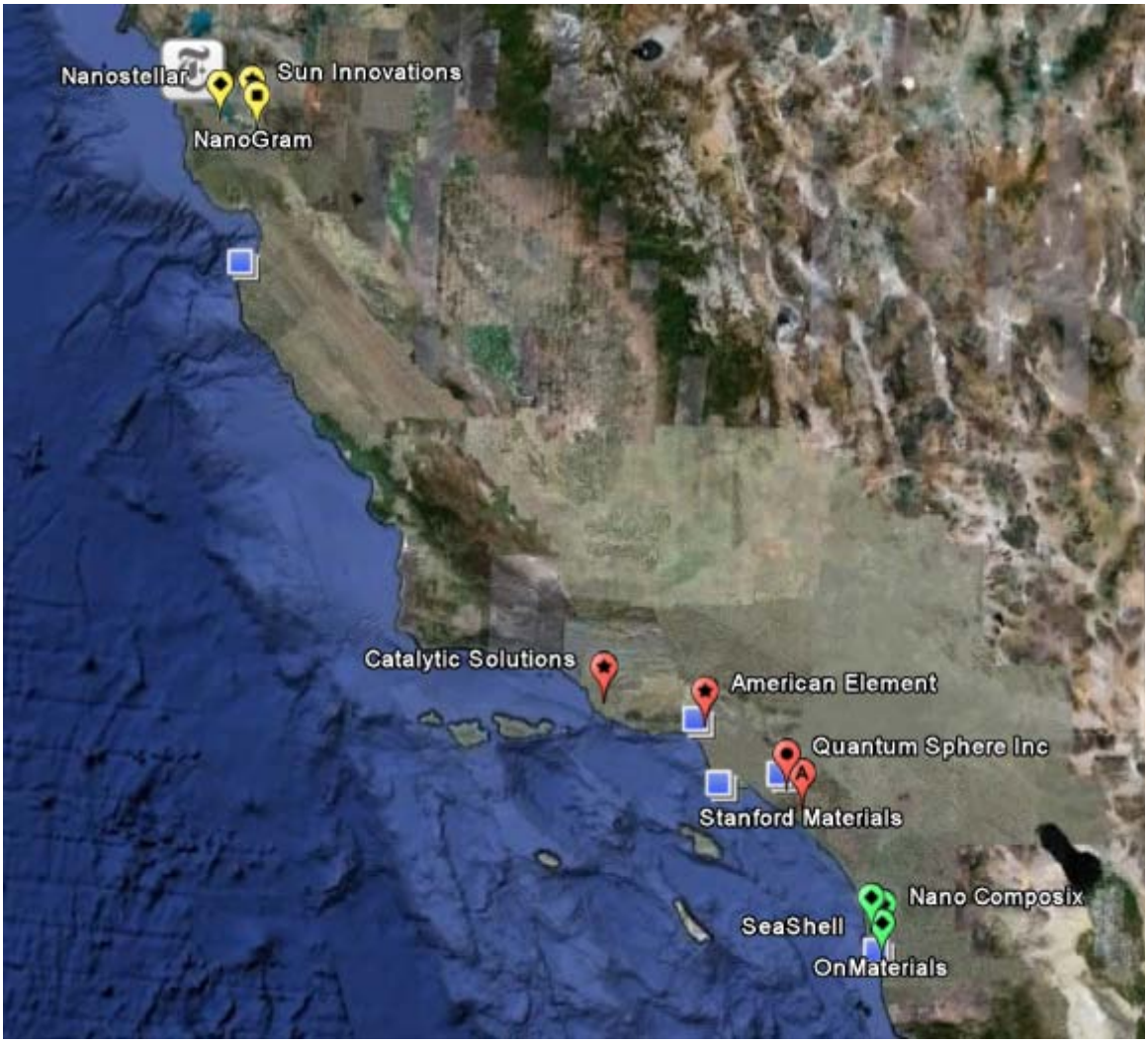
NANOMATERIAL COMPANY VISITS REPORT



Office of Chief Scientist

Department of Toxic Substances Control

2009

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PURPOSE

Nanotechnology is the design, characterization, production, and application of structures, and devices and systems which control the shape and size at near-atomic scale (nanometer scale). Because nanomaterials have of unique properties, they offer the potential for tremendous improvement and advances in many fields, including medicine, pharmaceuticals, electronics, energy, and many other uses. According to the Consumer Products Inventory, maintained by the Woodrow Wilson International Center for Scholars, more than 1000 commercial products on the market in February 2009 reportedly contained nanomaterials. By 2015, the global market for nanotechnology-related products is predicted to reach $1 trillion and employ one million workers in the United States (Lux 2007). However, recent studies have indicated that nanomaterials may impact health and safety of workers and users, and may also impact the environment. Therefore, more data is needed to determine transport mechanisms and toxicity factors for nanomaterials.

In 2006, California Assembly Bill (AB) 289 (Chan) was enacted, giving authority to designated state agencies to request information from chemical manufacturers in order to ensure availability of public information concerning new commercially available chemicals, and to promote increased public protection. In accordance with AB 289, the Department of Toxic Substances Control (DTSC) sent a formal chemical information Call-In Letter on January 22, 2009 to manufacturers who produce or import Carbon Nanotubes (CNT) in California.

Currently, DTSC has identified chemical information data gaps concerning nanometals and nanometal oxides. The specific chemicals of interest include nano silver, and nano zerovalent iron, aluminum oxide, cerium oxide, copper oxide, silicon dioxide, titanium dioxide, and zinc oxide. The information that DTSC will request may include but is not limited to analytical test methods, bio-concentration factor for human, and other relevant information on the environmental fate and transport mechanisms.

In the spirit of collaboration, DTSC has engaged “manufacturers” to seek their inputs related to compliance with AB289 and has establish a dialogue to obtain information and recommendations concerning materials, product synthesis, distribution, and product safety. As part of this research process, between May and November of 2009, DTSC’s AB 289 team members initiated visits to ten (10) California manufacturing companies which are currently producing nanometals and nanometal oxides.

DTSC’s visits to each of the companies included the following: 1) DTSC’s presentation regarding legal requirements contained in California Assembly Bill (AB) 289 Chemical Information Call-In; 2) review and discussion of the DTSC nanomaterials questionnaire; and 3) general consultation regarding nanomaterials, and solicitation of company suggestions for product health and safety, and regulatory approaches for nanomaterials.

