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Produktinformation



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Diagnostik & molekulare Diagnostik



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Lieferung & Zahlungsart

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Zuschläge

- Mindermengenzuschlag
- Trockeneiszuschlag
- Gefahrgutzuschlag
- Expressversand

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Titanium(IV) butoxide

sc-253702



The Power is Question

Material Safety Data Sheet

Hazard Alert Code Key: **EXTREME** **HIGH** **MODERATE** **LOW**

Section 1 - CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME

Titanium(IV) butoxide

STATEMENT OF HAZARDOUS NATURE

CONSIDERED A HAZARDOUS SUBSTANCE ACCORDING TO OSHA 29 CFR 1910.1200.

NFPA



SUPPLIER

Santa Cruz Biotechnology, Inc.
2145 Delaware Avenue
Santa Cruz, California 95060
800.457.3801 or 831.457.3800

EMERGENCY:

ChemWatch
Within the US & Canada: 877-715-9305
Outside the US & Canada: +800 2436 2255
(1-800-CHEMCALL) or call +613 9573 3112

SYNONYMS

C16-H36-O4-Ti, Ti[O(CH2)3CH3]4, "tetra-n-butoxy titanium", "butyl titanate", "titanium tetrabutoxide", "titanium butoxide", "titanium butylate", "tetra-n-butyltitanate", "Tyzor TBT", "titanic acid, tetrabutyl ester", "titanium alkoxide", "1-butanol, titanium (IV) salt", "n-butanol titanium salt", "butyl orthotitanate", "tetrabutyl orthotitanate"

Section 2 - HAZARDS IDENTIFICATION

CHEMWATCH HAZARD RATINGS

	Min	Max
Flammability:	1	
Toxicity:	2	
Body Contact:	3	
Reactivity:	1	
Chronic:	2	

Min/Nil=0
Low=1
Moderate=2
High=3
Extreme=4



CANADIAN WHMIS SYMBOLS



EMERGENCY OVERVIEW

RISK

Causes burns.
Risk of serious damage to eyes.
HARMFUL - May cause lung damage if swallowed.

POTENTIAL HEALTH EFFECTS

ACUTE HEALTH EFFECTS

SWALLOWED

- The material can produce chemical burns within the oral cavity and gastrointestinal tract following ingestion.
- Swallowing of the liquid may cause aspiration into the lungs with the risk of chemical pneumonitis; serious consequences may result. (ICSC13733).
- Accidental ingestion of the material may be damaging to the health of the individual.
- Dusts of titanium and titanium compounds are thought to exhibit little or no toxic effects.
- Overexposure to non-ring alcohols causes nervous system symptoms. These include headache, muscle weakness and inco-ordination, giddiness, confusion, delirium and coma. Digestive symptoms may include nausea, vomiting and diarrhea. Aspiration is much more dangerous than ingestion because lung damage can occur and the substance is absorbed into the body. Alcohols with ring structures and secondary and tertiary alcohols cause more severe symptoms, as do heavier alcohols.

EYE

- The material can produce chemical burns to the eye following direct contact. Vapors or mists may be extremely irritating.
- If applied to the eyes, this material causes severe eye damage.

SKIN

- The material can produce chemical burns following direct contact with the skin.
- Skin contact is not thought to have harmful health effects, however the material may still produce health damage following entry through wounds, lesions or abrasions.
- Most liquid alcohols appear to act as primary skin irritants in humans. Significant percutaneous absorption occurs in rabbits but not apparently in man.
- Open cuts, abraded or irritated skin should not be exposed to this material.
- Entry into the blood-stream, through, for example, cuts, abrasions or lesions, may produce systemic injury with harmful effects. Examine the skin prior to the use of the material and ensure that any external damage is suitably protected.

INHALED

- If inhaled, this material can irritate the throat and lungs of some persons.
- Inhalation of vapours may cause drowsiness and dizziness. This may be accompanied by narcosis, reduced alertness, loss of reflexes, lack of coordination and vertigo.
- Inhalation of aerosols (mists, fumes), generated by the material during the course of normal handling, may be damaging to the health of the individual.
- Aliphatic alcohols with more than 3-carbons cause headache, dizziness, drowsiness, muscle weakness and delirium, central depression, coma, seizures and behavioral changes. Secondary respiratory depression and failure, as well as low blood pressure and irregular heart rhythms, may follow. Nausea and vomiting are seen, and liver and kidney damage is possible as well following massive exposures. Symptoms are more acute the more carbons there are in the alcohol.
- Inhaling corrosive bases may irritate the respiratory tract. Symptoms include cough, choking, pain and damage to the mucous membrane. In severe cases, lung swelling may develop, sometimes after a delay of hours to days. There may be low blood pressure, a weak and rapid pulse, and crackling sounds.
- Inhalation hazard is increased at higher temperatures.
- Inhalation of high concentrations of gas/vapor causes lung irritation with coughing and nausea, central nervous depression with headache and dizziness, slowing of reflexes, fatigue and inco-ordination.

