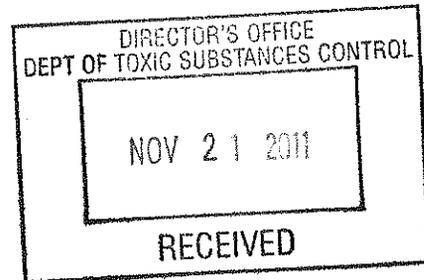




ISHIHARA CORPORATION (U.S.A.)

November 18, 2011

Dr. Jeffrey Wong
Chief Scientist
California Environmental Protection Agency
Department of Toxic Substances Control
1001 "I" Street
P.O. Box 806
Sacramento, CA 95812-0806



Dear Dr. Wong:

Thank you for your letter of December 21, which was a formal request for chemical information and analytical test methods for specified nanomaterials. We are sending along our responses to sections A, B, C, D, E, and F of the questionnaire.

Ishihara Corporation (U.S.A.) is a subsidiary of Ishihara Sangyo Kaisha of Japan, who is the manufacturer of the nanoparticle titanium dioxide products that we sell. Ishihara Corporation (U.S.A.) is an importer, not a manufacturer, so for the annual production volume we have responded based on the volume of these products that we have provided to customers here in California. We discussed this matter with Mr. Hamid Saebfar shortly after we received the referenced request for information.

Mr. Saebfar suggested that we report on our sales volume for a single year. However, after looking through our sales records for recent years, we found that the volumes we supplied to California locations were very small. Therefore we decided to report on our sales volume over the past several years.

Since January 1, 2009, Ishihara has sold or sent samples of five of our nanoparticle titanium dioxide grades to companies located in California. These grades are TTO-55B, TTO-55D, TTO-55N, ET-300W, and ST-01. We have provided the information requested in sections D, E, and F of the questionnaire for each of these grades.

You can see that the California sales volume, which is listed under the annual production volume, is very small. Almost all of our sales of nanoparticle titanium dioxide in California are samples for testing or analysis. We would like to note for your reference that Ishihara sells

some of these products in larger volumes to companies located in other states, but we do not have any regular commercial business for these products in California. We would also like to note that we store ET-300W at a public warehouse in Pico Rivera, California for sales to customers in other states. We do not store any other nanoparticle titanium dioxide products in California.

We would also like to note that Ishihara Corporation (U.S.A.) is a small sales office, and we do not have technical staff. We therefore asked the technical staff at Ishihara Sangyo Kaisha, our parent company, to prepare the technical data requested for section D of the questionnaire.

Thank you for your attention.

Best Regards,

A handwritten signature in black ink, appearing to read "David Duenwald". The signature is fluid and cursive, with a large initial "D".

David Duenwald

Vice President - Marketing
Ishihara Corporation (U.S.A.)

STATE OF CALIFORNIA
Department of Toxic Substances Control

Health and Safety Code Section 57019 Chemical Information Call-in Information
for Nanometals, Nanometal Oxides, and Quantum Dots
December 2010

This enclosure is provided for your convenience. You may provide the requested information in writing, and attaching any supplementary materials or explanatory information, in letter or report form.

SECTION A: CHEMICAL(S) (check each one which applies for your company)		
<input type="checkbox"/> Nano Silver	<input checked="" type="checkbox"/> Nano Titanium Dioxide	<input type="checkbox"/> Nano Cerium Oxide
<input type="checkbox"/> Nano Zero Valent Iron	<input type="checkbox"/> Nano Zinc Oxide	<input type="checkbox"/> Quantum Dot(s)

SECTION B: BUSINESS IDENTIFICATION INFORMATION (check one and complete items 1 - 10)				
<input type="checkbox"/> Sole Owner	<input checked="" type="checkbox"/> Corporation	<input type="checkbox"/> Limited Liability Company (LLC)	<input type="checkbox"/> Limited Liability Partnership (LLP)	<input type="checkbox"/> Unincorporated Business Trust
<input type="checkbox"/> Spouses' Co-ownership	<input type="checkbox"/> Registered Domestic Partnership	<input type="checkbox"/> General Partnership	<input type="checkbox"/> Limited Partnership	<input type="checkbox"/> Other: (describe)
1. Name of Sole Owner, Corporation, Partnership, Institution, Other. <i>Ishihara Corporation (U.S.A.)</i>				
2. Business Trade Name ("Doing Business As," if any)				
3. Business Address (physical location of your business: street number and name, city, state, country, zip or postal code) <i>601 California Street, Suite 1700, San Francisco, CA 94108</i>				
4. Mailing Address (street name and number, P.O. box, city, state, country, zip or postal code, if different from 3)				
5. Business Website Address(es): <i>www.ishihara.com</i>				
6. Name of Owner, Responsible Corporate Officer, Partner, (Other). <i>David Duenwald, Vice President - Marketing</i>				
7. Contact Information for Person in 6 above.				
Name: <i>David Duenwald</i>		Title: <i>Vice President - Marketing</i>		
Business Telephone: <i>415-421-8207</i>		Email: <i>duenwald@ishihara.com</i>		
8. Number of Employees (California employees). <i>7</i>				
9. NAICS Code(s) for this business: Primary: Other: Other:				
10. Nano Chemical Business Type: (check applicable) <input type="checkbox"/> Manufacturer <input checked="" type="checkbox"/> Importer <input type="checkbox"/> Researcher				

SECTION C: CERTIFICATION (FOR THIS COMPLETE SUBMITTAL)		
I am duly authorized to prepare and submit this information, as a formal response to the request pursuant to Health and Safety Code section 57019(d)(1), and certify the information and statements made herein, and in the attachments, are correct to the best of my knowledge and belief.		
Name: (type or print)	Signature:	Date:
<i>David Duenwald</i>	<i>David Duenwald</i>	<i>11/18/11</i>

SECTION D: NANOMATERIAL CHEMICAL AND PHYSICAL PROPERTIES (Attach additional pages as needed)

PRODUCT / PRODUCTION INFORMATION

NANO CHEMICAL NAME: (Use a separate page for each unique chemical)
 TTO-55 (B)

COMMERCIAL NAME(S): ISHIHARA SANGYO KAISHA, LTD.

ANNUAL PRODUCTION VOLUME: 2009 - 2 ; 2010 - 2 ; 2011 - 20.3 KG

PRODUCTION METHOD(S): Hydrolysis - see attached

IDENTIFICATION OF THE SUPPLIER(S): Yokkaichi Plant, Japan

PARAMETER	VALUE / RANGE (include units)	NAME OF ANALYTICAL METHOD(S)
-----------	----------------------------------	------------------------------

PHYSICAL PROPERTIES

SHAPE (MORPHOLOGY)	powder	-
DENSITY	3.5~4.2 (g/cm ³)	Measured by Ultra-pycnometer
SURFACE AREA	37.5~42.5 m ² /g	BET method
PARTICLE SIZE DISTRIBUTION	Air	not applicable
	Liquid	not applicable
	Solid / Powder	0.03~0.05 μm
OTHER (Specify)	Document-4	

CHEMICAL PROPERTIES

CHEMICAL COMPOSITION	Titanium dioxide (TiO ₂)	/	
SURFACE MODIFICATION (COATING, FUNCTIONALIZATION)	Aluminium Hydroxide Al(OH) ₃		
PURITY	90~93%		ASTM D-1394
SURFACE CHARGE	unknown		
DISPERSION ²	Air		unknown
	Liquid		to be developed
	Solid		unknown
IDENTIFYING AND DETERMINING CONCENTRATION OF NANO CHEMICAL, ITS METABOLITES, AND DEGRADATION PRODUCTS IN SPECIFIED MATRICES ² Water, Air, Soil, Sediment, Sludge, Chemical Waste, Fish, Blood, Adipose Tissue, Urine, Other (specify)	Water, Air, Soil: Not Metabolites and Degradation. The other items do not have information.		
SOLUBILITY	Water Solubility		not dissolve
	Solubility in Organic Solvent		not dissolve
N-OCTANOL-WATER PARTITION COEFFICIENT	to be developed		
STABILITY AND REACTIVITY	Flammability	not applicable	
	Explosiveness	not applicable	
	Oxidizing Properties	not applicable	
	Oxidation Reduction Potential	not applicable	
	Storage Stability and Reactivity (Container Material)	Not regulated for packaging and container	
	Stability to Thermal, Sunlight, and Metal(s)	Inert to most chemicals, reagents.	

§2 Manufacturing procedure of ultra-fine TiO₂

2-1 General manufacturing methods

Although there are a lot of suggestions concerning the manufacturing method of ultra-fine TiO₂, the methods shown in Table 2-1 are commonly adopted.

1) Neutralization and hydrolysis of titanium chloride ²⁾ $\text{TiCl}_4 + 4\text{NaOH} \longrightarrow \text{TiO}_2 + 4\text{NaCl} + 2\text{H}_2\text{O}$ <p style="text-align: center;">↳ Calcination</p>
2) Oxidization of titanium chloride in vapor phase ³⁾ $\text{TiCl}_4 + \text{O}_2 \longrightarrow \text{TiO}_2 + 2\text{Cl}_2$
3) Neutralization of sodium titanate ⁴⁾ <p style="text-align: center;">NaOH treatment HCl treatment</p> $\text{TiO}_2 \cdot n\text{H}_2\text{O} \longrightarrow \text{Na}_2\text{TiO}_3 \longrightarrow \text{TiO}_2 + \text{NaCl}$ <p style="text-align: center;">↳ Calcination</p>
4) Hydrolysis of titanium alkoxide ⁵⁾ $\text{Ti}(\text{O}-\text{R})_4 + 2\text{H}_2\text{O} \longrightarrow \text{TiO}_2 + 4\text{R}-\text{OH}$ <p style="text-align: center;">↳ Low-temp calcination</p>
5) Vapor phase cracking of titanium alkoxide ⁶⁾ <p style="text-align: center;">Heating</p> $\text{Ti}(\text{O}-\text{R})_4 \longrightarrow \text{TiO}_2 + \text{H}_2\text{O} + \text{alkene}$

Fig. 2-1 Production methods of ultra-fine TiO₂

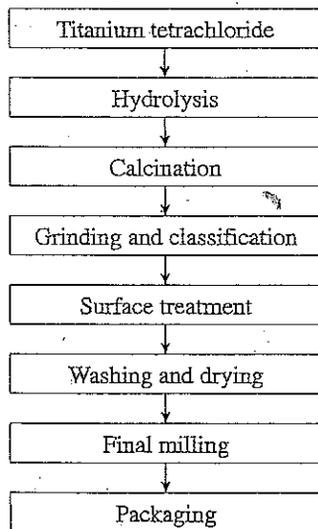


Fig. 2-1 Production procedure of TTO-55, 51, F

2-2 ISK's manufacturing methods

For manufacturing ISK's ultra-fine TiO₂, TTO series, we use two different methods, whose rough procedures are illustrated in Fig.2-1 and Fig.2-2 respectively ((1) and (3) of Fig.2-1). With either method, different grades are variously characterized by controlling the purity of raw material TiCl₄, hydrolysis, calcination, leaching and surface treatment. In order to avoid confusion hereinafter, we call the flow of Fig.2-1 "TTO calcination method", while the one in Fig.2-2 "TTO wet method". Recently, ISK has established a new manufacturing process. Ultra-fine TiO₂ manufactured by the new process exhibits new properties that can not be obtained by existing grades. More detail about the grades by the new process is given in § 5-2.

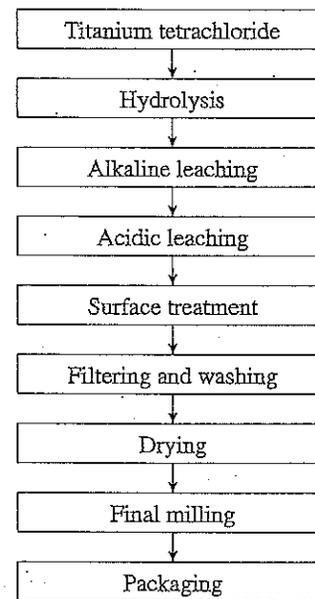


Fig. 2-2 Production procedure of TTO-S and D

Quality Assurance Group,
Quality Assurance Division ,
ISHIHARA SANGYO KAISHA LTD.