The following table lists the ten companies that were visited, with their website addresses and visit dates:

Company Name	Visit Date	Web Site
Quantum Sphere, Inc.	14-May-09	http://www.qsinano.com
NanoComposix, Inc.	15-Jun-09	http://www.nanocomposix.com
Sun Innovations, Inc.	3-Aug-09	http://sun-innovations.com
OnMaterials, Inc.	19-Aug-09	http://www.onmaterials.com
Seashell Technology, Inc.	19-Aug-09	http://www.seashelltech.com
American Elements	8-Sep-09	http://www.americanelements.com
Catalytic Solutions, Inc.	8-Sep-09	http://www.catalyticsolutions.com
Nanogram Corporation	26-Oct-09	http://www.nanogram.com
Nanostellar, Inc.	26-Oct-09	http://www.nanostellar.com
Stanford Materials Corporation	10-Nov-09	http://www.stanfordmaterials.com

PRESENTATIONS

DTSC's presentation to the ten chemical manufacturers introduced the provisions of AB 289, including the call-in of chemical information, and identification of chemicals covered under AB 289. In addition, the presentations provided a summary of general information concerning nanotechnology and related health and safety concerns associated with nanomaterials. The presentations were generally well-received by the manufacturers, who understood and agreed with the need for expanded research into the use of nanomaterials, and appreciated the AB 289 health protection concerns. Several companies expressed their concerns with safeguarding trade secret information, and noted their limited availability of resources to provide DTSC with some of the data required under the statute. The following is an example of a presentation that was discussed during the visit.

California Approach to Nanotechnology & the Future

California Department of Toxic Substances Control

Department of Toxic Substances Control

- ***Protect Public Health and the Environment***
- Part of the Cal/EPA
- Comprised of environmental professionals such as chemistry, geology, engineering, and toxicology
- Functions of the department:
  - Permitting hazardous waste facilities and transporters
  - Remediation of contaminated sites
  - Pollution Prevention & *Green Chemistry* programs
  - Scientific Leadership – ***Emerging Contaminants – Nanomaterials***

California and Nanotechnology

Sustain innovation and success in California
by
creating trust in the marketplace

- **Protect public health and the environment.**
- Get information into the marketplace.
- Sustain California.
  - Sustain innovation.
  - Sustain investments.
  - Lead markets.
  - Create economic centers

The Promise of Nanomaterials

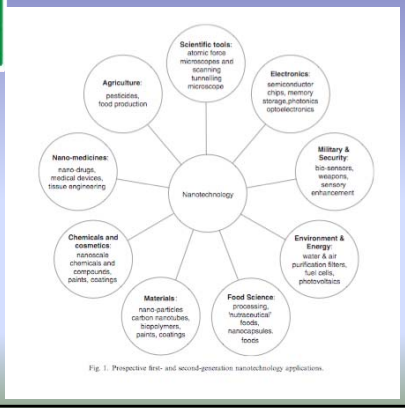
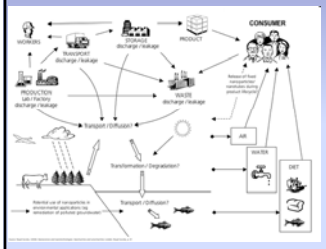


Fig. 1. Prospective first- and second-generation nanotechnology applications.

Concerns Regarding Nanomaterials



- Unique properties
- Uncertain about hazards that maybe associated with size, shape, chemical/physical properties, etc.
- Unknown exposures
- Lack of standardized analytical and hazard evaluation methodologies…
- Need solutions up front, ie. Pollution Prevention (P2) and Green Chemistry

http://www.clarkson.edu/projects/nanobird/images/health_safety/exposure.png

Nanomaterials Information Needs

- **Physical properties, including:**
  - **size**
  - **shape**
  - **surface area (including biologically available surface area)**
  - **solubility**
  - **surface chemistry**
  - **size distribution**
  - **Particle and bulk density**
  - **surface reactivity**
  - **Porosity**
  - **Surface charge**
- **Commercial names**
- **Common form(s)**
- **Chemical composition**
- **Molecular structure**
- **Crystal structure**
- **Physical form(s)**
- **Purity**
- **Adhesion, diffusion, agglomeration, and aggregation behavior**
- **Dispersability**
- **Dose-response and toxicological modes of action**
- **Routes of exposure into the body**
- **Octanol-water partition coefficient**
- **Bioconcentration factor for humans**
- **Metabolism, including but not limited to bioaccumulation sites**
- **Analytical test methods, including methods for metabolites and degradation products**
- **Workplace detection and monitoring**
- **Environmental monitoring**
- **Effectiveness of personal protection equipment**
- **Fate and transport**
- **Physicochemical properties for characterization to enable prediction for biointeractions**
- **Stability in liquid and solid matrices, particularly those in commercial use**
- **Waste handling**

AB289
Chemical Information Call-in

- Assembly Member Wilma Chan (2006)
- Health and Safety Code, Chapter 699, Sections 57019-57020
- Authorized Agency
- Manufacturers Responsible

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Purpose

- Chemical information related to public health and the environment are developed
- Shift the burden of developing chemical information to manufacturers
- Minimize the cost burden by coordinating with manufacturers

AB289 Process

- Identify California manufacturers and information needs for each chemical;
- Search state, federal and intergovernmental databases;
- Build a bibliographic database of the information gathered;
- **Identify information** needs for each chemical
- **Consult** with external experts on information needs (universities, industry associations and others)

AB289 PROCESS

Consult with manufacturers;
Post the information request on the DTSC and Cal/EPA web sites;
MAKE FORMAL REQUEST
Collaborate with manufacturers to identify additional information needed;
Manufacturers have up to **one year to provide** the requested information;
Protect trade secret claims;
Organize information as it is received;
Evaluate/Request additional information, if necessary;
Share the information.

WHAT MAY BE REQUESTED ?

The information that the state agency requests may include, *but is NOT limited to*, any of the following:

- An analytical test method for that chemical, or for metabolites and degradation products for that chemical that are biologically relevant in the matrix specified by the state agency.
- The octanol-water partition coefficient and bioconcentration factor for humans for that chemical.
- Other relevant information on the fate and transport of that chemical in the environment.

Information requested - CNT

- What is the value chain for your company? For example, in what products are your carbon nanotubes used by others? In what quantities? Who are your major customers?
- What sampling, detection and measurement methods are you using to monitor (detect and measure) the presence of your chemical in the workplace and the environment? Provide a full description of all required sampling, detection, measurement and verification methodologies. Provide full QA/QC protocol.
- What is your knowledge about the current and projected presence of your chemical in the environment that results from manufacturing, distribution, use, and end-of-life disposal?
- What is your knowledge about the safety of your chemical in terms of occupational safety, public health and the environment?
- What methods are you using to protect workers in the research, development and manufacturing environment?
- When released, does your material constitute a hazardous waste under California Health &Safety Code provisions? Are discarded off-spec materials a hazardous waste? Once discarded are the carbon nanotubes you produce a hazardous waste? What are your waste handling practices for carbon nanotubes?