CHRONIC HEALTH EFFECTS

- Repeated or prolonged exposure to corrosives may result in the erosion of teeth, inflammatory and ulcerative changes in the mouth and necrosis (rarely) of the jaw. Bronchial irritation, with cough, and frequent attacks of bronchial pneumonia may ensue. Gastrointestinal disturbances may also occur. Chronic exposures may result in dermatitis and/or conjunctivitis.

Limited evidence suggests that repeated or long-term occupational exposure may produce cumulative health effects involving organs or biochemical systems.

Long term exposure to titanium and several of its compounds produces lung scarring and chronic bronchitis. Breathing is impaired and cardiac changes with right heart enlargements occur. There is an increased chance of developing cancers of the respiratory tract.

Section 3 - COMPOSITION / INFORMATION ON INGREDIENTS

NAME	CAS RN	%
titanium(IV) butoxide	5593-70-4	>98
decomposes in water or moisture to produce		

Section 4 - FIRST AID MEASURES

SWALLOWED

· For advice, contact a Poisons Information Center or a doctor at once. · Urgent hospital treatment is likely to be needed. · If swallowed do NOT induce vomiting. · If vomiting occurs, lean patient forward or place on left side (head-down position, if possible) to maintain open airway and prevent aspiration. · Observe the patient carefully. · Never give liquid to a person showing signs of being sleepy or with reduced awareness; i.e. becoming unconscious. · Give water to rinse out mouth, then provide liquid slowly and as much as casualty can comfortably drink. · Transport to hospital or doctor without delay. · If spontaneous vomiting appears imminent or occurs, hold patient's head down, lower than their hips to help avoid possible aspiration of vomitus.

EYE

■ If this product comes in contact with the eyes: · Immediately hold eyelids apart and flush the eye continuously with running water. · Ensure complete irrigation of the eye by keeping eyelids apart and away from eye and moving the eyelids by occasionally lifting the upper and lower lids. · Continue flushing until advised to stop by the Poisons Information Center or a doctor, or for at least 15 minutes. · Transport to hospital or doctor without delay. · Removal of contact lenses after an eye injury should only be undertaken by skilled personnel.

SKIN

■ If skin or hair contact occurs: · Immediately flush body and clothes with large amounts of water, using safety shower if available. · Quickly remove all contaminated clothing, including footwear. · Wash skin and hair with running water. Continue flushing with water until advised to stop by the Poisons Information Center. · Transport to hospital, or doctor.

INHALED

· If fumes or combustion products are inhaled remove from contaminated area. · Lay patient down. Keep warm and rested. · Prostheses such as false teeth, which may block airway, should be removed, where possible, prior to initiating first aid procedures. · Apply artificial respiration if not breathing, preferably with a demand valve resuscitator, bag-valve mask device, or pocket mask as trained. Perform CPR if necessary. · Transport to hospital, or doctor. Inhalation of vapors or aerosols (mists, fumes) may cause lung edema. Corrosive substances may cause lung damage (e.g. lung edema, fluid in the lungs). As this reaction may be delayed up to 24 hours after exposure, affected individuals need complete rest (preferably in semi-recumbent posture) and must be kept under medical observation even if no symptoms are (yet) manifested. Before any such manifestation, the administration of a spray containing a dexamethasone derivative or beclomethasone derivative may be considered. This must definitely be left to a doctor or person authorized by him/her. (ICSC13719).

NOTES TO PHYSICIAN

■ Any material aspirated during vomiting may produce lung injury. Therefore emesis should not be induced mechanically or pharmacologically. Mechanical means should be used if it is considered necessary to evacuate the stomach contents; these include gastric lavage after endotracheal intubation. If spontaneous vomiting has occurred after ingestion, the patient should be monitored for difficult breathing, as adverse effects of aspiration into the lungs may be delayed up to 48 hours.

For acute or short-term repeated exposures to highly alkaline materials:

- Respiratory stress is uncommon but present occasionally because of soft tissue edema.
- Unless endotracheal intubation can be accomplished under direct vision, cricothyroidotomy or tracheotomy may be necessary.
- Oxygen is given as indicated.
- The presence of shock suggests perforation and mandates an intravenous line and fluid administration.
- Damage due to alkaline corrosives occurs by liquefaction necrosis whereby the saponification of fats and solubilization of proteins allow deep penetration into the tissue.

Alkalis continue to cause damage after exposure.

INGESTION:

- Milk and water are the preferred diluents

No more than 2 glasses of water should be given to an adult.

- Neutralizing agents should never be given since exothermic heat reaction may compound injury.

* Catharsis and emesis are absolutely contra-indicated.

* Activated charcoal does not absorb alkali.

* Gastric lavage should not be used.

