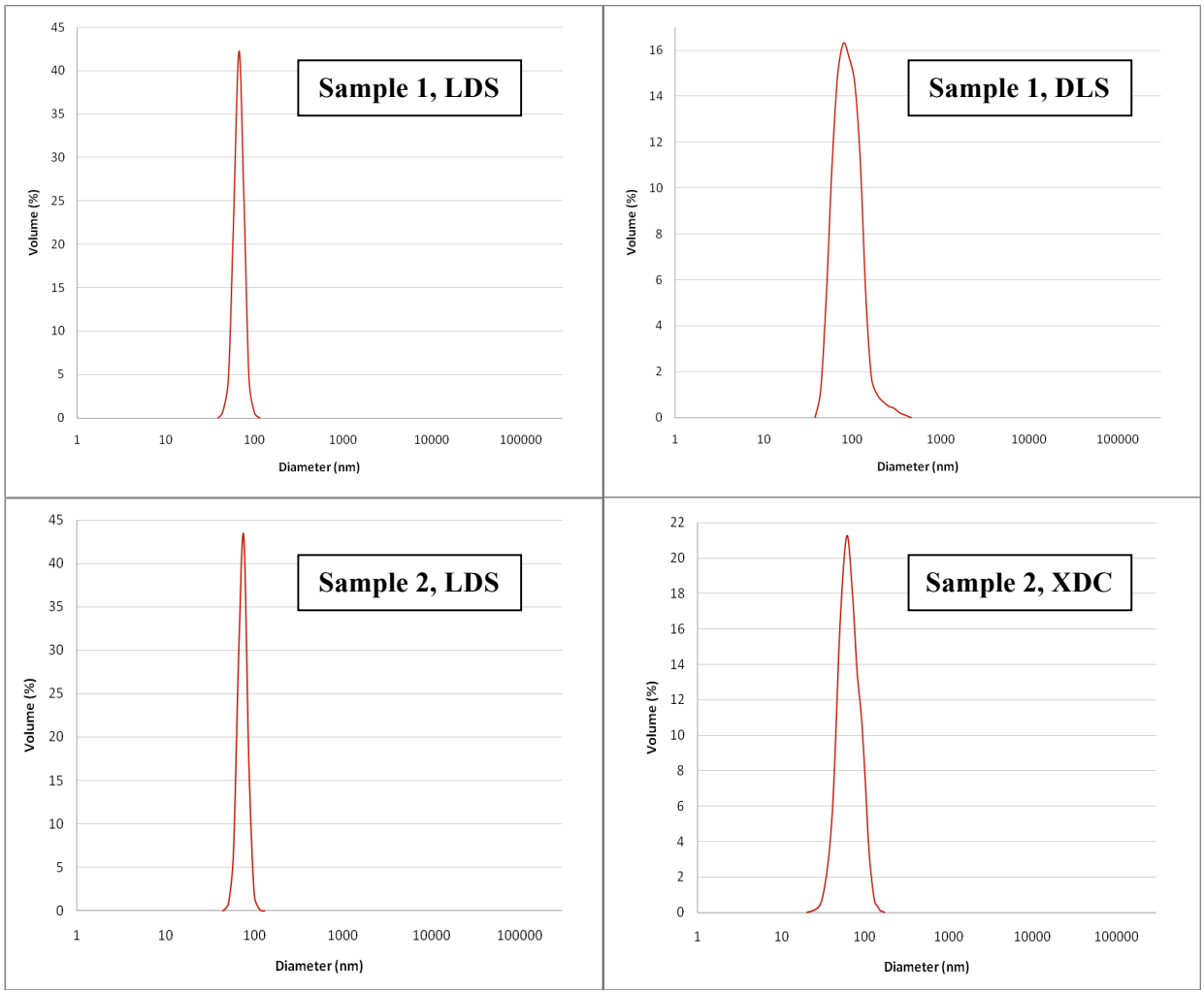

Figure A1. Representative PSDs obtained for 10 mg/mL SRM 1898 dispersions. Results from LDS (top, left) and DLS (top, right) for "Sample 1", and LDS (bottom, left) and XDC (bottom, right) for "Sample 2". All dispersions were obtained using the optimized sonication sequence. Sample labels are arbitrary.

Table A1. Averages and uncertainties (95 % confidence interval) for mean diameter (D_m), mode diameter (D_M), D_{10} and D_{90} values of SRM 1898 10 mg/mL dispersions measured using LDS, XDC and DLS. Averages and uncertainties were obtained from the measurement of three independent dispersions with each technique. All dispersions were obtained following the optimized sonication sequence.

Technique	D_m (nm)	D_M (nm)	D_{10} (nm)	D_{90} (nm)
LDS	71.1 ± 3.9	70.9 ± 2.7	59.3 ± 1.6	84.3 ± 4.8
XDC	77.0 ± 6.6	54.3 ± 5.7	31.7 ± 22.4	119.3 ± 22.5
DLS	112.4 ± 4.0	113.8 ± 5.1	67.8 ± 8.0	151.1 ± 3.5

As shown in Figure A1 and Table A1, LDS and XDC yielded a good statistical match (with respect to the confidence intervals) for the sample mean diameters, and a reasonable consistency

with respect to the other characteristic percentiles. By contrast, DLS exhibited larger mean diameter and D_{90} values, which reflects, in part, the known sensitivity of DLS to the presence of small quantities of large particles.[e] Additionally, DLS measures the equivalent spherical hydrodynamic envelope defined by the primary aggregate's displaced volume, including entrained solution and a hydration shell; thus, DLS hydrodynamic size is typically larger than a hard core based size. As XDC and LDS are orthogonal in nature, and less sensitive to artifacts that commonly impact DLS measurements, these two methods in combination provide validation of the characteristic PSD profile of dispersions prepared following the prescribed protocol. Since LDS requires substantially less sample mass to perform measurements, compared with XDC, it was therefore adopted as the principal size characterization technique for all further validation tests.

The obtained results show a high repeatability for the prescribed protocol in terms of yielding consistent PSDs for dispersions obtained from a single P25 production lot (NIST SRM 1898) and at a single particle concentration of 10 mg/mL, as indicated by the relatively low variation in the measured size parameters, based on LDS. It must be noted that the higher relative uncertainty for the XDC D_{10} value is likely due to the fact that it is close to the lower detection limit of the instrument (≈ 10 nm). As shown in the following sections, further tests were performed to assess the repeatability of the protocol for the preparation of dispersions at different particle concentrations and using different P25 production lots.

A.2 Repeatability of dispersion protocol at different particle concentrations

To evaluate the repeatability of the protocol with respect to producing consistent PSDs at different particle concentrations, NIST SRM 1898 was dispersed at concentrations of (0.5, 1, 10 and 20) mg/mL, in 50 mL of DI water. PSD profiles of the resulting dispersions were measured using LDS, showing comparable distributions in all cases (Figure A2, Table A2).

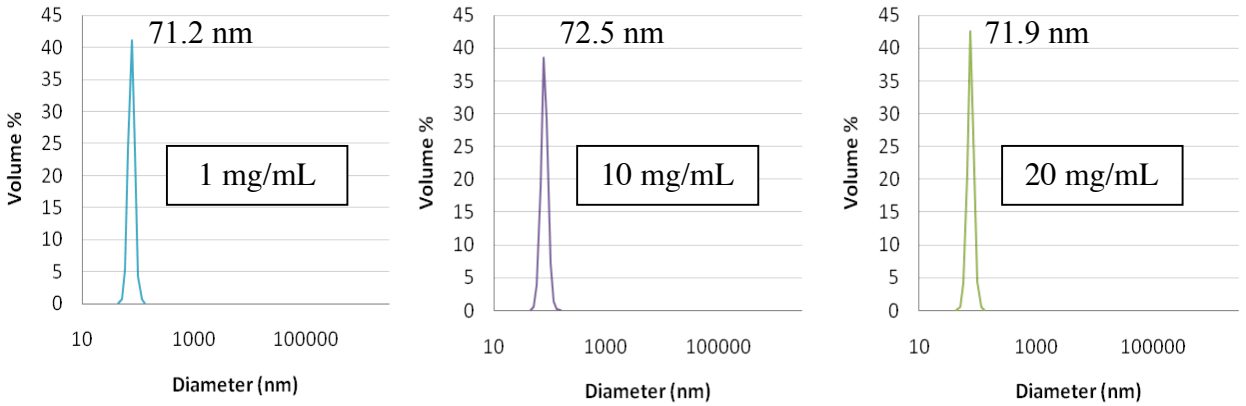

Figure A2. LDS PSD profiles of SRM 1898 dispersions at concentrations of 1 mg/mL (left), 10 mg/mL (middle) and 20 mg/mL (right). Peak values are shown in each plot. PSDs of 0.5 mg/mL dispersions are shown in Figure A3.

[e] In the DLS analysis, conversion from an intensity-based to a volumetric-based PSD necessarily involves greater uncertainty, compared with LDS and XDC, due to the inherent low resolution associated with photon correlation based analysis and the reliance on a single scattering angle.

Table A2. Mean diameter (D_m), mode diameter (D_M), D_{10} and D_{90} values of (0.5, 1, 10 and 20) mg/mL SRM 1898 dispersions prepared following the prescribed protocol.

P25 Conc. (mg/mL)	D_m (nm)	D_M (nm)	D_{10} (nm)	D_{90} (nm)
0.5	69.5	69.8	58.7	82.2
1	71.6	71.2	59.4	84.8
10	74.0	72.5	60.4	86.9
20	72.4	71.9	60.1	85.1

As shown in Table A3, all of the measured D_m, D_{10} and D_{90} values of dispersions prepared at different particle concentrations were within the 95 % confidence intervals obtained from the PSD validation tests, shown in Appendix A, Table A2 - LDS.

A.3 Repeatability of dispersion protocol for different P25 sources

The repeatability of the protocol for the preparation of dispersions with consistent PSDs using different P25 production lots was tested using material from SRM 1898 (P25 control no. 4166091998, produced in 2006) and two additional P25 lots: CN 4168112198, produced in 2008 and used in the OECD testing Program, and CN 11B1, produced in 2001. The prescribed protocol was applied to all three powder production lots, at a concentration of 0.5 mg/mL. The PSDs of the obtained dispersions were measured using LSD. Results are shown in Figure A3 and Table A3.

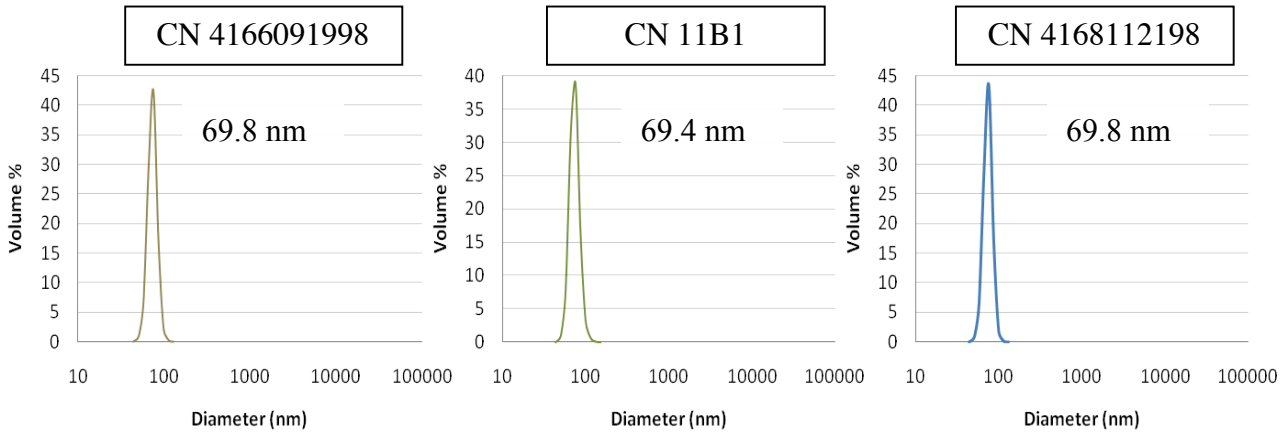

Figure A3. LDS derived PSD profiles for 0.5 mg/mL dispersions obtained using different P25 sources (control numbers for each lot indicated above each plot). Mode diameters (i.e., most frequent value) are indicated in each size plot.

Table A3. Mean diameter (D_m), mode diameter (D_M), D_{10} and D_{90} values for P25 dispersions prepared from different production lots, by applying the prescribed protocol.

P25 Source	Production year	Dm (nm)	D_M (nm)	D_{10} (nm)	D_{90} (nm)
CN 11B1	2001	69.5	69.4	58.4	83.1
CN 4166091998	2006	69.5	69.8	58.7	82.2
CN 4168112198	2008	69.4	69.8	58.8	81.9

As shown in Figure A3 and Table A4, the protocol produced statistically identical results (relative to the 95 % confidence interval) with narrow PSDs and a single mode centered near 70 nm, independent of the material source. All of the measured D_m, D_{10} and D_{90} values for the dispersions prepared from different P25 production lots were within the 95 % confidence intervals obtained from the PSD validation tests (Appendix A, Table A2 – LDS).

It must be noted that the protocol was also tested for the dispersion of two additional P25 lots manufactured more than 15 years ago. These two powder sources could not be fully dispersed, showing a minor microscale size mode upon application of the prescribed procedure. This deviation may be related to actual differences in the production process relative to more recently produced material, or to aging-induced physicochemical changes in these powder sources, which possibly manifest in the strengthening of agglomerate/aggregate bonding over time. Nonetheless, further optimization tests were carried out to evaluate the possibility of dispersing sources affected by aging. For this purpose, the oldest available production lot (with a production date around 1988) was subject to further optimization tests. By increasing the sonication time and power (sonication time increased by 5 min and power by ≈ 30 W, with respect to protocol conditions), this powder was successfully dispersed to a monomodal ≈ 70 nm peak fraction with an absence of microscale agglomerates. While we do not intend to prescribe specific dispersion procedures for compromised P25 sources, it is worth noting that production date, aging and/or other factors (such as inadequate storing conditions) may result in an incomplete dispersion of the powder, even if the protocol is applied properly. However, based on our findings, it is believed that further optimization steps can potentially allow for the attainment of complete dispersion to a reproducible and single mode PSD for any P25 source material. The reader is advised to consult [7] and Appendix C for optimization guidelines and procedures.

Appendix B. pH and Stability of Dispersions

B.1 IEP determination

To better understand the stability of dispersions, in light of their intended use for the preparation of dispersions in complex biological or environmental media, the isoelectric point (IEP) of SRM 1898 dispersed according to the prescribed protocol was evaluated by determining the zeta potential (derived from electrophoretic mobility measurements) over an appropriate range of pH values.

Zeta potential measurements were performed using a Zetasizer Nano ZS (Malvern Instruments Inc., MA, USA), operating in the monomodal analysis mode and using a palladium electrode dip cell. Zeta potential values were calculated from the measured electrophoretic mobility using the Smoluchowski relationship, which assumes thin double layer conditions and may not be strictly applicable to particles with a relatively thick electrical double layer and small diameter; however, the absolute magnitude of the zeta potential is not critical for the determination of the IEP, and the Smoluchowski value is commonly reported in the literature and is a default setting on many commercial instruments. Therefore, Smoluchowski-derived values are reported here for comparative purposes only.

pH measurements were conducted using an Orion 3-Star pH meter (Thermo Electron Corp., MA, USA) , outfitted with an InLab Semi-Micro polymer electrolyte pH electrode (Mettler Toledo, OH, USA) and an Orion 927006MD Automatic Temperature Compensation probe (Thermo Electron Corp., MA, USA).

The SRM 1898 dispersion used for these tests was prepared following the protocol at a concentration of 0.5 mg/mL. After sonication, two sets of zeta potential versus pH measurements were obtained; one set starting from the basic pH end and titrating towards acid pH values, and another set with the reverse titration trend. For the basic-to-acid titration, 1.25 mL of the sonicated SRM 1898 suspension was transferred into 50 mL of a 10^{-3} mol/L NaOH solution (for a starting pH near 11) in a 60 mL plastic beaker with a magnetic stir bar. While stirring, the pH was lowered by addition of HCl (aq), and zeta potential measurements obtained at selected pH values down to ≈ pH 3. At each relevant pH value, an aliquot of 1 mL was taken from the suspension and used to measure the zeta potential. A similar procedure was followed for the reverse (acid-to-basic) titration set, in this case using 50 mL of a 10^{-3} mol/L HCl solution for a starting pH near 3, and titrating with NaOH (aq) to ≈ pH 11.

Since the pH, zeta potential and IEP are used here within a qualitative context, uncertainties are not reported for these values.

The titrations as described above converged to an IEP near pH 7, as shown in Figure B1. For pH values above 7, the basic to acid titration values are shown, while for pH values below 7, the acid-to-basic titration values are shown.

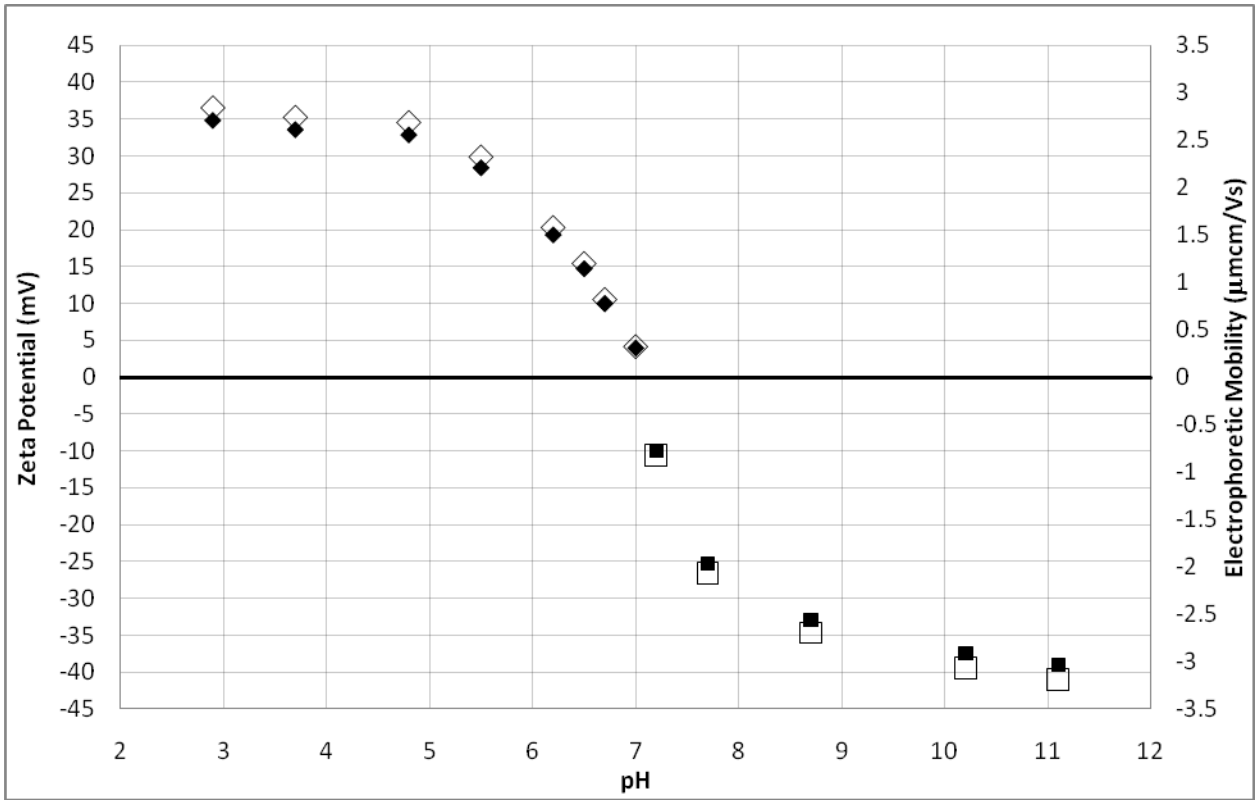

Figure B1. Acid-to-basic (diamonds) and basic-to-acid (squares) titration sets for electrophoretic mobility (filled markers) and zeta potential (hollow markers) as a function of pH for SRM 1898 prepared following the prescribed protocol; titrations converge to an IEP at ≈ pH 7.

The obtained IEP suggests that the suspended nanoparticles are most susceptible to agglomeration at biologically and environmentally relevant pH values (i.e., near neutral pH). This finding stresses the importance of measuring the stability of the particles in relevant media and adopting measures, such as using relevant stabilizing agents (e.g., proteins), to control agglomeration that can potentially result from changes in pH, which are likely to manifest upon inoculation in relevant media.

B.2 pH of dispersions at different concentrations

The prepared dispersions showed pH values in the (3.7 to 4.9) range, with dispersions at high particle concentrations showing lower pH values than dispersions at low concentrations (see Figure B2 for representative dispersion pHs at different particle concentrations).

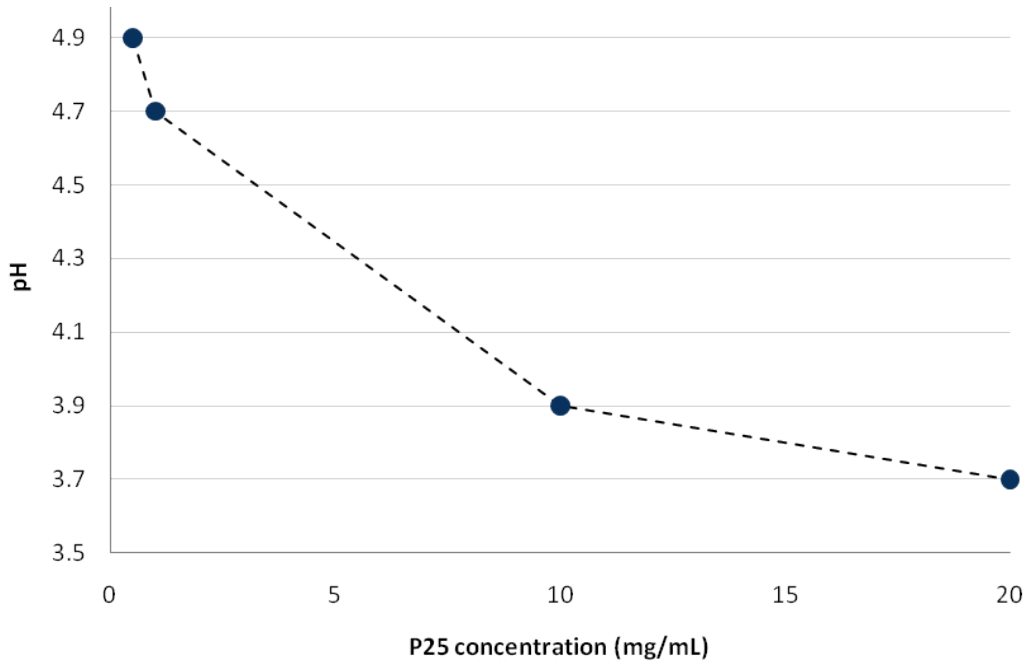

Figure B2. Representative pH values for aqueous dispersions of SRM 1898 at different concentrations.

The measured acidic pH values of the as-prepared dispersions are consistent with the manufacturer reported pH values for aqueous P25 dispersions (pH range of 3 to 5) [13] and are explained by the release of protons into the water from residual HCl in the P25 dry powder. The residual HCl is a byproduct of the gas phase pyrogenic hydrolysis of titanium tetrachloride, which is the basis of the AEROSIL process by which P25 is produced. Accordingly, and as experimentally confirmed, higher P25 concentrations yield lower pH values due to a greater quantity of protons released into the same volume of medium.

While the aqueous dispersions obtained in this work are not intended for use "as is" in toxicological or environmental tests - but instead to be employed as stock solutions that are applied towards the preparation of dispersions in relevant biological or environmental media - the measured acidic pH for SRM 1898 aqueous dispersions points to the need for pH measurements of TiO_2 (and other metal oxide) dispersions in relevant media, to ensure that their pH meets the desired value for the intended test. The stability of the SRM 1898 aqueous dispersions prepared following the optimized sonication sequence was measured in terms of the conservation of the PSD profile over 48 h.

All of the prepared dispersions at the tested particle concentrations were stored in capped amber glass vials at room temperature and retained their PSD over at least 24 h, with the 10 mg/mL and 20 mg/mL dispersions retaining their PSD for more than 48 h. If dispersions prepared following the protocol prescribed herein are intended for use over longer periods of time, stability should be validated accordingly.

Appendix C. Optimization of Dispersion Procedure

As mentioned previously, the technique adopted to obtain nanoparticles from the ENM source powder was direct (probe) sonication. This technique is a simple operation that can achieve a

higher degree of powder fragmentation, at constant specific energy, than other conventional dispersion techniques [7, 21-23].

Sonication parameters (power, time and operation mode) were optimized to achieve the smallest possible nanoparticle dimensions and a monomodal size distribution. A Branson 450 analog horn sonicator (Branson Ultrasonics Corp., CT, USA) was used for all dispersion tests.

Uncertainties associated with reported sonication power values are based on a Type A uncertainty analysis. The sample standard deviation (or standard uncertainty) was first calculated under repeatability conditions for replicate measurement results. The standard deviation was then multiplied by k, where k=2 is the coverage factor approximating a 95 % confidence interval. The resulting uncertainty value is referred to as the expanded uncertainty. [20]

LDS was selected as the size characterization technique for dispersion optimization studies. For a detailed discussion on the selection and suitability of this technique over other conventional techniques (such as DLS) for the measurement of size profiles in dispersion optimization studies, please refer to [19, 24].

C.1.Sonication power

Prior to the evaluation of the dispersion effect of sonication power, the probe sonicator used for the optimization tests was calibrated in order to correlate different sonicator settings to quantifiable power values. The calibration was performed as prescribed in [12]. Table C1 summarizes representative power values for different sonicator settings.

Table C1. Calorimetrically measured delivered sonication power corresponding to different sonicator settings (see [12] for calibration details). Averages and associated uncertainties correspond to a 95 % confidence interval for triplicate measurements.

Setting	**Power (W)**
1	9.25 ± 1.15
3	32.2 ± 2.3
5	52.34 ± 0.96
8	96.95 ± 4.35
10	123.3 ± 12.6

For power optimization tests, 0.025 g of SRM 1898 was added to a 100 mL, 5 cm diameter glass beaker. Then, 50 mL of DI water was added to the beaker with the powder to yield a 0.5 mg/mL P25 concentration. The beaker was immersed in an ice water bath that covered the beaker just above the water level contained within the beaker. The sonicator horn was fitted with a standard 0.5 inch (1.3 cm) flat tip and immersed in the beaker at an immersion depth of ≈ 2.5 cm below the water level in the beaker. Sonicator settings from 1 to 10 were then applied, operating in

continuous mode for 1 min. Representative PSD profiles and characteristic size parameters obtained for dispersions prepared under different power levels are shown in Figures C1 and C2.

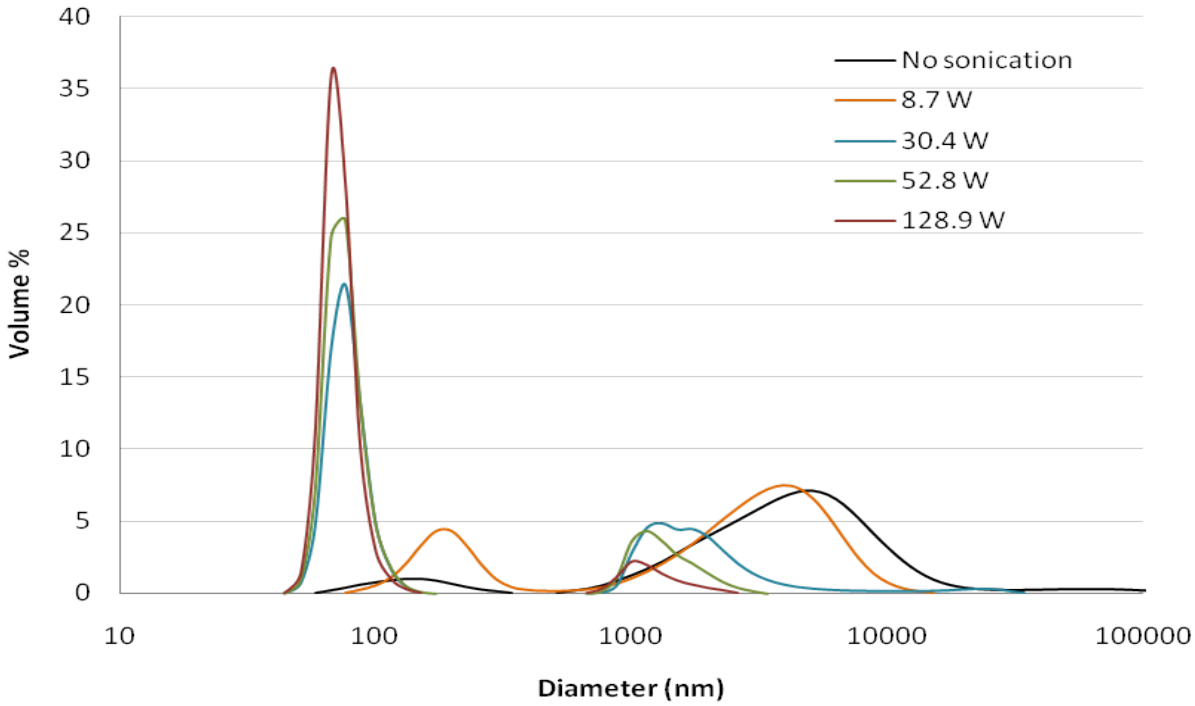

Figure C1. PSD profiles obtained using LSD for SRM 1898 dispersed in DI water at different sonicator power levels (sonication time 1 min, continuous mode).

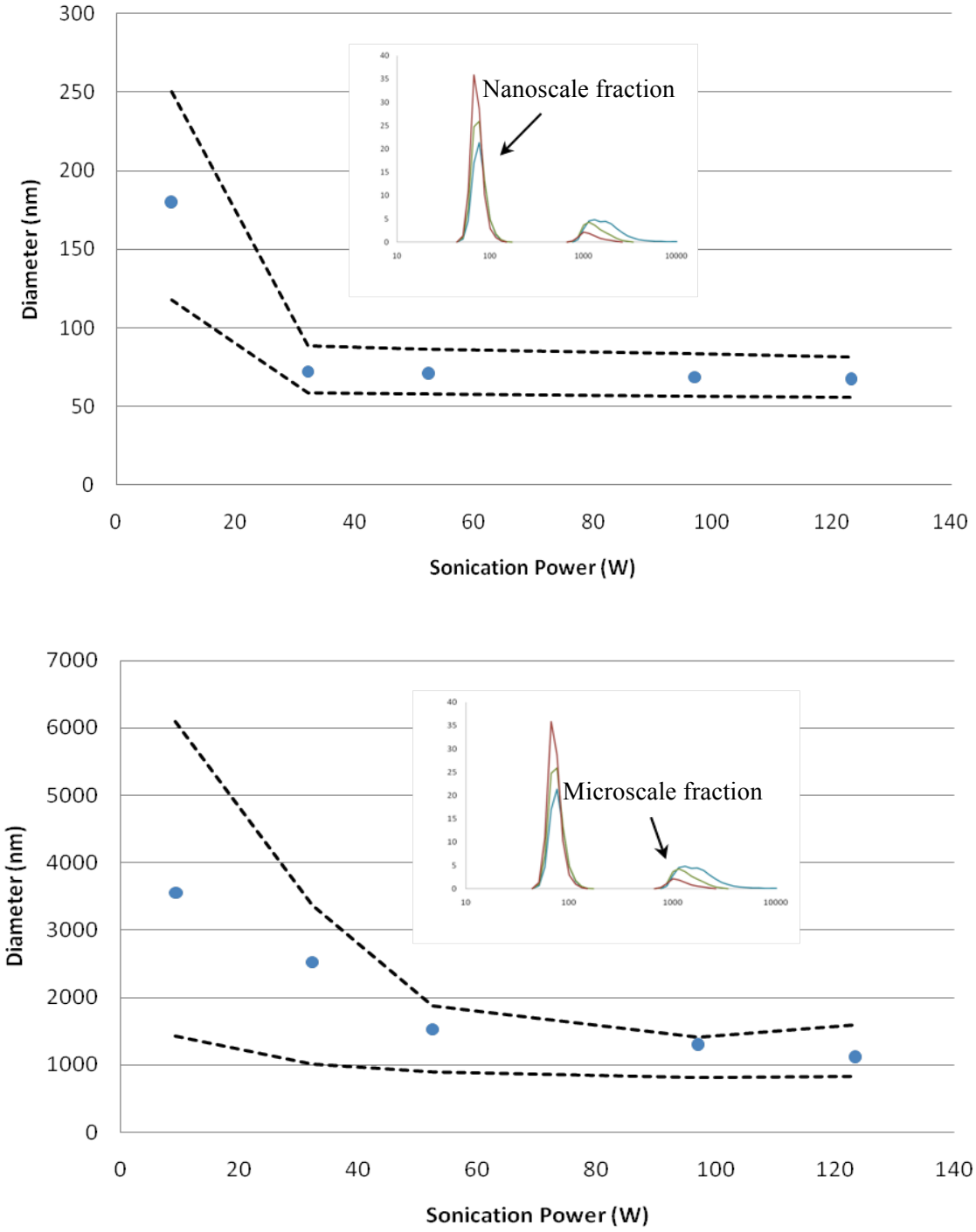

Figure C2. Mean diameters (dots), D_{10} (lower dashed line) and D_{90} (upper dashed line) values for each of the two size fractions (nanoscale -top and microscale -bottom) observed in the bimodal PSDs of SRM 1898 aqueous suspensions sonicated at different power levels (sonication time 1 min, continuous mode).

As shown in Figure C2, the unsonicated dispersion shows a highly polydisperse and multimodal PSD predominantly in the (1 to 10) μm range, with a major fraction (93 % of the total particulate volume) centered at around 6 μm and a minor fraction of particles with a peak at around 130 nm. As the powder in suspension undergoes sonication induced fragmentation, the original PSD profile shifts to a well-defined bimodal distribution, showing a microscale fraction with a peak at (1 to 3) μm and a nanoscale fraction with a peak at (50 to 80) nm. As sonication power is increased, the relative predominance of the microscale fraction decreases, going down to 20 % of the total particulate volume after sonication at 50 W (from the original 93 % for the non-sonicated suspension). These trends (size fraction characteristic peak values and decrease of the microscale fraction) are consistently observed as sonication power increases and, in particular, at powers at or above ≈ 50 W, wherein two consistent size fractions develop, one with a peak approaching ≈ 1 μm and a nanoscale fraction with a peak at ≈ 70 nm (Figure C1). These two peaks remain relatively unaltered at power values above 50 W. The observed behavior suggests two configurations for P25 aggregates/agglomerates, wherein the 70 nm peak likely indicates primary aggregates (i.e., small assemblies consisting of fused primary crystallites), while the 1 μm peak suggests that the 70 nm aggregates associate, likely through weaker Van der Waals attractive forces or a small number of cleavable contact points, forming larger *metastable* agglomerates that tend towards a specific size mode (i.e., at around ≈ 1 μm).

C.2. Sonication time and operation mode

As no significant difference in the bimodal distribution peak sizes or fraction spreads were observed beyond a power of ≈ 50 W (see section C.1) and higher power settings could further result in excessive sample heating and undesirable side effects under longer sonication times, a sonicator power setting of 5 (≈ 50 W) was chosen for further time optimization steps (setting is specific to the device used in this study; other device and probe combinations would require calibration according to reference 12).

Under otherwise similar conditions to those explained in section C.1, and operating at power setting 5 in continuous mode, different sonication times (30 s, 1 min and 5 min) were tested. As shown in Figure C3, increasing sonication time resulted in a significant decrease in the microscale fraction relative volume, while the nanoscale peak position remained relatively unaltered. This trend further confirms that the micrometer scale peak corresponds to weakly bound agglomerates that can be further fragmented if sufficient energy is delivered, while the 70 nm peak corresponds to hard "primary aggregates" consisting of strongly bound primary crystallites that cannot be further disrupted via sonication at the tested delivered energies.

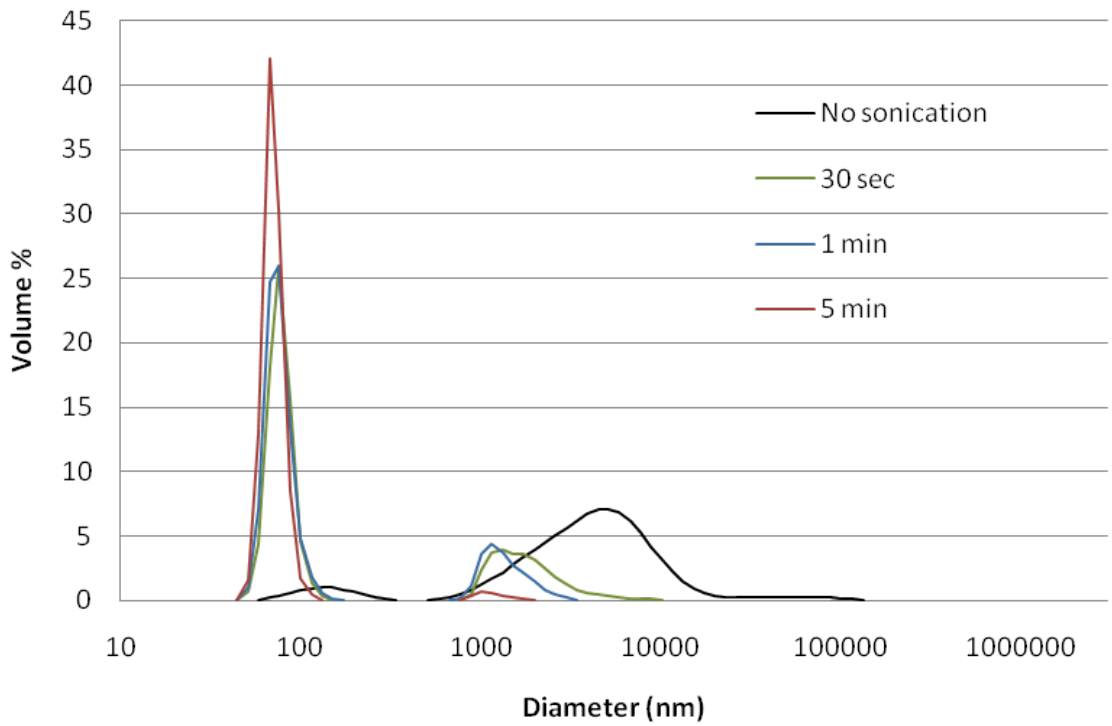

Figure C3. PSD profiles for SRM 1898 in DI water at different sonication times (sonication power setting 5, continuous mode).

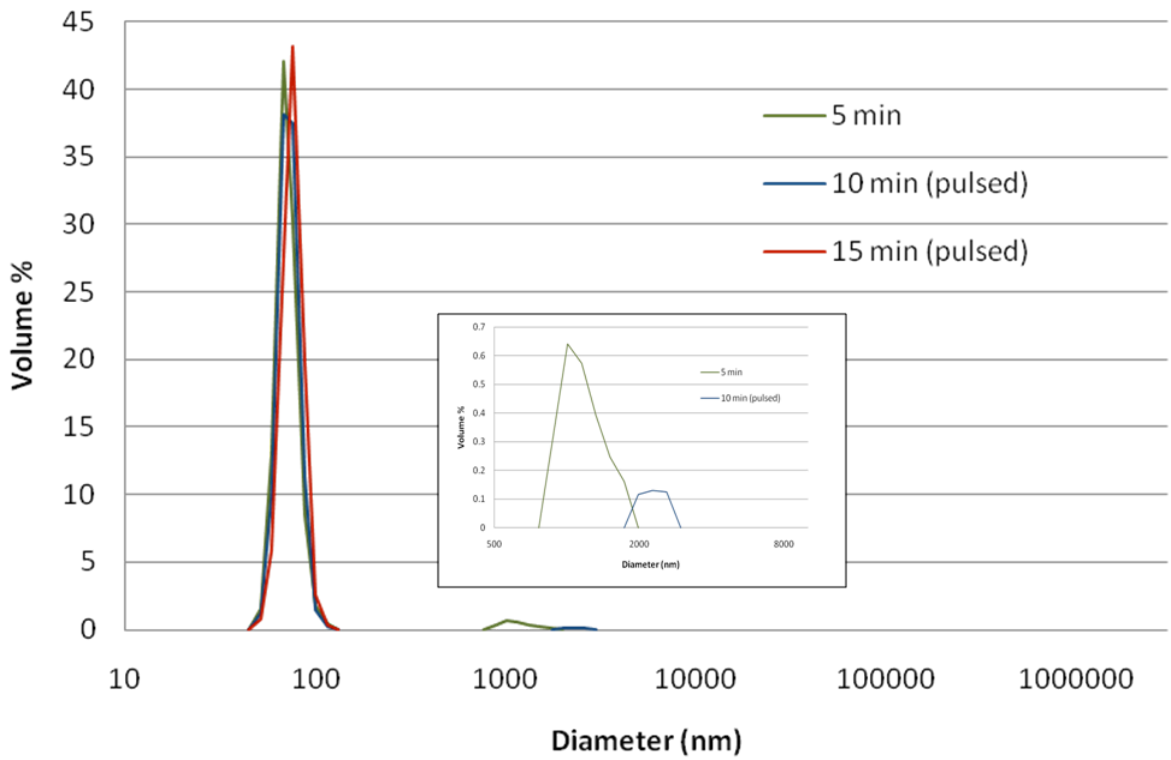

Figure C4. PSD profiles for SRM 1898 in DI water at different sonication times (sonication power setting 5, continuous -5 min- and pulsed modes -10 min and 15 min); inset shows an expanded view of the microscale size range.

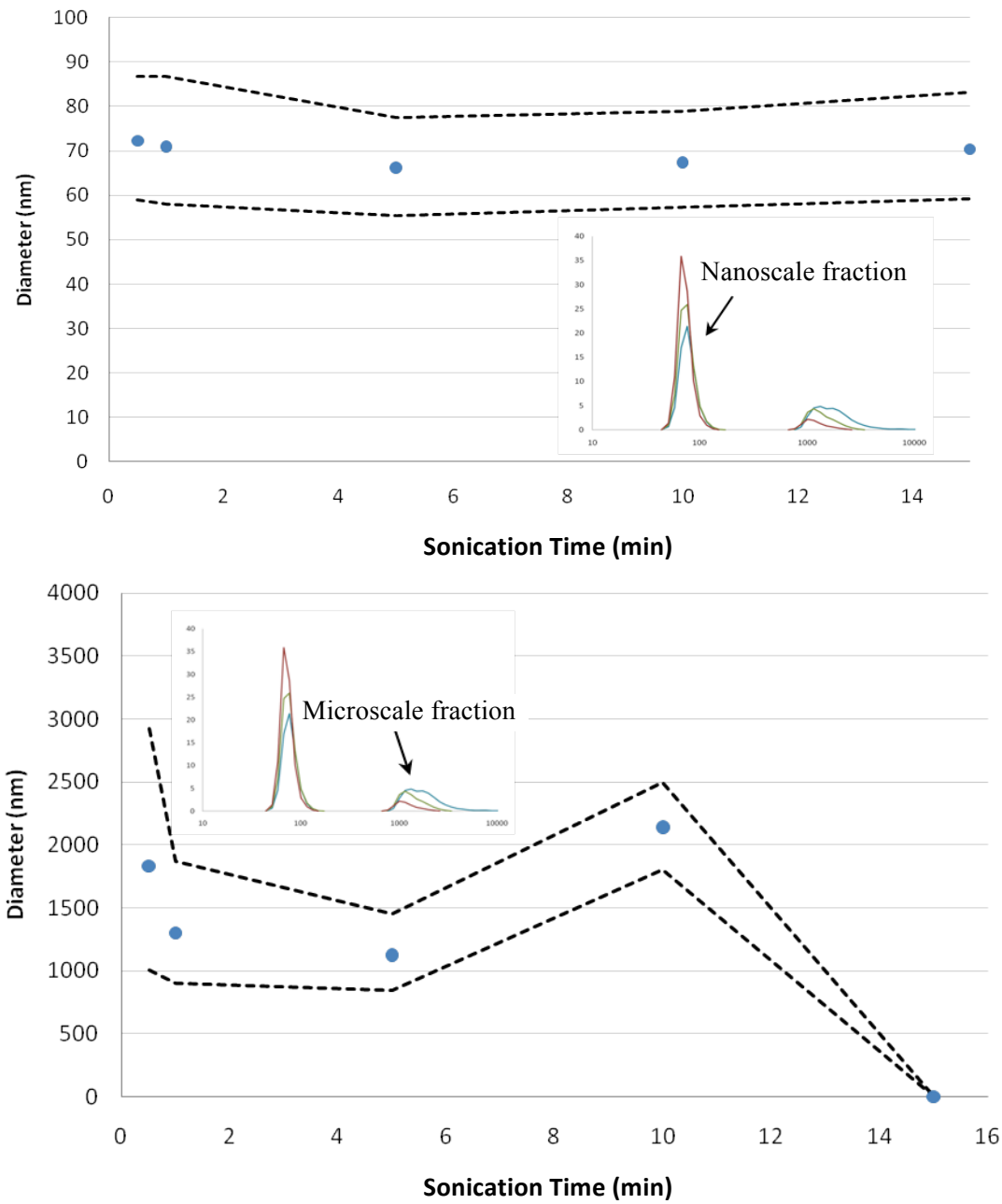

Figure C5. Mean diameters (filled circles), D_{10} (lower dashed line) and D_{90} (upper dashed line) values for each of the two size fractions (nanoscale shown in top graph and microscale on bottom) observed in the bimodal PSDs for SRM 1898 aqueous suspensions sonicated at different times and operation modes (sonication power setting 5, continuous up to 5 min- and pulsed modes -10 min and 15 min).

At sonication times above 5 min in continuous mode, the heating of the suspension was appreciable, even when immersed in the ice water bath. For this reason, pulsed operation was employed for further time optimization tests. Sonication times where then tested under an 80 % pulsation regime (0.8 s on, 0.2 s off). As shown in Figures C4 and C5, at 10 min of sonication there was still an identifiable - though minor - microscale peak, while after 15 min of sonication

the microscale peak was fully eliminated. Therefore, a sonication time of 15 min with an 80 % pulsation mode were selected for further tests.

From the above tests, an optimal set of sonication conditions was obtained: sonication power of ≈ 50 W and sonication time of 15 min at an 80 % pulsation mode for a TiO_2 concentration of 0.5 mg/mL in 50 mL of DI water using a flat tip at a water immersion depth of 2.5 cm in a cylindrical 100 mL, 5 cm diameter glass beaker. These sonication conditions yielded a narrowly dispersed, monomodal ≈ 70 nm mean particle diameter aqueous dispersion with no measurable microscale size fraction. A detailed, step by step description of the preparation procedure under optimized conditions is given in section 5 of the protocol. Validation tests for the optimized procedure prescribed herein are given in Appendix A.

Abbreviations

DI	de-ionized
DLS	dynamic light scattering
ENM	engineered nanomaterial
IEP	isoelectric point
ISO	International Organization for Standardization
LDS	laser diffraction spectrometry
NIST	National Institute of Standards and Technology
OECD	Organization for Economic Cooperation and Development
PSD	particle size distribution
SRM	Standard Reference Material
XDC	X-ray disc centrifugation

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CEINT/NIST PROTOCOL FOR

PREPARATION OF NANOPARTICLE DISPERSIONS FROM POWDERED MATERIAL USING ULTRASONIC DISRUPTION

Ver. 1

June 3, 2010

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PREPARATION OF NANOPARTICLE DISPERSIONS FROM POWDERED MATERIAL USING ULTRASONIC DISRUPTION

Version 1.0

Scope

This protocol is generic in nature and is intended to provide relevant guidelines for the preparation of nanoparticle dispersions in liquid media by the application of ultrasonic energy (a process referred to here as sonication). It applies specifically to source engineered nanoscale materials (ENM) obtained in dry powder form, but can be extended to the treatment of previously suspended ENMs (e.g., for purposes of re-dispersion).

For a more in depth discussion of specific parameters addressed in this protocol, the reader is advised to consult reference [1]. For guidelines on reporting relevant conditions and critical parameters relating to the ultrasonic dispersion of ENMs, refer to [2]. For additional relevant and general considerations on the application of ultrasound, the reader is urged to consult the references [3-10].

General Considerations

Ultrasonic waves are generated in a liquid suspension either by immersing an ultrasound probe or "horn" into the suspension (direct sonication), or by introducing the sample container with the suspension into a bath containing a liquid through which ultrasonic waves are propagated (indirect sonication).

In a sonication bath (indirect sonication), the ultrasonic waves must traverse the bath liquid and then pass through the wall of the sample container before reaching the suspension. In direct sonication, the probe is immersed directly into the suspension, reducing the physical barriers to delivering the power to the dispersion.

Direct sonication is recommended over indirect sonication for the purpose of dispersing dry powders, as it yields a higher effective energy output into the suspension. Indirect sonication can be used to re-suspend ENMs which have been pre-processed via direct sonication, or for ENMs that may be subject to unintended modifications or damage under direct sonication (e.g., cleavage of single wall carbon nanotubes).

Sonication is a highly system-specific dispersion procedure, involving a variety of concomitant complex physicochemical interactions that can result in either cluster breakdown or further agglomeration, as well as other effects including chemical reactions.

For a given system, optimal sonication conditions must be determined by assessing the effect of a variety of sonication parameters on the dispersion state of the suspension under a broad range of relevant conditions. Moreover, the total effective acoustic energy utilized in fragmenting powder clusters is influenced by a number of instrument- and system-specific parameters.

Adequate personal protective equipment (sound protection and respirator when applicable, goggles and labcoat) should be worn at all times. An acoustic enclosure is recommended for probe-based sonication procedures. A combination of ear plugs (recommended protection level NRR 30/SNR 34) and/or ear muffs should be used when in close proximity to the ultrasound source.

Specific Considerations

Temperature

During sonication, the extreme local heating cycles that take place at the micro-scale bubble interface due to cavitation will result in a bulk heating of the liquid over time. Excessive bulk heating can cause substantial liquid evaporation, resulting in changes to the sonicated volume, or the degradation of the material or medium components.

A simple approach to minimize temperature driven side effects is to avoid substantial high-temperature excursions by immersing the suspension container in a cooling bath. The container should be immersed to a level roughly equal to that of the internal suspension.

An ice-water bath is often sufficient to prevent suspensions from overheating. If, however, ice water is not sufficient (e.g., the sample volume is too low, the sonication time is too long, or high sonication powers are used) an ice-salt bath can be substituted.

Working with containers made of materials with high thermal conductivities helps ensure a rapid release of heat from the suspension. The following container materials are suggested, in order of decreasing thermal conductivity: aluminum, stainless steel, glass, plastic. When selecting the container, consideration must also be given to the chemical compatibility between the container material and the suspension components. For instance, aluminum is incompatible with acidic suspensions, and glass is incompatible with alkaline solutions.

Additionally, an aluminum foil or other cover with an opening just big enough to allow the probe to pass through, is recommended to reduce the evaporative loss of liquid content, especially when sonicating in volatile solvents (e.g., ethanol) or for substantial durations. Cooling the sample will also reduce evaporative loss. The volume of suspension before and after sonication should be verified and any corrections for evaporation reported. The cover will also minimize the potential release of aerosols generated by the sonication process.

Sonication time and operation mode

The total amount of energy (E) delivered to a suspension not only depends on the applied power (P) but also on the total amount of time (t) that the suspension is subject to the ultrasonic treatment: $E = P \times t$. Consequently, two suspensions treated at the same power for different times can show significantly different dispersion states.

Ultrasonic disruptors can typically operate in either continuous or pulsed mode. In pulsed mode, ultrasonic intervals are alternated with static (sonication off) intervals. The duration of on and off intervals can be regulated. Operating in pulsed mode retards the rate of temperature increase in the medium, minimizing unwanted side effects and allowing better temperature control than continuous mode operation. Pulse mode operation is therefore generally recommended.

Sample volume and concentration

While sonication power and time describe the amount of energy *delivered* to the suspension, samples of different volumes and particle concentrations can respond differently to the same amount of delivered energy.

At constant volume, higher particle concentrations result in an increased particle collision frequency. In principle, an increased collision frequency can enhance particle breakage due to an increase in particle-particle impact events. However, if sufficient local activation and sintering energies are achieved, increased collision frequencies can also induce agglomerate or aggregate formation as particles collide and coalesce. The effect of concentration is thus dependent on both the energy delivered into the suspension and the physiochemical properties of the suspension.

At the particle concentrations commonly encountered in environmental and toxicological evaluations, no significant impact on the medium's acoustic properties is anticipated as a direct result of the particle phase.

The effect of suspension volume (at equal particle concentrations) is measured as *energy density* (W·s/mL). This magnitude expresses the amount of delivered energy per unit of suspension volume. In principle, at equal power and particle concentration, higher energy densities (i.e., lower suspension volumes) will result in higher disruptive effect.

When working with small volumes the temperature of the suspension will rise more rapidly; therefore, more intense cooling conditions may be required.

Sonicator probe, container geometry and tip immersion

The sonicator probe (or horn) is the acoustic element that conducts the acoustic energy from the transducer into the suspension. The amount of acoustic energy transferred to the suspension will depend on the shape and diameter of the probe and its immersion depth in the suspension.

The vibrational amplitude of the horn at a given power setting is dependent on the horn taper. Usually, more pronounced tapers result in larger vibrational amplitudes, and consequently a higher delivered power.

At equivalent instrumental power settings, microtip probes vibrate with larger amplitudes than conventional flat tip probes. However, microtips are less mechanically robust and are limited in terms of the maximum power setting at which they can be used. The manufacturer will typically specify a maximum power setting (based on a percentage of the maximum power output) for use with microtips. Microtips are appropriate for small suspension volumes (e.g., 25 mL or less).

The way in which the ultrasonic energy is distributed within the suspension is also heavily influenced by the container geometry. When possible, it is recommended to use the smallest diameter vessel that allows for the probe to be inserted without touching the container walls. Using smaller container diameters raises the height of the liquid and maximizes the liquid-probe surface area exposed to the acoustic waves, as well as the container wall surface/volume ratio for dissipation of heat by the cooling bath.

Conical bottom, flat bottom and round bottom flasks will show different energy maxima and minima distribution profiles, which will in turn vary significantly for different probe tapers and probe tip immersion depths. Cylindrical, flat bottom beakers are recommended, especially for small volumes.

Probe immersion depths between (2 to 5) cm are recommended when operating with standard ½" horns having flat tips or with microtips. Probes should be placed no closer than about 1 cm from the bottom of the sample container, and contact between the probe and the container walls should be avoided.

Medium properties

The ultrasonic energy delivered to a suspension is partly attenuated and dissipated by the suspending medium. Attenuation is determined by the medium's viscosity, density, acoustic wave speed and chemical composition, all of which impact on the amount of delivered energy that is effectively utilized to disrupt powder clusters. For instance, in principle, a higher medium viscosity will result in a greater acoustic attenuation. Additionally, higher viscosities will dampen the cavitation process, requiring higher power inputs to achieve dispersion. The medium's density and acoustic wave speed will also impact on the amount of vibrational energy that is transformed into acoustic energy.

For media relevant to biological testing, the salt content is likely to have a measurable impact on the acoustic properties relative to pure water, since the presence of physiological salt levels will slightly alter the density and viscosity of the solution. Overall, however, the effect of salt content is relatively small compared with other factors discussed previously.

Calibration of Delivered Power

The calorimetric method

Calorimetry is a relatively simple, fast, and inexpensive procedure that allows for the direct measurement of the effective acoustic energy delivered to a sonicated liquid in a device-independent manner. The method is based on the measurement of the temperature increase in a liquid medium over time as a result of cavitation induced in a liquid by an immersed ultrasound probe.

At a given device output power setting, the temperature increase in the liquid is recorded over time and the effective delivered power can be calculated using the following equation:

$$P = \frac{dT}{dt} M C_p \tag{1}$$

where P is the delivered acoustic power (W), T and t are temperature (K) and time (s), respectively, C_p is the specific heat of the liquid (J/g·K) and M is the mass of liquid (g).

The following steps are recommended for the determination of direct sonication calorimetric curves.

1. Fill a 600 mL cylindrical borosilicate beaker with 500 mL of de-ionized water (resistivity > 18 MΩ.cm)
2. Determine the mass of the liquid using a top loading balance. First tare the empty 600 mL beaker.
3. Immerse the sonicator probe (horn) approximately 2.5 cm (1") below the liquid surface
4. Immerse a temperature probe connected to a temperature meter and data logger (e.g., an Extech HD 200[§] temperature meter and datalogger coupled to a Type K immersion

[§] Certain trade names and company products are mentioned in the text or identified in illustrations in order to specify adequately the experimental procedure and equipment used. In no case does such identification imply recommendation or endorsement by National Institute of Standards and Technology, nor does it imply that the products are necessarily the best available for the purpose.

temperature probe). The probe tip should be about 1 cm away from the sonicator probe (Figure 1).

5. Select a sonicator output power setting and, operating in continuous mode, record the water temperature increase for the initial 5 minutes. During sonication, ensure that the beaker does not shift position, especially when operating at high power settings; this can be accomplished for instance, using a clamp attached to a ring stand.
6. Using the recorded values, create a temperature vs. time curve and obtain the best linear fit for the curve using least squares regression.

With the obtained slope, calculate the delivered power using Eq. 1. The procedure should be repeated for all power settings, relating each setting level to the measured power. The power obtained via calorimetry is the recommended reported power value for sonication-based dispersion procedures.

Using a different water volume, a container of a different material or a different type of horn than those recommended herein can result in changes in the measured temperature vs time slope for a given power setting due to variations in the rate of heat transference between the sonicated water and the environment. If conditions other than those recommended herein are used to measure calorimetric curves, the altered conditions should be clearly reported.

Figure 2 shows calorimetric curves and calculated delivered power at different device output settings, obtained using the above method for a Branson 450 analog disruptor using a standard ½" horn.

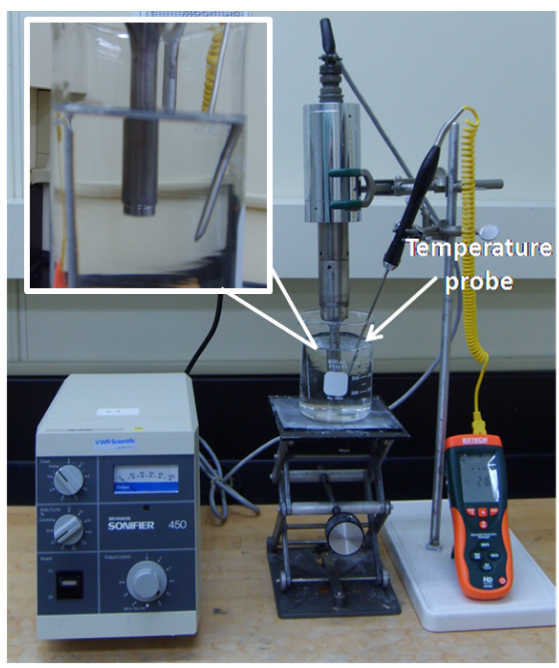

Figure 1. Setup for the measurement of calorimetric curves. Inset shows sonicator tip and temperature probe immersion depths. Sound protection enclosure was omitted for clarity of the image.

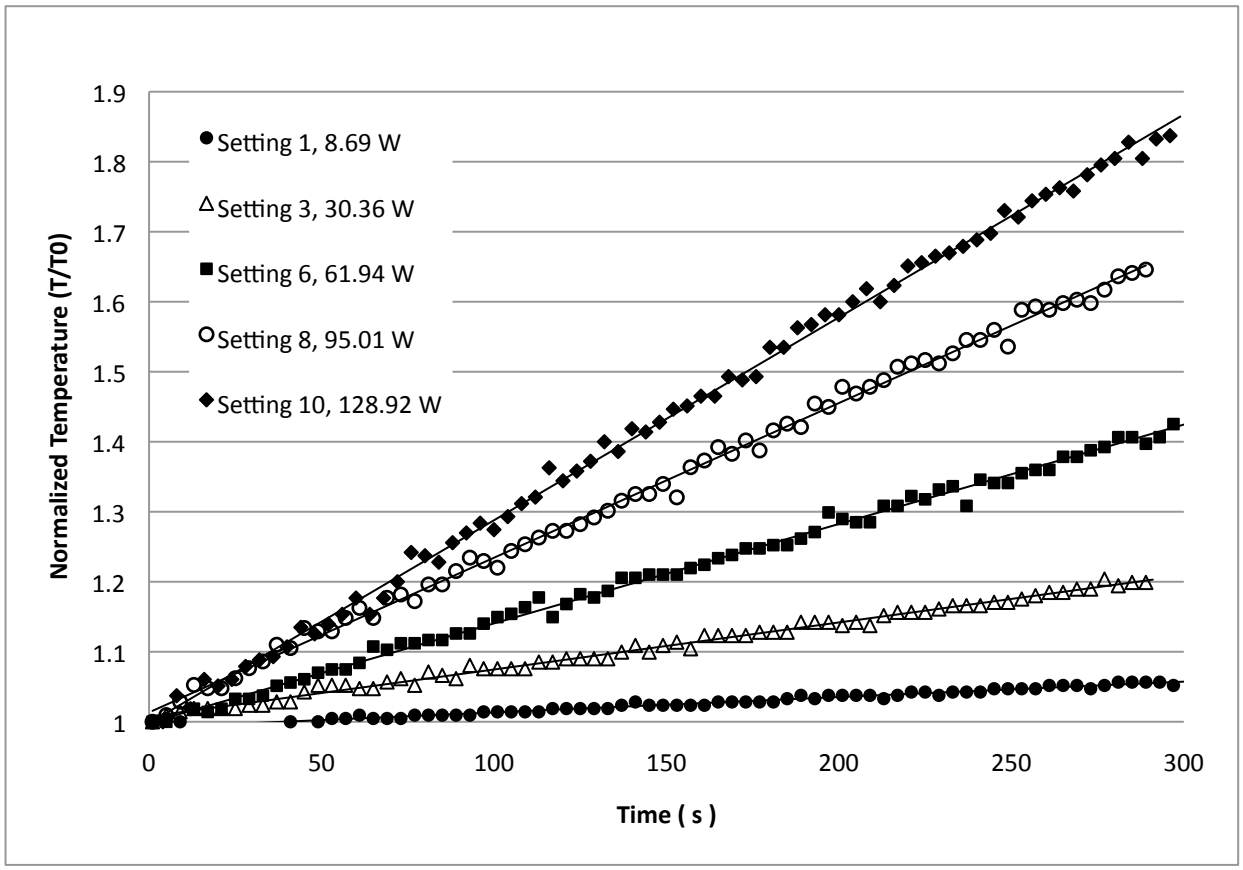

Figure 2. Calorimetric data, linear fits, and corresponding calculated delivered power for different operational settings, obtained using a Branson 450 analog disruptor.

Determination of optimal process parameters

As previously indicated, the treatment conditions required to achieve complete ENM dispersion are highly system specific. The guidelines offered in this protocol are intended as tools for the interpretation of the observed behavior at a given set of sonication conditions, and to determine the appropriate parameter modifications to be made in response. The ultimate goal of the optimization procedure is to achieve the desired degree of dispersion with the least possible energy input, in order to minimize unwanted side effects.

The process to determine such conditions is based on a trial and error approach. The optimization process must scan parameter values covering a range both above and below a starting point.

The first trial set of sonication conditions for an untreated powder in suspension should be intended to ensure that dispersion can in fact be achieved. The starting point of the optimization must therefore provide a high energy input to the suspension. The following table offers a general guideline of starting points for power, time, and volume selection [11]

Table 1. Guidelines for optimization starting points.

Energy Density (W·s/mL)	Sample Volume (mL)	Power (W)	Time (s)
Below 100	10	50	Below 20
100 to 500	10	50	20 to 100
Over 500	10	50	Over 100

The choice for the starting powder concentration is subject to the desired application. It is also possible to start with concentrations higher than the target one, and then if needed dilute the processed suspension to the desired level. Concentrations in the (50 to 1000) μg/mL range are commonly used for toxicological studies.

The effectiveness of the applied sonication conditions can be evaluated by measuring the particle size distribution (PSD) of the sonicated suspension. In principle, reduction of the average particle size and polydispersity are indicative of more effective dispersion.

Once a starting set of values for time, concentration, and volume has been selected, and keeping all other processing parameters constant, sonication power is varied. As a general guideline:

1) Scan the effect of power in increments of 10 W both above and below the starting sonication power.

2) Using the power value that yields the smallest mean particle size and lowest polydispersity, proceed to scan for sonication times in increments of 30 s above and below the starting point. Operation in pulsed mode is recommended for sonication times above 1 min, particularly when using small volumes (below 50 mL).

3) For the optimized time, power, and selected volume, the effect of particle concentration both above and below the concentration stating point and down to the minimum acceptable concentration for the desired application, may be evaluated if desired. If the optimal concentration is above the desired value for the particular application, the suspension's PSD must be measured after dilution to check for changes.

Operation and maintenance considerations

Aerosoling and foaming

If the sonicator probe is not sufficiently immersed in the suspension it can give rise to surface agitation resulting in nebulization (formation and release of aerosols). This could pose a risk if ENPs or other potentially harmful medium components are released in this manner.

Aerosoling may be indicated by changes in the audible sound pitch during operation, fluctuating power readings, or by the appearance of a fine aerosol in the vicinity of the probe. If aerosoling

occurs, one should cease operation and lower the probe deeper into the suspension before resuming operation.