Ultra-fine Particle Size Titanium Dioxide

Specification for TTO-55(B)

ITEM	SPEC.	TEST METHOD
Oil Absorption (g/100g)	29~38	ASTM D-281
Specific Surface Area (m ² /g)	37.5~42.5	BET method
pH	6.5~8.0	ASTM D-1208
330mesh Residue (%)	Max.0.1	ASTM D-185
Soluble Salts (%)	Max.0.1	ASTM D-1208
TiO ₂ Content (%)	90.0~93.0	ASTM D-1394
Moisture (%)	Max.2.0	ASTM D-280

E

FM-35-1
Page 1 of 5
Revised : May 22, 2007
MSDS No. AU-105



MATERIAL SAFETY DATA SHEET

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product name : Ultrafine Particle Size Titanium Dioxide TTO-55(B)
Synonyms : Titanium Dioxide , Titania
MSDS No. AU-105

MANUFACTURER :

Company Name : Ishihara Sangyo Kaisha, Ltd.
Address : 3-15 Edobori, 1-Chome Nishi-Ku Osaka 550-0002 Japan
Telephone number 81-6-6444-1451
Fax number 81-6-6445-7798

EMERGENCY TELEPHONE NUMBER :

CHEMITREC
United States : (800)424-9300 24 hours Everyday
International : +1-(703)527-3887(Collect) 24 hours Everyday

2. COMPOSITION, INFORMATION ON INGREDIENTS

Chemical name	%	CAS Registry No.
Titanium Dioxide	88.0~94.0	13463-67-7
Aluminium Hydroxide	4.0~7.0 (as Al ₂ O ₃)	21645-51-2



MATERIAL SAFETY DATA SHEET

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW:

Odorless white powder. Chemically stable, inert nuisance dust. Incombustible.
May have a drying effect on mucous membranes.

POTENTIAL HEALTH EFFECTS:

PRIMARY ROUTE OF EXPOSURE

Inhalation : Temporary irritation to mucous membranes may result from excessive exposure.

Eye : Inert foreign body hazard only.

Skin : May have a drying effect on the skin.

Ingestion : This material is unlikely to be hazardous by ingestion.

4. FIRST-AID MEASURES

Inhalation : Remove patient from exposure.

Skin contact : Wash well with water and mild soap.

Eye contact : Flush with plenty of water.

Ingestion : In case of excessive ingestion, rinse out the mouth, drink a quarter or more of water. Call a physician.

5. FIRE-FIGHTING MEASURES

Incombustible

Extinguishing media : Not required. Use media required for other substances in the area.

Special fire-fighting procedures : None.



MATERIAL SAFETY DATA SHEET

6. ACCIDENTAL RELEASE MEASURES

Personal precaution measures : None.

Environmental precautions and methods for clean up :

Prevent spilled material entering drains.

Waste material should be disposed of in accordance with governmental and local regulations.

7. HANDLING AND STORAGE

Handling : Keep work area free of spills.

Storage : Store in clean , dry place at room temperature.

8. EXPOSURE CONTROLS, PERSONAL PROTECTION

Control Parameters :

OSHA PEL(TiO₂) 15mg/m³(Total), 5mg/m³(Respirable)

Personal protective equipment :

Respiratory : Use a purifying respirator equipped with filters for protection against dust.

Eyes : Safety glasses with side shields or goggles may be worn.

Skin : Gloves and other protective clothing may be worn.

9. PHYSICAL & CHEMICAL PROPERTIES

Appearance :	White powder.
Odor :	None
Solubility :	Insoluble in water.
Vapor pressure :	Not applicable.
Melting point :	> 1500°C .
Boiling point :	Not applicable.
Specific gravity :	4.0~4.2
Bulk Density :	0.2~1.2



MATERIAL SAFETY DATA SHEET

10. STABILITY AND REACTIVITY

Stability : Stable under normal conditions.
Conditions to avoid : See under item 7.
Materials to avoid : None.

11. TOXICOLOGICAL INFORMATION

Toxicity: None of the components in this material is listed as toxic.
Carcinogenicity (TiO₂) : IARC Group 2B (Possibly carcinogenic to humans)

12. ECOLOGICAL INFORMATION

No data are available as to its effects on the environment.

13. DISPOSAL CONSIDERATION

Comply with governmental and local regulations.

14. TRANSPORT INFORMATION

Not classified as dangerous for transport.

15. REGULATORY INFORMATION

OSHA STATUS : None of the components in this material is defined as a hazardous substance.

TSCA STATUS : All components are listed on TSCA inventory.

SARA TITLE III : This material does not contain toxic chemicals 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.

HMIS Rating :

Health	1	Flammability	0
Reactivity	0	Personal Protection	F

CANADIAN DSL : All components are listed on DSL inventory.



MATERIAL SAFETY DATA SHEET

16. OTHER INFORMATION

Although the information contained herein was believed to be accurate at the time of preparation, ISHIHARA SANGYO KAISHA makes no guarantees and assumes no responsibility for how this information is used. Users of this product should independently research data that may be pertinent to their application.

Prepared by : Quality Assurance Grou
Quality Assurance Division
(Telephone Number : 81-593-45-6148 Japan)

Approved by and Responsible to:
Global Environmental Division
(Telephone Number : 81-6-6444-5813 Japan)

F

November 18, 2011

QUALITY ASSURANCE GROUP
QUALITY ASSURANCE DIVISION
ISHIHARA SANGYO KAISHA, LTD.

Measurement method

DENSITY

DENSITY is measured by MULTIPYCNOMETER.

MULTIPYCNOMETER is employed the Archimedean principle of fluid/gas displacement to measure the volume. The gas pycnometry operating principle is Gas Law: $PV = nRT$ Where P is the gas pressure, V is the volume containing the gas, n is the number of moles of the gas, R is the universal gas constant and T is the temperature of the gas. Introducing a sample into an analysis chamber of a known volume we determine the volume of a gas displaced by the sample and true volume of the analysed material.

1) Apparatus

MULTI PYCNOMETER MVP-1

2) Measurement condition

Commonly used gas is helium (He).

November 18, 2011

QUALITY ASSURANCE GROUP
QUALITY ASSURANCE DIVISION
ISHIHARA SANGYO KAISHA, LTD.

Measurement method

SURFACE AREA (SSA)

SSA is measured by Well-known BET method (one point surface measurement).
Measurement method is as follows.

1) Apparatus

Flowsorb Model 2300

(MICROMERITICS INSTRUMENT CORPORATION)

2) Measurement condition

Deaeration : 150°C × 30min (by N₂ Gas)

It is measured under N₂ and a mixture of He after what deaerated it

November 18, 2011

QUALITY ASSURANCE GROUP
QUALITY ASSURANCE DIVISION
ISHIHARA SANGYO KAISHA, LTD.

Measurement method

PARTICLE SIZE DISTRIBUTION

1) Electron micrograph

Transmission electron micrographs of sample was taken and the primary particle size distribution was measured with Zeiss particle analyzer TGZ-3.

Transmission electron micrograph : $\times 100,000 \sim 200,000$ times.

2) A calculated value based on the specific surface area

We suppose a particle to be a spherical and calculate it by the next expression.

$$\text{Particle size}(\mu\text{ m}) = \frac{6}{\text{Specific surface area}(\text{m}^2/\text{g}) \times \text{Density}(\text{g}/\text{cm}^3)}$$

November 18, 2011

QUALITY ASSURANCE GROUP
QUALITY ASSURANCE DIVISION
ISHIHARA SANGYO KAISHA, LTD.

Measurement method

PURITY

This method is a "Total Titanium by the Aluminum reduction method" in ASTM D-1394-76 "standard test methods for Chemical analysis of white Titanium pigments".

Titanium dioxide final product was dissolved by sulfuric acid and ammonium sulfate mix. Then Ti^{4+} in the solution was reduced to Ti^{3+} by aluminum metal. The Ti^{3+} was titrated by 0.1 mol/L ammonium iron(III) sulfate solution with ammonium thiocyanate as indicator.

TiO_2 sample and ammonium sulfate are weighed. And add small amount of water and sulfuric acid and then heat to dissolve TiO_2 sample. Then the solution is cooled. Dilute the solution with water and add hydrochloric acid. Add the aluminum metal into the solution and heat in order to dissolve aluminum metal, to reduce from Ti^{4+} to Ti^{3+} in the solution. After cooling, the solution is titrate with ammonium iron(III) sulfate standard solution.

SECTION D: NANOMATERIAL CHEMICAL AND PHYSICAL PROPERTIES (Attach additional pages as needed)

PRODUCT / PRODUCTION INFORMATION				
NANO CHEMICAL NAME: (Use a separate page for each unique chemical) TTO-55 (D)				
COMMERCIAL NAME(S): ISHIHARA SANGYO KAISHA, LTD.				
ANNUAL PRODUCTION VOLUME: 2009 - Q, 2010 - Q, 2011 - 300 grams				
PRODUCTION METHOD(S): Hydrolysis - see attached				
IDENTIFICATION OF THE SUPPLIER(S): Yokkaichi Plant, Japan				
PARAMETER	VALUE / RANGE (include units)	NAME OF ANALYTICAL METHOD(S)		
PHYSICAL PROPERTIES				
SHAPE (MORPHOLOGY)	powder	-		
DENSITY	3.5~4.2 (g/cm ³)	Measured by Ultra-pycnometer		
SURFACE AREA	65~80m ² /g	BET method		
PARTICLE SIZE DISTRIBUTION	Air	not applicable	-	
	Liquid	not applicable	-	
	Solid / Powder	0.03~0.05 μm	median particle size measured by electron micrograph	
OTHER (Specify)	Document-5			
CHEMICAL PROPERTIES				
CHEMICAL COMPOSITION	Titanium dioxide (TiO ₂)	/		
SURFACE MODIFICATION (COATING, FUNCTIONALIZATION)	Aluminium Hydroxide (Al(OH) ₃) Zirconium Oxide (ZrO ₂) Tin Oxide (SnO ₂)			
PURITY	76~81%			ASTM D-1394
SURFACE CHARGE	unknown			
DISPERSION ²	Air			unknown
	Liquid	to be developed		
	Solid	unknown		
IDENTIFYING AND DETERMINING CONCENTRATION OF NANO CHEMICAL, ITS METABOLITES, AND DEGRADATION PRODUCTS IN SPECIFIED MATRICES ² Water, Air, Soil, Sediment, Sludge, Chemical Waste, Fish, Blood, Adipose Tissue, Urine, Other (specify)	Water, Air, Soil: Not Metabolites and Degradation. The other items do not have information.	/		
SOLUBILITY	Water Solubility			not dissolve
	Solubility in Organic Solvent			not dissolve
N-OCTANOL-WATER PARTITION COEFFICIENT	to be developed			
STABILITY AND REACTIVITY	Flammability			not applicable
	Explosiveness	not applicable		
	Oxidizing Properties	not applicable		
	Oxidation Reduction Potential	not applicable		
	Storage Stability and Reactivity (Container Material)	Not regulated for packaging and container		
	Stability to Thermal, Sunlight, and Metal(s)	Inert to most chemicals, reagents.		

§2 Manufacturing procedure of ultra-fine TiO₂

2-1 General manufacturing methods

Although there are a lot of suggestions concerning the manufacturing method of ultra-fine TiO₂, the methods shown in Table 2-1 are commonly adopted.

1) Neutralization and hydrolysis of titanium chloride ²⁾ $\text{TiCl}_4 + 4\text{NaOH} \longrightarrow \text{TiO}_2 + 4\text{NaCl} + 2\text{H}_2\text{O}$ <p style="text-align: center;">↳ Calcination</p>
2) Oxidization of titanium chloride in vapor phase ³⁾ $\text{TiCl}_4 + \text{O}_2 \longrightarrow \text{TiO}_2 + 2\text{Cl}_2$
3) Neutralization of sodium titanate ⁴⁾ <p style="text-align: center;">NaOH treatment HCl treatment</p> $\text{TiO}_2 \cdot n\text{H}_2\text{O} \longrightarrow \text{Na}_2\text{TiO}_3 \longrightarrow \text{TiO}_2 + \text{NaCl}$ <p style="text-align: center;">↳ Calcination</p>
4) Hydrolysis of titanium alkoxide ⁵⁾ $\text{Ti}(\text{O}-\text{R})_4 + 2\text{H}_2\text{O} \longrightarrow \text{TiO}_2 + 4\text{R}-\text{OH}$ <p style="text-align: center;">↳ Low-temp calcination</p>
5) Vapor phase cracking of titanium alkoxide ⁶⁾ <p style="text-align: center;">Heating</p> $\text{Ti}(\text{O}-\text{R})_4 \longrightarrow \text{TiO}_2 + \text{H}_2\text{O} + \text{alkene}$

Fig. 2-1 Production methods of ultra-fine TiO₂

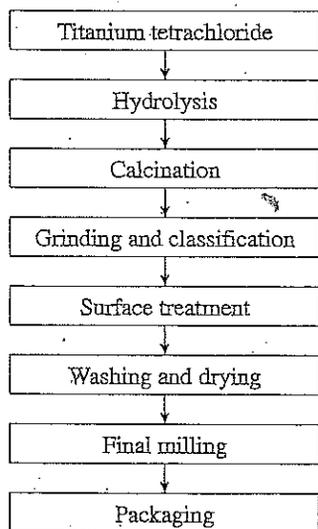


Fig. 2-1 Production procedure of TTO-55,51,F

2-2 ISK's manufacturing methods

For manufacturing ISK's ultra-fine TiO₂, TTO series, we use two different methods, whose rough procedures are illustrated in Fig.2-1 and Fig.2-2 respectively ((1) and (3) of Fig.2-1). With either method, different grades are variously characterized by controlling the purity of raw material TiCl₄, hydrolysis, calcination, leaching and surface treatment. In order to avoid confusion hereinafter, we call the flow of Fig.2-1 "TTO calcination method", while the one in Fig.2-2 "TTO wet method". Recently, ISK has established a new manufacturing process. Ultra-fine TiO₂ manufactured by the new process exhibits new properties that can not be obtained by existing grades. More detail about the grades by the new process is given in § 5-2.