Trade Secret / Confidential Business Information

- Supply supporting documentation
- Designate the material as trade secret
- Period of time for which CBI treatment is desired
- Explore innovative methods of maintaining CBI with manufacturers

TRADE SECRET

- Designate the material as trade secret
- Supply supporting documentation
- A trade secret determination is a question of "fact" not "of law"

TRADE SECRET SUPPORTING DOCUMENTATION

- the portions of the information that you allege are entitled to confidential treatment;
- the period of time for which confidential treatment is desired (e.g., until a certain date, until the occurrence of a specified event or permanently);

More Information

www.dtsc.ca.gov/TechnologyDevelopment/Nanotechnology/nanoport.cfm

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QUESTIONNAIRES

-- SURVEY QUESTIONS FOR COMPANIES THAT PRODUCE OR IMPORT NANO-MATERIALS

Thirty-eight survey questions (see specific questions, below) were distributed to the company president or chief officer of each of the 10 facilities prior to DTSC's visits to the companies. During the visits, facilities provided the answers to the questions, either verbally or in written format (Attachment); responses were generally brief. Based on the answers provided, DTSC staff confirmed that a large data gap exists concerning knowledge of potential health and safety impacts related to handling of nanomaterials. Because most of the facilities are currently producing very small quantities for the research and development purposes, less emphasis appeared to have been placed on health and safety issues. Several companies were unwilling to share value chain information,and were also reluctant to share their confidential business information (CBI) with the public and competitors. Several companies also indicated their lack of sufficient resources to provide data regarding toxicity, fate and transport of nanomaterials.

A. General

1. What is the history of your company? (Number of years in nano-technology manufacturing and/or importing)
2. What is the size of your company? How many employees work for your company? How many facilities does your company utilize within California?
3. What is the value chain for your company? For example, in what products are your nano-metals used by others? In what quantities per year? Who are your major customers?

B. Production

4. What are the raw materials in your nano-products? Can you provide a general physical and chemical description of your nano-material products?
5. What is the shape of your nano-products? (Sphere, rod, hollow tube, etc.)
6. What nano-metals, other nano-materials or nano intermediates do you produce or import into California?
7. What products are made from your nano-materials?
8. What is the estimated production capacity of your nano-materials for the last one or two years? (kg/yr)
9. Are any produced in California? If not, where?
10. What production method(s) do you use?
11. Do you use any post-treatment of your nano-products to increase functionality?

12. Do you have any nano-sized byproducts?
13. When released, do your nano-materials constitute a hazardous waste under California Health and Safety Code provisions? Do you have an emergency response plan to handle the accidental release of the hazardous nano-materials?
14. Do you have R&D operations, production or both? If yes, where are these operations located?
15. Do you have any quality control process or testing procedures after you manufacture or import the product?
16. Do you take the health and safety consideration during the product design phase?

C. Shipping, Labeling & Handling

17. How do you store and package your nano-products?
18. Do you have a warehouse in California to store nano-products?
19. How do you ship/transport nanomaterials? Is there a DOT or other shipping bill of lading?
20. What is the shipment form when you ship your nanmaterials to the customers? (Powder, solution, embedded, etc.)
21. Is there any special protocol for your nanomaterials shipment?
22. When you ship your products, do you inform your customers about special properties of your nano-materials?
23. How did you label your product? Do you have any labeling and handling instruction provided to the customer?

D. Health & Safety

24. What health and safety guidance do you follow?
25. What measures do you employ to quantify potential employee exposure to nano-particles?
26. During cleaning activities (machines or apparatus), what type of exposure control methods does your company employ (engineering, work practices, personal protective equipment). Please be specific.
27. What sampling, detection and measurement methods are used to monitor (detect and measure) the presence of chemicals in the workplace and the environment? Please provide a full description of all required sampling, detection, measurement and verification methodologies. Provide full QA/QC protocol.
28. What is your knowledge about the safety of your chemical in terms of occupational safety, public health and the environment?
29. What type of exposure control methods does your company employ to protect workers in the research, development and manufacturing environment?
30. Consistent with 8 CCR 5194 (Cal-OSHA Hazard Communication Standard), please describe measures your company employs to communicate with employees regarding the safe handling of materials they are or may be exposed to in their jobs and on the ways in which they can protect themselves from those materials. Do you have any training in the facility to teach the employee how to handle the hazardous nano- material or nano-waste?

31. Consistent with 8 CCR 5194, what measures has your company taken to assess the physical and health hazards associated with the nano- particles your company manufactures or repackages? Has your company developed Material Safety Data Sheets (MSDS') for these products? If so, please submit these MSDS' along with your response packet.

E. End of life

32. What wastes are created and how are they disposed? Who receive your generated waste?
33. What is your knowledge about the current and projected presence of your chemical in the environment that results from manufacturing, distribution, and end-of-life disposal?
34. Are the discarded off-specification materials a hazardous waste? Once discarded are the nano-materials you produce a hazardous waste? What are your waste handling practices for disposal nano-materials?
35. Did you characterize your disposed nano-materials according to the Title 22, Chapter 11?
36. What is the average storage time for the waste you generated before you dispose them? What's the storage container/packaging method for your nano-product waste? What is the annual generation of the nano-waste?
37. Do you consolidate the wastes that are generated during different nano- product process?
38. Do you keep a record of all the waste that is generated and shipped each year?
39. Do you do any treatment of the waste that is generated during the nano production?

OVERVIEW OF NANOMATERIALS ACTIVITIES AT 10 COMPANIES

1. Overview of Nanomaterials Activities:

The production or use of nanomaterials may include various activities, or combinations of activities, such as: 1) manufacture and sale of nanomaterials; 2) manufacture and incorporation of nanomaterials into other products; 3) purchase of nanomaterials for use in manufacturing of products for sale; 4) import of nanomaterials from other countries or other states for sale to other companies; or 5) nanomaterials characterization and/or consultation. The following table describes the activities of the ten subject companiesin the nanomaterials manufacture or usage:

Activity	Company Name
Produce and sell nanomaterials	QuantumSphere, Inc. Nanocomposix, Sun innovations, Nanostellar, Nanogram
Produce and incorporate nanomaterials into other products for sale	OnMaterials, Catalytic Solutions
Buy nanomaterials and produce products for sale	Seashell Technology
Buy/import nanomaterials and sale	Sun innovations, American Elements, Stanford Materials
Characterization and/or consultation	Nanocomposix

Table: Description of the companies' activities in the nanomaterials manufacture or usage.