Additionally, if surfactants are present, the suspension could foam during sonication, and the presence of a stable foam in contact with the horn surface will interfere with the delivery of ultrasonic energy to the suspension in a self-limiting process. Pulse mode operation with long off periods will help avoid foaming in samples subject to this effect. Sonication should be ceased in the event that foaming occurs, and the foam removed or allowed to dissipate before continuing.

Tip maintenance

Tip erosion is an unavoidable side effect in direct sonication. When the tip erodes, microscopic tip residues (typically titanium metal) are released from the tip into the sonicated suspension, introducing impurities and potentially contaminating the suspension. Tip erosion also results in a reduced energy output.

If used on a daily basis, tips should be inspected at least once weekly. Tip erosion can be recognized by the appearance of a grayish matting, as opposed to the lustrous appearance of a non-eroded tip (Figure 3).

The adverse effects of erosion can be mitigated by maintaining a well dressed tip surface. A matted tip can be reconstituted (dressed) by buffing with a fine grit crocus cloth, carbide paper or emery cloth (note: avoid use of conventional "sand paper"). In the case of a removable tip, set the tip perpendicular to the buffing material placed on a hard, flat work surface and work the tip lightly across the grit in a circular pattern until the matte grey finish is replaced by a finely criss-crossed pattern with a metallic appearance. Substantially eroded tips (i.e., those with visible pitting) should be replaced. Refer to sonicator manufacturer recommendations for further tip cleaning details.

If the probe's tip is removable, frequent operation may eventually loosen the tip resulting in a lower acoustic power conversion and energy yield. The probe tip should be periodically inspected, and if necessary retightened.

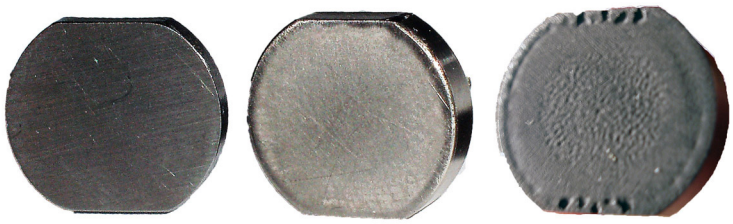

Figure 3. Surface appearance for removable ½" flat tip, ranging from pristine (left) to matted (center) to badly eroded with pitting (right).

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International Alliance for NanoEHS Harmonization
an interdisciplinary alliance of scientific experts
including CDC, NIOSH, NIST, and UCLA

METHODS

1. Preparation of 10X Ca2+- and Mg2+-Free Phosphate Buffered Saline (PBS)

A. Weigh out the following

450 mM NaCl (FW=58.44)	84.75 g
0.050 mM KCl (FW=74.56)	3.72 g
0.094 mM Na2HPO4 (FW=141.96)	13.29 g
0.019 mM NaH2PO4 x H2O (FW=137.99)	2.62 g

B. Dissolve above ingredients in 1L distilled H2O.
C. pH will be approximately 6.8 without titration.
D. Store the 10X solution at room temperature.

2. Preparation of 1X Ca2+- and Mg2+-Free Phosphate Buffered Saline (PBS)

A. Mix 100 ml 10X solution with 900 ml distilled H2O, then add 0.99 g D-glucose (FW=180.2).
B. Filter sterilize (0.22 µm pore filter) into an autoclaved reagent bottle.
C. Store 1X PBS solution at 4°C.
D. pH will be approximately 7.4 without titration.

3. Preparation of DSPC Stock Solution (10 mg DSPC/ml)

A. Let DSPC (Sigma cat #P-0763) come to room temperature in desiccator.
B. Make 10 mg DSPC/ml solution using 100% EtOH as solvent.
C. Prepare fresh daily as needed.
D. Preparation of Bovine Serum Albumin Stock Solution (1 mg/ml)
   1. Let bovine serum albumin (BSA; Sigma cat #A-4503) come to room temperature in desiccator.
   2. Make 1 mg/ml solution using 1X PBS as solvent.
   3. Prepare fresh daily as needed.

4. Preparation of Nanoparticle Dispersion Medium (DM)

DM is PBS with 0.6 mg/ml bovine serum albumin and 10 µg/ml DSPC. The final concentration of EtOH in DM is 0.1% (v/v).

For each 10 ml DM, mix:	1 X PBS	3.990 ml
	1 mg/ml BSA	6.00 ml
	DSPC	0.010 ml

Sonicate for 1 minute (continuous 5W output) after mixing.

5. Nanoparticle Dispersion

A. Place nanoparticles (NP) in 50 ml conical centrifuge tube.
B. Add dispersion medium (DM) to bring NP concentration to 0.5 mg/ml concentration. Note: Prepare a minimum total volume of 15 ml to prevent sample foaming.
C. Mix sample by manual inversion to suspend the NPs.
D. Place conical centrifuge tube in beaker containing wet ice and small amount of water to create an ice water bath to dissipate heat during sonication.
E. Lower probe of probe sonicator into sample, and sonicate for 30 minutes (continuous 20W output). Note: Ramp up power from minimal setting to 20 W output to avoid sample loss.

invitrogen™

Qdot® Conjugates
Protocol Handbook

Quantum Dot
invitrogen nanocrystal technologies

Molecular Probes™
invitrogen detection technologies

PN 90-0153, Rev 1.2

mp19029 19-June-2007

Table of Contents

Immunocytochemistry with Qdot® Conjugates in Cultured Cells.....2

Immunolabeling Formalin-fixed Paraffin Embedded Tissue Sections.....8

Immunolabeling Frozen Tissue Sections.....12

Western Blotting with Qdot Secondary Antibody Conjugates.....15

Immunocytochemistry with Qdot® Conjugates in Cultured Cells

PLEASE READ ENTIRE PROTOCOL AND APPLICATION NOTES BEFORE STARTING.
Additional information can be obtained from the product page on our website at http://probes.invitrogen.com/products/qdot/

This protocol describes an optimized fixation, permeabilization, and labeling procedure for use of Qdot® secondary antibody and Qdot® streptavidin conjugates in cultured adherent mammalian cells. This protocol has been developed and optimized for targets in cell lines such as HeLa adenocarcinoma cells and NIH-3T3 fibroblast cells. It is important to note that cell labeling protocols appropriate for Qdot® conjugates can differ depending on the cell type and growth status, target antigen, primary antibody source, and fluorescence detection method. Traditional cell-labeling protocols developed for organic fluorescent dye conjugates may need modification to be successful with Qdot® secondary antibodies and streptavidin conjugates. Thus, this basic protocol is a starting point for the optimization of your system for use with Qdot® secondary antibodies and Qdot® streptavidin conjugates. These conjugates perform optimally when used within the range of 10 nM to 40 nM, but the exact concentration needed should be determined by titration for each system. Additionally, imaging Qdot® conjugates is optimal with filters designed specifically for these nanocrystals. These filters are available from Omega Optical or Chroma (see *application note 1*).

Antigen labeling with Qdot® conjugates:

Detecting cellular targets with Qdot® secondary antibody and streptavidin conjugates can be performed individually by using a single Qdot® secondary antibody or Qdot® streptavidin conjugate with one primary antibody, or multiplexed by using a combination of primary antibodies and various Qdot® nanocrystal colors. Golgi, tubulin, mitochondrial, peroxisome, nucleolin, nucleosome and ki-67 targets have been validated with this labeling protocol (for a complete list of primary antibodies validated, see *application note 2*). Other targets and cell lines, however, may require further optimization of this protocol. For example, reducing the fixation time may improve cell penetration and conjugate access for some targets as may increasing the concentration of permeabilization reagent or incubation time with the permeabilization buffer. Furthermore, if biotinylated antibodies are to be detected with streptavidin conjugates, it becomes imperative to block endogenous biotin-containing proteins expressed in mitochondria (the Endogenous Biotin Blocking Kit (Invitrogen Cat. no. E21390) noted in the protocol is used for this purpose).

Materials

Fixative: 4% formaldehyde in PBS

Recommendation: freshly prepare 40 mL of 4% formaldehyde (ultrapure, MeOH-free, 16% formaldehyde solution; Polysciences, Inc. Cat. no. 18814) in 1X PBS by combining 10 mL of formaldehyde, 4 mL of 10X PBS, pH 7.4 (Invitrogen Cat. no. 70011-044) and 26 mL of distilled water.

Option: Prepare 40 mL of 3.7% formaldehyde (from 37% stock) in 1X PBS

Permeabilization buffer: 0.25% Triton® X-100 in PBS

Prepare 40 mL of permeabilization buffer by adding 100 µL of Triton® X-100 (Sigma Cat. no. T9284) to 40 mL of 1X PBS. Rock or stir until the Triton® X-100 goes into solution.

Rinse buffer: 1X PBS

Prepare 2 L of 1X PBS by combining 200 mL of 10X PBS and 1.8 L of distilled water.

Endogenous Biotin Blocking Kit (for use if performing streptavidin-based labeling): Invitrogen Cat. no. E21390 contains two ready-to-use reagents.

Blocking buffer: 6% BSA/10% normal serum in PBS

Add to 3 g of BSA (RIA grade, Fraction V, minimum 96%; Sigma Cat. no. A-7888) 5 mL of normal serum from the host species of the secondary antibody (preferably heat inactivated at 56˚C for 1 hour), 5 mL of 10X PBS, and distilled water to a total of 40 mL. Rock until the BSA is completely dissolved. Add distilled water to a final volume of 50 mL and mix well with gentle rocking or stirring. If storing the blocking buffer, add sodium azide to a final concentration of 0.02% and keep at 4˚C.
See application note 3.

Secondary incubation buffer: 6% BSA in PBS

Add to 3 g of BSA (RIA grade, Fraction V, minimum 96%; Sigma Cat. no. A-7888) 5 mL of 10X PBS, and distilled water to 40 mL. Rock until BSA is completely dissolved. Add distilled water to a final volume of 50 mL and mix well with gentle rocking or stirring.

Qdot® secondary antibody or Qdot® streptavidin conjugate:

DO NOT VORTEX PRODUCT VIAL. Centrifuge the Qdot® nanocrystal conjugate product vial for 3 minutes at 10,000 × g prior to use. If a pellet appears, only use the supernatant. Dilute the conjugate by adding 2 μL of the stock (1 μM) conjugate to 100 μL secondary incubation buffer immediately prior to use (in most cases this is optimal but it may need to be titrated between 10 nM and 40 nM final concentration). Use for current experiment, do not store diluted. See *application note 4*.

Dehydration solutions:

Prepare in containers suitable for a dehydration series EtOH/H_2O dilutions (v/v) of 30%, 50%, 70%, and 90%, as well as 100% EtOH and 100% toluene.

Mounting reagents:

The recommended mounting media is Cytoseal 60 (Richard-Allan Scientific Cat. no. 8310-4). This requires dehydration of the specimen in EtOH and toluene. Prepare in containers suitable for this process EtOH/H_2O dilutions (v/v) of 30%, 50%, 70%, and 90%, as well as 100% EtOH and 100% toluene.

Cell preparation:

Culture cells in the appropriate medium to the desired confluency and physiological state (typically 1–2 days for HeLa cells). It is recommended that cells be below 80% confluency at the time of fixation, depending on experimental requirements and imaging method.

A. Fixation and Permeabilization

All of the steps are performed at room temperature.

1.1 Rinse 2 times with 1X PBS. If cells were grown in a large dish (i.e., 100 mm petri dish), add a large enough volume of 1X PBS to completely cover the specimen (~25 mL for a 100 mm petri dish) swirl gently, pour off or aspirate the solution and repeat. If grown in a smaller container (i.e., 6-well plate), wash 3 times, 5 minutes each by adding enough 1X PBS to completely cover specimen. After 5 minutes, pour off or aspirate the rinse solution.

1.2 Incubate in 4% formaldehyde/PBS for 15 minutes to fix the specimen.

1.3 Repeat step 1.1.

1.4 Incubate in 0.25% Triton® X-100/PBS for 15 minutes to permeabilize the specimen (see *application note 5*).

1.5 Repeat step 1.1.

B. Target Labeling and Detection

All of the following incubations are performed in a humidity chamber at room temperature (see *application note 6*). Avoid specimen drying as this can cause high levels of nonspecific background and autofluorescence. At the end of each step, carefully remove or blot excess solution from the sample before moving to the next step.

If using Qdot® secondary antibody conjugates proceed to step 2.1.

If using Qdot® streptavidin conjugates, perform endogenous biotin blocking with the Endogenous Biotin Blocking Kit (Invitrogen Cat. no. E21390) or equivalent. If using Invitrogen product E21390:

a) Incubate in component A for 30 minutes.
b) Wash 3 times, 5 minutes each, in 1X PBS.
c) Incubate in component B for 30 minutes.
d) Wash 3 times, 5 minutes each in 1X PBS.

Proceed to step 2.1.

2.1 Incubate with blocking buffer for 1 hour.

2.2 Pour off blocking buffer and incubate for 1 hour with primary antibody diluted in blocking buffer (see *application note 7*).

2.3 Wash 3 times, 5 minutes each, in 1X PBS.
Note: If using a biotinylated secondary antibody, repeat steps 2.2 and 2.3 using the biotinylated antibody before continuing.

2.4 Incubate for 1 hour with Qdot® secondary antibody conjugate or Qdot® streptavidin conjugate, diluted to an optimal concentration (titrate between 10 nM and 40 nM for optimal results) in secondary incubation buffer.

2.5 Wash 3 times, 5 minutes each, in 1X PBS.
Note: If counterstaining is necessary, most counterstain procedures may be performed at this point, followed by any necessary wash steps and subsequent dehydration and mounting (see *application note 8*).

2.6 Dehydrate specimen. Submerge specimen for 5 seconds in 30%, 50%, 70%, and 90% EtOH/H_2O, twice in 100% EtOH, and twice in 100% toluene with the final dip ~10 seconds.

2.7 Mount in one drop Cytoseal 60 and let cure at least 4 hours before imaging. For optimal performance, image within 24 hours.

Application Notes

Note 1: For optimal imaging of Qdot® conjugates, including reduced spectral bleed-through effects in multicolor applications, it is recommended that you use filter sets optimized for the excitation and emission of the Qdot® nanocrystal(s) in use. These filters are available from Omega Optical or Chroma. Additional information can be obtained from the Qdot® nanocrystals web page at http://probes.invitrogen.com/products/qdot/.

Note 2: If new to immunocytochemistry (ICC), it is recommended that you include a positive labeling control for protocol execution validation. For example, an optional control for Qdot® goat-anti-mouse secondary antibodies is anti-OxPhos Complex V Inhibitor Protein (Invitrogen Cat. no. A21355), which targets mitochondria. An optional control for Qdot® goat-anti-rabbit secondary antibodies is rabbit anti-giantin (Covance Cat. no. PRB-114C), which targets Golgi bodies. Other antibodies used in optimization of this protocol, and therefore suitable as positive controls include: rabbit anti-AIF (Cell Signaling Cat. no. 4642), mouse anti–ki-67 (Ventana Medical Systems Cat. no. 790-2910), mouse anti–α-tubulin (Sigma Cat. no. T6074), rabbit anti–α-tubulin (Affinity Bioreagents Cat. no. PA1-20988), mouse anti-nucleosome (BD Pharmingen Cat. no. 51-80591N), and mouse anti-nucleolin (Invitrogen Cat. no. 39-6400; Stressgen Cat. no. KAM-CP100).

Note 3: If background is observed with Qdot® secondary antibody conjugates, use a blocking buffer of 6% BSA in PBS with 10% heat-inactivated (56˚C for 1 hour) normal serum from the host species of the secondary (goat or rabbit). Please note that BSA can vary by lot and producer, so re-optimization of blocking conditions may be required for best results when substituting alternate sources for this component. Avoid using blocking solutions containing casein as these may quench the Qdot® fluorescence.

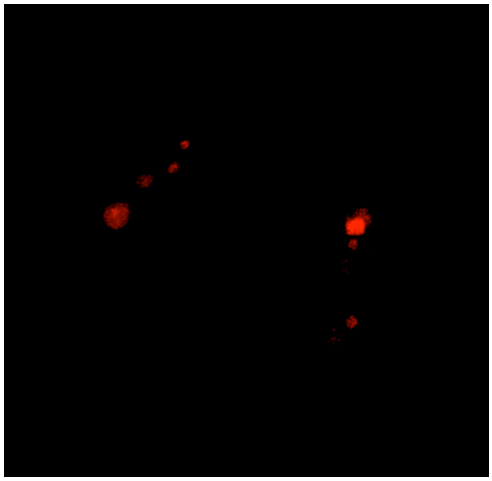
Note 4: Qdot® secondary antibody conjugates and Qdot® streptavidin conjugates should be stored at 4˚C in their concentrated (shipped) form. They should not be diluted to their working concentration until the day they will be used, as they may not be stable in dilute form. It is best to only make up as much as is needed for each experiment rather than to create and store a stock of diluted working solution.

Note 5: Changing fixation time or permeabilization time or concentration may be necessary for achieving labeling of certain targets.

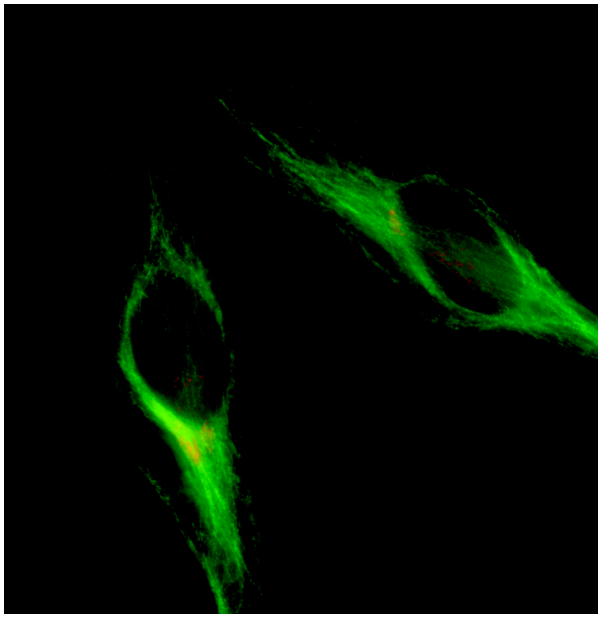
Note 6: A simple humidity chamber prevents labeling reagent concentration changes due to evaporation during incubations. To make a simple humidity chamber, place a piece of filter paper in a petri dish and saturate the filter paper with water. Next, place a piece of Parafilm® on the filter paper. During incubations, place a lid on the petri dish. Gentle agitation during incubations is optional.

Note 7: Briefly centrifuge the PRIMARY antibody prior to use. It may be necessary to titrate the concentration of the primary antibody for optimal target labeling.

Note 8: UV excitation of DAPI (Invitrogen Cat. no. D1306) resulting in emission around 600 nm has been observed and may not be appropriate for use with all Qdot® nanocrystals. Other nuclear counterstain options, many available in kit form with optimized protocols for their use, include SelectFX® Nuclear Labeling Kit (Invitrogen Cat. no. S33025), SYTOX® Green nucleic acid stain (Invitrogen Cat. no. S7020), 7-aminoactinomycin D (7-AAD) (Invitrogen Cat. no. A1310), propidium iodide (Invitrogen Cat. no. P3566), and TO-PRO®-3 iodide (Invitrogen Cat. no. T3605).



Multiplex labeling of HeLa cells using Qdot® conjugates. HeLa cells were prepared according to the protocol above. Tubulin was labeled with a mouse anti-tubulin primary antibody (Sigma, Cat. no. T6074) followed by a Qdot® 525 goat anti–mouse IgG secondary antibody (green, Cat. no. Q11041MP). Giantin was labeled with a rabbit anti-giantin primary antibody (Covance, Cat. no. PRB-114C) followed by a Qdot® 655 goat anti–rabbit IgG secondary antibody (red, Cat. no. Q11421MP). Images were captured using the optimal filter sets recommended in Appendix 1 of the Supplemental Information Guide (available online at http://probes.invitrogen.com/media/pis/mp19009.pdf).



Nuclear labeling in HeLa cells using Qdot® conjugates. HeLa cells were prepared according to the protocol above. Nucleoli were labeled with a mouse anti-nucleolin primary antibody (Novus, Cat. no NB 600-241A2) followed by a Qdot® 655 goat anti–mouse IgG secondary antibody (red, Cat. no. Q11021MP) and imaged using the optimal filter sets recommended in Appendix 1 of the Supplemental Information Guide (available online at http://probes.invitrogen.com/media/pis/mp19009.pdf).

Immunolabeling Formalin-fixed Paraffin Embedded Tissue Sections

PLEASE READ ENTIRE PROTOCOL BEFORE STARTING.
Additional information can be obtained from our website at www.invitrogen.com.

This protocol is intended to be a starting point for immunolabeling formalin-fixed tissues that were embedded in paraffin. It is expected that for a given antibody, certain steps in this procedure will change to improve immunolabeling and reduce background staining. Antigen retrieval conditions, primary antibody concentrations and incubation times, and secondary antibody concentrations and incubation times that successfully immunolabel tissue with other detection methods should be used as a starting point for this protocol. Steps are included for using Qdot® Streptavidin Conjugates as tertiary reagents in conjunction with biotinylated secondary antibodies or for using Qdot® Secondary Antibody Conjugates.

Materials

Primary Antibody: 1 – 10 µg / ml in TBS with 3 – 10% IgG free BSA
Control Tissue: positive and negative controls as appropriate
Antigen Retrieval:
- DAKO® Target Retrieval Solution 10X Concentrate (DakoCytomation, Cat. # S1699)

Blocking Reagents:
- TBS-BSA: 2% bovine serum albumin (IgG-free BSA, Jackson Immunoresearch, Cat # 001-000-162 or equivalent) in Tris buffered saline
- Normal serum(s) matching secondary antibody hosts (Jackson Immunoresearch)
- Borate-BSA: 2% BSA (see above) in 50 mM borate buffer (pH 8.3)

Secondary Detection Reagents Antibody: Dilutions are in TBS-BSA.
- Qdot Secondary Antibody Conjugate
- Biotin rabbit anti-mouse Fab (DakoCytomation, Cat # E0413 or equivalent)
- Biotin swine Anti-rabbit Fab (DakoCytomation, Cat # E0431 or equivalent)
- Biotin donkey anti-goat IgG (Jackson Immunoresearch, Cat # 705-065-147 or equivalent)

Tertiary reagents:
- Qdot Streptavidin Conjugate

Nuclear counter stain
- Hoechst 33342 , trihydrochloride, trihydrate *10 mg/mL solution in water* (Molecular Probes, Cat # H3570) diluted 1:10000 – 1:20000 in TBS

Buffers:
- TBS; Tris buffered saline, (DakoCytomation, Cat # S1968)
- TBST, TBS with 0.2% Tween-20 (DakoCytomation, Cat # S3306)
- PBS (Sigma, Cat # P3563)
- 50 mM Borate buffer (pH 803)

Mounting media:
- Cytoseal™ 60 (Richard-Allan Scientific, Cat # 8310)
- Polyvinyl alcohol with DABCO (Sigma, Cat # 10981)
- 90% Glycerol in 50 mM borate buffer

ImmEdge Hydrophobic Barrier Pen (Vector Laboratories, Cat # H-4000)

Procedure

1. Deparaffinize sections.
   1.1. 3 changes of xylene or xylene substitute, 5 min
   1.2. 3 changes 100% ethanol, 3 min each
   1.3. 1 change 95% ethanol, 3 min
   1.4. 1 change 90% ethanol, 3 min
   1.5. 1 change 70% ethanol, 3 min
   1.6. 1 changes deionized water > go to antigen retrieval step if needed, i.e. tissue fixed in formalin.
   1.7. 2 changes of TBS > go to step 3 blocking buffer if antigen retrieval is not needed (i.e. tissue not fixed in formalin).
2. Antigen retrieve formalin-fixed tissues. (p.3)
3. Place in dH_2O.
4. Optional: A PAP pen (or hydrophobic pen) can be used to circumscribe the tissue section in order to conserve on reagent usage. However, some PAP pens can quench the fluorescence of quantum dots. We recommend that the ImmEdge Pen be used for this purpose.

The following steps can be done on an autostainer if available

5. Block for 20 min in TBS-BSA.
6. Shake off the blocking reagent (do not rinse).
7. Incubate in primary antibody in TBS-BSA (1-10 μg/ml).
   Suggested times – these can be changed to suit the antibody and antigen conditions.
   7.1. 60 -120 min at room temperature RT in humid chamber
   7.2. Overnight at 4°C or room temperature
8. Wash in TBS 2 x 3min.
9. Block in TBS-BSA.
10. Qdot Secondary Antibody Conjugate: 1 – 20 nM in TBS-BSA @ room temperature or 37°C for 30 - 60 min. Skip to step 13.
    Or Biotinylated secondary antibody: 1 -2 μg/ml in TBS-BSA for 30 – 60 min at room temperature or 37°C.
11. Wash TBST (TBS-Tween) 2 changes @ 3 min each.
12. Qdot Streptavidin Conjugate in TBS-BSA (1-10 nM) @ RT for 30 min.
13. Wash TBST 2 x 3 min.
14. Counterstain nuclei with Hoechst 33342 in TBS for 15 min. (dilute 10mg/ml stock by 1:5000 in TBS) (see Technical note at end)
15. Wash in TBS 2 changes for 5 min.
16. Coverslip
    16.1. Polyvinyl alcohol mounting media with DABCO
    Or Cytoseal 60 mounting media
    16.2. After buffer, place in water bath 20-30 sec.
    16.3. Then 30% alcohol 30 sec.
    16.4. Then 70% alcohol 30 sec.
    16.5. Then 95% alcohol 30 sec.
    16.6. Then 100% alcohol 30 sec.
    16.7. Then xylene or toluene 30 sec.
    16.8. Place one drop of mounting media on section and apply coverslip.
17. Image sections on microscope with filter set optimized for quantum dots.

ANTIGEN RETRIEVAL

Restores antibody binding to proteins in formalin-fixed paraffin embedded tissues.

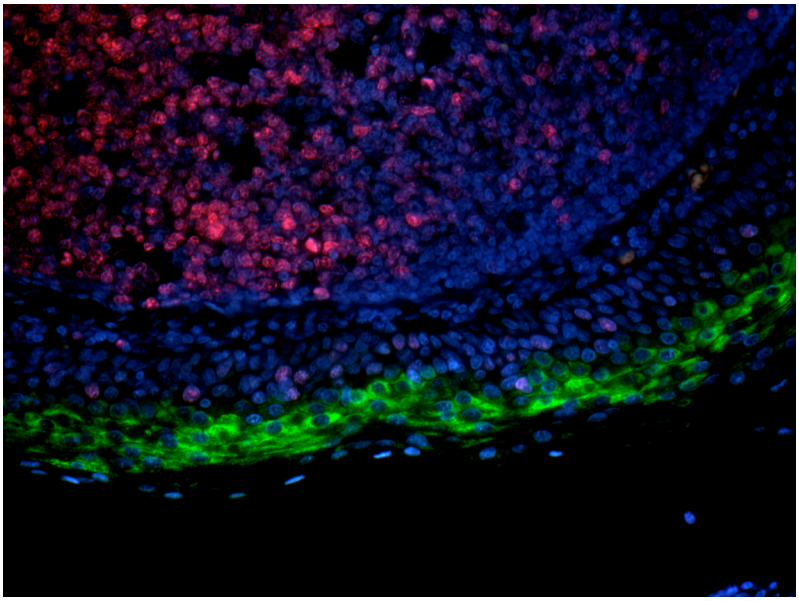
Materials

1 part - DAKO® Target Retrieval Solution 10X Concentrate
9 parts - dH_2O (Milli-Q® Ultrapure or distilled)

1) Preheat water bath or steamer to 95° C.
2) Heat working retrieval solution to 95° C in an appropriate container.
3) Place deparaffinized slides to the heated target Retrieval Solution. (Step #2)
4) Leave at 95° C for **10 – 40 min**.
5) Remove container with slides and cool on bench (to 50ºC or less) in Retrieval solution.
6) Remove slides and rinse in deionized water for 3 minute.
7) Proceed with blocking step 9 above.

Technical note:

The introduction of Hoechst to the sections allows for visualizing nuclei and imaging with a standard RGB camera. However, Hoechst and DAPI have a long emission tail that can bleed into the single band-pass filters for 525, 565, and 585 nm quantum dots. Hence nuclear immunolabeling that requires the use of these DNA labels should use the 605 nm or 655 nm Qdot Conjugates to visualize nuclear antigens. Other DNA dyes are available that excite at different wavelengths and can be more compatible with the appropriate colors of quantum dots. Typically these dyes would be selected to absorb and emit at longer wavelengths than the quantum dots being used. One such dye is DRAQ 5™ (Biostatus Limited)



Multiplex labeling of human tonsil section for Ki67 and keratin with Qdot Conjugates. Ki67 in the nuclei of proliferating B cells (red) were labeled with Rabbit anti-Ki67 (Lab Vision, Cat # RB-1510) followed by Qdot 585 Anti-rabbit Secondary Conjugate (Cat # Q11411MP). Keratin in the peripheral stromal cells (green) was labeled with mouse monoclonal anti-pan keratin antibody (Lab Vision, Cat # MS-356) followed by biotin-goat anti-mouse IgG and Qdot 525 Streptavidin Conjugate (Cat #Q10143MP). Nuclei (blue) were counterstained with Hoechst 33342.

Immunolabeling Frozen Tissue Sections

PLEASE READ ENTIRE PROTOCOL BEFORE STARTING.
Additional information can be obtained from our website at www.invitrogen.com.

This protocol is intended to be a starting point for immunolabeling paraformaldehyde-fixed tissues that were frozen. It is expected that for a given antibody, certain steps in this procedure will change to improve immunolabeling and reduce background staining.

Materials

2% Paraformaldehyde
30% Sucrose
Superfrost™ Plus Slides (Erie Scientific Company, Cat # 4951 or equivalent)
Phosphate Buffered Saline (PBS; Sigma Chemical, Cat # P3563)
Primary Antibody
Wash Buffer: 0.5% bovine serum albumin, IgG-free BSA, (Jackson Immunoresearch, Cat # 001-000-162 or equivalent) in PBS
Blocking Buffer: 2% bovine serum albumin, IgG-free BSA, (Jackson Immunoresearch, Cat. # 001-000-162 or equivalent) in PBS
Qdot Secondary Antibody Conjugate
Nuclear counter stain
DAPI: 10 µg/ml DI water (Molecular Probes, Cat # D1306)
Mounting media:
Gelvatol: Prepared according to recipe at the following link:
http://www.feinberg.northwestern.edu/cif/gelvatol.htm
ImmEdge Hydrophobic Barrier Pen (Vector Laboratories, Cat. # H-4000)

Procedures

Preparing Tissue Sections:

Fix tissue in 2% Paraformaldehyde.
1. Cryo-protect in 30% sucrose overnight at 4º C.
2. Prepare 6 µm sections using a cryostat and place on Superfrost™ Plus slides.
3. Keep slides at -20º C until ready for use.

Immunolabeling:
Note: All wash steps are 4 minutes.

4. Rehydrate sections with 3 washes in PBS.
5. Wash 3 times with Wash Buffer.
6. Block for 45 minutes at room temperature in Blocking Buffer.
7. Wash 5 times with Wash Buffer.
8. Incubate with Primary Antibody for 60 minutes at room temperature (antibody diluted in Wash Buffer).
9. Wash 5 times with Wash Buffer.
10. Incubate with Qdot Secondary Antibody Conjugate for 60 minutes at room temperature (antibody diluted in Wash Buffer).

11. Wash 5 times with Wash Buffer.
12. Wash 5 times with PBS.
13. Stain with DAPI for 30 seconds at room temperature.
14. Wash 2 times with PBS.
15. Mount coverslip with Gelvatol and refrigerate.
16. Dry slides overnight at 4º C in the dark.

Note: Some PAP pens can quench the signal from the quantum dots. If your protocol requires the use of a PAP pen, we recommend the ImmEdge Hydrophobic Barrier Pen (H-4000) from Vector Labs.

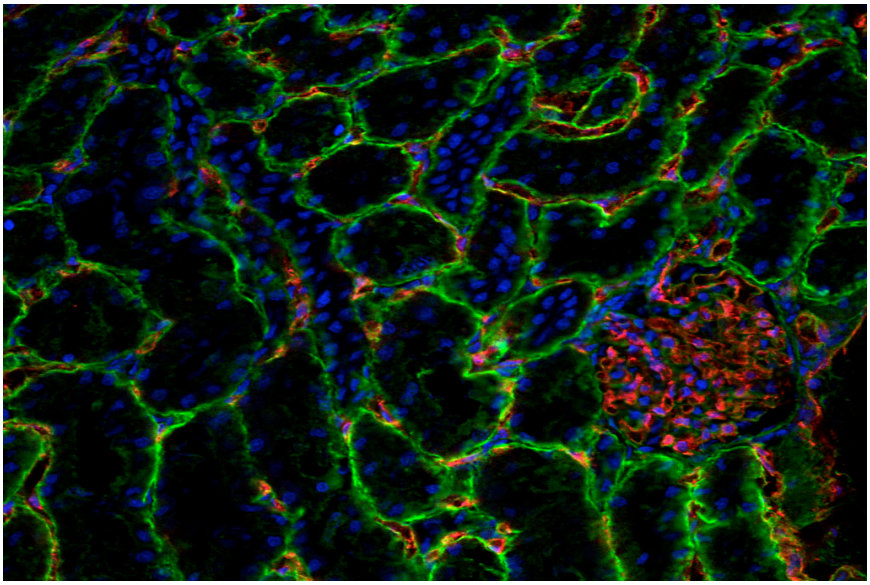


Figure 1. Laminin (Qdot 565 Goat anti-Rabbit IgG Conjugate; Green), PECAM (Qdot 655 Goat anti-Mouse IgG Conjugate; Red) and Nucleus (DRAQ5™; Blue) staining in a Rat Kidney Section.

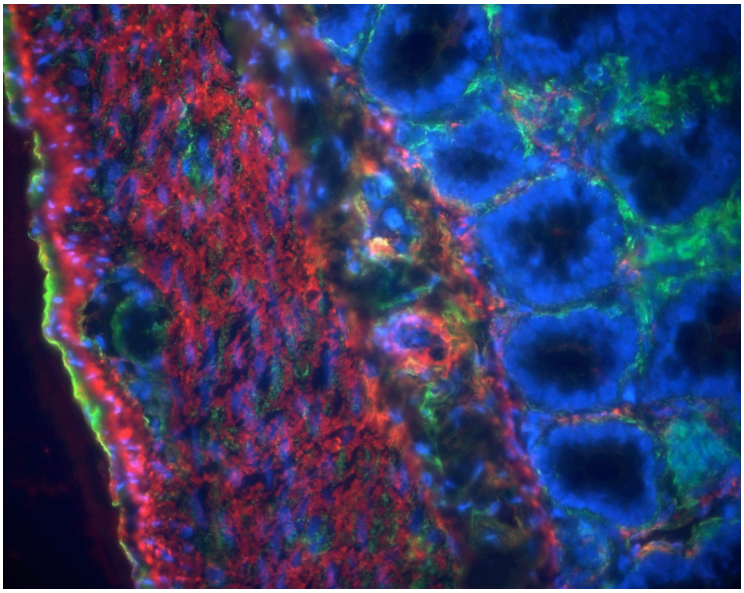


Figure 2. Laminin (Qdot 565 Goat anti-Rabbit IgG Conjugate; Green), Smooth Muscle Actin (Qdot 655 Goat anti-Mouse IgG Conjugate; Red) and Nucleus (DAPI; Blue) staining in a Rat Gut Section.

Western Blotting with Qdot Secondary Antibody Conjugates

PLEASE READ ENTIRE PROTOCOL BEFORE STARTING
Additional information can be obtained from our website at www.invitrogen.com.

This protocol is based on standard polyacrylamide gel electrophoresis and Western blotting procedures. Concentrations of both the primary and secondary antibodies should be optimized for each user's particular system.

Materials

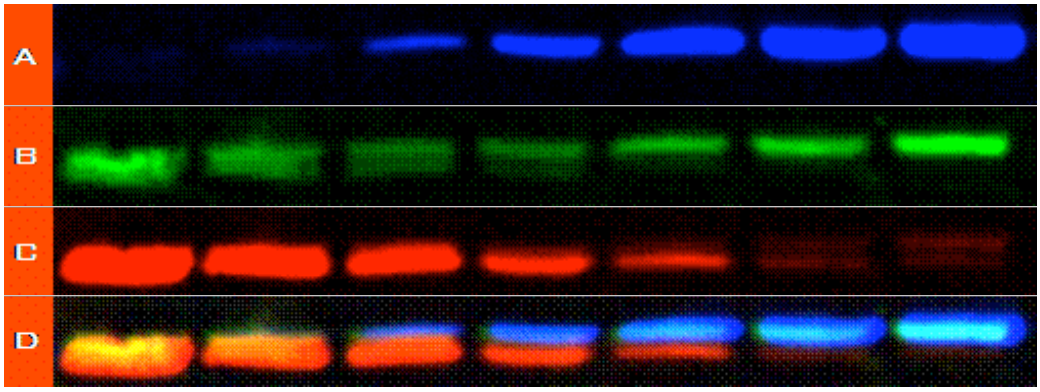
Qdot Secondary Antibody Conjugates
PVDF (recommended: Millipore Immobilon™ FL PVDF) or Nitrocellulose membrane
Blocking buffer (recommended: SEA BLOCK; Pierce Chemical, Cat. #37527)
1X TBS-T (0.1M Tris, 150 mM NaCl, 0.1% Tween-20)
1X TBS (0.1M Tris, 150 mM NaCl)
Electroblotting apparatus, power supply, and buffers
Rocking or oscillating platform
Methanol
100 X 15 mm square petri dish (such as Falcon, Cat. #351112) or plastic bags for incubation steps
Primary antibody: mouse and/or rabbit IgG
Gel Imaging instrument with filters appropriate for Qdot conjugates

Procedure

Polyacrylamide Gel Electrophoresis (PAGE) and electroblotting to PVDF should be performed as per laboratory routine or instructions provided with electroblotting apparatus.

Note: Always wear gloves and use forceps when manipulating gels and membranes. Blotting membranes should be handled with care to prevent scratching or folding.

1. All membrane incubations are designed to be performed with **8-10 ml volumes** of reagent in an appropriately sized container (such as a square petri dish or sandwich bag---Plastic food storage containers are not recommended). These incubations should be performed on a rocking table under continuous motion.
2. Wash membrane in 8 ml TBS-T 2 X 5 minutes with gentle shaking.
3. Incubate membrane in 8 ml SEABLOCK for 1 hour at room temperature or overnight at 4°C with continuous rocking.
4. Add primary antibody to petri dish containing membrane and SEABLOCK to a final concentration of 1-2 μg/ml (The amount of primary antibody may need to be optimized for specific experiments).
5. Incubate the membrane at room temperature for 1 hour with constant rocking.
6. Wash membrane in 8 ml TBS-T 3 X 5 minutes with gentle shaking.
7. Incubate membrane for 1 hr at room temperature in Qdot® Secondary Antibody Conjugates diluted 1:1000 in 8-10 mL SEABLOCK (1 nM final concentration).
8. Wash membrane in 8 ml TBS-T 3 X 5 minutes each with gentle shaking.
9. Transfer the membrane to TBS and wash 2 X 3 minutes each. Store in TBS at 4°C until imaged.



Western blots of serial dilutions of a mixture of lysates from *E. coli* which expressed individual epitope tags. In addition to the two secondary antibodies included in the 605/705 Western Blotting Kit (Q24021MP), the Qdot 565 Goat anti-GST Conjugate (Q14631MP) was also used. A: cMyc (705, pseudo-colored blue), B: GST (565, green), C: HA (605, red), D: combination of all three antibodies.

Blot Image Capture

Western blot data can be collected on a wide variety of instruments. Qdot Conjugate labeled blots can be imaged in gel imaging systems equipped with a digital camera, UV epi-illumination, and band-pass filters matched to the quantum dot emission wavelengths. Trans-illumination may also be used but the autofluorescent light from the membrane is significantly higher, resulting in an approximately 10-fold decrease in the overall sensitivity of detection.

For the highest sensitivity and multiplexed detection with the quantum dots, be sure to obtain custom filters for your instrument that are designed to discriminate the signal from the distinct Qdot Conjugates. These filters can be obtained from Omega Optical (www.omegafilters.com) or Chroma Technology (www.chroma.com), and have to be ordered in sizes appropriate to the particular system. Consult your instrument specifications to determine the appropriate size before ordering custom filters

An alternate imaging strategy is to use a color digital camera with a UV-transilluminator. In these cases, a high quality color camera with a standard Haze2A (UV Blocking) filter at the front of the lens can be used as a quick, inexpensive, semi-quantitative method for imaging single or multicolor blots with visibly distinguishable colors such as 565 and 655. If a Haze2A filter is unavailable, the image can be taken through the UV blocking plate or mask available in most laboratories.

NOTE: When using UV illuminators, one must wear appropriate eyewear to prevent UV exposure and serious health risks.

For additional information on detection of Qdot Conjugates or for recommendation on instruments, please refer to our web page: www.invitrogen.com.

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NANOTECHNOLOGY CHARACTERIZATION LABORATORY

NCL Method STE-1
Version 1.0

Detection of Endotoxin Contamination by End Point Chromogenic LAL Assay

Nanotechnology Characterization Laboratory
National Cancer Institute at Frederick
SAIC-Frederick, Inc.
Frederick, MD 21702
(301)-846-6939
ncl@ncifcrf.gov

October 2005

This protocol assumes an intermediate level of scientific competency with regard to techniques, instrumentation, and safety procedures. Rudimentary assay details have been omitted for the sake of brevity.

Method is written by: _____ 9 Mar 06.

Marina A. Dobrovolskaia, Ph.D. Date

Testing facility: NCL, NCI-Frederick, Bldg 469, Room 250.

1. Introduction

This document describes a protocol for a quantitative detection of Gram negative bacterial endotoxin in nanoparticle preparations using an end-point Limulus Amebocyte Lysate (LAL) assay. The protocol is based on QCL-1000 kit insert manufactured by BioWhittaker/Cambrex Corporation (10.1) and the US FDA Guideline "Validation of the LAL test as an end-product endotoxin test for human and animal parenteral drugs, biological products, and medical devices" (10.2). Gram negative bacterial endotoxin catalyzes the activation of proenzyme in the Limulus Amebocyte Lysate. The activated enzyme then catalyzes the splitting of p-nitroanilin from the colorless substrate. The released p-nitroanilin is measured photometrically at 405 nm after reaction is terminated with a stop reagent. Concentration of endotoxin in a sample is in direct proportion with absorbance and is calculated from a standard curve. The assay requires approximately 1.0 mg of test nanomaterial.

2. Reagents

2.1. Sodium Hydroxide, Sigma, cat. #S2770

2.2. Hydrochloric acid, Sigma H9892

2.3. QCL-1000 LAL test kit, BioWhittaker

2.4. Glacial acetic acid, Sigma, cat#A9967

2.5. SDS, Sigma cat #L6026

2.6 Test-nanimaterial

Note: Equivalent reagents from other vendors can be used

3. Equipment

3.1. Pipettors covering range from 0.05 to 1 mL

3.2. Microcentrifuge tubes 1.5 mL

3.3. Microcentrifuge

3.4. Refrigerator, 2-8°C

3.5. Freezer, -20°C

3.6. Vortex

3.7. Pipet tips 0.5 μL – 1.0 mL

3.8. Plate reader

3.9. Disposable endotoxin-free glass dilution tubes (13x100mm)

3.10. Reagent reservoirs

3.11. Multichannel pipettor

3.12. Sterile 96-well plates

4. Reagent Preparation

4.1. Sodium Hydroxide

Prepare from concentrated stock by dilution into pyrogen-free LAL reagent water to make solution with final concentration of 0.1N.

4.2. Hydrochloric Acid

Prepare from concentrated stock by dilution into pyrogen-free LAL reagent water to make solution with final concentration of 0.1N.

5. Preparation of Standard Curve and Quality Controls

5.1. Preparation of Stock Solution

E.coli LPS supplied with the kit is a USP certified reference standard endotoxin (RSE) provided as a lyophilized powder. The contents of the vial containing RSE should be reconstituted with 1.0 mL of pyrogen-free LAL reagent water to a final concentration of 15-40 EU/mL. The actual concentration of the vial will be determined by value stated on the enclosed certificate of quality supplied with each kit. During reconstitution and prior to use, the stock solution should be vortexed vigorously and allowed to equilibrate to room temperature.

5.2 Preparation of stop solution

Prepare 25% v/v glacial acetic acid or 10% SDS in water for use as a stop solution.

5.3. Preparation of Calibration Standards

Level	Nominal Conc.,EU/mL	Preparation Procedure
Cal 1	1.0	100 µL stock + (X-1)/10 mL LAL reagent water*
Cal 2	0.50	500 µL Cal1 + 500 µL LAL reagent water
Cal 3	0.25	500 µL Cal2 + 500 µL LAL reagent water
Cal 4	0.10	100 µL Cal1 + 900 µL LAL reagent water

* - X is concentration of the stock, e.g. if stock concentration is 23 EU/mL, then 100µL of this stock should be diluted with 2.2 mL [(23-1)/10] of LAL reagent water.

5.4. Preparation of Quality Controls

Level	Nominal Conc.,EU/mL	Preparation Procedure
QC1	0.4	100 µL Cal1+ 150 µL LAL reagent water

Legend: * - intermediate solution A is prepared only to make QC2 and is not used in assay.

5.5. Preparation of Inhibition/Enhancement Control

Level	Nominal Conc.,EU/mL	Preparation Procedure
*IntA**	*1.0*	10 µL stock + (X-1)/100 mL *NP suspension/solution***
IEC	0.4	100 µL IntA + 150 µL NP suspension/solution**

Legend: * - intermediate solution A is prepared only to make IEC and is not used in the assay; X is concentration of the stock, e.g. if stock concentration is 23 EU/mL, then 10µL of this stock should be diluted with 0.22 mL [(23-1)/100] of NP solution/suspension.** - concentration of nanoparticles should be equal to one assayed in test-sample.

6. Preparation of Study Samples

Study samples should be reconstituted in either LAL reagent water or sterile pyrogen-free PBS to a final concentration of 1.0 mg/mL. The pH of the study sample is checked using pH microelectrode and adjusted if necessary to be within the range 6.0-8.0 with sterile NaOH or HCl. Do not adjust pH of unbuffered solutions. To avoid sample contamination from microelectrode, always collect a small aliquot of the sample and use it to measure the pH. If sample was prepared in PBS, blank PBS should be tested in the assay.

7. Experimental Procedure

7.1. Prepare standard curve, quality control, inhibition/enhancement control and unknown samples as described above.

7.2. Create run template on a plate reader.

7.3. Carefully dispense 50 µL of LAL reagent water blank (4 wells), calibration standards (2 wells/each), controls (2 wells/each) and unknown samples (2 wells/each) into appropriate wells of pre-warmed to 37±1°C microplate.

7.4. Using multichannel pipet add 50µL of LAL reagent to all wells containing blanks, calibration standards, controls and unknown samples. Incubate for 10 minutes at 37±1°C.

7.5. Add 100 µL of pre-warmed substrate solution and incubate at a nominal temperature of 37±1°C for another 6 minutes.

7.6. Using multichannel pipet, add 100 µL of the stop solution to samples in the microplate and read absorbance at 405 nm.

8. Assay Acceptance Criteria

8.1. Linear regression algorithm is used to build standard curve. Precision (%CV) and accuracy (PDFT) of each calibration standard and quality control should be within 25%.

8.2. At least three calibration standards should be available in order for assay to be considered acceptable.

8.3. The correlation coefficient of the standard curve must be at least 0.980.

8.4. If quality controls fail to meet acceptance criterion described in 8.1 run should be repeated.

8.5. If standard curve fails to meet acceptance criterion described in 8.1-8.3 the run should be repeated.

8.6. Precision of the study sample should be within 25%.

8.7. Precision and accuracy of inhibition/enhancement control should be within 25% if no endotoxin is detected in a study sample and within 50% is endotoxin is detected in a study sample. If accuracy of IEC is outside of the specified above range, then study sample is interfering with the assay.

8.8. If sample interference is detected then analysis of diluted sample should be performed. Dilution of the study sample should not exceed minimum valid dilution (MVD). For detailed guide on how to prepare MVD please refer to reference 10.2. If no data such as maximum human (rabbit) dose or acceptable

limit are available for a given particle then MVD is calculated according to the following formula:

$$MVD = \frac{0.5\ (0.06)\ EU/mL \times 1.0\ mg/mL}{0.1\ EU/mL}$$

9. Sample Acceptance Criteria

9.1. The following limits are approved by the US FDA

Devices: 0.5EU/mL, except device in contact with CSF, for which limit is 0.06EU/mL.

Parenteral drugs: limit is equal to K/M, i.e. 5.0 EU/Kg /Maximum human (rabbit) dose/Kg administered in a single 1hour period.

Parenteral Drugs administered intrathecally: limit is equal to K/M, i.e. 0.2 EU/Kg /Maximum human dose/Kg administered in a single 1hour period.

9.2. The nanoparticle formulations will be treated as devices for acceptance/rejection, unless data for K/M formula are available.

10. References

10.1. Kinetic-QCL kit insert, BioWhittaker/Cambrex Corporation

10.2. FDA Guideline on validation of the Limulus Amebocyte Lysate test as an end-product endotoxin test for human and animal parenteral drugs, biological products, and medical devices. December 1987.

10.3. Second Supplement to US 24-NF19. <85>. Bacterial Endotoxins. Rockville, MD: United States Pharmacopeia, 2000, 2875-2879.

NANOTECHNOLOGY CHARACTERIZATION LABORATORY

NCL Method STE-2
Version 1.0

Detection of Microbial Contamination Assay

Nanotechnology Characterization Laboratory
National Cancer Institute at Frederick
SAIC-Frederick, Inc.
Frederick, MD 21702
(301)-846-6939
ncl@ncifcrf.gov

July 2005

This protocol assumes an intermediate level of scientific competency with regard to techniques, instrumentation, and safety procedures. Rudimentary assay details have been omitted for the sake of brevity.

Method is written by: _____ 9 Mar 06.

Marina A. Dobrovolskaia, Ph.D. Date

Testing facility: NCL, NCI-Frederick, Bldg 469, Room 250.

1. Introduction

This protocol describes a procedure for quantitative determination of microbial contamination in a nanoparticle preparation. The protocol includes tests for yeast, mold and bacteria using Millipore sampler devices and is based on Millipore Samplers, dilution kits and swab test kits user guide. The assay requires 1.0 mg of test nanomaterial.

2. Reagents

2.1. Sterile PBS, Sigma, cat # D8537

2.2. Yeast and mold sampler, Millipore Corp., cat# MY0010025

2.3. Total count sampler, Millipore Corp., cat# MT0010025

2.4. HPC Count sampler, Millipore Corp., cat# MHPC10025

2.5. Test nanomaterial

2.6. Buffer used to reconstitute test nanomaterial

2.7. Sodium Hydroxide, Sigma, cat.#S2770

2.8. Hydrochloric acid, Sigma H9892

Note: Equivalent reagents from other vendors can be used

3. Equipment

3.1. Pipettes covering range from 0.05 to 1 mL

3.2. Sterile tubes 5 mL

3.3. Vortex

3.4. Pipet tips 0.5 µL – 1.0 mL

3.5. Sterile pipets, 1-10 mL

3.6. Incubator, set at 35°C

4. Reagent Preparation

4.1. <u>Sodium Hydroxide</u>

Prepare from concentrated stock by dilution into sterile water to make solution with final concentration of 0.1N.

4.2. <u>Hydrochloric Acid</u>

Prepare from concentrated stock by dilution into sterile water to make solution with final concentration of 0.1N.

5. Preparation of Quality Controls

Use sterile PBS or water as negative control. Negative control is acceptable if no CFU is observed upon completion of the test. For the positive control use bacterial or yeast cell cultures (ATCC #25254 and MYA774 , respectively) at dilution to allow at least 10 CFU/mL. If standard cultures are not available, a sample from other source (e.g. rain water, floor swipe etc) known to contain bacteria and yeast/mold may be used. A positive control is acceptable if it allows identification of at least 10 CFU/mL.

6. Preparation of Study Samples

Test nanoparticles should be reconstituted in sterile PBS to a final concentration of 1 mg/mL. The pH of the study sample is checked using pH microelectrode and is adjusted with sterile either NaOH or HCl as necessary to be within pH range 6-8. If NaOH or HCl is not compatible with a given nanoparticles formulation, adjust pH using a procedure recommended by nanomaterial manufacturer. To avoid sample contamination from microelectrode, always collect a small aliquot of the sample and use it to measure the pH.

7. Experimental Procedure

7.1. Remove the Sampler from its plastic bag and write on the case with indelible marker the date, and the sample reference number.

7.2. Using sterile conditions remove a paddle from case and apply 1 mL of nanoparticle preparation or dilution onto the surface of a filter. Allow liquid to absorb, then recap the paddle. To prevent the paddle from drying out during incubation, it should be seated firmly in the case to form air-tight seal.

7.3. Incubate for 72h at a nominal temperature of 35°C.

7.4. Remove paddle from case and examine for appearance of colonies. Perform colonies count.

7.5. Report results according to the following formula: # colonies x dilution = CFU/mL

8. Acceptance Criteria

8.1. The test result is acceptable if positive and negative controls are acceptable.

8.2. Test nanomaterial is acceptable if it demonstrated negative results.

9. References

9.1. Samplers, Dilution kits and swab test kits user guide. P15325, Rev. D., 8/99 Millipore Corp.

Section F: QD Characterization and Ecotoxicity Screening

Laboratory of Professor Patricia Holden, PhD
UCSB Bren School of Environmental Science & Management
Center for Environmental Implications of Nanotechnology

METHODS

QD Dissolution

The analytical approach for distinguishing nanoparticulate QD-cadmium from dissolved Cd(II) involves measuring total cadmium by ICP-AES and dissolved cadmium by the Measure iT assay, then calculating nanoparticulate QD-cadmium as the difference. By this approach, CdSe QD dissolution in water is rapid. Dissolution for 75 mg/L (total cadmium basis) citrate-stabilized CdSe QDs in de-ionized water is calculated using predicted values modeled using the Noyes – Whitney relation for sparingly soluble solids in aqueous solutions. The Measure iT assay is performed similarly in LB broth, spent (24 h) culture supernatant and water, and the QD dissolution extent (by dialysis) is also similar across these solutions (data not shown). As expected, higher initial Cd masses (as QDs) resulted in higher dissolved Cd(II) concentrations. The amount of dissolved Cd(II) from the QDs is also measured intra and extracellularly in *P. aeruginosa* cultures.

Intra- and Extra-cellular QD Concentrations

Assuming a cell width of 1 µm, and the aspect ratio for QD-treated cells (above) of 3.3, the cellular concentration of these “intracellular QDs” is then approximately 7.2×1019 QDs/liter. Cellular (i.e. a combination of membrane-associated and internally-distributed), QD-associated cadmium is then estimated, assuming 109 cadmium atoms per nanoparticle by extrapolating from Kasuya *et al*., to be 0.0083 pg of cadmium per cell. The presence of intracellular QDs is supported by the observed co-localization of Cd and Se inside cells. Using this same density of cadmium atoms per nanoparticle and the dissolution data for QDs in LB broth, then the extracellular concentration of QDs is calculated at approximately 2.5×1018 QDs /liter, which is approximately 30 fold less than the intracellular concentration.

Biomacromolecule Contents

For the 75 mg/L (total cadmium) concentration, intracellular DNA is similar (P=0.31) for the QD-treated (2.52 ± 0.11 × 10-6 ng/cell) and Cd(CH3COO))2-treated (2.03 ± 0.88 × 10-6 ng/cell) cultures but significantly (P=0.00) greater than the no-metal controls (1.12 ± S60.18 × 10-6 ng/cell). Intracellular protein contents for the QD and Cd(II) treatments are similar and averaged 92.6 ± 9.8 pg/cell which is significantly (P = 0.01) greater than the controls (51.6 ± 5.1 pg/cell). Similarly, intracellular carbohydrate contents for the QD and Cd(II) treatments are similar and averaged 4.6 ± 0.3 pg/cell which is significantly (P = 0.01) greater than the controls (1.7 ± 0.1 pg/cell).

Abiotic dissolution

A Spectra/Por DispoDialyzer® was used to measure supernatant at regular intervals for dissolved Cd(II) (Fisher Scientific, Hampton, NH). The analytical approach for distinguishing nanoparticulate QD-cadmium from dissolved Cd(II) involved measuring total cadmium by ICP-AES and dissolved cadmium by the Measure iT assay, then calculating nanoparticulate QD-cadmium as the difference.

Abiotic ROS Generation

Generation of reactive oxygen species (ROS, as H2O2 equivalents per liter) produced abiotically is calculated using various concentrations of CdSe QDs added to either sterile water or sterile LB broth. ROS is related to either A) total cadmium concentration in the form of QDs or B) dissolved cadmium after 6 hours, i.e. the time of entry into exponential phase when cells are present. Similar measurements are made for cadmium acetate in both aqueous conditions, but no ROS were produced across the same cadmium concentration range.

Results indicate that after correcting for background fluorescence (as above) and again converting fluorescence to H2O2 equivalents, sterile LB broth plus DCFH yielded an ROS concentration of 534 ± 183 mg/L H2O2. When added to either LB or to water, CdSe QDs also generated ROS abiotically, albeit to a much lesser extent in water as compared to LB broth and to a much greater extent than LB alone. Cadmium salts added to either sterile LB or water did not result in ROS formation.

Assessment of Cytotoxicity

Images were acquired using either an FEI Tecnai G2 F30 FEG microscope (FEI Company, Hillsboro, OR) operating at 300 kV or an FEI Nano600 FEG microscope operating at 30 kV accelerating voltage, each with a STEM detector at a working distance of 6.7 mm. EDXA line scans were performed with a sub-nanometer (0.5 nm or less) electron beam to verify the locally arranged QDs and spectra were analyzed using Genesis software (EDAX, Inc., Mahwah, NJ).

STEM images of *P. aeruginosa* PG201 cell grown in the presence of 75 mg/L CdSe Qds show cell damage and deposition of Cd and Se. The EDS spectra, acquired for the line scan across the cell, can reveal regions rich in Cd and Se, and cell envelope damage (blebbing). STEM micrographs of CdSe QD-cultured cells can show membrane holes, blebbing, and cell wall detached from the plasma membrane.

XANES spectra for cells amended with CdSe QDs (Q.D.s + cells) and all relevant standards is used to compare the oxidation state of selenium associated with cells grown with CdSe QDs with that of elemental selenium, Se(0), and to compare to the other relevant standards tested.

Diffraction peak: XRD profiles were generated using Cu Kα radiation (1.5405Å) at 40 kV and

50 mA from a Phillips Xpert Diffractometer. Diffraction peaks between 2θ values of 2° and 70° were recorded and compared to standards.

Oxidation state: XANES analysis was used to compare Se oxidation state to standards. X-ray energy was selected using a Si(220) double-crystal monochromator, in fluorescence mode using a 30- element Ge array detector.

ROS generation: ROS concentrations were calculated using epifluorescence microscopy to compare H2O2 equivalents in samples to background levels found in standards (units mg/L H2O2).

For more information, see: Prietster et al, 2009

Section F: ZnO and Ag Characterizations and Identification of Nanometals in Wastewater

Laboratory of Diego Rosso, PhD
UCI Department of Civil & Environmental Engineering

METHODS

Nano Zinc (Oxide) and Silver Stock Suspensions and Characterization

Zinc oxide and silver nanoparticles were obtained in 1% suspensions from NEI Corporation. Below discusses methods use to characterize the stock material.

Scanning Electron Microscopy (SEM) - Samples were prepared by adding several drops of a specific undiluted (1%) stock solution onto a nitrocellulose filtration membrane and dried such that the top of the filter was visibly coated with the nanomaterial. After drying, each membrane was then cut and attached, using conductive carbon adhesive, to aluminum SEM stubs. Before analysis all samples were coated with Au/Pt. The SEM was set to a voltage of 10 kV and a working distance of 7.8 mm.

Energy Dispersive X-ray Spectroscopy (EDS) - EDS analysis was also completed on the samples using the same SEM to confirm the composition and purity of the samples. The SEM was set to a voltage of 15 kV and a working distance of 5.6 mm. Data was collected over a period of 5 minutes for each sample.

Transmission Electron Microscopy (TEM) **-** TEM analysis was performed by diluting stock solutions with MilliQ water to 10 mg/L and adding drop wise to a TEM tray to determine individual and aggregate particle size.

Nanoparticle Size Distribution - Stock solutions were diluted with MilliQ water to 10 mg/L and the diluted samples were sonicated for 1 hour immediately using a at 100W and 42kHz setting, prior to analysis. Then a 3 ml sample was added to a plastic cuvette and immediately analyzed with Brookhaven ZetaPALS (Holtsville, NY) to determine particle size distribution in a solution. The instrument was set at 25ºC and the refractive index was set at 2.004.

Ionic Solutions

A zinc standard in a 2% HNO_3 matrix was obtained from VHG Labs at a concentration at 1 g/L.

A silver standard of $AgNO_3$ in a 2% HNO_3 matrix was obtained from Ricca Chemical with a 10 g/L concentration.

Ionic copper solutions were made from $CuCl_2$ salt dissolved in DI water.

Analyses of Nanoscale Suspended Particles by DLS Methods

A Zatasizer Nano (Malvern Instruments, Westborough, MA) was used to analyze submicrometer /nanoscale particle size distribution and particle count in the filtrate (0.45 *µ*m) samples. The instrument uses a dynamic light scattering (DLS) technology to measure particle distribution in the range 0.6 nm to 6 *µ*m. Statistical analyses performed using the photon count rate data indicated that this data can be a useful technique to qualitatively measure *relative* nanoparticle removal in wastewaters (Ganesh et al., 2008, Smeraldi et al., 2011). Hence, the photon count rate measured during particle analyses was used to determine *relative* particle count in various samples. The submicrometer particles measured during the filtrate analyses include naturally occurring submicrometer particles in the wastewater, nanoparticles, and colloidal fraction of the added salts.

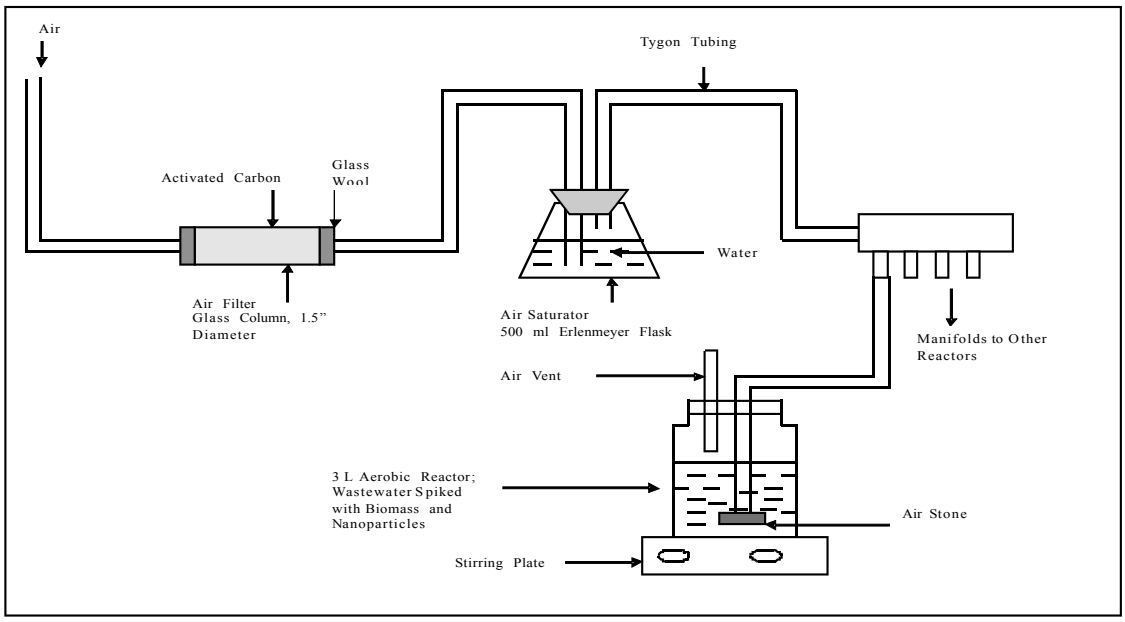
Removal of Nanomaterial from Wastewater

These studies were performed to evaluate removal of nanomaterials in the presence and absence of activated sludge biomass. Nanomaterials removed in the absence of biomass were assumed to represent the fraction removed by abiotic processes such as settling and aggregation. The nanomaterials removed in the presence of sludge biomass would include the fraction removed by biosorption and possible uptake, in addition to that removed by the abiotic process. The intent of these tests are to estimate the amount of nanomaterials in suspension (dissolved or nanosuspended forms), the fraction of the material that is directly associated with biomass, and the fraction that is settled, but not associated with the biomass. This information can then help understand any toxic effects occurring in the presence of these materials.

To evaluate nanomaterial removal by abiotic processes, activated sludge samples collected from OCSD were filtered using 0.45 µm filters and spiked with 2 or 10 mg/l of nanomaterials or ionic salts. Currently no data are available on current or projected concentrations of the nanomaterials in actual wastewaters. A maximum concentration of 10 mg/L was selected for this study since it is unlikely that concentrations higher than this will enter wastewater treatment plants. Samples (100 ml) were then equilibrated in 250 mL flasks for 20 hours at 25 °C, at 100 rpm using a Gyratory Water Bath shaker. The addition of either the nanoparticle or the ions altered the pH within 0.2 units. No further pH adjustments were made. After equilibration, samples were then filtered by 0.45 µm filters and the filtrate was analyzed by ICP.