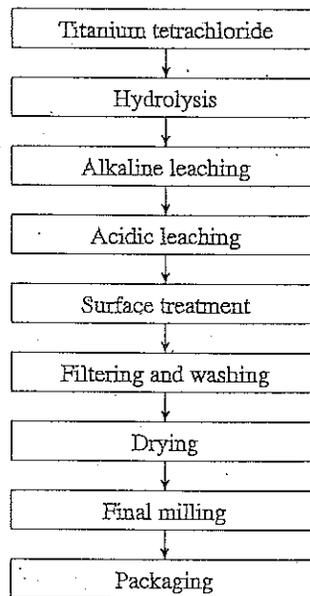


Fig. 2-2 Production procedure of TTO-S and D

Quality Assurance Group,
Quality Assurance Division ,
ISHIHARA SANGYO KAISHA LTD.

Ultra-fine Particle Size Titanium Dioxide

Specification for TTO-55(D)

ITEM	SPEC.	TEST METHOD
Oil Absorption (g/100g)	35~45	ASTM D-281
Specific Surface Area (m ² /g)	65~80	BET method
pH	6.5~8.0	ASTM D-1208
330mesh Residue (%)	Max.0.1	ASTM D-185
Soluble Salts (%)	Max.0.1	ASTM D-1208
TiO ₂ Content (%)	76.0~81.0	ASTM D-1394
Moisture (%)	Max.4.0	ASTM D-280

E

FM-35-1
Page 1 of 5
Revised : May 22, 2007
MSDS No. AU-107



MATERIAL SAFETY DATA SHEET

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

Product name : Ultrafine Particle Size Titanium Dioxide TTO-55(D)
Synonyms : Titanium Dioxide , Titania
MSDS No. AU-107

MANUFACTURER :

Company Name : Ishihara Sangyo Kaisha, Ltd.
Address : 3-15 Edobori, 1-Chome Nishi-Ku Osaka 550-0002 Japan
Telephone number 81-6-6444-1451
Fax number 81-6-6445-7798

EMERGENCY TELEPHONE NUMBER :

CHEMITREC

United States : (800)424-9300 24 hours Everyday
International : +1-(703)527-3887(Collect) 24 hours Everyday

2. COMPOSITION, INFORMATION ON INGREDIENTS

Chemical name	%	CAS Registry No.
Titanium Dioxide	70.0~80.0	13463-67-7
Aluminium Hydroxide	10.0~15.0 (as Al ₂ O ₃)	21645-51-2
Zirconium Oxide	2.0~5.0	1314-23-4



MATERIAL SAFETY DATA SHEET

3. HAZARDS IDENTIFICATION

EMERGENCY OVERVIEW:

Odorless white powder. Chemically stable, inert nuisance dust. Incombustible.

May have a drying effect on mucous membranes.

POTENTIAL HEALTH EFFECTS:

PRIMARY ROUTE OF EXPOSURE

Inhalation : Temporary irritation to mucous membranes may result from excessive exposure.

Eye : Inert foreign body hazard only.

Skin : May have a drying effect on the skin.

Ingestion : This material is unlikely to be hazardous by ingestion.

4. FIRST-AID MEASURES

Inhalation : Remove patient from exposure.

Skin contact : Wash well with water and mild soap.

Eye contact : Flush with plenty of water.

Ingestion : In case of excessive ingestion, rinse out the mouth, drink a quarter or more of water. Call a physician.

5. FIRE-FIGHTING MEASURES

Incombustible

Extinguishing media : Not required. Use media required for other substances in the area.

Special fire-fighting procedures : None.



MATERIAL SAFETY DATA SHEET

6. ACCIDENTAL RELEASE MEASURES

Personal precaution measures : None.

Environmental precautions and methods for clean up :

Prevent spilled material entering drains.

Waste material should be disposed of in accordance with governmental and local regulations.

7. HANDLING AND STORAGE

Handling : Keep work area free of spills.

Storage : Store in clean , dry place at room temperature.

8. EXPOSURE CONTROLS, PERSONAL PROTECTION

Control Parameters :

OSHA PEL(TiO₂) 15mg/m³(Total), 5mg/m³(Respirable)

Personal protective equipment :

Respiratory : Use a purifying respirator equipped with filters for protection against dust.

Eyes : Safety glasses with side shields or goggles may be worn.

Skin : Gloves and other protective clothing may be worn.

9. PHYSICAL & CHEMICAL PROPERTIES

Appearance :	White powder.
Odor :	None
Solubility :	Insoluble in water.
Vapor pressure :	Not applicable.
Melting point :	> 1500°C .
Boiling point :	Not applicable.
Specific gravity :	3.8~4.1
Bulk Density :	0.2~1.2



MATERIAL SAFETY DATA SHEET

10. STABILITY AND REACTIVITY

Stability : Stable under normal conditions.
Conditions to avoid : See under item 7.
Materials to avoid : None.

11. TOXICOLOGICAL INFORMATION

Toxicity: None of the components in this material is listed as toxic.
Carcinogenicity (TiO₂) : IARC Group 2B (Possibly carcinogenic to humans)

12. ECOLOGICAL INFORMATION

No data are available as to its effects on the environment.

13. DISPOSAL CONSIDERATION

Comply with governmental and local regulations.

14. TRANSPORT INFORMATION

Not classified as dangerous for transport.

15. REGULATORY INFORMATION

OSHA STATUS : None of the components in this material is defined as a hazardous substance.

TSCA STATUS : All components are listed on TSCA inventory.

SARA TITLE III : This material does not contain toxic chemicals 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.

HMIS Rating :

Health	1	Flammability	0
Reactivity	0	Personal Protection	F



MATERIAL SAFETY DATA SHEET

16. OTHER INFORMATION

Although the information contained herein was believed to be accurate at the time of preparation, ISHIHARA SANGYO KAISHA makes no guarantees and assumes no responsibility for how this information is used. Users of this product should independently research data that may be pertinent to their application.

Prepared by : Quality Assurance Group
 Quality Assurance Division
 (Telephone Number : 81-593-45-6148 Japan)

Approved by and Responsible to:
 Global Environmental Division
 (Telephone Number : 81-6-6444-5813 Japan)

F

November 18, 2011

QUALITY ASSURANCE GROUP
QUALITY ASSURANCE DIVISION
ISHIHARA SANGYO KAISHA, LTD.

Measurement method

DENSITY

DENSITY is measured by MULTIPYCNOMETER.

MULTIPYCNOMETER is employed the Archimedean principle of fluid/gas displacement to measure the volume. The gas pycnometry operating principle is Gas Law: $PV = nRT$ Where P is the gas pressure, V is the volume containing the gas, n is the number of moles of the gas, R is the universal gas constant and T is the temperature of the gas. Introducing a sample into an analysis chamber of a known volume we determine the volume of a gas displaced by the sample and true volume of the analysed material.

1) Apparatus

MULTI PYCNOMETER MVP-1

2) Measurement condition

Commonly used gas is helium (He).

November 18, 2011

QUALITY ASSURANCE GROUP
QUALITY ASSURANCE DIVISION
ISHIHARA SANGYO KAISHA, LTD.

Measurement method

SURFACE AREA (SSA)

SSA is measured by Well-known BET method (one point surface measurement).
Measurement method is as follows.

1) Apparatus

Flowsorb Model 2300

(MICROMERITICS INSTRUMENT CORPORATION)

2) Measurement condition

Deaeration : 150°C × 30min (by N₂ Gas)

It is measured under N₂ and a mixture of He after what deaerated it

November 18, 2011

QUALITY ASSURANCE GROUP
QUALITY ASSURANCE DIVISION
ISHIHARA SANGYO KAISHA, LTD.

Measurement method

PARTICLE SIZE DISTRIBUTION

1) Electron micrograph

Transmission electron micrographs of sample was taken and the primary particle size distribution was measured with Zeiss particle analyzer TGZ-3.

Transmission electron micrograph : $\times 100,000 \sim 200,000$ times.

2) A calculated value based on the specific surface area

We suppose a particle to be a spherical and calculate it by the next expression.

$$\text{Particle size}(\mu\text{m}) = \frac{6}{\text{Specific surface area}(\text{m}^2/\text{g}) \times \text{Density}(\text{g}/\text{cm}^3)}$$

November 18, 2011

QUALITY ASSURANCE GROUP
QUALITY ASSURANCE DIVISION
ISHIHARA SANGYO KAISHA, LTD.

Measurement method

PURITY

This method is a "Total Titanium by the Aluminum reduction method" in ASTM D-1394-76 "standard test methods for Chemical analysis of white Titanium pigments".

Titanium dioxide final product was dissolved by sulfuric acid and ammonium sulfate mix. Then Ti^{4+} in the solution was reduced to Ti^{3+} by aluminum metal. The Ti^{3+} was titrated by 0.1 mol/L ammonium iron(III) sulfate solution with ammonium thiocyanate as indicator.

TiO_2 sample and ammonium sulfate are weighed. And add small amount of water and sulfuric acid and then heat to dissolve TiO_2 sample. Then the solution is cooled. Dilute the solution with water and add hydrochloric acid. Add the aluminum metal into the solution and heat in order to dissolve aluminum metal, to reduce from Ti^{4+} to Ti^{3+} in the solution. After cooling, the solution is titrate with ammonium iron(III) sulfate standard solution.

SECTION D: NANOMATERIAL CHEMICAL AND PHYSICAL PROPERTIES. (Attach additional pages as needed)

PRODUCT / PRODUCTION INFORMATION			
NANO CHEMICAL NAME: (Use a separate page for each unique chemical) TTO-55 (N)			
COMMERCIAL NAME(S): ISHIHARA SANGYO KAISHA, LTD.			
ANNUAL PRODUCTION VOLUME: 2009 - 0 ; 2010 - 1 LB. ; 2011 - 0			
PRODUCTION METHOD(S): Hydrolysis - See attached			
IDENTIFICATION OF THE SUPPLIER(S): Yokkaichi Plant, Japan			
PARAMETER	VALUE / RANGE / (include units)	NAME OF ANALYTICAL METHOD(S)	
PHYSICAL PROPERTIES			
SHAPE (MORPHOLOGY)	powder	-	
DENSITY	3.5~4.2 (g/cm ³)	Measured by Ultra-pycnometer	
SURFACE AREA	35~45m ² /g	BET method	
PARTICLE SIZE DISTRIBUTION	Air	not applicable	
	Liquid	not applicable	
	Solid / Powder	0.03~0.05 μm	median particle size measured by electron micrograph
OTHER (Specify)	Document-1		
CHEMICAL PROPERTIES			
CHEMICAL COMPOSITION	Titanium dioxide (TiO ₂)	/	
SURFACE MODIFICATION (COATING, FUNCTIONALIZATION)	Amorphous Silica (SiO ₂)		
PURITY	Min. 95%		ASTM D-1394
SURFACE CHARGE	unknown		-
DISPERSION ²	Air		unknown
	Liquid		to be developed
	Solid		unknown
IDENTIFYING AND DETERMINING CONCENTRATION OF NANO CHEMICAL, ITS METABOLITES, AND DEGRADATION PRODUCTS IN SPECIFIED MATRICES ² Water, Air, Soil, Sediment, Sludge, Chemical Waste, Fish, Blood, Adipose Tissue, Urine, Other (specify)	Water, Air, Soil: Not Metabolites and Degradation. The other items do not have information.		
SOLUBILITY	Water Solubility	not dissolve	
	Solubility in Organic Solvent	not dissolve	
N-OCTANOL-WATER PARTITION COEFFICIENT	to be developed		
STABILITY AND REACTIVITY	Flammability	not applicable	
	Explosiveness	not applicable	
	Oxidizing Properties	not applicable	
	Oxidation Reduction Potential	not applicable	
	Storage Stability and Reactivity (Container Material)	Not regulated for packaging and container	
	Stability to Thermal, Sunlight, and Metal(s)	Inert to most chemicals, reagents.	