Supportive care involves the following:

- Withhold oral feedings initially.
- If endoscopy confirms transmucosal injury start steroids only within the first 48 hours.
- Carefully evaluate the amount of tissue necrosis before assessing the need for surgical intervention.
- Patients should be instructed to seek medical attention whenever they develop difficulty in swallowing (dysphagia).

SKIN AND EYE:

- Injury should be irrigated for 20-30 minutes.
- Eye injuries require saline. [Ellenhorn & Barceloux: Medical Toxicology].

Section 5 - FIRE FIGHTING MEASURES

Vapour Pressure (mmHG):	Not available
Upper Explosive Limit (%):	12
Specific Gravity (water=1):	0.996
Lower Explosive Limit (%):	2

EXTINGUISHING MEDIA

- Alcohol stable foam.
- Dry chemical powder.
- BCF (where regulations permit).
- Carbon dioxide.
- Water spray or fog - Large fires only.

FIRE FIGHTING

- Alert Emergency Responders and tell them location and nature of hazard.
- Wear full body protective clothing with breathing apparatus.
- Prevent, by any means available, spillage from entering drains or water course.
- Use fire fighting procedures suitable for surrounding area.
- DO NOT approach containers suspected to be hot.
- Cool fire exposed containers with water spray from a protected location.
- If safe to do so, remove containers from path of fire.
- Equipment should be thoroughly decontaminated after use.

GENERAL FIRE HAZARDS/HAZARDOUS COMBUSTIBLE PRODUCTS

- Combustible.
 - Slight fire hazard when exposed to heat or flame.
 - Heating may cause expansion or decomposition leading to violent rupture of containers.
 - On combustion, may emit toxic fumes of carbon monoxide (CO).
 - May emit acrid smoke.
 - Mists containing combustible materials may be explosive.
- Combustion products include: carbon dioxide (CO₂), metal oxides, other pyrolysis products typical of burning organic material.
May emit corrosive fumes.

FIRE INCOMPATIBILITY

- Avoid contamination with oxidizing agents i.e. nitrates, oxidizing acids, chlorine bleaches, pool chlorine etc. as ignition may result.

PERSONAL PROTECTION

Glasses:

Safety Glasses.

Full face- shield.

Gloves:

Respirator:

Type A Filter of sufficient capacity

Section 6 - ACCIDENTAL RELEASE MEASURES

MINOR SPILLS

- Drains for storage or use areas should have retention basins for pH adjustments and dilution of spills before discharge or disposal of material.
- Check regularly for spills and leaks.
- Clean up all spills immediately.
- Avoid breathing vapors and contact with skin and eyes.
- Control personal contact by using protective equipment.
- Contain and absorb spill with sand, earth, inert material or vermiculite.
- Wipe up.
- Place in a suitable labeled container for waste disposal.

MAJOR SPILLS

- Chemical Class: alcohols and glycols

For release onto land: recommended sorbents listed in order of priority.

SORBENT TYPE	RANK	APPLICATION	COLLECTION	LIMITATIONS
LAND SPILL - SMALL				
cross-linked polymer - particulate	1	shovel	shovel	R, W, SS
cross-linked polymer - pillow	1	throw	pitchfork	R, DGC, RT
sorbent clay - particulate	2	shovel	shovel	R, I, P
wood fiber - pillow	3	throw	pitchfork	R, P, DGC, RT
treated wood fiber - pillow	3	throw	pitchfork	DGC, RT
foamed glass - pillow	4	throw	pitchfork	R, P, DGC, RT
LAND SPILL - MEDIUM				
cross-linked polymer - particulate	1	blower	skiloader	R, W, SS
polypropylene - particulate	2	blower	skiloader	W, SS, DGC
sorbent clay - particulate	2	blower	skiloader	R, I, W, P, DGC
polypropylene - mat	3	throw	skiloader	DGC, RT
expanded mineral - particulate	3	blower	skiloader	R, I, W, P, DGC
polyurethane - mat	4	throw	skiloader	DGC, RT

Legend

DGC: Not effective where ground cover is dense

R: Not reusable
 I: Not incinerable
 P: Effectiveness reduced when rainy
 RT: Not effective where terrain is rugged
 SS: Not for use within environmentally sensitive sites
 W: Effectiveness reduced when windy
 Reference: Sorbents for Liquid Hazardous Substance Cleanup and Control;
 R.W Melvold et al: Pollution Technology Review No. 150: Noyes Data Corporation 1988.
 Chemical Class: bases

For release onto land: recommended sorbents listed in order of priority.