The above activities may occur in either an industrial, manufacturing setting or a research and development (R&D) setting. As indicated in the following figure, seven of the ten companies (70%) identified themselves as R&D facilities, and two (20%) were importers (e.g. Stanford Materials Corporate and American Element) who obtained nanomaterials from other countries or other States for sale in California. Only one (10%) of the companies self-identified as a manufacturing facility (Catalytic Solutions Inc.) using nanomaterials for catalytic convertor cores for gasoline and diesel vehicles. Only one company (Nanocomposix) specialized in the characterization of nanoparticles such as silver, gold, and composite materials.

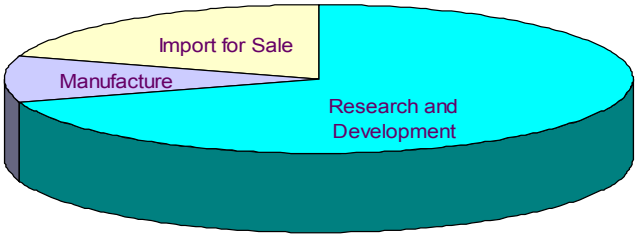


Figure: The distribution of facilities/companies activities among the ten facilities that were visited.

The following Table depicts company size through the number of employees, and compares years of operation. As indicated, these ten subject companies are small-scale facilities, with 2 to 25 employees; years of operation range from five to 16 years.

Company Name	Number of Employees	Years of Operation
Quantum Sphere, Inc.	21	8
NanoComposix, Inc.	Not Available	5
Sun Innovations, Inc.	6	6
OnMaterials, Inc.	3	10
Seashell Technology, Inc.	7	14
American Elements	8	9
Catalytic Solutions, Inc.	25	14
Nanogram Corporation	16	7
Nanostellar, Inc.	Not Available	6
Stanford Materials Corporation	2	16

Table Summary of Number of Employees and Years of Operation among the ten companies

Because the subject ten companies visited by DTSC are small R&D-oriented facilities, it must be noted that the observations from these ten facilities/companies may not be representative of the total nanotechnology companies. Additionally, the impacts of AB 289 are challenging for these small businesses. DTSC identified three major activities, i.e., import for sale, manufacture, research and development, conducted at the ten companies, with broad diversity in safety protocols and exposure levels, detection instrumentation, and material

characterization etc. During the discussions with the companies' representatives, we realized that for this cutting edge innovative technology, good collaboration between the research institution, industries and stake holders is desirable. It is also important that we select and prioritize the companies that may have high potential of nanomaterials exposure to the environment and put more effort to address the nanomaterials health and safety issues.

2. Applications and Nanomaterials:

The ten nanomaterials companies are in small to medium size, but the nanomaterials types and application fields are in a quite large spectrum.

Company Name	Nanomaterials Types	Applications
Quantum Sphere, Inc.	iron, silver, copper, nickel, cobalt, manganese, gold, palladium and alloys	battery manufacturer, defense contractor, automotive and electronic OEMs
NanoComposix, Inc.	Silver, gold and composite	chemical fabrication, integration and characterization
Sun Innovations, Inc.	CNT, Fe, TiO_2, Au, Fe, Ag, Ti, Zn, CO, Cu, Ni, Si, Ti, and Al	display devices
OnMaterials, Inc.	zero-valent iron	remediation products
Seashell Technology, Inc.	Au and Ag	medical/biological research, defense
American Elements	Yttrium Zirconia (YZ), lanthanum, Ni	sales, consulting, fuel cell
Catalytic Solutions, Inc.	Al, nano-rare earth oxides, colloidal silica, colloidal titanium, colloidal rare earth oxides and colloidal alumina	catalytic convertor cores, sales
Nanogram Corporation	Si and SiO_2	solar panels
Nanostellar, Inc.	Pt, Pd, and Au	catalytic converters
Stanford Materials Corporation	ZnO, TiO_2, Fe_3O_4, CuO, and Si	Sales

Table Summary of application and nanomaterials descriptions of ten companies

Above ten companies may change the nanomaterials that they produced or purchased within different period of time based on the market demand. Sun Innovation Inc. handled both carbon nanotubes and nanometal and nanometal oxide materials. Because of the different types of nanomaterials, the health and safety issues may be different. Sun Innovations Inc. may have to have different safety protocols for different type of nanomaterials. We may have to try a proper approach of AB289 for the nanomaterials based on the business models.

Because of the applications of nanomaterials varied from medical/biological research, batteries, and solar panels, the life cycle analysis can be complicate; the nanomaterials can be released into the environment through different path ways. It is urgent to obtain the fate and transport data of nanomaterials from application products to prevent the early entries to the environment without the future inabilities to remediate the release of environment.

3. Health and Safety:

Following Table listed the health and safety approaches of nano material companies. Most companies follow certain guidelines or protocols to protect workers.

Company Name	Health and Safety
Quantum Sphere, Inc.	Following the precautionary principle, and is working with NIOSH to ensure employees follow "best practices" in manufacturing and safe materials handling. Any waste or off-specification materials that are not recycled are drummed and sent to a Class I hazardous waste disposal facility in Texas.
NanoComposix, Inc.	Use solution-based wet-chemistry to handle their products, negative pressure in processing rooms and hoods/vents to inhibit the release of nano-particles.
Sun Innovations, Inc.	This company has a minimal health and safety protocols, using conventional personal protective clothing and techniques, e.g., glove box, and gloves.
OnMaterials, Inc.	The company's Health and Safety protocol is under development by a contractor.
Seashell Technology, Inc.	Nanomaterials at their facility are maintained in a liquid phase, suspended in a glycol solution which poses less hazard than from powder. The company would not permit
American Elements	NA
Catalytic Solutions, Inc.	NA

Nanogram Corporation	Use a hand held TSI particle counter, glove box with laminar flow, and respirators when conducting maintenance activities
Nanostellar, Inc.	Follow DuPont's Environmental Defense program for health and safety protocols and risk assessment
Stanford Materials Corporation	Has no information about how their products are used by their customers. The company provides MSDS information to customers, which is based on bulk materials, not on nanomaterials.