§2 Manufacturing procedure of ultra-fine TiO₂

2-1 General manufacturing methods

Although there are a lot of suggestions concerning the manufacturing method of ultra-fine TiO₂, the methods shown in Table 2-1 are commonly adopted.

1) Neutralization and hydrolysis of titanium chloride ²⁾ $\text{TiCl}_4 + 4\text{NaOH} \longrightarrow \text{TiO}_2 + 4\text{NaCl} + 2\text{H}_2\text{O}$ <p style="text-align: right;">↳ Calcination</p>
2) Oxidization of titanium chloride in vapor phase ³⁾ $\text{TiCl}_4 + \text{O}_2 \longrightarrow \text{TiO}_2 + 2\text{Cl}_2$
3) Neutralization of sodium titanate ⁴⁾ NaOH treatment HCl treatment $\text{TiO}_2 \cdot n\text{H}_2\text{O} \longrightarrow \text{Na}_2\text{TiO}_3 \longrightarrow \text{TiO}_2 + \text{NaCl}$ <p style="text-align: right;">↳ Calcination</p>
4) Hydrolysis of titanium alkoxide ⁵⁾ $\text{Ti}(\text{O}-\text{R})_4 + 2\text{H}_2\text{O} \longrightarrow \text{TiO}_2 + 4\text{R}-\text{OH}$ <p style="text-align: right;">↳ Low-temp calcination</p>
5) Vapor phase cracking of titanium alkoxide ⁶⁾ Heating $\text{Ti}(\text{O}-\text{R})_4 \longrightarrow \text{TiO}_2 + \text{H}_2\text{O} + \text{alkene}$

Fig. 2-1 Production methods of ultra-fine TiO₂

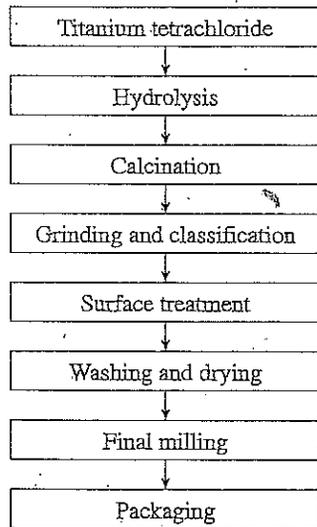


Fig. 2-1 Production procedure of TTO-55,51,F

2-2 ISK's manufacturing methods

For manufacturing ISK's ultra-fine TiO₂, TTO series, we use two different methods, whose rough procedures are illustrated in Fig.2-1 and Fig.2-2 respectively ((1) and (3) of Fig.2-1). With either method, different grades are variously characterized by controlling the purity of raw material TiCl₄, hydrolysis, calcination, leaching and surface treatment. In order to avoid confusion hereinafter, we call the flow of Fig.2-1 "TTO calcination method", while the one in Fig.2-2 "TTO wet method". Recently, ISK has established a new manufacturing process. Ultra-fine TiO₂ manufactured by the new process exhibits new properties that can not be obtained by existing grades. More detail about the grades by the new process is given in § 5-2.

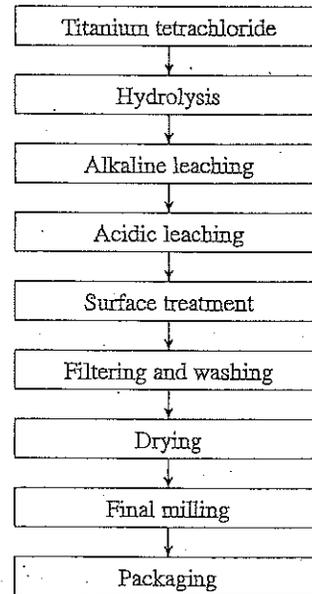


Fig. 2-2 Production procedure of TTO-S and D

Quality Assurance Group,
Quality Assurance Division,
ISHIHARA SANGYO KAISHA LTD.

Ultra-fine Particle Size Titanium Dioxide
Specification for TTO-55(N)

ITEM	SPEC.	TEST METHOD
Oil Absorption (g/100g)	23~30	ASTM D-281
Specific Surface Area (m ² /g)	35~45	BET method
pH	6.5~8.0	ASTM D-1208
330mesh Residue (%)	Max.0.1	ASTM D-185
Soluble Salts (%)	Max.0.1	ASTM D-1208
TiO ₂ Content (%)	96.0~99.0	ASTM D-1394
Moisture (%)	Max.2.0	ASTM D-280

E



MATERIAL SAFETY DATA SHEET

1. PRODUCT AND COMPANY IDENTIFICATION

Product name : Ultrafine Particle Size Titanium Dioxide TTO-55(N)
 Product use : Cosmetics etc
 Manufacturer : Company Name: ISHIHARA SANGYO KAISHA, LTD.
 Address: 3-15 EDOBORI, 1-CHOME, NISHI-KU, OSAKA,
 550-0002 JAPAN
 Phone Number: +81-6-6444-1451

Emergency phone number: +81-6-6444-5812

2. HAZARDS IDENTIFICATION

GHS Classification

		Titanium dioxide
Physical Hazards :		
	Explosives	Not applicable
	Flammable gases	Not applicable
	Flammable aerosols	Not applicable
	Oxidizing gases	Not applicable
	Gases under pressure	Not applicable
	Flammable liquids	Not applicable
	Flammable solids	Not classified
	Self-reactive substances and mixtures	Not applicable
	Pyrophoric liquids	Not applicable
	Pyrophoric solids	Not classified
	Self-heating substances and mixtures	Not classified
	Substances and mixtures which, in contact with water, emit flammable gases	Not classified
	Oxidizing liquids	Not applicable
	Oxidizing solids	Not classified
	Organic peroxides	Not applicable
	Corrosive to metals	Classification not possible
Health Hazards :		
	Acute toxicity (oral)	Not classified
	Acute toxicity (dermal)	Not classified
	Acute toxicity (inhalation : gases)	Not applicable
	Acute toxicity (inhalation : vapor)	Classification not possible
	Acute toxicity (inhalation : dusts)	Not classified
	Acute toxicity (inhalation : mists)	Not applicable
	Skin corrosion/ irritation	Not classified

	Serious eye damage/ eye irritation	Category 2B
	Respiratory sensitization	Classification not possible
	Skin sensitization	Not classified
	Germ cell mutagenicity	Not classified
	Carcinogenicity	Category 2B ¹⁾
	Reproductive toxicity	Classification not possible
	Specific target organ toxicity -Single exposure	Category 3 (irritation to respiratory tract)
	Specific target organ toxicity -Repeated exposure	Category 1 (inhalation: lungs)
	Aspiration hazards	Not classified
Environmental Hazards :		
	Acute aquatic toxicity	Not classified
	Chronic aquatic toxicity	Category 4

GHS label elements, including precautionary statements.

Signal word: Danger

Pictograms or hazard symbols: (The name of the symbol)

Exclamation mark, Harmful to health



Hazard statements: Irritation to eyes.
Suspect of causing cancer.
May cause respiratory irritation.
Harmful by prolonged or repeated exposure through inhalation.
Harmful to aquatic organisms: may cause long-term adverse effects in the aquatic environment.

Precautionary statements:

Do not eat, drink or smoke when using this product.
Use only outside or in a well-ventilated area.
Do not inhale dusts.
Wash hands at the end of work.
Avoid release to the environment.

Avoid storage at high-temperature and high-humidity.
Do not pile up high to prevent the second aggregation.
Do not store together with water.
Keep container tightly sealed.
Not regulated for packaging and container.

Dispose in compliance with governmental and local regulations.

3. COMPOSITION/ INFORMATION ON INGREDIENTS

Chemical identity.

Common chemical names or synonyms: Titanium dioxide
Titanium(IV) oxide

Component	Formula	CAS No.	EINECS No.	Concentration
Titanium Dioxide	TiO ₂	13463-67-7	236-675-5	Min. 95
Amorphous Silica	SiO ₂	7631-86-9	231-545-4	Max. 1

Impurities and stabilizing additives which are themselves classified and which contribute to the classification of substance; None

4. FIRST-AID MEASURES

Inhalation:

Remove person from dust contaminated area. Wash in the mouth and the nose.
Call a physician if you feel unwell.

Skins:

Wash off with water and soap. If irritation develops, call a physician.

Eyes:

Rinse out with plenty of water. If irritation develops, call a physician.

Ingestion:

Do not swallow. If you swallow, gargle and drink a quart or more of water, or a glass of milk. Call a physician if you feel unwell.

Most important symptoms/ effects, acute and delayed ²⁾:

Redness of skin and eyes

5. FIRE-FIGHTING MEASURES

Flammable limits: Incombustible

Extinguishing media: Not required.

Special fire fighting procedures:

Remove from fire-fighting area.

If the container is at high-temperature, do not touch.

Protective equipment for fire-fighting:

Do not stay in dangerous zone without self-contained breathing apparatus.

Wear entire protective equipment.

6. ACCIDENTAL RELEASE MEASURES

Person-related safety precaution:

Keep unprotected person away.

Wear adequate protective equipment (see section 8). Avoid contact with eyes, skin and clothing. And also avoid inhalation of dusts.

Measures for environmental protection:

Do not allow material to be released to the environment.

Procedures for cleaning/ absorption:

Use any feasible mechanical means to remove "spilled" material, such as broom, brush, scoop, vacuum, or wet absorbent materials. Avoid spreading dust during clean up.

7. HANDLING AND STORAGE

Precautions to be taken in handling and storing:

Store in clean and at dry place. Keep work area free of spill. Avoid ingestion as a common sense measure.

Handling:

Ensure good ventilation at working place. In accordance with SECTION 8, control dust-concentration and wear protective equipments.

Do not inhale and swallow.

Avoid contact with eyes, skin and clothing.

Wash hands at the end of work.

Do not eat, drink or smoke when using this product.

Use only outside or in a well-ventilated area.

In addition, see SECTION 10 to avoid contact.

Storage:

Avoid storage at high-temperature and high-humidity.

Do not pile up high to prevent the second aggregation.

Store under storage room with roof, and avoid together with water.

Not regulated for packaging and container, and ensure to keep container tightly sealed.

8. EXPOSURE CONTROLS/ PERSONAL PROTECTION

Control concentration:

Specification not provided.

Permitted concentration:

JSOH (Edt.2005)	Dust (Class II), respirable dust	1mg/m ³
	total dust	4mg/m ³
ACGIH	TLV-TWA	10mg/m ³

Equipment measures:

If dust is emitted and the concentration cannot be maintained at or below the standards in the above, then a local ventilation equipment should be made.

The local ventilation equipment should work when dust is emitted.

Place eyecup at working place and storage room.

Protective equipment and hygienic measures:

- Breathing equipment: Use suitable respirator when high concentrations are present.
- Protection of hands: Wear suitable gloves.
- Eye protection: Wear safety glasses.
- Body protection: Wear protective work clothing. Protective clothing should be selected specifically for the working place, depending on concentration and quantity of the substance handled.
- Wash hands at the end of work.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance (physical state, color, etc.) :	White Powder ³⁾
Odor :	None
Odor threshold :	No data available.
pH :	Indicate neutral pH (litmus) when suspended in water (1:10). ⁴⁾
Melting point/ freezing point :	1820~1850°C
Initial boiling point and boiling range:	2500~3000°C ³⁾
Flash Point:	Incombustible ⁴⁾
Evaporation rate (acetic acid = 1):	Not applicable.
Flammability (solid, gas) :	Incombustible ⁵⁾
Upper/lower flammability or explosive limits:	Incombustible ⁴⁾
Vapor pressure:	No data available.
Vapour density (air=1):	No data available.
Specific gravity:	3.5-4.2
Solubility(ies):	Insoluble in water, and organic solvents. Soluble in hot concentrated sulfuric acid.
Partition coefficient: n-octanol/water:	No data available.
Auto ignition temperature:	No data available.
Decomposition temperature:	No data available.
Viscosity:	Not applicable.