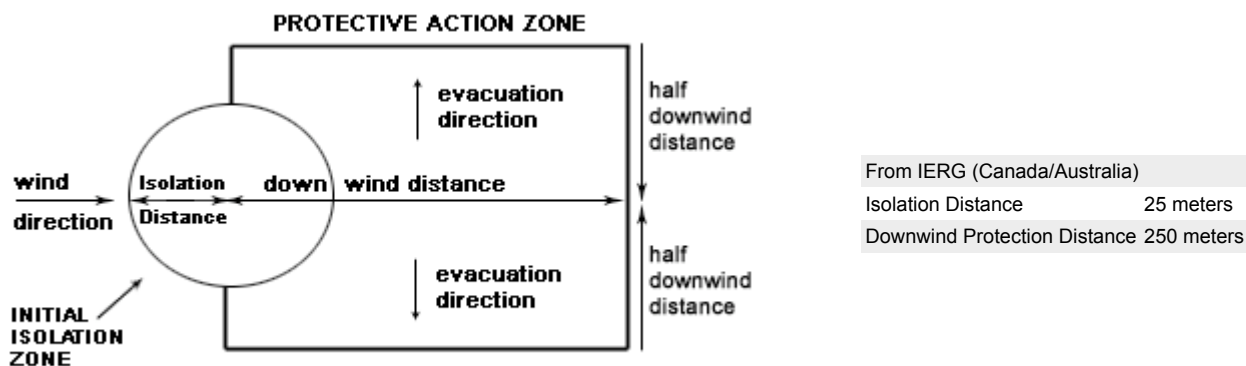
SORBENT TYPE	RANK	APPLICATION	COLLECTION	LIMITATIONS
LAND SPILL - SMALL				
cross-linked polymer - particulate	1	shovel	shovel	R,W,SS
cross-linked polymer - pillow	1	throw	pitchfork	R, DGC, RT
sorbent clay - particulate	2	shovel	shovel	R, I, P
foamed glass - pillow	2	throw	pitchfork	R, P, DGC, RT
expanded minerals - particulate	3	shovel	shovel	R, I, W, P, DGC
foamed glass - particulate	4	shovel	shovel	R, W, P, DGC,
LAND SPILL - MEDIUM				
cross-linked polymer -particulate	1	blower	skidloader	R,W, SS
sorbent clay - particulate	2	blower	skidloader	R, I, P
expanded mineral - particulate	3	blower	skidloader	R, I,W, P, DGC
cross-linked polymer - pillow	3	throw	skidloader	R, DGC, RT
foamed glass - particulate	4	blower	skidloader	R, W, P, DGC
foamed glass - pillow	4	throw	skidloader	R, P, DGC., RT

Legend

DGC: Not effective where ground cover is dense
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 Reference: Sorbents for Liquid Hazardous Substance Cleanup and Control;
 R.W Melvold et al: Pollution Technology Review No. 150: Noyes Data Corporation 1988.

- Clear area of personnel and move upwind.
- Alert Emergency Responders and tell them location and nature of hazard.
- Wear full body protective clothing with breathing apparatus.
- Prevent, by any means available, spillage from entering drains or water course.
- Consider evacuation.
- Stop leak if safe to do so.
- Contain spill with sand, earth or vermiculite.
- Collect recoverable product into labeled containers for recycling.
- Neutralize/decontaminate residue.
- Collect solid residues and seal in labeled drums for disposal.
- Wash area and prevent runoff into drains.
- After clean up operations, decontaminate and launder all protective clothing and equipment before storing and re-using.
- If contamination of drains or waterways occurs, advise emergency services.

PROTECTIVE ACTIONS FOR SPILL



FOOTNOTES

- 1 PROTECTIVE ACTION ZONE is defined as the area in which people are at risk of harmful exposure. This zone assumes that random changes in wind direction confines the vapour plume to an area within 30 degrees on either side of the predominant wind direction, resulting in a crosswind protective action distance equal to the downwind protective action distance.
- 2 PROTECTIVE ACTIONS should be initiated to the extent possible, beginning with those closest to the spill and working away from the site in the downwind direction. Within the protective action zone a level of vapour concentration may exist resulting in nearly all unprotected persons becoming incapacitated and unable to take protective action and/or incurring serious or irreversible health effects.
- 3 INITIAL ISOLATION ZONE is determined as an area, including upwind of the incident, within which a high probability of localised wind reversal may expose nearly all persons without appropriate protection to life-threatening concentrations of the material.
- 4 SMALL SPILLS involve a leaking package of 200 litres (55 US gallons) or less, such as a drum (jerrican or box with inner containers). Larger packages leaking less than 200 litres and compressed gas leaking from a small cylinder are also considered "small spills". LARGE SPILLS involve many small leaking packages or a leaking package of greater than 200 litres, such as a cargo tank, portable tank or a "one-tonne" compressed gas cylinder.
- 5 Guide 153 is taken from the US DOT emergency response guide book.
- 6 IERG information is derived from CANUTEC - Transport Canada.