Subsequently, the procedure was repeated using unfiltered activated sludge samples. After equilibration the samples were filtered (0.45 µm Fisherbrand Nitrocellulose Filteres) and analyzed by ICP (EPA Method 200.7). If needed, samples were digested using EPA Method 200.2 prior to ICP analyses. The difference in the amount of nanomaterials removed in the presence of biomass and in the absence of biomass was

assumed to be the fraction removed by biomass mediated processes such as biosorption.



Inhibitory Effects of Nanomaterial during Biological Wastewater Treatment

Possible inhibitory effects due to release of nanomaterials were studied by evaluating i) growth of key microbial communities (coliform and ammonia oxidizing bacteria) using Most Probable Number (MPN) test, ii) respiration rate of wastewater microorganisms and iii) critical process / operational parameters (e.g. COD, MLSS) that may affect biological treatment processes.

Most Probable Number (MPN) Test

MPN tests determine whether the presence of nanomaterial adversely affects the growth of coliform and ammonia oxidizing bacteria populations in activated sludge. This technique involves a pattern of positive and negative test results based on pH sensitive dye. Coliform bacteria were chosen for this study because they are more prevalent in wastewater and other aquatic environments. *Lauryl Tryptose* growth media was used to evaluate the coliform growth with Brilliant Green Bile Broth used as the confirmation stage. This broth required an incubation time to 24 to 48 hours for each step at 25 °C. The growth of coliform bacteria is identified by visual inspection (samples turn cloudy upon microbial growth) and gas production due to microbial respiration. Ammonia oxidizing bacteria were used because they were more sensitive than coliform bacteria to upsets during wastewater treatment. *Nitrosomonas* media was used to determine the growth of nitrifying microorganisms and requires incubation at 35 °C. The color of the media changes from pink to yellow upon growth of ammonia oxidizers. After the specified times the MPN was calculated for both the nitrifying and coliform bacteria. Tests were performed using nanomaterials as well as ionic salts.

Initially, copper and zinc nanomaterial inhibition of coliform bacteria was tested by spiking the media with 10 or 2 mg/l concentration of nanocopper, nano zinc oxide material or their ionic salts. Initially, nanomaterials (or salts) were added to a batch bioreactor containing activated sludge samples and equilibrated for four hours. Subsequently, well mixed samples were collected from the reactors, diluted to predetermined ratios and added to the spiked growth media in triplicates. Preliminary screening studies indicated that up to 10^{-6} of dilution is required to monitor growth of coliform bacteria and 10^{-2} dilution was required to monitor the growth of ammonia oxidizing bacteria. Figure 3-3 shows the procedure used to obtain the required dilution for MPN values. Microbial growth was analyzed for each dilution over a period of several days and MPN was calculated. Subsequently, experiments were conducted using 2 mg/L of zinc and silver nanomaterials to evaluate inhibition to coliform and ammonia oxidizing bacteria.

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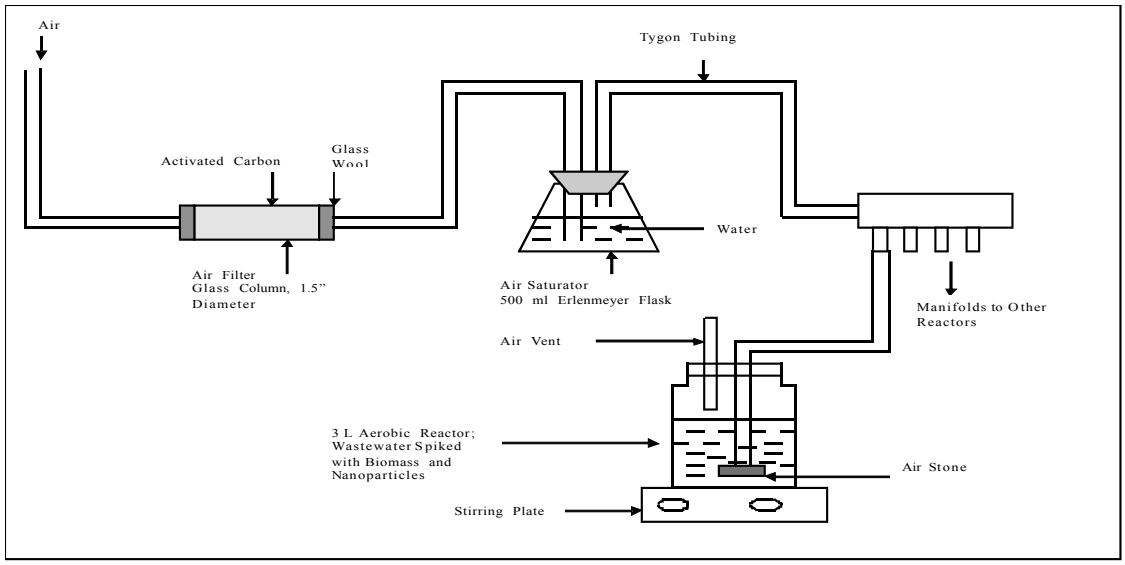
Inhibition of Key Operational Parameters

The effect of nanomaterial on several commonly tested parameters was evaluated during biological treatment. While the MPN test provided effect of nanomaterials for a specific group of microorganisms, evaluation of operating parameters such as chemical oxygen demand (COD) and mixed liquor suspended solids (MLSS) in a bioreactor system provides insight into the collective response of the microbial population to these materials.

Bioreactor Studies

In the bioreactor set up, initially, air is passed through a glass column filled with activated carbon to remove oil and dust particles. It is then saturated by passing through a flask filled with water. A manifold is used to distribute the air between five bioreactors. An air stone attached to the end of the tube facilitates distribution of air evenly within the reactors. A magnetic stirrer is used in each reactor to keep the biomass in suspension. See figure below.

For the bioreactor studies, activated sludge collected from OCSD was allowed to settle for 1 hour and the supernatant was decanted. This was then replaced by the same amount of primary effluent. This was done in an attempt to replicate the treatment process with the combination of return activated sludge and primary effluent. Then 3 L of the mixture is distributed to each of the five batch reactors. Zinc oxide or silver nanomaterials (2 or 0.2 mg/l) were added to the bioreactors. The bioreactors were operated for up to seven days. Initial samples were collected at 0, and 4 hours after seting up the reactors. Subsequently, samples collected and analyzed once each day or once every two days depending on the trends observed. Table 3-4 shows the parameters analyzed and the frequency of analyses. Sample analyses included chemical oxygen demand (sCOD), mixed liquor suspended solids (MLSS), pH, nitrite, nitrate, and metals. Except for MLSS, all the other analyzes were performed on filtered (0.45 µm) samples.



Removal of Nanomaterial in a Media Filter

Column studies were performed to evaluate fate of nanomaterials during media filtration during wastewater treatment. A glass column (10 cm length, 1 cm diameter) was packed with 5 cm of sand with grain sizes of either 0.175 or 0.45 mm. Secondary effluent samples from OCSD plant were spiked with 2 mg/l nano zinc oxide or ionic salt and allowed approximately 1 hour for any solids formed to settle to prevent clogging. The supernatant was then collected, analyzed for metals concentration and used as the feed water for media filtration studies. A peristaltic pump was used to maintain flow rates of 0.98 ml/min or 0.49 ml/min (loading rates of 0.15 and 0.3 gpm/sq. ft) through the column.

Effect of nanomaterial on Disinfection Efficiency

This was performed to determine whether the presence of nanomaterials could affect the disinfection of secondary effluents. To this end, the chlorine demand was estimated for effluents spiked with 2 mg/l of nano zinc oxide or ionic zinc. Secondary effluents with no added nano or ionic zinc were used as controls. A procedure based on Standard Method 2350 B (Chlorine Demand) was used. Triplicate samples, (50 ml) of OCSD secondary effluent was transferred to 150 ml flask and spiked with 2 mg/l of nano or ioni zinc. A 2 mg/L concentration of chlorine (sodium hypochlorite) was added to each flask. Each flask was then covered in foil and placed in a dark room to prevent exposure to light. The samples were incubated at room temperature for 1 h using a Gyratory Water Bath shaker set to 100 rpm. After incubation samples were analyzed for total chlorine with Hach Colorimetric (DPD, Hach Method 8167). The demand was estimated using the following formula:

Chlorine Demand (mg/L) = $(D_s - R_s) - (D_c - R_c)$

Where,

D_s – Initial Chlorine Dose in the nanomaterials containing sample (mg/L)
R_s – Residual Chlorine in the nanomaterials containing sample after the contact time (mg/L)
D_c – Chlorine Dose in the control sample (unspiked OCSD effluent) (mg//L)
R_c – Residual Chlorine in the control sample after the contact time (mg/L)

Section F: ZnO Bioassay for Neurotoxicity

Laboratory of Dimitri D. Deheyn, PhD
Marine Biology Research Division
UCSD Scripps Institution of Oceanography

METHODS

Bioluminescent organisms can use their luminous reactives as a molecular defense mechanism by reducing the effects of reactive oxygen species. The light production of brittlestars (starfish cousin) is used as a bioassay to assess sub-lethal neuro-toxicity of nanometal contaminants. Some brittlestars indeed are bioluminescent, and the light production is under nervous control. The nervous system in these organisms (Echinoderms) is interesting because very closely related to the ones of vertebrates (the nervous control follows a cholinergic adrenergic system, like for our nervous system). The light is always produced with a specific pattern or profile (combination of intensity and kinetics). This profile can change upon induced dysfunction of the nervous control. This change in light production as an early assay is used to detect neuro-toxicity of compounds, including nanomaterials. This toxicological approach helps identify whether the nervous system is a target or not.

The assay can also be done on isolated light producing cells from the same organism, which then allows more specific assessment of cellular functions impairment. For specific localization of the compounds, techniques such as ICP (Induced Coupled Plasma Spectrophotometry) are used to identify the amount of contaminant accumulated in the organisms (versus what it was exposed to). We do not usually look at the sub-organ localization, though have considered it using specific markers viewed in auto-radiography or confocal microscopy. In terms of the nanoparticles however, we are looking at their specific localization and identification using Scanning Electron Microscopy (SEM) equipped with EDX (X-ray diffraction).

Anesthetization and bioluminescence measurement are generally performed on the same day, the anesthetization occurring during the afternoon and the bioluminescence measurement at night (from 21.00 to 00.00 h) to consider the ophiuroid day/night cycle of bioluminescence (Deheyn et al., 1999). After stimulation using 200 mM KCl (light production maximal under these conditions; Mallefet et al., 1992), the produced light is recorded during 180 s using a Berthold LB 9507 luminometer. Two parameters were used to characterize the bioluminescence: the maximal light intensity (LMax) and the kinetic parameter (TLMax) (Deheyn et al., 1997). LMax represents the maximal bioluminescence energetically possible for the arm (and thus for the individual) and is expressed in Relative Light Units (RLU) produced per second normalized per millimeter of arm (RLU/s/mm). TLMax is the time taken for the arm to reach maximal light intensity. It is linked to the interaction between the reactives (including cofactors) of the bioluminescence and is expressed in seconds (s).

For more information: Deheyn D, Jangoux M, Warnau M, Alteration of bioluminescence in Amphipholis squamata (Ophiuroidea: Echinodermata) by heavy metal contamination: a field study. The Science of the Total Environment 247: 41-49

Section F: ZnO Characterization and Cytoxicity Screening

Laboratory of Andre Nel, MD, PhD and Jeff Zink, PhD
UCLA Division of Nanomedicine and Department of Chemistry
Center for Environmental Implications of Nanotechnology

METHODS

Nanoparticle Dispersion in Cell Culture Media

Nanoparticle stock solutions (5 mg/mL) are prepared by dispersing the nanoparticle powder in deionized water by probe sonication (3 W). To ensure proper dispersion of nanoparticles, the stock solution is sonicated before removing aliquots to prepare working solutions. To coat the surface of nanoparticles with bovine serum albumin (BSA), the aliquoted nanoparticle suspension (~10 uL) is mixed with an equal volume of 4% BSA (Fraction-V; Gemini Bioproducts, USA) and equilibrated for 1 h at room temperature. Cell culture media (1 mL) are added to the BSA-coated nanoparticle suspensions. The particle suspensions in BEGM are further stabilized by the addition of BSA at a final concentration of 2 mg/mL. The nanoparticle suspensions are sonicated (3 W) for 15 s prior to the addition to tissue culture plates.

Aggregate Size Distribution and Zeta Potential Measurement

Aggregate size distribution (PSD) is assessed in a ZetaSizer Nano (Malvern Instruments, Westborough, MA). This instrument measures DLS (173°) of nanoparticles in the range of 100-6000 nm by backscattering. The same instrument is used to measure the electrophoretic mobility of nanoparticle suspensions. Electrophoretic mobility is used as an approximation of particle surface charge and is transformed into zeta-potential using the Helmholtz-Smoluchowski equation. Particle size distribution and electrophoretic mobility are performed in complete cell culture media at pH 7.4.

Brunauer-Emmett-Teller (BET) and X-ray Diffraction (XRD) Analysis of Nanoparticles

N2 adsorption-desorption measurements are carried out at 77 K using a Quantachrome NOVA 4000e Autosorb gas sorption system. The BET method is used to determine the specific surface areas of the samples. The powders are placed in a test cell and allowed to degas for 2 h at 200 °C in flowing nitrogen. Data are obtained by introducing or removing a known quantity of adsorbing gas in or out of a sample cell containing the solid adsorbent maintained at a constant liquid nitrogen temperature. The specific surface area of ZnO, CeO2, and TiO2 are found to be 52.11 (±0.13), 164.03 (±2. 22), 144.91(±3.16) m2/g corresponding to particle sizes of 20.2, 5.01, and 9.71 nm, respectively. XRD is collected in a reflection mode on the PW 3040/60 X'Pert PRO diffractometer equipped with X'Celerator linear detector using a Cu Kalpha (lambda = 0.154 nm) radiation and step size of 0.01°.

Transmission Electron Microscopic Analysis of Nanoparticles

The FSP-generated metal oxide nanoparticles are sonicated (water bath) in ethanol for 3 h before TEM analysis. The microscopic imaging of the specimens are investigated with a FEI Titan 80/ 300 microscope equipped with a Cs corrector for the objective lens, a Fischione high angle annular dark field detector (HAADF), GATAN postcolumn imaging filter, and a cold field emission gun operated at 300 kV as an acceleration voltage. To obtain EELS spectrum, Gatan parallel EELS spectrometer is operated at 0.2 eV per channel as an energy dispersive detector. Kevex energy dispersive X-ray spectrometer is used at 10 eV per channel for EELS spectra, SAED patterns, and EDX. Spectra are taken at each sampling point in order to identify the homogeneity of the samples. EFTEM images of pre- and post-edges of elemental mappings are obtained from the data by energy calibration and background subtraction. Zero loss and low loss spectra are also taken at each sampling point for energy calibration and for sample thickness. Calibration is made by using the energy of the zero loss, low loss, or core loss at the lower energy.

Cell Culture and Coincubation with Nanoparticles

All cell cultures are maintained in 25 cm2 cell culture flasks, in which the cells are passaged at 70-80% confluency every 2-4 days depending on the cell type. Recently thawed RAW 264.7 cells (ATCC no. TIB71) are cultured in Dulbecco's modified eagle medium (DMEM) (In Vitrogen, Carlsbad, USA) containing 10% FBS, 100 U/mL penicillin, 100 ug/mL streptomycin, and 2 mM L-glutamine (complete medium). These cells are plated at 5000 cells per well into 384 well plates (CellBound, Corning Inc., MA). Cells are cultured overnight at 37 °C in a 5% CO2 incubator before nanoparticle treatment. BEAS-2B (ATCC no. CRL-9609) cells are cultured in BEGM (Lonza, San Diego, CA) in type-I rat tail collagen-coated flasks. Trypsinized cells are washed and plated at 5000 cells per well (in 50 uL) into 384 well plates. RAW 264.7 cells are cultured overnight at 37 °C in a 5% CO2 incubator while BEAS-2B cells are cultured for 2 days before nanoparticle treatment. Nanoparticles prior coated with BSA and then dispersed in CD-MEM or BEGM added with 2 mg/mL BSA are used to treat RAW 264.7 and BEAS-2B cells, respectively. Nanoparticle exposures are carried out at concentrations of 6.25, 12.5, 25, and 50 ug/mL for 3 h or are exposed to 50 ug/mL nanoparticles for 1, 2, 3, and 6h.

Cellular Staining with Fluorescent Probes and High Content Epifluoresence Microscopy

Two cocktails of fluorescent probe mixtures are prepared by mixing wavelength-compatible fluorescent probes in DMEM media devoid of phenol red. The first cocktail contained Hoechst 33342 (1 uM) and JC1 (1 uM) while the second cocktail contained Hoechst 33342 (1 uM), Fluo-4 (5 uM), and propidium iodide (5 uM). The utility of these dyes, their excitation-emission wavelengths, and cellular responses are summarized in Figure 2A. Cells in each well of the multiwell plates are incubated with 50 uL of dye mixture for 30 min under standard cell culture conditions in the dark. Unincorporated dyes are removed by washing, following which tissue culture wells are replenished with phenol red-free DMEM or BEGM. Plates are acquired on an Image-Xpressmicro (Molecular Devices, Sunnyvale, CA) equipped with laser autofocus. Images are processed using MetaXpress (Molecular Devices, Sunnyvale, CA) under a 10X

magnification. DAPI, FITC, and TRITC filter/dichroic combinations are used to image Hoechst 33342 (blue), Fluo-4 (green), and PI (red), respectively. The total number of nuclei is counted using the following thresholds: In the Hoechst/DAPI channel the approximate minimum width is 3 um (about 3 pixels) and the approximate maximum width is 10 um (about 7 pixels). The intensity above background level is 100 gray levels. For the FITC and TRITC channels the approximate minimum width is 5 um (about 6 pixels) and the approximate maximum width is 30 um (about 22 pixels). The intensity above background is 250 and 500 gray levels, respectively. The percentage of cells positive for a given cellular response is calculated on the basis of the total number of cells (Hoechst 33342 positive cells) and total number of cells having fluorescence intensity above the defined threshold intensity for that parameter. The raw data are exported to an Excel file for comparison and statistical analysis.

ZnO Nanoparticle Dissolution Studies

The effect of iron doping on the rate of ZnO dissolution and Zn^{2+} release is studied by adding 6.7-6.9 mg of material to 25 mL of a 0.1 M sodium perchlorate solution at pH 7 and 22 °C. Following an initial pH drop, the pH rebounded as expected for the reaction:

$$ZnO_s + 2H^+ \rightarrow Zn^{2+}_{aq} + H_2O$$

Solution pH is maintained at pH 7.0-0.4 by the addition of nitric acid controlled by the pH stat function of a Mettler-Toledo T70 autotitrator. The reaction is followed by recording the addition of acid with time and by periodic sampling of 100 uL aliquots for total zinc analysis following dilution with 1 mL of electrolyte solution and centrifugation for 5 min at 20000 g to remove nondissolved suspended nanoparticles. A 500 uL portion of supernatant is acidified with 500 uL of 7% ultra high purity nitric acid, and the zinc ion concentration, [Zn], is measured with inductively coupled plasma mass spectrometry (ICP-MS) using Perkin-Elmer SCIEX Elan DRCII. There is close agreement between the measured [Zn] and the predicted concentrations based on the rate of acid addition assuming eq 1, indicating this to be the dominant process, with no significant formation of solid or aqueous phase protonated species, as expected for pH 7. We used the phreeqc code to estimate the equilibrium concentration of Zn (aq) in 0.1 M NaClO4 at pH 7 due to the dissolution of bulk zincite at 25 °C. [Zn] eq ~ 4.4 mM, indicating that equilibrium is not reached during the dissolution studies.

The effect of iron doping on the long-term dissolved zinc concentration is studied by equilibrating 1 mg of each nanomaterial with 1 mL of a 0.1 M solution of 1,4-piperazinediethanesulfonic acid (PIPES) buffer at pH 7 for 10 days. The PIPES buffer exhibits weak affinity for divalent metal ions and thus is not anticipated to affect the zinc oxide solubility product through complexation with aqueous species. The samples are centrifuged for 1 h with temperature control, and 100 uL of supernatant is removed for ICP-MS analysis of total zinc.

Additional information: George et al 2009, Use of a Rapid Cytotoxicity Screening Approach To Engineer a Safer Zinc Oxide Nanoparticle through Iron Doping.

Material Safety Data Sheet

acc. to OSHA and ANSI

Printing date 11/10/2008 Reviewed on 11/10/2008

1 Identification of substance:

Product details:

Product name: Titanium (IV) oxide

Stock number: 14631

Manufacturer/Supplier:
Alfa Aesar, A Johnson Matthey Company
Johnson Matthey Catalog Company, Inc.
30 Bond Street
Ward Hill, MA 01835-8099
Emergency Phone: (978) 521-6300
CHEMTREC: (800) 424-9300
Web Site: www.alfa.com

Information Department: Health, Safety and Environmental Department
Emergency information:
During normal hours the Health, Safety and Environmental Department.
After normal hours call Chemtrec at (800) 424-9300.

2 Composition/Data on components:

Chemical characterization:
Description: (CAS#)
Titanium (IV) oxide, rutile (CAS# 1317-80-2): 100%
Identification number(s):
EINECS Number: 215-282-2

3 Hazards identification

Hazard description:

Xn Harmful

Information pertaining to particular dangers for man and environment
R 40 Limited evidence of a carcinogenic effect.
Classification system
HMIS ratings (scale 0-4)
(Hazardous Materials Identification System)

HEALTH	1
FIRE	0
REACTIVITY	0

Health (acute effects) = 1
Flammability = 0
Reactivity = 0

4 First aid measures

After inhalation
Supply fresh air. If required, provide artificial respiration. Keep patient warm.
Seek immediate medical advice.
After skin contact
Immediately wash with water and soap and rinse thoroughly.
Seek immediate medical advice.
After eye contact
Rinse opened eye for several minutes under running water. Then consult a doctor.

(Contd. on page 2)

Material Safety Data Sheet
acc. to OSHA and ANSI

Printing date 11/10/2008 Reviewed on 11/10/2008

Product name: Titanium (IV) oxide

(Contd. of page 1)

After swallowing Seek immediate medical advice.

5 Fire fighting measures

Suitable extinguishing agents
Product is not flammable. Use fire fighting measures that suit the surrounding fire.
Protective equipment:
Wear self-contained respirator.
Wear fully protective impervious suit.

6 Accidental release measures

Person-related safety precautions:
Wear protective equipment. Keep unprotected persons away.
Ensure adequate ventilation
Measures for environmental protection:
Do not allow material to be released to the environment without proper governmental permits.
Measures for cleaning/collecting:
Dispose contaminated material as waste according to item 13.
Ensure adequate ventilation.
Additional information:
See Section 7 for information on safe handling
See Section 8 for information on personal protection equipment.
See Section 13 for disposal information.

7 Handling and storage

Handling
Information for safe handling:
Keep container tightly sealed.
Store in cool, dry place in tightly closed containers.
Ensure good ventilation at the workplace.
Prevent formation of dust.
Information about protection against explosions and fires:
No special measures required.

Storage
Requirements to be met by storerooms and receptacles:
No special requirements.
Information about storage in one common storage facility: Not required.
Further information about storage conditions:
Keep container tightly sealed.
Store in cool, dry conditions in well sealed containers.

8 Exposure controls and personal protection

Additional information about design of technical systems:
Properly operating chemical fume hood designed for hazardous chemicals and having an average face velocity of at least 100 feet per minute.

Components with limit values that require monitoring at the workplace:

Titanium dioxide
mg/m3

(Contd. on page 3)

Material Safety Data Sheet
acc. to OSHA and ANSI

Printing date 11/10/2008 Reviewed on 11/10/2008

Product name: Titanium (IV) oxide

(Contd. of page 2)

ACGIH TLV	10; Not classifiable as a human carcinogen
Austria MAK	6
Belgium TWA	10
Denmark	6(Ti)
France VME	10
Germany MAK	6
Korea TLV	10; Not classifiable as a human carcinogen
Norway TWA	5
Poland TWA	10(Ti); 30(Ti)-STEL
Sweden NGV	5
United Kingdom TWA	10 (total inhalable dust) 4 (respirable dust)
OSHA PEL	15 (total dust)

Additional information: No data

Personal protective equipment

General protective and hygienic measures

The usual precautionary measures for handling chemicals should be followed.
Keep away from foodstuffs, beverages and feed.
Remove all soiled and contaminated clothing immediately.
Wash hands before breaks and at the end of work.

Breathing equipment:
Use suitable respirator when high concentrations are present.

Protection of hands: Impervious gloves

Eye protection: Safety glasses

Body protection: Protective work clothing.

9 Physical and chemical properties:

General Information	
Form:	Powder
Color:	White
Odor:	Odorless
Change in condition	
Melting point/Melting range:	1830-1850°C (3326-3362°F)
Boiling point/Boiling range:	2500-3000°C (4532-5432°F)
Sublimation temperature / start:	Not determined
Flash point:	Not applicable
Ignition temperature:	Not determined
Decomposition temperature:	Not determined
Danger of explosion:	Product does not present an explosion hazard.
Explosion limits:	
Lower:	Not determined
Upper:	Not determined
Vapor pressure:	Not determined
Density at 20°C (68°F):	4.23 g/cm³

(Contd. on page 4)

Material Safety Data Sheet

acc. to OSHA and ANSI

Printing date 11/10/2008 Reviewed on 11/10/2008

Product name: Titanium (IV) oxide

(Contd. of page 3)

Solubility in / Miscibility with
Water: Insoluble

10 Stability and reactivity

Thermal decomposition / conditions to be avoided:
Decomposition will not occur if used and stored according to specifications.
Materials to be avoided:
Acids
Metal powders
Dangerous reactions No dangerous reactions known
Dangerous products of decomposition:
No dangerous decomposition products known

11 Toxicological information

Acute toxicity:

LD/LC50 values that are relevant for classification:		
Irritation of skin	mild	300 µg/3D-I (human)

Primary irritant effect:
on the skin: May cause irritation
on the eye: Irritating effect.
Sensitization: No sensitizing effects known.
Other information (about experimental toxicology):
Tumorigenic effects have been observed on tests with laboratory animals.
Carcinogenic effects have been observed on tests with laboratory animals.
Mutagenic effects have been observed on tests with laboratory animals.
Subacute to chronic toxicity:
Subacute to chronic toxicity:
The Registry of Toxic Effects of Chemical Substances (RTECS) reports the following effects in laboratory animals:
Biochemical - Enzyme inhibition, induction, or change in blood or tissue levels - other enzymes.
Blood - changes in serum composition (e.g. TP, bilirubin, cholesterol).
Blood - lymphoma, including Hodgkin's disease.
Gastrointestinal - hypermotility, diarrhea.
Gastrointestinal - other changes.
Lungs, Thorax, or Respiration - structural or functional change in trachea or bronchi.
Lungs, Thorax, or Respiration - chronic pulmonary edema.
Lungs, Thorax, or Respiration - other changes.
Lungs, Thorax, or Respiration - tumors.
Tumorigenic - carcinogenic by RTECS criteria.
Tumorigenic - neoplastic by RTECS criteria.
Tumorigenic - tumors at site of application.
Tumorigenic - equivocal tumorigenic agent by RTECS criteria.
Additional toxicological information:
To the best of our knowledge the acute and chronic toxicity of this substance is not fully known.

(Contd. on page 5)

Material Safety Data Sheet
acc. to OSHA and ANSI

Printing date 11/10/2008 Reviewed on 11/10/2008

Product name: Titanium (IV) oxide

(Contd. of page 4)

IARC-2B: Possibly carcinogenic to humans: limited evidence in humans in the absence of sufficient evidence in experimental animals.
ACGIH A4: Not classifiable as a human carcinogen: Inadequate data on which to classify the agent in terms of its carcinogenicity in humans and/or animals.
The Registry of Toxic Effects of Chemical Substances (RTECS) contains tumorigenic and/or carcinogenic and/or neoplastic data for components in this product.

12 Ecological information:

General notes:
Do not allow undiluted product or large quantities of it to reach ground water, water course or sewage system.
Do not allow material to be released to the environment without proper governmental permits.

13 Disposal considerations

Product:
Recommendation
Consult state, local or national regulations to ensure proper disposal.

Uncleaned packagings:
Recommendation: Disposal must be made according to official regulations.

14 Transport information

Not a hazardous material for transportation.

DOT regulations:
Hazard class: None

Land transport ADR/RID (cross-border)
ADR/RID class: None

Maritime transport IMDG:
IMDG Class: None

Air transport ICAO-TI and IATA-DGR:
ICAO/IATA Class: None

Transport/Additional information:
Not dangerous according to the above specifications.

15 Regulations

Product related hazard informations:

Hazard symbols:
Xn Harmful

Risk phrases:
40 Limited evidence of a carcinogenic effect.

Safety phrases:
36/37 Wear suitable protective clothing and gloves.

(Contd. on page 6)

Material Safety Data Sheet

acc. to OSHA and ANSI

Printing date 11/10/2008 Reviewed on 11/10/2008

Product name: Titanium (IV) oxide

(Contd. of page 5)

National regulations
All components of this product are listed in the U.S. Environmental Protection Agency Toxic Substances Control Act Chemical substance Inventory.

Information about limitation of use:
For use only by technically qualified individuals.

16 Other information:

Employers should use this information only as a supplement to other information gathered by them, and should make independent judgement of suitability of this information to ensure proper use and protect the health and safety of employees. This information is furnished without warranty, and any use of the product not in conformance with this Material Safety Data Sheet, or in combination with any other product or process, is the responsibility of the user.

Department issuing MSDS: Health, Safety and Environmental Department.
Contact: Paul V. Connolly

TITANIUM DIOXIDE

MSDS Number: T3627 --- *Effective Date: 02/15/98*

1. Product Identification

Synonyms: Titanium (IV) Oxide; C.I. 77891; Titania
CAS No.: 13463-67-7
Molecular Weight: 79.87
Chemical Formula: TiO2
Product Codes:
J.T. Baker: 4162, 4962
Mallinckrodt: 0993

2. Composition/Information on Ingredients

Ingredient	CAS No	Percent	Hazardous
Titanium Dioxide	13463-67-7	99 - 100%	Yes

3. Hazards Identification

Emergency Overview

CAUTION! MAY CAUSE IRRITATION TO SKIN, EYES, AND RESPIRATORY TRACT. MAY AFFECT LUNGS.

J.T. Baker SAF-T-DATA(tm) Ratings (Provided here for your convenience)

Health Rating: 3 - moderate
Flammability Rating: 0 - None
Reactivity Rating: 0 - None
Contact Rating: 3 - Moderate
Lab Protective Equip: GOGGLES; LAB COAT
Storage Color Code: Orange (General Storage)

Potential Health Effects

Inhalation:
May cause mild irritation to the respiratory tract.
Ingestion:
Not expected to be a health hazard via ingestion.
Skin Contact:
May cause mild irritation and redness.
Eye Contact:
May cause mild irritation, possible reddening.
Chronic Exposure:
Long-term exposure to titanium dioxide dust may result in mild fibrosis (scarring of the lungs).
Aggravation of Pre-existing Conditions:
Persons with pre-existing lung disease may be more susceptible to the effects of this substance.

4. First Aid Measures

Inhalation:
Remove to fresh air. Get medical attention for any breathing difficulty.
Ingestion:
Not expected to require first aid measures. If large amounts were swallowed, give water to drink and get medical advice.
Skin Contact:
Immediately flush skin with plenty of soap and water for at least 15 minutes. Remove contaminated clothing and shoes. Wash clothing before reuse. Thoroughly clean shoes before reuse. Get medical attention if irritation develops.
Eye Contact:
Immediately flush eyes with plenty of water for at least 15 minutes, lifting upper and lower eyelids occasionally. Get medical attention if irritation persists.

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5. Fire Fighting Measures

Fire:
Not considered to be a fire hazard.
Explosion:
Not considered to be an explosion hazard.
Fire Extinguishing Media:
Use any means suitable for extinguishing surrounding fire.
Special Information:
In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode.

---

6. Accidental Release Measures

Ventilate area of leak or spill. Wear appropriate personal protective equipment as specified in Section 8. Spills: Sweep up and containerize for reclamation or disposal. Vacuuming or wet sweeping may be used to avoid dust dispersal.

---

7. Handling and Storage

Keep in a tightly closed container, stored in a cool, dry, ventilated area. Protect against physical damage. Containers of this material may be hazardous when empty since they retain product residues (dust, solids); observe all warnings and precautions listed for the product.

---

8. Exposure Controls/Personal Protection

Airborne Exposure Limits:
Titanium Dioxide:
- OSHA Permissible Exposure Limit (PEL) -
15 mg/m3 (TWA).
- ACGIH Threshold Limit Value (TLV) -
10 mg/m3 (TWA), A4 - Not classifiable as a human carcinogen.
Ventilation System:
A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.
Personal Respirators (NIOSH Approved):
If the exposure limit is exceeded, a half-face dust/mist respirator may be worn for up to ten times the exposure limit or the maximum use concentration specified by the appropriate regulatory agency or respirator supplier, whichever is lowest. A full-face piece dust/mist respirator may be worn up to 50 times the exposure limit, or the

maximum use concentration specified by the appropriate regulatory agency, or respirator supplier, whichever is lowest. For emergencies or instances where the exposure levels are not known, use a full-facepiece positive-pressure, air-supplied respirator. WARNING: Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.

Skin Protection:
Wear protective gloves and clean body-covering clothing.

Eye Protection:
Use chemical safety goggles and/or full face shield where dusting or splashing of solutions is possible. Maintain eye wash fountain and quick-drench facilities in work area.

---

9. Physical and Chemical Properties

Appearance:
White Powder.

Odor:
Odorless.

Solubility:
Insoluble in water.

Specific Gravity:
4.26

pH:
ca. 6 - 7

% Volatiles by volume @ 21C (70F):
0

Boiling Point:
2500 - 3000C (4532 - 5432F)

Melting Point:
1855C (3371F)

Vapor Density (Air=1):
Not applicable.

Vapor Pressure (mm Hg):
Not applicable.

Evaporation Rate (BuAc=1):
No information found.

---

10. Stability and Reactivity

Stability:
Stable under ordinary conditions of use and storage.

Hazardous Decomposition Products:
No information found.

Hazardous Polymerization:
Will not occur.

Incompatibilities:
For Titanium Dioxide: A violent reaction with lithium occurs around 200C (392F) with a flash of light; the temperature can reach 900C. Violent or incandescent reaction may also occur with other metals such as aluminum, calcium, magnesium, potassium, sodium, and zinc.

Conditions to Avoid:
Dusting and incompatibles.

---

11. Toxicological Information

Toxicological Data:
No LD50/LC50 information found relating to normal routes of occupational exposure. Investigated as a tumorigen and mutagen.

Carcinogenicity:
NIOSH considers this substance to be a potential occupational carcinogen.

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--------\Cancer Lists\-----------------------------------------------------
                                        ---NTP Carcinogen---
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Ingredient	Known	Anticipated	IARC Category
Titanium Dioxide (13463-67-7)	Yes	Yes	3

15. Regulatory Information

--------\Chemical Inventory Status - Part 1\----------

Ingredient	TSCA	EC	Japan	Australia
Titanium Dioxide (13463-67-7)	Yes	Yes	Yes	Yes

--------\Chemical Inventory Status - Part 2\----------

Ingredient	Korea	--Canada-- DSL	NDSL	Phil.
Titanium Dioxide (13463-67-7)	Yes	Yes	No	No

--------\Federal, State & International Regulations - Part 1\----------

Ingredient	-SARA 302- RQ	TPQ	------SARA 313------ List	Chemical Catg.
Titanium Dioxide (13463-67-7)	No	No	No	No

--------\Federal, State & International Regulations - Part 2\----------

Ingredient	CERCLA	-RCRA- 261.33	-TSCA- 8(d)
Titanium Dioxide (13463-67-7)	No	No	No

Chemical Weapons Convention: No TSCA 12(b): No CDTA: No
SARA 311/312: Acute: Yes Chronic: Yes Fire: No Pressure: No
Reactivity: No (Pure / Solid)

Australian Hazchem Code: No information found.
Poison Schedule: No information found.
WHMIS:
This MSDS has been prepared according to the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all of the information required by the CPR.

16. Other Information

NFPA Ratings: Health: **3** Flammability: **0** Reactivity: **0**
Label Hazard Warning:
CAUTION! MAY CAUSE IRRITATION TO SKIN, EYES, AND RESPIRATORY TRACT. MAY AFFECT LUNGS.
Label Precautions:
Avoid contact with eyes, skin and clothing.
Wash thoroughly after handling.
Avoid breathing dust.
Keep container closed.
Use with adequate ventilation.
Label First Aid:
In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes. Get medical attention if irritation develops or persists. If inhaled, remove to fresh air. Get medical attention for any breathing difficulty.
Product Use:
Laboratory Reagent.
Revision Information:
MSDS Section(s) changed since last revision of document include: 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 16.
Disclaimer:
****
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Prepared by: Strategic Services Division
Phone Number: (314) 539-1600 (U.S.A.)

DEGUSSA CORP -- TITANIUM DIOXIDE P-25 -- 6810-00N057044

========== Product Identification ==========

Product ID:TITANIUM DIOXIDE P-25
MSDS Date:01/20/1994
FSC:6810
NIIN:00N057044
MSDS Number: BWRPJ
=== Responsible Party ===
Company Name:DEGUSSA CORP
Address:65 CHALLENGER RD
City:RIDGEFIELD
State:NJ
ZIP:07660
Country:US
Info Phone Num:201-641-6100
Emergency Phone Num:800-424-9300(CHEMTREC)
CAGE:8C791
=== Contractor Identification ===
Company Name:DEGUSSA CORP
Address:65 CHALLENGER RD
City:RIDGEFIELD PARK
State:NJ
ZIP:07660
Country:US
Phone:201-818-3706
CAGE:8C791

========== Composition/Information on Ingredients ==========

Ingred Name:TITANIUM OXIDE; (TITANIUM DIOXIDE)
CAS:13463-67-7
RTECS #:XR2275000
Fraction by Wt: >99.5%
OSHA PEL:15 MG/M3 TDUST
ACGIH TLV:10 MG/M3 TDUST

========== Hazards Identification ==========

LD50 LC50 Mixture:LD50 (ORAL,RAT): >10,000 MG/KG.
Routes of Entry: Inhalation:YES Skin:YES Ingestion:YES
Reports of Carcinogenicity:NTP:NO IARC:NO OSHA:NO
Health Hazards Acute and Chronic:EYE: MAY CAUSE DISCOMFORT. SKIN: MAY CAUSE DRYING OF SKIN. SKIN ABSORPTION: NOT EXPECTED TO BE ABSORBED THROUGH SKIN. INHALATION: MAY CAUSE PHYSICAL DISCOMFORT TO RESPIRATORY TRACT. INGESTION: NOT EXP ECTED TO BE TOXIC BY INGESTION.
Explanation of Carcinogenicity:NOT RELEVANT.
Effects of Overexposure:SEE HEALTH HAZARDS.
Medical Cond Aggravated by Exposure:CONJUNCTIVITIS OF EYE, DERMATITIS OF SKIN, ASTHMA AND RESPIRATORY DISEASES.

========== First Aid Measures ==========

First Aid:EYE: FLUSH WITH WATER FOR AT LEAST 15 MINUTES. CALL PHYSICIAN IF DISCOMFORT PERSISTS. SKIN: WASH WITH SOAP AND WATER. CALL PHYSICIAN IF DRYING PERSISTS. SKIN ABSORPTION: FLUSH WITH SOAP AND WATER. INH ALATION: REMOVE TO FRESH AIR. IF DISCOMFORT PERSISTS, CALL PHYSICIAN. INGESTION: CALL MD IMMEDIATELY .

Fire Fighting Measures

Flash Point:NON-FLAMMABLE
Lower Limits:NONE
Upper Limits:NONE
Extinguishing Media:USE MEDIA SUITABLE FOR SURROUNDING FIRE CONDITIONS .
Fire Fighting Procedures:WEAR NIOSH/MSHA APPROVED SCBA AND FULL PROTECTIVE EQUIPMENT . EVACUATE ENCLOSED AND SURROUNDING AREAS.
Unusual Fire/Explosion Hazard:NONE SPECIFIED BY MANUFACTURER.

Accidental Release Measures

Spill Release Procedures:FOR SMALL SPILLS, SWEEP OR SHOVEL SOLIDS INTO PROPER CONTAINER FOR DISPOSAL.
Neutralizing Agent:NONE SPECIFIED BY MANUFACTURER.

Handling and Storage

Handling and Storage Precautions:STORE IN COOL, DRY, WELL-VENTILATED AREA AWAY FROM SOURCES OF IGNITION. KEEP CONTAINERS TIGHTLY CLOSED WHEN NOT IN USE.
Other Precautions:NONE SPECIFIED BY MANUFACTURER.

Exposure Controls/Personal Protection

Respiratory Protection:ATMOSPHERIC LEVELS SHOULD BE MAINTAINED BELOW EXPOSURE LIMITS LISTED BY USING ENGINEERING CONTROLS. IF NOT FEASIBLE, USE A NIOSH/MSHA APPROVED AIR-PURIFYING RESPIRATOR WITH APPROVED FILTERS AND/OR SOR BENTS.
Ventilation:PROVIDE GEN &/OR LOC EXHST VENT TO MAINTAIN AIRBORNE LEVS BELOW EXPOS LIMITS.REFER TO "INDUSTRIAL VENT" BY ACGIH(SUPDAT)
Protective Gloves:CHEMICAL RESISTANT GLOVES.
Eye Protection:ANSI APPROVED CHEM WORKERS GOGG .
Other Protective Equipment:LOTIONS & BARRIER CREAMS ARE ALSO RECOM TO PVNT DRYING OF SKIN.IF RPTD/PRLNGD SKIN CONT/CONTAM IS LIKELY, PROT (SUPDAT)
Work Hygienic Practices:ESTABLISH GOOD PERSONAL HYGIENE AND WORK PRACTICES. ALWAYS WASH HANDS AND FACE BEFORE EATING, DRINKING OR SMOKING.
Supplemental Safety and Health
PH: 3.0-4.0. VENTILATION: FOR MANUAL OF RECOMMENDED PRACTICES. OTHER PROTECTIVE EQUIPMENT: CLOTHING SHOULD BE WORN.

Physical/Chemical Properties

HCC:C3
Melt/Freeze Pt:M.P/F.P Text:3362F,1850C
Spec Gravity:3.8
pH:SUPDAT
Solubility in Water:INSOLUBLE
Appearance and Odor:WHITE POWDER WITH NO ODOR.

Stability and Reactivity Data

Stability Indicator/Materials to Avoid:YES
NONE SPECIFIED BY MANUFACTURER.
Stability Condition to Avoid:NONE SPECIFIED BY MANUFACTURER.
Hazardous Decomposition Products:NONE KNOWN.

Disposal Considerations

Waste Disposal Methods:DISPOSE OF IN ACCORDANCE WITH ALL LOCAL, STATE AND FEDERAL REGULATIONS. CONTACT DEGUSSA AT (205) 443-4000, EXT. 2287 OR EXT. 2427 FOR ASSISTANCE WITH DISPOSAL REQUIREMENTS.

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CdSe/ZnS Core Shell EviDots in Toluene

MSDS

Section 1 - Chemical Product

Product Family #:	CdSe/ZnS Core Shell EviDots
Substance:	Core Shell EviDots packed in Toluene
Trade Names/Synonyms:	Core Shell EviDots
Chemical Family:	Matrix: aromatic hydrocarbon Nanocrystal: IV-VI semiconductor compound

Section 2 - Composition, Information on Ingredients

Component	CAS#	EC#	% By Weight
Toluene	108-88-3	203-625-9	~ 99.9
Cadmium Selenide (as nano-crystal compound)	1306-24-7	215-148-3	< 0.1
Zinc Sulfide (as nanocrystal compound)	1314-98-3	215-251-3	< 0.1

Section 3 - Hazards Identification

Hazard Description:	Toxic, Dangerous to the Environment
NFPA Rating:	Health = 2 Fire = 3 Reactivity = 0

Emergency Overview	
Color:	Yellow-brown
Physical Form:	Liquid
Odor:	Distinct aromatic odor

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Emergency Overview	
Major Health Hazards:	Respiratory tract irritation, skin irritation, eye irritation, aspiration hazard, central nervous system depression, nerve damage.
Physical Hazards:	Flammable

Potential Health Effects	
Inhalation:	Irritation, nausea, headache, drowsiness, dizziness, disorientation, sleep disturbances, loss of coordination, dilated pupils, kidney damage and liver damage
Skin Contact:	Irritation
Eye Contact:	Irritation
Ingestion:	Nausea, stomach pain, headache, drowsiness, dizziness, disorientation, sleep disturbances, loss of coordination, dilated pupils, kidney damage, liver damage, aspiration hazard.

Carcinogen Status:	Toluene	Cadmium Compounds	Selenium Compounds
OSHA:	No	Yes	No
NTP:	No	Yes	No
IARC:	No	Yes	No

Section 4 - First Aid Measures

Inhalation:	If inhaled, remove to fresh air. If not breathing give artificial respiration and seek medical attention.
Skin Contact:	Wash skin with soap and water for at least 15 minutes while removing contaminated personal protective equipment, clothing and shoes. Seek medical attention if needed.
Eye Contact:	Irrigate eyes for at least 15 minutes. Seek medical attention.
Ingestion:	If ingested, do not induce vomiting, seek medical attention immediately.

Section 5 - Fire Fighting Measures

Extinguishing Media:	Dry chemical, carbon dioxide and foam extinguisher
Fire Fighting:	Avoid Inhalation of material or combustion by-products
Flash Point:	39F (4C) (closed cup)
Flammable Limits:	1.2% LEL -7.1% UEL
Autoignition Point:	896 F (480 C)
Flammability Class:	OSHA Class IB

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Section 6 - Accidental Release Measures

Small Spills:	Utilize personal protective equipment as described in section 8 and absorb with spill pillow or other non-combustible material. Collect spilled material in appropriate container for disposal.

Section 7 - Handling and Storage

Use good hygienic work practices and wash hands after use. Store in a tightly closed container. Store in a cool dry place.

Section 8 - Engineering Controls & Personal Protective Equipment

Exposure Limits	
Toluene	200ppm OSHA TWA PEL 300ppm ceiling OSHA 50ppm ACGIH TWA (skin) 100ppm (375 mg/m3) NIOSH TWA 10hour 190mg/m3 DFG MAK 50ppm (191 mg/m3) UK OES TWA
Cadmium Compounds (as Cd):	5 ug/m3 OSHA TWA (metal and compounds) 2.5 ug/m3 OSHA action level (metal and compounds) 0.2 mg/m3 OSHA TWA (dust) (where cadmium standard 1910.1027 is not in effect) 0.6 mg/m3 OSHA ceiling (dust) (where cadmium standard 1910.1027 is not in effect) 0.01 mg/m3 ACGIH TWA (compounds and metal) 0.002 mg/m3 ACGIH TWA (respirable particulate, compounds and metal) 0.015 mg/m3 AGS TRK (inhalable dust fraction) (others) 0.025 mg/m3 UK MEL TWA (metal and compounds)
Selenium Compounds (as Se):	0.2 mg/m3 OSHA TWA 0.2 mg/m3 ACGIH TWA 0.2 mg/m3 NIOSH recommended TWA 10 hour(s) 0.05 mg/m3 DFG MAK (peak limitation category - II, with excursion factor of 4) (inhalable dust fraction) (metal and inorganic compounds) 0.1 mg(Se)/m3 UK OES TWA
Zinc Sulfide	15mg/m3 OSHA TWA (particulates not otherwise regulated)

Ventiliation:	Provide local exhaust ventilation system or work in a chemical fume hood. Considerations should be made for the use of non-sparking or intrinsically safe ventilation systems and equipment if explosive concentrations of material are present. Ensure compliance with applicable exposure limits.
Eye Protection:	Wear safety glasses with side shields as a minimum level of protection. If splash or splatter is possible, wear chemical/splash resistant safety goggles and or face shield. Emergency eye wash station and quick drench shower should be provided in the immediate work area as per the ANSI Z358.1 guidelines.
Clothing:	Wear appropriate chemical resistant clothing.
Gloves:	Wear appropriate chemical resistant gloves for type of exposure. (polyvinyl alcohol, Teflon™ and Viton™ are resistant to toluene exposure)
Respirator:	Refer to 29CFR1910.134 for selection of appropriate respiratory protection. Organic vapor cartridge with a ½ or full face mask, where toluene vapors do not exceed the assigned protection factor for the respirator. For unknown concentrations or IDLH atmospheres wear self-contained breathing apparatus or supplied air with escape bottle.

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Section 9 - Physical & Chemical Properties

Cadmium Selenide Core EviDots in Toluene	
Physical State:	liquid
Color:	Yellow-brown
Odor:	distinct aromatic odor
Odor Threshold:	~10-15 ppm
Molecular Weight:	92.14
Boiling Point:	232F (111 C)
Freezing Point:	-139 F (-95 C)
Vapor Pressure:	22mmHg @20C
Vapor Density (air = 1):	3.14
Specific Gravity (water = 1):	0.8669
pH:	No data available

Section 10 - Reactivity

Stability:	Stable at standard temperatures and pressure.
Conditions to avoid:	Avoid heat, sparks and other sources of ignition.
Incompatible:	Incompatible with oxidizing materials, halogens, acids, combustible materials and metal salts
Hazards Decomposition:	Combustion produces toxic by-products.
Polymerization:	Will not polymerize.

Section 11 - Toxicological Information

Toluene	
Irritation Data:	300 ppm eyes-human; 435 mg skin-rabbit mild; 500 mg skin-rabbit moderate; 20mg/24hours skin-rabbit moderate
Toxicity Data:	719ul/kg oral-man LDLo; 50 mg/kg oral-human LDLo; 200 ppm inhalation-human TCLo; 100 ppm inhalation-man TCLo; 636 mg/kg oral-rat LD50; 49 gm/m3/4 hours inhalation-rat LC50; 1332 mg/kg intraperitoneal-rat LD50; 1960 mg/kg intravenous-rat LD50; 6900 mg/kg unreported-rat LD50; 400 ppm/24hours inhalation-mouse LC50; 59 mg/kg intraperitoneal-mouse LD50; 2250 mg/kg subcutaneous-mouse LD50; 2gm/kg unreported-mouse LD50; 14100ul/kg skin-rabbit LD50; 130mg/kg intravenous-rabbit LDLo; 1600 ppm inhalation-guinea pig LCLo
Local Effects:	Irritant; inhalation, skin, eye
Slightly Toxic:	Inhalation & dermal absorption
Moderately Toxic:	Ingestion
Target Organs:	Nervous system

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Cadmium Compounds	
Acute Inhalation:	Exposure to sufficiently high concentrations of cadmium dusts may result in upper respiratory tract irritation with delayed symptoms of cough, sore throat, wheezing, headache, chest pain, dizziness, abdominal pain, nausea, diarrhea and vomiting. Exposure may also cause sweating, chills, and difficulty in breathing. Severe exposures may result in lung, kidney or liver damage or death from massive pulmonary edema.
Chronic Inhalation:	Cadmium is highly cumulative and respiratory effects from repeated or prolonged exposure to dusts or fumes may include rhinitis, bronchitis, emphysema, cough, dyspnea, abnormal lung function, obstructive disease, and possibly fibrosis. Ulceration of the nasal septum and yellow discoloration of the teeth may occur. Cadmium induced kidney damage is irreversible and may progress after exposure ceases; some cases of progression to kidney failure have been described. Osteomalacia, osteoporosis, and spontaneous and pseudofractures may occur and may be manifested as back pain , pain in the extremities, difficulty in walking, and pain on bone pressure. Other effects may include irritability, weight loss, fatigue, mild to moderate anemia, eosinophilia, damage to the olfactory nerve with anosmia, and liver damage. An epidemiological study suggests a relationship between cadmium levels in air and cardiovascular disease, but a causal association has not been proved. Occupational exposure to cadmium is implicated in a significant increase in the incidence of prostatic and respiratory cancers.
Acute Ingestion of Cadmium Compounds:	The persistent vomiting induced by cadmium compounds may limit the amount retained, but if sufficient amounts are absorbed, symptoms of systemic toxicity may begin within 15 minutes to 2 hours. Salivation, choking, severe nausea, abdominal pain, diarrhea, tenesmus, blurred vision, dizziness, headache, muscular cramps, exhaustion, collapse, shock, unconsciousness and rarely, convulsions may occur. Recovery may begin within 5-10 hours; sequelae may include delayed liver and kidney damage. Single doses of 10-20 mg of soluble cadmium salts have induced severe toxic effects and doses above 300 mg may be fatal. Death due to shock and dehydration may occur within 24 hours or may be delayed 7-14 days and be due to renal failure or cardiopulmonary depression.
Chronic Ingestion of Cadmium Compounds:	Cadmium accumulates in the body and prolonged low level exposure may cause irreversible renal tubular dysfunction and bone effects as described in the chronic inhalation section.

Selenium Compounds	
Acute Inhalation:	May cause irritation and inflammation of the upper respiratory tract, redness of mucous membranes, sneezing, coughing, sore throat, metallic taste in the mouth, and gastrointestinal distress. Exposure to high concentrations of fumes may cause dyspnea and possibly slight tracheobronchitis. Central nervous effects may include frontal headaches, nervousness, convulsions, and death from respiratory depression.
Chronic Inhalation:	Repeated or prolonged exposure may result in a metallic taste in the mouth followed by a garlic odor of the breath and sweat. Other symptoms may include pallor, coated tongue, gastrointestinal disturbances including nausea, vomiting, abdominal pain, diarrhea, weight loss, lumbar pain, depression, lassitude, fatigue, giddiness, and emotional instability. Liver and spleen effects and albuminuria, porphyrinuria, and urobilinuria have also been reported.
Acute Skin Exposure:	Contact with selenium compounds may cause irritation, rashes and skin eruptions. Some compounds are strong vesicants and can cause destruction of skin and possibly burns.
Chronic Skin Exposure:	Repeated or prolonged exposure to light dust concentrations of selenium compounds may cause dermatitis, paronychia, and skin eruptions. Some selenium compounds are absorbed through the skin and may result in effects as detailed in the inhalation section.
Acute Ingestion:	Ingestion may cause severe irritation and disturbances of the gastrointestinal tract, metallic taste in the mouth, tachycardia, chills, and central nervous system effects as detailed in acute inhalation.
Chronic Ingestion:	Repeated or prolonged ingestion may result in a metallic taste in the mouth, garlic odor of breath and sweat, and other symptoms as described in chronic inhalation. Additional effects reported from ingestion of food and water containing excessive amounts of selenium include skin hyperpigmentation, nail changes, gingivitis, excess dental caries, malocclusion, weight loss, vestibulotoxicity, amyotrophic lateral sclerosis, arthritis, problems walking, diminished reflexes, substernal pain, disturbances of respiratory and endocrine function, jaundice, hepatic disease, and socio-psychologic effects. In extreme cases, loss of nails and hair, numbness and incoordination of arms and legs, paralysis, lack of mental alertness and death from respiratory paralysis may occur.

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Selenium Compounds	
Additional toxicological information:	To the best of our knowledge the acute and chronic toxicity of this substance is not fully known. Cadmium Selenide, in the form of a nanocrystal may or may not present the same health hazards as a larger cadmium or selenium containing molecules. It is therefore encouraged to use caution when handling this product as its toxicity and modes of exposure are not well characterized or understood.

Zinc Sulfide	
Toxicity Data:	Oral Rat > 2,000 mg/kg LD50; Inhalation Rat > 5,040 mg/m3 LC50; Skin Rat> 2,000 mg/kg LD50
Acute inhalation, skin and eye toxicity:	Zinc Sulfide is an irritant to the eyes, respiratory system and skin.

Section 12 - Ecological Information

Do not allow material to be released to the environment (ground, air or water bodies) without proper permits. Toluene is not persistent in the environment.

Section 13 - Transportation Information

U.S. DOT:	Class 3, packing group II, UN1294
Canadian Transportation of Dangerous Goods:	UN 1294 Class 3
Land Transport ADR/RID:	UN1294, Class 3, Class Code F1, Pack group II
Air Transport IATA/ICAO:	UN1294, Class or Division 3, pack group II
Exceptions:	49 CFR 173.4

Section 14 - Disposal

U.S. EPA 40 CFR 262: Hazardous Waste Number: D001 (Flammable), U220 (toluene)
Dispose in accordance with all applicable local, state and federal regulations.

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Section 15 - Regulatory Information

US Regulations

Toluene:
CERCLA: 1000 Lbs RQ
SARA Title III, sec. 302, 304: Not regulated
SARA Title III, Section 311/312
Acute: Yes
Chronic: Yes
Fire: No
Reactive: No
Sudden Release: No
US Inventory (TSCA) listed: Yes

Canadian Regulations

WHMIS Classification: Not available

European Regulations

EC Classification:
F Highly Flammable
Xn-Harmful

EC Risk Phrases

R11, R20, S2, S16, S25, S29, S33

Section 16 - Other Information

The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. Evident Technologies shall not be held liable for any damage resulting from handling or from contact with the above product. See packing slip for additional terms and conditions of sale.

Revision Date: 1/1/05
Creation Date: 1/1/05

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1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

Product information

Trade name	:	AEROXIDE® TiO2 P 25
Use of the Substance / Preparation	:	Catalyst support Stabilizer UV-filters
Company	:	Evonik Degussa Corporation 379 Interpace Parkway Parsippany,NJ 07054 USA
Telephone	:	973-541-8000
Telefax	:	973-541-8040
US: CHEMTREC EMERGENCY NUMBER	:	800-424-9300
CANADA: CANUTEC EMERGENCY NUMBER	:	613-996-6666
Product Regulatory Services	:	973-541-8060

2. HAZARDS IDENTIFICATION

***** EMERGENCY OVERVIEW *****

***Form**-powder* ***Color**-white* **Odor**-*odorless*

May cause eye, skin and respiratory tract irritation.

POTENTIAL HEALTH EFFECTS

Eye contact

May cause eye irritation.

Skin Contact

May cause drying of the skin.

Inhalation

May cause irritations of the respiratory tract.

Ingestion

No hazard expected in normal use.

Chronic Health Hazard

High concentrations of titanium dioxide dust caused microscopic lung tumors in rats in lifetime inhalation studies. However, DuPont, the primary US manufacturer, based on a review of the test data and based on an epidemiological study of employees, concludes that titanium dioxide pigment will not cause chronic respiratory disease in humans at concentrations experienced in the workplace.
IARC Category 2B (possibly carcinogenic to human).

3. COMPOSITION/INFORMATION ON INGREDIENTS

Information on ingredients / Hazardous components

Titanium dioxide
CAS-No. 13463-67-7 Percent (Wt./ Wt.) 100 %

Other information

This material is classified as hazardous under OSHA regulations.
IARC Category 2B (possibly carcinogenic to human).

4. FIRST AID MEASURES

Inhalation

In case product dust is released: Possible discomfort: cough, sneezing
Move victims into fresh air.

Skin contact

Wash off with soap and plenty of water.

Eye contact

In case of contact, immediately flush eyes with plenty of water for at least 15 minutes or until all material has been removed. Obtain medical attention.

Ingestion

If accidentally swallowed, rinse mouth thoroughly with water and afterwards, drink plenty of water. In case of discomfort, obtain medical attention.

5. FIRE-FIGHTING MEASURES

Flash point	not applicable
Lower explosion limit	not applicable
Upper explosion limit	not applicable
Autoignition temperature	not applicable

Suitable extinguishing media

All extinguishing substances suitable.

Specific hazards during fire fighting

None known.
This material has an exceptional tendency to accumulate static charge.

Special protective equipment for fire-fighters

As in any fire, wear self-contained positive-pressure breathing apparatus, (MSHA/NIOSH approved or equivalent) and full protective gear.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions

Wear personal protective equipment.

Environmental precautions

Obey relevant local, state, provincial and federal laws and regulations. Do not contaminate any lakes, streams, ponds, groundwater or soil.

Methods for cleaning up

Sweep up or vacuum up spillage and collect in suitable container for disposal.
Avoid dust formation.

7. HANDLING AND STORAGE

Handling

Safe handling advice

Use with adequate ventilation.

Advice on protection against fire and explosion

Take precautionary measures against static discharges.

Storage

Requirements for storage areas and containers

Keep containers tightly closed in a dry, cool place.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Component occupational exposure guidelines

- **Titanium dioxide**

CAS-No.	13463-67-7	
Control parameters	10 mg/m3 15 mg/m3 Total dust.	Time Weighted Average (TWA):(ACGIH) PEL:(OSHA Z1)
	5 mg/m3 as Ti	Time Weighted Average (TWA) Permissible Exposure Limit (PEL):(US CA OEL)
	Respirable fraction.	
	10 mg/m3 as Ti	Time Weighted Average (TWA)

Permissible Exposure Limit (PEL):(US CA OEL)

Total dust.

Personal protective equipment

Respiratory protection

A respiratory protection program that meets OSHA 1910.134 and ANSI Z88.2 or applicable federal/provincial requirements must be followed whenever workplace conditions warrant respirator use. NIOSH's "Respirator Decision Logic" may be useful in determining the suitability of various types of respirators.

Hand protection

Use impermeable gloves.

Eye protection

Wear safety glasses with side shields. In case dusts are formed, wear close fitting protective goggles.

Skin and body protection

A safety shower and eye wash fountain should be readily available.
To identify additional Personal Protective Equipment (PPE) requirements, it is recommended that a hazard assessment in accordance with the OSHA PPE Standard (29CFR1910.132) be conducted before using this product.

Hygiene measures

When using, do not eat, drink or smoke. Wash face and/or hands before break and end of work. Avoid contaminating clothes with product. Wash contaminated clothing after use.

Protective measures

Handle in accordance with good industrial hygiene and safety practices.
If there is the possibility of skin/eye contact, the indicated hand/eye/body protection should be used.
If the workplace threshold limit value is exceeded and/or the substance is released, use appropriate respiratory protection.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance

Form	powder
Color	white
Odor	odorless

Safety data

pH	3.5 - 4.5	(40 g / l)	(20 °C)
Melting point/range	ca. 1850 °C		
Boiling point/range	not applicable		
Flash point	not applicable		
Flammability	not applicable		

Autoignition temperature:	not applicable
Autoinflammability	not applicable
Lower explosion limit	not applicable
Upper explosion limit	not applicable
Minimum ignition energy	> 10 Joule
Vapor pressure	not applicable
Density	ca. 3.8 g/cm3 (20 °C)
Tapped density	ca. 130 g / l Method: DIN 53 194
Water solubility	insoluble
Partition coefficient (n-octanol/water)	not applicable
Viscosity, dynamic	not applicable

10. STABILITY AND REACTIVITY

Hazardous decomposition products	None known.
Thermal decomposition	> 2000 °C

11. TOXICOLOGICAL INFORMATION

Product Acute oral toxicity	LD50 Rat: > 10000 mg/kg Method: literature (limit test)
Product Acute dermal toxicity	LD50 Rabbit: >= 10000 mg/kg Method: literature
Product Skin irritation	Rabbit Not irritating. Method: literature
Product Eye irritation	Rabbit Not irritating. Method: literature
Product Sensitization	Optimizations-test guinea pig: not sensitizing Method: literature

Patch test : not sensitizing
Method: literature

Product Gentoxicity in vitro

Microorganisms, cell cultures
Method: literature
Shown no mutagenic/genotoxic effect.

Product Gentoxicity in vivo

Microorganisms, cell cultures
Method: literature
Shown no mutagenic/genotoxic effect.

Product Carcinogenicity

The scientific discussion of the tumorigenic effect of sparingly soluble inorganic particles (fine dusts)- such as titanium dioxide - is ongoing. It is the opinion of many inhalation toxicologists that the tumor formation observed in rats results from a species-specific mechanism involving overloading of the rat lung (overload phenomenon). Corresponding findings resulting from exposure of humans have not been observed to date. On the other hand, the International Agency for Research on Cancer (IARC) assessed, in February of 2006, the available rat model studies as constituting sufficient proof of the carcinogenicity of titanium dioxide in animal models. For humans, the IARC does not see sufficient evidence of a carcinogenic effect of titanium dioxide. However, the IARC evaluation scheme results in an overall assessment of titanium dioxide as "possibly carcinogenic to humans" (Group 2B).

Oral rat, mouse: 103 weeks
Method: literature
No evidence that cancer may be caused.

Inhalative Rat: 2 years
Method: literature
Increased incidence of lung tumors.
According to many inhalation toxicologists the tumor response observed in the rat studies is species specific.

Inhalative (mouse): 2 years
Method: literature
No evidence that cancer may be caused.

Component carcinogenicity assessment

Titanium dioxide
13463-67-7
Contains a component which is classified as an IARC 2B carcinogen (possibly carcinogenic to humans).

12. ECOLOGICAL INFORMATION

Ecotoxicity effects

Toxicity to fish

LC50 Fundulus heteroclitus: > 1000 mg/l / 96 h

Method: literature

Toxicity to daphnia — EC0 Daphnia magna: 1000 mg/l / 48 h
Method: literature

Toxicity to bacteria — EC0 Pseudomonas fluorencens: 10000 mg/l / 24 h
Method: DEV, DIN 38412, T. 8 (modified).

13. DISPOSAL CONSIDERATIONS

WASTE DISPOSAL

Advice on disposal — Waste must be disposed of in accordance with federal, state and local regulations. Incineration is the preferred method.