10. STABILITY AND REACTIVITY ⁶⁾

Reactivity:	Inert to most chemicals, reagents.
Chemical stability:	Stable under normal conditions.
Possibility of hazardous reactions:	No information.
Conditions to avoid:	Emit dusts.
Incompatible materials:	None
Hazardous decomposition products:	No information.

11. TOXICOLOGICAL INFORMATION

- Acute toxicity:
- | | |
|--------------------------|--|
| Oral: | LD50 > 12000mg/kg in rats. ^{7) 8)} |
| Dermal : | LD50 > 10000mg/kg in rabbits. ⁹⁾ |
| Intramuscular injection: | TDL0 360mg/kg /2 years in rats. ¹⁰⁾ |
| | TD 260mg/kg/84 weeks in rats. ¹¹⁾ |
- Inhalation (Dusts): TCL0 250mg/m³/6hrs/2years in rats. ¹²⁾
 No evidence of lung disease in humans and animals by long-term exposure through respiration system. ¹³⁾
- Skin corrosion: No specific records available.
- Skin irritation: Very slight irritation to the skin could occur. ^{9) 14)}
- Serious eye damage and eye irritation: Mild irritation in rabbits. ⁹⁾
 Irritation to eyes.(Category 2B)
- Respiratory and skin sensitization:
 Gross overexposure by inhalation may include mild and temporary upper respiratory irritation. ¹⁵⁾
 Negative by patch test in human. ⁹⁾
- Germ cell mutagenicity: No literature available.
 Negative by mouse micronucleus test, and also by test for chromosomal abnormalities. ¹⁶⁾
- Carcinogenicity: IARC ¹⁾: Group 2B (Possibly carcinogenic to humans)
 ACGIH: A4 (Not classifiable as to carcinogenicity)
 Suspect of causing cancer. (Category 2B)
 Several epidemiology studies in Europe and the USA suggested that TiO₂ dust did not show the relation to a carcinogenic effect to lung. It is therefore concluded that TiO₂ concentrations experienced in the working place will not cause lung cancer to the workers.
- Reproductive toxicity: No data available.
- Specific target-organ toxicity-Single exposure:
 Fume irritates respiratory system as described in ref. .
 Gross overexposure by inhalation may include mild and temporary upper respiratory irritation. ⁴⁾
 May cause respiratory irritation. (Category 3)
- Specific target-organ toxicity-Repeated exposure:
 No specific signs of toxicity were observed in dogs, cats, rabbits and pigs after ingestion of TiO₂ over 390 days. ¹⁷⁾ A little bit of workers who work over 20 years showed pneumoconiosis on X-ray.
 The specific target-organ by repeated exposure is therefore decided to be lung. ¹⁸⁾
 Harmful by prolonged or repeated exposure through inhalation. (Category 1)
- Aspiration hazard: No data available.

12. ECOLOGICAL INFORMATION

Acute aquatic toxicity: Daphnia magna EC50>1000mg/L (48 hr) (Aquire, 2003)
Insoluble in water. (HSDB, 2004)
(Not classified)

Chronic aquatic toxicity: This is metal compound, and its long-term behavior under aquatic environment is unknown. May cause long lasting harmful effects to aquatic life. (Category 4)

13. DISPOSAL CONSIDERATIONS

Waste Disposal:

Dispose in compliance with governmental and local regulations.

14. TRANSPORT INFORMATION

UN No.: Not applicable.
IMDG: Not regulated for transport.
Packing: Not dangerous for transport.

Not regulated for transport by DOT/ IMO/ IATA.

Do not pile up high to avoid falling and loosening. Product should be prevented from falling, loosening or tumbling during transport. Avoid direct sunlight.

15. REGULATORY INFORMATION

Comply with governmental and local regulations.

International inventories:

EINECS Status : On the inventory, or in compliance with the act.
AICS Status : On the inventory, or in compliance with the act.
DSL Status : On the inventory, or in compliance with the act.
ENCS (JP) Status : On the inventory, or in compliance with the act.
KECI (KR) Status : On the inventory, or in compliance with the act.
PICCS (PH) Status : On the inventory, or in compliance with the act.
IECSC (CN) Status : On the inventory, or in compliance with the act.

In the USA:

TSCA Status: On the inventory, or in compliance with the inventory.
SARA III Section 311: No
Section 312: No
Section 313: No
California Proposition 65: Not listed.

Hazardous materials identification system (HMIS)

Health;	1
Flammability;	0
Reactivity;	0
Maximum Personal Protection;	E

16. OTHER INFORMATION

References:

- 1) IARC RECENTLY EVALUATED 「TITANIUM DIOXIDE」 5. SUMMARY OF DATA REPORTED POSTED 27 FEBRUARY 2006
- 2) ICSC (2001)
- 3) ICSC (2002)
- 4) HSDB (2005)
- 5) Hommel (1991)
- 6) Kis-net, Kanagawa Environmental Research Center
- 7) FRAGRANCE JOURNAL, No.80, p.40 (1986)
- 8) IPCS Environmental Health Criteria 24. Titanium (1982)
- 9) IUCLID (2000)
- 10) Progress Report for Contract NO.PH-43-64-886, Submitted to the National Cancer Institute by the Institute of Chemical Biology, University of San Francisco., JUL(1968)
- 11) Progress Report for Contract No.PH-43-64-886, Submitted to the National Cancer Institute by the Institute of Chemical Biology, University of San Francisco., AUG(1969)
- 12) Toxicology and Applied Pharmacology, 79, p179 (1985)I
- 13) ARC MONOGRAPH ON THE EVALUATION OF CARCINOGENIC RISKS TO HUMANS 「TITANIUM DIOXIDE」 (WHO IARC)47 307(1989)
- 14) Cutaneous Toxicity V.A. Drill and P.Iasar. eds., New York, Academic Press p127 (1977)
- 15) TITANIUM DIOXIDE (Japan Titanium Dioxide Industry Association), No.62, p.1 (1988)
- 16) NTP DB (2005)
- 17) IPCS Environmental Health Criteria 24. Titanium (1982)
- 18) DFGOT vol.2 (1991)

Information provided in this material safety data sheet (MSDS) is prepared based on the best of knowledge and information at the date of its publication. The MSDS therefore will be amended when novel knowledge is obtained. The information given, including safe handling, use, storage, transport, disposal and release, is described to be considered under ordinal condition. Gathering any information you need in yourself then should be encouraged. ISHIHARA SANGYO KAISHA makes no guarantees for quality specification and use, and assumes no responsibility for how this information is used.

Prepared by : Quality Assurance Division

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Approved by : Environment, Safety & Health Administration Division

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F

November 18, 2011

QUALITY ASSURANCE GROUP
QUALITY ASSURANCE DIVISION
ISHIHARA SANGYO KAISHA, LTD.

Measurement method

DENSITY

DENSITY is measured by MULTIPYCNOMETER.

MULTIPYCNOMETER is employed the Archimedean principle of fluid/gas displacement to measure the volume. The gas pycnometry operating principle is Gas Law: $PV = nRT$ Where P is the gas pressure, V is the volume containing the gas, n is the number of moles of the gas, R is the universal gas constant and T is the temperature of the gas. Introducing a sample into an analysis chamber of a known volume we determine the volume of a gas displaced by the sample and true volume of the analysed material.

1) Apparatus

MULTI PYCNOMETER MVP-1

2) Measurement condition

Commonly used gas is helium (He).

November 18, 2011

QUALITY ASSURANCE GROUP
QUALITY ASSURANCE DIVISION
ISHIHARA SANGYO KAISHA, LTD.

Measurement method

SURFACE AREA (SSA)

SSA is measured by Well-known BET method (one point surface measurement).
Measurement method is as follows.

1) Apparatus

Flowsorb Model 2300

(MICROMERITICS INSTRUMENT CORPORATION)

2) Measurement condition

Deaeration : 150°C × 30min (by N₂ Gas)

It is measured under N₂ and a mixture of He after what deaerated it

November 18, 2011

QUALITY ASSURANCE GROUP
QUALITY ASSURANCE DIVISION
ISHIHARA SANGYO KAISHA, LTD.

Measurement method

PARTICLE SIZE DISTRIBUTION

1) Electron micrograph

Transmission electron micrographs of sample was taken and the primary particle size distribution was measured with Zeiss particle analyzer TGZ-3.

Transmission electron micrograph : $\times 100,000 \sim 200,000$ times.

2) A calculated value based on the specific surface area

We suppose a particle to be a spherical and calculate it by the next expression.

$$\text{Particle size}(\mu\text{m}) = \frac{6}{\text{Specific surface area}(\text{m}^2/\text{g}) \times \text{Density}(\text{g}/\text{cm}^3)}$$

November 18, 2011

QUALITY ASSURANCE GROUP
QUALITY ASSURANCE DIVISION
ISHIHARA SANGYO KAISHA, LTD.

Measurement method

PURITY

This method is a "Total Titanium by the Aluminum reduction method" in ASTM D-1394-76 "standard test methods for Chemical analysis of white Titanium pigments".

Titanium dioxide final product was dissolved by sulfuric acid and ammonium sulfate mix. Then Ti^{4+} in the solution was reduced to Ti^{3+} by aluminum metal. The Ti^{3+} was titrated by 0.1 mol/L ammonium iron(III) sulfate solution with ammonium thiocyanate as indicator.

TiO_2 sample and ammonium sulfate are weighed. And add small amount of water and sulfuric acid and then heat to dissolve TiO_2 sample. Then the solution is cooled. Dilute the solution with water and add hydrochloric acid. Add the aluminum metal into the solution and heat in order to dissolve aluminum metal, to reduce from Ti^{4+} to Ti^{3+} in the solution. After cooling, the solution is titrate with ammonium iron(III) sulfate standard solution.

SECTION D: NANOMATERIAL CHEMICAL AND PHYSICAL PROPERTIES. (Attach additional pages as needed)

PRODUCT / PRODUCTION INFORMATION				
NANO CHEMICAL NAME: (Use a separate page for each unique chemical) ET-300W				
COMMERCIAL NAME(S): ISHIHARA SANGYO KAISHA, LTD.				
ANNUAL PRODUCTION VOLUME: 2009-8 ; 2010-100grams ; 2011-8				
PRODUCTION METHOD(S): Hydrolysis				
IDENTIFICATION OF THE SUPPLIER(S): Yokkaichi Plant, Japan				
PARAMETER	VALUE / RANGE / (include units)	NAME OF ANALYTICAL METHOD(S)		
PHYSICAL PROPERTIES				
SHAPE (MORPHOLOGY)	powder	—		
DENSITY	5.0 (g/cm ³)	Measured by Ultra-pycnometer		
SURFACE AREA	25~35m ² /g	BET method		
PARTICLE SIZE DISTRIBUTION	Air	not applicable	—	
	Liquid	not applicable	—	
	Solid / Powder	0.03~0.06 μm	median particle size measured by electron micrograph	
OTHER (specify)	Document-2			
CHEMICAL PROPERTIES				
CHEMICAL COMPOSITION	Titanium dioxide (TiO ₂)	/		
SURFACE MODIFICATION (COATING, FUNCTIONALIZATION)	Sb-doped SnO ₂			
PURITY	TiO ₂ :Min. 50%			ASTM D-1394
SURFACE CHARGE	unknown			
DISPERSION ²	Air			unknown
	Liquid			to be developed
	Solid			unknown
IDENTIFYING AND DETERMINING CONCENTRATION OF NANO CHEMICAL, ITS METABOLITES, AND DEGRADATION PRODUCTS IN SPECIFIED MATRICES ² Water, Air, Soil, Sediment, Sludge, Chemical Waste, Fish, Blood, Adipose Tissue, Urine, Other (specify)	Water, Air, Soil: Not Metabolites and Degradation. The other items do not have information.			
SOLUBILITY	Water Solubility	not dissolve		
	Solubility in Organic Solvent	not dissolve		
n-OCTANOL-WATER PARTITION COEFFICIENT	to be developed			
STABILITY AND REACTIVITY	Flammability	not applicable		
	Explosiveness	not applicable		
	Oxidizing Properties	not applicable		
	Oxidation Reduction Potential	not applicable		
	Storage Stability and Reactivity (Container Material)	Not regulated for packaging and container		
	Stability to Thermal, Sunlight, and Metal(s)	Inert to most chemicals, reagents.		

Quality Assurance Group,
Quality Assurance Division ,
ISHIHARA SANGYO KAISHA LTD.