Section 7 - HANDLING AND STORAGE

PROCEDURE FOR HANDLING

- DO NOT allow clothing wet with material to stay in contact with skin.
- Avoid all personal contact, including inhalation.
- Wear protective clothing when risk of exposure occurs.
- Use in a well-ventilated area.
- Avoid contact with moisture.
- Avoid contact with incompatible materials.
- When handling, DO NOT eat, drink or smoke.
- Keep containers securely sealed when not in use.
- Avoid physical damage to containers.
- Always wash hands with soap and water after handling.
- Work clothes should be laundered separately. Launder contaminated clothing before re-use.
- Use good occupational work practice.
- Observe manufacturer's storing and handling recommendations.
- Atmosphere should be regularly checked against established exposure standards to ensure safe working conditions are maintained.

RECOMMENDED STORAGE METHODS

- Lined metal can, Lined metal pail/drum
- Plastic pail
- Polyliner drum
- Packing as recommended by manufacturer.
- Check all containers are clearly labeled and free from leaks.

For low viscosity materials

- Drums and jerricans must be of the non-removable head type.
- Where a can is to be used as an inner package, the can must have a screwed enclosure.

For materials with a viscosity of at least 2680 cSt. (23 deg. C) and solids (between 15 C deg. and 40 deg C.):

- Removable head packaging;
- Cans with friction closures and
- low pressure tubes and cartridges may be used.- Where combination packages are used, and the inner packages are of glass, porcelain or stoneware, there must be sufficient inert cushioning material in contact with inner and outer packages unless the outer packaging is a close fitting molded plastic box and the substances are not incompatible with the plastic.

STORAGE REQUIREMENTS

- Store in original containers.
 - Keep containers securely sealed.
 - Store in a cool, dry, well-ventilated area.
 - Store away from incompatible materials and foodstuff containers.
 - Protect containers against physical damage and check regularly for leaks.
 - Observe manufacturer's storing and handling recommendations.
- DO NOT store near acids, or oxidizing agents.

- No smoking, naked lights, heat or ignition sources.
- Material is hygroscopic, i.e. absorbs moisture from the air. Keep containers well sealed in storage.

SAFE STORAGE WITH OTHER CLASSIFIED CHEMICALS



X: Must not be stored together

O: May be stored together with specific preventions

+: May be stored together

Section 8 - EXPOSURE CONTROLS / PERSONAL PROTECTION

EXPOSURE CONTROLS

Source	Material	TWA ppm	TWA mg/m ³	STEL ppm	STEL mg/m ³	Peak ppm	Peak mg/m ³	Notes
Canada - Alberta Occupational Exposure Limits	n-butanol (n-Butanol (n-Butyl alcohol))	20	60					
Canada - British Columbia Occupational Exposure Limits	n-butanol (n-Butanol)	15				30		
Canada - Ontario Occupational Exposure Limits	n-butanol (n-Butanol, also known as n-Butyl alcohol)	20						
US ACGIH Threshold Limit Values (TLV)	n-butanol (n-Butanol)	20						TLV Basis: eye & upper respiratory tract irritation
US NIOSH Recommended Exposure Limits (RELs)	n-butanol (n-Butyl alcohol)					50	150	[skin]
US - Tennessee Occupational Exposure Limits - Limits For Air Contaminants	n-butanol (n-Butyl alcohol)					50	150	
US - Vermont Permissible Exposure Limits Table Z-1-A Transitional Limits for Air Contaminants	n-butanol (n-Butyl alcohol)	100	300					
US - Vermont Permissible Exposure Limits Table Z-1-A Final Rule Limits for Air Contaminants	n-butanol (n-Butyl alcohol)					50	150	
US - Minnesota Permissible Exposure Limits (PELs)	n-butanol (n-Butyl alcohol)					50	150	
US - California Permissible Exposure Limits for Chemical	n-butanol (n-Butyl alcohol; 1-butanol)	50	150					C

Contaminants					
US - Idaho - Limits for Air Contaminants	n-butanol (n-Butyl alcohol)	100	300		
US OSHA Permissible Exposure Levels (PELs) - Table Z1	n-butanol (n-Butyl alcohol)	100	300		
US - Hawaii Air Contaminant Limits	n-butanol (n-Butyl alcohol)			50	150
US - Alaska Limits for Air Contaminants	n-butanol (n-Butyl alcohol)			50	150
US - Michigan Exposure Limits for Air Contaminants	n-butanol (n-Butyl alcohol(n-butanol))			50	150
Canada - Yukon Permissible Concentrations for Airborne Contaminant Substances	n-butanol (n-Butyl alcohol - Skin)	50	150	-	-
US - Washington Permissible exposure limits of air contaminants	n-butanol (n-Butyl alcohol)			50	
Canada - Saskatchewan Occupational Health and Safety Regulations - Contamination Limits	n-butanol (n-Butyl alcohol (n-butanol))	20		30	
Canada - Prince Edward Island Occupational Exposure Limits	n-butanol (n-Butanol)	20			TLV Basis: eye & upper respiratory tract irritation
US - Wyoming Toxic and Hazardous Substances Table Z1 Limits for Air Contaminants	n-butanol (n-Butyl alcohol)	100	300		
Canada - Quebec Permissible Exposure Values for Airborne Contaminants (English)	n-butanol (n-Butyl alcohol)			50	152
US - Oregon Permissible Exposure Limits (Z-1)	n-butanol (n-Butyl alcohol)	100	300		
Canada - Northwest Territories Occupational Exposure Limits (English)	n-butanol (n-Butyl alcohol - Skin)			50	152
Canada - Nova Scotia Occupational Exposure Limits	n-butanol (n-Butanol)	20			TLV Basis: eye & upper respiratory tract irritation
US OSHA Permissible Exposure Levels (PELs) - Table Z3	titanic acid (Inert or Nuisance Dust: (d) Respirable fraction)		5		
US OSHA Permissible Exposure Levels (PELs) - Table Z3	titanic acid (Inert or Nuisance Dust: (d) Total dust)		15		