For the import and sales companies, there is a concern that people in the offices are not expert of nanomaterials, they are not able to provide the hazardous information of nanomaterials they sale to the customers. MSDS of nanomaterials should contain more concrete information of nanomaterials, but not only the information of bulk materials. A follow up of this visit will ensure that some of these companies will have the proper worker's safety protocols in place. The MSDS of nanomaterials is based on the nanomaterials.

During the visit, some companies believe that the nanomaterials they handled were in small quantities, and in the liquid phase. The health and safety concern should be minimal. More investigation should be performed to verify this assumption and exposure threshold level is required to clear the health and safety concerns regard to the quantities and liquid phase hazard.

COMPANY PROFILE

Quantum Sphere, Inc.

OVERVIEW

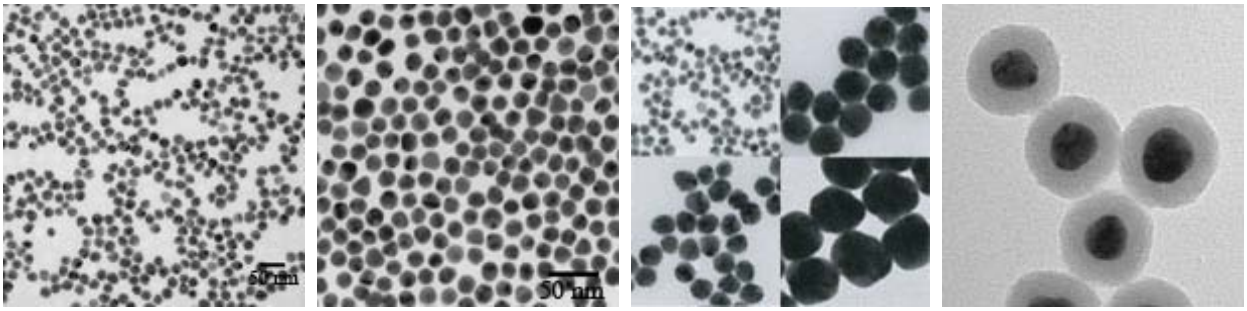
On May 14, 2009, DTSC staff met with QuantumSphere Inc., (QSI) Brendan McKenney, Director of Operations, Dr. Doug Carpentor, Senior Science Advisor and Kevin Maloney, CEO. QSI is located at 2905 Tech Center Drive, Santa Ana, CA 92705.

QSI is mainly an R&D facility founded in 2002. It has eight reactors producing a variety of nanomaterials and alloys including iron, silver, copper, nickel, cobalt, manganese, gold, palladium and alloys of the same materials. The production volume for each element varies, from 5 kg/yr to 120 kg/yr. The major applications for these nanomaterials are in catalytic formulation, conductive inks and advanced battery & fuel cell systems. QSI's major customers are global battery manufacturer, defense contractor, automotive and electronic OEMs. QSI currently has 21 employees; the company addresses workplace safety and health issues following the precautionary principle, and is working with NIOSH to ensure employees follow "best practices" in manufacturing and safe materials handling. Any waste or off-specification materials that are not recycled are drummed and sent to a Class I hazardous waste disposal facility in Texas.

More information on QSI at http://www.qsinano.com

NanoComposix, Inc.

Silver Nanoparticles **Gold Nanoparticles** **NanoTox Panels** **Custom Nanoparticles**



OVERVIEW

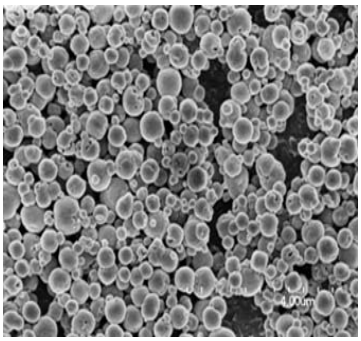
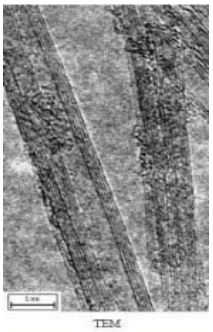
On June 15, 2009, DTSC staff met with Dr. Steven Oldenburg, President and Dr. Arianne Neigh, Senior Scientist, of NanoComposix, located at 4878 Ronson Court, San Diego, CA 92111.

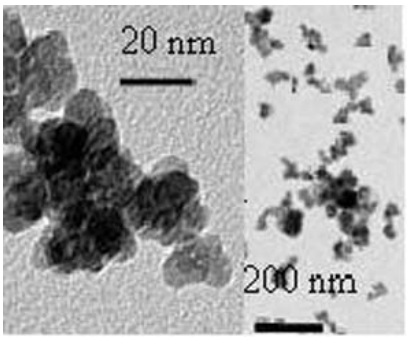
NanoComposix is mainly an R&D facility that specializes in the chemical fabrication, integration and characterization of nanoparticles such as silver, gold, and composite materials (core/shell structure), with a production capacity of about 0.50kg/year. They have also procured from outside sources approximately 15kg of nano copper, brass, and aluminum over the past 2 years. The company started about 4 years ago, and has received DOD, NASA, NIH, NSF grants to study health and safety and the environmental fate and transport of nanomaterials. The facility has a) Transmission Electron Microscopy (TEM) for imaging and sizing analysis; b) Dynamic Light Scattering (DLS) for size analysis for nanoparticles in solution; c) Spectroscopic Analysis to quantify scattering, absorption, and total electromagnetic extinction; and d) Zeta Potential Analysis to measure the surface charge density of nanoparticles in solution.

NanoComposix employees use solution-based wet-chemistry to handle their products, e.g., spherical silver nanoparticles; in this way, the company believes that their employees are protected from exposure to nanoparticles. In addition, employees use several other technologies, such as negative pressure in processing rooms and hoods/vents to inhibit the release of nanoparticles.

More information at http://www.nanocomposix.com

Sun Innovations, Inc.



OVERVIEW

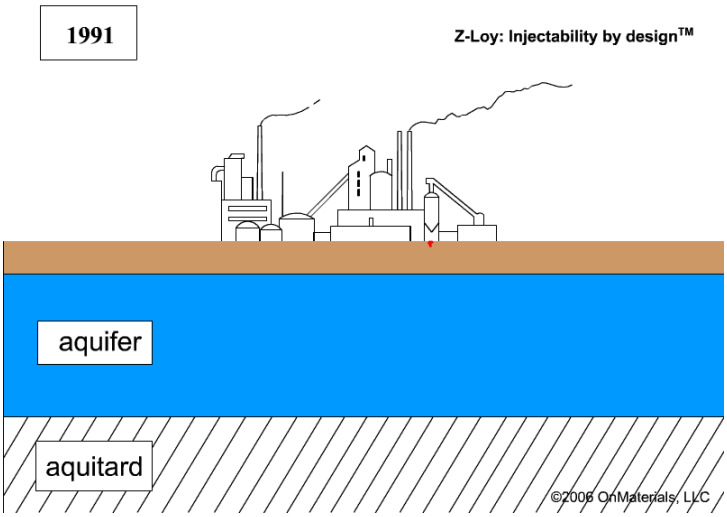
On August 3, 2009, DTSC staff met with Doug Bragdon of Sun Innovations, located at 43241 Osgood Road, Fremont CA 94539.