14. TRANSPORT INFORMATION

Transport/further information

Not classified as dangerous in the meaning of transport regulations.

15. REGULATORY INFORMATION

US Federal Regulations

OSHA

If listed below, chemical specific standards apply to the product or components:

- None listed

Clean Air Act Section (112)

If listed below, components present at or above the de minimus level are hazardous air pollutants:

- None listed

CERCLA Reportable Quantities

If listed below, a reportable quantity (RQ) applies to the product based on the percent of the named component:

- None listed

SARA Title III Section 311/312 Hazard Categories

The product meets the criteria only for the listed hazard classes:

- Acute Health Hazard

SARA Title III Section 313 Reportable Substances

If listed below, components are subject to the reporting requirements of Section 313 of Title III of the Superfund Amendments and Reauthorization Act of 1986 and 40 CFR Part 372:

- None listed

Toxic Substances Control Act (TSCA)

If listed below, non-proprietary substances are subject to export notification under Section 12 (b) of TSCA:

- None listed

State Regulations

The Listing requirements of the Right to Know (RTK) legislation varies by state. All information for NJ, PA, MA and other states can be derived from the listing of hazardous and non-hazardous components in section 2 and 15 of this MSDS.

California Proposition 65

A warning under the California Drinking Water Act is required only if listed below:

- None listed

International Chemical Inventory Status

Unless otherwise noted, this product is in compliance with the inventory listing of the countries shown below. For information on listing for countries not shown, contact Evonik Degussa Corporation Product Regulatory Services Department:

• Europe (EINECS/ELINCS)	Listed/registered
• USA (TSCA)	Listed/registered
• Canada (DSL)	Listed/registered
• Australia (AICS)	Listed/registered
• Japan (MITI)	Listed/registered
• Korea (TCCL)	Listed/registered
• Philippines (PICCS)	Listed/registered
• China	Listed/registered

16. OTHER INFORMATION

HMIS Ratings

Health :	1
Flammability :	0
Physical Hazard :	0

NFPA Ratings

Health :	1
Flammability :	0
Reactivity :	0

Further information

Changes since the last version are highlighted in the margin. This version replaces all previous versions.

The information provided in this Safety Data Sheet is correct to the best of our knowledge, information and belief at the date of its publication. The information given is designed only as a guidance for safe handling, use, processing, storage, transportation, disposal and release and is not to be considered a warranty or quality specification. The information relates only to the specific material designated and may not be valid for such material used in combination with any other materials or in any process, unless specified in the text

Material Safety Data Sheet
Zinc oxide

ACC# 25490

Section 1 - Chemical Product and Company Identification

MSDS Name: Zinc oxide
Catalog Numbers: AC194890000, AC194890010, AC315790000, AC315790250, AC422740000, AC422740010, AC422740050, Z50-12, Z50-212, Z50-500, Z52-10, Z52-500
Synonyms: Zinc white; Chinese white; C.I. Pigment White 4; C.I. 77947.
Company Identification:
Fisher Scientific
1 Reagent Lane
Fair Lawn, NJ 07410
For information, call: 201-796-7100
Emergency Number: 201-796-7100
For CHEMTREC assistance, call: 800-424-9300
For International CHEMTREC assistance, call: 703-527-3887

Section 2 - Composition, Information on Ingredients

CAS#	Chemical Name	Percent	EINECS/ELINCS
1314-13-2	Zinc oxide	>99	215-222-5

Section 3 - Hazards Identification

EMERGENCY OVERVIEW

Appearance: white or yellow-white solid.
Caution! May cause eye, skin, and respiratory tract irritation. Inhalation of fumes may cause metal-fume fever. The toxicological properties of this material have not been fully investigated.
Target Organs: No data found.

Potential Health Effects
Eye: Dust may cause mechanical irritation.
Skin: Prolonged and/or repeated contact may cause irritation and/or dermatitis.
Ingestion: May cause gastrointestinal irritation with nausea, vomiting and diarrhea. Moderately toxic to humans by ingestion. The toxicological properties of this substance have not been fully investigated.
Inhalation: Effects may be delayed. May cause respiratory tract irritation. Inhalation of fumes may cause metal fume fever, which is characterized by flu-like symptoms with metallic taste, fever, chills, cough, weakness, chest pain, muscle pain and increased white blood cell count. The toxicological properties of this substance have not been fully investigated. Can produce delayed pulmonary edema. Zinc oxide dust is considered to be of low toxicity and is classified as a nuisance particulate by the

ACGIH. However, inhalation fumes or very fine dust may causes "zinc fume fever", which is characterized by flu-like symptoms with metallic taste, coughing, weakness, fatigue, muscular pain, and nausea, followed by fever and chills. Onset of symptoms occurs about 4-12 hours after exposure.
Chronic: Effects may be delayed.

Section 4 - First Aid Measures

Eyes: Flush eyes with plenty of water for at least 15 minutes, occasionally lifting the upper and lower eyelids. Get medical aid.
Skin: Get medical aid. Flush skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Wash clothing before reuse.
Ingestion: Never give anything by mouth to an unconscious person. Get medical aid. Do NOT induce vomiting. If conscious and alert, rinse mouth and drink 2-4 cupfuls of milk or water.
Inhalation: Remove from exposure and move to fresh air immediately. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical aid. Do NOT use mouth-to-mouth resuscitation. If breathing has ceased apply artificial respiration using oxygen and a suitable mechanical device such as a bag and a mask.
Notes to Physician: Treat symptomatically and supportively.

Section 5 - Fire Fighting Measures

General Information: As in any fire, wear a self-contained breathing apparatus in pressure-demand, MSHA/NIOSH (approved or equivalent), and full protective gear. Material will not burn.
Extinguishing Media: Substance is noncombustible; use agent most appropriate to extinguish surrounding fire.
Flash Point: Not applicable.
Autoignition Temperature: Not applicable.
Explosion Limits, Lower: Not available.
Upper: Not available.
NFPA Rating: (estimated) Health: 1; Flammability: 0; Instability: 0

Section 6 - Accidental Release Measures

General Information: Use proper personal protective equipment as indicated in Section 8.
Spills/Leaks: Vacuum or sweep up material and place into a suitable disposal container. Clean up spills immediately, observing precautions in the Protective Equipment section. Avoid generating dusty conditions. Provide ventilation.

Section 7 - Handling and Storage

Handling: Minimize dust generation and accumulation. Avoid contact with eyes, skin, and clothing. Keep container tightly closed. Use with adequate ventilation. Wash clothing before reuse. Avoid breathing dust.

Storage: Store in a tightly closed container. Store in a cool, dry, well-ventilated area away from incompatible substances.

Section 8 - Exposure Controls, Personal Protection

Engineering Controls: Use process enclosure, local exhaust ventilation, or other engineering controls to control airborne levels below recommended exposure limits. Facilities storing or utilizing this material should be equipped with an eyewash facility and a safety shower.

Exposure Limits

Chemical Name	ACGIH	NIOSH	OSHA - Final PELs
Zinc oxide	2 mg/m3 TWA (respirable fraction); 10 mg/m3 STEL (respirable fraction)	5 mg/m3 TWA (dust and fume) 500 mg/m3 IDLH	5 mg/m3 TWA (fume); 15 mg/m3 TWA (total dust); 5 mg/m3 TWA (respirable fraction)

OSHA Vacated PELs: Zinc oxide: 5 mg/m3 TWA (fume); 10 mg/m3 TWA (total dust); 5 mg/m3 TWA (respirable fraction)

Personal Protective Equipment

Eyes: Wear appropriate protective eyeglasses or chemical safety goggles as described by OSHA's eye and face protection regulations in 29 CFR 1910.133 or European Standard EN166.

Skin: Wear appropriate protective gloves to prevent skin exposure.

Clothing: Wear appropriate protective clothing to minimize contact with skin.

Respirators: A respiratory protection program that meets OSHA's 29 CFR 1910.134 and ANSI Z88.2 requirements or European Standard EN 149 must be followed whenever workplace conditions warrant respirator use.

Section 9 - Physical and Chemical Properties

Physical State: Solid
Appearance: white or yellow-white
Odor: odorless
pH: Not applicable.
Vapor Pressure: Not available.
Vapor Density: Not available.
Evaporation Rate: Not available.
Viscosity: Not available.
Boiling Point: Not available.
Freezing/Melting Point:1975 deg C
Decomposition Temperature: Sublimes.
Solubility: Negligible in water
Specific Gravity/Density:5.6
Molecular Formula: ZnO
Molecular Weight:81.37

Section 10 - Stability and Reactivity

Chemical Stability: Stable at room temperature in closed containers under normal storage and handling conditions.
Conditions to Avoid: Dust generation.
Incompatibilities with Other Materials: Magnesium, chlorinated rubber.
Hazardous Decomposition Products: Toxic fumes of zinc oxide.
Hazardous Polymerization: Has not been reported.

Section 11 - Toxicological Information

RTECS#:
CAS# 1314-13-2: ZH4810000; ZH4817000
LD50/LC50:
CAS# 1314-13-2:
Draize test, rabbit, eye: 500 mg/24H Mild;
Draize test, rabbit, skin: 500 mg/24H Mild;
Inhalation, mouse: LC50 = 2500 mg/m3;
Oral, mouse: LD50 = 7950 mg/kg;
.

Carcinogenicity:
CAS# 1314-13-2: Not listed by ACGIH, IARC, NTP, or CA Prop 65.

Epidemiology: No information found
Teratogenicity: No information found
Reproductive Effects: No information found
Mutagenicity: No information found
Neurotoxicity: No information found
Other Studies:

Section 12 - Ecological Information

Ecotoxicity: No data available. No information available.
Environmental: No information available.
Physical: Testing of aquatic toxicity is not meaningful as solubility is poor.
Other: After exposing rainbow trout to zinc for a period of 30 days in river water, it was concluded that zinc accumulates in the gills, liver, kidney and opercular bone, but not the muscle.

Section 13 - Disposal Considerations

Chemical waste generators must determine whether a discarded chemical is classified as a hazardous waste. US EPA guidelines for the classification determination are listed in 40 CFR Parts 261.3. Additionally, waste generators must consult state and local hazardous waste regulations to ensure complete and accurate classification.
RCRA P-Series: None listed.
RCRA U-Series: None listed.

Section 14 - Transport Information

	US DOT	Canada TDG
Shipping Name:	NOT REGULATED FOR DOMESTIC TRANSPORT	ENVIRONMENTALLY HAZARDOUS SUBSTANCE, SOL
Hazard Class:	XCP	9
UN Number:		UN3077
Packing Group:		III

Section 15 - Regulatory Information

US FEDERAL

TSCA
CAS# 1314-13-2 is listed on the TSCA inventory.
Health & Safety Reporting List
None of the chemicals are on the Health & Safety Reporting List.
Chemical Test Rules
None of the chemicals in this product are under a Chemical Test Rule.
Section 12b
None of the chemicals are listed under TSCA Section 12b.
TSCA Significant New Use Rule
None of the chemicals in this material have a SNUR under TSCA.
CERCLA Hazardous Substances and corresponding RQs
None of the chemicals in this material have an RQ.
SARA Section 302 Extremely Hazardous Substances
None of the chemicals in this product have a TPQ.
SARA Codes
CAS # 1314-13-2: immediate.
Section 313
This material contains Zinc oxide (listed as Zinc compounds), >99%, (CAS# 1314-13-2) which is subject to the reporting requirements of Section 313 of SARA Title III and 40 CFR Part 373.
Clean Air Act:
This material does not contain any hazardous air pollutants.
This material does not contain any Class 1 Ozone depletors.
This material does not contain any Class 2 Ozone depletors.
Clean Water Act:
None of the chemicals in this product are listed as Hazardous Substances under the CWA.
None of the chemicals in this product are listed as Priority Pollutants under the CWA. CAS# 1314-13-2 is listed as a Toxic Pollutant under the Clean Water Act.
OSHA:
None of the chemicals in this product are considered highly hazardous by OSHA.
STATE
CAS# 1314-13-2 can be found on the following state right to know lists: California, New Jersey, Pennsylvania, Minnesota, Massachusetts.

California Prop 65

California No Significant Risk Level: None of the chemicals in this product are listed.

European/International Regulations

European Labeling in Accordance with EC Directives

Hazard Symbols:

N

Risk Phrases:

R 50/53 Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

Safety Phrases:

S 60 This material and its container must be disposed of as hazardous waste.

S 61 Avoid release to the environment. Refer to special instructions /safety data sheets.

WGK (Water Danger/Protection)

CAS# 1314-13-2: 0

Canada - DSL/NDSL

CAS# 1314-13-2 is listed on Canada's DSL List.

Canada - WHMIS

not available.

This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations and the MSDS contains all of the information required by those regulations.

Canadian Ingredient Disclosure List

CAS# 1314-13-2 is listed on the Canadian Ingredient Disclosure List.

Section 16 - Additional Information

MSDS Creation Date: 12/12/1997
Revision #10 Date: 10/08/2008

The information above is believed to be accurate and represents the best information currently available to us. However, we make no warranty of merchantability or any other warranty, express or implied, with respect to such information, and we assume no liability resulting from its use. Users should make their own investigations to determine the suitability of the information for their particular purposes. In no event shall Fisher be liable for any claims, losses, or damages of any third party or for lost profits or any special, indirect, incidental, consequential or exemplary damages, howsoever arising, even if Fisher has been advised of the possibility of such damages.

invitrogen™

Material Safety Data Sheet

Revision Date: 11-Dec-2007

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product code A10200
Product name Qdot® 625 ITK™ carboxyl quantum dots *8 µM solution*

Company/Undertaking Identification

INVITROGEN CORPORATON
1600 FARADAY AVENUE
PO BOX 6482
CARLSBAD, CA 92008
760-603-7200

INVITROGEN CORPORATION
2270 INDUSTRIAL STREET
BURLINGTON, ONT
CANADA L7P 1A1
800-263-6236

GIBCO PRODUCTS
INVITROGEN CORPORATION
3175 STALEY ROAD P.O. BOX 68
GRAND ISLAND, NY 14072
716-774-6700

2. COMPOSITION/INFORMATION ON INGREDIENTS

Hazardous/Non-hazardous Components
The product contains no substances which at their given concentration, are considered to be hazardous to health

3. HAZARDS IDENTIFICATION

Emergency Overview
The product contains no substances which at their given concentration, are considered to be hazardous to health

Form
Liquid

Principle Routes of Exposure/ Potential Health effects

Eyes	No information available
Skin	No information available
Inhalation	No information available

3. HAZARDS IDENTIFICATION

Ingestion No information available

Specific effects

Carcinogenic effects No information available
Mutagenic effects No information available
Reproductive toxicity No information available
Sensitization No information available

Target Organ Effects No information available

HMIS

Health	0
Flammability	0
Reactivity	0

4. FIRST AID MEASURES

Skin contact Wash off immediately with plenty of water
Eye contact Rinse thoroughly with plenty of water, also under the eyelids.
Ingestion Never give anything by mouth to an unconscious person
Inhalation Move to fresh air
Notes to physician Treat symptomatically.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media Dry chemical
Special protective equipment for firefighters Wear self-contained breathing apparatus and protective suit

6. ACCIDENTAL RELEASE MEASURES

Personal precautions Use personal protective equipment
Methods for cleaning up Soak up with inert absorbent material.

7. HANDLING AND STORAGE

Handling No special handling advice required
Storage Keep in properly labelled containers

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Occupational exposure controls

Exposure limits
Engineering measures Ensure adequate ventilation, especially in confined areas

Personal protective equipment

Respiratory protection In case of insufficient ventilation wear suitable respiratory equipment
Hand protection Protective gloves
Eye protection Safety glasses with side-shields
Skin and body protection Lightweight protective clothing.
Hygiene measures Handle in accordance with good industrial hygiene and safety practice

Environmental exposure controls	Prevent product from entering drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

General Information

Form	Liquid

Important Health Safety and Environmental Information

Boiling point/range	**°C** No data available	**°F** No data available
Melting point/range	**°C** No data available	**°F** No data available
Flash point	**°C** No data available	**°F** No data available
Autoignition temperature	**°C** No data available	**°F** No data available
Oxidizing properties	No information available	
Water solubility	No data available	

10. STABILITY AND REACTIVITY

Stability	Stable.
Materials to avoid	No information available
Hazardous decomposition products	No information available
Polymerization	Hazardous polymerisation does not occur.

11. TOXICOLOGICAL INFORMATION

Acute toxicity

Principle Routes of Exposure/ Potential Health effects

Eyes	No information available
Skin	No information available
Inhalation	No information available
Ingestion	No information available

Specific effects

Carcinogenic effects	No information available
Mutagenic effects	No information available
Reproductive toxicity	No information available
Sensitization	No information available

Target Organ Effects No information available

12. ECOLOGICAL INFORMATION

Ecotoxicity effects	No information available.
Mobility	No information available.
Biodegradation	Inherently biodegradable.
Bioaccumulation	Does not bioaccumulate.

13. DISPOSAL CONSIDERATIONS

Dispose of in accordance with local regulations

14. TRANSPORT INFORMATION

IATA

Proper shipping name	Not classified as dangerous in the meaning of transport regulations
Hazard Class	No information available
Subsidiary Class	No information available
Packing group	No information available
UN-No	No information available

15. REGULATORY INFORMATION

International Inventories

U.S. Federal Regulations

SARA 313
This product is not regulated by SARA.

Clean Air Act, Section 112 Hazardous Air Pollutants (HAPs) (see 40 CFR 61)
This product does not contains HAPs.

U.S. State Regulations

California Proposition 65
This product does not contain chemicals listed under Proposition 65

WHMIS hazard class:
Non-controlled

This product has been classified according to the hazard criteria of the CPR and the MSDS contains all of the information required by the CPR

16. OTHER INFORMATION

This material is sold for research and development purposes only. It is not for any human or animal therapeutic or clinical diagnostic use. It is not intended for food, drug, household, agricultural, or cosmetic use. An individual technically qualified to handle potentially hazardous chemicals must supervise the use of this material.

The above information was acquired by diligent search and/or investigation and the recommendations are based on prudent application of professional judgment. The information shall not be taken as being all inclusive and is to be used only as a guide. All materials and mixtures may be present unknown hazards and should be used with caution. Since Invitrogen Corporation cannot control the actual methods, volumes, or conditions of use, the Company shall not be held liable for any damages or losses resulting from the handling or from contact with the product as described herein. THE INFORMATION IN THIS MSDS DOES NOT CONSTITUTE A WARRANTY, EXPRESS OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTCULAR PURPOSE.

End of Safety Data Sheet

invitrogen™

Material Safety Data Sheet

Revision Date: 22-Jan-2009

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product code	Q10001MP COMPONENT A
Product name	Qdot® 605 ITK™ streptavidin conjugate *2 µM solution*

Company/Undertaking Identification

INVITROGEN CORPORATON
5791 VAN ALLEN WAY
PO BOX 6482
CARLSBAD, CA 92008
760-603-7200

INVITROGEN CORPORATION
5250 MAINWAY DRIVE
BURLINGTON, ONT
CANADA L7L 6A4
800-263-6236

GIBCO PRODUCTS
INVITROGEN CORPORATION
3175 STALEY ROAD P.O. BOX 68
GRAND ISLAND, NY 14072
716-774-6700

2. COMPOSITION/INFORMATION ON INGREDIENTS

Hazardous/Non-hazardous Components
The product contains no substances which at their given concentration, are considered to be hazardous to health. We recommend handling all chemicals with caution.

3. HAZARDS IDENTIFICATION

Emergency Overview
The product contains no substances which at their given concentration, are considered to be hazardous to health

Form
Liquid

Principle Routes of Exposure/ Potential Health effects

Eyes	No information available
Skin	No information available

3. HAZARDS IDENTIFICATION

Inhalation No information available
Ingestion No information available

Specific effects

Carcinogenic effects No information available
Mutagenic effects No information available
Reproductive toxicity No information available
Sensitization No information available

Target Organ Effects No information available

HMIS

Health	0
Flammability	0
Reactivity	0

4. FIRST AID MEASURES

Skin contact Wash off immediately with plenty of water
Eye contact Rinse thoroughly with plenty of water, also under the eyelids.
Ingestion Never give anything by mouth to an unconscious person
Inhalation Move to fresh air
Notes to physician Treat symptomatically.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media Dry chemical
Special protective equipment for firefighters Wear self-contained breathing apparatus and protective suit

6. ACCIDENTAL RELEASE MEASURES

Personal precautions Use personal protective equipment
Methods for cleaning up Soak up with inert absorbent material.

7. HANDLING AND STORAGE

Handling No special handling advice required
Storage Keep in properly labelled containers

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Occupational exposure controls

Exposure limits
Engineering measures Ensure adequate ventilation, especially in confined areas

Personal protective equipment

Respiratory protection In case of insufficient ventilation wear suitable respiratory equipment
Hand protection Protective gloves
Eye protection Safety glasses with side-shields
Skin and body protection Lightweight protective clothing.

Hygiene measures	Handle in accordance with good industrial hygiene and safety practice
Environmental exposure controls	Prevent product from entering drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

General Information

Form	Liquid

Important Health Safety and Environmental Information

Boiling point/range	**°C** No data available	**°F** No data available
Melting point/range	**°C** No data available	**°F** No data available
Flash point	**°C** No data available	**°F** No data available
Autoignition temperature	**°C** No data available	**°F** No data available
Oxidizing properties	No information available	
Water solubility	No data available	

10. STABILITY AND REACTIVITY

Stability	Stable.
Materials to avoid	No information available
Hazardous decomposition products	No information available
Polymerization	Hazardous polymerisation does not occur.

11. TOXICOLOGICAL INFORMATION

Acute toxicity

Principle Routes of Exposure/ Potential Health effects

Eyes	No information available
Skin	No information available
Inhalation	No information available
Ingestion	No information available

Specific effects

Carcinogenic effects	No information available
Mutagenic effects	No information available
Reproductive toxicity	No information available
Sensitization	No information available

Target Organ Effects No information available

12. ECOLOGICAL INFORMATION

Ecotoxicity effects	No information available.
Mobility	No information available.
Biodegradation	Inherently biodegradable.
Bioaccumulation	Does not bioaccumulate.

13. DISPOSAL CONSIDERATIONS

13. DISPOSAL CONSIDERATIONS

Dispose of in accordance with local regulations

14. TRANSPORT INFORMATION

IATA

Proper shipping name	Not classified as dangerous in the meaning of transport regulations
Hazard Class	No information available
Subsidiary Class	No information available
Packing group	No information available
UN-No	No information available

15. REGULATORY INFORMATION

International Inventories

U.S. Federal Regulations

SARA 313
This product is not regulated by SARA.

Clean Air Act, Section 112 Hazardous Air Pollutants (HAPs) (see 40 CFR 61)
This product does not contains HAPs.

U.S. State Regulations

California Proposition 65
This product does not contain chemicals listed under Proposition 65

WHMIS hazard class:
Non-controlled

This product has been classified according to the hazard criteria of the CPR and the MSDS contains all of the information required by the CPR

16. OTHER INFORMATION

This material is sold for research and development purposes only. It is not for any human or animal therapeutic or clinical diagnostic use. It is not intended for food, drug, household, agricultural, or cosmetic use. An individual technically qualified to handle potentially hazardous chemicals must supervise the use of this material.

The above information was acquired by diligent search and/or investigation and the recommendations are based on prudent application of professional judgment. The information shall not be taken as being all inclusive and is to be used only as a guide. All materials and mixtures may be present unknown hazards and should be used with caution. Since Invitrogen Corporation cannot control the actual methods, volumes, or conditions of use, the Company shall not be held liable for any damages or losses resulting from the handling or from contact with the product as described herein. THE INFORMATION IN THIS MSDS DOES NOT CONSTITUTE A WARRANTY, EXPRESS OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTCULAR PURPOSE.

End of Safety Data Sheet

invitrogen™

Material Safety Data Sheet

Revision Date: 22-Jan-2009

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product code Q10001MP COMPONENT B
Product name Qdot® incubation buffer

Company/Undertaking Identification

INVITROGEN CORPORATON
5791 VAN ALLEN WAY
PO BOX 6482
CARLSBAD, CA 92008
760-603-7200

INVITROGEN CORPORATION
5250 MAINWAY DRIVE
BURLINGTON, ONT
CANADA L7L 6A4
800-263-6236

GIBCO PRODUCTS
INVITROGEN CORPORATION
3175 STALEY ROAD P.O. BOX 68
GRAND ISLAND, NY 14072
716-774-6700

2. COMPOSITION/INFORMATION ON INGREDIENTS

Hazardous/Non-hazardous Components
The product contains no substances which at their given concentration, are considered to be hazardous to health. We recommend handling all chemicals with caution.

3. HAZARDS IDENTIFICATION

Emergency Overview
The product contains no substances which at their given concentration, are considered to be hazardous to health

Form
Liquid

Principle Routes of Exposure/ Potential Health effects

Eyes No information available
Skin No information available

3. HAZARDS IDENTIFICATION

Inhalation No information available
Ingestion No information available

Specific effects

Carcinogenic effects No information available
Mutagenic effects No information available
Reproductive toxicity No information available
Sensitization No information available

Target Organ Effects No information available

HMIS

Health	0
Flammability	0
Reactivity	0

4. FIRST AID MEASURES

Skin contact Wash off immediately with plenty of water
Eye contact Rinse thoroughly with plenty of water, also under the eyelids.
Ingestion Never give anything by mouth to an unconscious person
Inhalation Move to fresh air
Notes to physician Treat symptomatically.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media Dry chemical
Special protective equipment for firefighters Wear self-contained breathing apparatus and protective suit

6. ACCIDENTAL RELEASE MEASURES

Personal precautions Use personal protective equipment
Methods for cleaning up Soak up with inert absorbent material.

7. HANDLING AND STORAGE

Handling No special handling advice required
Storage Keep in properly labelled containers

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Occupational exposure controls

Exposure limits
Engineering measures Ensure adequate ventilation, especially in confined areas

Personal protective equipment

Respiratory protection In case of insufficient ventilation wear suitable respiratory equipment
Hand protection Protective gloves
Eye protection Safety glasses with side-shields
Skin and body protection Lightweight protective clothing.

Hygiene measures	Handle in accordance with good industrial hygiene and safety practice
Environmental exposure controls	Prevent product from entering drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

General Information

Form	Liquid

Important Health Safety and Environmental Information

Boiling point/range	**°C** No data available	**°F** No data available
Melting point/range	**°C** No data available	**°F** No data available
Flash point	**°C** No data available	**°F** No data available
Autoignition temperature	**°C** No data available	**°F** No data available
Oxidizing properties	No information available	
Water solubility	No data available	

10. STABILITY AND REACTIVITY

Stability	Stable.
Materials to avoid	No information available
Hazardous decomposition products	No information available
Polymerization	Hazardous polymerisation does not occur.

11. TOXICOLOGICAL INFORMATION

Acute toxicity

Principle Routes of Exposure/ Potential Health effects

Eyes	No information available
Skin	No information available
Inhalation	No information available
Ingestion	No information available

Specific effects

Carcinogenic effects	No information available
Mutagenic effects	No information available
Reproductive toxicity	No information available
Sensitization	No information available

Target Organ Effects No information available

12. ECOLOGICAL INFORMATION

Ecotoxicity effects	No information available.
Mobility	No information available.
Biodegradation	Inherently biodegradable.
Bioaccumulation	Does not bioaccumulate.

13. DISPOSAL CONSIDERATIONS

13. DISPOSAL CONSIDERATIONS

Dispose of in accordance with local regulations

14. TRANSPORT INFORMATION

IATA

Proper shipping name	Not classified as dangerous in the meaning of transport regulations
Hazard Class	No information available
Subsidiary Class	No information available
Packing group	No information available
UN-No	No information available

15. REGULATORY INFORMATION

International Inventories

U.S. Federal Regulations

SARA 313
This product is not regulated by SARA.

Clean Air Act, Section 112 Hazardous Air Pollutants (HAPs) (see 40 CFR 61)
This product does not contains HAPs.

U.S. State Regulations

California Proposition 65
This product does not contain chemicals listed under Proposition 65

WHMIS hazard class:
Non-controlled

This product has been classified according to the hazard criteria of the CPR and the MSDS contains all of the information required by the CPR

16. OTHER INFORMATION

This material is sold for research and development purposes only. It is not for any human or animal therapeutic or clinical diagnostic use. It is not intended for food, drug, household, agricultural, or cosmetic use. An individual technically qualified to handle potentially hazardous chemicals must supervise the use of this material.

The above information was acquired by diligent search and/or investigation and the recommendations are based on prudent application of professional judgment. The information shall not be taken as being all inclusive and is to be used only as a guide. All materials and mixtures may be present unknown hazards and should be used with caution. Since Invitrogen Corporation cannot control the actual methods, volumes, or conditions of use, the Company shall not be held liable for any damages or losses resulting from the handling or from contact with the product as described herein. THE INFORMATION IN THIS MSDS DOES NOT CONSTITUTE A WARRANTY, EXPRESS OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTCULAR PURPOSE.

End of Safety Data Sheet

invitrogen™

Material Safety Data Sheet

Revision Date: 21-Jan-2009

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product code Q10101MP
Product name Qdot® 605 streptavidin conjugate

Company/Undertaking Identification

INVITROGEN CORPORATON
5791 VAN ALLEN WAY
PO BOX 6482
CARLSBAD, CA 92008
760-603-7200

INVITROGEN CORPORATION
5250 MAINWAY DRIVE
BURLINGTON, ONT
CANADA L7L 6A4
800-263-6236

GIBCO PRODUCTS
INVITROGEN CORPORATION
3175 STALEY ROAD P.O. BOX 68
GRAND ISLAND, NY 14072
716-774-6700

2. COMPOSITION/INFORMATION ON INGREDIENTS

Hazardous/Non-hazardous Components
The product contains no substances which at their given concentration, are considered to be hazardous to health. We recommend handling all chemicals with caution.

3. HAZARDS IDENTIFICATION

Emergency Overview
The product contains no substances which at their given concentration, are considered to be hazardous to health

Form
Liquid

Principle Routes of Exposure/ Potential Health effects

Eyes No information available
Skin No information available

3. HAZARDS IDENTIFICATION

Inhalation No information available
Ingestion No information available

Specific effects

Carcinogenic effects No information available
Mutagenic effects No information available
Reproductive toxicity No information available
Sensitization No information available

Target Organ Effects No information available

HMIS

Health	0
Flammability	0
Reactivity	0

4. FIRST AID MEASURES

Skin contact Wash off immediately with plenty of water
Eye contact Rinse thoroughly with plenty of water, also under the eyelids.
Ingestion Never give anything by mouth to an unconscious person
Inhalation Move to fresh air
Notes to physician Treat symptomatically.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media Dry chemical
Special protective equipment for firefighters Wear self-contained breathing apparatus and protective suit

6. ACCIDENTAL RELEASE MEASURES

Personal precautions Use personal protective equipment
Methods for cleaning up Soak up with inert absorbent material.

7. HANDLING AND STORAGE

Handling No special handling advice required
Storage Keep in properly labelled containers

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Occupational exposure controls

Exposure limits
Engineering measures Ensure adequate ventilation, especially in confined areas

Personal protective equipment

Respiratory protection In case of insufficient ventilation wear suitable respiratory equipment
Hand protection Protective gloves
Eye protection Safety glasses with side-shields
Skin and body protection Lightweight protective clothing.

Hygiene measures	Handle in accordance with good industrial hygiene and safety practice
Environmental exposure controls	Prevent product from entering drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

General Information

Form	Liquid

Important Health Safety and Environmental Information

Boiling point/range	**°C** No data available	**°F** No data available
Melting point/range	**°C** No data available	**°F** No data available
Flash point	**°C** No data available	**°F** No data available
Autoignition temperature	**°C** No data available	**°F** No data available
Oxidizing properties	No information available	
Water solubility	No data available	

10. STABILITY AND REACTIVITY

Stability	Stable.
Materials to avoid	No information available
Hazardous decomposition products	No information available
Polymerization	Hazardous polymerisation does not occur.

11. TOXICOLOGICAL INFORMATION

Acute toxicity

Principle Routes of Exposure/ Potential Health effects

Eyes	No information available
Skin	No information available
Inhalation	No information available
Ingestion	No information available

Specific effects

Carcinogenic effects	No information available
Mutagenic effects	No information available
Reproductive toxicity	No information available
Sensitization	No information available

Target Organ Effects No information available

12. ECOLOGICAL INFORMATION

Ecotoxicity effects	No information available.
Mobility	No information available.
Biodegradation	Inherently biodegradable.
Bioaccumulation	Does not bioaccumulate.

13. DISPOSAL CONSIDERATIONS

13. DISPOSAL CONSIDERATIONS

Dispose of in accordance with local regulations

14. TRANSPORT INFORMATION

IATA

Proper shipping name	Not classified as dangerous in the meaning of transport regulations
Hazard Class	No information available
Subsidiary Class	No information available
Packing group	No information available
UN-No	No information available

15. REGULATORY INFORMATION

International Inventories

U.S. Federal Regulations

SARA 313
This product is not regulated by SARA.

Clean Air Act, Section 112 Hazardous Air Pollutants (HAPs) (see 40 CFR 61)
This product does not contains HAPs.

U.S. State Regulations

California Proposition 65
This product does not contain chemicals listed under Proposition 65

WHMIS hazard class:
Non-controlled

This product has been classified according to the hazard criteria of the CPR and the MSDS contains all of the information required by the CPR

16. OTHER INFORMATION

This material is sold for research and development purposes only. It is not for any human or animal therapeutic or clinical diagnostic use. It is not intended for food, drug, household, agricultural, or cosmetic use. An individual technically qualified to handle potentially hazardous chemicals must supervise the use of this material.

The above information was acquired by diligent search and/or investigation and the recommendations are based on prudent application of professional judgment. The information shall not be taken as being all inclusive and is to be used only as a guide. All materials and mixtures may be present unknown hazards and should be used with caution. Since Invitrogen Corporation cannot control the actual methods, volumes, or conditions of use, the Company shall not be held liable for any damages or losses resulting from the handling or from contact with the product as described herein. THE INFORMATION IN THIS MSDS DOES NOT CONSTITUTE A WARRANTY, EXPRESS OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTCULAR PURPOSE.

End of Safety Data Sheet

invitrogen™

Material Safety Data Sheet

Revision Date: 21-Jan-2009

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product code Q10121MP
Product name Qdot® 655 streptavidin conjugate

Company/Undertaking Identification

INVITROGEN CORPORATON
5791 VAN ALLEN WAY
PO BOX 6482
CARLSBAD, CA 92008
760-603-7200

INVITROGEN CORPORATION
5250 MAINWAY DRIVE
BURLINGTON, ONT
CANADA L7L 6A4
800-263-6236

GIBCO PRODUCTS
INVITROGEN CORPORATION
3175 STALEY ROAD P.O. BOX 68
GRAND ISLAND, NY 14072
716-774-6700

2. COMPOSITION/INFORMATION ON INGREDIENTS

Hazardous/Non-hazardous Components
The product contains no substances which at their given concentration, are considered to be hazardous to health. We recommend handling all chemicals with caution.

3. HAZARDS IDENTIFICATION

Emergency Overview
The product contains no substances which at their given concentration, are considered to be hazardous to health

Form
Liquid

Principle Routes of Exposure/ Potential Health effects

Eyes No information available
Skin No information available

3. HAZARDS IDENTIFICATION

Inhalation No information available
Ingestion No information available

Specific effects

Carcinogenic effects No information available
Mutagenic effects No information available
Reproductive toxicity No information available
Sensitization No information available

Target Organ Effects No information available

HMIS

Health	0
Flammability	0
Reactivity	0

4. FIRST AID MEASURES

Skin contact Wash off immediately with plenty of water
Eye contact Rinse thoroughly with plenty of water, also under the eyelids.
Ingestion Never give anything by mouth to an unconscious person
Inhalation Move to fresh air
Notes to physician Treat symptomatically.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media Dry chemical
Special protective equipment for firefighters Wear self-contained breathing apparatus and protective suit

6. ACCIDENTAL RELEASE MEASURES

Personal precautions Use personal protective equipment
Methods for cleaning up Soak up with inert absorbent material.

7. HANDLING AND STORAGE

Handling No special handling advice required
Storage Keep in properly labelled containers

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Occupational exposure controls

Exposure limits
Engineering measures Ensure adequate ventilation, especially in confined areas

Personal protective equipment

Respiratory protection In case of insufficient ventilation wear suitable respiratory equipment
Hand protection Protective gloves
Eye protection Safety glasses with side-shields
Skin and body protection Lightweight protective clothing.

Hygiene measures	Handle in accordance with good industrial hygiene and safety practice
Environmental exposure controls	Prevent product from entering drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

General Information

Form	Liquid

Important Health Safety and Environmental Information

Boiling point/range	**°C** No data available	**°F** No data available
Melting point/range	**°C** No data available	**°F** No data available
Flash point	**°C** No data available	**°F** No data available
Autoignition temperature	**°C** No data available	**°F** No data available
Oxidizing properties	No information available	
Water solubility	No data available	

10. STABILITY AND REACTIVITY

Stability	Stable.
Materials to avoid	No information available
Hazardous decomposition products	No information available
Polymerization	Hazardous polymerisation does not occur.

11. TOXICOLOGICAL INFORMATION

Acute toxicity

Principle Routes of Exposure/ Potential Health effects

Eyes	No information available
Skin	No information available
Inhalation	No information available
Ingestion	No information available

Specific effects

Carcinogenic effects	No information available
Mutagenic effects	No information available
Reproductive toxicity	No information available
Sensitization	No information available

Target Organ Effects No information available

12. ECOLOGICAL INFORMATION

Ecotoxicity effects	No information available.
Mobility	No information available.
Biodegradation	Inherently biodegradable.
Bioaccumulation	Does not bioaccumulate.

13. DISPOSAL CONSIDERATIONS

13. DISPOSAL CONSIDERATIONS

Dispose of in accordance with local regulations

14. TRANSPORT INFORMATION

IATA

Proper shipping name	Not classified as dangerous in the meaning of transport regulations
Hazard Class	No information available
Subsidiary Class	No information available
Packing group	No information available
UN-No	No information available

15. REGULATORY INFORMATION

International Inventories

U.S. Federal Regulations

SARA 313
This product is not regulated by SARA.

Clean Air Act, Section 112 Hazardous Air Pollutants (HAPs) (see 40 CFR 61)
This product does not contains HAPs.

U.S. State Regulations

California Proposition 65
This product does not contain chemicals listed under Proposition 65

WHMIS hazard class:
Non-controlled

This product has been classified according to the hazard criteria of the CPR and the MSDS contains all of the information required by the CPR

16. OTHER INFORMATION

This material is sold for research and development purposes only. It is not for any human or animal therapeutic or clinical diagnostic use. It is not intended for food, drug, household, agricultural, or cosmetic use. An individual technically qualified to handle potentially hazardous chemicals must supervise the use of this material.

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End of Safety Data Sheet

invitrogen™

Material Safety Data Sheet

Revision Date: 21-Jan-2009

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product code Q10131MP
Product name Qdot® 565 streptavidin conjugate

Company/Undertaking Identification

INVITROGEN CORPORATON
5791 VAN ALLEN WAY
PO BOX 6482
CARLSBAD, CA 92008
760-603-7200

INVITROGEN CORPORATION
5250 MAINWAY DRIVE
BURLINGTON, ONT
CANADA L7L 6A4
800-263-6236

GIBCO PRODUCTS
INVITROGEN CORPORATION
3175 STALEY ROAD P.O. BOX 68
GRAND ISLAND, NY 14072
716-774-6700

2. COMPOSITION/INFORMATION ON INGREDIENTS

Hazardous/Non-hazardous Components
The product contains no substances which at their given concentration, are considered to be hazardous to health. We recommend handling all chemicals with caution.

3. HAZARDS IDENTIFICATION

Emergency Overview
The product contains no substances which at their given concentration, are considered to be hazardous to health

Form
Liquid

Principle Routes of Exposure/ Potential Health effects

Eyes No information available
Skin No information available

3. HAZARDS IDENTIFICATION

Inhalation No information available
Ingestion No information available

Specific effects

Carcinogenic effects No information available
Mutagenic effects No information available
Reproductive toxicity No information available
Sensitization No information available

Target Organ Effects No information available

HMIS

Health	0
Flammability	0
Reactivity	0

4. FIRST AID MEASURES

Skin contact Wash off immediately with plenty of water
Eye contact Rinse thoroughly with plenty of water, also under the eyelids.
Ingestion Never give anything by mouth to an unconscious person
Inhalation Move to fresh air
Notes to physician Treat symptomatically.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media Dry chemical
Special protective equipment for firefighters Wear self-contained breathing apparatus and protective suit

6. ACCIDENTAL RELEASE MEASURES

Personal precautions Use personal protective equipment
Methods for cleaning up Soak up with inert absorbent material.

7. HANDLING AND STORAGE

Handling No special handling advice required
Storage Keep in properly labelled containers

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Occupational exposure controls

Exposure limits
Engineering measures Ensure adequate ventilation, especially in confined areas

Personal protective equipment

Respiratory protection In case of insufficient ventilation wear suitable respiratory equipment
Hand protection Protective gloves
Eye protection Safety glasses with side-shields
Skin and body protection Lightweight protective clothing.

Hygiene measures	Handle in accordance with good industrial hygiene and safety practice
Environmental exposure controls	Prevent product from entering drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

General Information

Form	Liquid

Important Health Safety and Environmental Information

Boiling point/range	**°C** No data available	**°F** No data available
Melting point/range	**°C** No data available	**°F** No data available
Flash point	**°C** No data available	**°F** No data available
Autoignition temperature	**°C** No data available	**°F** No data available
Oxidizing properties	No information available	
Water solubility	No data available	

10. STABILITY AND REACTIVITY

Stability	Stable.
Materials to avoid	No information available
Hazardous decomposition products	No information available
Polymerization	Hazardous polymerisation does not occur.

11. TOXICOLOGICAL INFORMATION

Acute toxicity

Principle Routes of Exposure/ Potential Health effects

Eyes	No information available
Skin	No information available
Inhalation	No information available
Ingestion	No information available

Specific effects

Carcinogenic effects	No information available
Mutagenic effects	No information available
Reproductive toxicity	No information available
Sensitization	No information available

Target Organ Effects No information available

12. ECOLOGICAL INFORMATION

Ecotoxicity effects	No information available.
Mobility	No information available.
Biodegradation	Inherently biodegradable.
Bioaccumulation	Does not bioaccumulate.

13. DISPOSAL CONSIDERATIONS

13. DISPOSAL CONSIDERATIONS

Dispose of in accordance with local regulations

14. TRANSPORT INFORMATION

IATA

Proper shipping name	Not classified as dangerous in the meaning of transport regulations
Hazard Class	No information available
Subsidiary Class	No information available
Packing group	No information available
UN-No	No information available

15. REGULATORY INFORMATION

International Inventories

U.S. Federal Regulations

SARA 313
This product is not regulated by SARA.

Clean Air Act, Section 112 Hazardous Air Pollutants (HAPs) (see 40 CFR 61)
This product does not contains HAPs.

U.S. State Regulations

California Proposition 65
This product does not contain chemicals listed under Proposition 65

WHMIS hazard class:
Non-controlled

This product has been classified according to the hazard criteria of the CPR and the MSDS contains all of the information required by the CPR

16. OTHER INFORMATION

This material is sold for research and development purposes only. It is not for any human or animal therapeutic or clinical diagnostic use. It is not intended for food, drug, household, agricultural, or cosmetic use. An individual technically qualified to handle potentially hazardous chemicals must supervise the use of this material.

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End of Safety Data Sheet

invitrogen™

Material Safety Data Sheet

Revision Date: 21-Jan-2009

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product code Q10141MP
Product name Qdot® 525 streptavidin conjugate

Company/Undertaking Identification

INVITROGEN CORPORATON
5791 VAN ALLEN WAY
PO BOX 6482
CARLSBAD, CA 92008
760-603-7200

INVITROGEN CORPORATION
5250 MAINWAY DRIVE
BURLINGTON, ONT
CANADA L7L 6A4
800-263-6236

GIBCO PRODUCTS
INVITROGEN CORPORATION
3175 STALEY ROAD P.O. BOX 68
GRAND ISLAND, NY 14072
716-774-6700

2. COMPOSITION/INFORMATION ON INGREDIENTS

Hazardous/Non-hazardous Components
The product contains no substances which at their given concentration, are considered to be hazardous to health. We recommend handling all chemicals with caution.

3. HAZARDS IDENTIFICATION

Emergency Overview
The product contains no substances which at their given concentration, are considered to be hazardous to health

Form
Liquid

Principle Routes of Exposure/ Potential Health effects

Eyes No information available
Skin No information available

3. HAZARDS IDENTIFICATION

Inhalation No information available
Ingestion No information available

Specific effects

Carcinogenic effects No information available
Mutagenic effects No information available
Reproductive toxicity No information available
Sensitization No information available

Target Organ Effects No information available

HMIS

Health	0
Flammability	0
Reactivity	0

4. FIRST AID MEASURES

Skin contact Wash off immediately with plenty of water
Eye contact Rinse thoroughly with plenty of water, also under the eyelids.
Ingestion Never give anything by mouth to an unconscious person
Inhalation Move to fresh air
Notes to physician Treat symptomatically.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media Dry chemical
Special protective equipment for firefighters Wear self-contained breathing apparatus and protective suit

6. ACCIDENTAL RELEASE MEASURES

Personal precautions Use personal protective equipment
Methods for cleaning up Soak up with inert absorbent material.

7. HANDLING AND STORAGE

Handling No special handling advice required
Storage Keep in properly labelled containers

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Occupational exposure controls

Exposure limits
Engineering measures Ensure adequate ventilation, especially in confined areas

Personal protective equipment

Respiratory protection In case of insufficient ventilation wear suitable respiratory equipment
Hand protection Protective gloves
Eye protection Safety glasses with side-shields
Skin and body protection Lightweight protective clothing.

Hygiene measures	Handle in accordance with good industrial hygiene and safety practice
Environmental exposure controls	Prevent product from entering drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

General Information

Form	Liquid

Important Health Safety and Environmental Information

Boiling point/range	**°C** No data available	**°F** No data available
Melting point/range	**°C** No data available	**°F** No data available
Flash point	**°C** No data available	**°F** No data available
Autoignition temperature	**°C** No data available	**°F** No data available
Oxidizing properties	No information available	
Water solubility	No data available	

10. STABILITY AND REACTIVITY

Stability	Stable.
Materials to avoid	No information available
Hazardous decomposition products	No information available
Polymerization	Hazardous polymerisation does not occur.

11. TOXICOLOGICAL INFORMATION

Acute toxicity

Principle Routes of Exposure/ Potential Health effects

Eyes	No information available
Skin	No information available
Inhalation	No information available
Ingestion	No information available

Specific effects

Carcinogenic effects	No information available
Mutagenic effects	No information available
Reproductive toxicity	No information available
Sensitization	No information available

Target Organ Effects No information available

12. ECOLOGICAL INFORMATION

Ecotoxicity effects	No information available.
Mobility	No information available.
Biodegradation	Inherently biodegradable.
Bioaccumulation	Does not bioaccumulate.

13. DISPOSAL CONSIDERATIONS

13. DISPOSAL CONSIDERATIONS

Dispose of in accordance with local regulations

14. TRANSPORT INFORMATION

IATA

Proper shipping name	Not classified as dangerous in the meaning of transport regulations
Hazard Class	No information available
Subsidiary Class	No information available
Packing group	No information available
UN-No	No information available

15. REGULATORY INFORMATION

International Inventories

U.S. Federal Regulations

SARA 313
This product is not regulated by SARA.

Clean Air Act, Section 112 Hazardous Air Pollutants (HAPs) (see 40 CFR 61)
This product does not contains HAPs.

U.S. State Regulations

California Proposition 65
This product does not contain chemicals listed under Proposition 65

WHMIS hazard class:
Non-controlled

This product has been classified according to the hazard criteria of the CPR and the MSDS contains all of the information required by the CPR

16. OTHER INFORMATION

This material is sold for research and development purposes only. It is not for any human or animal therapeutic or clinical diagnostic use. It is not intended for food, drug, household, agricultural, or cosmetic use. An individual technically qualified to handle potentially hazardous chemicals must supervise the use of this material.

The above information was acquired by diligent search and/or investigation and the recommendations are based on prudent application of professional judgment. The information shall not be taken as being all inclusive and is to be used only as a guide. All materials and mixtures may be present unknown hazards and should be used with caution. Since Invitrogen Corporation cannot control the actual methods, volumes, or conditions of use, the Company shall not be held liable for any damages or losses resulting from the handling or from contact with the product as described herein. THE INFORMATION IN THIS MSDS DOES NOT CONSTITUTE A WARRANTY, EXPRESS OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTCULAR PURPOSE.

End of Safety Data Sheet

invitrogen™

Material Safety Data Sheet

Revision Date: 22-Jan-2009

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product code	Q10321MP COMPONENT A
Product name	Qdot® 655 biotin conjugate *2 µM solution*

Company/Undertaking Identification

INVITROGEN CORPORATON
5791 VAN ALLEN WAY
PO BOX 6482
CARLSBAD, CA 92008
760-603-7200

INVITROGEN CORPORATION
5250 MAINWAY DRIVE
BURLINGTON, ONT
CANADA L7L 6A4
800-263-6236

GIBCO PRODUCTS
INVITROGEN CORPORATION
3175 STALEY ROAD P.O. BOX 68
GRAND ISLAND, NY 14072
716-774-6700

2. COMPOSITION/INFORMATION ON INGREDIENTS

Hazardous/Non-hazardous Components
The product contains no substances which at their given concentration, are considered to be hazardous to health. We recommend handling all chemicals with caution.

3. HAZARDS IDENTIFICATION

Emergency Overview
The product contains no substances which at their given concentration, are considered to be hazardous to health

Form
Liquid

Principle Routes of Exposure/ Potential Health effects

Eyes	No information available
Skin	No information available

3. HAZARDS IDENTIFICATION

Inhalation No information available
Ingestion No information available

Specific effects

Carcinogenic effects No information available
Mutagenic effects No information available
Reproductive toxicity No information available
Sensitization No information available

Target Organ Effects No information available

HMIS

Health	0
Flammability	0
Reactivity	0

4. FIRST AID MEASURES

Skin contact Wash off immediately with plenty of water
Eye contact Rinse thoroughly with plenty of water, also under the eyelids.
Ingestion Never give anything by mouth to an unconscious person
Inhalation Move to fresh air
Notes to physician Treat symptomatically.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media Dry chemical
Special protective equipment for firefighters Wear self-contained breathing apparatus and protective suit

6. ACCIDENTAL RELEASE MEASURES

Personal precautions Use personal protective equipment
Methods for cleaning up Soak up with inert absorbent material.

7. HANDLING AND STORAGE

Handling No special handling advice required
Storage Keep in properly labelled containers

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Occupational exposure controls

Exposure limits
Engineering measures Ensure adequate ventilation, especially in confined areas

Personal protective equipment

Respiratory protection In case of insufficient ventilation wear suitable respiratory equipment
Hand protection Protective gloves
Eye protection Safety glasses with side-shields
Skin and body protection Lightweight protective clothing.

Hygiene measures	Handle in accordance with good industrial hygiene and safety practice
Environmental exposure controls	Prevent product from entering drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

General Information

Form	Liquid

Important Health Safety and Environmental Information

Boiling point/range	**°C** No data available	**°F** No data available
Melting point/range	**°C** No data available	**°F** No data available
Flash point	**°C** No data available	**°F** No data available
Autoignition temperature	**°C** No data available	**°F** No data available
Oxidizing properties	No information available	
Water solubility	No data available	

10. STABILITY AND REACTIVITY

Stability	Stable.
Materials to avoid	No information available
Hazardous decomposition products	No information available
Polymerization	Hazardous polymerisation does not occur.

11. TOXICOLOGICAL INFORMATION

Acute toxicity

Principle Routes of Exposure/ Potential Health effects

Eyes	No information available
Skin	No information available
Inhalation	No information available
Ingestion	No information available

Specific effects

Carcinogenic effects	No information available
Mutagenic effects	No information available
Reproductive toxicity	No information available
Sensitization	No information available

Target Organ Effects No information available

12. ECOLOGICAL INFORMATION

Ecotoxicity effects	No information available.
Mobility	No information available.
Biodegradation	Inherently biodegradable.
Bioaccumulation	Does not bioaccumulate.

13. DISPOSAL CONSIDERATIONS

13. DISPOSAL CONSIDERATIONS

Dispose of in accordance with local regulations

14. TRANSPORT INFORMATION

IATA

Proper shipping name	Not classified as dangerous in the meaning of transport regulations
Hazard Class	No information available
Subsidiary Class	No information available
Packing group	No information available
UN-No	No information available

15. REGULATORY INFORMATION

International Inventories

U.S. Federal Regulations

SARA 313
This product is not regulated by SARA.

Clean Air Act, Section 112 Hazardous Air Pollutants (HAPs) (see 40 CFR 61)
This product does not contains HAPs.

U.S. State Regulations

California Proposition 65
This product does not contain chemicals listed under Proposition 65

WHMIS hazard class:
Non-controlled

This product has been classified according to the hazard criteria of the CPR and the MSDS contains all of the information required by the CPR

16. OTHER INFORMATION

This material is sold for research and development purposes only. It is not for any human or animal therapeutic or clinical diagnostic use. It is not intended for food, drug, household, agricultural, or cosmetic use. An individual technically qualified to handle potentially hazardous chemicals must supervise the use of this material.

The above information was acquired by diligent search and/or investigation and the recommendations are based on prudent application of professional judgment. The information shall not be taken as being all inclusive and is to be used only as a guide. All materials and mixtures may be present unknown hazards and should be used with caution. Since Invitrogen Corporation cannot control the actual methods, volumes, or conditions of use, the Company shall not be held liable for any damages or losses resulting from the handling or from contact with the product as described herein. THE INFORMATION IN THIS MSDS DOES NOT CONSTITUTE A WARRANTY, EXPRESS OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTCULAR PURPOSE.

End of Safety Data Sheet

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product code Q21341MP
Product name Qdot® 525 ITK™ carboxyl quantum dots *8 µM solution*

Company/Undertaking Identification

INVITROGEN CORPORATON
5791 VAN ALLEN WAY
PO BOX 6482
CARLSBAD, CA 92008
760-603-7200

INVITROGEN CORPORATION
5250 MAINWAY DRIVE
BURLINGTON, ONT
CANADA L7L 6A4
800-263-6236

GIBCO PRODUCTS
INVITROGEN CORPORATION
3175 STALEY ROAD P.O. BOX 68
GRAND ISLAND, NY 14072
716-774-6700

2. COMPOSITION/INFORMATION ON INGREDIENTS

Hazardous/Non-hazardous Components
The product contains no substances which at their given concentration, are considered to be hazardous to health. We recommend handling all chemicals with caution.

3. HAZARDS IDENTIFICATION

Emergency Overview
The product contains no substances which at their given concentration, are considered to be hazardous to health

Form
Liquid

Principle Routes of Exposure/ Potential Health effects

Eyes No information available
Skin No information available

3. HAZARDS IDENTIFICATION

Inhalation No information available
Ingestion No information available

Specific effects

Carcinogenic effects No information available
Mutagenic effects No information available
Reproductive toxicity No information available
Sensitization No information available

Target Organ Effects No information available

HMIS

Health	0
Flammability	0
Reactivity	0

4. FIRST AID MEASURES

Skin contact Wash off immediately with plenty of water
Eye contact Rinse thoroughly with plenty of water, also under the eyelids.
Ingestion Never give anything by mouth to an unconscious person
Inhalation Move to fresh air
Notes to physician Treat symptomatically.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media Dry chemical
Special protective equipment for firefighters Wear self-contained breathing apparatus and protective suit

6. ACCIDENTAL RELEASE MEASURES

Personal precautions Use personal protective equipment
Methods for cleaning up Soak up with inert absorbent material.

7. HANDLING AND STORAGE

Handling No special handling advice required
Storage Keep in properly labelled containers

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Occupational exposure controls

Exposure limits
Engineering measures Ensure adequate ventilation, especially in confined areas

Personal protective equipment

Respiratory protection In case of insufficient ventilation wear suitable respiratory equipment
Hand protection Protective gloves
Eye protection Safety glasses with side-shields
Skin and body protection Lightweight protective clothing.

Hygiene measures	Handle in accordance with good industrial hygiene and safety practice
Environmental exposure controls	Prevent product from entering drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

General Information

Form	Liquid

Important Health Safety and Environmental Information

Boiling point/range	**°C** No data available	**°F** No data available
Melting point/range	**°C** No data available	**°F** No data available
Flash point	**°C** No data available	**°F** No data available
Autoignition temperature	**°C** No data available	**°F** No data available
Oxidizing properties	No information available	
Water solubility	No data available	

10. STABILITY AND REACTIVITY

Stability	Stable.
Materials to avoid	No information available
Hazardous decomposition products	No information available
Polymerization	Hazardous polymerisation does not occur.

11. TOXICOLOGICAL INFORMATION

Acute toxicity

Principle Routes of Exposure/ Potential Health effects

Eyes	No information available
Skin	No information available
Inhalation	No information available
Ingestion	No information available

Specific effects

Carcinogenic effects	No information available
Mutagenic effects	No information available
Reproductive toxicity	No information available
Sensitization	No information available

Target Organ Effects No information available

12. ECOLOGICAL INFORMATION

Ecotoxicity effects	No information available.
Mobility	No information available.
Biodegradation	Inherently biodegradable.
Bioaccumulation	Does not bioaccumulate.

13. DISPOSAL CONSIDERATIONS

13. DISPOSAL CONSIDERATIONS

Dispose of in accordance with local regulations

14. TRANSPORT INFORMATION

IATA

Proper shipping name	Not classified as dangerous in the meaning of transport regulations
Hazard Class	No information available
Subsidiary Class	No information available
Packing group	No information available
UN-No	No information available

15. REGULATORY INFORMATION

International Inventories

U.S. Federal Regulations

SARA 313
This product is not regulated by SARA.

Clean Air Act, Section 112 Hazardous Air Pollutants (HAPs) (see 40 CFR 61)
This product does not contains HAPs.

U.S. State Regulations

California Proposition 65
This product does not contain chemicals listed under Proposition 65

WHMIS hazard class:
Non-controlled

This product has been classified according to the hazard criteria of the CPR and the MSDS contains all of the information required by the CPR

16. OTHER INFORMATION

This material is sold for research and development purposes only. It is not for any human or animal therapeutic or clinical diagnostic use. It is not intended for food, drug, household, agricultural, or cosmetic use. An individual technically qualified to handle potentially hazardous chemicals must supervise the use of this material.

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End of Safety Data Sheet

invitrogen™

Material Safety Data Sheet

Revision Date: 11-Dec-2007

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product code Q21371MP
Product name Qdot® 800 ITK™ carboxyl quantum dots

Company/Undertaking Identification

INVITROGEN CORPORATON
1600 FARADAY AVENUE
PO BOX 6482
CARLSBAD, CA 92008
760-603-7200

INVITROGEN CORPORATION
2270 INDUSTRIAL STREET
BURLINGTON, ONT
CANADA L7P 1A1
800-263-6236

GIBCO PRODUCTS
INVITROGEN CORPORATION
3175 STALEY ROAD P.O. BOX 68
GRAND ISLAND, NY 14072
716-774-6700

2. COMPOSITION/INFORMATION ON INGREDIENTS

Hazardous/Non-hazardous Components
The product contains no substances which at their given concentration, are considered to be hazardous to health

3. HAZARDS IDENTIFICATION

Emergency Overview
The product contains no substances which at their given concentration, are considered to be hazardous to health

Form
Liquid

Principle Routes of Exposure/ Potential Health effects

Eyes No information available
Skin No information available
Inhalation No information available

3. HAZARDS IDENTIFICATION

Ingestion No information available

Specific effects

Carcinogenic effects No information available
Mutagenic effects No information available
Reproductive toxicity No information available
Sensitization No information available

Target Organ Effects No information available

HMIS

Health	0
Flammability	0
Reactivity	0

4. FIRST AID MEASURES

Skin contact Wash off immediately with plenty of water
Eye contact Rinse thoroughly with plenty of water, also under the eyelids.
Ingestion Never give anything by mouth to an unconscious person
Inhalation Move to fresh air
Notes to physician Treat symptomatically.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media Dry chemical
Special protective equipment for firefighters Wear self-contained breathing apparatus and protective suit

6. ACCIDENTAL RELEASE MEASURES

Personal precautions Use personal protective equipment
Methods for cleaning up Soak up with inert absorbent material.

7. HANDLING AND STORAGE

Handling No special handling advice required
Storage Keep in properly labelled containers

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Occupational exposure controls

Exposure limits
Engineering measures Ensure adequate ventilation, especially in confined areas

Personal protective equipment

Respiratory protection In case of insufficient ventilation wear suitable respiratory equipment
Hand protection Protective gloves
Eye protection Safety glasses with side-shields
Skin and body protection Lightweight protective clothing.
Hygiene measures Handle in accordance with good industrial hygiene and safety practice

Environmental exposure controls	Prevent product from entering drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

General Information

Form	Liquid

Important Health Safety and Environmental Information

Boiling point/range	**°C** No data available	**°F** No data available
Melting point/range	**°C** No data available	**°F** No data available
Flash point	**°C** No data available	**°F** No data available
Autoignition temperature	**°C** No data available	**°F** No data available
Oxidizing properties	No information available	
Water solubility	No data available	

10. STABILITY AND REACTIVITY

Stability	Stable.
Materials to avoid	No information available
Hazardous decomposition products	No information available
Polymerization	Hazardous polymerisation does not occur.

11. TOXICOLOGICAL INFORMATION

Acute toxicity

Principle Routes of Exposure/ Potential Health effects

Eyes	No information available
Skin	No information available
Inhalation	No information available
Ingestion	No information available

Specific effects

Carcinogenic effects	No information available
Mutagenic effects	No information available
Reproductive toxicity	No information available
Sensitization	No information available

Target Organ Effects No information available

12. ECOLOGICAL INFORMATION

Ecotoxicity effects	No information available.
Mobility	No information available.
Biodegradation	Inherently biodegradable.
Bioaccumulation	Does not bioaccumulate.

13. DISPOSAL CONSIDERATIONS

Dispose of in accordance with local regulations

14. TRANSPORT INFORMATION

IATA

Proper shipping name	Not classified as dangerous in the meaning of transport regulations
Hazard Class	No information available
Subsidiary Class	No information available
Packing group	No information available
UN-No	No information available

15. REGULATORY INFORMATION

International Inventories

U.S. Federal Regulations

SARA 313
This product is not regulated by SARA.

Clean Air Act, Section 112 Hazardous Air Pollutants (HAPs) (see 40 CFR 61)
This product does not contains HAPs.

U.S. State Regulations

California Proposition 65
This product does not contain chemicals listed under Proposition 65

WHMIS hazard class:
Non-controlled

This product has been classified according to the hazard criteria of the CPR and the MSDS contains all of the information required by the CPR

16. OTHER INFORMATION

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End of Safety Data Sheet

Molecular Probes™
invitrogen detection technologies

Material Safety Data Sheet

Revision Date: 19-Oct-2005

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product code Q21701MP
Product name Qdot® 605 ITK™ organic quantum dots

Company/Undertaking Identification

MOLECULAR PROBES, INC.
29851 Willow Creek Road
Eugene, OR 97402
U.S.A.
541-465-8300

2. COMPOSITION/INFORMATION ON INGREDIENTS

Hazardous/Non-hazardous Components

Chemical Name	CAS-No	Weight %
Decane	124-18-5	>99.9

3. HAZARDS IDENTIFICATION

Emergency Overview
Flammable. Irritating to eyes. Irritating to skin.

Form
Liquid

Principle Routes of Exposure/ Potential Health effects

Eyes May cause eye irritation with susceptible persons.
Skin May cause skin irritation in susceptible persons.
Inhalation No information available
Ingestion No information available

Specific effects

Carcinogenic effects No information available
Mutagenic effects No information available
Reproductive toxicity No information available
Sensitization No information available

Target Organ Effects Eyes. Skin.

4. FIRST AID MEASURES

Skin contact	Wash off immediately with plenty of water
Eye contact	Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes
Ingestion	Never give anything by mouth to an unconscious person
Inhalation	Move to fresh air
Notes to physician	Treat symptomatically

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media	Dry chemical
Special protective equipment for firefighters	Wear self-contained breathing apparatus and protective suit

6. ACCIDENTAL RELEASE MEASURES

Personal precautions	Use personal protective equipment
Methods for cleaning up	Soak up with inert absorbent material

7. HANDLING AND STORAGE

Handling	Avoid contact with skin and eyes.
Storage	Keep away from heat and sources of ignition.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Occupational exposure controls

Exposure limits

Chemical Name	OSHA PEL (TWA)	OSHA PEL (Ceiling)	ACGIH OEL (TWA)	ACGIH OEL (STEL)
Decane	-	-	-	-

Engineering measures	Ensure adequate ventilation, especially in confined areas

Personal protective equipment

Respiratory protection	In case of insufficient ventilation wear suitable respiratory equipment
Hand protection	Protective gloves
Eye protection	Safety glasses with side-shields
Skin and body protection	Lightweight protective clothing
Hygiene measures	Handle in accordance with good industrial hygiene and safety practice
Environmental exposure controls	Prevent product from entering drains

9. PHYSICAL AND CHEMICAL PROPERTIES

General Information

Form	Liquid

Important Health Safety and Environmental Information

Boiling point/range	**°C** No data available	**°F** No data available
Melting point/range	**°C** No data available	**°F** No data available
Flash point	**°C** No data available	**°F** No data available
Autoignition temperature	**°C** No data available	**°F** No data available
Oxidizing properties	No information available	
Water solubility	No data available	

10. STABILITY AND REACTIVITY

Stability Stable under normal conditions.
Materials to avoid No information available
Hazardous decomposition products No information available
Polymerization Hazardous polymerisation does not occur

11. TOXICOLOGICAL INFORMATION

Acute toxicity

Chemical Name	LD50 (oral,rat/mouse)	LD50 (dermal,rat/rabbit)	LC50 (inhalation,rat/mouse)
Decane	No data available	No data available	72300 mg/m³ (Mouse)

Principle Routes of Exposure/ Potential Health effects

Eyes May cause eye irritation with susceptible persons.
Skin May cause skin irritation in susceptible persons.
Inhalation No information available
Ingestion No information available

Specific effects

Carcinogenic effects No information available
Mutagenic effects No information available
Reproductive toxicity No information available
Sensitization No information available

Target Organ Effects Eyes. Skin.