White Electroconductive Titanium Dioxide

Specification for ET-300W

ITEM	SPEC.	TEST METHOD
Powder Color L Value ¹⁾	$-5 \leq \Delta L \leq 5$	ISK method
Oil Absorption(g/100g)	25~35	ASTM D-281
pH	2.5~4.0	ASTM D-1208
330mesh Residue(%)	Max.0.1	ASTM D-185
Soluble Salts(%)	Max.0.1	ASTM D-1208
Moisture(%)	Max.1.0	ASTM D-280
Powder Resistance (Ω cm)	Max.30	ISK method ²⁾

1) The value in parentheses represent value of standard lot(#0312).

2) 9.807MPa pressured powder.



MATERIAL SAFETY DATA SHEET

1. PRODUCT AND COMPANY IDENTIFICATION

Product name : White Electroconductive Titanium Dioxide ET-300W

Product use : Antistatic paint, fiber, plastic etc

Manufacturer : Company Name; ISHIHARA SANGYO KAISHA, LTD.
Address; 3-15 EDOBORI, 1-CHOME, NISHI-KU, OSAKA,
550-0002 JAPAN
Phone Number; +81-6-6444-1451

Emergency phone number: +81-6-6444-5812

2. HAZARDS IDENTIFICATION

GHS Classification

		ET-300W
Physical Hazards :		
	Explosives	Not applicable
	Flammable gases	Not applicable
	Flammable aerosols	Not applicable
	Oxidizing gases	Not applicable
	Gases under pressure	Not applicable
	Flammable liquids	Not applicable
	Flammable solids	Not classified
	Self-reactive substances and mixtures	Not applicable
	Pyrophoric liquids	Not applicable
	Pyrophoric solids	Not classified
	Self-heating substances and mixtures	Not classified
	Substances and mixtures which, contact with water, emit flammable gases	Not classified
	Oxidizing liquids	Not applicable
	Oxidizing solids	Not classified
	Organic peroxides	Not applicable
	Corrosive to metals	Classification not possible
Health Hazards :		
	Acute toxicity (oral)	Not classified
	Acute toxicity (dermal)	Not classified
	Acute toxicity (inhalation : gases)	Not applicable
	Acute toxicity (inhalation : vapor)	Classification not possible

Acute toxicity (inhalation : dusts)	Not classified
Acute toxicity (inhalation : mists)	Not applicable
Skin corrosion/ irritation	Not classified
Serious eye damage/ eye irritation	Category 2B
Respiratory sensitization	Classification not possible
Skin sensitization	Not classified
Germ cell mutagenicity	Not classified
Carcinogenicity	Category 2B ¹⁾
Reproductive toxicity	Classification not possible
Specific target organ toxicity -Single exposure	Category 3 (irritation to respiratory tract)
Specific target organ toxicity -Repeated exposure	Category 1 (inhalation: lungs)
Aspiration hazards	Not classified
Environmental Hazards :	
Acute aquatic toxicity	Not classified
Chronic aquatic toxicity	Category 4

GHS label elements, including precautionary statements.

Signal word: Danger

Pictograms or hazard symbols: (The name of the symbol)

Exclamation mark, Harmful to health



Hazard statements: Irritation to eyes.

Suspect of causing cancer.

May cause respiratory irritation.

Harmful by prolonged or repeated exposure through inhalation.

Harmful to aquatic organisms: may cause long-term adverse effects in the aquatic environment.

Precautionary statements:

Do not eat, drink or smoke when using this product.

Use only outside or in a well-ventilated area.

Do not inhale dusts.

Wash hands at the end of work.

Avoid release to the environment.

Avoid storage at high-temperature and high-humidity.

Do not pile up high to prevent the second aggregation.

Do not store together with water.

Keep container tightly sealed.

Not regulated for packaging and container.

Dispose in compliance with governmental and local regulations.

3. COMPOSITION/ INFORMATION ON INGREDIENTS

Chemical identity.

Common chemical names or synonyms: Titanium dioxide
Titanium(IV) oxide

Component	Formula	CAS No.	EINECS No.	Concentration
Titanium Dioxide	TiO ₂	13463-67-7	236-675-5	Min. 50
Tin Oxide (Stannic Oxide)	SnO ₂	18282-10-5	242-159-0	Min. 40
Antimony Pentoxide (Antimony Compound as Sb ₂ O ₅)	Sb ₂ O ₅	1314-60-9	215-237-7	Max. 10

Impurities and stabilizing additives which are themselves classified and which contribute to the classification of substance: None

4. FIRST-AID MEASURES

Inhalation:

Remove person from dust contaminated area. Wash in the mouth and the nose.
Call a physician if you feel unwell.

Skins:

Wash off with water and soap. If irritation develops, call a physician.

Eyes:

Rinse out with plenty of water. If irritation develops, call a physician.

Ingestion:

Do not swallow. If you swallow, gargle and drink a quart or more of water, or a glass of milk. Call a physician if you feel unwell.

Most important symptoms/ effects, acute and delayed ²⁾:

Redness of skin and eyes

5. FIRE-FIGHTING MEASURES

Flammable limits: Incombustible

Extinguishing media: Not required.

Special fire fighting procedures:

Remove from fire-fighting area.

If the container is at high-temperature, do not touch.

Protective equipment for fire-fighting:

Do not stay in dangerous zone without self-contained breathing apparatus.

Wear entire protective equipment.

6. ACCIDENTAL RELEASE MEASURES

Person-related safety precaution:

Keep unprotected person away.

Wear adequate protective equipment (see section 8). Avoid contact with eyes, skin and clothing. And also avoid inhalation of dusts.

Measures for environmental protection:

Do not allow material to be released to the environment.

Procedures for cleaning/ absorption:

Use any feasible mechanical means to remove "spilled" material, such as broom, brush, scoop, vacuum, or wet absorbent materials. Avoid spreading dust during clean up.

7. HANDLING AND STORAGE

Precautions to be taken in handling and storing:

Store in clean and at dry place. Keep work area free of spill. Avoid ingestion as a common sense measure.

Handling:

Ensure good ventilation at working place. In accordance with SECTION 8, control dust-concentration and wear protective equipments.

Do not inhale and swallow.

Avoid contact with eyes, skin and clothing.

Wash hands at the end of work.

Do not eat, drink or smoke when using this product.

Use only outside or in a well-ventilated area.

In addition, see SECTION 10 to avoid contact.

Storage:

Avoid storage at high-temperature and high-humidity.

Do not pile up high to prevent the second aggregation.

Store under storage room with roof, and avoid together with water.

Not regulated for packaging and container, and ensure to keep container tightly sealed.

8. EXPOSURE CONTROLS/ PERSONAL PROTECTION

Control concentration:

Specification not provided.

Permitted concentration:

< TiO ₂ >			
JSOH (Edt.2005)	Dust (Class II), respirable dust		1mg/m ³
	total dust		4mg/m ³
ACGIH	TLV-TWA		10mg/m ³
< Sb >			
JSOH (Edt.2005)			
Antimony Compound (as Sb)			0.1mg/m ³
ACGIH			
Antimony Compound (as Sb)	TLV-TWA		0.5mg/m ³

<Sn>

JSOH (Edt.2005)

SnO ₂	Dust (Class III) ,	respirable dust	2mg/m ³
		total dust	8mg/m ³

ACGIH

Sn (Oxide or Inorganic compound)	TLV-TWA	2mg/m ³
----------------------------------	---------	--------------------

Equipment measures:

If dust is emitted and the concentration cannot be maintained at or below the standards in the above, then a local ventilation equipment should be made.

The local ventilation equipment should work when dust is emitted.

Place eyecup at working place and storage room.

Protective equipment and hygienic measures:

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

Protection of hands: Wear suitable gloves.

Eye protection: Wear safety glasses.

Body protection: Wear protective work clothing. Protective clothing should be selected specifically for the working place, depending on concentration and quantity of the substance handled.

Wash hands at the end of work.

 9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance (physical state, color, etc.) :	White Powder ³⁾
Odor :	None
Odor threshold :	No data available.
pH :	Indicate neutral pH (litmus) when suspended in water (1:10). ⁴⁾
Melting point/ freezing point :	1820~1850°C
Initial boiling point and boiling range:	2500~3000°C ³⁾
Flash Point:	Incombustible ⁴⁾
Evaporation rate (acetic acid = 1):	Not applicable.
Flammability (solid, gas) :	Incombustible ⁵⁾
Upper/lower flammability or explosive limits:	Incombustible ⁴⁾
Vapor pressure:	No data available.
Vapour density (air=1):	No data available.
Specific gravity:	4.5-5.0
Solubility(ies):	Insoluble in water, and organic solvents. Soluble in hot concentrated sulfuric acid.
Partition coefficient; n-octanol/water:	No data available.
Auto ignition temperature:	No data available.
Decomposition temperature:	No data available.
Viscosity:	Not applicable.

10. STABILITY AND REACTIVITY ⁶⁾

Reactivity:	Inert to most chemicals, reagents.
Chemical stability:	Stable under normal conditions.
Possibility of hazardous reactions:	No information.
Conditions to avoid:	Emit dusts.
Incompatible materials:	None
Hazardous decomposition products:	No information.

11. TOXICOLOGICAL INFORMATION

Acute toxicity:	
Oral:	LD ₅₀ > 12000mg/kg in rats. ^{7) 8)}
Dermal :	LD ₅₀ > 10000mg/kg in rabbits. ⁹⁾
Intramuscular injection:	TDL ₀ 360mg/kg /2 years in rats. ¹⁰⁾ TD 260mg/kg/84 weeks in rats. ¹¹⁾
Inhalation (Dusts):	TCL ₀ 250mg/m ³ /6hrs/2years in rats. ¹²⁾ No evidence of lung disease in humans and animals by long-term exposure through respiration system. ¹³⁾
Skin corrosion:	No specific records available.
Skin irritation:	Very slight irritation to the skin could occur. ^{9) 14)}
Serious eye damage and eye irritation:	Mild irritation in rabbits. ⁹⁾ Irritation to eyes.(Category 2B)
Respiratory and skin sensitization:	
Gross overexposure by inhalation may include mild and temporary upper respiratory irritation. ¹⁵⁾	
Negative by patch test in human. ⁹⁾	
Germ cell mutagenicity:	No literature available. Negative by mouse micronucleus test, and also by test for chromosomal abnormalities. ¹⁶⁾
Carcinogenicity:	IARC ¹⁾ : Group 2B (Possibly carcinogenic to humans) ACGIH: A4 (Not classifiable as to carcinogenicity) Suspect of causing cancer. (Category 2B) Several epidemiology studies in Europe and the USA suggested that TiO ₂ dust did not show the relation to a carcinogenic effect to lung. It is therefore concluded that TiO ₂ concentrations experienced in the working place will not cause lung cancer to the workers.
Reproductive toxicity:	No data available.
Specific target-organ toxicity-Single exposure:	
Fume irritates respiratory system as described in ref. .	
Gross overexposure by inhalation may include mild and temporary upper respiratory irritation. ⁴⁾	
May cause respiratory irritation. (Category 3)	

Specific target-organ toxicity-Repeated exposure:

No specific signs of toxicity were observed in dogs, cats, rabbits and pigs after ingestion of TiO₂ over 390 days. ¹⁷⁾ A little bit of workers who work over 20 years showed pneumoconiosis on X-ray.

The specific target-organ by repeated exposure is therefore decided to be lung. ¹⁸⁾

Harmful by prolonged or repeated exposure through inhalation. (Category 1)

Aspiration hazard:

No data available.

12. ECOLOGICAL INFORMATION

Acute aquatic toxicity: Daphnia magna EC₅₀>1000mg/L (48 hr) (Aquire, 2003)
 Insoluble in water. (HSDB, 2004)
 (Not classified)

Chronic aquatic toxicity: This is metal compound, and its long-term behavior under aquatic environment is unknown. May cause long lasting harmful effects to aquatic life. (Category 4)

13. DISPOSAL CONSIDERATIONS**Waste Disposal:**

Dispose in compliance with governmental and local regulations.

14. TRANSPORT INFORMATION

UN No.: Not applicable.
 IMDG: Not regulated for transport.
 Packing: Not dangerous for transport.

Not regulated for transport by DOT/ IMO/ IATA.

Do not pile up high to avoid falling and loosening. Product should be prevented from falling, loosening or tumbling during transport. Avoid direct sunlight.

15. REGULATORY INFORMATION

Comply with governmental and local regulations.

International inventories:

EINECS Status : On the inventory, or in compliance with the act.
 AICS Status : On the inventory, or in compliance with the act.
 DSL Status : On the inventory, or in compliance with the act.
 ENCS (JP) Status : On the inventory, or in compliance with the act.
 KECI (KR) Status : On the inventory, or in compliance with the act.
 PICCS (PH) Status : On the inventory, or in compliance with the act.
 IECSC (CN) Status : On the inventory, or in compliance with the act.