Sun Innovations (SI) was established in 2004 and has 6 employees. They are mostly R&D Company working for government and industry, and anticipate working with UC's in the future. SI primary business focus is not nanomaterials. They make only nano-phosphors (Yttrium compounds) for display devices. They also import small quantities of CNT, Fe, TiO_2, Au, Fe, Ag, Ti, Zn, CO, Cu, Ni, Si, Ti, and Al from China in various forms, including powders, dispersions, and colloids. Some of these materials are sold to universities and research institution in quantities less than 10 gm.

This company has a minimal health and safety protocols, using conventional personal protective clothing and techniques, e.g., glove box, and gloves.

More information at http://sun-innovations.com

OnMaterials, Inc.



OVERVIEW

On August 19, 2009, DTSC staff met with John Freim, President of OnMaterials in his California office, located at 1425 Russ Boulevard, Suite T-107E, San Diego, CA 92101.

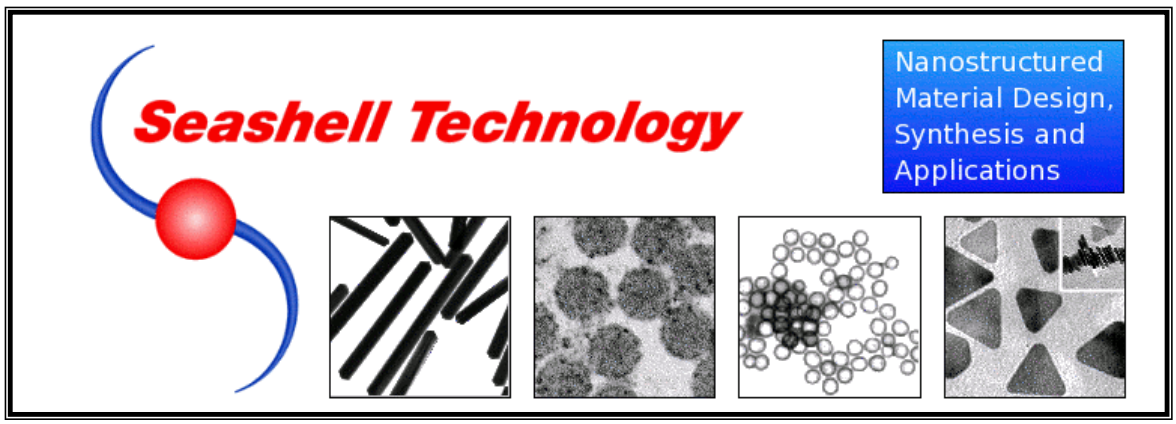
OnMaterials was formed in 2000 and has been working on remediation products since 2003. They produce zero-valent iron (ZVFe), which is used for groundwater remediation. The company's production takes place in Akron, Ohio using the foundry and facility called "Union Process". OnMaterials also has an office in San Diego which specializes in R&D, analytical work, and administrative functions. The company does not see their product as a nanomaterial.

Using mechanical deposition, Fe particles are absorbed on the surface of Al_2O_3, to create a core (oxide)/shell (Fe) structure. Average Fe powder particle diameter size is between 250 nm to 1 micrometer; however, 500 nm is the ideal size of their product. Particles are water soluble, and agglomerate in aqueous environments. OnMaterials product is suspended in a propylene glycol 50%/50% solution. The ZVFe product is shipped in totes or drums, and can be administered with bio-remediation agents. Generally, 100 lbs. to 1500 lbs. of ZVFe are used per injection well.

Last year, OnMaterials initiated approximately 30 groundwater injection projects using ZVFe; they currently are operating an injection well in Texas for groundwater remediation. The company's Health and Safety protocol is under development by a contractor.

More information at http://www.onmaterials.com

Seashell Technology, Inc.



OVERVIEW

On August 19, 2009, DTSC staff met with Dr. David Schultz, Vice President, Dr. James R. Glass, Senior Staff Scientist Seashell Technology, at the company's office located at 3252 Holiday Court, Suite 227, La Jolla, CA 92037.

Seashell Technology was incorporated in 1996 and has seven employees. They have approximately 7 years experience as a spinoff R&D company from UC San Diego. Their major products are Au and Ag which is used in the field of medical/biological research. Au particles are used for pregnancy testing, bioassays for cellular interactions and development, and imaging applications. Because silver particles with sizes between 40 to 100 nm have unique physical properties, they use it in imaging applications, e.g. nano-labeling. Seashell Technology produces nano-composite products, the chemical surfaces of which are modified by nanomaterials, range in size from 500 nm to 2 um and are sold to R&D material markets and

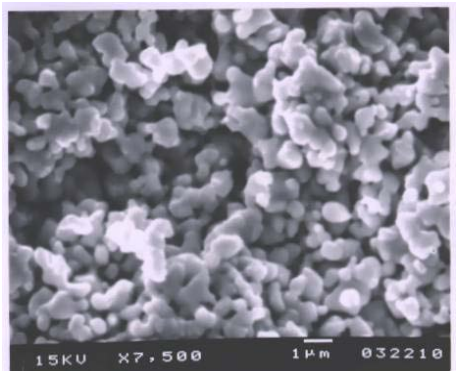
universities. Seashell Technologies has also conducted research of TiO_2 nanomaterial filters, and conducts some functionalized treatments using Au and Ag.

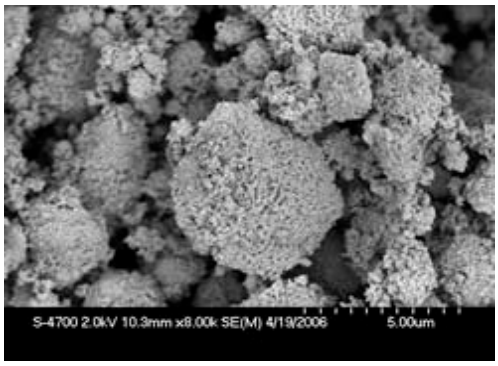
In addition, Seashell has developed specialized coatings with unique functionality for the defense industry. This ultra hydrophobic coating prevents aircraft corrosion; is not yet on the market. Previously, Seashell Technology initiated a successful study for the U.S. Army, testing effectiveness of different mesh sizes for the filtering system on face masks.