12. ECOLOGICAL INFORMATION

Ecotoxicity effects No information available.
Mobility No information available.
Biodegradation No information available.
Bioaccumulation No information available.

13. DISPOSAL CONSIDERATIONS

Dispose of in accordance with local regulations

14. TRANSPORT INFORMATION

IATA

Proper shipping name Flammable liquid, n.o.s (decane solution)
Hazard Class 3
Subsidiary Class No information available
Packing group III
UN-No UN1993

15. REGULATORY INFORMATION

International Inventories

Chemical Name	TSCA	PICCS	ENCS	DSL	NDSL	AICS
Decane	Listed	Listed	Listed	Listed	-	Listed

U.S. Federal Regulations

SARA 313
Not regulated

Clean Air Act, Section 112 Hazardous Air Pollutants (HAPs) (see 40 CFR 61)
This product contains the following HAPs:

U.S. State Regulations

Chemical Name	Massachusetts - RTK	New Jersey - RTK	Pennsylvania - RTK	Illinois - RTK	Rhode Island - RTK
Decane	-	Listed	Listed	-	Listed

California Proposition 65
This product contains the following Proposition 65 chemicals:

WHMIS hazard class:
Not determined

This product has been classified according to the hazard criteria of the CPR and the MSDS contains all of the information required by the CPR

16. OTHER INFORMATION

This material is sold for research and development purposes only. It is not for any human or animal therapeutic or clinical diagnostic use. It is not intended for food, drug, household, agricultural, or cosmetic use. An individual technically qualified to handle potentially hazardous chemicals must supervise the use of this material.

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End of Safety Data Sheet

Molecular Probes™
invitrogen detection technologies

Material Safety Data Sheet

Revision Date: 19-Oct-2005

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product code Q21731MP
Product name Qdot® 565 ITK™ organic quantum dots

Company/Undertaking Identification

MOLECULAR PROBES, INC.
29851 Willow Creek Road
Eugene, OR 97402
U.S.A.
541-465-8300

2. COMPOSITION/INFORMATION ON INGREDIENTS

Hazardous/Non-hazardous Components

Chemical Name	CAS-No	Weight %
Decane	124-18-5	>99.9

3. HAZARDS IDENTIFICATION

Emergency Overview
Flammable. Irritating to eyes. Irritating to skin.

Form
Liquid

Principle Routes of Exposure/ Potential Health effects

Eyes May cause eye irritation with susceptible persons.
Skin May cause skin irritation in susceptible persons.
Inhalation No information available
Ingestion No information available

Specific effects

Carcinogenic effects No information available
Mutagenic effects No information available
Reproductive toxicity No information available
Sensitization No information available

Target Organ Effects Eyes. Skin.

4. FIRST AID MEASURES

Skin contact	Wash off immediately with plenty of water
Eye contact	Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes
Ingestion	Never give anything by mouth to an unconscious person
Inhalation	Move to fresh air
Notes to physician	Treat symptomatically

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media	Dry chemical
Special protective equipment for firefighters	Wear self-contained breathing apparatus and protective suit

6. ACCIDENTAL RELEASE MEASURES

Personal precautions	Use personal protective equipment
Methods for cleaning up	Soak up with inert absorbent material

7. HANDLING AND STORAGE

Handling	Avoid contact with skin and eyes.
Storage	Keep away from heat and sources of ignition.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Occupational exposure controls

Exposure limits

Chemical Name	OSHA PEL (TWA)	OSHA PEL (Ceiling)	ACGIH OEL (TWA)	ACGIH OEL (STEL)
Decane	-	-	-	-

Engineering measures	Ensure adequate ventilation, especially in confined areas

Personal protective equipment

Respiratory protection	In case of insufficient ventilation wear suitable respiratory equipment
Hand protection	Protective gloves
Eye protection	Safety glasses with side-shields
Skin and body protection	Lightweight protective clothing
Hygiene measures	Handle in accordance with good industrial hygiene and safety practice
Environmental exposure controls	Prevent product from entering drains

9. PHYSICAL AND CHEMICAL PROPERTIES

General Information

Form	Liquid

Important Health Safety and Environmental Information

Boiling point/range	**°C** No data available	**°F** No data available
Melting point/range	**°C** No data available	**°F** No data available
Flash point	**°C** No data available	**°F** No data available
Autoignition temperature	**°C** No data available	**°F** No data available
Oxidizing properties	No information available	
Water solubility	No data available	

10. STABILITY AND REACTIVITY

Stability Stable under normal conditions.
Materials to avoid No information available
Hazardous decomposition products No information available
Polymerization Hazardous polymerisation does not occur

11. TOXICOLOGICAL INFORMATION

Acute toxicity

Chemical Name	LD50 (oral,rat/mouse)	LD50 (dermal,rat/rabbit)	LC50 (inhalation,rat/mouse)
Decane	No data available	No data available	72300 mg/m³ (Mouse)

Principle Routes of Exposure/ Potential Health effects

Eyes May cause eye irritation with susceptible persons.
Skin May cause skin irritation in susceptible persons.
Inhalation No information available
Ingestion No information available

Specific effects

Carcinogenic effects No information available
Mutagenic effects No information available
Reproductive toxicity No information available
Sensitization No information available

Target Organ Effects Eyes. Skin.

12. ECOLOGICAL INFORMATION

Ecotoxicity effects No information available.
Mobility No information available.
Biodegradation No information available.
Bioaccumulation No information available.

13. DISPOSAL CONSIDERATIONS

Dispose of in accordance with local regulations

14. TRANSPORT INFORMATION

IATA

Proper shipping name Flammable liquid, n.o.s (decane solution)
Hazard Class 3
Subsidiary Class No information available
Packing group III
UN-No UN1993

15. REGULATORY INFORMATION

International Inventories

Chemical Name	TSCA	PICCS	ENCS	DSL	NDSL	AICS
Decane	Listed	Listed	Listed	Listed	-	Listed

U.S. Federal Regulations

SARA 313
Not regulated

Clean Air Act, Section 112 Hazardous Air Pollutants (HAPs) (see 40 CFR 61)
This product contains the following HAPs:

U.S. State Regulations

Chemical Name	Massachusetts - RTK	New Jersey - RTK	Pennsylvania - RTK	Illinois - RTK	Rhode Island - RTK
Decane	-	Listed	Listed	-	Listed

California Proposition 65
This product contains the following Proposition 65 chemicals:

WHMIS hazard class:
Not determined

This product has been classified according to the hazard criteria of the CPR and the MSDS contains all of the information required by the CPR

16. OTHER INFORMATION

This material is sold for research and development purposes only. It is not for any human or animal therapeutic or clinical diagnostic use. It is not intended for food, drug, household, agricultural, or cosmetic use. An individual technically qualified to handle potentially hazardous chemicals must supervise the use of this material.

The above information was acquired by diligent search and/or investigation and the recommendations are based on prudent application of professional judgment. The information shall not be taken as being all inclusive and is to be used only as a guide. All materials and mixtures may be present unknown hazards and should be used with caution. Since Invitrogen Corporation cannot control the actual methods, volumes, or conditions of use, the Company shall not be held liable for any damages or losses resulting from the handling or from contact with the product as described herein. THE INFORMATION IN THIS MSDS DOES NOT CONSTITUTE A WARRANTY, EXPRESS OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTCULAR PURPOSE.

End of Safety Data Sheet

Molecular Probes™
invitrogen detection technologies

Material Safety Data Sheet

Revision Date: 19-Oct-2005

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product code Q21791MP
Product name Qdot® 545 ITK™ organic quantum dots

Company/Undertaking Identification

MOLECULAR PROBES, INC.
29851 Willow Creek Road
Eugene, OR 97402
U.S.A.
541-465-8300

2. COMPOSITION/INFORMATION ON INGREDIENTS

Hazardous/Non-hazardous Components

Chemical Name	CAS-No	Weight %
Decane	124-18-5	>99.9

3. HAZARDS IDENTIFICATION

Emergency Overview
Flammable. Irritating to eyes. Irritating to skin.

Form
Liquid

Principle Routes of Exposure/ Potential Health effects

Eyes May cause eye irritation with susceptible persons.
Skin May cause skin irritation in susceptible persons.
Inhalation No information available
Ingestion No information available

Specific effects

Carcinogenic effects No information available
Mutagenic effects No information available
Reproductive toxicity No information available
Sensitization No information available

Target Organ Effects Eyes. Skin.

4. FIRST AID MEASURES

Skin contact	Wash off immediately with plenty of water
Eye contact	Rinse immediately with plenty of water, also under the eyelids, for at least 15 minutes
Ingestion	Never give anything by mouth to an unconscious person
Inhalation	Move to fresh air
Notes to physician	Treat symptomatically

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media	Dry chemical
Special protective equipment for firefighters	Wear self-contained breathing apparatus and protective suit

6. ACCIDENTAL RELEASE MEASURES

Personal precautions	Use personal protective equipment
Methods for cleaning up	Soak up with inert absorbent material

7. HANDLING AND STORAGE

Handling	Avoid contact with skin and eyes.
Storage	Keep away from heat and sources of ignition.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Occupational exposure controls

Exposure limits

Chemical Name	OSHA PEL (TWA)	OSHA PEL (Ceiling)	ACGIH OEL (TWA)	ACGIH OEL (STEL)
Decane	-	-	-	-

Engineering measures	Ensure adequate ventilation, especially in confined areas

Personal protective equipment

Respiratory protection	In case of insufficient ventilation wear suitable respiratory equipment
Hand protection	Protective gloves
Eye protection	Safety glasses with side-shields
Skin and body protection	Lightweight protective clothing
Hygiene measures	Handle in accordance with good industrial hygiene and safety practice
Environmental exposure controls	Prevent product from entering drains

9. PHYSICAL AND CHEMICAL PROPERTIES

General Information

Form	Liquid

Important Health Safety and Environmental Information

Boiling point/range	**°C** No data available	**°F** No data available
Melting point/range	**°C** No data available	**°F** No data available
Flash point	**°C** No data available	**°F** No data available
Autoignition temperature	**°C** No data available	**°F** No data available
Oxidizing properties	No information available	
Water solubility	No data available	

10. STABILITY AND REACTIVITY

Stability Stable under normal conditions.
Materials to avoid No information available
Hazardous decomposition products No information available
Polymerization Hazardous polymerisation does not occur

11. TOXICOLOGICAL INFORMATION

Acute toxicity

Chemical Name	LD50 (oral,rat/mouse)	LD50 (dermal,rat/rabbit)	LC50 (inhalation,rat/mouse)
Decane	No data available	No data available	72300 mg/m³ (Mouse)

Principle Routes of Exposure/ Potential Health effects

Eyes May cause eye irritation with susceptible persons.
Skin May cause skin irritation in susceptible persons.
Inhalation No information available
Ingestion No information available

Specific effects

Carcinogenic effects No information available
Mutagenic effects No information available
Reproductive toxicity No information available
Sensitization No information available

Target Organ Effects Eyes. Skin.

12. ECOLOGICAL INFORMATION

Ecotoxicity effects No information available.
Mobility No information available.
Biodegradation No information available.
Bioaccumulation No information available.

13. DISPOSAL CONSIDERATIONS

Dispose of in accordance with local regulations

14. TRANSPORT INFORMATION

IATA

Proper shipping name Flammable liquid, n.o.s (decane solution)
Hazard Class 3
Subsidiary Class No information available
Packing group III
UN-No UN1993

15. REGULATORY INFORMATION

International Inventories

Chemical Name	TSCA	PICCS	ENCS	DSL	NDSL	AICS
Decane	Listed	Listed	Listed	Listed	-	Listed

U.S. Federal Regulations

SARA 313
Not regulated

Clean Air Act, Section 112 Hazardous Air Pollutants (HAPs) (see 40 CFR 61)
This product contains the following HAPs:

U.S. State Regulations

Chemical Name	Massachusetts - RTK	New Jersey - RTK	Pennsylvania - RTK	Illinois - RTK	Rhode Island - RTK
Decane	-	Listed	Listed	-	Listed

California Proposition 65
This product contains the following Proposition 65 chemicals:

WHMIS hazard class:
Not determined

This product has been classified according to the hazard criteria of the CPR and the MSDS contains all of the information required by the CPR

16. OTHER INFORMATION

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End of Safety Data Sheet

invitrogen™

Material Safety Data Sheet

Revision Date: 12-Dec-2008

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND THE COMPANY/UNDERTAKING

Product code	Q22041MPA
Product name	Qdot® 525 nanocrystals, amine functionalized *4 µM solution*

Company/Undertaking Identification

INVITROGEN CORPORATON
5791 VAN ALLEN WAY
PO BOX 6482
CARLSBAD, CA 92008
760-603-7200

INVITROGEN CORPORATION
5250 MAINWAY DRIVE
BURLINGTON, ONT
CANADA L7L 6A4
800-263-6236

GIBCO PRODUCTS
INVITROGEN CORPORATION
3175 STALEY ROAD P.O. BOX 68
GRAND ISLAND, NY 14072
716-774-6700

2. COMPOSITION/INFORMATION ON INGREDIENTS

Hazardous/Non-hazardous Components
The product contains no substances which at their given concentration, are considered to be hazardous to health. We recommend handling all chemicals with caution.

3. HAZARDS IDENTIFICATION

Emergency Overview
The product contains no substances which at their given concentration, are considered to be hazardous to health

Form
Solid

Principle Routes of Exposure/ Potential Health effects

Eyes	May cause eye irritation with susceptible persons.
Skin	No information available

3. HAZARDS IDENTIFICATION

Inhalation May cause irritation of respiratory tract.
Ingestion No information available

Specific effects

Carcinogenic effects No information available
Mutagenic effects No information available
Reproductive toxicity No information available
Sensitization No information available

Target Organ Effects No information available

HMIS

Health	0
Flammability	0
Reactivity	0

4. FIRST AID MEASURES

Skin contact Wash off immediately with plenty of water
Eye contact Rinse thoroughly with plenty of water, also under the eyelids.
Ingestion Never give anything by mouth to an unconscious person
Inhalation Move to fresh air
Notes to physician Treat symptomatically.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media Dry chemical
Special protective equipment for firefighters Wear self-contained breathing apparatus and protective suit

6. ACCIDENTAL RELEASE MEASURES

Personal precautions Use personal protective equipment
Methods for cleaning up Soak up with inert absorbent material.

7. HANDLING AND STORAGE

Handling No special handling advice required
Storage Keep in properly labelled containers

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Occupational exposure controls

Exposure limits
Engineering measures Ensure adequate ventilation, especially in confined areas

Personal protective equipment

Respiratory protection In case of insufficient ventilation wear suitable respiratory equipment
Hand protection Protective gloves
Eye protection Safety glasses with side-shields
Skin and body protection Lightweight protective clothing.

Hygiene measures	Handle in accordance with good industrial hygiene and safety practice
Environmental exposure controls	Prevent product from entering drains.

9. PHYSICAL AND CHEMICAL PROPERTIES

General Information

Form	Solid

Important Health Safety and Environmental Information

Boiling point/range	**°C** No data available	**°F** No data available
Melting point/range	**°C** No data available	**°F** No data available
Flash point	**°C** No data available	**°F** No data available
Autoignition temperature	**°C** No data available	**°F** No data available
Oxidizing properties	No information available	
Water solubility	No data available	

10. STABILITY AND REACTIVITY

Stability	Stable.
Materials to avoid	No information available
Hazardous decomposition products	No information available
Polymerization	Hazardous polymerisation does not occur.

11. TOXICOLOGICAL INFORMATION

Acute toxicity

Principle Routes of Exposure/ Potential Health effects

Eyes	May cause eye irritation with susceptible persons.
Skin	No information available
Inhalation	May cause irritation of respiratory tract.
Ingestion	No information available

Specific effects

Carcinogenic effects	No information available
Mutagenic effects	No information available
Reproductive toxicity	No information available
Sensitization	No information available

Target Organ Effects No information available

12. ECOLOGICAL INFORMATION

Ecotoxicity effects	No information available.
Mobility	No information available.
Biodegradation	Inherently biodegradable.
Bioaccumulation	Does not bioaccumulate.

13. DISPOSAL CONSIDERATIONS

13. DISPOSAL CONSIDERATIONS

Dispose of in accordance with local regulations

14. TRANSPORT INFORMATION

IATA

Proper shipping name	Not classified as dangerous in the meaning of transport regulations
Hazard Class	No information available
Subsidiary Class	No information available
Packing group	No information available
UN-No	No information available

15. REGULATORY INFORMATION

International Inventories

U.S. Federal Regulations

SARA 313
This product is not regulated by SARA.

Clean Air Act, Section 112 Hazardous Air Pollutants (HAPs) (see 40 CFR 61)
This product does not contains HAPs.

U.S. State Regulations

California Proposition 65
This product does not contain chemicals listed under Proposition 65

WHMIS hazard class:
Non-controlled

This product has been classified according to the hazard criteria of the CPR and the MSDS contains all of the information required by the CPR

16. OTHER INFORMATION

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End of Safety Data Sheet

invitrogen™

Qdot® Conjugates
Protocol Handbook

Quantum Dot
invitrogen nanocrystal technologies

Molecular Probes™
invitrogen detection technologies

PN 90-0153, Rev 1.2

mp19029 19-June-2007

Table of Contents

Immunocytochemistry with Qdot® Conjugates in Cultured Cells.....2

Immunolabeling Formalin-fixed Paraffin Embedded Tissue Sections.....8

Immunolabeling Frozen Tissue Sections.....12

Western Blotting with Qdot Secondary Antibody Conjugates.....15

Immunocytochemistry with Qdot® Conjugates in Cultured Cells

PLEASE READ ENTIRE PROTOCOL AND APPLICATION NOTES BEFORE STARTING.
Additional information can be obtained from the product page on our website at http://probes.invitrogen.com/products/qdot/

This protocol describes an optimized fixation, permeabilization, and labeling procedure for use of Qdot® secondary antibody and Qdot® streptavidin conjugates in cultured adherent mammalian cells. This protocol has been developed and optimized for targets in cell lines such as HeLa adenocarcinoma cells and NIH-3T3 fibroblast cells. It is important to note that cell labeling protocols appropriate for Qdot® conjugates can differ depending on the cell type and growth status, target antigen, primary antibody source, and fluorescence detection method. Traditional cell-labeling protocols developed for organic fluorescent dye conjugates may need modification to be successful with Qdot® secondary antibodies and streptavidin conjugates. Thus, this basic protocol is a starting point for the optimization of your system for use with Qdot® secondary antibodies and Qdot® streptavidin conjugates. These conjugates perform optimally when used within the range of 10 nM to 40 nM, but the exact concentration needed should be determined by titration for each system. Additionally, imaging Qdot® conjugates is optimal with filters designed specifically for these nanocrystals. These filters are available from Omega Optical or Chroma (see *application note 1*).

Antigen labeling with Qdot® conjugates:

Detecting cellular targets with Qdot® secondary antibody and streptavidin conjugates can be performed individually by using a single Qdot® secondary antibody or Qdot® streptavidin conjugate with one primary antibody, or multiplexed by using a combination of primary antibodies and various Qdot® nanocrystal colors. Golgi, tubulin, mitochondrial, peroxisome, nucleolin, nucleosome and ki-67 targets have been validated with this labeling protocol (for a complete list of primary antibodies validated, see *application note 2*). Other targets and cell lines, however, may require further optimization of this protocol. For example, reducing the fixation time may improve cell penetration and conjugate access for some targets as may increasing the concentration of permeabilization reagent or incubation time with the permeabilization buffer. Furthermore, if biotinylated antibodies are to be detected with streptavidin conjugates, it becomes imperative to block endogenous biotin-containing proteins expressed in mitochondria (the Endogenous Biotin Blocking Kit (Invitrogen Cat. no. E21390) noted in the protocol is used for this purpose).

Materials

Fixative: 4% formaldehyde in PBS

Recommendation: freshly prepare 40 mL of 4% formaldehyde (ultrapure, MeOH-free, 16% formaldehyde solution; Polysciences, Inc. Cat. no. 18814) in 1X PBS by combining 10 mL of formaldehyde, 4 mL of 10X PBS, pH 7.4 (Invitrogen Cat. no. 70011-044) and 26 mL of distilled water.

Option: Prepare 40 mL of 3.7% formaldehyde (from 37% stock) in 1X PBS

Permeabilization buffer: 0.25% Triton® X-100 in PBS

Prepare 40 mL of permeabilization buffer by adding 100 µL of Triton® X-100 (Sigma Cat. no. T9284) to 40 mL of 1X PBS. Rock or stir until the Triton® X-100 goes into solution.

Rinse buffer: 1X PBS

Prepare 2 L of 1X PBS by combining 200 mL of 10X PBS and 1.8 L of distilled water.

Endogenous Biotin Blocking Kit (for use if performing streptavidin-based labeling): Invitrogen Cat. no. E21390 contains two ready-to-use reagents.

Blocking buffer: 6% BSA/10% normal serum in PBS

Add to 3 g of BSA (RIA grade, Fraction V, minimum 96%; Sigma Cat. no. A-7888) 5 mL of normal serum from the host species of the secondary antibody (preferably heat inactivated at 56˚C for 1 hour), 5 mL of 10X PBS, and distilled water to a total of 40 mL. Rock until the BSA is completely dissolved. Add distilled water to a final volume of 50 mL and mix well with gentle rocking or stirring. If storing the blocking buffer, add sodium azide to a final concentration of 0.02% and keep at 4˚C.
See application note 3.

Secondary incubation buffer: 6% BSA in PBS

Add to 3 g of BSA (RIA grade, Fraction V, minimum 96%; Sigma Cat. no. A-7888) 5 mL of 10X PBS, and distilled water to 40 mL. Rock until BSA is completely dissolved. Add distilled water to a final volume of 50 mL and mix well with gentle rocking or stirring.

Qdot® secondary antibody or Qdot® streptavidin conjugate:

DO NOT VORTEX PRODUCT VIAL. Centrifuge the Qdot® nanocrystal conjugate product vial for 3 minutes at 10,000 × g prior to use. If a pellet appears, only use the supernatant. Dilute the conjugate by adding 2 μL of the stock (1 μM) conjugate to 100 μL secondary incubation buffer immediately prior to use (in most cases this is optimal but it may need to be titrated between 10 nM and 40 nM final concentration). Use for current experiment, do not store diluted. See *application note 4*.

Dehydration solutions:

Prepare in containers suitable for a dehydration series EtOH/H_2O dilutions (v/v) of 30%, 50%, 70%, and 90%, as well as 100% EtOH and 100% toluene.

Mounting reagents:

The recommended mounting media is Cytoseal 60 (Richard-Allan Scientific Cat. no. 8310-4). This requires dehydration of the specimen in EtOH and toluene. Prepare in containers suitable for this process EtOH/H_2O dilutions (v/v) of 30%, 50%, 70%, and 90%, as well as 100% EtOH and 100% toluene.

Cell preparation:

Culture cells in the appropriate medium to the desired confluency and physiological state (typically 1–2 days for HeLa cells). It is recommended that cells be below 80% confluency at the time of fixation, depending on experimental requirements and imaging method.

A. Fixation and Permeabilization

All of the steps are performed at room temperature.

1.1 Rinse 2 times with 1X PBS. If cells were grown in a large dish (i.e., 100 mm petri dish), add a large enough volume of 1X PBS to completely cover the specimen (~25 mL for a 100 mm petri dish) swirl gently, pour off or aspirate the solution and repeat. If grown in a smaller container (i.e., 6-well plate), wash 3 times, 5 minutes each by adding enough 1X PBS to completely cover specimen. After 5 minutes, pour off or aspirate the rinse solution.

1.2 Incubate in 4% formaldehyde/PBS for 15 minutes to fix the specimen.

1.3 Repeat step 1.1.

1.4 Incubate in 0.25% Triton® X-100/PBS for 15 minutes to permeabilize the specimen (see *application note 5*).

1.5 Repeat step 1.1.

B. Target Labeling and Detection

All of the following incubations are performed in a humidity chamber at room temperature (see *application note 6*). Avoid specimen drying as this can cause high levels of nonspecific background and autofluorescence. At the end of each step, carefully remove or blot excess solution from the sample before moving to the next step.

If using Qdot® secondary antibody conjugates proceed to step 2.1.

If using Qdot® streptavidin conjugates, perform endogenous biotin blocking with the Endogenous Biotin Blocking Kit (Invitrogen Cat. no. E21390) or equivalent. If using Invitrogen product E21390:

a) Incubate in component A for 30 minutes.
b) Wash 3 times, 5 minutes each, in 1X PBS.
c) Incubate in component B for 30 minutes.
d) Wash 3 times, 5 minutes each in 1X PBS.

Proceed to step 2.1.

2.1 Incubate with blocking buffer for 1 hour.

2.2 Pour off blocking buffer and incubate for 1 hour with primary antibody diluted in blocking buffer (see *application note 7*).

2.3 Wash 3 times, 5 minutes each, in 1X PBS.
Note: If using a biotinylated secondary antibody, repeat steps 2.2 and 2.3 using the biotinylated antibody before continuing.

2.4 Incubate for 1 hour with Qdot® secondary antibody conjugate or Qdot® streptavidin conjugate, diluted to an optimal concentration (titrate between 10 nM and 40 nM for optimal results) in secondary incubation buffer.

2.5 Wash 3 times, 5 minutes each, in 1X PBS.
Note: If counterstaining is necessary, most counterstain procedures may be performed at this point, followed by any necessary wash steps and subsequent dehydration and mounting (see *application note 8*).

2.6 Dehydrate specimen. Submerge specimen for 5 seconds in 30%, 50%, 70%, and 90% EtOH/H_2O, twice in 100% EtOH, and twice in 100% toluene with the final dip ~10 seconds.

2.7 Mount in one drop Cytoseal 60 and let cure at least 4 hours before imaging. For optimal performance, image within 24 hours.

Application Notes

Note 1: For optimal imaging of Qdot® conjugates, including reduced spectral bleed-through effects in multicolor applications, it is recommended that you use filter sets optimized for the excitation and emission of the Qdot® nanocrystal(s) in use. These filters are available from Omega Optical or Chroma. Additional information can be obtained from the Qdot® nanocrystals web page at http://probes.invitrogen.com/products/qdot/.

Note 2: If new to immunocytochemistry (ICC), it is recommended that you include a positive labeling control for protocol execution validation. For example, an optional control for Qdot® goat-anti-mouse secondary antibodies is anti-OxPhos Complex V Inhibitor Protein (Invitrogen Cat. no. A21355), which targets mitochondria. An optional control for Qdot® goat-anti-rabbit secondary antibodies is rabbit anti-giantin (Covance Cat. no. PRB-114C), which targets Golgi bodies. Other antibodies used in optimization of this protocol, and therefore suitable as positive controls include: rabbit anti-AIF (Cell Signaling Cat. no. 4642), mouse anti–ki-67 (Ventana Medical Systems Cat. no. 790-2910), mouse anti–α-tubulin (Sigma Cat. no. T6074), rabbit anti–α-tubulin (Affinity Bioreagents Cat. no. PA1-20988), mouse anti-nucleosome (BD Pharmingen Cat. no. 51-80591N), and mouse anti-nucleolin (Invitrogen Cat. no. 39-6400; Stressgen Cat. no. KAM-CP100).

Note 3: If background is observed with Qdot® secondary antibody conjugates, use a blocking buffer of 6% BSA in PBS with 10% heat-inactivated (56˚C for 1 hour) normal serum from the host species of the secondary (goat or rabbit). Please note that BSA can vary by lot and producer, so re-optimization of blocking conditions may be required for best results when substituting alternate sources for this component. Avoid using blocking solutions containing casein as these may quench the Qdot® fluorescence.

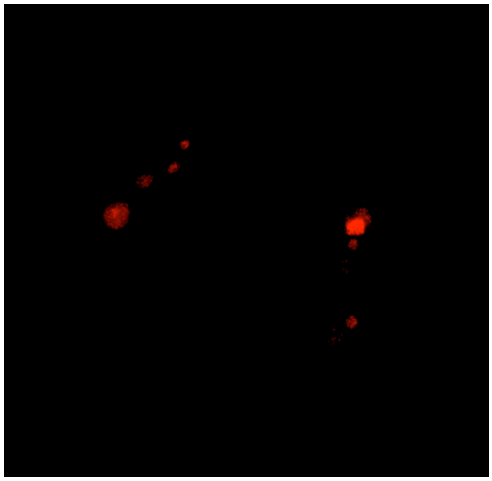
Note 4: Qdot® secondary antibody conjugates and Qdot® streptavidin conjugates should be stored at 4˚C in their concentrated (shipped) form. They should not be diluted to their working concentration until the day they will be used, as they may not be stable in dilute form. It is best to only make up as much as is needed for each experiment rather than to create and store a stock of diluted working solution.

Note 5: Changing fixation time or permeabilization time or concentration may be necessary for achieving labeling of certain targets.

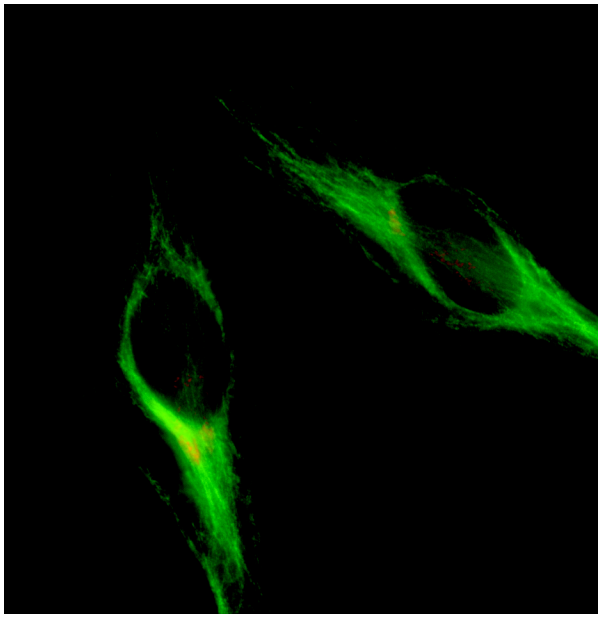
Note 6: A simple humidity chamber prevents labeling reagent concentration changes due to evaporation during incubations. To make a simple humidity chamber, place a piece of filter paper in a petri dish and saturate the filter paper with water. Next, place a piece of Parafilm® on the filter paper. During incubations, place a lid on the petri dish. Gentle agitation during incubations is optional.

Note 7: Briefly centrifuge the PRIMARY antibody prior to use. It may be necessary to titrate the concentration of the primary antibody for optimal target labeling.

Note 8: UV excitation of DAPI (Invitrogen Cat. no. D1306) resulting in emission around 600 nm has been observed and may not be appropriate for use with all Qdot® nanocrystals. Other nuclear counterstain options, many available in kit form with optimized protocols for their use, include SelectFX® Nuclear Labeling Kit (Invitrogen Cat. no. S33025), SYTOX® Green nucleic acid stain (Invitrogen Cat. no. S7020), 7-aminoactinomycin D (7-AAD) (Invitrogen Cat. no. A1310), propidium iodide (Invitrogen Cat. no. P3566), and TO-PRO®-3 iodide (Invitrogen Cat. no. T3605).



Multiplex labeling of HeLa cells using Qdot® conjugates. HeLa cells were prepared according to the protocol above. Tubulin was labeled with a mouse anti-tubulin primary antibody (Sigma, Cat. no. T6074) followed by a Qdot® 525 goat anti–mouse IgG secondary antibody (green, Cat. no. Q11041MP). Giantin was labeled with a rabbit anti-giantin primary antibody (Covance, Cat. no. PRB-114C) followed by a Qdot® 655 goat anti–rabbit IgG secondary antibody (red, Cat. no. Q11421MP). Images were captured using the optimal filter sets recommended in Appendix 1 of the Supplemental Information Guide (available online at http://probes.invitrogen.com/media/pis/mp19009.pdf).



Nuclear labeling in HeLa cells using Qdot® conjugates. HeLa cells were prepared according to the protocol above. Nucleoli were labeled with a mouse anti-nucleolin primary antibody (Novus, Cat. no NB 600-241A2) followed by a Qdot® 655 goat anti–mouse IgG secondary antibody (red, Cat. no. Q11021MP) and imaged using the optimal filter sets recommended in Appendix 1 of the Supplemental Information Guide (available online at http://probes.invitrogen.com/media/pis/mp19009.pdf).

Immunolabeling Formalin-fixed Paraffin Embedded Tissue Sections

PLEASE READ ENTIRE PROTOCOL BEFORE STARTING.
Additional information can be obtained from our website at www.invitrogen.com.

This protocol is intended to be a starting point for immunolabeling formalin-fixed tissues that were embedded in paraffin. It is expected that for a given antibody, certain steps in this procedure will change to improve immunolabeling and reduce background staining. Antigen retrieval conditions, primary antibody concentrations and incubation times, and secondary antibody concentrations and incubation times that successfully immunolabel tissue with other detection methods should be used as a starting point for this protocol. Steps are included for using Qdot® Streptavidin Conjugates as tertiary reagents in conjunction with biotinylated secondary antibodies or for using Qdot® Secondary Antibody Conjugates.

Materials

Primary Antibody: 1 – 10 µg / ml in TBS with 3 – 10% IgG free BSA
Control Tissue: positive and negative controls as appropriate
Antigen Retrieval:
- DAKO® Target Retrieval Solution 10X Concentrate (DakoCytomation, Cat. # S1699)

Blocking Reagents:
- TBS-BSA: 2% bovine serum albumin (IgG-free BSA, Jackson Immunoresearch, Cat # 001-000-162 or equivalent) in Tris buffered saline
- Normal serum(s) matching secondary antibody hosts (Jackson Immunoresearch)
- Borate-BSA: 2% BSA (see above) in 50 mM borate buffer (pH 8.3)

Secondary Detection Reagents Antibody: Dilutions are in TBS-BSA.
- Qdot Secondary Antibody Conjugate
- Biotin rabbit anti-mouse Fab (DakoCytomation, Cat # E0413 or equivalent)
- Biotin swine Anti-rabbit Fab (DakoCytomation, Cat # E0431 or equivalent)
- Biotin donkey anti-goat IgG (Jackson Immunoresearch, Cat # 705-065-147 or equivalent)

Tertiary reagents:
- Qdot Streptavidin Conjugate

Nuclear counter stain
- Hoechst 33342 , trihydrochloride, trihydrate *10 mg/mL solution in water* (Molecular Probes, Cat # H3570) diluted 1:10000 – 1:20000 in TBS

Buffers:
- TBS; Tris buffered saline, (DakoCytomation, Cat # S1968)
- TBST, TBS with 0.2% Tween-20 (DakoCytomation, Cat # S3306)
- PBS (Sigma, Cat # P3563)
- 50 mM Borate buffer (pH 803)

Mounting media:
- Cytoseal™ 60 (Richard-Allan Scientific, Cat # 8310)
- Polyvinyl alcohol with DABCO (Sigma, Cat # 10981)
- 90% Glycerol in 50 mM borate buffer

ImmEdge Hydrophobic Barrier Pen (Vector Laboratories, Cat # H-4000)

Procedure

1. Deparaffinize sections.
   1.1. 3 changes of xylene or xylene substitute, 5 min
   1.2. 3 changes 100% ethanol, 3 min each
   1.3. 1 change 95% ethanol, 3 min
   1.4. 1 change 90% ethanol, 3 min
   1.5. 1 change 70% ethanol, 3 min
   1.6. 1 changes deionized water > go to antigen retrieval step if needed, i.e. tissue fixed in formalin.
   1.7. 2 changes of TBS > go to step 3 blocking buffer if antigen retrieval is not needed (i.e. tissue not fixed in formalin).
2. Antigen retrieve formalin-fixed tissues. (p.3)
3. Place in dH_2O.
4. Optional: A PAP pen (or hydrophobic pen) can be used to circumscribe the tissue section in order to conserve on reagent usage. However, some PAP pens can quench the fluorescence of quantum dots. We recommend that the ImmEdge Pen be used for this purpose.

The following steps can be done on an autostainer if available

5. Block for 20 min in TBS-BSA.
6. Shake off the blocking reagent (do not rinse).
7. Incubate in primary antibody in TBS-BSA (1-10 μg/ml).
   Suggested times – these can be changed to suit the antibody and antigen conditions.
   7.1. 60 -120 min at room temperature RT in humid chamber
   7.2. Overnight at 4°C or room temperature
8. Wash in TBS 2 x 3min.
9. Block in TBS-BSA.
10. Qdot Secondary Antibody Conjugate: 1 – 20 nM in TBS-BSA @ room temperature or 37°C for 30 - 60 min. Skip to step 13.
    Or Biotinylated secondary antibody: 1 -2 μg/ml in TBS-BSA for 30 – 60 min at room temperature or 37°C.
11. Wash TBST (TBS-Tween) 2 changes @ 3 min each.
12. Qdot Streptavidin Conjugate in TBS-BSA (1-10 nM) @ RT for 30 min.
13. Wash TBST 2 x 3 min.
14. Counterstain nuclei with Hoechst 33342 in TBS for 15 min. (dilute 10mg/ml stock by 1:5000 in TBS) (see Technical note at end)
15. Wash in TBS 2 changes for 5 min.
16. Coverslip
    16.1. Polyvinyl alcohol mounting media with DABCO
    Or Cytoseal 60 mounting media
    16.2. After buffer, place in water bath 20-30 sec.
    16.3. Then 30% alcohol 30 sec.
    16.4. Then 70% alcohol 30 sec.
    16.5. Then 95% alcohol 30 sec.
    16.6. Then 100% alcohol 30 sec.
    16.7. Then xylene or toluene 30 sec.
    16.8. Place one drop of mounting media on section and apply coverslip.
17. Image sections on microscope with filter set optimized for quantum dots.

ANTIGEN RETRIEVAL

Restores antibody binding to proteins in formalin-fixed paraffin embedded tissues.

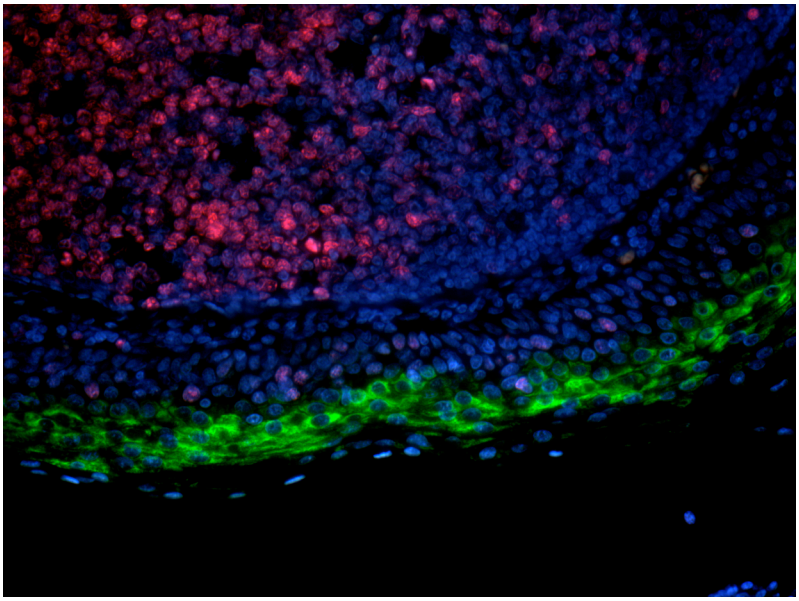
Materials

1 part - DAKO® Target Retrieval Solution 10X Concentrate
9 parts - dH_2O (Milli-Q® Ultrapure or distilled)

1) Preheat water bath or steamer to 95° C.
2) Heat working retrieval solution to 95° C in an appropriate container.
3) Place deparaffinized slides to the heated target Retrieval Solution. (Step #2)
4) Leave at 95° C for **10 – 40 min**.
5) Remove container with slides and cool on bench (to 50ºC or less) in Retrieval solution.
6) Remove slides and rinse in deionized water for 3 minute.
7) Proceed with blocking step 9 above.

Technical note:

The introduction of Hoechst to the sections allows for visualizing nuclei and imaging with a standard RGB camera. However, Hoechst and DAPI have a long emission tail that can bleed into the single band-pass filters for 525, 565, and 585 nm quantum dots. Hence nuclear immunolabeling that requires the use of these DNA labels should use the 605 nm or 655 nm Qdot Conjugates to visualize nuclear antigens. Other DNA dyes are available that excite at different wavelengths and can be more compatible with the appropriate colors of quantum dots. Typically these dyes would be selected to absorb and emit at longer wavelengths than the quantum dots being used. One such dye is DRAQ 5™ (Biostatus Limited)



Multiplex labeling of human tonsil section for Ki67 and keratin with Qdot Conjugates. Ki67 in the nuclei of proliferating B cells (red) were labeled with Rabbit anti-Ki67 (Lab Vision, Cat # RB-1510) followed by Qdot 585 Anti-rabbit Secondary Conjugate (Cat # Q11411MP). Keratin in the peripheral stromal cells (green) was labeled with mouse monoclonal anti-pan keratin antibody (Lab Vision, Cat # MS-356) followed by biotin-goat anti-mouse IgG and Qdot 525 Streptavidin Conjugate (Cat #Q10143MP). Nuclei (blue) were counterstained with Hoechst 33342.

Immunolabeling Frozen Tissue Sections

PLEASE READ ENTIRE PROTOCOL BEFORE STARTING.
Additional information can be obtained from our website at www.invitrogen.com.

This protocol is intended to be a starting point for immunolabeling paraformaldehyde-fixed tissues that were frozen. It is expected that for a given antibody, certain steps in this procedure will change to improve immunolabeling and reduce background staining.

Materials

2% Paraformaldehyde
30% Sucrose
Superfrost™ Plus Slides (Erie Scientific Company, Cat # 4951 or equivalent)
Phosphate Buffered Saline (PBS; Sigma Chemical, Cat # P3563)
Primary Antibody
Wash Buffer: 0.5% bovine serum albumin, IgG-free BSA, (Jackson Immunoresearch, Cat # 001-000-162 or equivalent) in PBS
Blocking Buffer: 2% bovine serum albumin, IgG-free BSA, (Jackson Immunoresearch, Cat. # 001-000-162 or equivalent) in PBS
Qdot Secondary Antibody Conjugate
Nuclear counter stain
DAPI: 10 µg/ml DI water (Molecular Probes, Cat # D1306)
Mounting media:
Gelvatol: Prepared according to recipe at the following link:
http://www.feinberg.northwestern.edu/cif/gelvatol.htm
ImmEdge Hydrophobic Barrier Pen (Vector Laboratories, Cat. # H-4000)

Procedures

Preparing Tissue Sections:

Fix tissue in 2% Paraformaldehyde.
1. Cryo-protect in 30% sucrose overnight at 4º C.
2. Prepare 6 µm sections using a cryostat and place on Superfrost™ Plus slides.
3. Keep slides at -20º C until ready for use.

Immunolabeling:
Note: All wash steps are 4 minutes.

4. Rehydrate sections with 3 washes in PBS.
5. Wash 3 times with Wash Buffer.
6. Block for 45 minutes at room temperature in Blocking Buffer.
7. Wash 5 times with Wash Buffer.
8. Incubate with Primary Antibody for 60 minutes at room temperature (antibody diluted in Wash Buffer).
9. Wash 5 times with Wash Buffer.
10. Incubate with Qdot Secondary Antibody Conjugate for 60 minutes at room temperature (antibody diluted in Wash Buffer).

11. Wash 5 times with Wash Buffer.
12. Wash 5 times with PBS.
13. Stain with DAPI for 30 seconds at room temperature.
14. Wash 2 times with PBS.
15. Mount coverslip with Gelvatol and refrigerate.
16. Dry slides overnight at 4º C in the dark.

Note: Some PAP pens can quench the signal from the quantum dots. If your protocol requires the use of a PAP pen, we recommend the ImmEdge Hydrophobic Barrier Pen (H-4000) from Vector Labs.

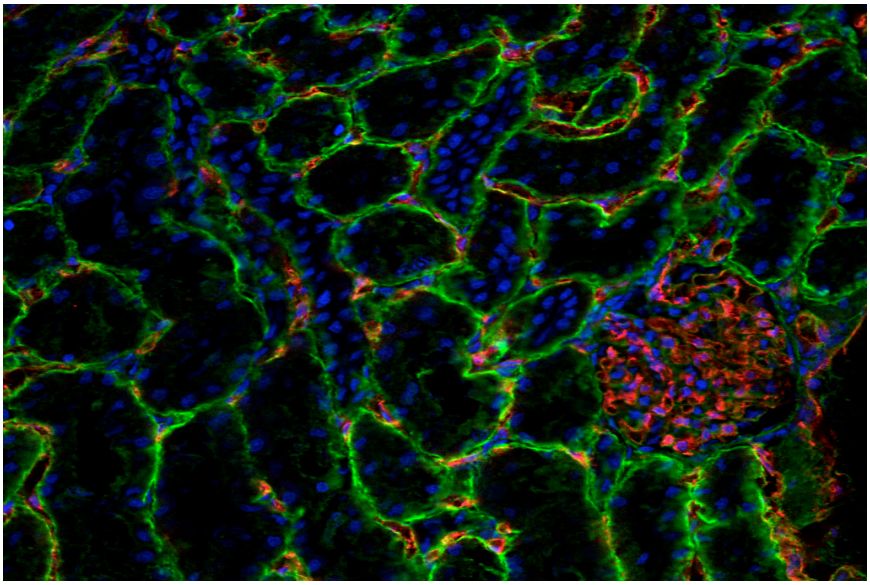


Figure 1. Laminin (Qdot 565 Goat anti-Rabbit IgG Conjugate; Green), PECAM (Qdot 655 Goat anti-Mouse IgG Conjugate; Red) and Nucleus (DRAQ5™; Blue) staining in a Rat Kidney Section.

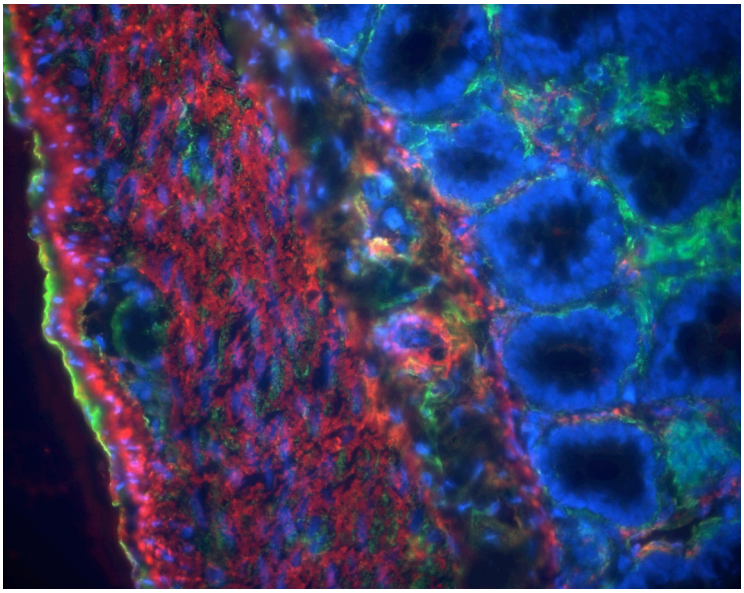


Figure 2. Laminin (Qdot 565 Goat anti-Rabbit IgG Conjugate; Green), Smooth Muscle Actin (Qdot 655 Goat anti-Mouse IgG Conjugate; Red) and Nucleus (DAPI; Blue) staining in a Rat Gut Section.

Western Blotting with Qdot Secondary Antibody Conjugates

PLEASE READ ENTIRE PROTOCOL BEFORE STARTING
Additional information can be obtained from our website at www.invitrogen.com.

This protocol is based on standard polyacrylamide gel electrophoresis and Western blotting procedures. Concentrations of both the primary and secondary antibodies should be optimized for each user's particular system.

Materials

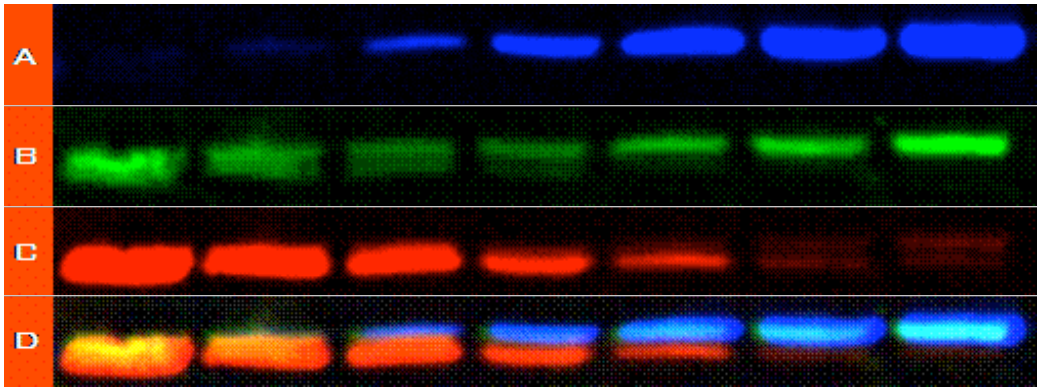
Qdot Secondary Antibody Conjugates
PVDF (recommended: Millipore Immobilon™ FL PVDF) or Nitrocellulose membrane
Blocking buffer (recommended: SEA BLOCK; Pierce Chemical, Cat. #37527)
1X TBS-T (0.1M Tris, 150 mM NaCl, 0.1% Tween-20)
1X TBS (0.1M Tris, 150 mM NaCl)
Electroblotting apparatus, power supply, and buffers
Rocking or oscillating platform
Methanol
100 X 15 mm square petri dish (such as Falcon, Cat. #351112) or plastic bags for incubation steps
Primary antibody: mouse and/or rabbit IgG
Gel Imaging instrument with filters appropriate for Qdot conjugates

Procedure

Polyacrylamide Gel Electrophoresis (PAGE) and electroblotting to PVDF should be performed as per laboratory routine or instructions provided with electroblotting apparatus.

Note: Always wear gloves and use forceps when manipulating gels and membranes. Blotting membranes should be handled with care to prevent scratching or folding.

1. All membrane incubations are designed to be performed with **8-10 ml volumes** of reagent in an appropriately sized container (such as a square petri dish or sandwich bag---Plastic food storage containers are not recommended). These incubations should be performed on a rocking table under continuous motion.
2. Wash membrane in 8 ml TBS-T 2 X 5 minutes with gentle shaking.
3. Incubate membrane in 8 ml SEABLOCK for 1 hour at room temperature or overnight at 4°C with continuous rocking.
4. Add primary antibody to petri dish containing membrane and SEABLOCK to a final concentration of 1-2 μg/ml (The amount of primary antibody may need to be optimized for specific experiments).
5. Incubate the membrane at room temperature for 1 hour with constant rocking.
6. Wash membrane in 8 ml TBS-T 3 X 5 minutes with gentle shaking.
7. Incubate membrane for 1 hr at room temperature in Qdot® Secondary Antibody Conjugates diluted 1:1000 in 8-10 mL SEABLOCK (1 nM final concentration).
8. Wash membrane in 8 ml TBS-T 3 X 5 minutes each with gentle shaking.
9. Transfer the membrane to TBS and wash 2 X 3 minutes each. Store in TBS at 4°C until imaged.



Western blots of serial dilutions of a mixture of lysates from *E. coli* which expressed individual epitope tags. In addition to the two secondary antibodies included in the 605/705 Western Blotting Kit (Q24021MP), the Qdot 565 Goat anti-GST Conjugate (Q14631MP) was also used. A: cMyc (705, pseudo-colored blue), B: GST (565, green), C: HA (605, red), D: combination of all three antibodies.

Blot Image Capture

Western blot data can be collected on a wide variety of instruments. Qdot Conjugate labeled blots can be imaged in gel imaging systems equipped with a digital camera, UV epi-illumination, and band-pass filters matched to the quantum dot emission wavelengths. Trans-illumination may also be used but the autofluorescent light from the membrane is significantly higher, resulting in an approximately 10-fold decrease in the overall sensitivity of detection.

For the highest sensitivity and multiplexed detection with the quantum dots, be sure to obtain custom filters for your instrument that are designed to discriminate the signal from the distinct Qdot Conjugates. These filters can be obtained from Omega Optical (www.omegafilters.com) or Chroma Technology (www.chroma.com), and have to be ordered in sizes appropriate to the particular system. Consult your instrument specifications to determine the appropriate size before ordering custom filters

An alternate imaging strategy is to use a color digital camera with a UV-transilluminator. In these cases, a high quality color camera with a standard Haze2A (UV Blocking) filter at the front of the lens can be used as a quick, inexpensive, semi-quantitative method for imaging single or multicolor blots with visibly distinguishable colors such as 565 and 655. If a Haze2A filter is unavailable, the image can be taken through the UV blocking plate or mask available in most laboratories.

NOTE: When using UV illuminators, one must wear appropriate eyewear to prevent UV exposure and serious health risks.

For additional information on detection of Qdot Conjugates or for recommendation on instruments, please refer to our web page: www.invitrogen.com.

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The Qdot® Nanocrystal products may be the subject of one or more patents owned by Quantum Dot Corporation (U.S. Patent Nos. 6,649,138, 6,815,064) or licensed to Quantum Dot Corporation (i) by The Regents of the University of California (including 5,990,479, 6,207,392, 6,423,551, 6,699,723) and (ii) by Massachusetts Institute of Technology (6,251,303, 6,322,901, 6,444,143).

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Qdot® Streptavidin Conjugates

Table 1. Contents and storage information.

Material	Amount	Concentration	Storage	Stability
Qdot® streptavidin conjugate	200 µL or 50 µL	1 µM solution in 1 M betaine, 50 mM borate, pH 8.3 with 0.05% sodium azide*	• 2–6°C • Do not freeze	When stored as directed, product is stable for at least 6 months.
*Betaine acts as a cryoprotectant during shipping and does not affect the fluorescence of Qdot® conjugates.				
Approximate fluorescence excitation/emission maxima: See Figure 3.				

Introduction

Structure of Qdot® Nanocrystals

The Qdot® streptavidin conjugate is made from a nanometer-scale crystal of a semiconductor material (CdSe), which is coated with an additional semiconductor shell (ZnS) to improve the optical properties of the material. These materials have a narrow, symmetric emission spectrum with the emission maximum near 525 nm (Q10141MP), 565 nm (Q10131MP), 585 nm (Q10111MP), 605 nm (Q10101MP), 625 nm (A10196), 655 nm (Q10121MP), 705 nm (Q10161MP), or 800 nm (Q10171MP). The Qdot® 705 and Qdot® 800 streptavidin conjugates, which include CdSeTe, are made in a similar fashion. This core-shell material (Figure 1A) is further coated with a polymer shell that allows the materials to be conjugated to biological molecules and to retain their optical properties. This polymer shell is directly coupled to streptavidin (Figure 1B). The Qdot® streptavidin conjugate is the size of a large macromolecule or protein (~15–20 nm).

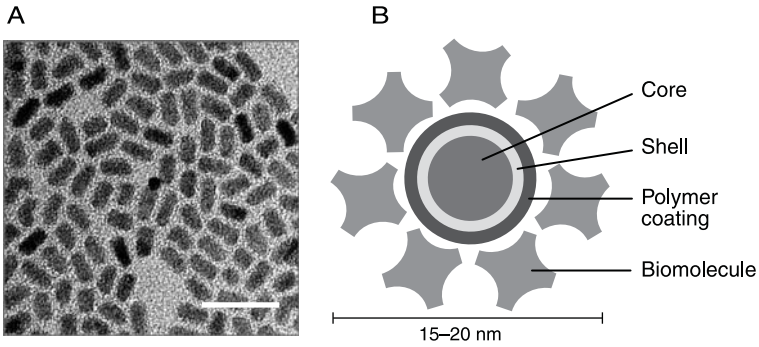

Figure 1. A. Transmission electron microscope image of core-shell Qdot® nanoparticles at 200,000x magnification. Scale bar = 20 nm. **B.** Schematic of the overall structure of a Qdot® streptavidin conjugate. The layers represent the distinct structural elements of the Qdot® nanocrystal conjugates, and are roughly to scale.

Optical Properties

The optical properties of Qdot® conjugates are different than those of typical dye molecules. The color of light that the Qdot® nanocrystal emits is strongly dependent on the particle size, creating a common platform of labels from the green to the red, all manufactured from the same underlying semiconductor material (see *Bibliography*, references 1–11 in the *Appendix*). The size of Qdot® nanocrystals are tightly controlled in the production process, resulting in materials with narrow and symmetric emission spectra, that are extremely bright and photostable. While the fluorescence emission from the Qdot® 705 and Qdot® 800 streptavidin conjugates are broader than the other Qdot® conjugates, the fluorophores have similar intensities and photostabilities. Note that the 705 and 800 nm quantum dot emission cannot be seen by eye, but is easily detected by many cameras and detectors. These properties are exploited in a variety of immunofluorescence techniques, and can result in substantially better results than are attainable with conventional immunofluorescent labels (see *Bibliography*, references 12–18). Though these materials are compatible with a number of standard immunofluorescent techniques, there are some novel aspects of their chemistry and detection that require careful consideration to attain optimal assay results.

Biological Activity

The surface chemistry dictates many of the important properties of the Qdot® nanocrystal in a biological experiment. The surface has been prepared to have a low nonspecific signal when incubated with samples in a variety of aqueous buffers. Qdot® nanocrystals have been coupled to streptavidin directly through an active ester coupling reaction.[19] This yields a material with streptavidin covalently attached on the surface (typically 5–10 streptavidins/Qdot® conjugate), which results in Qdot® streptavidin conjugates with high specific biological activity. The probes should generally be used as if there were one streptavidin per Qdot® nanocrystal. Though one quantum dot is capable of bridging multiple antigens through a biotinylated IgG, the dominant binding mode is one Qdot® conjugate per analyte if the assay is carried out at a saturating concentration. (Figure 2.)

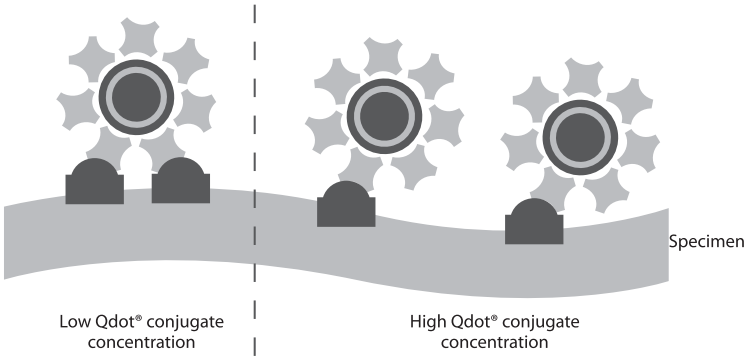

Figure 2. Impact of working at the appropriate concentration range for Qdot® streptavidin conjugates. Due to the multivalency of the conjugates, use of conditions below the appropriate saturation concentration may result in artificially reduced signals due to antigen bridging with a single quantum dot conjugate.

Spectral Characteristics

Typical fluorescent dyes have excitation and emission spectra with a relatively small Stokes shift, which means that the optimal excitation wavelength is close to the emission peak. Filter sets used with fluorescent dyes reflect this characteristic.[20] Qdot® nanocrystals have absorbance spectra that increase dramatically to the blue of the emission (Figure 3). These unique spectral properties are due to the semiconductor that makes up the core of the Qdot® conjugates, which gives rise to both the absorbance and emission properties of the materials (see *Bibliography*, references 1–11). Despite the broad absorbance, the emission wavelength is independent of the excitation wavelength; so whether exciting at 633 nm or at 400 nm, the shape of the emission remains the same, while the intensity is approximately 11-fold

higher with 400 nm excitation. The absorbance and excitation at shorter wavelength, with fixed emission for the material results in a large "apparent Stokes shift" which improves sensitivity by reducing auto-fluorescence, and greatly simplifies the multiplexed detection of several Qdot® conjugates. See *Appendix 3* for extinction coefficients at common excitation wavelengths of the different materials.

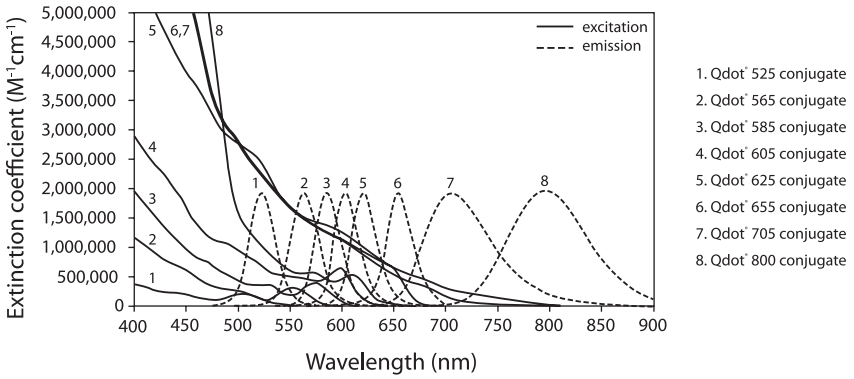

Figure 3. Typical absorption and emission spectra of Qdot® 525 streptavidin conjugate (1), Qdot® 565 streptavidin conjugate (2), Qdot® 585 streptavidin conjugate (3), Qdot® 605 streptavidin conjugate (4), Qdot® 625 streptavidin conjugate (5), Qdot® 655 streptavidin conjugate (6), Qdot® 705 streptavidin conjugate (7), Qdot® 800 streptavidin conjugate (8).

Optical Filter Selection

To achieve the optimal signal from Qdot® streptavidin conjugates, we recommend using Qdot® optimized filter sets that are available from Omega Optical, Semrock, or Chroma Technology Corporation (see *Appendix 2* for details).

The Qdot® streptavidin conjugate can also be viewed through some standard filter sets,

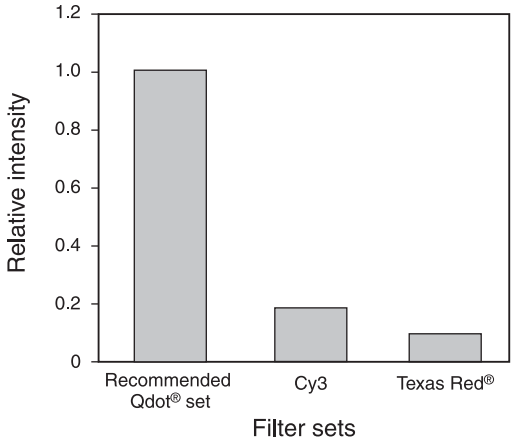

Figure 4. Detection of Qdot® conjugates on tissue sections with recommended and standard filter sets. Mouse kidney sections were stained with Qdot® 605 streptavidin conjugate, and then images were collected on a Nikon epi-fluorescence microscope in 16 bit capture mode. The mean fluorescence of positively stained samples was extracted using Scion Image software. The recommended Qdot® filter set included a 460 nm short pass exciter, a 475 nm dichroic, and a 605/20 nm band pass emitter. The Cy3 filter set included a 545/30 nm exciter, a 570 nm dichroic, and a 610/75 nm emitter. The Texas Red® filter set included a 560/40 nm exciter, a 595 nm dichroic, and a 630/60 nm emitter.

albeit with lower detection efficiency and reduced brightness. For example, three Omega Optical standard filter sets capable of detecting Qdot® 705 conjugates are XF140-2 (Alexa Fluor® 633 & Alexa Fluor® 647), XF70 (Alexa Fluor® 660 & Cy5), and XF141-2 (Cy5.5). Visualization of Qdot® conjugates using a custom filter set is preferred because excitation and detection is less efficient using filters that have not been selected specifically for use with Qdot® conjugates. Using a custom filter set, Qdot® 605 streptavidin conjugate signal is approximately five times as bright as it is using the TRITC filter set, and approximately ten times brighter than it is using the Texas Red®/Cy3.5 filter set (Figure 4). Qdot® optimal filters and standard filter sets are available from many different filter manufacturers. *Appendix 2* illustrates some common filter sets and the optimal filter set recommendations for the available Qdot® streptavidin conjugates. Use of the optimal filter set is critical for attaining optimal signal and sensitivity in your experiments. For detailed technical notes and examples of how to set up specific instruments to detect Qdot® conjugates optimally, visit www.invitrogen.com.

Before You Begin

Qdot® nanocrystals have chemical and optical properties that provide significant advantages over conventional fluorophores in both sensitivity and stability in immunofluorescent labeling of cells and tissue sections. We have conjugated streptavidin to Qdot® nanocrystals to allow use of the materials in a wide variety of labeling applications. Biotinylated antibodies can be obtained or easily prepared using available reagents without substantial disruption of the specificity or affinity of the native antibody. These antibodies can be specifically bound to the biological specimen and then detected through a second round of staining with a Qdot® streptavidin conjugate.