In the USA: < TiO₂, SnO₂, Sb₂O₅>

TSCA Status ; All components are listed on TSCA inventory.

SARA III Section 311/312

SnO₂ ; Acute Health Hazard, Chronic Health Hazard

Sb₂O₅ ; Acute Health Hazard

Section 313 This material contains Antimony Compounds.

California Proposition 65 ; All components are Not listed.

Hazardous materials identification system (HMIS)

Health:	1
Flammability:	0
Reactivity:	0
Maximum Personal Protection:	E

16. OTHER INFORMATION

References:

- 1) IARC RECENTLY EVALUATED 「TITANIUM DIOXIDE」 5. SUMMARY OF DATA REPORTED POSTED 27 FEBRUARY 2006
- 2) ICSC (2001)
- 3) ICSC (2002)
- 4) HSDB (2005)
- 5) Hommel (1991)
- 6) Kis-net, Kanagawa Environmental Research Center
- 7) FRAGRANCE JOURNAL, No.80, p.40 (1986)
- 8) IPCS Environmental Health Criteria 24. Titanium (1982)
- 9) IUCLID (2000)
- 10) Progress Report for Contract NO.PH-43-64-886, Submitted to the National Cancer Institute by the Institute of Chemical Biology, University of San Francisco., JUL(1968)
- 11) Progress Report for Contract No.PH-43-64-886, Submitted to the National Cancer Institute by the Institute of Chemical Biology, University of San Francisco., AUG(1969)
- 12) Toxicology and Applied Pharmacology, 79, p179 (1985)I
- 13) ARC MONOGRAPH ON THE EVALUATION OF CARCINOGENIC RISKS TO HUMANS 「TITANIUM DIOXIDE」 (WHO IARC)47 307(1989)
- 14) Cutaneous Toxicity V.A. Drill and P.Iasar. eds., New York, Academic Press p127 (1977)
- 15) TITANIUM DIOXIDE (Japan Titanium Dioxide Industry Association), No.62, p.1 (1988)
- 16) NTP DB (2005)
- 17) IPCS Environmental Health Criteria 24. Titanium (1982)
- 18) DFGOT vol.2 (1991)

Information provided in this material safety data sheet (MSDS) is prepared based on the best of knowledge and information at the date of its publication. The MSDS therefore will be amended when novel knowledge is obtained. The information given, including safe handling, use, storage, transport, disposal and release, is described to be considered under ordinal condition. Gathering any information you need in yourself then should be

encouraged. ISHIHARA SANGYO KAISHA makes no guarantees for quality specification and use, and assumes no responsibility for how this information is used.

Prepared by : Quality Assurance Division

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Approved by : Environment, Safety & Health Administration Division

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F

November 18, 2011

QUALITY ASSURANCE GROUP
QUALITY ASSURANCE DIVISION
ISHIHARA SANGYO KAISHA, LTD.

Measurement method

DENSITY

DENSITY is measured by MULTIPYCNOMETER.

MULTIPYCNOMETER is employed the Archimedean principle of fluid/gas displacement to measure the volume. The gas pycnometry operating principle is Gas Law: $PV = nRT$ Where P is the gas pressure, V is the volume containing the gas, n is the number of moles of the gas, R is the universal gas constant and T is the temperature of the gas. Introducing a sample into an analysis chamber of a known volume we determine the volume of a gas displaced by the sample and true volume of the analysed material.

1) Apparatus

MULTI PYCNOMETER MVP-1

2) Measurement condition

Commonly used gas is helium (He).

November 18, 2011

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Measurement method

SURFACE AREA (SSA)

SSA is measured by Well-known BET method (one point surface measurement).
Measurement method is as follows.

1) Apparatus

Flowsorb Model 2300

(MICROMERITICS INSTRUMENT CORPORATION)

2) Measurement condition

Deaeration : 150°C × 30min (by N₂ Gas)

It is measured under N₂ and a mixture of He after what deaerated it

November 18, 2011

QUALITY ASSURANCE GROUP
QUALITY ASSURANCE DIVISION
ISHIHARA SANGYO KAISHA, LTD.

Measurement method

PARTICLE SIZE DISTRIBUTION

1) Electron micrograph

Transmission electron micrographs of sample was taken and the primary particle size distribution was measured with Zeiss particle analyzer TGZ-3.

Transmission electron micrograph : $\times 100,000 \sim 200,000$ times.

2) A calculated value based on the specific surface area

We suppose a particle to be a spherical and calculate it by the next expression.

$$\text{Particle size}(\mu\text{m}) = \frac{6}{\text{Specific surface area}(\text{m}^2/\text{g}) \times \text{Density}(\text{g}/\text{cm}^3)}$$

November 18, 2011

QUALITY ASSURANCE GROUP
QUALITY ASSURANCE DIVISION
ISHIHARA SANGYO KAISHA, LTD.

Measurement method

PURITY

This method is a "Total Titanium by the Aluminum reduction method" in ASTM D-1394-76 "standard test methods for Chemical analysis of white Titanium pigments".

Titanium dioxide final product was dissolved by sulfuric acid and ammonium sulfate mix. Then Ti^{4+} in the solution was reduced to Ti^{3+} by aluminum metal. The Ti^{3+} was titrated by 0.1 mol/L ammonium iron(III) sulfate solution with ammonium thiocyanate as indicator.

TiO_2 sample and ammonium sulfate are weighed. And add small amount of water and sulfuric acid and then heat to dissolve TiO_2 sample. Then the solution is cooled. Dilute the solution with water and add hydrochloric acid. Add the aluminum metal into the solution and heat in order to dissolve aluminum metal, to reduce from Ti^{4+} to Ti^{3+} in the solution. After cooling, the solution is titrate with ammonium iron(III) sulfate standard solution.

SECTION D: NANOMATERIAL CHEMICAL AND PHYSICAL PROPERTIES (Attach additional pages as needed)

PRODUCT / PRODUCTION INFORMATION		
NANO CHEMICAL NAME: (Use a separate page for each unique chemical) ST-01		
COMMERCIAL NAME(S): ISHIHARA SANGYO KAISHA, LTD.		
ANNUAL PRODUCTION VOLUME: 2009 - 1400 grams; 2010 - 2; 2011 - 2		
PRODUCTION METHOD(S): Hydrolysis		
IDENTIFICATION OF THE SUPPLIER(S): Yokkaichi Plant, Japan		
PARAMETER	VALUE / RANGE ^{1/} (include units)	NAME OF ANALYTICAL METHOD(S) ^{2/}
PHYSICAL PROPERTIES		
SHAPE (MORPHOLOGY)	powder	—
DENSITY	3.9 (g/cm ³)	Measured by Ultra-pycnometer
SURFACE AREA	250~350m ² /g	BET method
PARTICLE SIZE DISTRIBUTION	Air	not applicable
	Liquid	not applicable
	Solid / Powder	0.007 μm
OTHER (Specify)	Document-3	
CHEMICAL PROPERTIES		
CHEMICAL COMPOSITION	Titanium dioxide (TiO ₂)	
SURFACE MODIFICATION (COATING, FUNCTIONALIZATION)	no coating	
PURITY	Min. 85%	ASTM D-1394
SURFACE CHARGE	unknown	—
DISPERSION ^{3/}	Air	unknown
	Liquid	to be developed
	Solid	unknown
IDENTIFYING AND DETERMINING CONCENTRATION OF NANO CHEMICAL, ITS METABOLITES, AND DEGRADATION PRODUCTS IN SPECIFIED MATRICES ^{4/} Water, Air, Soil, Sediment, Sludge, Chemical Waste, Fish, Blood, Adipose Tissue, Urine, Other (specify)	Water, Air, SOil: Not Metabolites and Degradation. The other items do not have information.	
SOLUBILITY	Water Solubility	not dissolve
	Solubility in Organic Solvent	not dissolve
N-OCTANOL-WATER PARTITION COEFFICIENT	to be developed	
STABILITY AND REACTIVITY	Flammability	not applicable
	Explosiveness	not applicable
	Oxidizing Properties	not applicable
	Oxidation Reduction Potential	not applicable
	Storage Stability and Reactivity (Container Material)	Not regulated for packaging and container
	Stability to Thermal, Sunlight, and Metal(s)	Inert to most chemicals, reagents.

Quality Assurance Group,
Quality Assurance Division ,
ISHIHARA SANGYO KAISHA LTD.

Photo-Catalyst Titanium Dioxide

Specification for ST-01

ITEM	SPEC.	TEST METHOD
pH	6.0~8.0	ASTM D-1208
330mesh Residue (%)	Max.0.5	ASTM D-185
Moisture (%)	Max.15	ASTM D-280
Specific Surface Area (m ² /g)	250~350	BET method
Bulk Density (%)	0.2~0.4	ISK method
TiO ₂ Content (%)	Min.85	ASTM D-1394
Ignition loss(%)	Max.15	ISK method



MATERIAL SAFETY DATA SHEET

1. PRODUCT AND COMPANY IDENTIFICATION

Product name : Photocatalytic Titanium Dioxide ST-01

Product use : Photocatalytic etc

Manufacturer : Company Name; ISHIHARA SANGYO KAISHA, LTD.
Address; 3-15 EDOBORI, 1-CHOME, NISHI-KU, OSAKA,
550-0002 JAPAN
Phone Number; +81-6-6444-1451

Emergency phone number: +81-6-6444-5812

2. HAZARDS IDENTIFICATION

GHS Classification

		Titanium dioxide
Physical Hazards :		
	Explosives	Not applicable
	Flammable gases	Not applicable
	Flammable aerosols	Not applicable
	Oxidizing gases	Not applicable
	Gases under pressure	Not applicable
	Flammable liquids	Not applicable
	Flammable solids	Not classified
	Self-reactive substances and mixtures	Not applicable
	Pyrophoric liquids	Not applicable
	Pyrophoric solids	Not classified
	Self-heating substances and mixtures	Not classified
	Substances and mixtures which, in contact with water, emit flammable gases	Not classified
	Oxidizing liquids	Not applicable
	Oxidizing solids	Not classified
	Organic peroxides	Not applicable
	Corrosive to metals	Classification not possible
Health Hazards :		
	Acute toxicity (oral)	Not classified
	Acute toxicity (dermal)	Not classified
	Acute toxicity (inhalation : gases)	Not applicable
	Acute toxicity (inhalation : vapor)	Classification not possible
	Acute toxicity (inhalation : dusts)	Not classified
	Acute toxicity (inhalation : mists)	Not applicable
	Skin corrosion/ irritation	Not classified

	Serious eye damage/ eye irritation	Category 2B
	Respiratory sensitization	Classification not possible
	Skin sensitization	Not classified
	Germ cell mutagenicity	Not classified
	Carcinogenicity	Category 2B ¹⁾
	Reproductive toxicity	Classification not possible
	Specific target organ toxicity -Single exposure	Category 3 (irritation to respiratory tract)
	Specific target organ toxicity -Repeated exposure	Category 1 (inhalation: lungs)
	Aspiration hazards	Not classified
Environmental Hazards :		
	Acute aquatic toxicity	Not classified
	Chronic aquatic toxicity	Category 4

GHS label elements, including precautionary statements.

Signal word: Danger

Pictograms or hazard symbols: (The name of the symbol)

Exclamation mark, Harmful to health



Hazard statements: Irritation to eyes.
Suspect of causing cancer.
May cause respiratory irritation.
Harmful by prolonged or repeated exposure through inhalation.
Harmful to aquatic organisms: may cause long-term adverse effects in the aquatic environment.

Precautionary statements:

Do not eat, drink or smoke when using this product.
Use only outside or in a well-ventilated area.
Do not inhale dusts.
Wash hands at the end of work.
Avoid release to the environment.

Avoid storage at high-temperature and high-humidity.
Do not pile up high to prevent the second aggregation.
Do not store together with water.
Keep container tightly sealed.
Not regulated for packaging and container.

Dispose in compliance with governmental and local regulations.

3. COMPOSITION/ INFORMATION ON INGREDIENTS

Chemical identity.

Common chemical names or synonyms: Titanium dioxide
Titanium(IV) oxide

Component	Formula	CAS No.	EINECS No.	Concentration
Titanium Dioxide	TiO ₂	13463-67-7	236-675-5	Min. 85
Water	H ₂ O	7732-18-5	—	Max. 15

Impurities and stabilizing additives which are themselves classified and which contribute to the classification of substance: None

4. FIRST-AID MEASURES

Inhalation:

Remove person from dust contaminated area. Wash in the mouth and the nose.
Call a physician if you feel unwell.