US - Oregon Permissible Exposure Limits (Z-3)	titanic acid (Inert or Nuisance Dust: Respirable fraction)	5	(d)
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US - Oregon Permissible Exposure Limits (Z-3)	titanic acid (Inert or Nuisance Dust: Total dust)	10	(d)
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ENDOELTABLE

The following materials had no OELs on our records

- titanium(IV) butoxide: CAS:5593-70-4

EMERGENCY EXPOSURE LIMITS

Material Revised IDLH Value (mg/m³) Revised IDLH Value (ppm)

n-butanol 1,400 [LEL]

NOTES

Values marked LEL indicate that the IDLH was based on 10% of the lower explosive limit for safety considerations even though the relevant toxicological data indicated that irreversible health effects or impairment of escape existed only at higher concentrations.

MATERIAL DATA

N-BUTANOL:

TITANIUM(IV) BUTOXIDE:

- Exposed individuals are reasonably expected to be warned, by smell, that the Exposure Standard is being exceeded.

Odor Safety Factor (OSF) is determined to fall into either Class A or B.

The Odor Safety Factor (OSF) is defined as:

OSF= Exposure Standard (TWA) ppm/ Odor Threshold Value (OTV) ppm

Classification into classes follows:

Class	OSF	Description
A	550	Over 90% of exposed individuals are aware by smell that the Exposure Standard (TLV-TWA for example) is being reached, even when distracted by working activities
B	26-550	Idem for 50-90% of persons being distracted
C	1-26	Idem for less than 50% of persons being distracted
D	0.18-1	0-50% of persons aware of being tested perceive by smell that the Exposure Standard is being reached
E	<0.18	Idem for less than 10% of persons aware of being tested

Amoore and Hautala * have determined that it is only at an OSF value of 26 that 50% of distracted persons can detect the substance at the Exposure Standard value. In the case of alerted persons, an OSF of 26 means that 99% of them can detect the odor at the Exposure Standard value. It is ONLY for substances belonging to Class A and B that there is a reasonable chance of being warned in time, that the Exposure Standard is being exceeded. * Journal Applied Toxicology: Vol 3, 1983, p272

NOTE: The use of the OSF may be inappropriate for mixtures where substances mask the odor of others.

N-BUTANOL:

TITANIUM(IV) BUTOXIDE:

- For n-butanol:

Odour Threshold Value: 0.12-3.4 ppm (detection), 1.0-3.5 ppm (recognition)

NOTE: Detector tubes for n-butanol, measuring in excess of 5 ppm are commercially available.

Exposure at or below the TLV-TWA is thought to provide protection against hearing loss due to vestibular and auditory nerve damage in younger workers and to protect against the significant risk of headache and irritation.

25 ppm may produce mild irritation of the respiratory tract 50 ppm may produce headache and vertigo.

Higher concentrations may produce marked irritation, sore throat, coughing, nausea, shortness of breath, pulmonary injury and central nervous system depression characterised by headache, dizziness, dullness and drowsiness.

6000 ppm may produce giddiness, prostration, narcosis, ataxia, and death.

Odour Safety Factor (OSF)

OSF=60 (n-BUTANOL).

TITANIUM(IV) BUTOXIDE:

- No exposure limits set by NOHSC or ACGIH.

TITANIC ACID:

- These "dusts" have little adverse effect on the lungs and do not produce toxic effects or organic disease. Although there is no dust which does not evoke some cellular response at sufficiently high concentrations, the cellular response caused by P.N.O.C.s has the following characteristics:

- the architecture of the air spaces remain intact,
- scar tissue (collagen) is not synthesised to any degree,
- tissue reaction is potentially reversible.

Extensive concentrations of P.N.O.C.s may:

- seriously reduce visibility,
- cause unpleasant deposits in the eyes, ears and nasal passages,

- contribute to skin or mucous membrane injury by chemical or mechanical action, per se, or by the rigorous skin cleansing procedures necessary for their removal. [ACGIH]

This limit does not apply:

- to brief exposures to higher concentrations
- nor does it apply to those substances that may cause physiological impairment at lower concentrations but for which a TLV has as yet to be determined.