Note: The 705 and 800 nm emission cannot be seen by eye, but is easily detected by many cameras and detectors.

General Considerations

Buffer compatibility

The Qdot® streptavidin conjugates have stable emission in a number of distinct buffers, across a range of pH conditions. At working concentrations, the quantum yield and colloidal dispersion of these materials has been found to be remarkably stable across pH 6–9 (not investigated outside this range) in Tris, HEPES, phosphate, and borate buffers. The Qdot® streptavidin conjugates are stable and non-aggregated in buffered NaCl up to 200 mM at working concentrations. Higher salt concentrations result in microscopic aggregates, but do not appear to cause bulk precipitation of the materials at working dilutions. In addition, a number of surfactants and additives such as Tween 20, Triton® X-100, Pluronic F68, NDSB 201, and EDTA, among others have been shown to maintain the fluorescence when used at 0.05% concentration. In contrast, gelatin and dextran sulfate were found to promote aggregation of the Qdot® 605 streptavidin conjugate at 0.05% concentration, and should be avoided in labeling applications. In general, we recommend storage of Qdot® conjugates at the concentration at which it is shipped, rather than at a high dilution. Storage of Qdot® conjugates at working dilution over longer periods of time may result in substantial performance degradation. While we have not characterized the stability of all Qdot® streptavidin conjugates in all of these conditions, we anticipate similar levels of stability across the range of product colors.

Controls

If you are using the Qdot® conjugates or the labeling protocol for the first time, we recommend including a positive labeling control. For example, an optional control for Qdot® goat-anti-mouse secondary antibodies is anti-OxPhos Complex V Inhibitor Protein (Invitrogen Cat. no. A21355) which targets mitochondria. Other antibodies used in the optimization of this protocol and suitable as positive controls include: rabbit-anti-giantin

(Covance, Cat. no. PRB-114C), rabbit anti-AIF (Cell Signaling, Cat. no. 4642), mouse anti-ki-67 (Ventana Medical Systems, Cat. no. 790-2910), mouse anti-alpha tubulin (Sigma, Cat. no. T6074), rabbit anti-alpha tubulin (Affinity Bioreagents, Cat. no. PA1-20988), mouse anti-nucleosome (BD Pharmingen, Cat. no. 51-80591N), and mouse anti-nucleolin (Invitrogen, Cat. no. 39-6400; Stressgen, Cat. no. KAM-CP100).

Antigen labeling with Qdot® conjugates

Detecting cellular targets with Qdot® streptavidin conjugates can be performed individually by using a single Qdot® streptavidin conjugate with one primary antibody, or multiplexed by using a combination of primary antibodies and various Qdot® nanocrystal colors. Golgi, tubulin, mitochondrial, peroxisome, nucleolin, nucleosome, and ki-67 targets have been validated with this labeling protocol (for a complete list of primary antibodies validated, see above). Other targets and cell lines, however, may require further optimization of this protocol. For example, reducing the fixation time may improve cell penetration and conjugate access for some targets as may increasing the concentration of permeabilization reagent or incubation time with the permeabilization buffer.

Qdot® nanocrystal toxicity

We have not investigated the toxicity of the Qdot® streptavidin conjugate. The materials are provided in a solution which is ~2 mM total Cd concentration; however, the CdSe core is encapsulated in a shell of ZnS and the polymer shell, which may help prevent formation of free Cd. We have demonstrated the utility of these materials in a variety of live-cell *in vitro* labeling experiments, but do not have systematic data on the toxicity of the materials to humans, to animals, or to cells in culture.

FRET or close-proximity quenching

We have not systematically investigated the energy transfer properties of the Qdot® nanocrystals, though they may have useful properties as energy transfer donors and acceptors. We have investigated the fluorescence of Qdot® 605 streptavidin conjugates which are coupled to each other through a bis-biotin linker, and found that the emission intensity of the materials was unperturbed at any concentration of biotin cross-linker. These results suggest that the interparticle quenching of these Qdot® conjugates is negligible. Recent published literature indicates that Qdot® nanocrystals can be used as energy acceptors in time-resolved FRET (TR-FRET) studies.[21]

Disposal of Qdot® Conjugate

The Qdot® conjugate contains cadmium and selenium in an inorganic crystalline form. Dispose of the material in compliance with all applicable local, state, and federal regulations for disposal of these classes of material. For more information on the composition of these materials, consult the Material Safety Data Sheet.

Materials Required but Not Provided

- 10X PBS, pH 7.4 (phosphate buffered saline, Invitrogen Cat. no. 70011-044)
- Fixative: 4% formaldehyde in PBS
- Permeabilization buffer: 0.25% Triton® X-100 in PBS
- Wash buffer: 1X PBS, pH 7.4
- Endogenous Biotin Blocking Kit (Invitrogen Cat. no. E21390)
- Blocking buffer: 6% BSA (bovine serum albumin) and 10% normal serum in PBS
- Primary antibody, biotinylated primary antibody, or other biotinylated protein
- Biotinylated secondary antibody if using non-biotinylated primary antibody
- Secondary incubation buffer: 6% BSA in PBS
- Dehydration solutions: Prepare in containers suitable for a dehydration series ethanol/water dilutions (v/v) of 30%, 50%, 70%, and 90%, as well as 100% ethanol and 100% toluene
- Mounting reagent: Cytoseal™ 60 (Richard-Allan Scientific, Cat. no. 8310-16) is recommended

Preparing Solutions

The amount of solutions prepared as described below is sufficient to process approximately 20 coverslips.

Fixative: 4% formaldehyde in PBS

Prepare 40 mL of fixative **fresh** by combining 10 mL of formaldehyde (ultrapure, methanol-free, 16% formaldehyde solution, Polysciences, Inc. Cat. no. 18814) and 4 mL of 10X PBS, pH 7.4 (Invitrogen Cat. no. 70011-044) with 26 mL of distilled water. Mix well.

Permeabilization buffer: 0.25% Triton® X-100 in PBS

Prepare 40 mL of Permeabilization buffer by adding 100 µL of Triton® X-100 (Sigma, Cat. no. T9284) to 40 mL of 1X PBS. Stir until the Triton® X-100 goes into solution. Store any remaining Permeabilization buffer at 4°C for up to a week.

Wash buffer: 1X PBS, pH 7.4

Prepare 2 L of 1X PBS by combining 200 mL of 10X PBS, pH 7.4 (Invitrogen Cat. no. 70011-044) and 1.8 L of distilled water. Mix well.

Blocking buffer: 6% BSA/10% normal serum in PBS

To prepare 50 mL Blocking buffer, add 3 g of BSA (RIA grade, Fraction V, minimum 96%, Sigma Cat. no. A-7888), 5 mL of normal serum from the host species of the secondary antibody (preferably heat inactivated at 56°C for 1 hour), and 5 mL of 10X PBS, pH 7.4 to 40 mL distilled water. Mix well until the BSA is completely dissolved and adjust the volume to 50 mL with distilled water. Mix well with gentle rocking or stirring. If storing the blocking buffer, add sodium azide to a final concentration of 0.02% and store at 4°C.

Note: Avoid using blocking buffers with casein as casein can cause quenching of Qdot® conjugates.

Primary antibody, biotinylated primary antibody, or other biotinylated protein

Dilute the primary antibody, biotinylated primary antibody, or other biotinylated protein in Blocking buffer at the concentration recommended by the manufacturer.

Note: Briefly centrifuge the primary antibody prior to use. You may need to titrate the primary antibody concentration in preliminary experiments to achieve optimal target labeling.

Biotinylated secondary antibody (required if using non-biotinylated primary antibody)

Dilute the biotinylated secondary antibody in Blocking buffer at the concentration recommended by the manufacturer.

Secondary incubation buffer: 6% BSA in PBS

To prepare 50 mL Secondary incubation buffer, add 3 g of BSA (RIA grade, Fraction V, minimum 96%, Sigma Cat. no. A-7888) and 5 mL of 10X PBS, pH 7.4 to 40 mL of distilled water. Mix well until BSA is completely dissolved and adjust the final volume to 50 mL with distilled water. Mix well with gentle rocking or stirring. If storing the Secondary incubation buffer, add sodium azide to a final concentration of 0.02% and store at 4°C.

Dehydration solutions

Prepare in containers suitable for a dehydration series with ethanol/water dilutions (v/v) of 30%, 50%, 70%, and 90%, as well as 100% ethanol and 100% toluene.

Preparing Qdot® Streptavidin Conjugate

Do not vortex the Qdot® streptavidin conjugate vial. Prepare the required amount of the diluted Qdot® streptavidin conjugate needed for the experiment on the day of use. You will need 40–200 µL Qdot® streptavidin conjugate per coverslip depending on your protocol and the type of humidity chamber you use.

1.1 Centrifuge the Qdot® streptavidin conjugate vial at 5000 × g for 3 minutes prior to use. Use only the supernatant and discard any pellet.

1.2 Dilute the conjugate by adding 2 µL of the stock (1 µM) conjugate to 100 µL Secondary incubation buffer immediately prior to use to obtain the Qdot® streptavidin conjugate concentration of 20 nM (you may use between 10 nM and 40 nM Qdot® streptavidin conjugate final concentration).

1.3 Use the diluted Qdot® streptavidin conjugate immediately for the current experiment. **Do not** store any diluted Qdot® streptavidin conjugate.

Preparing Cells

Culture cells in the appropriate medium to the desired confluency and physiological state (typically 1–2 days for HeLa cells). Make sure the cells are below 80% confluency at the time of fixation, depending on experimental requirements and the imaging method.

Experimental Protocols

Cell Labeling Protocol

Please read entire protocol before starting.

This protocol was validated with HeLa and NIH 3T3 cells, but can be adapted for any adherent mammalian cell types. For tissue labeling protocols, refer to the Qdot® Conjugates Protocol Handbook (mp19029) available for downloading from www.invitrogen.com. Perform all steps of the procedure at room temperature. For a flowchart of the labeling protocol, see Figure 5.

The optimal signal-to-background ratio is obtained from an assay that has been optimized with respect to all of the probe concentrations. Excess concentrations of the primary or secondary antibodies can cause increases in background staining. The optimal concentrations of these reagents can be determined by testing the signal-to-background ratio of control and positive samples that are treated with a dilution series of each antibody, and then stained under typical conditions.

Fixation and Permeabilization

2.1 Rinse cells briefly in 1X PBS prewarmed to 37°C.

2.2 Fix cells in Fixative for 15 minutes. Pour off or aspirate the solution.

2.3 Wash cells 3 times with 1X PBS. If cells are grown on coverslips in a large dish (i.e., 100 mm petri dish), add sufficient volume of 1X PBS to completely cover the specimen (~5 mL for a 100 mm petri dish), swirl gently, pour off or aspirate the solution and repeat. If cells are grown on coverslips in a smaller container (i.e., 6-well plate), wash cells 3 times for 5 minutes each by adding enough 1X PBS to completely cover the specimen. After 5 minutes, pour off or aspirate the solution.

2.4 Permeabilize the specimen with Permeabilization buffer for 15 minutes. Pour off or aspirate the solution.

2.5 Repeat step 2.3.

Note: Changing fixation or permeabilization times, or reagent concentrations may be needed for achieving labeling of certain targets.

Target Labeling and Detection

All incubations are performed in a humidity chamber at room temperature (see **Note**, below). Avoid specimen drying as this can cause high levels of non-specific background and autofluorescence. At the end of each step, carefully remove or blot excess solution from the sample before moving to the next step.

Note: A simple humidity chamber prevents labeling reagent concentration changes due to

evaporation during incubations. To make a simple humidity chamber, place a piece of filter paper in a Petri dish and saturate the filter paper with water. Place a piece of laboratory film on the filter paper and place the coverslip with the solution on the laboratory film. During incubations, place a lid on the Petri dish. Gentle agitation during incubation steps is optional.

2.6 Perform blocking of endogenous biotin with the Endogenous Biotin Blocking Kit (Invitrogen, Cat. no. E21390) as follows. The kit contains two reagents supplied in a ready-to-use format.

a) Incubate in Component A for 30 minutes.

b) Wash 3 times with 1X PBS for 5 minutes each.

c) Incubate in Component B for 30 minutes.

d) Wash 3 times with 1X PBS for 5 minutes each.

2.7 Add Blocking buffer and incubate for 1 hour. Pour off or aspirate the blocking buffer.

2.8 Incubate for 1 hour with primary antibody, biotinylated primary antibody, or other biotinylated protein, diluted in blocking buffer. Pour off or aspirate the solution.

2.9 Wash 3 times with 1X PBS for 5 minutes each.

Note: If using a biotinylated secondary antibody, repeat step 2.8 with the biotinylated antibody and perform wash step 2.9 before proceeding to the next step.

2.10 Incubate for 1 hour with Qdot® streptavidin conjugate, diluted to an optimal concentration (titrate between 10 nM and 40 nM for optimal results) in secondary incubation buffer. Pour off or aspirate the solution.

2.11 Wash 3 times with 1X PBS for 5 minutes each.

2.12 **Optional:** If counterstaining is necessary, most counterstain procedures may be performed at this point, followed by necessary wash steps.

Note: UV excitation of DAPI (Invitrogen, Cat. no.D1306) resulting in emission around 600 nm has been observed, and may not be appropriate for use with all Qdot® nanocrystals. Several other nuclear counterstain options are available in a kit form with optimized protocols for use with Qdot® conjugates such as SelectFX® Nuclear Labeling Kit (Invitrogen, Cat. no. S33025), SYTOX® Green nucleic acid stain (Invitrogen, Cat. no. S7020), 7-aminoactinomycin D (7-AAD) (Invitrogen, Cat. no. A1310), propidium iodide (Invitrogen, Cat. no. P3566), and TO-PRO®-3 iodide (Invitrogen, Cat. no. T3605).

2.13 Dehydrate the specimen by submerging the coverslip sequentially for 5 seconds in 30%, 50%, 70%, and 90% ethanol/water, twice in 100% ethanol, once in 100% toluene, and the final dip in 100% toluene for 10 seconds.

When transferring the coverslip from the last toluene wash to the mounting medium, blot any excess toluene with a laboratory wipe, but allow a sheen of toluene to remain on the coverslip surface. **Do not** allow the residual toluene on the coverslip to completely evaporate prior to mounting, as this can lead to cell morphology damage and/or high background.

2.14 Mount using one drop of Cytoseal™ 60 and allow the specimen to cure at least 4 hours before imaging. For optimal performance, image within 24 hours.

Imaging Guidelines

For optimal imaging of Qdot® streptavidin conjugates, including reduced spectral bleedthrough effects in multi-color applications, use filter sets optimized for the excitation and emission of the Qdot® conjugates in use. These filters are available from Omega Optical, Semrock, or Chroma Technology Corporation (see *Appendix 2* for details). For additional information, visit probes.invitrogen.com/products/qdot.

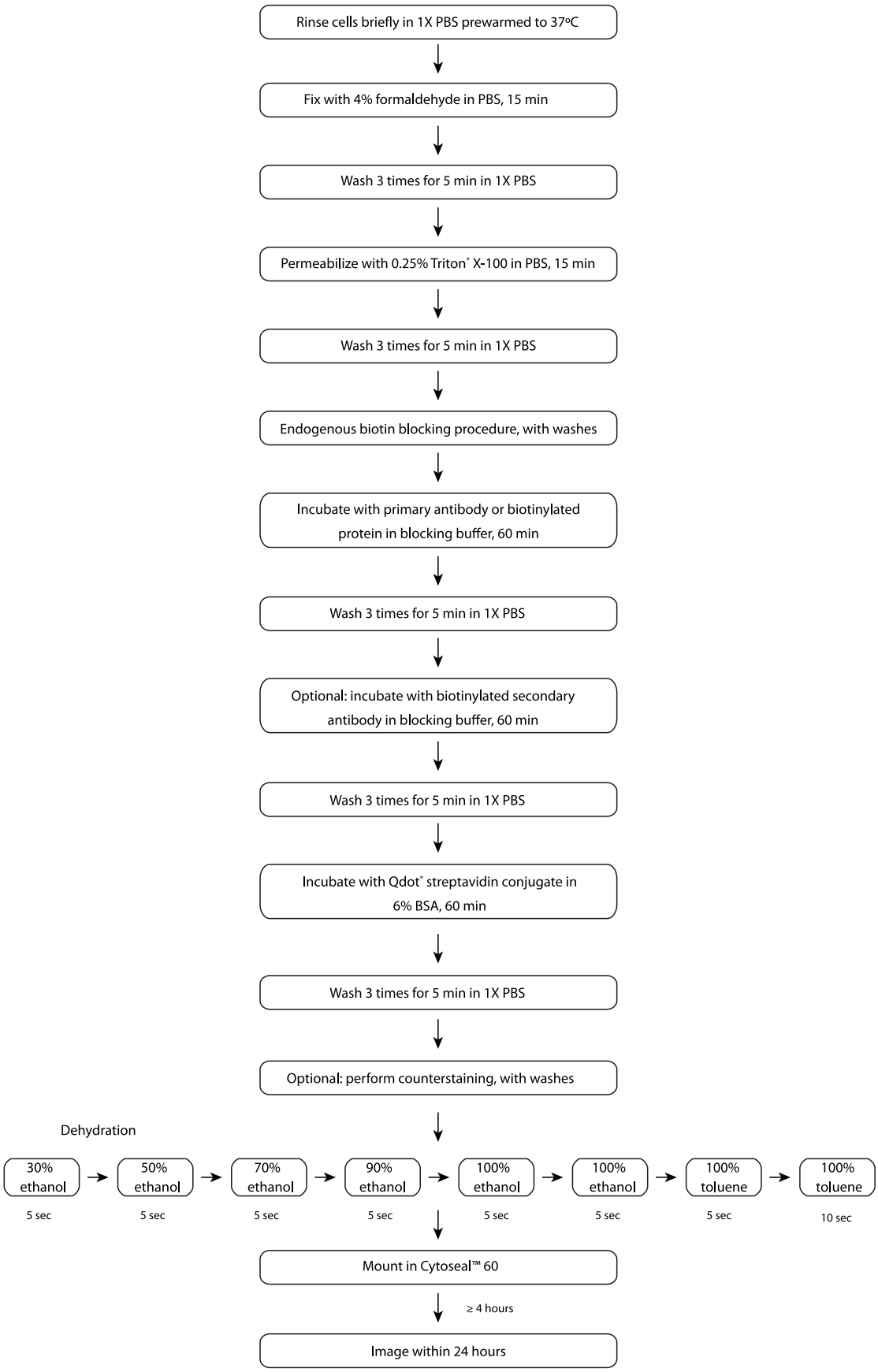

Figure 5. Cell labeling flowchart.

Appendix 1: Troubleshooting Guide

The properties of Qdot® conjugates are different from fluorescent dyes and may require slight modifications to current protocols. We've included this section to help with some specific issues that may arise while using these materials.

No Signal

Setup suitability

Make sure that you are using an appropriate filter set to detect the signals. See *Appendix 2* for a list of appropriate and optimal filters for the Qdot® conjugates. Contact Technical Support (probestech@invitrogen.com) for more details on particular filter set requirements.

Qdot® conjugate luminosity

Qdot® conjugates normally fluoresce brightly under a hand-held ultraviolet lamp (long wave, such as the type used to visualize ethidium bromide on agarose gels). The 705 and 800 nm quantum dot emission cannot be seen by eye, but is detected by many cameras and detectors. Though we have not seen pronounced loss of fluorescence of these materials under any storage conditions that we have investigated, we have not been able to examine all storage conditions. If the Qdot® streptavidin conjugates do not appear to fluoresce under the long wave UV excitation, contact Technical Support (probestech@invitrogen.com) for assistance.

Specificity and titer of primary antibody

Make sure the antibody recognizes the intended targets and that there is sufficient primary antibody bound to the targets. This verification can be performed by ELISA based capture of the antigen of interest, or by other techniques that can be found in lab manuals such as the *Current Protocols in Immunology*.[22]

Biotinylation of antibody

Make sure your antibodies (the primary antibodies for two-layer and the secondary antibodies for three-layer detection) are effectively biotinylated. It may be necessary to independently adjust the concentration of the primary and secondary antibodies used in the assay to obtain optimal signal and minimal background.

High Background

High level of endogenous biotin

Increasing blocking times for the Endogenous Biotin Blocking Kit (Invitrogen Cat. no. E21390) steps may help reduce background due to endogenous biotin.

BSA lot variability

BSA used in the blocking buffer can vary by lot and producer. If unacceptable background is observed, re-optimization of blocking conditions may be required for best results when substituting alternate sources for BSA.

Antibody and Qdot® conjugate concentration optimization

Adjusting the level of biotinylated antibody for the staining can often be used to optimize the specific signal. High levels of biotinylated antibody maybe necessary to obtain the specific labeling, but overly high levels contribute to the nonspecific binding of the antibody to the sample. Nonspecifically bound biotinylated antibody will bind to the Qdot® streptavidin conjugate, resulting in higher background staining.

Appendix 2: Optimal Usable Filter Sets for Qdot® Conjugates

Table 2. Omega Optical filter set for Qdot® streptavidin conjugates.

Color	Optimal filter sets	Usable filter sets
525	XF301 Qdot®525 filter set (Exciter 1: 425DF45 or Exciter 2: 415WB100/ Dichroic: 475DCLP Emitter: 525WB20)	XF100-3, XF100-2, XF115-2, XF89-2
565	XF302 Qdot® 565 filter set (Exciter 1: 425DF45 or Exciter 2: 415WB100/ Dichroic: 475DCLP/ Emitter 565WB20)	XF104-2, XF105-2
585	XF303 Qdot® 585 filter set (Exciter: 1 425DF45 or Exciter 2: 415WB100/ Dichroic: 475DCLP/ Emitter: 585WB20)	XF101-2, XF137-2, XF152-2
605	XF304 Qdot® 605 filter set (Exciter 1: 425DF45 or Exciter 2: 415WB100/ Dichroic: 475DCLP/ Emitter: 605WB20)	XF108-2, XF102-2, XF103-2
655	XF305 Qdot® 655 filter set (Exciter 1: 425DF45 or Exciter 2: 415WB100/ Dichroic: 475DCLP/ Emitter: 655WB20)	XF102-2, XF40-2, XF42, XF45
705*	XF306 Qdot® 705 filter set (Exciter 1: 425DF45 or Exciter 2: 415WB100/ Dichroic: 475DCLP/ Emitter: 710AF40)	XF140-2, XF70, XF110-2, XF141-2, XF48-2
800 *	XF307 Qdot® 800 filter set (Exciter 1: 425DF45 or Exciter 2: 415WB100/ Dichroic: 475DCLP/ Emitter: 800WB80)	XF308 Qdot® 800 filter set for multiplexing (Exciter 1: 425DF45 or Exciter 2: 415WB100/ Dichroic: 475DCLP/ Emitter: 840WB80)
All colors†	XF300 Qdot® filter set (Exciter 1: 425DF45 or Exciter 2: 415WB100/ Dichroic: 475DCLP Emitters: 800WB80, 840WB80, 710AF40, 655WB20, 605WB20, 585WB20, 565WB20, and 525WB20)	XF129-2, XF130-2

*The 705 and 800 nm quantum dot emission cannot be seen by eye and must be detected with an IR-sensitive detector.
†For viewing multiple colors of Qdot® nanocrystals through microscope eyepieces.

Table 3. Semrock filter sets for Qdot® streptavidin conjugates.

Color	Optimal filter sets	Usable filter sets
525	Brightline® QD525-A Filter Sets: QD525-A-000 or QD525-A-000-ZERO (Exciter: FF01-435/40-25) (Dichroic: FF510-Di01-25 x 36) (Emitter: FF01-525/15-25)	GFP-3035B
565	--	FITC-3504B or YFP-2427A
585	--	TRITC-A
605	Brightline® QD605-A Filter Sets: QD605-A-000 or QD605-A-000-ZERO (Exciter: FF01-435/40-25) (Dichroic: FF510-Di01-25 x 36) (Emitter: FF01-605/15-25)	TRITC-A
625	Brightline® QD625-A Filter Sets: QD625-A-000 or QD625-A-000-ZERO (Exciter: FF01-435/40-25) (Dichroic: FF510-Di01-25 x 36) (Emitter: FF01-625/15-25)	Texas Red® (4040B)
655	Brightline® QD655-A Filter Sets: QD655-A-000 or QD655-A-000-ZERO (Exciter: FF01-435/40-25) (Dichroic: FF510-Di01-25 x 36) (Emitter: FF01-655/15-25)	Texas Red® (4040B)
705*	--	Cy5-4040A or Cy5.5-A
800*	--	Cy7-A
LP multi†	QDLP-A Filter Set: QDLP-A-000 (Exciter: FF01-435/40-25) (Dichroic: FF510-Di01-25 x 36) (Emitter: FF01-500/LP-25)	CFW-LP01-CLINICAL

*The 705 and 800 nm quantum dot emission cannot be seen by eye and must be detected with an IR-sensitive detector.
†For viewing multiple colors of Qdot® nanocrystals through microscope eyepieces.

Table 4. Chroma Technology filter sets for Qdot® streptavidin conjugates.

Color	Optimal filter sets	Usable filter sets
525	Qdot® 525 filter set (20 nm EM; 32006) (460SPUV/475DCXRU/D525/20nm) Qdot® 525 filter set (40 nm EM; 32010) (460SPUV/475DCXRU/D525/40nm)	FITC/RSGFP/Bodipy®/Fluo-3/DiO (41001), FITC/RSGFP Longpass (40012), BFP to GFP FRET (31032), BFP to GFP FRET wide excitation (31034), GFP wide blue excitation (31054)
565	Qdot® 565 filter set (20 nm EM; 32005) (460SPUV/475DCXRU/D565/20nm) Qdot® 565 filter set (40 nm EM; 32009) (460SPUV/475DCXRU/D565/40nm)	Eosin (41011), Cascade Yellow™ (31038), JP2(YGFP with EGFP-31040, Auramine (31015)
585	Qdot® 585 filter set (20 nm EM; 32004) (460SPUV/475DCXRU/D585/20nm) Qdot® 585 filter set (40 nm EM; 32008) (460SPUV/475DCXRU/D585/40nm)	R-PE (41003), Rhodamine LP (41032, FITC/PI (41016)
605	Qdot® 605 filter set (20 nm EM; 32003) (460SPUV/475DCXRU/D605/20nm) Qdot® 605 filter set (40 nm EM; 32007) (460SPUV/475DCXRU/D605/40nm)	Cy3 narrow excitation (41007a), Texas Red®/Cy3.5 (31004), TRITC (41002, 41002a, 41002b), Ethidium Bromide (41006)
655	Qdot® 655 filter set (20 nm EM; 32011) (460SPUV/475DCXRU/D655/20nm) Qdot® 655 filter set (40 nm EM; 32012) (460SPUV/475DCXRU/D655/40nm)	Texas Red® (41004), Propidium Iodide (41005), Fura Red™ (31012), Chlorophyll (31017), Allophycocyanin (31006)
705*	Qdot® 705 filter set (20 nm EM; 32014) (460SPUV/475DCXRU/D705/20nm) Qdot® 705 filter set (40 nm EM; 32015) (460SPUV/475DCXRU/D705/40nm)	Cy5 Longpass (41024), Cy5 (41008), Cy5 narrow excitation (41033), Cy5.5 (41023), Alexa Fluor® 680 (41042), Cy5.5 (red-shifted; 41022)
800*	Qdot® 800 filter set (30 nm EM; 32020) (460SPUV/475DCXRU/D800/30nm) Qdot® 800 filter set (50 nm EM; 32021) (460SPUV/475DCXRU/D800/50nm)	Cy7 (41009), Li-Cor for IRDye 800 (41037), Cy7 (SP106)
All colors†	Qdot® Multiple Emission Set (71014) (460SPUV, 475DCXRU, D525/20nm, D605/20nm, D565/20nm, D585/20nm)	UV (11000V2), Blue/Violet (11003V2), UV/Violet (11011V2)

*The 705 and 800 nm quantum dot emission cannot be seen by eye and must be detected with an IR-sensitive detector.
†For viewing multiple colors of Qdot® nanocrystals through microscope eyepieces.

Appendix 3: Extinction Coefficients

Table 5. Extinction coefficients of Qdot® streptavidin conjugates at common excitation wavelengths.

Product	350 nm, in $cm^{-1}M^{-1}$	405 nm, in $cm^{-1}M^{-1}$	488 nm, in $cm^{-1}M^{-1}$	532 nm, in $cm^{-1}M^{-1}$
Qdot® 525 nanocrystals	710,000	360,000	130,000	Not applicable
Qdot® 565 nanocrystals	1,900,000	1,100,000	290,000	139,000
Qdot® 585 nanocrystals	3,500,000	2,200,000	530,000	305,000
Qdot® 605 nanocrystals	4,400,000	2,800,000	1,100,000	580,000
Qdot® 625 nanocrystals	14,700,000	9,900,000	2,700,000	870,000
Qdot® 655 nanocrystals	9,100,000	5,700,000	2,900,000	2,100,000
Qdot® 705 nanocrystals	12,900,000	8,300,000	3,000,000	2,100,000
Qdot® 800 nanocrystals	12,600,000	8,000,000	3,000,000	2,000,000

Appendix 4: Bibliography

There are a number of references that describe the size-dependent properties of the semiconductor nanocrystals. These range in complexity from fairly straightforward descriptions to fairly comprehensive mathematical and physical descriptions of the optical properties. In addition, we have included some representative references that describe the core-shell structures, and the improved chemical properties that are obtained through such structures. References 8–11 describe quantum dots and FRET:

1. Sci Am 285, 66 (2001); **2.** J Phys Chem B 100, 13226 (1996); **3.** J Am Chem Soc 115, 8706 (1993); **4.** Phys Rev B 53, 16338 (1996); **5.** J Phys Chem 100, 468 (1996); **6.** J Phys Chem B. 101, 9463 (1997); **7.** J Am Chem Soc 119, 7019 (1997); **8.** Nano Lett 1, 469 (2001); **9.** J. Am. Chem. Soc 126, 301 (2004); **10.** Nat Mater 2, 630 (2003); **11.** Nat Biotechnol 21, 1387 (2003).

A number of references describe the biological properties of some quantum dots used in experiments. These papers are selected to represent some of the different classes of applications, but this list is not exhaustive. These materials are all quite different from the Qdot® conjugates that are sold by Invitrogen, and the results are not necessarily representative of results attainable with these materials:

12. Science 281, 2013 (1998); **13.** Science 281, 2016 (1998); **14.** J Am Chem Soc 124, 4586 (2002); **15.** Proc Natl Acad Sci U S A. 99, 12617 (2002); **16.** Science 298, 1759 (2002); **17.** Nat Biotechnol 21, 41 (2003); **18.** Nat Biotechnol 21, 47 (2003).

Also of interest:

19. Hermanson, GT. *Bioconjugate Techniques*, Academic Press, 1996; **20.** Lakowicz, J. *Principles of Fluorescence Spectroscopy*. Kluwer Academic Publishing, 1999; **21.** J Am Chem Soc 128, 12800 (2006); **22.** Colligan et. al. *Current Protocols in Immunology*. J. Wiley, Annually Updated, 2002.

Product List **Current prices may be obtained from our website or from our Customer Service Department.**

Cat no.	Product Name	Unit Size
A10196	Qdot® 625 streptavidin conjugate *1 µM solution*	200 µL
Q10101MP	Qdot® 605 streptavidin conjugate *1 µM solution*	200 µL
Q10103MP	Qdot® 605 streptavidin conjugate, starter kit *1 µM solution*	50 µL
Q10111MP	Qdot® 585 streptavidin conjugate *1 µM solution*	200 µL
Q10113MP	Qdot® 585 streptavidin conjugate, starter kit *1 µM solution*	50 µL
Q10121MP	Qdot® 655 streptavidin conjugate *1 µM solution*	200 µL
Q10123MP	Qdot® 655 streptavidin conjugate, starter kit *1 µM solution*	50 µL
Q10131MP	Qdot® 565 streptavidin conjugate *1 µM solution*	200 µL
Q10133MP	Qdot® 565 streptavidin conjugate, starter kit *1 µM solution*	50 µL
Q10141MP	Qdot® 525 streptavidin conjugate *1 µM solution*	200 µL
Q10143MP	Qdot® 525 streptavidin conjugate, starter kit *1 µM solution*	50 µL
Q10151MP	Qdot® Streptavidin Sampler Kit *1 µM solutions*	1 kit
Q10161MP	Qdot® 705 streptavidin conjugate *1 µM solution*	200 µL
Q10163MP	Qdot® 705 streptavidin conjugate, starter kit *1 µM solution*	50 µL
Q10171MP	Qdot® 800 streptavidin conjugate *1 µM solution*	200 µL
Q10173MP	Qdot® 800 streptavidin conjugate, starter kit *1 µM solution*	50 µL
A1310	7-aminoactinomycin D (7-AAD)	1 mg
A21355	anti-OxPhos Complex V inhibitor protein, mouse IgG1, monoclonal 5E2 (anti-ATP synthase IP; anti-F1F0-ATPase IP) *human mitochondrial reactivity*	100 µg
E21390	Endogenous Biotin-Blocking Kit *100 assays*	1 kit
P3356	Propidium iodide *1.0 mg/mL solution in water*	10 mL
S33025	SelectFX® Nuclear Labeling Kit *DAPI, SYTOX® Green, 7-AAD, TO-PRO®-3 iodide* *for fixed cells*	1 kit
S7020	SYTOX® Green nucleic acid stain *5 mM solution in DMSO*	250 µL
T3605	TO-PRO®-3 iodide (642/661) *1 mM solution in DMSO*	1 mL
39-6400	Mouse anti-Nucleolin	100 µg
70011-044	Phosphate-Buffered Saline (PBS), pH 7.4 (10X), liquid	500 mL

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probesorder@invitrogen.com

Toll-Free Ordering for USA:
Order Phone: (800) 438-2209
Order Fax: (800) 438-0228

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Meliorum Technologies, Inc.
Cerium Oxide Nanopowder
Material Safety Data Sheet

1 Identification of substance:

Product details:

Product name: Cerium (IV) oxide

Manufacturer/Supplier:
Meliorum Technologies, Inc.

Information Department: Health, Safety and Environmental Department

Emergency information:
During normal hours the Health, Safety and Environmental Department. After normal hours call Chemtrec at (800) 424-9300.

2 Composition/Data on components:

Chemical characterization:
Description: (CAS#)
Cerium (IV) oxide (CAS# 1306-38-3), 100%

Identification number(s):

EINECS Number: 215-150-4

3 Hazards identification

Hazard description: · Not applicable

Information pertaining to particular dangers for man and environment
Not applicable

Classification system

HMIS ratings (scale 0-4)

(Hazardous Materials Identification System)
Health (acute effects) = 1
Flammability = 1
Reactivity = 1

4 First aid measures

After inhalation
Supply fresh air. If required, provide artificial respiration. Keep patient warm.
Seek immediate medical advice.

After skin contact
Immediately wash with water and soap and rinse thoroughly.
Seek immediate medical advice.

After eye contact
Rinse opened eye for several minutes under running water. Then consult a doctor.

After swallowing Seek medical treatment.

Information for doctor

The following symptoms may occur: Gastric or intestinal disorders.

5 Fire fighting measures

Suitable extinguishing agents
Product is not flammable. Use fire fighting measures that suit the surrounding fire.

Protective equipment:
Wear self-contained respirator.
Wear fully protective impervious suit.

6 Accidental release measures

Person-related safety precautions:
Wear protective equipment. Keep unprotected persons away.
Ensure adequate ventilation

Measures for environmental protection:
Do not allow material to be released to the environment without proper governmental permits.

Measures for cleaning/collecting: Pick up mechanically.

Additional information:
See Section 7 for information on safe handling
See Section 8 for information on personal protection equipment.
See Section 13 for disposal information.

7 Handling and storage

Handling

Information for safe handling:
Keep container tightly sealed.
Store in cool, dry place in tightly closed containers.
No special precautions are necessary if used correctly.

Information about protection against explosions and fires:
The product is not flammable

Storage

Requirements to be met by storerooms and receptacles:
No special requirements.

Information about storage in one common storage facility:
Store away from oxidizing agents.

Further information about storage conditions:
Protect from carbon dioxide.
Keep container tightly sealed.
Store in cool, dry conditions in well sealed containers.

8 Exposure controls and personal protection

Additional information about design of technical systems:
Properly operating chemical fume hood designed for hazardous chemicals and having an average face velocity of at least 100 feet per minute.

Components with limit values that require monitoring at the workplace:
Not required.

Additional information: No data

Personal protective equipment

General protective and hygienic measures
The usual precautionary measures for handling chemicals should be followed.
Keep away from foodstuffs, beverages and feed.
Remove all soiled and contaminated clothing immediately.
Wash hands before breaks and at the end of work.

Breathing equipment:
Use suitable respirator when high concentrations are present.

Protection of hands: Impervious gloves

Eye protection: Safety glasses

Body protection: Protective work clothing.

9 Physical and chemical properties:

General Information

Form: Pieces

Color: Light yellow

Odor: Not determined

	Value/Range	Unit	Method
Change in condition			
Melting point/Melting range:	2600	° C	
Boiling point/Boiling range:	Not determined		
Sublimation temperature / start:	Not determined		
Flash point:	Not applicable		

Flammability (solid, gaseous) Product is not flammable.

Ignition temperature: Not determined

Decomposition temperature: Not determined

Danger of explosion:
Product does not present an explosion hazard.

Explosion limits:

Lower: Not determined

Upper: Not determined

Vapor pressure: Not determined

Density: at 20 ° C 7.132 g/cm³

Solubility in / Miscibility with

Water: Insoluble

10 Stability and reactivity

Thermal decomposition / conditions to be avoided:
Decomposition will not occur if used and stored according to specifications.

Materials to be avoided: Oxidizing agents

Dangerous reactions No dangerous reactions known

Dangerous products of decomposition: None known.

11 Toxicological information

Acute toxicity:

LD/LC50 values that are relevant for classification:
Oral: LD50: >5000 mg/kg (rat)

Primary irritant effect:

on the skin: Powder: irritant effect

on the eye: Powder: irritant effect

Sensitization: No sensitizing effects known.

Subacute to chronic toxicity:
Cerium salts increase the blood coagulation rate. Exposure to cerium salts may increase sensitivity to heat, itching and skin lesions. Large doses to experimental animals have caused writhing, ataxia, labored respiration, sedation, hypotension and death by cardiovascular collapse.

Additional toxicological information:
To the best of our knowledge the acute and chronic toxicity of this substance is not fully known.
No classification data on carcinogenic properties of this material is available from the EPA, IARC, NTP, OSHA or ACGIH.

12 Ecological information:

General notes:
Do not allow material to be released to the environment without proper governmental permits.

13 Disposal considerations

Product:

Recommendation
Consult state, local or national regulations to ensure proper disposal.

Uncleaned packagings:

Recommendation:
Disposal must be made according to official regulations.

14 Transport information

Not a hazardous material for transportation.

DOT regulations:

Hazard class: None

Land transport ADR/RID (cross-border)

ADR/RID class: None

Maritime transport IMDG:

IMDG Class: None

Air transport ICAO-TI and IATA-DGR:

ICAO/IATA Class: None

Transport/Additional information:
Not dangerous according to the above specifications.

15 Regulations

Product related hazard informations:
Observe the general safety regulations when handling chemicals

National regulations
All components of this product are listed in the U.S. Environmental Protection Agency Toxic Substances Control Act Chemical substance Inventory.
All components of this product are listed on the Canadian Domestic Substances List (DSL).

Information about limitation of use:
For use only by technically qualified individuals.

16 Other information:

Employers should use this information only as a supplement to other information gathered by them, and should make independent judgement of suitability of this information to ensure proper use and protect the health and safety of employees. This information is furnished without warranty, and any use of the product not in conformance with this Material Safety Data Sheet, or in combination with any other product or process, is the responsibility of the user.

Meliorum Technologies, Inc.
Zinc Oxide MSDS

1 Identification of substance:

Product name: Zinc oxide

Manufacturer/Supplier:
Meliorum Technologies, Inc.
CHEMTREC: (800) 424-9300
Web Site: www.meliorum.com

Information Department: Health, Safety and Environmental Department

Emergency information:
During normal hours the Health, Safety and Environmental Department. After normal hours call Chemtrec at (800) 424-9300.

2 Composition/Data on components:

Chemical characterization:
Description: (CAS#)
Zinc oxide (CAS# 1314-13-2): 100%

Identification number(s):

EINECS Number: 215-222-5

3 Hazards identification

Hazard description: Xn Harmful

Information pertaining to particular dangers for man and environment
R 20 Harmful by inhalation.

Classification system

HMIS ratings (scale 0-4)

(Hazardous Materials Identification System)
Health (acute effects) = 1
Flammability = 0

Reactivity = 0

4 First aid measures

After inhalation
Supply fresh air. If required, provide artificial respiration. Keep patient warm.
Seek immediate medical advice.

After skin contact
Immediately wash with water and soap and rinse thoroughly.
Seek immediate medical advice.

After eye contact
Rinse opened eye for several minutes under running water. Then consult a doctor.

After swallowing Seek immediate medical advice.

5 Fire fighting measures

Suitable extinguishing agents
Product is not flammable. Use fire fighting measures that suit the surrounding fire.

Special hazards caused by the material, its products of combustion or resulting gases:
In case of fire, the following can be released:
Metal oxide fume

Protective equipment:
Wear self-contained respirator.
Wear fully protective impervious suit.

6 Accidental release measures

Person-related safety precautions:
Wear protective equipment. Keep unprotected persons away.
Ensure adequate ventilation

Measures for environmental protection:
Do not allow material to be released to the environment without proper governmental permits.

Measures for cleaning/collecting:
Dispose contaminated material as waste according to item 13.

Ensure adequate ventilation.

Additional information:
See Section 7 for information on safe handling
See Section 8 for information on personal protection equipment.
See Section 13 for disposal information.

7 Handling and storage

Handling

Information for safe handling:
Keep container tightly sealed.
Store in cool, dry place in tightly closed containers.
Ensure good ventilation at the workplace.

Information about protection against explosions and fires:
No special measures required.

Storage

Requirements to be met by storerooms and receptacles:
No special requirements.

Information about storage in one common storage facility: Not required.

Further information about storage conditions:
Keep container tightly sealed.
Store in cool, dry conditions in well sealed containers.

8 Exposure controls and personal protection

Additional information about design of technical systems:
Properly operating chemical fume hood designed for hazardous chemicals and having an average face velocity of at least 100 feet per minute.

Components with limit values that require monitoring at the workplace:

Zinc oxide

	mg/m3
ACGIH TLV	5; 10-STEL (fume)
	10 (dust)

Belgium TWA	5; 10-STEL (fume)
Denmark TWA	4
Finland TWA	5 (fume)
France TWA	5 (fume)
	10 (dust)
Hungary TWA	5
Netherlands TWA	5
Poland TWA	5; 10-STEL (fume)
Sweden TWA	5
Switzerland TWA	5
United Kingdom TWA	5; 10-STEL (fume)
USA PEL	5 (respirable dust)
	10 (total dust)
	5 (fume)

Additional information: No data

Personal protective equipment

General protective and hygienic measures
The usual precautionary measures for handling chemicals should be followed.
Keep away from foodstuffs, beverages and feed.
Remove all soiled and contaminated clothing immediately.
Wash hands before breaks and at the end of work.

Breathing equipment:
Use suitable respirator when high concentrations are present.

Protection of hands: Impervious gloves

Eye protection: Safety glasses

Body protection: Protective work clothing.

9 Physical and chemical properties:

General Information

Form: Powder

Color: White

Odor: Odorless

	Value/Range	Unit	Method
Change in condition			
Melting point/Melting range:	1975	° C	
Boiling point/Boiling range:	Not determined		
Sublimation temperature / start:	Not determined		
Flash point:	Not applicable		
Ignition temperature:	Not determined		
Decomposition temperature:	Not determined		

Danger of explosion:
Product does not present an explosion hazard.

Explosion limits:

Lower:	Not determined
Upper:	Not determined

Vapor pressure:	Not determined		
Density:	at 20 ° C	5.606	g/cm³

Solubility in / Miscibility with

Water:	Insoluble

10 Stability and reactivity

Thermal decomposition / conditions to be avoided:

Decomposition will not occur if used and stored according to specifications.

Materials to be avoided:
Alkali metals
Alkaline earth metals

Dangerous reactions Reacts with various metals

Dangerous products of decomposition:
No dangerous decomposition products known
Metal oxide fume

11 Toxicological information

Acute toxicity:
LD/LC50 values that are relevant for classification:
Oral: LD50: 7950 mg/kg (mus)
LD50: >8437 mg/kg (rat)
LDLo: 500 mg/kg (hmn)
Inhalative: LC50: 2500 mg/m3 (mus)
Irritation of skin: mild: 500 mg/24H (rbt)
Irritation of eyes: mild: 500 mg/24H (rbt)

Primary irritant effect:

on the skin: Irritant to skin and mucous membranes.

on the eye: Irritating effect.

Sensitization: No sensitizing effects known.

Other information (about experimental toxicology):
Reproductive effects have been observed on tests with laboratory animals.
Mutagenic effects have been observed on tests with bacteria.
Mutagenic effects have been observed on tests with laboratory animals.

Subacute to chronic toxicity:
Zinc containing fumes may cause metal fume fever. Effects include dry throat, metallic taste, chest pain, dyspnea, rales and dry cough. Several hours later, chills may occur with lassitude, malaise, fatigue, headache, back pain, muscle cramps, blurred vision, nausea, fever, perspiration, vomiting and leukocytosis.

Subacute to chronic toxicity:
The Registry of Toxic Effects of Chemical Substances (RTECS) reports the following effects in laboratory animals:

Lungs, Thorax, or Respiration - dyspnea.
Lungs, Thorax, or Respiration - other changes.
Lung, Thorax, or Respiration - cough.
Lung, Thorax, or Respiration - changes in lung weight.
Biochemical - Enzyme inhibition, induction, or change in blood or tissue levels - dehydrogenases.
Biochemical - Enzyme inhibition, induction, or change in blood or tissue levels - other enzymes.
Biochemical - Enzyme inhibition, induction, or change in blood or tissue levels - phosphatases.
Nutritional and Gross Metabolic - weight loss or decreased weight gain.
Blood - changes in serum composition.
Behavioral - changes in motor activity (specific assay).
Reproductive - Effects on Newborn - growth statistics (e.g.%, reduced weight gain).
Endocrine - changes in growth hormone.
Endocrine - evidence of thyroid hypofunction.
Reproductive - Specific Developmental Abnormalities - homeostasis.
Reproductive - Effects on Newborn - stillbirth.

Additional toxicological information:
To the best of our knowledge the acute and chronic toxicity of this substance is not fully known.
EPA-D: Not classifiable as to human carcinogenicity: inadequate human and animal evidence of carcinogenicity or no data are available.

12 Ecological information:

General notes:
Do not allow material to be released to the environment without proper governmental permits.

13 Disposal considerations

Product:

Recommendation
Consult state, local or national regulations to ensure proper disposal.

Uncleaned packagings:

Recommendation:
Disposal must be made according to official regulations.

14 Transport information

Not a hazardous material for transportation.

DOT regulations:

Hazard class: None

Land transport ADR/RID (cross-border)

ADR/RID class: None

Maritime transport IMDG:

IMDG Class: None

Air transport ICAO-TI and IATA-DGR:

ICAO/IATA Class: None

Transport/Additional information:
Not dangerous according to the above specifications.

15 Regulations

Product related hazard informations:

Hazard symbols: Xn Harmful

Risk phrases: 20 Harmful by inhalation.

Safety phrases:
9 Keep container in a well-ventilated place.
36 Wear suitable protective clothing.

National regulations
All components of this product are listed in the U.S. Environmental Agency Toxic Substances Control Act Chemical substance Inventory.

Information about limitation of use:
For use only by technically qualified individuals.

16 Other information:

Employers should use this information only as a supplement to other information gathered by them, and should make independent judgement of suitability of this information to ensure proper use and protect the health and safety of employees. This information is furnished without warranty, and any use of the product not in conformance with this Material Safety Data Sheet, or in combination with any other product or process, is the responsibility of the user.

Department issuing MSDS: Health, Safety and Environmental Department.

Material Safety Data Sheet

Revision Number: 1.2
Revision Date: 22-Jan-2009

Product and Company Identification

Product Name: Qdot® 655 ITK™ amino (PEG) quantum dots *8 μM solution*
Catalog Number: Q21521MP
Unit Size: 250 μL
Manufacturer/Supplier: Molecular Probes, Inc.
29851 Willow Creek Road, Eugene, OR 97402-9132, USA
For US and Canada, Toll-Free Phone: 1-800-438-2209 · Fax: 1-800-438-0228
Phone: (541)465-8300 · Fax: (541)335-0305 · Web: http://probes.invitrogen.com
Technical Assistance: (541)335-0353 · E-mail: probestech@invitrogen.com
Emergency Information: **24-HOUR EMERGENCY PHONE FOR TRANSPORTATION 866-536-0631, 301-431-8585, Outside of the U.S. ++1-301-431-8585**

Composition / Information on Ingredients

- Qdot® 655 ITK™ amino (PEG) quantum dots *8 μM solution*

Molecular Formula: N/A
Molecular Weight: 0.0
CAS Number/Name: N/A

Hazards Identification

Emergency Overview: We are not aware of any reported health hazards for this product. We recommend treating all chemicals with caution.

Potential Health Effects
Inhalation: Not hazardous
Ingestion: Not hazardous
Skin: Not hazardous
Eyes: Not hazardous
Chronic Exposures: Not determined
Target Organs: Not determined

First Aid Measures

Potentially harmful. Avoid prolonged or repeated exposure. Wash thoroughly after handling. If eye or skin contact occurs, wash affected area with water for 15 minutes and seek medical advice. If inhaled, move individual to fresh air and seek medical advice. If swallowed, seek medical advice.

Fire Fighting Measures

Use dry chemical powder or appropriate foam extinguisher.

Accidental Release Measures

Use appropriate protective equipment and methods to clean up spilled substances promptly. Absorb spill onto an appropriate material. Collect and dispose of all waste in accordance with applicable laws.

Handling and Storage

Store at 2-6°C, DO NOT FREEZE.

Exposure Controls / Personal Protection

Wear appropriate gloves, protective clothing and eyewear and follow safe laboratory practices.
ACGIH/OSHA Permissible Exposure Limit Data: Not determined

Physical and Chemical Properties

Form:	Solution
Odor:	Not disclosed
Solubility in Water:	Not disclosed
Specific Gravity:	Not disclosed
pH:	Not disclosed
Boiling Point:	Not disclosed
Melting Point:	Not disclosed
Flash Point:	Not disclosed
Vapor Pressure:	Not disclosed

Stability and Reactivity

Thermal Decomposition: No decomposition if used according to specifications.
Dangerous Reactions: No dangerous reactions identified.
Dangerous Products of Decomposition: No dangerous decomposition products identified.

Toxicological Information

RTECS Number:	Not disclosed
Toxicity:	To our knowledge, the health hazards have not been thoroughly investigated.
Health Hazards:	We are not aware of any reported health hazards for this product. We recommend treating all chemicals with caution.
Potential Hazards:	See health hazards above.
Carcinogenicity:	Not listed by NTP, IARC or OSHA.

Ecological Information

Do not allow product to reach ground water, water course, or sewage system.

Disposal Considerations

Consult local, state or national regulations for proper disposal.

Transport Information

Hazard Class: Not regulated for transport.
Identification Number: Not disclosed
Packing Group: Not classified
Proper Shipping Name (Technical Name): Not disclosed

Regulations

US Toxic Substances Control Act (TSCA): Not disclosed
US Other: Not disclosed
EEC EINECS Number: Not disclosed
EEC Risk Statements: None identified
Other Country Regulations: Not disclosed

Other Information

This material is sold for research purposes only and is not required to appear on the TSCA inventory. It is not intended for food, drug, household, agricultural or cosmetic use. Its use must be supervised by a technically qualified individual experienced in handling potentially hazardous chemicals. The above information is correct to the best of our knowledge. Users should make independent decisions regarding completeness of the information based on all sources available. Molecular Probes shall not be held liable for any damage resulting from handling or contact with the above product.

Material Safety Data Sheet: Zinc Oxide

MTI Corporation
2700 Rydin Road, Unit D
Richmond, CA 94804
USA

Telephone: (510) 525-3070
Fax: (510) 525-4705
www.mtixtl.com

Section 1, Product Identification

Trade Name: Zinc Oxide Formula: ZnO
Synonyms: Natural zincite; flowers of zinc; philosopher's wool; zinc white; CI pigment
Chemical Nature: Inorganic II-VI Compound; Metal Oxide

OSHA PEL: 15 mg/m^3 ACGIH TLV: 10 mg/m^3 Other Limits: 5 mg/m^3
EPA EPCRA: *302 TPQ: No, *304 RQ: No *313 Report: No
HMIS Ratings: Health: 2 Flammability : 0 Reactivity : 0

Section 2: Composition/Ingredients

INGREGIENT	CAS#	Percent
zinc oxide	1314-13-2	100

Section 3: Physical/Chemical Data

Boiling Point: N/A or N/E Specific Gravity (H2O=1):5.606
Vapor Pressure (mm Hg): N/A or N/E Vapor Density (Air = 1): N/A or N/E
% Volatile by Volume: N/A or N/E Evaporation Rate (Butyl Acetate=1): 0
Solubility in Water: Insoluble Melting Point: 1975 deg C
Solubility in Mineral Acids: N/A
Appearance and Odor: white to yellowish transparent appearance with no odor

Section 4: Fire and Explosion Hazard Data

Flash Point: N/A Auto-ignition Temperature: N/A
LEL: N/A UEL: N/A Flammable Limits: Nonflammable
Extinguishing Media: Use suitable extinguishing media for surrounding materials and type of fire
Special Fire Fighting Procedures: Firefighters must wear full face, self-contained breathing apparatus with full protective clothing to prevent contact with skin and eyes. Fumes from fire are hazardous. Isolate runoff to prevent environmental pollution.
Unusual Fire and Explosion Hazards: When heated to decomposition, zinc oxide may emit toxic fumes of oxides of zinc. May explode when mixed with chlorinated rubber. Violent reaction with magnesium, linseed oil.

Section 5: Reactivity Data

Stability: Stable Conditions to Avoid: None
Incompatibility (Conditions to Avoid): Aluminum, hexachloroethane, chlorinated rubber, linseed oil, magnesium.
Hazardous Polymerization: Will not occur
Hazardous Decomposition Products: Zinc oxide and oxide of zinc

Section 6: Health Hazard Data

Routes of Entry (Under Normal Conditions of Use):
Inhalation – Yes Skin – Yes Ingestion – Yes Eye – Yes

Target Organs: No target organs recorded.
Medical Conditions Generally Aggravated by Exposure: Pre-existing respiratory and disorders.

Carcinogenicity: None listed
NTP – Not Listed IARC Monograph – No OSHA Regulated – No

Health Hazards (Acute and Chronic):

Zinc compounds have variable toxicity, but generally are of low toxicity. Zinc is not inherently a toxic element. However, when heated, it evolves a fume of zinc oxide which when inhaled fresh can cause a disease known as "brass founders", "ague" or "brass chills'. Zinc oxide dust which is not freshly formed is virtually innocuous. There is no cumulative effect from the inhalation of zinc fumes. (Sax, Dangerous Properties of Industrial Materials, eighth edition)

Inhalation:
Acute: May cause respiratory tract irritation with nasopharynitis and laryngitis.
Chronic: May cause human system effect.

Ingestion:
Acute: Moderately toxic. May cause gastrointestinal disturbances.
Chronic: No chronic health effects recorded

Skin:
Acute: May cause irritation.
Chronic: No chronic health effects recorded

Eyes:
Acute: May cause irritation.
Chronic: No chronic health effects recorded

Emergency and First Aid Procedures: Treat symptomatically
Eyes: Flush eyes with lukewarm water, lifting upper and lower eyelids, for at least 15 minutes. Seek medical attention.
Skin: Remove contaminated clothing. Brush material off skin. Wash affected area with soap and water. Seek medical attention.
Inhalation: Remove victim to fresh air, keep warm and quiet, Administer oxygen if breathing is difficult. Seek medical attention
Ingestion: Give victim fluids and do not induce vomiting. Never induce vomiting or give anything by mouth to an unconscious person. Seek immediate medical attention.

Section 7: Precautions for Safe Handling and Use

Steps to be Taken in Case Material is Released or Spilled: Wear a self-contained breathing apparatus and full protective clothing. Isolate the area where the spill occurred and insure that proper ventilation is available. Vacuum up spill using a high efficiency particulate absolute (HEPA) air filter and place in a container for proper disposal. Take care not to raise dust.

Waste Disposal Method: In accordance with Local, State and Federal Waste Disposal Regulations.

Section 8: Control Measures

Respiratory Protection (Specify Type): Wear NIOSH-approved dust cartridge respirator
Ventilation: Local Exhaust: Maintain exposure below TLV/PEL level
Protective Gloves: Neoprene; Rubber Eye Protection: Safety Glasses
Other Protective Clothing or Equipment: Wear protective clothing to prevent contamination of skin and clothes. Barrier creams may help prevent irritation in hypersensitive individuals.

Work/Hygienic Practices: Wash hands and face thoroughly after handling and before meals; Do not blow dust off clothing or skin with compressed air. Store in tightly closed containers, in a cool, dry place. Use good housekeeping and sanitation practices.

Material Safety Data Sheet

acc. to OSHA and ANSI

1 Identification of substance:

- **Product details:**
- **Trade name:** Titanium (IV) oxide, anatase
- **Stock number:** 5430MR
- **Manufacturer/Supplier:**
  Nanostructured & Amorphous Materials, Inc.
  16840 Clay Road, Suite #113
  Houston, TX 77084, USA

2 Composition/Data on components:

- **Chemical characterization:**
  Description:
  (CAS#)
  Titanium (IV) oxide, anatase (CAS# 13463-67-7), 99.7%
- **Identification number(s):**
- **EINECS Number:** 215-282-2

3 Hazards identification

- **Hazard description:** Xn Harmful
- **Information pertaining to particular dangers for man and environment**
  R 20 Harmful by inhalation.
  R 40 Possible risks of irreversible effects.

4 First aid measures

- **After inhalation**
  Supply fresh air. If required, provide artificial respiration. Keep patient warm.
  Seek immediate medical advice.

- **After skin contact**
  Immediately wash with water and soap and rinse thoroughly.
  Seek immediate medical advice.

- **After eye contact**
  Rinse opened eye for several minutes under running water.
  Then consult a doctor.

- **After swallowing** Seek immediate medical advice.

5 Fire fighting measures

- **Suitable extinguishing agents**
  Product is not flammable. Use fire fighting measures that suit the surrounding fire.

- **Protective equipment:**
  Wear self-contained respirator.
  Wear fully protective impervious suit.

6 Accidental release measures

- **Person-related safety precautions:**
  Wear protective equipment. Keep unprotected persons away.
  Ensure adequate ventilation

- **Measures for environmental protection:**
  Do not allow material to be released to the environment without proper governmental permits.

- **Measures for cleaning/collecting:**
  Dispose contaminated material as waste according to item 13.
  Ensure adequate ventilation.

- **Additional information:**
  See Section 7 for information on safe handling
  See Section 8 for information on personal protection equipment.
  See Section 13 for disposal information.

7 Handling and storage

- **Handling**

- **Information for safe handling:**
  Keep container tightly sealed.

Store in cool, dry place in tightly closed containers.
Ensure good ventilation at the workplace.
Prevent formation of dust.

- **Information about protection against explosions and fires:**
  No special measures required.

- **Storage**

- **Requirements to be met by storerooms and receptacles:**
  No special requirements.

- **Information about storage in one common storage facility:**
  Not required.

- **Further information about storage conditions:**
  Keep container tightly sealed.
  Store in cool, dry conditions in well sealed containers.

8 Exposure controls and personal protection

- **Additional information about design of technical systems:**
  Properly operating chemical fume hood designed for hazardous chemicals and having an average face velocity of at least 100 feet per minute.

Components with limit values that require monitoring at the workplace:

Titanium dioxide

	mg/m^3
ACGIH TLV	10; A4
Belgium TWA	10
Denmark	6
France TWA	10
Germany TWA	1.5 (respirable fraction of the aerosol)
Ireland TWA	5 (respirable dust)
	10 (total inhalable dust)
Netherlands TWA	10 (inhalable)
Switzerland TWA	6
United Kingdom TWA	4 (respirable dust)
	10 (total inhalable dust)
OSHA PEL	15 (total dust)

Not applicable

- **Additional information:** No data

- **Personal protective equipment**

- **General protective and hygienic measures**
  The usual precautionary measures for handling chemicals should be followed.
  Keep away from foodstuffs, beverages and feed.
  Remove all soiled and contaminated clothing immediately.
  Wash hands before breaks and at the end of work.

- **Breathing equipment:**
  Use suitable respirator when high concentrations are present.

- **Protection of hands:** Impervious gloves

- **Eye protection:** Safety glasses

- **Body protection:** Protective work clothing.

9 Physical and chemical properties:

- **Form:** Powder

- **Color:** White

- **Odor:** Odorless

	Value/Range	Unit	Method
Change in condition			
Melting point/Melting range:	1830-1850	° C	
Boiling point/Boiling range:	2500-3000	° C	
Sublimation temperature / start:	Not determined		
Flash point:	Not applicable		
Ignition temperature:	Not determined		
Decomposition temperature:	Not determined		

- **Danger of explosion:**
  Product does not present an explosion hazard.

- **Explosion limits:**

- **Lower:** Not determined

- **Upper:** Not determined

- **Vapor pressure:** Not determined

- **Density:** at 20 ° C 3.9 g/cm³

- **Solubility in / Miscibility with**

- **Water:** Insoluble

10 Stability and reactivity

- **Thermal decomposition / conditions to be avoided:**
  Decomposition will not occur if used and stored according to specifications.

- **Materials to be avoided:**
  Acids
  Metal powders

- **Dangerous reactions** No dangerous reactions known

- **Dangerous products of decomposition:**
  No dangerous decomposition products known

11 Toxicological information

- **Acute toxicity:**

- **Primary irritant effect:**

- **on the skin:** Irritant to skin and mucous membranes.

- **on the eye:** Irritating effect.

- **Sensitization:** No sensitizing effects known.

- **Other information (about experimental toxicology):**

Tumorigenic effects have been observed on tests with laboratory animals.
Carcinogenic effects have been observed on tests with laboratory animals.

- **Additional toxicological information:**
  To the best of our knowledge the acute and chronic toxicity of this substance is not fully known.
  IARC-3: Not classifiable as to carcinogenicity to humans.
  ACGIH A4: Not classifiable as a human carcinogen:
  Inadequate data on which to classify the agent in terms of it's carcinogenicity in humans and/or animals.
  The Registry of Toxic Effects of Chemical Substances (RTECS) contains tumorigenic and/or carcinogenic and/or neoplastic data for components in this product.

12 Ecological information:

- **General notes:**
  Do not allow material to be released to the environment without proper governmental permits.

13 Disposal considerations

- **Product:**

- **Recommendation**
  Consult state, local or national regulations for proper disposal.

- **Uncleaned packagings:**

- **Recommendation:**
  Disposal must be made according to official regulations.

14 Transport information

Not a hazardous material for transportation.

- **DOT regulations:**

- **Hazard class:** None

- **Land transport ADR/RID (cross-border)**
- **ADR/RID class:** None
- **Maritime transport IMDG:**
- **IMDG Class:** None
- **Air transport ICAO-TI and IATA-DGR:**
- **ICAO/IATA Class:** None
- **Transport/Additional information:**
  Not dangerous according to the above specifications.

15 Regulations

- **Product related hazard informations:**
- **Hazard symbols:** Xn Harmful
- **Risk phrases:**
  20 Harmful by inhalation.
  40 Possible risks of irreversible effects.
- **Safety phrases:** 22 Do not breathe dust.
- **National regulations**
  All components of this product are listed in the U.S. Environmental Protection Agency Toxic Substances Control Act Chemical Substance Inventory.
- **Information about limitation of use:**
  For use only by technically qualified individuals.

16 Other information:

Employers should use this information only as a supplement to

other information gathered by them, and should make independent judgement of suitability of this information to ensure proper use and protect the health and safety of employees. This information is furnished without warranty, and any use of the product not in conformance with this Material Safety Data Sheet, or in combination with any other product or process, is the responsibility of the user.

Material Safety Data Sheet

acc. to OSHA and ANSI

1 Identification of substance:

- **Product details:**
- **Trade name:** Zinc oxide
- **Stock number:** 5810HT
- **Manufacturer/Supplier:**
  Nanostructured & Amorphous Materials, Inc.
  16840 Clay Road, Suite #113
  Houston, TX 77084, USA

2 Composition/Data on components:

- **Chemical characterization:**

Description: (CAS#)
zinc oxide (CAS# 1314-13-2); 99.5%

- **Identification number(s):**
- **EINECS Number:** 215-222-5

3 Hazards identification

- **Hazard description:** Xn Harmful
- **Information pertaining to particular dangers for man and environment**
  R 20 Harmful by inhalation.

4 First aid measures

- **After inhalation**
  Supply fresh air. If required, provide artificial respiration. Keep patient warm.
  Seek immediate medical advice.
- **After skin contact**
  Immediately wash with water and soap and rinse thoroughly.
  Seek immediate medical advice.
- **After eye contact**
  Rinse opened eye for several minutes under running water. Then consult

a doctor.

- **After swallowing** Seek immediate medical advice.

5 Fire fighting measures

- **Suitable extinguishing agents**
  Product is not flammable. Use fire fighting measures that suit the surrounding fire.