Skins:

Wash off with water and soap. If irritation develops, call a physician.

Eyes:

Rinse out with plenty of water. If irritation develops, call a physician.

Ingestion:

Do not swallow. If you swallow, gargle and drink a quart or more of water, or a glass of milk. Call a physician if you feel unwell.

Most important symptoms/ effects, acute and delayed ²⁾:

Redness of skin and eyes

5. FIRE-FIGHTING MEASURES

Flammable limits: Incombustible

Extinguishing media: Not required.

Special fire fighting procedures:

Remove from fire-fighting area.

If the container is at high-temperature, do not touch.

Protective equipment for fire-fighting:

Do not stay in dangerous zone without self-contained breathing apparatus.

Wear entire protective equipment.

6. ACCIDENTAL RELEASE MEASURES

Person-related safety precaution:

Keep unprotected person away.

Wear adequate protective equipment (see section 8). Avoid contact with eyes, skin and clothing. And also avoid inhalation of dusts.

Measures for environmental protection:

Do not allow material to be released to the environment.

Procedures for cleaning/ absorption:

Use any feasible mechanical means to remove "spilled" material, such as broom, brush, scoop, vacuum, or wet absorbent materials. Avoid spreading dust during clean up.

7. HANDLING AND STORAGE

Precautions to be taken in handling and storing:

Store in clean and at dry place. Keep work area free of spill. Avoid ingestion as a common sense measure.

Handling:

Ensure good ventilation at working place. In accordance with SECTION 8, control dust-concentration and wear protective equipments.

Do not inhale and swallow.

Avoid contact with eyes, skin and clothing.

Wash hands at the end of work.

Do not eat, drink or smoke when using this product.

Use only outside or in a well-ventilated area.

In addition, see SECTION 10 to avoid contact.

Storage:

Avoid storage at high-temperature and high-humidity.

Do not pile up high to prevent the second aggregation.

Store under storage room with roof, and avoid together with water.

Not regulated for packaging and container, and ensure to keep container tightly sealed.

8. EXPOSURE CONTROLS/ PERSONAL PROTECTION

Control concentration:

Specification not provided.

Permitted concentration:

JSOH (Edt.2005)	Dust (Class II), respirable dust	1mg/m ³
	total dust	4mg/m ³
ACGIH	TLV-TWA	10mg/m ³

Equipment measures:

If dust is emitted and the concentration cannot be maintained at or below the standards in the above, then a local ventilation equipment should be made.

The local ventilation equipment should work when dust is emitted.

Place eyecup at working place and storage room.

Protective equipment and hygienic measures:

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

Protection of hands: Wear suitable gloves.

Eye protection: Wear safety glasses.

Body protection: Wear protective work clothing. Protective clothing should be selected specifically for the working place, depending on concentration and quantity of the substance handled.

Wash hands at the end of work.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance (physical state, color, etc.) :	White Powder ³⁾
Odor :	None
Odor threshold :	No data available.
pH :	Indicate neutral pH (litmus) when suspended in water (1:10). ⁴⁾
Melting point/ freezing point :	1820~1850°C
Initial boiling point and boiling range:	2500~3000°C ³⁾
Flash Point:	Incombustible ⁴⁾
Evaporation rate (acetic acid = 1):	Not applicable.
Flammability (solid, gas) :	Incombustible ⁵⁾
Upper/lower flammability or explosive limits:	Incombustible ⁴⁾
Vapor pressure:	No data available.
Vapour density (air=1):	No data available.
Specific gravity:	3.5-4.2
Solubility(ies):	Insoluble in water, and organic solvents. Soluble in hot concentrated sulfuric acid.
Partition coefficient: n-octanol/water:	No data available.
Auto ignition temperature:	No data available.
Decomposition temperature:	No data available.
Viscosity:	Not applicable.

10. STABILITY AND REACTIVITY ⁶⁾

Reactivity:	Inert to most chemicals, reagents.
Chemical stability:	Stable under normal conditions.
Possibility of hazardous reactions:	No information.
Conditions to avoid:	Emit dusts.
Incompatible materials:	None
Hazardous decomposition products:	No information.

11. TOXICOLOGICAL INFORMATION

Acute toxicity:

Oral: LD50 > 12000mg/kg in rats. ^{7) 8)}
 Dermal: LD50 > 10000mg/kg in rabbits. ⁹⁾
 Intramuscular injection: TDL0 360mg/kg /2 years in rats. ¹⁰⁾
 TD 260mg/kg/84 weeks in rats. ¹¹⁾

Inhalation (Dusts): TCL0 250mg/m³/6hrs/2years in rats. ¹²⁾
 No evidence of lung disease in humans and animals by long-term exposure through respiration system. ¹³⁾

Skin corrosion: No specific records available.
 Skin irritation: Very slight irritation to the skin could occur. ^{9) 14)}

Serious eye damage and eye irritation: Mild irritation in rabbits. ⁹⁾
 Irritation to eyes. (Category 2B)

Respiratory and skin sensitization:
 Gross overexposure by inhalation may include mild and temporary upper respiratory irritation. ¹⁵⁾
 Negative by patch test in human. ⁹⁾

Germ cell mutagenicity: No literature available.
 Negative by mouse micronucleus test, and also by test for chromosomal abnormalities. ¹⁶⁾

Carcinogenicity: IARC ¹⁾: Group 2B (Possibly carcinogenic to humans)
 ACGIH: A4 (Not classifiable as to carcinogenicity)
 Suspect of causing cancer. (Category 2B)
 Several epidemiology studies in Europe and the USA suggested that TiO₂ dust did not show the relation to a carcinogenic effect to lung. It is therefore concluded that TiO₂ concentrations experienced in the working place will not cause lung cancer to the workers.

Reproductive toxicity: No data available.

Specific target-organ toxicity-Single exposure:
 Fume irritates respiratory system as described in ref. .
 Gross overexposure by inhalation may include mild and temporary upper respiratory irritation. ⁴⁾
 May cause respiratory irritation. (Category 3)

Specific target-organ toxicity-Repeated exposure:
 No specific signs of toxicity were observed in dogs, cats, rabbits and pigs after ingestion of TiO₂ over 390 days. ¹⁷⁾ A little bit of workers who work over 20 years showed pneumoconiosis on X-ray.
 The specific target-organ by repeated exposure is therefore decided to be lung. ¹⁸⁾
 Harmful by prolonged or repeated exposure through inhalation. (Category 1)

Aspiration hazard: No data available.

12. ECOLOGICAL INFORMATION

Acute aquatic toxicity: Daphnia magna EC50>1000mg/L (48 hr) (Aquire, 2003)
Insoluble in water. (HSDB, 2004)
(Not classified)

Chronic aquatic toxicity: This is metal compound, and its long-term behavior under aquatic environment is unknown. May cause long lasting harmful effects to aquatic life. (Category 4)

13. DISPOSAL CONSIDERATIONS

Waste Disposal:

Dispose in compliance with governmental and local regulations.

14. TRANSPORT INFORMATION

UN No.: Not applicable.
IMDG: Not regulated for transport.
Packing: Not dangerous for transport.

Not regulated for transport by DOT/ IMO/ IATA.

Do not pile up high to avoid falling and loosening. Product should be prevented from falling, loosening or tumbling during transport. Avoid direct sunlight.

15. REGULATORY INFORMATION

Comply with governmental and local regulations.

International inventories:

EINECS Status : On the inventory, or in compliance with the act.
AICS Status : On the inventory, or in compliance with the act.
DSL Status : On the inventory, or in compliance with the act.
ENCS (JP) Status : On the inventory, or in compliance with the act.
KECI (KR) Status : On the inventory, or in compliance with the act.
PICCS (PH) Status : On the inventory, or in compliance with the act.
IECSC (CN) Status : On the inventory, or in compliance with the act.

In the USA:

TSCA Status: On the inventory, or in compliance with the inventory.
SARA III Section 311: No
Section 312: No
Section 313: No
California Proposition 65: Not listed.

Hazardous materials identification system (HMIS)

Health;	1
Flammability;	0
Reactivity;	0
Maximum Personal Protection;	E

16. OTHER INFORMATION

References:

- 1) IARC RECENTLY EVALUATED 「TITANIUM DIOXIDE」 5. SUMMARY OF DATA REPORTED POSTED 27 FEBRUARY 2006
- 2) ICSC (2001)
- 3) ICSC (2002)
- 4) HSDB (2005)
- 5) Hommel (1991)
- 6) Kis-net, Kanagawa Environmental Research Center
- 7) FRAGRANCE JOURNAL, No.80, p.40 (1986)
- 8) IPCS Environmental Health Criteria 24. Titanium (1982)
- 9) IUCLID (2000)
- 10) Progress Report for Contract NO.PH-43-64-886, Submitted to the National Cancer Institute by the Institute of Chemical Biology, University of San Francisco., JUL(1968)
- 11) Progress Report for Contract No.PH-43-64-886, Submitted to the National Cancer Institute by the Institute of Chemical Biology, University of San Francisco., AUG(1969)
- 12) Toxicology and Applied Pharmacology, 79, p179 (1985)I
- 13) ARC MONOGRAPH ON THE EVALUATION OF CARCINOGENIC RISKS TO HUMANS 「TITANIUM DIOXIDE」 (WHO IARC)47 307(1989)
- 14) Cutaneous Toxicity V.A. Drill and P.Iasar. eds., New York, Academic Press p127 (1977)
- 15) TITANIUM DIOXIDE (Japan Titanium Dioxide Industry Association), No.62, p.1 (1988)
- 16) NTP DB (2005)
- 17) IPCS Environmental Health Criteria 24. Titanium (1982)
- 18) DFGOT vol.2 (1991)

Information provided in this material safety data sheet (MSDS) is prepared based on the best of knowledge and information at the date of its publication. The MSDS therefore will be amended when novel knowledge is obtained. The information given, including safe handling, use, storage, transport, disposal and release, is described to be considered under ordinal condition. Gathering any information you need in yourself then should be encouraged. ISHIHARA SANGYO KAISHA makes no guarantees for quality specification and use, and assumes no responsibility for how this information is used.

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Measurement method

DENSITY

DENSITY is measured by MULTIPYCNOMETER.

MULTIPYCNOMETER is employed the Archimedean principle of fluid/gas displacement to measure the volume. The gas pycnometry operating principle is Gas Law: $PV = nRT$ Where P is the gas pressure, V is the volume containing the gas, n is the number of moles of the gas, R is the universal gas constant and T is the temperature of the gas. Introducing a sample into an analysis chamber of a known volume we determine the volume of a gas displaced by the sample and true volume of the analysed material.

1) Apparatus

MULTI PYCNOMETER MVP-1

2) Measurement condition

Commonly used gas is helium (He).

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Measurement method

SURFACE AREA (SSA)

SSA is measured by Well-known BET method (one point surface measurement).
Measurement method is as follows.

1) Apparatus

Flowsorb Model 2300

(MICROMERITICS INSTRUMENT CORPORATION)

2) Measurement condition

Deaeration : 150°C × 30min (by N₂ Gas)

It is measured under N₂ and a mixture of He after what deaerated it

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Measurement method

PARTICLE SIZE DISTRIBUTION

1) Electron micrograph

Transmission electron micrographs of sample was taken and the primary particle size distribution was measured with Zeiss particle analyzer TGZ-3.

Transmission electron micrograph : $\times 100,000 \sim 200,000$ times.

2) A calculated value based on the specific surface area

We suppose a particle to be a spherical and calculate it by the next expression.

$$\text{Particle size}(\mu\text{m}) = \frac{6}{\text{Specific surface area}(\text{m}^2/\text{g}) \times \text{Density}(\text{g}/\text{cm}^3)}$$

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Measurement method

PURITY

This method is a "Total Titanium by the Aluminum reduction method" in ASTM D-1394-76 "standard test methods for Chemical analysis of white Titanium pigments".

Titanium dioxide final product was dissolved by sulfuric acid and ammonium sulfate mix. Then Ti^{4+} in the solution was reduced to Ti^{3+} by aluminum metal. The Ti^{3+} was titrated by 0.1 mol/L ammonium iron(III) sulfate solution with ammonium thiocyanate as indicator.

TiO_2 sample and ammonium sulfate are weighed. And add small amount of water and sulfuric acid and then heat to dissolve TiO_2 sample. Then the solution is cooled. Dilute the solution with water and add hydrochloric acid. Add the aluminum metal into the solution and heat in order to dissolve aluminum metal, to reduce from Ti^{4+} to Ti^{3+} in the solution. After cooling, the solution is titrate with ammonium iron(III) sulfate standard solution.



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