Seashell Technology has incorporated suppliers MSDS information into their own; however, the company representatives indicated that they were unaware of the toxicity of their products never-the-less their nanomaterials at their facility are maintained in a liquid phase, suspended in a glycol solution which poses less hazard than from powder. The company would not permit us to tour their manufacturing facility, indicating that they are very protective of intellectual property and trade secrets.

More information at http://www.seashelltech.com

American Elements





OVERVIEW

On September 8, 2009, DTSC staff met with Michael Silver, President of American Elements, whose office is located at 10884 Weyburn Avenue, Los Angeles, CA 90024. This company operates as a "middle-man" in the supply chain. They do not operate a manufacturing facility;

instead, they generally purchase nanomaterials from Sigma-Aldrich and sell to R&D facilities. They also provide their customers with literature search related to nanomaterials.

The company has 8 employees and now focuses on fuel cell materials, such as Yttrium Zirconia (YZ), lanthanum, Ni; they do not currently deal with CNT.

More information at http://www.americanelements.com

Catalytic Solutions, Inc.

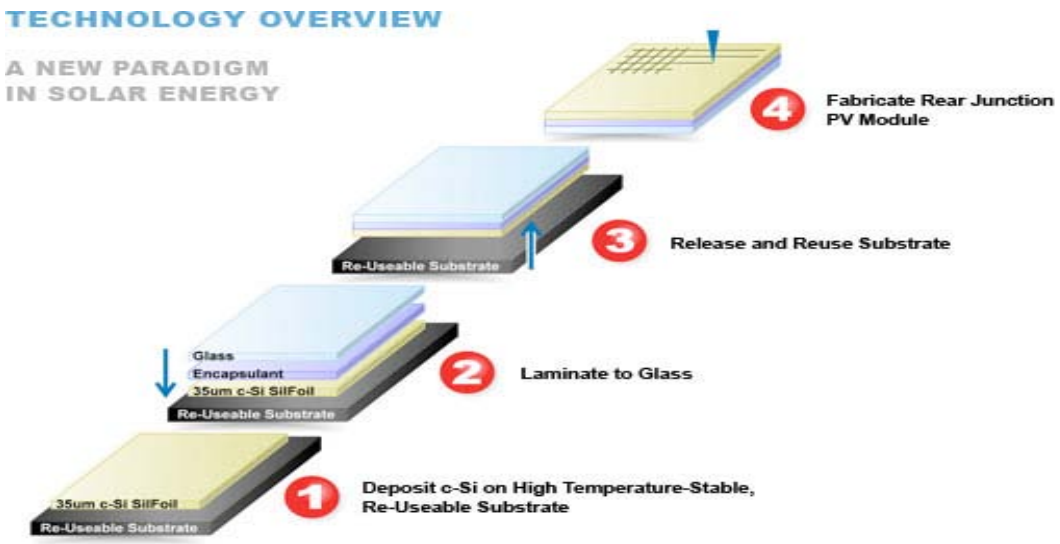
OVERVIEW

On September 8, 2009, DTSC staff met with Ms. Alison Currie of Catalytic Solutions, whose office is located at 1620 Emerson Avenue, Oxnard, CA 93033.

Catalytic Solutions (CSI) manufactures catalytic convertor cores for gasoline and diesel vehicles, using materials such as Al_2O_3, CeO_2, ZrO_2 and Pt particles. They claim that the raw materials they use are not at nano-scale. The coatings used in their manufacturing are primarily composed of Alumina, rare earth oxides, platinum group metals and water. The raw materials that are nano-scale are used for research and engineering purposes. The nano materials they are currently using are Al, nano-rare earth oxides, colloidal silica, colloidal titanium, colloidal rare earth oxides and colloidal alumina. They claim that the nanomaterials that are disposed of are not considered hazardous waste.

More information at http://www.catalyticsolutions.com

Nanogram Corporation



OVERVIEW

On October 26, 2009, DTSC staff met with Mr. Bill McGovern, Director Plant Engineering Dr. Igor Altman, Senior Scientist of Nanogram, whose offices are located at 165 Topaz Street, Milpitas, CA 95035.

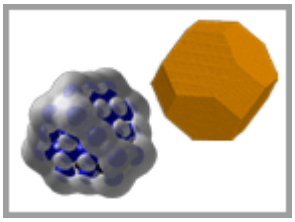
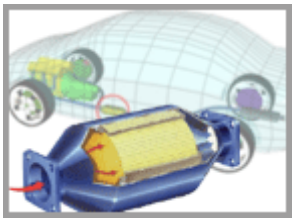
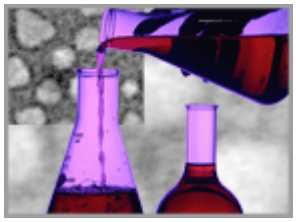
Nanogram is an R&D facility with 25 employees (last year they had 85 employers). Major materials they work with are Si and SiO_2, for application of solar panels. Average particle size is between 5-30 nm; to calculate surface areas of particles, the BET method is used with XRD for additional characterization of particles. Nanogram in the past produced TiO_2.

To make nanoparticles, they use CO_2 laser beams, for which the precursor is a gas mixture. This precursor is claimed to be a confidential trade secret by the company. Nanoparticles are collected after quenching in the collection system. The process exhaust, caused by flammable by-products, is collected with 0.2 µm filter in two stages, and neutralized with CO_2 gas.

For personal protection, Nanogram uses a hand held TSI particle counter, glove box with laminar flow, and respirators when conducting maintenance activities.

More information at http://www.nanogram.com

Nanostellar, Inc.

OVERVIEW

On October 26, 2009, DTSC staff met with Mr. Pankaj Dhingra, Nanostellar CEO at their facility located at 3696 Haven Avenue, Suite B, Redwood City, CA 94063.

Nanostellar is an R&D company with 16 employees. They provide technology to manufacturing companies with license to produce their R&D results. Europe is the major market for this company, because Nanostellar's technology is centered on catalytic converters for exhaust gas, with special focus on diesel fuels. Catalysts are nanometer size (Pt, Pd, and Au) but supporting material (Al_2O_3) is µm range. Additional support materials used are Pt, Pd, Au ($PtNo_3$, $PdNo_3$, and $HAuCl_4$) + Al_2O_3.