- **Protective equipment:**
  Wear self-contained respirator.
  Wear fully protective impervious suit.

6 Accidental release measures

- **Person-related safety precautions:**
  Wear protective equipment. Keep unprotected persons away.
  Ensure adequate ventilation

- **Measures for environmental protection:**
  Do not allow material to be released to the environment without proper governmental permits.

- **Measures for cleaning/collecting:**
  Dispose contaminated material as waste according to item 13.
  Ensure adequate ventilation.

- **Additional information:**
  See Section 7 for information on safe handling
  See Section 8 for information on personal protection equipment.
  See Section 13 for disposal information.

7 Handling and storage

- **Handling**

- **Information for safe handling:**
  Keep container tightly sealed.
  Store in cool, dry place in tightly closed containers.
  Ensure good ventilation at the workplace.

- **Information about protection against explosions and fires:**
  No special measures required.

- **Storage**

- **Requirements to be met by storerooms and receptacles:**
  No special requirements.

- **Information about storage in one common storage facility:** Not required.

- **Further information about storage conditions:**
  Keep container tightly sealed.
  Store in cool, dry conditions in well sealed containers.

8 Exposure controls and personal protection

- **Additional information about design of technical systems:**
  Properly operating chemical fume hood designed for hazardous chemicals and having an average face velocity of at least 100 feet per minute.

  Components with limit values that require monitoring at the workplace:

Zinc oxide	mg/m^3
ACGIH TLV	10
Belgium TWA	10, 5 mg/m^3 STEL
Denmark TWA	4
Finland TWA	5 fume
France TWA	5 fume
Hungary TWA	5
Ireland TWA	5, 10 mg/m^3 STEL fume
Netherlands TWA	5 fume
Poland TWA	5 fume
Sweden TWA	5
Switzerland TWA	5
United Kingdom TWA	5, 10 mg/m^3 STEL
USA PEL	15 total dust, 5 mg/m^3 respirable

- **Additional information:** No data

- **Personal protective equipment**

- **General protective and hygienic measures**
  The usual precautionary measures for handling chemicals should be followed.
  Keep away from foodstuffs, beverages and feed.
  Remove all soiled and contaminated clothing immediately.
  Wash hands before breaks and at the end of work.

- **Breathing equipment:**
  Use suitable respirator when high concentrations are present.

- **Protection of hands:** Impervious gloves

- **Eye protection:** Safety glasses

- **Body protection:** Protective work clothing.

9 Physical and chemical properties:

- **Form:** Powder

- **Color:** Milky White

- **Odor:** Odorless

-

	Value/Range	Unit	Method

- **Change in condition**

- **Melting point/Melting range:** 1975 °C

- **Boiling point/Boiling range:** Not determined

- **Sublimation temperature / start:** Not determined

- **Flash point:** Not applicable

- **Ignition temperature:** Not determined

- **Decomposition temperature:** Not determined

- **Danger of explosion:**
  Product does not present an explosion hazard.

- **Explosion limits:**

- **Lower:** Not determined

- **Upper:** Not determined

- **Vapor pressure:** Not determined

- **Density:** at 20 °C 5.606 g/cm^3

- **Solubility in / Miscibility with**

- **Water:** Insoluble

10 Stability and reactivity

- **Thermal decomposition / conditions to be avoided:**
  Decomposition will not occur if used and stored according to specifications.

- **Materials to be avoided:**
  Alkali metals
  Alkaline earth metals

- **Dangerous reactions** Reacts with various metals

- **Dangerous products of decomposition:**
  No dangerous decomposition products known

11 Toxicological information

- **Acute toxicity:**
  LD/Lc50 values that are relevant for classification:
  zinc oxide (CAS# 1314-13-2); 100%
  Oral: LD50: 7950 mg/kg (mus)
  LD50: 8437 mg/kg (rat)

Inhalative: LC50: 2500 mg/m^3 (mus)

- **Primary irritant effect:**

- **on the skin:** Irritant to skin and mucous membranes.

- **on the eye:** Irritating effect.

- **Sensitization:** No sensitizing effects known.

- **Subacute to chronic toxicity:**
  Zinc containing fumes may cause metal fume fever. Effects include dry throat, metallic taste, chest pain, dyspnea, rales and dry cough. Several hours later, chills may occur with lassitude, malaise, fatigue, headache, back pain, muscle cramps, blurred vision, nausea, fever, perspiration, vomiting and leukocytosis.

- **Additional toxicological information:**
  To the best of our knowledge the acute and chronic toxicity of this substance is not fully known.
  EPA-D: Not classifiable as to human carcinogenicity: inadequate human and animal evidence of carcinogenicity or no data are available.

12 Ecological information:

- **General notes:**
  Do not allow material to be released to the environment without proper governmental permits.

13 Disposal considerations

- **Product:**

- **Recommendation**
  Consult state, local or national regulations for proper disposal.

- **Uncleaned packagings:**

- **Recommendation:**
  Disposal must be made according to official regulations.

14 Transport information

- **DOT**

  Proper Shipping Name: None

  Non-Hazardous for Transport: This substance is considered to be non-hazardous for transport.

- **IATA**

  Non-Hazardous for Air Transport: Non-hazardous for air transport.

15 Regulations

- **Product related hazard informations:**

- **Hazard symbols:** Xn Harmful

- **Risk phrases:** 20 Harmful by inhalation.

- **Safety phrases:**
  9 Keep container in a well-ventilated place.
  36 Wear suitable protective clothing.

- **National regulations**
  All components of this product are listed in the U.S. Environmental Protection Agency Toxic Substances Control Act Chemical Substance Inventory.

- **Information about limitation of use:**
  For use only by technically qualified individuals.

16 Other information:

Employers should use this information only as a supplement to other information gathered by them, and should make independent judgement of suitability of this information to ensure proper use and protect the health and safety of employees. This information is furnished without warranty, and any use of the product not in conformance with this Material Safety Data Sheet, or in combination with any other product or process, is the responsibility of the user.

MATERIAL SAFETY DATA SHEET
NanoXact™ Silver Nanoparticles (AGPN)

Manufacturer: nanoComposix, Inc.
4878 Ronson CT STE K
San Diego, CA 92111-1806

NANOCOMPOSIX CUSTOMER SERVICE: (858) 565-4227
CHEMTREC (EMERGENCY ONLY): (800) 424-9300
POISON CENTER: (800) 562-8236

SECTION 1 Product Identification

CHEMICAL NAME: Colloidal silver nanoparticles

CAS REGISTRY NUMBER: 9015-51-4 (silver colloid)

FORMULA: Ag

EINECS NUMBER: NA (See components)

CHEMICAL FAMILY: metal

SYNONYM: silver nanoparticles, colloidal silver, nano silver, BioPure™ Silver

SECTION 2 Composition and Information on Ingredients

INGREDIENTS	CAS #	% by Mass	Hazardous
Silver (as colloid)	9015-51-4	0.002	No
Polyvinylpyrrolidone	9003-39-8	trace	No
Water	231-791-2	>99	No

SECTION 3 Hazards Identification

EMERGENCY OVERVIEW:

OSHA Hazards: No known OSHA hazards. Not a dangerous substance according to GHS.

HMIS CLASSIFICATION

Health Hazard: 0
Flammability: 0
Physical Hazards: 0

NFPA RATING

Health Hazard: 0
Fire: 0
Reactivity Hazard: 0

APPEARANCE: Yellow/brown, yellow/grey or yellow/opal colored liquid.

PRIMARY ROUTES OF EXPOSURE: Ingestion, dermal contact.

EYE CONTACT: May cause eye irritation. Prolonged exposure may cause eye damage.

SKIN CONTACT: May be harmful if absorbed through skin. May cause skin irritation.

INHALATION: May be harmful if inhaled. May cause respiratory tract irritation.

INGESTION: May be harmful if ingested.

ACUTE HEALTH EFFECTS: May be irritating to skin, eyes and digestive tract.

CHRONIC HEALTH EFFECTS: Repeated and prolonged exposures have not been studied.

AGGRAVATION of PRE-EXISTING CONDITIONS: Persons with preexisting conditions may be more susceptible.

SECTION 4 First Aid Measures

EYE EXPOSURE: Remove contacts if present. Immediately flush the eyes with water for at least 10-15 minutes. Seek medical attention if irritation persists.

SKIN EXPOSURE: Wash the affected area with soap and water. Remove contaminated clothes if necessary. Seek medical assistance if irritation persists.

INHALATION: If breathed in, move person to fresh air. If not breathing, give artificial respiration.

INGESTION: If the person is conscious, rinse their mouth out with water. Never give anything by mouth to an unconscious person.

SECTION 5 Fire Fighting Measures

FLASH POINT: Not applicable.

AUTO IGNITION TEMPERATURE: Not applicable.

EXPLOSION LIMITS: Not applicable.

EXTINGUSHING MEDIUM: Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

SPECIAL FIRE FIGHTING PROCEDURES: Wear self contained breathing apparatus for fire fighting if necessary.

HAZARDOUS COMBUSTION AND DECOMPOSITION PRODUCTS: None.

UNUSUAL FIRE OR EXPLOSION HAZARDS: None.

SECTION 6 Accidental Release Measures

SPILL AND LEAK PROCEDURES: Small spills can be swept up or diluted flushed with water to dilute according to local, state, and federal disposal guidelines. Solid surface should be wiped with a detergent-based cleaner to clean any remaining materials.

SECTION 7 Handling and Storage

HANDLING: Avoid contact with skin, eyes and clothing. Avoid prolonged or repeat exposure.

STORAGE: Closed container stored at 4°C away from light. DO NOT FREEZE.

SECTION 8 Exposure Controls and Personal Protection

Contains no substances with occupational exposure limit values.

EYE PRODUCTION: Always wear approved safety glasses when handling a chemical substance in the laboratory.

SKIN PROTECTION: Wear protective clothing and gloves.

VENTILIATION: None.

RESPIRATOR: Respiratory protection not required.

ADDITIONAL PROTECTION: No additional protection required.

SECTION 9 Physical and Chemical Properties

FORM:	Liquid, individual particles 5-150nm total diameter.
COLOR:	Yellow/brown, yellow/grey or yellow/opal.
MOLECULAR WEIGHT:	No data available.
MELTING POINT (°C):	No data available.
BOILING POINT (°C):	No data available.
VAPOR PRESSURE:	No data available.
SPECIFIC GRAVITY:	No data available.
ODOR:	No data available.
SOLUBILITY IN WATER:	No data available.

SECTION 10 Stability and Reactivity

STABILITY: Stable under recommended storage conditions. DO NOT FREEZE.

POSSIBILITY OF HAZARDOUS REACTIONS: No data available.

CONDITIONS TO AVOID: No data available.

MATERIALS TO AVOID: No data available.

HAZARDOUS DECOMPOSITION PRODUCTS:
Hazardous decomposition products may be formed under fire conditions – Silver/silver oxides
Hazardous decomposition products may be formed under fire conditions – Nature of decomposition products not known.

SECTION 11 Toxicological Information

ACUTE TOXICITY

Oral LD50:	No data available.
Inhalation LD50:	No data available.
Dermal LD50:	No data available.
Other information on acute toxicity:	No data available.
SKIN CORROSION/IRITATION:	No data available.
SERIOUS EYE DAMAGE/IRRITATION	No data available.
RESPIRATORY OR SKIN SENSITIZATION	No data available.
GERM CELL MUTAGENICITY	No data available.

CARCINOGENICITY

IARC: No component of this product is identified as a probable or confirmed human carcinogen by IARC.

ACGIH: No component of this product is identified as a probable or confirmed human carcinogen by ACGIH.

NTP: No component of this product is identified as a probable or confirmed human carcinogen by NTP.

OSHA: No component of this product is identified as a probable or confirmed human carcinogen by OSHA.

REPRODUCTIVE TOXICITY:	No data available
TERATOGENICITY:	No data available
SPECIFIC TARGET ORGAN TOXICITY	No data available
APIRATION HAZARD	No data available
POTENTIAL HEALTH EFFECTS	
Inhalation:	May be harmful if inhaled. May cause respiratory tract irritation.
Ingestion:	May be harmful if swallowed.
Skin:	May be harmful if absorbed through skin. May cause skin irritation.
Eyes:	May cause eye irritation.

SIGNS AND SYMPTOMS OF EXPOSURE: May cause argyria (a slate-grey or bluish discoloration of the skin and deep tissues to the deposit of insoluble albuminate of silver.

SYNERGISTIC EFFECTS:	No data available.
ADDITIONAL INFORMATION:	RTECS note available.

SECTION 12 Ecological Information

APIRATION HAZARD	No data available.
PERSISTANCE AND DEGRADABILITY:	No data available.
BIOACCUMULATIVE POTENTIAL:	No data available.
MOBILITY IN SOIL:	No data available.
PBT AND vPvB ASSESSMENT:	No data available.
OTHER ADVERSE EFFECTS:	No data available.

SECTION 13 Disposal Considerations

DISPOSAL: Dispose of according to local, state and federal regulations.

SECTION 14 Transportation Information

DOT (US):	Not dangerous goods.
IMDG:	Not dangerous goods.
IATA:	Not dangerous goods.
SHIPPING NAME (CFR):	Non-hazardous.
SHIPPING NAME (IATA):	Non-hazardous.

SECTION 15 Regulatory Information

OSHA HAZARDS: No known OSHA hazards

DSL STATUS: All components of this product are on the Canadian DSL list

SARA 302 COMPONENTS: No chemicals in this material are subject the reporting requirements of SARA Section 302.

SARA 313 COMPONENTS: No chemicals in this material are subject to the reporting requirements of SARA Section 313.

SARA 311/312 HAZARDS: No SARA Hazards.

MA RIGHT TO KNOW COMPONENTS: No components are subject to the MA Right to Know Act.

PA RIGHT TO KNOW COMPONENTS:

INGREDIENTS	CAS #	% by Mass	Hazardous
Silver (as colloid)	9015-51-4	0.002	No
Polyvinylpyrrolidone	9003-39-8	trace	No
Water	231-791-2	>99	No

NJ RIGHT TO NOW COMPONENTS

INGREDIENTS	CAS #	% by Mass	Hazardous
Silver (as colloid)	9015-51-4	0.002	No
Polyvinylpyrrolidone	9003-39-8	trace	No
Water	231-791-2	>99	No

CA PROP 65 COMPONENTS: This product does not contain any chemicals known to the State of CA to cause cancer, birth defects, or any other reproductive harm.

SECTION 16 Other Information

DISCLAIMER: The information herein is believed to be accurate and reliable as of the date compiled. However, nanoComposix, Inc. makes no representation, warranty, or guarantee of any kind with respect to the information contained in this document or any use of the product based on this information.

PREPARATION DATE: 10/11/2010
REVISION DATE: 5/1/2011

MATERIAL SAFETY DATA SHEET
BioPure™ Silver Nanoparticles (AGCB)

Manufacturer: nanoComposix, Inc.
4878 Ronson CT STE K
San Diego, CA 92111-1806

NANOCOMPOSIX CUSTOMER SERVICE: (858) 565-4227
CHEMTREC (EMERGENCY ONLY): (800) 424-9300
POISON CENTER: (800) 562-8236

SECTION 1 Product Identification

CHEMICAL NAME: Colloidal silver nanoparticles

CAS REGISTRY NUMBER: 9015-51-4 (silver colloid)

FORMULA: Ag

EINECS NUMBER: NA (See components)

CHEMICAL FAMILY: metal

SYNONYM: silver nanoparticles, colloidal silver, nano silver, BioPure™ Silver

SECTION 2 Composition and Information on Ingredients

INGREDIENTS	CAS #	% by Mass	Hazardous
Silver (as colloid)	9015-51-4	0.1	No
Sodium Citrate Dihydrate	6132-04-3	5.8×10^{-5}	No
Water	231-791-2	>99	No

SECTION 3 Hazards Identification

EMERGENCY OVERVIEW:

OSHA Hazards: No known OSHA hazards. Not a dangerous substance according to GHS.

HMIS CLASSIFICATION

Health Hazard: 0
Flammability: 0
Physical Hazards: 0

NFPA RATING

Health Hazard: 0
Fire: 0
Reactivity Hazard: 0

APPEARANCE: Yellow/brown, yellow/grey or yellow/opal colored liquid; opaque.

PRIMARY ROUTES OF EXPOSURE: Ingestion, dermal contact.

EYE CONTACT: May cause eye irritation. Prolonged exposure may cause eye damage.

SKIN CONTACT: May be harmful if absorbed through skin. May cause skin irritation.

INHALATION: May be harmful if inhaled. May cause respiratory tract irritation.

INGESTION: May be harmful if ingested.

ACUTE HEALTH EFFECTS: May be irritating to skin, eyes and digestive tract.

CHRONIC HEALTH EFFECTS: Repeated and prolonged exposures have not been studied.

AGGRAVATION of PRE-EXISTING CONDITIONS: Persons with preexisting conditions may be more susceptible.

SECTION 4 First Aid Measures

EYE EXPOSURE: Remove contacts if present. Immediately flush the eyes with water for at least 10-15 minutes. Seek medical attention if irritation persists.

SKIN EXPOSURE: Wash the affected area with soap and water. Remove contaminated clothes if necessary. Seek medical assistance if irritation persists.

INHALATION: If breathed in, move person to fresh air. If not breathing, give artificial respiration.

INGESTION: If the person is conscious, rinse their mouth out with water. Never give anything by mouth to an unconscious person.

SECTION 5 Fire Fighting Measures

FLASH POINT: Not applicable.

AUTO IGNITION TEMPERATURE: Not applicable.

EXPLOSION LIMITS: Not applicable.

EXTINGUSHING MEDIUM: Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

SPECIAL FIRE FIGHTING PROCEDURES: Wear self contained breathing apparatus for fire fighting if necessary.

HAZARDOUS COMBUSTION AND DECOMPOSITION PRODUCTS: None.

UNUSUAL FIRE OR EXPLOSION HAZARDS: None.

SECTION 6 Accidental Release Measures

SPILL AND LEAK PROCEDURES: Small spills can be swept up or diluted flushed with water to dilute according to local, state, and federal disposal guidelines. Solid surface should be wiped with a detergent-based cleaner to clean any remaining materials.

SECTION 7 Handling and Storage

HANDLING: Avoid contact with skin, eyes and clothing. Avoid prolonged or repeat exposure.

STORAGE: Closed container stored at 4°C away from light. DO NOT FREEZE.

SECTION 8 Exposure Controls and Personal Protection

Contains no substances with occupational exposure limit values.

EYE PRODUCTION: Always wear approved safety glasses when handling a chemical substance in the laboratory.

SKIN PROTECTION: Wear protective clothing and gloves.

VENTILIATION: None.

RESPIRATOR: Respiratory protection not required.

ADDITIONAL PROTECTION: No additional protection required.

SECTION 9 Physical and Chemical Properties

FORM:	Liquid, individual particles 5-150nm total diameter.
COLOR:	Yellow/brown, yellow/grey or yellow/opal; opaque.
MOLECULAR WEIGHT:	No data available.
MELTING POINT (°C):	No data available.
BOILING POINT (°C):	No data available.
VAPOR PRESSURE:	No data available.
SPECIFIC GRAVITY:	No data available.
ODOR:	No data available.
SOLUBILITY IN WATER:	No data available.

SECTION 10 Stability and Reactivity

STABILITY: Stable under recommended storage conditions. DO NOT FREEZE.

POSSIBILITY OF HAZARDOUS REACTIONS: No data available.

CONDITIONS TO AVOID: No data available.

MATERIALS TO AVOID: No data available.

HAZARDOUS DECOMPOSITION PRODUCTS:
Hazardous decomposition products may be formed under fire conditions – Silver/silver oxides
Hazardous decomposition products may be formed under fire conditions – Nature of decomposition products not known.

SECTION 11 Toxicological Information

ACUTE TOXICITY

Oral LD50:	No data available.
Inhalation LD50:	No data available.
Dermal LD50:	No data available.
Other information on acute toxicity:	No data available.
SKIN CORROSION/IRITATION:	No data available.
SERIOUS EYE DAMAGE/IRRITATION	No data available.
RESPIRATORY OR SKIN SENSITIZATION	No data available.
GERM CELL MUTAGENICITY	No data available.

CARCINOGENICITY

IARC: No component of this product is identified as a probable or confirmed human carcinogen by IARC.

ACGIH: No component of this product is identified as a probable or confirmed human carcinogen by ACGIH.

NTP: No component of this product is identified as a probable or confirmed human carcinogen by NTP.

OSHA: No component of this product is identified as a probable or confirmed human carcinogen by OSHA.

REPRODUCTIVE TOXICITY:	No data available
TERATOGENICITY:	No data available
SPECIFIC TARGET ORGAN TOXICITY	No data available
APIRATION HAZARD	No data available
POTENTIAL HEALTH EFFECTS	
Inhalation:	May be harmful if inhaled. May cause respiratory tract irritation.
Ingestion:	May be harmful if swallowed.
Skin:	May be harmful if absorbed through skin. May cause skin irritation.
Eyes:	May cause eye irritation.

SIGNS AND SYMPTOMS OF EXPOSURE: May cause argyria (a slate-grey or bluish discoloration of the skin and deep tissues to the deposit of insoluble albuminate of silver.

SYNERGISTIC EFFECTS:	No data available.
ADDITIONAL INFORMATION:	RTECS note available.

SECTION 12 Ecological Information

APIRATION HAZARD	No data available.
PERSISTANCE AND DEGRADABILITY:	No data available.
BIOACCUMULATIVE POTENTIAL:	No data available.
MOBILITY IN SOIL:	No data available.
PBT AND vPvB ASSESSMENT:	No data available.
OTHER ADVERSE EFFECTS:	No data available.

SECTION 13 Disposal Considerations

DISPOSAL: Dispose of according to local, state and federal regulations.

SECTION 14 Transportation Information

DOT (US):	Not dangerous goods.
IMDG:	Not dangerous goods.
IATA:	Not dangerous goods.
SHIPPING NAME (CFR):	Non-hazardous.
SHIPPING NAME (IATA):	Non-hazardous.

SECTION 15 Regulatory Information

OSHA HAZARDS: No known OSHA hazards

DSL STATUS: All components of this product are on the Canadian DSL list

SARA 302 COMPONENTS: No chemicals in this material are subject the reporting requirements of SARA Section 302.

SARA 313 COMPONENTS: No chemicals in this material are subject to the reporting requirements of SARA Section 313.

SARA 311/312 HAZARDS: No SARA Hazards.

MA RIGHT TO KNOW COMPONENTS: No components are subject to the MA Right to Know Act.

PA RIGHT TO KNOW COMPONENTS:

INGREDIENTS	CAS #	% by Mass	Hazardous
Silver (as colloid)	9015-51-4	0.1	No
Sodium Citrate Dihydrate	6132-04-3	5.8×10^{-5}	No
Water	231-791-2	>99	No

NJ RIGHT TO NOW COMPONENTS

INGREDIENTS	CAS #	% by Mass	Hazardous
Silver (as colloid)	9015-51-4	0.1	No
Sodium Citrate Dihydrate	6132-04-3	5.8×10^{-5}	No
Water	231-791-2	>99	No

CA PROP 65 COMPONENTS: This product does not contain any chemicals known to the State of CA to cause cancer, birth defects, or any other reproductive harm.

SECTION 16 Other Information

DISCLAIMER: The information herein is believed to be accurate and reliable as of the date compiled. However, nanoComposix, Inc. makes no representation, warranty, or guarantee of any kind with respect to the information contained in this document or any use of the product based on this information.

PREPARATION DATE: 10/11/2010
REVISION DATE: 5/1/2011

NANOIRON
FUTURE TECHNOLOGY

MATERIAL SAFETY DATA SHEET

SECTION I — IDENTIFICATION OF THE SUBSTANCE / MANUFACTURER IDENTIFICATION

Product name:	NANOFER 25S
Manufacturer identification:	NANO IRON, s.r.o. Štefánikova 116 664 61 Rajhrad, CZECH REPUBLIC
Telephone number:	+420 547 230 016
Fax number:	+420 547 230 212
E-mail:	info@nanoiron.cz

SECTION II — COMPOSITION / INFORMATION ON INGREDIENTS

Generic name: stabilized water dispersion of nanoscale zero-valent iron

CAS:	7439-89-6	1317-61-9	7440-44-0	7732-18-5	
Ingredients:	Fe	Fe_3O_4	C	H_2O	surfactant
Composition:	(14-18)%	(6-2)%	(0-1)%	77%	3%

SECTION III — HAZARDS IDENTIFICATION

Physical and chemical hazards:	no applicable information was found.
Human health hazards:	no applicable information was found.
Environmental hazards:	no applicable information was found.

SECTION IV — FIRST AID MEASURES

Eye contact:	Rinse eyes with large amounts of low pressure water and get immediate medical attention.
Skin contact:	Wash affected area with soap and water, get medical attention if irritation develops.
Inhalation:	Move to fresh air and get immediate medical attention.
Ingestion:	Drink plenty of water and induce vomiting, get immediate medical attention.

SECTION V — FIRE FIGHTING MEASURES

Extinguishing media:	Extinguishing powder.
Fire hazard:	Dried powder could be accumulated with heat by oxidation in air, but will not be exploded. Do not scatter the particles.

SECTION VI — ACCIDENTAL RELEASE MEASURES

Personal precautions:	no applicable information was found.
Environmental precautions:	no applicable information was found.
Spillage control:	Cover with inert, absorbent material and remove to water-filled container (particles react with water to iron oxide form) and dispose as non-hazardous waste. Spill area may be slippery. Flush with plenty of water.

Material Safety Data Sheet

1 Product and Company Information:

Product name: **CdSe Core Quantum Dots in Toluene**

Catalog Number(s): QCO500-QCO640

Revision Date: November 8, 2008

Manufacturer/Supplier:

Ocean NanoTech LLC

2143 Worth Lane

Springdale, AR 72764

Tel: 479 751-5500 (M-F: 8 a.m. - 5 p.m. CST), Fax: 479 751-5502

Web Site: www.oceannanotech.com

2 Composition/Information on Ingredients:

CAS Name/Number: CdSe/1306-24-7; Toluene/108-88-3

3 Hazards identification

Emergency Overview: The health hazards of this product have not been fully tested and should be used with caution.

Not all potential health effects are listed here.

Health Hazards: Exposure to skin, eyes, and respiratory tract could cause irritation.

Physical Hazards: Flammable

POTENTIAL HEALTH EFFECTS

Inhalation: Possible irritation to respiratory tract and symptoms of nausea. Headache, drowsiness, dizziness, disorientation, sleep disturbances, loss of coordination, dilated pupils, kidney damage and liver damage.

Skin Contact: Possible irritation

Eye Contact: Possible irritation

Ingestion: Possible stomach pain and symptoms of nausea. Headache, drowsiness, dizziness, disorientation, sleep disturbances, loss of coordination, dilated pupils. Damage to kidney or liver.

4 First aid measures

Skin Contact: Wash the skin thoroughly with soap and water and seek medical advice.

Eye contact: If eye contact occurs, rinse eye thoroughly and seek medical advice

Inhalation: If inhaled, supply fresh air or respirator and seek medical advice.

Ingestion: If swallowed, seek medical attention immediately

5 Fire fighting measures

Extinguishing Media: Dry chemical or foam extinguisher.

6 Accidental release measures

Personal Precautions: Always use proper protective equipment.

Environmental Precautions: Do not allow material to reach drains or ground water.

Cleanup of small spills: Use appropriate material to absorb liquid.

Disposal: Collect and dispose of all waste in an appropriate container.

7 Handling and storage

Handling: Follow safe laboratory practices. The product should only be used by or closely supervised by an individual trained to handle potentially hazardous materials.

Storage: Store at 4-24 ^{o}C in a tightly sealed container. Store in same type of container (glass/plastic) as shipped. Do not freeze.

8 Exposure controls and personal protection

Engineering Controls: Use fume hood with proper ventilation. Only a properly trained lab technician should handle this product.

Personal Protection: Gloves, lab coat, and goggles. Proper laboratory safety procedures should be implemented.

9 Physical and chemical properties:

Form: Liquid. Possible settling could occur based on storage methods.

Color: Green to dark red. Dilution dependant

Specific Gravity: Not disclosed

Odor: Not disclosed

Solubility in Water: Not soluble

Boiling point: Not disclosed

pH: Not disclosed

Freezing point: Not disclosed

Melting point: Not disclosed

Vapor Pressure: Not disclosed

10 Stability and reactivity

Stability: Not determined

Conditions to avoid: Not fully determined. Avoid heat/ flames

Thermal decomposition: Not determined. May produce toxins.

Materials to avoid: Not fully determined. Reactive or incompatible with oxidizing materials and acids

11 Toxicological information

RTECS Number: Not disclosed

Toxicity: Not disclosed

Health Hazards: Refer to section 4

Carcinogenicity: No information is available

12 Ecological information:

No data available. See section 6 environmental precautions.

13 Disposal considerations

Dispose of in accordance with local, state, or national regulations.

14 Transport information

U.S. DOT Classification: Class 3
Identification Number: UN1294
Packing Group: II

Exceptions: 49 CFR 173.4 for small quantities of hazardous materials less than 30 ml (Toluene)

15 Regulations

No data available for TSCA, EEC EINECS number, EEC risk statements, or other regulations.

16 Other information:

Disclaimer: For R&D only. Not intended for food, drug, household, agricultural or cosmetic use.

The above information is believed to be correct. Ocean NanoTech LLC shall not be held liable for any damage resulting from handling or contact with the above product.

Material Safety Data Sheet

1 Product and Company Information:

Product name: **CdSe/ZnS Core/Shell Quantum Dot Powder**

Catalog Number(s): QSP580-QSP630

Revision Date: November 8, 2008

Manufacturer/Supplier:

Ocean NanoTech LLC

2143 Worth Lane

Springdale, AR 72764

Telephone: 479-751-5500 Fax: 479-751-5502

Web Site: www.oceannanotech.com

2 Composition/Information on Ingredients:

CAS Name/Number: CdSe/1306-24-7; ZnS/1314-98-3

3 Hazards identification

Emergency Overview: The health hazards of this product have not been fully tested and should be used with caution.

Exposure to skin, eyes, and respiratory tract could cause irritation.

POTENTIAL HEALTH EFFECTS

Inhalation: Not available

Skin Contact: Not available

Ingestion: Not available

Eye Contact: Not available

4 First aid measures

Skin Contact: Wash the skin thoroughly with soap and water and seek medical advice.

Eye contact: If eye contact occurs, rinse eye thoroughly and seek medical advice

Inhalation: If inhaled, supply fresh air or respirator and seek medical advice.

Ingestion: If swallowed, seek medical attention immediately

5 Fire fighting measures

Extinguishing Media: N/A; Product is not flammable

6 Accidental release measures

Personal Precautions: Always use proper protective equipment.

Environmental Precautions: Do not allow material to reach drains or ground water.

Cleanup of small spills: Use appropriate material to absorb liquid.

Disposal: Collect and dispose of all waste in an appropriate container.

7 Handling and storage

Handling: Follow safe laboratory practices. The product should only be used by or closely supervised by an individual trained to handle potentially hazardous materials.

Storage: Store at 4-24 ^{o}C in a tightly sealed container. Store in same type of container (glass/plastic) as shipped. Do not freeze.

8 Exposure controls and personal protection

Engineering Controls: Use fume hood with proper ventilation.

Personal Protection: Gloves, lab coat, and goggles.

9 Physical and chemical properties:

Form: Powder

Color: Orange to dark red

Odor: Not disclosed

Solubility in Water: Not soluble

Specific Gravity: Not disclosed

pH: Not disclosed

Melting point: Not disclosed

Boiling point: Not applicable

Freezing point: Not applicable

Vapor Pressure: Not disclosed

10 Stability and reactivity

Stability: The product is stable

Conditions to avoid: Not determined

Thermal decomposition: Not determined

Materials to avoid: Not determined

11 Toxicological information

RTECS Number: Not disclosed

Toxicity: Not disclosed

Health Hazards: Refer to section 4

Carcinogenicity: No information is available

12 Ecological information:

No data available. See section 6

13 Disposal considerations

Dispose of in accordance with local, state, or national regulations.

14 Transport information

U.S. DOT Classification: Not a hazardous material for land or air transport.
Identification Number: Not applicable
Packing Group: Not applicable
Proper Shipping Name: Not applicable

15 Regulations

No data available for TSCA, EEC EINECS number, EEC risk statements, or other regulations.

16 Other information:

Disclaimer: For R&D only. Not intended for food, drug, household, agricultural or cosmetic use.

The above information is believed to be correct. Ocean NanoTech LLC shall not be held liable for any damage resulting from handling or contact with the above product.

MSDS

< Back to all MSDS

CdSe Nanocrystals in a Solvent MSDS

1. PRODUCT IDENTIFICATION
CAS No.: 1306-24-7 (CdSe)
Inorganic Unit (CdSe): 191.371
Chemical Name: Cadmium Selenide Nanocrystals
Chemical Formula: CdSe
Chemical Family: II-VI Compounds
Typical Solvents (CAS No): Toluene (108-88-3), Hexanes (110-54-3), Chloroform (67-66-3), Dichloromethane (75-09-2), Methanol (67-56-1), Water

2. HAZARDS IDENTIFICATION
Harmful by inhalation, in contact with skin and if swallowed.

3. FIRST AID MEASURES
Inhalation : Supply fresh air. If required, provide artificial respiration. Keep patient warm. Seek immediate medical advice.
Skin contact: Immediately wash with water and soap and rinse thoroughly. Seek immediate medical advice.
Eye contact : Rinse opened eye for several minutes under running water. Then consult a doctor.
Ingestion: Seek immediate medical advice.

4. FIRE FIGHTING MEASURES
Suitable extinguishing agents: Product is not flammable but the solvent is. Use fire fighting measures that suit the necessary solvent type.
Protective equipment: Wear self-contained respirator. Wear fully protective impervious suit.

5. ACCIDENTAL RELEASE MEASURES
Person-related safety precautions: Wear protective equipment. Keep unprotected persons away. Ensure adequate ventilation
Measures for environmental protection: Do not allow material to be released to the environment without proper governmental permits.
Measures for cleaning/collecting: Dispose contaminated material as waste according to item 12. Ensure adequate ventilation.

6. HANDLING AND STORAGE
Information for safe handling: Keep container tightly sealed. Store in cool, dry, and dark place in tightly closed containers. Ensure good ventilation at the workplace. Store dissolved in solvent to prevent the formation of dust.
Information about protection against explosions and fires: Know the requirements of the necessary solvent.
Requirements to be met by storerooms and receptacles: No special requirements.
Information about storage in one common storage facility: Do not store together with acids.
Further information about storage conditions: Keep container tightly sealed. Store in cool, dry, and dark conditions in well sealed containers.

7. EXPOSURE CONTROLS AND PERSONAL PROTECTION
Additional information about design of technical systems: Properly operating chemical fume hood designed for hazardous chemicals and having an average face velocity of at least 100 feet per minute.
General protective and hygienic measures: The usual precautionary measures for handling chemicals should be followed. Keep away from foodstuffs, beverages, and feed. Remove all soiled and contaminated clothing immediately. Wash hands before breaks and at the end of work. Avoid contact with the eyes and skin.
Breathing equipment: Use suitable respirator when high concentrations are present.
Protection of hands: Impervious gloves
Eye protection: Safety glasses
Body protection: Protective work clothing.

8. PHYSICAL AND CHEMICAL PROPERTIES:
Form: Liquid form. Crystalline powder, dissolved in a solvent
Color: Clear/Yellow – Red/Brown
Odor: Odor dependent upon solvent used. Crystalline powder is odorless
Melting point/Melting range: ~400°C to bulk melting point of CdSe crystals. The solvent is liquid and melting point depends on the chemical composition of the solvent.
Boiling point/Boiling range: Determined by solvent used
Sublimation temperature / start: approx. 1150 °C
Flash point: Dependent upon solvent used
Ignition temperature: Dependent upon solvent used

Decomposition temperature: Not determined
Danger of explosion: Dependent upon solvent used. Crystalline powder does not present an explosion hazard.
Explosion limits: Currently unknown for nanocrystals
Vapor pressure: Dependent upon solvent used
Density: 5.81 g/cm3 (crystal at 20 °C) for the nanocrystal powder if isolated
Solubility in / Miscibility with Polar Solvents: Soluble when hydrophilic ligands are present
Solubility in / Miscibility with Non-Polar Solvents: Soluble when hydrophobic ligands are present

9. STABILITY AND REACTIVITY
Thermal decomposition / conditions to be avoided: Not determined, but temperature should not be higher than 50°C to maintain their optical properties.
Materials to be avoided: Acids, Bases, Oxidants, Redutants, and Ligands to the nanocrystals should be used with caution.
Dangerous reactions: No dangerous reactions known

10. TOXICOLOGICAL INFORMATION
Skin: Irritant to skin and mucous membranes.
Eye: Irritating effect.
Sensitization: No sensitizing effects known.
Additional toxicological information: Danger through skin absorption.
To the best of our knowledge the acute and chronic toxicity of this substance is not fully known.
Target Organs: Lungs, Liver, Kidneys
EPA-B1: Probable human carcinogen, limited evidence of carcinogenicity from epidemiologic studies.
IARC-1: Carcinogenic to humans: sufficient evidence of carcinogenicity.
NTP-2: Reasonably anticipated to be a carcinogen: limited evidence from studies in humans or sufficient evidence from studies in experimental animals. Carcinogen as defined by OSHA.
ACGIH A2: Suspected human carcinogen: Agent is carcinogenic in experimental animals at dose levels, by route(s) of administration, at site(s), of histologic type(s), or by mechanism(s) considered relevant to worker exposure. Available epidemiologic studies are conflicting or insufficient to confirm an increased risk of cancer in exposed humans.
WARNING: Many of the toxic effects of CdSe nanocrystals are still being researched and are currently unknown at this point. Use at own risk.

11. ECOLOGICAL INFORMATION:
Do not allow material to be released to the environment without proper governmental permits.

12. DISPOSAL CONSIDERATIONS
Consult local or national regulations for proper disposal.

13. TRANSPORT INFORMATION
U.S. DOT 49 CFR 172.101
ID Number: UN1294
Hazard class: 3
Packing Group: II
Labeling Requirements: Flammable Liquid (Unnecessary when Water is the solvent)
Canadian Transportation of Dangerous Goods: UN1294, Class 3
Land Transport ADR/RID: UN1294, Class 3, Class Code F1, Pack group II
Air Transport IATA/ICAO: UN1294, Class or Division 3, Pack group II
Exceptions: 49 CFR 173.4

14. REGULATIONS
Hazard symbols: Xn Harmful
Risk phrases: 20/21/22 Harmful by inhalation, in contact with skin and if swallowed.
Safety phrases: 22 Do not breathe dust or vapors.
National regulations: All components of this product are listed in the U.S. Environmental Protection Agency Toxic
Substances Control Act Chemical Substance Inventory.
Information about limitation of use: For use only by technically qualified individuals.

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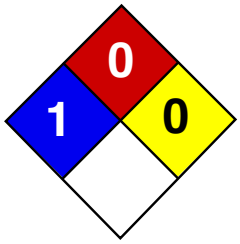
Chemicals & Laboratory Equipment



Health	1
Fire	0
Reactivity	0
Personal Protection	E

Material Safety Data Sheet
Cerium (IV) Oxide MSDS

Section 1: Chemical Product and Company Identification

Product Name: Cerium (IV) Oxide

Catalog Codes: SLC2314

CAS#: 1306-38-3

RTECS: FK6310000

TSCA: TSCA 8(b) inventory: Cerium (IV) Oxide

CI#: Not available.

Synonym: Ceria, Needlal, NIdoral, Opaline;

Chemical Name: Cerium Oxide; Cerium dioxide; Ceric Oxide

Chemical Formula: CeO2

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call: 1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Cerium (IV) Oxide	1306-38-3	100

Toxicological Data on Ingredients: Not applicable.

Section 3: Hazards Identification

Potential Acute Health Effects: Slightly hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion, of inhalation.

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Not available. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. Repeated or prolonged exposure is not known to aggravate medical condition.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention if irritation occurs.

Skin Contact: Wash with soap and water. Cover the irritated skin with an emollient. Get medical attention if irritation develops.

Serious Skin Contact: Not available.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Serious Inhalation: Not available.

Ingestion:
Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention if symptoms appear.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Non-flammable.

Auto-Ignition Temperature: Not applicable.

Flash Points: Not applicable.

Flammable Limits: Not applicable.

Products of Combustion: Not available.

Fire Hazards in Presence of Various Substances: Not applicable.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions: Not applicable.

Special Remarks on Fire Hazards: Not available.

Special Remarks on Explosion Hazards: Not available.

Section 6: Accidental Release Measures

Small Spill:
Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system.

Section 7: Handling and Storage

Precautions:
Do not ingest. Do not breathe dust. If ingested, seek medical advice immediately and show the container or the label. Keep away from incompatibles such as oxidizing agents.

Storage: Keep container tightly closed. Keep container in a cool, well-ventilated area.

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection: Safety glasses. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits: Not available.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid. (Powdered solid.)

Odor: Odorless.

Taste: Not available.

Molecular Weight: 172.12 g/mole

Color: White. Off-white.

pH (1% soln/water): Not applicable.

Boiling Point: Not available.

Melting Point: 2600°C (4712°F)

Critical Temperature: Not available.

Specific Gravity:
6.1 (Water = 1) Density: 7.13

Vapor Pressure: Not applicable.

Vapor Density: 5.9 (Air = 1)

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: Not available.

Solubility: Insoluble in cold water, hot water.

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Incompatible materials, dust generation

Incompatibility with various substances: Reactive with oxidizing agents.

Corrosivity: Not available.

Special Remarks on Reactivity: Not available.

Special Remarks on Corrosivity: Not available.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Inhalation. Ingestion.

Toxicity to Animals: Acute oral toxicity (LD50): 5000 mg/kg [Rat].

Chronic Effects on Humans: Not available.

Other Toxic Effects on Humans: Slightly hazardous in case of skin contact (irritant), of ingestion, of inhalation.

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans: Not available.

Special Remarks on other Toxic Effects on Humans:
Acute Potential Health Effects: Skin: May cause mild skin irritation. Eyes: Dust may be irritating to eyes. Inhalation: Dust may be irritating to respiratory tract. It is expected to be a low inhalation hazard for usual industrial handling. Ingestion: May cause gastrointestinal tract irritation with nausea, vomiting, and diarrhea. It is expected to be a low ingestion hazard for usual industrial handling.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The product itself and its products of degradation are not toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:
Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations: TSCA 8(b) inventory: Cerium (IV) Oxide

Other Regulations: EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC):
This product is not classified according to the EU regulations. S24/25- Avoid contact with skin and eyes.

HMIS (U.S.A.):

Health Hazard: 1

Fire Hazard: 0

Reactivity: 0

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 1

Flammability: 0

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Safety glasses.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

Created: 10/09/2005 04:36 PM

Last Updated: 11/01/2010 12:00 PM

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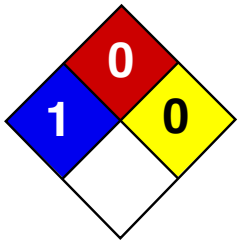

Health	2
Fire	0
Reactivity	0
Personal Protection	E

Material Safety Data Sheet
Zinc oxide MSDS

Section 1: Chemical Product and Company Identification

Product Name: Zinc oxide

Catalog Codes: SLZ1009, SLZ1114, SLZ1222, SLZ1057

CAS#: 1314-13-2

RTECS: ZH4810000

TSCA: TSCA 8(b) inventory: Zinc oxide

CI#: Not available.

Synonym: Calamine; Zinc white

Chemical Name: Zinc Oxide

Chemical Formula: ZnO

Contact Information:

Sciencelab.com, Inc.
14025 Smith Rd.
Houston, Texas 77396

US Sales: **1-800-901-7247**
International Sales: **1-281-441-4400**

Order Online: ScienceLab.com

CHEMTREC (24HR Emergency Telephone), call: 1-800-424-9300

International CHEMTREC, call: 1-703-527-3887

For non-emergency assistance, call: 1-281-441-4400

Section 2: Composition and Information on Ingredients

Composition:

Name	CAS #	% by Weight
Zinc oxide	1314-13-2	100

Toxicological Data on Ingredients: Zinc oxide: ORAL (LD50): Acute: 7950 mg/kg [Mouse].

Section 3: Hazards Identification

Potential Acute Health Effects:
Hazardous in case of inhalation. Slightly hazardous in case of skin contact (irritant), of eye contact (irritant), of ingestion.

Potential Chronic Health Effects:
CARCINOGENIC EFFECTS: Not available. MUTAGENIC EFFECTS: Mutagenic for mammalian somatic cells. Mutagenic for bacteria and/or yeast. TERATOGENIC EFFECTS: Not available. DEVELOPMENTAL TOXICITY: Not available. Repeated or prolonged exposure is not known to aggravate medical condition.

Section 4: First Aid Measures

Eye Contact:
Check for and remove any contact lenses. In case of contact, immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention if irritation occurs.

Skin Contact: Wash with soap and water. Cover the irritated skin with an emollient. Get medical attention if irritation develops.

Serious Skin Contact: Not available.

Inhalation:
If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.

Serious Inhalation: Not available.

Ingestion:
Do NOT induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Loosen tight clothing such as a collar, tie, belt or waistband. Get medical attention if symptoms appear.

Serious Ingestion: Not available.

Section 5: Fire and Explosion Data

Flammability of the Product: Non-flammable.

Auto-Ignition Temperature: Not applicable.

Flash Points: Not applicable.

Flammable Limits: Not applicable.

Products of Combustion: Not available.

Fire Hazards in Presence of Various Substances: Not applicable.

Explosion Hazards in Presence of Various Substances:
Risks of explosion of the product in presence of mechanical impact: Not available. Risks of explosion of the product in presence of static discharge: Not available.

Fire Fighting Media and Instructions: Not applicable.

Special Remarks on Fire Hazards: Slow addition of zinc oxide to cover linseed oil varnish causes generation of heat and ignition.

Special Remarks on Explosion Hazards:
May explode when mixed with chlorinated rubber. Zinc Oxide and Magnesium can react explosively when heated.

Section 6: Accidental Release Measures

Small Spill:
Use appropriate tools to put the spilled solid in a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and dispose of according to local and regional authority requirements.

Large Spill:
Use a shovel to put the material into a convenient waste disposal container. Finish cleaning by spreading water on the contaminated surface and allow to evacuate through the sanitary system. Be careful that the product is not present at a concentration level above TLV. Check TLV on the MSDS and with local authorities.

Section 7: Handling and Storage

Precautions:
Keep locked up.. Do not ingest. Do not breathe dust. Wear suitable protective clothing. In case of insufficient ventilation, wear suitable respiratory equipment. If ingested, seek medical advice immediately and show the container or the label. Keep away from incompatibles such as acids.

Storage: Keep container tightly closed. Keep container in a cool, well-ventilated area. Do not store above 25°C (77°F).

Section 8: Exposure Controls/Personal Protection

Engineering Controls:
Use process enclosures, local exhaust ventilation, or other engineering controls to keep airborne levels below recommended exposure limits. If user operations generate dust, fume or mist, use ventilation to keep exposure to airborne contaminants below the exposure limit.

Personal Protection: Safety glasses. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Gloves.

Personal Protection in Case of a Large Spill:
Splash goggles. Full suit. Dust respirator. Boots. Gloves. A self contained breathing apparatus should be used to avoid inhalation of the product. Suggested protective clothing might not be sufficient; consult a specialist BEFORE handling this product.

Exposure Limits:
TWA: 5 STEL: 10 (mg/m3) from ACGIH (TLV) [United States] Inhalation TWA: 15 (mg/m3) from OSHA (PEL) [United States] Inhalation Total. TWA: 5 STEL: 10 CEIL: 25 (mg/m3) from NIOSH Inhalation TWA: 5 STEL: 10 (mg/m3) from OSHA (PEL) [United States] Inhalation Respirable.Consult local authorities for acceptable exposure limits.

Section 9: Physical and Chemical Properties

Physical state and appearance: Solid. (Powdered solid.)

Odor: Odorless.

Taste: Bitter.

Molecular Weight: 81.38 g/mole

Color: White to yellowish-white

pH (1% soln/water): Not applicable.

Boiling Point: Not available.

Melting Point: 1975°C (3587°F)

Critical Temperature: Not available.

Specific Gravity: 5.607 (Water = 1)

Vapor Pressure: Not applicable.

Vapor Density: Not available.

Volatility: Not available.

Odor Threshold: Not available.

Water/Oil Dist. Coeff.: Not available.

Ionicity (in Water): Not available.

Dispersion Properties: Is not dispersed in cold water, hot water.

Solubility:
Insoluble in cold water, hot water Soluble in dilute acetic acid, or mineral acids, ammonia, ammonium carbonate, fixed alkali hydroxide solution..

Section 10: Stability and Reactivity Data

Stability: The product is stable.

Instability Temperature: Not available.

Conditions of Instability: Not available.

Incompatibility with various substances: Not available.

Corrosivity: Non-corrosive in presence of glass.

Special Remarks on Reactivity:
Reacts violently with magnesium, linseed oil. Reacts with hydrochloric acid to produce zinc chloride. Reacts with sulfuric acid to produce zinc sulfate. Reacts with hydrogen fluoride to produce zinc fluoride tetrahydrate. Gradually absorbs CO2 on exposure to air. Sublimes at normal pressure. Zinc Oxide reacts with Carbon Monoxide or hydrogen to produce elemental zinc.

Special Remarks on Corrosivity: Not available.

Polymerization: Will not occur.

Section 11: Toxicological Information

Routes of Entry: Dermal contact. Inhalation. Ingestion.

Toxicity to Animals: Acute oral toxicity (LD50): 7950 mg/kg [Mouse].

Chronic Effects on Humans: MUTAGENIC EFFECTS: Mutagenic for mammalian somatic cells. Mutagenic for bacteria and/or yeast.

Other Toxic Effects on Humans:
Hazardous in case of inhalation. Slightly hazardous in case of skin contact (irritant), of ingestion.

Special Remarks on Toxicity to Animals: Not available.

Special Remarks on Chronic Effects on Humans:
May cause adverse reproductive effects based on animal data. No human data found at this time. May affect genetic material (mutagenic).

Special Remarks on other Toxic Effects on Humans:
Acute Potential Health Effects: May cause mild skin irritation. Eyes: May cause mechanical eye irritation and conjunctivitis. Inhalation: May cause mechanical irritation of the respiratory tract. A few sources claim that finely divided zinc oxide dust can cause "metal fume fever." Zinc oxide dust is generally considered a nuisance dust; adverse effects are unlikely when exposures are kept under reasonable control. Inhalation of high concentrations of Zinc Oxide fume or dust may cause "Metal Fume Fever." Symptoms of metal fume fever may include a flu-like condition involving headache, chills, fever, sweats, nausea, vomiting, cough, muscle aches and pains, and difficulty breathing, ;ulmonary edema. May also affect the liver. Ingestion: May cause digestive tract irritation although Zinc oxide has a low toxicity by oral exposure route. Chronic Potential Health Effects: Ingestion: Prolonged or repeated ingestion of zinc oxide may affect blood, metabolism, and the thyroid.

Section 12: Ecological Information

Ecotoxicity: Not available.

BOD5 and COD: Not available.

Products of Biodegradation:
Possibly hazardous short term degradation products are not likely. However, long term degradation products may arise.

Toxicity of the Products of Biodegradation: The product itself and its products of degradation are not toxic.

Special Remarks on the Products of Biodegradation: Not available.

Section 13: Disposal Considerations

Waste Disposal:

Waste must be disposed of in accordance with federal, state and local environmental control regulations.

Section 14: Transport Information

DOT Classification: Not a DOT controlled material (United States).

Identification: Not applicable.

Special Provisions for Transport: Not applicable.

Section 15: Other Regulatory Information

Federal and State Regulations:
Illinois toxic substances disclosure to employee act: Zinc oxide Rhode Island RTK hazardous substances: Zinc oxide Pennsylvania RTK: Zinc oxide Minnesota: Zinc oxide Massachusetts RTK: Zinc oxide New Jersey: Zinc oxide California Director's List of Hazardous Substances: Zinc oxide TSCA 8(b) inventory: Zinc oxide

Other Regulations: EINECS: This product is on the European Inventory of Existing Commercial Chemical Substances.

Other Classifications:

WHMIS (Canada): Not controlled under WHMIS (Canada).

DSCL (EEC):
R40- Possible risks of irreversible effects. S2- Keep out of the reach of children. S36/37- Wear suitable protective clothing and gloves.

HMIS (U.S.A.):

Health Hazard: 2

Fire Hazard: 0

Reactivity: 0

Personal Protection: E

National Fire Protection Association (U.S.A.):

Health: 1

Flammability: 0

Reactivity: 0

Specific hazard:

Protective Equipment:
Gloves. Lab coat. Dust respirator. Be sure to use an approved/certified respirator or equivalent. Safety glasses.

Section 16: Other Information

References: Not available.

Other Special Considerations: Not available.

Created: 10/10/2005 08:34 PM

Last Updated: 11/01/2010 12:00 PM

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Material Safety Data Sheet

Version 4.0
Revision Date 07/29/2010
Print Date 04/28/2011

1. PRODUCT AND COMPANY IDENTIFICATION

Product name : Silver

Product Number : 576832
Brand : Aldrich

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA
Telephone : +1 800-325-5832
Fax : +1 800-325-5052
Emergency Phone # : (314) 776-6555

2. HAZARDS IDENTIFICATION

Emergency Overview

OSHA Hazards
No known OSHA hazards

HMIS Classification
Health hazard: 0
Flammability: 0
Physical hazards: 0

NFPA Rating
Health hazard: 0
Fire: 0
Reactivity Hazard: 0

Potential Health Effects

Inhalation May be harmful if inhaled. May cause respiratory tract irritation.
Skin May be harmful if absorbed through skin. May cause skin irritation.
Eyes May cause eye irritation.
Ingestion May be harmful if swallowed.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Formula : Ag
Molecular Weight : 107.87 g/mol

CAS-No.	EC-No.	Index-No.	Concentration
Silver			
7440-22-4	231-131-3	-	-

4. FIRST AID MEASURES

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration.

In case of skin contact
Wash off with soap and plenty of water.

In case of eye contact
Flush eyes with water as a precaution.

If swallowed
Never give anything by mouth to an unconscious person. Rinse mouth with water.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

Special protective equipment for fire-fighters
Wear self contained breathing apparatus for fire fighting if necessary.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions
Avoid dust formation. Avoid breathing vapors, mist or gas.

Environmental precautions
Do not let product enter drains.

Methods and materials for containment and cleaning up
Sweep up and shovel. Keep in suitable, closed containers for disposal.

7. HANDLING AND STORAGE

Precautions for safe handling
Provide appropriate exhaust ventilation at places where dust is formed. Normal measures for preventive fire protection.

Conditions for safe storage
Keep container tightly closed in a dry and well-ventilated place.

Air sensitive. Handle and store under inert gas. Keep in a dry place.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Components with workplace control parameters

Components	CAS-No.	Value	Control parameters	Update	Basis
Silver	7440-22-4	TWA	0.01 mg/m3	1993-06-30	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
		TWA	0.01 mg/m3	1989-03-01	USA. OSHA - TABLE Z-1 Limits for Air Contaminants - 1910.1000
		TWA	0.01 mg/m3	1997-08-04	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
		TWA	0.1 mg/m3	2008-01-01	USA. ACGIH Threshold Limit Values (TLV)
Remarks	Argyria				
		TWA	0.01 mg/m3	1989-01-19	USA. OSHA - TABLE Z-1 Limits for Air Contaminants - 1910.1000

Personal protective equipment

Respiratory protection
Respiratory protection is not required. Where protection from nuisance levels of dusts are desired, use type N95 (US) or type P1 (EN 143) dust masks. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Hand protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Eye protection
Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin and body protection
Choose body protection in relation to its type, to the concentration and amount of dangerous substances, and to the specific work-place., The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Hygiene measures
General industrial hygiene practice.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance

Form	powder

Safety data

pH	no data available
Melting point	960 °C (1,760 °F) - lit.
Boiling point	2,212 °C (4,014 °F) - lit.
Flash point	no data available
Ignition temperature	no data available
Lower explosion limit	no data available
Upper explosion limit	no data available
Density	10.49 g/mL
Water solubility	no data available

10. STABILITY AND REACTIVITY

Chemical stability
Stable under recommended storage conditions.

Conditions to avoid
no data available

Materials to avoid
Oxygen, Strong acids and strong bases

Hazardous decomposition products
Hazardous decomposition products formed under fire conditions. - Silver/silver oxides

11. TOXICOLOGICAL INFORMATION

Acute toxicity
LD50 Oral - rat - male - > 5,000 mg/kg

Skin corrosion/irritation
no data available

Serious eye damage/eye irritation

Respiratory or skin sensitization
no data available

Germ cell mutagenicity
no data available

Carcinogenicity

Carcinogenicity - rat - Unreported
Tumorigenic:Tumors at site or application.

Carcinogenicity classification not possible from current data.

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

ACGIH: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity

Specific target organ toxicity - single exposure (Globally Harmonized System)
no data available

Specific target organ toxicity - repeated exposure (Globally Harmonized System)
no data available

Aspiration hazard
no data available

Potential health effects

Inhalation	May be harmful if inhaled. May cause respiratory tract irritation.
Ingestion	May be harmful if swallowed.
Skin	May be harmful if absorbed through skin. May cause skin irritation.
Eyes	May cause eye irritation.

Signs and Symptoms of Exposure
May cause argyria (a slate-gray or bluish discoloration of the skin and deep tissues due to the deposit of insoluble albuminate of silver).

Additional Information

12. ECOLOGICAL INFORMATION

Toxicity

no data available

Persistence and degradability
no data available

Bioaccumulative potential

Mobility in soil

PBT and vPvB assessment
no data available

Other adverse effects

no data available

13. DISPOSAL CONSIDERATIONS

Product
Offer surplus and non-recyclable solutions to a licensed disposal company.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
UN-Number: 3077 Class: 9 Packing group: III
Proper shipping name: Environmentally hazardous substances, solid, n.o.s. (Silver)
Reportable Quantity (RQ): 1 lbs
Marine pollutant: No
Poison Inhalation Hazard: No

IMDG
Not dangerous goods

IATA
Not dangerous goods

15. REGULATORY INFORMATION

OSHA Hazards
No known OSHA hazards

DSL Status
All components of this product are on the Canadian DSL list.

SARA 302 Components
SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components

	CAS-No.	Revision Date
Silver	7440-22-4	1993-04-24

SARA 311/312 Hazards
No SARA Hazards

Massachusetts Right To Know Components

	CAS-No.	Revision Date
Silver	7440-22-4	1993-04-24

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Silver	7440-22-4	1993-04-24

New Jersey Right To Know Components

	CAS-No.	Revision Date
Silver	7440-22-4	1993-04-24

California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

Further information
Copyright 2010 Sigma-Aldrich Co. License granted to make unlimited paper copies for internal use only.
The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Co., shall not be held liable for any damage resulting from handling or from contact with the above product. See reverse side of invoice or packing slip for additional terms and conditions of sale.

Material Safety Data Sheet

Version 3.0
Revision Date 10/22/2009
Print Date 04/28/2011

1. PRODUCT AND COMPANY IDENTIFICATION

Product name : Decanethiol functionalized silver nanoparticles

Product Number : 673633
Brand : Aldrich

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA
Telephone : +1 800-325-5832
Fax : +1 800-325-5052
Emergency Phone # : (314) 776-6555

2. COMPOSITION/INFORMATION ON INGREDIENTS

Synonyms : Decylthiol functionalized silver nanoparticles

CAS-No.	EC-No.	Index-No.	Concentration
n-Hexane			
110-54-3	203-777-6	601-037-00-0	> 99 %
Decane-1-thiol			
143-10-2	205-584-2	-	< 1 %
Silver			
7440-22-4	231-131-3	-	< 1 %

3. HAZARDS IDENTIFICATION

Emergency Overview

OSHA Hazards
Flammable liquid, Target Organ Effect, Irritant

Target Organs

Peripheral nervous system., Kidney, Testes.

HMIS Classification
Health hazard: 2
Chronic Health Hazard: *
Flammability: 3
Physical hazards: 0

NFPA Rating
Health hazard: 2

Fire:	3
Reactivity Hazard:	0

Potential Health Effects

Inhalation	May be harmful if inhaled. Causes respiratory tract irritation. Vapours may cause drowsiness and dizziness.
Skin	May be harmful if absorbed through skin. Causes skin irritation.
Eyes	Causes eye irritation.
Ingestion	Aspiration hazard if swallowed - can enter lungs and cause damage. May be harmful if swallowed.

4. FIRST AID MEASURES

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.Move out of dangerous area.

If inhaled
If breathed in, move person into fresh air. If not breathing give artificial respiration Consult a physician.

In case of skin contact
Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

If swallowed
Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

5. FIRE-FIGHTING MEASURES

Flammable properties

Flash point	-26 °C (-15 °F) - closed cup
Ignition temperature	no data available

Suitable extinguishing media
For small (incipient) fires, use media such as "alcohol" foam, dry chemical, or carbon dioxide. For large fires, apply water from as far as possible. Use very large quantities (flooding) of water applied as a mist or spray; solid streams of water may be ineffective. Cool all affected containers with flooding quantities of water.

Special protective equipment for fire-fighters
Wear self contained breathing apparatus for fire fighting if necessary.

Further information
Use water spray to cool unopened containers.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions
Use personal protective equipment. Avoid breathing vapors, mist or gas. Ensure adequate ventilation. Remove all sources of ignition. Evacuate personnel to safe areas. Beware of vapours accumulating to form explosive concentrations. Vapours can accumulate in low areas.

Environmental precautions
Prevent further leakage or spillage if safe to do so. Do not let product enter drains. Discharge into the environment must be avoided.

Methods for cleaning up
Contain spillage, and then collect with non-combustible absorbent material, (e.g. sand, earth, diatomaceous earth, vermiculite) and place in container for disposal according to local / national regulations (see section 13).

7. HANDLING AND STORAGE

Handling
Avoid contact with skin and eyes. Avoid inhalation of vapour or mist.
Keep away from sources of ignition - No smoking. Take measures to prevent the build up of electrostatic charge.

Storage
Keep container tightly closed in a dry and well-ventilated place. Containers which are opened must be carefully resealed and kept upright to prevent leakage. Store in cool place.

Handle and store under inert gas.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Components with workplace control parameters

Components	CAS-No.	Value	Control parameters	Update	Basis
n-Hexane	110-54-3	TWA	50 ppm	2007-01-01	USA. ACGIH Threshold Limit Values (TLV)
Remarks	Central Nervous System impairment Eye irritation Peripheral neuropathy Substances for which there is a Biological Exposure Index or Indices (see BEI® section) Danger of cutaneous absorption				
		TWA	50 ppm 180 mg/m3	1989-01-19	USA. OSHA - TABLE Z-1 Limits for Air Contaminants - 1910.1000
		TWA	500 ppm 1,800 mg/m3	1997-08-04	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
	The value in mg/m3 is approximate.				

Personal protective equipment

Respiratory protection
Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multi-purpose combination (US) or type ABEK (EN 14387) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Hand protection
Handle with gloves.

Eye protection
Face shield and safety glasses

Skin and body protection
Choose body protection according to the amount and concentration of the dangerous substance at the work place.

Hygiene measures
Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance

Form	liquid

Safety data

pH	no data available
Melting point	no data available
Boiling point	68 - 70 °C (154 - 158 °F) at 1,013 hPa (760 mmHg)
Flash point	-26 °C (-15 °F) - closed cup
Ignition temperature	no data available
Lower explosion limit	1.2 %(V)
Upper explosion limit	7.7 %(V)
Vapour pressure	176 hPa (132 mmHg) at 20 °C (68 °F)
Density	0.672 g/mL at 25 °C (77 °F)
Water solubility	no data available
Evaporation rate	15.8

10. STABILITY AND REACTIVITY

Storage stability
Stable under recommended storage conditions.

Conditions to avoid
Heat, flames and sparks.

Materials to avoid
Strong bases, Oxidizing agents, Strong acids and strong bases, Oxygen

Hazardous decomposition products
Hazardous decomposition products formed under fire conditions. - Carbon oxides

Hazardous reactions
Vapours may form explosive mixture with air.

11. TOXICOLOGICAL INFORMATION

Acute toxicity

no data available

Irritation and corrosion

no data available

Sensitisation

no data available

Chronic exposure

IARC: No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.

ACGIH: No component of this product present at levels greater than or equal to 0.1% is identified as

a carcinogen or potential carcinogen by ACGIH.

NTP: No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.

OSHA: No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Signs and Symptoms of Exposure

Prolonged or repeated contact with skin may cause:, defatting, Dermatitis, Contact with eyes can cause:, Redness, Blurred vision, Provokes tears., Effects due to ingestion may include:, Gastrointestinal discomfort, Central nervous system depression, Lung irritation, chest pain, pulmonary edema

Potential Health Effects

Inhalation	May be harmful if inhaled. Causes respiratory tract irritation. Vapours may cause drowsiness and dizziness.
Skin	May be harmful if absorbed through skin. Causes skin irritation.
Eyes	Causes eye irritation.
Ingestion	Aspiration hazard if swallowed - can enter lungs and cause damage. May be harmful if swallowed.
Target Organs	Peripheral nervous system., Kidney, Testes.,

12. ECOLOGICAL INFORMATION

Elimination information (persistence and degradability)

no data available

Ecotoxicity effects

no data available

Further information on ecology

An environmental hazard cannot be excluded in the event of unprofessional handling or disposal.

Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

13. DISPOSAL CONSIDERATIONS

Product
Burn in a chemical incinerator equipped with an afterburner and scrubber but exert extra care in igniting as this material is highly flammable. Observe all federal, state, and local environmental regulations. Contact a licensed professional waste disposal service to dispose of this material.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
UN-Number: 1208 Class: 3 Packing group: II
Proper shipping name: Hexanes, solution
Reportable Quantity (RQ): 100 lbs
Marine pollutant: No
Poison Inhalation Hazard: No

IMDG
UN-Number: 1208 Class: 3 Packing group: II EMS-No: F-E, S-D
Proper shipping name: HEXANES, SOLUTION
Marine pollutant: No

IATA
UN-Number: 1208 Class: 3 Packing group: II
Proper shipping name: Hexanes, solution

15. REGULATORY INFORMATION

OSHA Hazards
Flammable liquid, Target Organ Effect, Irritant

DSL Status
This product contains the following components listed on the Canadian NDSL list. All other components are on the Canadian DSL list.

	CAS-No.
Decane-1-thiol	143-10-2

SARA 302 Components
SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components

	CAS-No.	Revision Date
n-Hexane	110-54-3	2007-07-01

SARA 311/312 Hazards
Fire Hazard, Acute Health Hazard, Chronic Health Hazard

Massachusetts Right To Know Components

	CAS-No.	Revision Date
n-Hexane	110-54-3	2007-07-01

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
n-Hexane	110-54-3	2007-07-01

New Jersey Right To Know Components

	CAS-No.	Revision Date
n-Hexane	110-54-3	2007-07-01

California Prop. 65 Components
This product does not contain any chemicals known to the State of California to cause cancer, birth, or any other reproductive defects.

16. OTHER INFORMATION

Further information
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The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Co., shall not be held liable for any damage resulting from handling or from contact with the above product. See reverse side of invoice or packing slip for additional terms and conditions of sale.

Material Safety Data Sheet

Version 3.4
Revision Date 04/07/2011
Print Date 04/27/2011

1. PRODUCT AND COMPANY IDENTIFICATION

Product name	:	Lumidot™ CdSe
Product Number	:	662445
Brand	:	Aldrich
Supplier	:	Sigma-Aldrich 3050 Spruce Street SAINT LOUIS MO 63103 USA
Telephone	:	+1 800-325-5832
Fax	:	+1 800-325-5052
Emergency Phone # (For both supplier and manufacturer)	:	(314) 776-6555
Preparation Information	:	Sigma-Aldrich Corporation Product Safety - Americas Region 1-800-521-8956

2. HAZARDS IDENTIFICATION

Emergency Overview

OSHA Hazards
Flammable liquid, Carcinogen, Target Organ Effect, Teratogen, Reproductive hazard

Target Organs

Bladder, Liver, Kidney, Brain.

GHS Classification
Flammable liquids (Category 2)
Acute toxicity, Inhalation (Category 3)
Skin irritation (Category 2)
Eye irritation (Category 2A)
Reproductive toxicity (Category 2)
Specific target organ toxicity - single exposure (Category 2)
Specific target organ toxicity - single exposure (Category 3)
Aspiration hazard (Category 1)
Acute aquatic toxicity (Category 2)
Chronic aquatic toxicity (Category 3)

GHS Label elements, including precautionary statements

Pictogram

Signal word Danger

Hazard statement(s)

H225	Highly flammable liquid and vapour.
H304	May be fatal if swallowed and enters airways.
H315	Causes skin irritation.
H319	Causes serious eye irritation.
H331	Toxic if inhaled.
H336	May cause drowsiness or dizziness.
H361	Suspected of damaging fertility or the unborn child.

H371	May cause damage to organs.
H401	Toxic to aquatic life.
H412	Harmful to aquatic life with long lasting effects.

Precautionary statement(s)

P210	Keep away from heat/sparks/open flames/hot surfaces. - No smoking.
P260	Do not breathe dust/ fume/ gas/ mist/ vapours/ spray.
P273	Avoid release to the environment.
P281	Use personal protective equipment as required.
P301 + P310	IF SWALLOWED: Immediately call a POISON CENTER or doctor/ physician.
P305 + P351 + P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P311	Call a POISON CENTER or doctor/ physician.
P331	Do NOT induce vomiting.

HMIS Classification

Health hazard:	2
Chronic Health Hazard:	*
Flammability:	3
Physical hazards:	0

NFPA Rating

Health hazard:	2
Fire:	3
Reactivity Hazard:	0

Potential Health Effects

Inhalation	May be harmful if inhaled. May cause respiratory tract irritation. Vapours may cause drowsiness and dizziness.
Skin	May be harmful if absorbed through skin. May cause skin irritation.
Eyes	May cause eye irritation.
Ingestion	May be harmful if swallowed. Aspiration hazard if swallowed - can enter lungs and cause damage.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Formula : CdSe

CAS-No.	EC-No.	Index-No.	Concentration
Toluene			
108-88-3	203-625-9	601-021-00-3	>= 99 %
Cadmium selenide			
1306-24-7	215-148-3	-	< 1 %

4. FIRST AID MEASURES

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.Move out of dangerous area.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Wash off with soap and plenty of water. Take victim immediately to hospital. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

If swallowed
Do NOT induce vomiting. Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media
For small (incipient) fires, use media such as "alcohol" foam, dry chemical, or carbon dioxide. For large fires, apply water from as far as possible. Use very large quantities (flooding) of water applied as a mist or spray; solid streams of water may be ineffective. Cool all affected containers with flooding quantities of water.

Special protective equipment for fire-fighters
Wear self contained breathing apparatus for fire fighting if necessary.

Hazardous combustion products
Hazardous decomposition products formed under fire conditions. - Carbon oxides

Further information
Use water spray to cool unopened containers.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions
Wear respiratory protection. Avoid breathing vapors, mist or gas. Ensure adequate ventilation. Remove all sources of ignition. Evacuate personnel to safe areas. Beware of vapours accumulating to form explosive concentrations. Vapours can accumulate in low areas.

Environmental precautions
Prevent further leakage or spillage if safe to do so. Do not let product enter drains. Discharge into the environment must be avoided.

Methods and materials for containment and cleaning up
Contain spillage, and then collect with an electrically protected vacuum cleaner or by wet-brushing and place in container for disposal according to local regulations (see section 13).

7. HANDLING AND STORAGE

Precautions for safe handling
Avoid contact with skin and eyes. Avoid inhalation of vapour or mist.
Use explosion-proof equipment. Keep away from sources of ignition - No smoking. Take measures to prevent the build up of electrostatic charge.

Conditions for safe storage
Store in cool place. Keep container tightly closed in a dry and well-ventilated place. Containers which are opened must be carefully resealed and kept upright to prevent leakage.

Recommended storage temperature: 2 - 8 °C

Light sensitive. Air and moisture sensitive. Handle and store under inert gas. Stench.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Components with workplace control parameters

Components	CAS-No.	Value	Control parameters	Basis
Toluene	108-88-3	TWA	100 ppm 375 mg/m3	USA. OSHA - TABLE Z-1 Limits for Air Contaminants - 1910.1000
		STEL	150 ppm 560 mg/m3	USA. OSHA - TABLE Z-1 Limits for Air Contaminants - 1910.1000
		TWA	200 ppm	USA. Occupational Exposure Limits (OSHA) - Table Z2
Remarks	Z37.12-1967			
		CEIL	300 ppm	USA. Occupational Exposure Limits (OSHA) - Table Z2
	Z37.12-1967			

		Peak	500 ppm	USA. Occupational Exposure Limits (OSHA) - Table Z2
	Z37.12-1967			
		TWA	20 ppm	USA. ACGIH Threshold Limit Values (TLV)
	Visual impairment Female reproductive Pregnancy loss 2010Adoption Substances for which there is a Biological Exposure Index or Indices (see BEI® section) Not classifiable as a human carcinogen: Agents which cause concern that they could be carcinogenic for humans but which cannot be assessed conclusively because of a lack of data. In vitro or animal studies do not provide indications of carcinogenicity which are sufficient to classify the agent into one of the other categories.			
		TWA	100 ppm 375 mg/m3	USA. NIOSH Recommended Exposure Limits
		ST	150 ppm 560 mg/m3	USA. NIOSH Recommended Exposure Limits
Cadmium selenide	1306-24-7	TWA	0.2 mg/m3	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
		TWA	0.2 mg/m3	USA. OSHA - TABLE Z-1 Limits for Air Contaminants - 1910.1000
		TWA	0.2 mg/m3	USA. ACGIH Threshold Limit Values (TLV)
		TWA	0.0020 mg/m3	USA. ACGIH Threshold Limit Values (TLV)
Remarks	Suspected human carcinogen: Human data are accepted as adequate in quality but are conflicting or insufficient to classify the agent as a confirmed human carcinogen; OR, the agent is carcinogenic in experimental animals at dose(s), by route(s) of exposure, at site(s), of histologic type(s), or by mechanism(s) considered relevant to worker exposure. The A2 is used primarily when there is limited evidence of carcinogenicity in humans and sufficient evidence of carcinogenicity in experimental animals with relevance to humans.			
		TWA	0.01 mg/m3	USA. ACGIH Threshold Limit Values (TLV)
	Kidney damage Substances for which there is a Biological Exposure Index or Indices (see BEI® section) Suspected human carcinogen: Human data are accepted as adequate in quality but are conflicting or insufficient to classify the agent as a confirmed human carcinogen; OR, the agent is carcinogenic in experimental animals at dose(s), by route(s) of exposure, at site(s), of histologic type(s), or by mechanism(s) considered relevant to worker exposure. The A2 is used primarily when there is limited evidence of carcinogenicity in humans and sufficient evidence of carcinogenicity in experimental animals with relevance to humans. varies			
		TWA	0.002 mg/m3	USA. ACGIH Threshold Limit Values (TLV)
	Kidney damage Substances for which there is a Biological Exposure Index or Indices (see BEI® section) Suspected human carcinogen: Human data are accepted as adequate in quality but are conflicting or insufficient to classify the agent as a confirmed human carcinogen; OR, the agent is carcinogenic in experimental animals at dose(s), by route(s) of exposure, at site(s), of histologic type(s), or by mechanism(s) considered relevant to worker exposure. The A2 is used primarily when there is limited evidence of carcinogenicity in humans and sufficient evidence of carcinogenicity in experimental animals with relevance to humans. varies			
		TWA	0.2 mg/m3	USA. ACGIH Threshold Limit Values (TLV)
	Eye & Upper Respiratory Tract irritation			
		TWA	0.2 mg/m3	USA. OSHA - TABLE Z-1 Limits for Air Contaminants - 1910.1000
		TWA	0.2 mg/m3	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants

	Potential Occupational Carcinogen See Appendix A			
	Potential Occupational Carcinogen See Appendix A			
		TWA	0.2 mg/m3	USA. NIOSH Recommended Exposure Limits

Personal protective equipment

Respiratory protection
Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multi-purpose combination (US) or type ABEK (EN 14387) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Hand protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Eye protection
Face shield and safety glasses Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin and body protection
Complete suit protecting against chemicals, Flame retardant antistatic protective clothing, The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Hygiene measures
Avoid contact with skin, eyes and clothing. Wash hands before breaks and immediately after handling the product.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance

Form	liquid
Colour	no data available

Safety data

pH	no data available
Melting point/freezing point	no data available
Boiling point	no data available
Flash point	4 °C (39 °F)
Ignition temperature	no data available
Autoignition temperature	no data available
Lower explosion limit	no data available
Upper explosion limit	no data available
Vapour pressure	no data available
Density	no data available
Water solubility	no data available
Partition coefficient: n-octanol/water	no data available
Relative vapour density	no data available
Odour	no data available

Odour Threshold	no data available
Evaporation rate	no data available

10. STABILITY AND REACTIVITY

Chemical stability
Stable under recommended storage conditions.

Possibility of hazardous reactions

Vapours may form explosive mixture with air.

Conditions to avoid
Heat, flames and sparks. Extremes of temperature and direct sunlight.

Materials to avoid
Oxidizing agents, Strong oxidizing agents, acids

Hazardous decomposition products
Hazardous decomposition products formed under fire conditions. - Carbon oxides
Other decomposition products - no data available

11. TOXICOLOGICAL INFORMATION

Acute toxicity

Oral LD50
Inhalation LC50
Dermal LD50
no data available

Other information on acute toxicity
no data available

Skin corrosion/irritation
no data available

Serious eye damage/eye irritation
Eyes: no data available

Respiratory or skin sensitization
no data available

Germ cell mutagenicity
no data available

Carcinogenicity

IARC:	3 - Group 3: Not classifiable as to its carcinogenicity to humans (Toluene)
	3 - Group 3: Not classifiable as to its carcinogenicity to humans (Cadmium selenide)
	1 - Group 1: Carcinogenic to humans (Cadmium selenide)
	3 - Group 3: Not classifiable as to its carcinogenicity to humans (Cadmium selenide)
IARC:	3 - Group 3: Not classifiable as to its carcinogenicity to humans (Cadmium selenide)
	1 - Group 1: Carcinogenic to humans (Cadmium selenide)
	3 - Group 3: Not classifiable as to its carcinogenicity to humans (Cadmium selenide)
NTP:	Known to be human carcinogenThe reference note has been added by TD based on the background information of the NTP. (Cadmium selenide)
OSHA:	No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity

no data available

Teratogenicity

no data available

Specific target organ toxicity - single exposure (Globally Harmonized System)
no data available

Specific target organ toxicity - repeated exposure (Globally Harmonized System)
no data available

Aspiration hazard
no data available

Potential health effects

Inhalation	May be harmful if inhaled. May cause respiratory tract irritation. Vapours may cause drowsiness and dizziness.
Ingestion	May be harmful if swallowed. Aspiration hazard if swallowed - can enter lungs and cause damage.
Skin	May be harmful if absorbed through skin. May cause skin irritation.
Eyes	May cause eye irritation.

Signs and Symptoms of Exposure
Acute inhalation exposure to cadmium fumes may cause "metal fume fever" with flu-like symptoms of weakness, fever, headache, chills, nausea, vomiting, dizziness, sweating, muscular pain, cough and difficulty breathing. Acute pulmonary edema may develop within 24 hours and reaches a maximum by three days.The first chronic effect of exposure to cadmium is generally kidney damage, manifested by excretion of excessive protein in the urine, followed by anemia, teeth discoloration and loss of smell. Cadmium also is believed to cause pulmonary emphysema and bone disease. Lung irritation, chest pain, pulmonary edema, Inhalation studies on toluene have demonstrated the development of inflammatory and ulcerous lesions of the penis, prepuce, and scrotum in animals.

Synergistic effects
no data available

Additional Information
RTECS: Not available

12. ECOLOGICAL INFORMATION

Toxicity

no data available

Persistence and degradability
no data available

Bioaccumulative potential
no data available

Mobility in soil
no data available

PBT and vPvB assessment
no data available

Other adverse effects

Toxic to aquatic life.

An environmental hazard cannot be excluded in the event of unprofessional handling or disposal.

13. DISPOSAL CONSIDERATIONS

Product
Burn in a chemical incinerator equipped with an afterburner and scrubber but exert extra care in igniting as this material is highly flammable. Offer surplus and non-recyclable solutions to a licensed disposal company. Contact a licensed professional waste disposal service to dispose of this material.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
UN number: 1294 Class: 3 Packing group: II
Proper shipping name: Toluene, solution
Reportable Quantity (RQ): 1000 lbs
Marine pollutant: No
Poison Inhalation Hazard: No

IMDG
UN number: 1294 Class: 3 Packing group: II EMS-No: F-E, S-D
Proper shipping name: TOLUENE, SOLUTION
Marine pollutant: No

IATA
UN number: 1294 Class: 3 Packing group: II
Proper shipping name: Toluene, solution

15. REGULATORY INFORMATION

OSHA Hazards
Flammable liquid, Carcinogen, Target Organ Effect, Teratogen, Reproductive hazard

SARA 302 Components
SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
The following components are subject to reporting levels established by SARA Title III, Section 313:

	CAS-No.	Revision Date
Toluene	108-88-3	2007-07-01
Cadmium selenide	1306-24-7	1987-01-01

SARA 311/312 Hazards
Fire Hazard, Chronic Health Hazard

Massachusetts Right To Know Components

	CAS-No.	Revision Date
Toluene	108-88-3	2007-07-01

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Toluene	108-88-3	2007-07-01
Cadmium selenide	1306-24-7	1987-01-01

New Jersey Right To Know Components

	CAS-No.	Revision Date
Toluene	108-88-3	2007-07-01
Cadmium selenide	1306-24-7	1987-01-01

California Prop. 65 Components

	CAS-No.	Revision Date
WARNING! This product contains a chemical known to the State of California to cause cancer. Cadmium selenide	1306-24-7	1987-10-01

California Prop. 65 Components

	CAS-No.	Revision Date
WARNING! This product contains a chemical known to the State of		

California to cause birth defects or other reproductive harm.	108-88-3	2009-02-01
Toluene		
Cadmium selenide	1306-24-7	1987-10-01

16. OTHER INFORMATION

Further information

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The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Co., shall not be held liable for any damage resulting from handling or from contact with the above product. See reverse side of invoice or packing slip for additional terms and conditions of sale.

MATERIAL SAFETY DATA SHEET

Date Printed: 04/27/2011
Date Updated: 05/18/2010
Version 1.4

Section 1 - Product and Company Information

Product Name	SILVER NANOPARTICLE INK, <150 NM (DLS), 20 WT. % DISPERSION IN ORGANIC SOLVENTS
Product Number	719048
Brand	ALDRICH
Company	Sigma-Aldrich
Address	3050 Spruce Street SAINT LOUIS MO 63103 US
Technical Phone:	800-325-5832
Fax:	800-325-5052
Emergency Phone:	314-776-6555

Section 2 - Composition/Information on Ingredient

Substance Name	CAS #	SARA 313
SILVER NANOPARTICLE INK, <150 NM PARTICLE SIZE (DLS), 20 WT % DISPERSION IN ORGANIC SOLVENTS	None	Yes

Ingredient Name	CAS #	Percent	SARA 313
ETHYLENE GLYCOL	107-21-1	>= 25 <= 60	Yes
ETHYL ALCOHOL, NON-DENATURED, 200 PROOF	64-17-5	>= 25 <= 60	No
SILVER	7440-22-4	20	Yes

Synonyms SunTronic(R) Silver

Section 3 - Hazards Identification

EMERGENCY OVERVIEW
Flammable (USA) Highly Flammable (EU). Harmful.
Highly flammable. Harmful if swallowed. Irritating to eyes, respiratory system and skin.
Target organ(s): Nerves. Liver. Heart. Kidneys. Eyes. Cardiovascular system.

HMIS RATING
HEALTH: 1*
FLAMMABILITY: 3
REACTIVITY: 0

NFPA RATING
HEALTH: 1
FLAMMABILITY: 3
REACTIVITY: 0

For additional information on toxicity, please refer to Section 11.

Section 4 - First Aid Measures

ORAL EXPOSURE
If swallowed, wash out mouth with water provided person is conscious. Call a physician.

INHALATION EXPOSURE
If inhaled, remove to fresh air. If not breathing give artificial respiration. If breathing is difficult, give oxygen.

DERMAL EXPOSURE
In case of skin contact, flush with copious amounts of water for at least 15 minutes. Remove contaminated clothing and shoes. Call a physician.

EYE EXPOSURE
In case of contact with eyes, flush with copious amounts of water for at least 15 minutes. Assure adequate flushing by separating the eyelids with fingers. Call a physician.

Section 5 - Fire Fighting Measures

FLAMMABLE HAZARDS
Flammable Hazards: Yes

EXPLOSION HAZARDS
Vapor may travel considerable distance to source of ignition and flash back. Container explosion can occur under fire conditions. In advanced or massive fires the area should be evacuated and the fire should be fought from a remote explosion-resistant location.

FLASH POINT
72 °F 22.2 °C

AUTOIGNITION TEMP
N/A

FLAMMABILITY
N/A

EXTINGUISHING MEDIA
Suitable: For small (incipient) fires, use media such as "alcohol" foam, dry chemical, or carbon dioxide. For large fires, apply water from as far as possible. Use very large quantities (flooding) of water applied as a mist or spray; solid streams of water may be ineffective. Cool all affected containers with flooding quantities of water.

FIREFIGHTING
Protective Equipment: Wear self-contained breathing apparatus and protective clothing to prevent contact with skin and eyes.
Specific Hazard(s): Flammable liquid. Emits toxic fumes under fire conditions.

Section 6 - Accidental Release Measures

PROCEDURE TO BE FOLLOWED IN CASE OF LEAK OR SPILL
Evacuate area. Shut off all sources of ignition.

PROCEDURE(S) OF PERSONAL PRECAUTION(S)
Wear self-contained breathing apparatus, rubber boots, and heavy rubber gloves.

METHODS FOR CLEANING UP

Cover with dry-lime, sand, or soda ash. Place in covered containers using non-sparking tools and transport outdoors. Ventilate area and wash spill site after material pickup is complete.

Section 7 - Handling and Storage

HANDLING

User Exposure: Do not breathe vapor. Avoid contact with eyes, skin, and clothing. Avoid prolonged or repeated exposure.

STORAGE

Suitable: Keep container closed. Keep away from heat, sparks, and open flame.
Store at 2-8°C

SPECIAL REQUIREMENTS

Do not freeze.

Section 8 - Exposure Controls / PPE

ENGINEERING CONTROLS

Safety shower and eye bath. Use nonsparking tools. Mechanical exhaust required.

PERSONAL PROTECTIVE EQUIPMENT

Respiratory: Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU). Where risk assessment shows air-purifying respirators are appropriate use a full-face respirator with multi-purpose combination (US) or type ABEK (EN 14387) respirator cartridges as a backup to engineering controls. If the respirator is the sole means of protection, use a full-face supplied air respirator.
Hand: Compatible chemical-resistant gloves.
Eye: Chemical safety goggles.

GENERAL HYGIENE MEASURES

Wash thoroughly after handling. Wash contaminated clothing before reuse.

Section 9 - Physical/Chemical Properties

Appearance: Physical State: Liquid

Property	Value	At Temperature or Pressure
pH	N/A	
BP/BP Range	60.0 - 90.0 °C	
MP/MP Range	N/A	
Freezing Point	N/A	
Vapor Pressure	N/A	
Vapor Density	N/A	
Saturated Vapor Conc.	N/A	
SG/Density	0.8 g/cm3	
Bulk Density	N/A	
Odor Threshold	N/A	
Volatile%	N/A	
VOC Content	N/A	
Water Content	N/A	
Solvent Content	N/A	
Evaporation Rate	N/A	

Viscosity	N/A
Surface Tension	N/A
Partition Coefficient	N/A
Decomposition Temp.	N/A
Flash Point	72 °F 22.2 °C
Explosion Limits	N/A
Flammability	N/A
Autoignition Temp	N/A
Refractive Index	N/A
Optical Rotation	N/A
Miscellaneous Data	N/A
Solubility	N/A

N/A = not available

Section 10 - Stability and Reactivity

STABILITY
Stable: Stable.
Materials to Avoid: Strong oxidizing agents.

HAZARDOUS DECOMPOSITION PRODUCTS
Hazardous Decomposition Products: Nature of decomposition products not known.

HAZARDOUS POLYMERIZATION
Hazardous Polymerization: Will not occur

Section 11 - Toxicological Information

ROUTE OF EXPOSURE
Skin Contact: May cause skin irritation.
Skin Absorption: May be harmful if absorbed through the skin.
Eye Contact: May cause eye irritation.
Inhalation: Material may be irritating to mucous membranes and upper respiratory tract. May be harmful if inhaled.
Ingestion: Harmful if swallowed.

TARGET ORGAN(S) OR SYSTEM(S)
Nerves. Liver. Cardiovascular system. Eyes. Central nervous system. Kidneys. Heart.

SIGNS AND SYMPTOMS OF EXPOSURE
Can cause CNS depression. Narcotic effect. Damage to the heart. When ingested early symptoms mimic alcohol inebriation and are followed by nausea, vomiting, abdominal pain, weakness, muscle tenderness, respiratory failure, convulsions, cardiovascular collapse, pulmonary edema, hypocalcemic tetany, and severe metabolic acidosis. Without treatment, death may occur in 8 to 24 hours. Victims who survive the initial toxicity period usually develop renal failure along with brain and liver damage. Exposure to and/or consumption of alcohol may increase toxic effects. May cause argyria (a slate-gray or bluish discoloration of the skin and deep tissues due to the deposit of insoluble albuminate of silver). To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

CONDITIONS AGGRAVATED BY EXPOSURE
May cause nervous system disturbances. Ethylene glycol is metabolized to glycoaldehyde, glycolic acid, and glyoxal, followed by conversion to glyoxylic acid, formic acid, and

oxalic acid. It has been shown that ethylene glycol is much less toxic than its metabolites. Glycolic acid is thought to be the major toxic metabolite causing acute as well as reproductive and developmental toxicity observed with ethylene glycol exposures.

CHRONIC EXPOSURE - CARCINOGEN
Result: This product is or contains a component that is probably not carcinogenic based on its IARC, ACGIH, NTP, or EPA classification.

CHRONIC EXPOSURE - TERATOGEN
Result: Laboratory experiments have shown teratogenic effects.

CHRONIC EXPOSURE - REPRODUCTIVE HAZARD
Result: Overexposure may cause reproductive disorder(s) based on tests with laboratory animals.

Section 12 - Ecological Information

No data available.

Section 13 - Disposal Considerations

APPROPRIATE METHOD OF DISPOSAL OF SUBSTANCE OR PREPARATION
Contact a licensed professional waste disposal service to dispose of this material. Burn in a chemical incinerator equipped with an afterburner and scrubber but exert extra care in igniting as this material is highly flammable. Observe all federal, state, and local environmental regulations.

Section 14 - Transport Information

DOT
Proper Shipping Name: Ethanol [or] Ethyl alcohol [or] Ethanol solutions [or] Ethyl alcohol solutions
UN#: 1170
Class: 3
Packing Group: Packing Group II
Hazard Label: Flammable liquid
PIH: Not PIH

IATA
Proper Shipping Name: Ethanol solution
IATA UN Number: 1170
Hazard Class: 3
Packing Group: II

Section 15 - Regulatory Information

EU ADDITIONAL CLASSIFICATION
Symbol of Danger: F-Xn
Indication of Danger: Highly Flammable. Harmful.
R: 11-22
Risk Statements: Highly flammable. Harmful if swallowed.
S: 9-16
Safety Statements: Keep container in a well-ventilated place. Keep away from sources of ignition - no smoking.

US CLASSIFICATION AND LABEL TEXT
Indication of Danger: Flammable (USA) Highly Flammable (EU). Harmful.
Risk Statements: Highly flammable. Harmful if swallowed.

Irritating to eyes, respiratory system and skin.
Safety Statements: Keep container in a well-ventilated place. Keep away from sources of ignition - no smoking. In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
US Statements: Target organ(s): Nerves. Liver. Heart. Kidneys. Eyes. Cardiovascular system.

UNITED STATES REGULATORY INFORMATION
SARA LISTED: Yes
NOTES: This product is or contains a component that is subject to SARA313 reporting requirements.

CANADA REGULATORY INFORMATION
WHMIS Classification: This product has been classified in accordance with the hazard criteria of the CPR, and the MSDS contains all the information required by the CPR.
DSL: Yes
NDSL: No

Section 16 - Other Information

DISCLAIMER
For R&D use only. Not for drug, household or other uses.

WARRANTY
The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Inc., shall not be held liable for any damage resulting from handling or from contact with the above product. See reverse side of invoice or packing slip for additional terms and conditions of sale.
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Material Safety Data Sheet

Version 4.0
Revision Date 02/27/2010
Print Date 04/27/2011

1. PRODUCT AND COMPANY IDENTIFICATION

Product name	:	Titanium(IV) oxide, anatase
Product Number	:	637254
Brand	:	Aldrich
Company	:	Sigma-Aldrich 3050 Spruce Street SAINT LOUIS MO 63103 USA
Telephone	:	+1 800-325-5832
Fax	:	+1 800-325-5052
Emergency Phone #	:	(314) 776-6555

2. HAZARDS IDENTIFICATION

Emergency Overview

OSHA Hazards
Irritant

GHS Label elements, including precautionary statements

Pictogram

Signal word: Warning

Hazard statement(s)

H315	Causes skin irritation.
H319	Causes serious eye irritation.
H332	Harmful if inhaled.
H335	May cause respiratory irritation.

Precautionary statement(s)

P261	Avoid breathing dust/fume/gas/mist/vapours/spray.
P264	Wash skin thoroughly after handling.
P271	Use only outdoors or in a well-ventilated area.
P280	Wear protective gloves/eye protection/face protection.
P302 + P352	IF ON SKIN: Wash with plenty of soap and water.
P304 + P340	IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing.
P305 + P351 + P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.
P312	Call a POISON CENTER or doctor/physician if you feel unwell.
P321	Specific treatment (see supplemental first aid instructions on this label).
P332 + P313	If skin irritation occurs: Get medical advice/attention.
P337 + P313	If eye irritation persists: Get medical advice/attention.
P362	Take off contaminated clothing and wash before reuse.
P403 + P233	Store in a well-ventilated place. Keep container tightly closed.
P405	Store locked up.
P501	Dispose of contents/container to an approved waste disposal plant.

HMIS Classification

Health hazard:	2
Flammability:	0
Physical hazards:	0

NFPA Rating

Health hazard: 2
Fire: 0
Reactivity Hazard: 0

Potential Health Effects

Inhalation May be harmful if inhaled. Causes respiratory tract irritation.
Skin May be harmful if absorbed through skin. Causes skin irritation.
Eyes Causes eye irritation.
Ingestion May be harmful if swallowed.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Synonyms : Titanium dioxide

Formula : O_2Ti
Molecular Weight : 79.87 g/mol

CAS-No.	EC-No.	Index-No.	Concentration
Anatase (TiO2)			
1317-70-0	215-280-1	-	-

4. FIRST AID MEASURES

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.Move out of dangerous area.

If inhaled
If breathed in, move person into fresh air. If not breathing give artificial respiration Consult a physician.

In case of skin contact
Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

If swallowed
Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

Special protective equipment for fire-fighters
Wear self contained breathing apparatus for fire fighting if necessary.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions
Use personal protective equipment. Avoid dust formation. Avoid breathing dust. Ensure adequate ventilation.

Environmental precautions
Do not let product enter drains.

Methods and materials for containment and cleaning up
Pick up and arrange disposal without creating dust. Keep in suitable, closed containers for disposal.

7. HANDLING AND STORAGE

Precautions for safe handling
Avoid contact with skin and eyes. Avoid formation of dust and aerosols.
Provide appropriate exhaust ventilation at places where dust is formed. Normal measures for preventive fire protection.

Conditions for safe storage
Keep container tightly closed in a dry and well-ventilated place.

Keep in a dry place.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Contains no substances with occupational exposure limit values.

Personal protective equipment

Respiratory protection
Where risk assessment shows air-purifying respirators are appropriate use a dust mask type N95 (US) or type P1 (EN 143) respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Hand protection
Handle with gloves.

Eye protection
Safety glasses with side-shields conforming to EN166

Skin and body protection
Choose body protection according to the amount and concentration of the dangerous substance at the work place.

Hygiene measures
Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance

Form	powder

Safety data

pH	no data available
Melting point	1,825 °C (3,317 °F) - lit.
Boiling point	no data available
Flash point	not applicable
Ignition temperature	no data available
Lower explosion limit	no data available
Upper explosion limit	no data available
Density	3.9 g/mL at 25 °C (77 °F)
Water solubility	no data available

10. STABILITY AND REACTIVITY

Chemical stability
Stable under recommended storage conditions.

Conditions to avoid
no data available

Materials to avoid
Strong oxidizing agents

Hazardous decomposition products
Hazardous decomposition products formed under fire conditions. - Titanium/titanium oxides

11. TOXICOLOGICAL INFORMATION

Acute toxicity
no data available

Skin corrosion/irritation
no data available

Serious eye damage/eye irritation
no data available

Respiratory or skin sensitization
no data available

Germ cell mutagenicity

no data available

Carcinogenicity

This product is or contains a component that is not classifiable as to its carcinogenicity based on its IARC, ACGIH, NTP, or EPA classification.

IARC:	No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.
ACGIH:	No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.
NTP:	No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.
OSHA:	No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity

no data available

Specific target organ toxicity - single exposure (GHS)
Inhalation - May cause respiratory irritation.

Specific target organ toxicity - repeated exposure (GHS)
no data available

Aspiration hazard
no data available

Potential health effects

Inhalation	May be harmful if inhaled. Causes respiratory tract irritation.
Ingestion	May be harmful if swallowed.
Skin	May be harmful if absorbed through skin. Causes skin irritation.
Eyes	Causes eye irritation.

Signs and Symptoms of Exposure
To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated.

Additional Information
RTECS: BV6550000

12. ECOLOGICAL INFORMATION

Toxicity

no data available

Persistence and degradability
no data available

Bioaccumulative potential
no data available

Mobility in soil
no data available

PBT and vPvB assessment
no data available

Other adverse effects

no data available

13. DISPOSAL CONSIDERATIONS

Product
Observe all federal, state, and local environmental regulations. Contact a licensed professional waste disposal service to dispose of this material.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
Not dangerous goods

IMDG
Not dangerous goods

IATA
Not dangerous goods

15. REGULATORY INFORMATION

OSHA Hazards
Irritant

DSL Status
This product contains the following components listed on the Canadian NDSL list. All other components are on the Canadian DSL list.

	CAS-No.
Anatase (TiO2)	1317-70-0

SARA 302 Components
SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components
SARA 313: This material does not contain any chemical components with known CAS numbers that exceed the threshold (De Minimis) reporting levels established by SARA Title III, Section 313.

SARA 311/312 Hazards
Acute Health Hazard

Massachusetts Right To Know Components
No components are subject to the Massachusetts Right to Know Act.

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Anatase (TiO2)	1317-70-0	1989-08-11

New Jersey Right To Know Components

	CAS-No.	Revision Date
Anatase (TiO2)	1317-70-0	1989-08-11

California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

Further information

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The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Co., shall not be held liable for any damage resulting from handling or from contact with the above product. See reverse side of invoice or packing slip for additional terms and conditions of sale.

Material Safety Data Sheet

Version 4.0
Revision Date 07/23/2010
Print Date 04/27/2011

1. PRODUCT AND COMPANY IDENTIFICATION

Product name	:	Zinc oxide
Product Number	:	544906
Brand	:	Aldrich
Company	:	Sigma-Aldrich 3050 Spruce Street SAINT LOUIS MO 63103 USA
Telephone	:	+1 800-325-5832
Fax	:	+1 800-325-5052
Emergency Phone #	:	(314) 776-6555

2. HAZARDS IDENTIFICATION

Emergency Overview

OSHA Hazards
No known OSHA hazards

GHS Label elements, including precautionary statements

Pictogram

Signal word: Warning

Hazard statement(s)

H316	Causes mild skin irritation.
H320	Causes eye irritation.
H400	Very toxic to aquatic life.

Precautionary statement(s)

P273	Avoid release to the environment.
P305 + P351 + P338	IF IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses, if present and easy to do. Continue rinsing.

HMIS Classification

Health hazard:	0
Flammability:	0
Physical hazards:	0

NFPA Rating

Health hazard:	0
Fire:	0
Reactivity Hazard:	0

Potential Health Effects

Inhalation	May be harmful if inhaled. May cause respiratory tract irritation.
Skin	May be harmful if absorbed through skin. May cause skin irritation.
Eyes	May cause eye irritation.
Ingestion	May be harmful if swallowed.

3. COMPOSITION/INFORMATION ON INGREDIENTS

Formula : OZn

Molecular Weight : 81.39 g/mol

CAS-No.	EC-No.	Index-No.	Concentration
Zinc oxide			
1314-13-2	215-222-5	030-013-00-7	-

4. FIRST AID MEASURES

General advice
Consult a physician. Show this safety data sheet to the doctor in attendance.

If inhaled
If breathed in, move person into fresh air. If not breathing, give artificial respiration. Consult a physician.

In case of skin contact
Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Rinse thoroughly with plenty of water for at least 15 minutes and consult a physician.

If swallowed
Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

5. FIRE-FIGHTING MEASURES

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

Special protective equipment for fire-fighters
Wear self contained breathing apparatus for fire fighting if necessary.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions
Use personal protective equipment. Avoid dust formation. Avoid breathing vapors, mist or gas. Ensure adequate ventilation. Evacuate personnel to safe areas. Avoid breathing dust.

Environmental precautions
Prevent further leakage or spillage if safe to do so. Do not let product enter drains. Discharge into the environment must be avoided.

Methods and materials for containment and cleaning up
Pick up and arrange disposal without creating dust. Sweep up and shovel. Keep in suitable, closed containers for disposal.

7. HANDLING AND STORAGE

Precautions for safe handling
Avoid contact with skin and eyes. Avoid formation of dust and aerosols.
Provide appropriate exhaust ventilation at places where dust is formed. Normal measures for preventive fire protection.

Conditions for safe storage
Keep container tightly closed in a dry and well-ventilated place.

Keep in a dry place.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Components with workplace control parameters

Components	CAS-No.	Value	Control parameters	Update	Basis
Zinc oxide	1314-13-2	TWA	2 mg/m3	2007-01-01	USA. ACGIH Threshold Limit Values (TLV)
Remarks	metal fume fever				

		STEL	10 mg/m3	2007-01-01	USA. ACGIH Threshold Limit Values (TLV)
	metal fume fever				
		TWA	5 mg/m3	1993-06-30	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
		TWA	15 mg/m3	2007-01-01	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
		TWA	5 mg/m3	2007-01-01	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
		TWA	10 mg/m3	1989-01-19	USA. OSHA - TABLE Z-1 Limits for Air Contaminants - 1910.1000
		TWA	5 mg/m3	1989-01-19	USA. OSHA - TABLE Z-1 Limits for Air Contaminants - 1910.1000
		TWA	5 mg/m3	2007-01-01	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
		TWA	5 mg/m3	1989-01-19	USA. OSHA - TABLE Z-1 Limits for Air Contaminants - 1910.1000
		STEL	10 mg/m3	1989-01-19	USA. OSHA - TABLE Z-1 Limits for Air Contaminants - 1910.1000

Personal protective equipment

Respiratory protection
For nuisance exposures use type P95 (US) or type P1 (EU EN 143) particle respirator.For higher level protection use type OV/AG/P99 (US) or type ABEK-P2 (EU EN 143) respirator cartridges. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Hand protection
Handle with gloves. Gloves must be inspected prior to use. Use proper glove removal technique (without touching glove's outer surface) to avoid skin contact with this product. Dispose of contaminated gloves after use in accordance with applicable laws and good laboratory practices. Wash and dry hands.

Eye protection
Safety glasses with side-shields conforming to EN166 Use equipment for eye protection tested and approved under appropriate government standards such as NIOSH (US) or EN 166(EU).

Skin and body protection
impervious clothing, The type of protective equipment must be selected according to the concentration and amount of the dangerous substance at the specific workplace.

Hygiene measures
Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance

Form	powder
Colour	white

Safety data

pH	no data available
Melting point	no data available
Boiling point	no data available
Flash point	not applicable

Ignition temperature	no data available
Lower explosion limit	no data available
Upper explosion limit	no data available
Density	5.610 g/cm3
Water solubility	no data available

10. STABILITY AND REACTIVITY

Chemical stability
Stable under recommended storage conditions.

Conditions to avoid
no data available

Materials to avoid
Strong oxidizing agents

Hazardous decomposition products
Hazardous decomposition products formed under fire conditions. - Zinc/zinc oxides

11. TOXICOLOGICAL INFORMATION

Acute toxicity
LD50 Oral - mouse - 7,950 mg/kg

LC50 Inhalation - mouse - 2,500 mg/m3

Skin corrosion/irritation
Skin - rabbit - Mild skin irritation - 24 h

Serious eye damage/eye irritation
Eyes - rabbit - Mild eye irritation - 24 h

Eyes - rabbit - Mild eye irritation - 24 h

Respiratory or skin sensitization
no data available

Germ cell mutagenicity

Genotoxicity in vitro - Hamster - Embryo
Unscheduled DNA synthesis

Genotoxicity in vitro - Hamster - Embryo
Morphological transformation.

Genotoxicity in vitro - Hamster - Embryo
Sister chromatid exchange

Genotoxicity in vivo - guinea pig - Inhalation
Unscheduled DNA synthesis

Carcinogenicity

IARC:	No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.
ACGIH:	No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.
NTP:	No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.
OSHA:	No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Reproductive toxicity

Developmental Toxicity - rat - Oral

Specific Developmental Abnormalities: Homeostasis Effects on Newborn: Stillbirth. Effects on Newborn: Growth statistics (e.g., reduced weight gain).

Specific target organ toxicity - single exposure (Globally Harmonized System)
no data available

Specific target organ toxicity - repeated exposure (Globally Harmonized System)
no data available

Aspiration hazard
no data available

Potential health effects

Inhalation	May be harmful if inhaled. May cause respiratory tract irritation.
Ingestion	May be harmful if swallowed.
Skin	May be harmful if absorbed through skin. May cause skin irritation.
Eyes	May cause eye irritation.

Signs and Symptoms of Exposure
Zinc oxide dust or fume can irritate the respiratory tract. Prolonged skin contact can produce a severe dermatitis called oxide pox. Exposure to high levels of dust or fume can cause metallic taste, marked thirst, coughing, fatigue, weakness, muscular pain, and nausea followed by fever and chills. Severe overexposure may result in bronchitis or pneumonia with a bluish tint to the skin., prolonged or repeated exposure can cause:, Reversible liver enzyme abnormalities., Diarrhoea

Additional Information
RTECS: ZH4810000

12. ECOLOGICAL INFORMATION

Toxicity

Toxicity to fish	LC50 - Oncorhynchus mykiss (rainbow trout) - 1.1 mg/l - 96.0 h
Toxicity to daphnia and other aquatic invertebrates.	EC50 - Daphnia magna (Water flea) - 0.098 mg/l - 48 h

Persistence and degradability
no data available

Bioaccumulative potential
no data available

Mobility in soil
no data available

PBT and vPvB assessment
no data available

Other adverse effects

An environmental hazard cannot be excluded in the event of unprofessional handling or disposal.

Very toxic to aquatic life.

13. DISPOSAL CONSIDERATIONS

Product
Offer surplus and non-recyclable solutions to a licensed disposal company.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
Not dangerous goods

IMDG
UN-Number: 3077 Class: 9 Packing group: III EMS-No: F-A, S-F

Proper shipping name: ENVIRONMENTALLY HAZARDOUS SUBSTANCE, SOLID, N.O.S. (Zinc oxide)
Marine pollutant: Marine pollutant

IATA
UN-Number: 3077 Class: 9 Packing group: III
Proper shipping name: Environmentally hazardous substance, solid, n.o.s. (Zinc oxide)

Further information
EHS-Mark required (ADR 2.2.9.1.10, IMDG code 2.10.3) for single packagings and combination packagings containing inner packagings with Dangerous Goods > 5L for liquids or > 5kg for solids.

15. REGULATORY INFORMATION

OSHA Hazards
No known OSHA hazards

DSL Status
All components of this product are on the Canadian DSL list.

SARA 302 Components
SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components

	CAS-No.	Revision Date
Zinc oxide	1314-13-2	2007-03-01

SARA 311/312 Hazards
No SARA Hazards

Massachusetts Right To Know Components

	CAS-No.	Revision Date
Zinc oxide	1314-13-2	2007-03-01

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Zinc oxide	1314-13-2	2007-03-01

New Jersey Right To Know Components

	CAS-No.	Revision Date
Zinc oxide	1314-13-2	2007-03-01

California Prop. 65 Components
This product does not contain any chemicals known to State of California to cause cancer, birth defects, or any other reproductive harm.

16. OTHER INFORMATION

Further information
Copyright 2010 Sigma-Aldrich Co. License granted to make unlimited paper copies for internal use only.
The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Co., shall not be held liable for any damage resulting from handling or from contact with the above product. See reverse side of invoice or packing slip for additional terms and conditions of sale.

SIGMA-ALDRICH

Material Safety Data Sheet

Version 3.0
Revision Date 10/22/2009
Print Date 04/27/2011

1. PRODUCT AND COMPANY IDENTIFICATION

Product name : Zinc oxide

Product Number : 677450
Brand : Aldrich

Company : Sigma-Aldrich
3050 Spruce Street
SAINT LOUIS MO 63103
USA
Telephone : +1 800-325-5832
Fax : +1 800-325-5052
Emergency Phone # : (314) 776-6555

2. COMPOSITION/INFORMATION ON INGREDIENTS

Formula : OZn

CAS-No.	EC-No.	Index-No.	Concentration
Zinc oxide			
1314-13-2	215-222-5	030-013-00-7	94 %
Aluminium oxide			
1344-28-1	215-691-6	-	6 %

3. HAZARDS IDENTIFICATION

Emergency Overview

OSHA Hazards
Delayed target organ effects

Target Organs

Lungs, Bone

HMIS Classification

Health hazard: 0
Chronic Health Hazard: *
Flammability: 0
Physical hazards: 0

NFPA Rating

Health hazard: 0
Fire: 0
Reactivity Hazard: 0

Potential Health Effects

Inhalation	May be harmful if inhaled. May cause respiratory tract irritation.
Skin	May be harmful if absorbed through skin. May cause skin irritation.
Eyes	May cause eye irritation.
Ingestion	May be harmful if swallowed.

4. FIRST AID MEASURES

If inhaled
If breathed in, move person into fresh air. If not breathing give artificial respiration Consult a physician.

In case of skin contact
Wash off with soap and plenty of water. Consult a physician.

In case of eye contact
Flush eyes with water as a precaution.

If swallowed
Never give anything by mouth to an unconscious person. Rinse mouth with water. Consult a physician.

5. FIRE-FIGHTING MEASURES

Flammable properties

Flash point	not applicable
Ignition temperature	no data available

Suitable extinguishing media
Use water spray, alcohol-resistant foam, dry chemical or carbon dioxide.

Special protective equipment for fire-fighters
Wear self contained breathing apparatus for fire fighting if necessary.

6. ACCIDENTAL RELEASE MEASURES

Personal precautions
Avoid dust formation. Ensure adequate ventilation.

Environmental precautions
Prevent further leakage or spillage if safe to do so. Do not let product enter drains. Discharge into the environment must be avoided.

Methods for cleaning up
Pick up and arrange disposal without creating dust. Keep in suitable, closed containers for disposal.

7. HANDLING AND STORAGE

Handling
Provide appropriate exhaust ventilation at places where dust is formed. Normal measures for preventive fire protection.

Storage
Keep container tightly closed in a dry and well-ventilated place.

strongly hygroscopic Keep in a dry place.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Components with workplace control parameters

Components	CAS-No.	Value	Control parameters	Update	Basis
Zinc oxide	1314-13-2	TWA	2 mg/m3	2007-01-01	USA. ACGIH Threshold

					Limit Values (TLV)
Remarks	metal fume fever				
		STEL	10 mg/m3	2007-01-01	USA. ACGIH Threshold Limit Values (TLV)
	metal fume fever				
		TWA	5 mg/m3	1993-06-30	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
		TWA	15 mg/m3	2007-01-01	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
		TWA	5 mg/m3	2007-01-01	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
		TWA	10 mg/m3	1989-01-19	USA. OSHA - TABLE Z-1 Limits for Air Contaminants - 1910.1000
		TWA	5 mg/m3	1989-01-19	USA. OSHA - TABLE Z-1 Limits for Air Contaminants - 1910.1000
		TWA	5 mg/m3	2007-01-01	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
		TWA	5 mg/m3	1989-01-19	USA. OSHA - TABLE Z-1 Limits for Air Contaminants - 1910.1000
		STEL	10 mg/m3	1989-01-19	USA. OSHA - TABLE Z-1 Limits for Air Contaminants - 1910.1000
Aluminium oxide	1344-28-1	TWA	15 mg/m3	1997-08-04	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
		TWA	5 mg/m3	1997-08-04	USA. Occupational Exposure Limits (OSHA) - Table Z-1 Limits for Air Contaminants
		TWA	10 mg/m3	1989-01-19	USA. OSHA - TABLE Z-1 Limits for Air Contaminants

					- 1910.1000
		TWA	5 mg/m3	1989-01-19	USA. OSHA - TABLE Z-1 Limits for Air Contaminants - 1910.1000

Personal protective equipment

Respiratory protection
Where risk assessment shows air-purifying respirators are appropriate use a dust mask type N95 (US) or type P1 (EN 143) respirator. Use respirators and components tested and approved under appropriate government standards such as NIOSH (US) or CEN (EU).

Hand protection
For prolonged or repeated contact use protective gloves.

Skin and body protection
Choose body protection according to the amount and concentration of the dangerous substance at the work place.

Hygiene measures
Handle in accordance with good industrial hygiene and safety practice. Wash hands before breaks and at the end of workday.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance

Form	powder

Safety data

pH	no data available
Melting point	no data available
Boiling point	no data available
Flash point	not applicable
Ignition temperature	no data available
Lower explosion limit	no data available
Upper explosion limit	no data available
Water solubility	no data available

10. STABILITY AND REACTIVITY

Storage stability
Stable under recommended storage conditions.

Materials to avoid
Halogenated hydrocarbon, Strong bases, Strong oxidizing agents, Strong acids, Vinyl compounds, Ethylene oxide, Chlorine trifluoride, Oxygen difluoride, Sodium nitrate

Hazardous decomposition products
Hazardous decomposition products formed under fire conditions. - Aluminum oxide, Zinc/zinc oxides

11. TOXICOLOGICAL INFORMATION

Acute toxicity

no data available

Irritation and corrosion

no data available

Sensitisation

no data available

Chronic exposure

IARC:	No component of this product present at levels greater than or equal to 0.1% is identified as probable, possible or confirmed human carcinogen by IARC.
ACGIH:	No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by ACGIH.
NTP:	No component of this product present at levels greater than or equal to 0.1% is identified as a known or anticipated carcinogen by NTP.
OSHA:	No component of this product present at levels greater than or equal to 0.1% is identified as a carcinogen or potential carcinogen by OSHA.

Signs and Symptoms of Exposure

To the best of our knowledge, the chemical, physical, and toxicological properties have not been thoroughly investigated., prolonged or repeated exposure can cause:, Damage to the lungs., Cough, chest pain, Difficulty in breathing, Gastrointestinal disturbance

Potential Health Effects

Inhalation	May be harmful if inhaled. May cause respiratory tract irritation.
Skin	May be harmful if absorbed through skin. May cause skin irritation.
Eyes	May cause eye irritation.
Ingestion	May be harmful if swallowed.
Target Organs	Lungs, Bone,

12. ECOLOGICAL INFORMATION

Elimination information (persistence and degradability)

no data available

Ecotoxicity effects

no data available

Further information on ecology

An environmental hazard cannot be excluded in the event of unprofessional handling or disposal.

Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

13. DISPOSAL CONSIDERATIONS

Product
Observe all federal, state, and local environmental regulations.

Contaminated packaging
Dispose of as unused product.

14. TRANSPORT INFORMATION

DOT (US)
Not dangerous goods

IMDG
UN-Number: 3077 Class: 9 Packing group: III EMS-No: F-A, S-F
Proper shipping name: ENVIRONMENTALLY HAZARDOUS SUBSTANCE, SOLID, N.O.S. (Zinc oxide)
Marine pollutant: No

IATA
UN-Number: 3077 Class: 9 Packing group: III
Proper shipping name: Environmentally hazardous substance, solid n.o.s. (Zinc oxide)

15. REGULATORY INFORMATION

OSHA Hazards
Delayed target organ effects

DSL Status
All components of this product are on the Canadian DSL list.

SARA 302 Components
SARA 302: No chemicals in this material are subject to the reporting requirements of SARA Title III, Section 302.

SARA 313 Components

	CAS-No.	Revision Date
Aluminium oxide	1344-28-1	2007-03-01
Zinc oxide	1314-13-2	2007-03-01

SARA 311/312 Hazards
Chronic Health Hazard

Massachusetts Right To Know Components

	CAS-No.	Revision Date
Aluminium oxide	1344-28-1	2007-03-01
Zinc oxide	1314-13-2	2007-03-01

Pennsylvania Right To Know Components

	CAS-No.	Revision Date
Aluminium oxide	1344-28-1	2007-03-01
Zinc oxide	1314-13-2	2007-03-01

New Jersey Right To Know Components

	CAS-No.	Revision Date
Aluminium oxide	1344-28-1	2007-03-01
Zinc oxide	1314-13-2	2007-03-01

California Prop. 65 Components
This product does not contain any chemicals known to the State of California to cause cancer, birth, or any other reproductive defects.

16. OTHER INFORMATION

Further information
Copyright 2009 Sigma-Aldrich Co. License granted to make unlimited paper copies for internal use only.
The above information is believed to be correct but does not purport to be all inclusive and shall be used only as a guide. The information in this document is based on the present state of our knowledge and is applicable to the product with regard to appropriate safety precautions. It does not represent any guarantee of the properties of the product. Sigma-Aldrich Co., shall not be held liable for any damage resulting from handling or from contact with the above product. See reverse side of invoice or packing slip for additional terms and conditions of sale.

TED PELLA, INC.
Microscopy Products for Science and Industry

Home Page

Material Safety Data Sheet

Product No. 15703-1SC, 15703-5SC, 15705-1SC, 15705-20SC, 15705-5SC, 15707-1CS, 15707-20SC, 15707-5SC, 15708-65SC, 15708-6SC, 15708-85SC, 15708-8SC, 15709-20SC, 15710-20SC Silver Colloids 10, 20, 40, 60, 80, nm
Issue Date (06-21-07)
Review Date (06-21-07)

Section 1: Product and Company Identification

Product Name: Silver Colloids 10, 20, 40, 60, 80, nm
Synonym: None
Manufacture/Vendor: BBinternational, Cardiff, CF14 5DX, UK
Company Name
Ted Pella, Inc. and PELCO International, P.O. Box 492477, Redding, CA 96049-2477
Domestic Phone (800) 237-3526 (Mon-Thu. 6:00AM to 4:30PM PST; Fri 6:00AM to 4:00PM PST)
International Phone (01) (530) 243-2200 (Mon-Thu. 6:00AM to 4:30PM PST; Fri 6:00AM to 4:00PM PST)
Chemtrec Emergency Number 1-800-424-9300 24 hrs a day.

Section 2: Composition / Information on Ingredients

Principle Hazardous Component(s) (chemical and common name(s)) (Cas. No)	%	OSHA PEL mg/m3	ACGIH TLV mg/m3	NTP	IARC	OSHA regulated
*Silver nitrate (7761-88-8)	< 0.001	0.01	0.01	No	No	No
*Sodium citrate dihydrate (6132-04-3)	ND	ND	ND	No	No	No

Silver(I) nitrate (1:1): RTECS #: VW4725000
Citric acid, trisodium salt RTECS #: GE8300000

Section 3: Hazard Identification

Emergency overview
Appearance: Clear yellow liquid (varies with size)
Immediate effects: ND
Potential health effects
Primary Routes of entry: Ingestion, inhalation, skin and eye contact.
Signs and Symptoms of Overexposure: ND
Eyes: May cause irritation.
Skin: May cause irritation.
Ingestion: ND
Inhalation: ND
Chronic Exposure: ND
Chemical Listed As Carcinogen Or Potential Carcinogen:
See Toxicological Information (Section11)
Potential environmental effects
See Ecological Information (Section 12)

Section 4: First Aid Measures
If accidental overexposure is suspected
Eye(s) Contact: In case of contact with eyes, flush with copious amounts of water for at least 15 minutes. Assure adequate flushing by separating the eyelids with fingers. Call a physician.
Skin Contact: In case of skin contact, flush with copious amounts of water.
Inhalation: If inhaled, remove to fresh air. If breathing becomes difficult, call a physician.
Ingestion: If swallowed, wash out mouth with water provided person is conscious. Call a physician.
Note to physician
Treatment: ND
Medical Conditions generally Aggravated by Exposure: ND

Section 5: Fire Fighting Measures
Flash Point: None
Flammable Limits: None
Auto-ignition point: None
Fire Extinguishing Media: NA
Special Fire Fighting Procedures: NA
Unusual Fire and Explosion Hazards: None
Hazardous combustion products: ND
DOT Class: Not regulated.

Section 6: Accidental Release Measures
Steps to be Taken in Case Material is Released or Spilled: Use absorbent material and collect into container for disposal.
Waste Disposal Methods: Dispose of waste according to Federal, State and Local Regulations.

Section 7: Handling and Storage
Precautions to be Taken in Handling and Storage: Do not freeze.
Storage temperature: Room temperature.
Storage Pressure: NA

Section 8: Exposure Controls / Personal Protection
Engineering Controls
Ventilation required: Not required under normal use
Personal Protection Equipment
Respiratory protection: Not required under normal use.
Protective gloves: gloves
Skin protection: Clothing
Eye protection: Safety glasses
Additional clothing and/or equipment: ND
Exposure Guidelines
See Composition/Information on Ingredients (Section2)

Section 9 Physical and Chemical Properties
Appearance and Physical State: Clear yellow liquid (varies with size)
Odor (threshold): ND
Specific Gravity (H_2O=1): ~1
Vapor Pressure (mm Hg): ND
Vapor Density (air=1): ND
Percent Volatile by volume: ND

Evaporation Rate (butyl acetate=1): ND
Boiling Point: ND
Freezing point / melting point: ND
pH: ND
Solubility in Water: Soluble
Molecular Weight: NA

Section 10: Stability and Reactivity
Stability: Stable
Conditions to Avoid: Freezing
Materials to Avoid (Incompatibility): ND
Hazardous Decomposition Products: ND
Hazardous Polymerization: Will not occur

Section 11: Toxicological Information
Results of component toxicity test performed:
Human experience: ND
This product **does not** contain any compounds listed by NTP or IARC or regulated by OSHA as a carcinogen.

Section 12: Ecological Information
Ecological Information: ND
Chemical Fate Information: ND

Section 13 Disposal Considerations
RCRA 40 CFR 261 Classification:
Federal, State and local laws governing disposal of materials can differ. Ensure proper disposal compliance with proper authorities before disposal.

Section 14: Transportation Information
US DOT Information: Proper shipping name: Not regulated.
IATA: Proper shipping name: Not regulated.
IMO: Proper shipping name: Not regulated.
Marine Pollutant: No
Canadian TDG: Not regulated.

Section 15: Regulatory Information
United States Federal Regulations
MSDS complies with OSHA's Hazard Communication Rule 29, CFR 1910.1200.
SARA: ND
SARA Title III: None
RCRA: None
TSCA: Components listed in Inventory
CERCLA: < 0.001% Silver nitrate (7761-88-8) RQ = 1 lbs (0.454 Kg)
State Regulations
California Proposition 65: No
International Regulations
Canada WHMIS: ND
Europe EINECS Numbers: ND

Section 16: Other Information
Label Information: ND

European Risk and Safety Phrases: ND
European symbols needed: ND
Canadian WHMIS Symbols:
Hazard Rating: Health: **ND**; Fire: **0**; Reactivity: **ND**
(0=least, 1=Slight, 2=Moderate, 3=High, 4=Extreme)

Abbreviations used in this document

NE= Not established
NA= Not applicable
NIF= No Information Found
ND= No Data

Disclaimer

Ted Pella, Inc. makes no warranty of any kind regarding the information furnished herein. Users should independently determine the suitability and completeness of information from all sources. While this data is presented in good faith and believed to be accurate, it should be considered only as a supplement to other information gathered by the user. It is the User's responsibility to assure the proper use and disposal of these materials as well as the safety and health of all personnel who may work with or otherwise come in contact with these materials.

MSDS Form 0013F1 V2

TMC
Titanium, Mineral & Chemicals

Tel 82-2-2675-5700 Fax 82-2- 2675-0576
E-Mail : tmc@tmc.co.kr
Homepage : http://tmc.co.kr/

MSDS (Material Safety Data Sheet)

Titanium Dioxide (TiO2) Rutile

Section 1 : Product and Company Identification

Synonyms: Titanium Dioxide, Rutile,
CAS No.: 13463-67-7
Molecular Weight: 79.90
Chemical Formula: TiO2
HS Number : 2823-00-9000

TMC Co., Ltd

Tel 82-2-2675-5700 Fax 82-2-2675-0576

e-mail : tmc@tmc.co.kr

Home page : http://tmc.co.kr
Creation date : Feb. 25. 2005

Section 2 : Composition/Information on Ingredients

Component : Titanium Dioxide
CAS number : 13463-67-7
HS Number : 2823-00-9000
Percentage : 95.5 % ~
Hazardous : No

Section 3 : Hazards Identification

EMERGENCY OVERVIEW

CAUSES IRRITATION TO EYES

NFPA Ratings (Scale 0-4): HEALTH=0 FIRE=0 REACTIVITY=0

EC Classification (Assigned):

R 36/38,EC Classification may be inconsistent with independently-researched data.

Color : white

Physical Form: powder

Odor: odorless

Major Health Hazards: respiratory irritation, eye irritation, mucous membrane irritation

POTENTIAL HEALTH EFFECTS:

INHALATION:

Short Term Exposure: no.

Long Term Exposure: same as effects reported in short term exposure.

SKIN CONTACT:

Short Term Exposure : no.

Long Term Exposure : same as effects reported in short term exposure.

EYE CONTACT:

Short Term Exposure : irritation.

Long Term Exposure : same as effects reported in short term exposure.

INGESTION:

Short Term Exposure : no.

Long Term Exposure : same as effects reported in short term exposure.

CHRONIC EXPOSURE : RESULTS OF EPIDEMIOLOGY STUDY SHOWED THAT EMPLOYEES WHO HAD BEEN EXPOSED TO TITANIUM DIOXIDE PIGMENTS WERE AT NO GREATER RISK OF DEVELOPING LUNG CANCER THAN WERE EMPLOYEES WHO NOT BEEN EXPOSED TO TITANIUM DIOXIDE

CARCINOGEN STATUS:N

OSHA: N

NTP: N

IARC: N

Section 4 : First Aid Measures

Inhalation: Remove to fresh air.
Ingestion: If swallowed, give several glasses of water to drink. Vomiting may occur spontaneously, but DO NOT INDUCE! Never give anything by mouth to an unconscious person. Get medical attention.
Skin Contact: Wipe off excess material from skin then flush skin with plenty of water. Remove contaminated clothing and shoes.
Eye Contact: Immediately flush eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally.

.

NOTE TO PHYSICIAN: For inhalation, consider oxygen.

Section 5 : Fire Fighting Measures

Fire: Not considered to be a fire hazard. Will not burn
Explosion: Sealed containers may rupture when heated.
Fire Extinguishing Media: Use any means suitable for extinguishing surrounding fire. Water spray may be used to keep fire exposed containers cool.
Special Information: In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive pressure mode.. Sealed containers of this material may rupture at moderate temperatures (release of water vapor)..

Section 6 : Accidental Release Measures

Soil Release: Dig holding area such as lagoon, pond or pit for containment. Cover with plastic sheet or tarp to minimize spreading and protect from contact with water.

Water Release: just wash out

Occupational Release:Ventilate area of leak or spill. Keep unnecessary and unprotected people away from area of spill. Wear appropriate personal protective equipment as specified in Section 8. Spills: Pick up and place in a suitable container for reclamation or disposal, using a method that does not generate dust.

Section 7 : Handling and Storage

Keep in a tightly closed container, stored in a cool, dry, ventilated area. Protect against physical damage; observe all warnings and precautions listed for the product.

Section 8 : Exposure Controls/Personal Protection

Airborne Exposure Limits: None established.
Ventilation System: A system of local and/or general exhaust is recommended to keep employee exposures as low as possible. Local exhaust ventilation is generally preferred because it can control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, *Industrial Ventilation, A Manual of Recommended Practices*, most recent edition, for details.
Personal Respirators (NIOSH Approved): For conditions of use where exposure to the dust or mist is apparent, a half-face dust/mist respirator may be worn. For emergencies or instances where the exposure levels are not known, use a full-face positive-pressure, air-supplied respirator. WARNING: Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.
Skin Protection: Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls.
Eye Protection: Use chemical safety goggles. Maintain eye wash fountain and quick-drench facilities in work area.

Clothing: Wear appropriate clothing.

Gloves: impervious gloves or none specified by manufacturer

Section 9 : Physical and Chemical Properties

Appearance: white powder
Odor: Odorless.

Color: white
Solubility: InSoluble in water.

Molecular Weight: 79.90

Molecular Formula: TiO2

Specific Gravity: 3.82-4.2

pH: neutral

% Volatiles by volume @ 21C (70F): 0

Vapor Density (Air=1): No information found.

Vapor Pressure (mm Hg): No information found.

Evaporation Rate (BuAc=1): No information founded

Coefficient of Water/Oil Distribution: Not available

Section 10 : Stability and Reactivity

Stability: Stable under ordinary conditions of use and storage.

Reactivity:. Stable at normal temperatures and pressure

Conditions to Avoid: Stable at normal temperatures and pressure

Polymerization: Will not polymerize.

Hazardous Decomposition Products: not occur

Hazardous Polymerization: Will not occur.

Section 11 : Toxicological Information

Irritation Data: ND

Toxicity Data: ND.

Local Effects: irritation eye

Tumorigenic Data: ND

Mutagenic Data: ND

Reproductive Effects Data: ND

Section 12 : Disposal Considerations

Whatever cannot be saved for recovery or recycling should be managed in an appropriate and approved waste disposal facility. Processing, use or contamination of this product may change the waste management options. State and local disposal regulations may differ from federal disposal regulations. Dispose of container and unused contents in accordance with federal, state and local requirements.

Section 13 : Transport Information

No hazard class in the world