This exposure standard applies to particles which

- are insoluble or poorly soluble* in water or, preferably, in aqueous lung fluid (if data is available) and
- have a low toxicity (i.e., are not cytotoxic, genotoxic, or otherwise chemically reactive with lung tissue, and do not emit ionizing radiation, cause immune sensitization, or cause toxic effects other than by inflammation or by a mechanism of lung overload).

PERSONAL PROTECTION



Consult your EHS staff for recommendations

EYE

- Chemical goggles.
- Full face shield.
- Contact lenses pose a special hazard; soft lenses may absorb irritants and all lenses concentrate them.

HANDS/FEET

■ Wear chemical protective gloves, eg. PVC.

Wear safety footwear or safety gumboots, eg. Rubber.

- When handling corrosive liquids, wear trousers or overalls outside of boots, to avoid spills entering boots.

Suitability and durability of glove type is dependent on usage. Important factors in the selection of gloves include: such as:

- frequency and duration of contact,
- chemical resistance of glove material,
- glove thickness and
- dexterity

Select gloves tested to a relevant standard (e.g. Europe EN 374, US F739).

- When prolonged or frequently repeated contact may occur, a glove with a protection class of 5 or higher (breakthrough time greater than 240 minutes according to EN 374) is recommended.

- When only brief contact is expected, a glove with a protection class of 3 or higher (breakthrough time greater than 60 minutes according to EN 374) is recommended.

- Contaminated gloves should be replaced.

Gloves must only be worn on clean hands. After using gloves, hands should be washed and dried thoroughly. Application of a non-perfumed moisturiser is recommended.

OTHER

- Overalls.
- PVC Apron.
- PVC protective suit may be required if exposure severe.
- Eyewash unit.
- Ensure there is ready access to a safety shower.

RESPIRATOR

■ Selection of the Class and Type of respirator will depend upon the level of breathing zone contaminant and the chemical nature of the contaminant. Protection Factors (defined as the ratio of contaminant outside and inside the mask) may also be important.

Breathing Zone Level ppm (volume)	Maximum Protection Factor	Half-face Respirator	Full-Face Respirator
1000	10	A-1	-
1000	50	-	A-1
5000	50	Airline*	-
5000	100	-	A-2
10000	100	-	A-3
	100+		Airline* *

* - Continuous Flow ** - Continuous-flow or positive pressure demand.

The local concentration of material, quantity and conditions of use determine the type of personal protective equipment required.

Use appropriate NIOSH-certified respirator based on informed professional judgement. In conditions where no reasonable estimate of exposure can be made, assume the exposure is in a concentration IDLH and use NIOSH-certified full face pressure demand SCBA with a minimum service life of 30 minutes, or a combination full facepiece pressure demand SAR with auxiliary self-contained air supply. Respirators provided only for escape from IDLH atmospheres shall be NIOSH-certified for escape from the atmosphere in which they will be used.

ENGINEERING CONTROLS

■ Local exhaust ventilation usually required. If risk of overexposure exists, wear an approved respirator. Correct fit is essential to obtain

adequate protection an approved self contained breathing apparatus (SCBA) may be required in some situations. Provide adequate ventilation in warehouse or closed storage area.

Air contaminants generated in the workplace possess varying "escape" velocities which, in turn, determine the "capture velocities" of fresh circulating air required to effectively remove the contaminant.

Type of Contaminant:	Air Speed:
solvent, vapors, degreasing etc., evaporating from tank (in still air).	0.25-0.5 m/s (50-100 f/min.)
aerosols, fumes from pouring operations, intermittent container filling, low speed conveyer transfers, welding, spray drift, plating acid fumes, pickling (released at low velocity into zone of active generation)	0.5-1 m/s (100-200 f/min.)
direct spray, spray painting in shallow booths, drum filling, conveyer loading, crusher dusts, gas discharge (active generation into zone of rapid air motion)	1-2.5 m/s (200-500 f/min.)
grinding, abrasive blasting, tumbling, high speed wheel generated dusts (released at high initial velocity into zone of very high rapid air motion).	2.5-10 m/s (500-2000 f/min.)

Within each range the appropriate value depends on:

Lower end of the range	Upper end of the range
1: Room air currents minimal or favorable to capture	1: Disturbing room air currents
2: Contaminants of low toxicity or of nuisance value only.	2: Contaminants of high toxicity
3: Intermittent, low production.	3: High production, heavy use
4: Large hood or large air mass in motion	4: Small hood-local control only

Simple theory shows that air velocity falls rapidly with distance away from the opening of a simple extraction pipe. Velocity generally decreases with the square of distance from the extraction point (in simple cases). Therefore the air speed at the extraction point should be adjusted, accordingly, after reference to distance from the contaminating source. The air velocity at the extraction fan, for example, should be a minimum of 1-2 m/s (200-400 f/min) for extraction of solvents generated in a tank 2 meters distant from the extraction point. Other mechanical considerations, producing performance deficits within the extraction apparatus, make it essential that theoretical air velocities are multiplied by factors of 10 or more when extraction systems are installed or used.