Their chemical process creates a coating of Pt, Pd, and Au on Al_2O_3 surface by precipitation. This product is called a "support catalyst". The support catalyst are coated on the catalyst converter structure (MnO compound, honeycomb or rectangular shape). Nanostellar's main function is making of Pt, Pu, Au + Al_2O_3 compounds. Nanomaterials are composed of 3 to 5 wt% in catalyst (Al_2O_3 + nanomaterials) and operating temperature range is 20ºC to 800ºC.

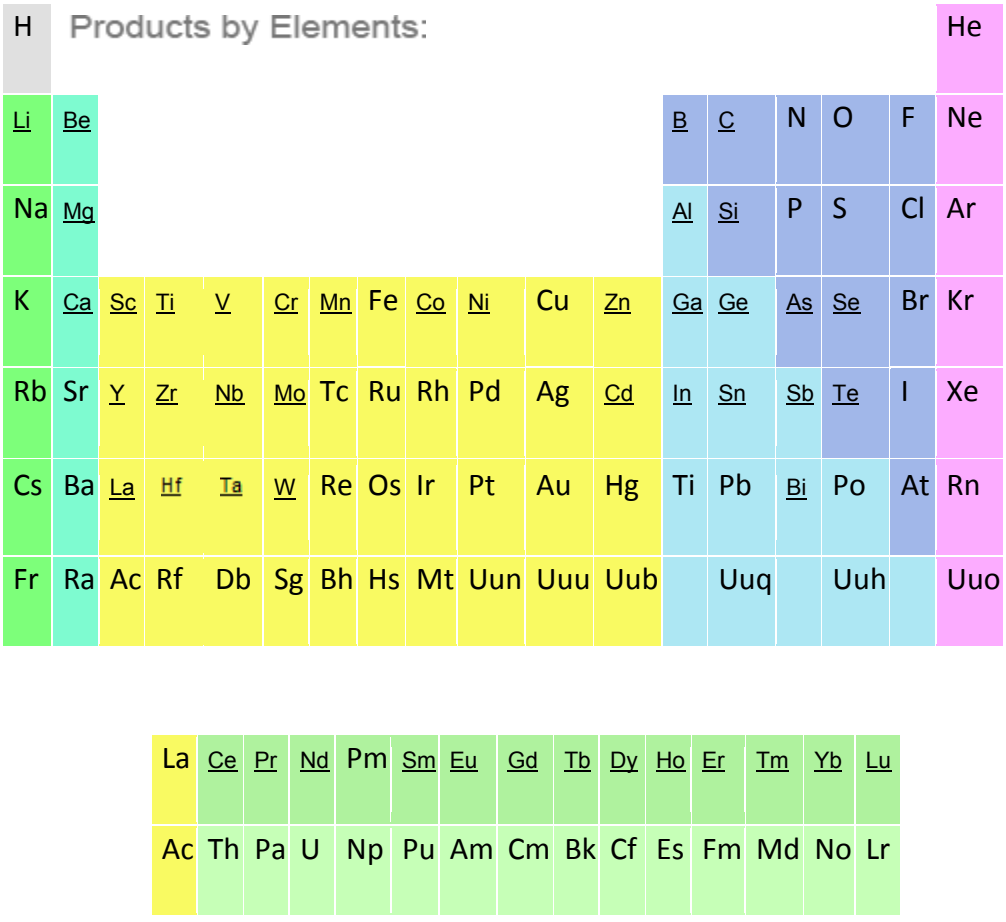
Raw materials, which are in solution in the form of $PtNO_3$, $PdNO_3$, and $HAuCl_4$ are purchased from Heauer in Germany; this solution does not contain nanometal particles, which have been

dissolved as components in the solution. Catalytic Solution, Johnson Mattheis, BASF, and Unicore are catalyst companies similar to Nanostellar.

Nanostellar follows DuPont's Environmental Defense program for health and safety protocols and risk assessment.

More information at http://www.nanostellar.com

Stanford Materials Corporation



OVERVIEW

On November 10, 2009, DTSC staff met with Dr. Chen, Stanford Materials at his home/office, located at 4 Meadowpoint, Aliso Viejo, CA 92656.

Stanford Materials is a family-owned business. The company imports nanometals and oxides from China to port of Los Angeles. Upon receipt of nanomaterials at the Port, the company ships the nanomaterials via FedEx to their customers. For the past 6 years, the company has been selling ZnO_2, TiO_2, Fe_3O_4, CuO, and Si to their customers. No carbon nanotubes have been imported recently; however, it would be imported if requested by customers.

Major customers of Stanford Materials are academia and some research labs; however, Stanford Materials has no information about how their products are used by their customers. The company provides MSDS information to customers, which is based on bulk materials, not on nanomaterials.

More information at http://www.stanfordmaterials.com

RECOMMENDATION

Beginning the second half of 2008, the Department of Toxic Substances Control (DTSC) started the process to request information regarding analytical test methods, fate and transport in the environment, and other relevant information from manufacturers of certain chemicals of concern, pursuant to Assembly Bill (AB) 289, which was signed into law in 2006. The term "manufacturers" includes persons and businesses that produce chemicals in California or import chemicals into California for sale. During the 10 companies visit, it seemed that some manufactures are not clear if the chemicals that are handled will be administered by AB289 call in program. For small companies, they lack the resources to conduct research on the analytical test methods, fate and transport in the environment. To choose the **proper target** companies for chemical information call in program might be able to collect valuable data to accomplish the mission of fill in the data gap in nanomaterials industries.

Secondly, it seemed to be very important to enforce the companies to provide **detailed MSDS** of nanomaterials that they are handling or imported. This MSDS information will provide safety information related with the nanomaterials and ensure that nanomaterials will not release to environment through the value chain or life cycle.

Thirdly, nanomaterials companies are quite diverse from raw material production to intermediate or to final integrated product. Because of the small size and small quantities, a proper **worker safety protocol** should be developed to adapt to the different working environment and different product conditions. All of the nano-material products should have proper labels to ensure that customer is aware of the nanomaterials in the product that they are handling.

Nanomaterials are small and wonderful things, but it is challenging regards the health and safe issues. It is desirable to encourage industries and research institutions have **collaboration** from the governmental perspective and fill in the data gaps related with the nanomaterials analytical test method, fate and transport behaviors, and toxicity etc. It is desirable to obtain the toxicity and other fate and transport information of a product before it is put on a market.