Section 9 - PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL PROPERTIES

Corrosive.

Alkaline.

State	LIQUID	Molecular Weight	340.36
Melting Range (°F)	-67 (forms glass)	Viscosity	Not Available
Boiling Range (°F)	590- 597.2	Solubility in water (g/L)	Reacts
Flash Point (°F)	170.6	pH (1% solution)	Not applicable
Decomposition Temp (°F)	Not Available	pH (as supplied)	Not applicable
Autoignition Temp (°F)	Not available	Vapour Pressure (mmHG)	Not available
Upper Explosive Limit (%)	12	Specific Gravity (water=1)	0.996
Lower Explosive Limit (%)	2	Relative Vapor Density (air=1)	11.5
Volatile Component (%vol)	Not available	Evaporation Rate	Not available

APPEARANCE

■ Material is hygroscopic, absorbs moisture from surrounding air. Colourless to pale yellow viscous liquid with an butyl alcohol odour; decomposes by water, liberating butanol and titanium hydroxide (titanic acid). Soluble in anhydrous organic solvents with the exception of ketones.

■ log Kow (Prager 1995) 0.88 ■ log Kow (Sangster 1997) 0.84 log Kow 0.88

Material	Value

Section 10 - CHEMICAL STABILITY

CONDITIONS CONTRIBUTING TO INSTABILITY

- Presence of incompatible materials.
- Product is considered stable.
- Hazardous polymerization will not occur.

STORAGE INCOMPATIBILITY

■ Avoid storage with strong acids, acid chlorides, acid anhydrides, oxidizing agents.
Segregate from alcohol, water.

- Avoid contact with copper, aluminium and their alloys.
- NOTE: May develop pressure in containers; open carefully. Vent periodically.

For incompatible materials - refer to Section 7 - Handling and Storage.

Section 11 - TOXICOLOGICAL INFORMATION

TITANIUM(IV) BUTOXIDE

TOXICITY AND IRRITATION

- unless otherwise specified data extracted from RTECS - Register of Toxic Effects of Chemical Substances.
- Asthma-like symptoms may continue for months or even years after exposure to the material ceases. This may be due to a non-allergenic condition known as reactive airways dysfunction syndrome (RADS) which can occur following exposure to high levels of highly irritating compound. Key criteria for the diagnosis of RADS include the absence of preceding respiratory disease, in a non-atopic individual, with abrupt onset of persistent asthma-like symptoms within minutes to hours of a documented exposure to the irritant. A reversible airflow pattern, on spirometry, with the presence of moderate to severe bronchial hyperreactivity on methacholine challenge testing and the lack of minimal lymphocytic inflammation, without eosinophilia, have also been included in the criteria for diagnosis of RADS. RADS (or asthma) following an irritating inhalation is an infrequent disorder with rates related to the concentration of and duration of exposure to the irritating substance. Industrial bronchitis, on the other hand, is a disorder that occurs as result of exposure due to high concentrations of irritating substance (often particulate in nature) and is completely reversible after exposure ceases. The disorder is characterised by dyspnea, cough and mucus production.

TITANIUM(IV) BUTOXIDE:

TOXICITY	IRRITATION
Oral (rat) LD50: 3122 mg/kg	Nil Reported
Intravenous (mouse) LD50: 180 mg/kg	

- The material may be irritating to the eye, with prolonged contact causing inflammation. Repeated or prolonged exposure to irritants may produce conjunctivitis.

The material may produce respiratory tract irritation, and result in damage to the lung including reduced lung function.

The material may cause skin irritation after prolonged or repeated exposure and may produce on contact skin redness, swelling, the production of vesicles, scaling and thickening of the skin.

TOXICITY	IRRITATION
N-BUTANOL:	
Oral (rat) LD50: 790 mg/kg	Skin (rabbit): 405 mg/24h-Moderate
Inhalation (human) TCLo: 25 ppm	Eye (human): 50 ppm - Irritant
Inhalation (rat) LC50: 8000 ppm/4h	Eye (rabbit): 1.6 mg-SEVERE
Dermal (rabbit) LD50: 3400 mg/kg	Eye (rabbit): 24 mg/24h-SEVERE
Inhalation (human) TCLo: 86000 mg/m ³	

- The material may produce severe irritation to the eye causing pronounced inflammation. Repeated or prolonged exposure to irritants may produce conjunctivitis.

The material may cause skin irritation after prolonged or repeated exposure and may produce on contact skin redness, swelling, the production of vesicles, scaling and thickening of the skin.

TITANIC ACID:

- No significant acute toxicological data identified in literature search.

SKIN

n-butanol	US - Tennessee Occupational Exposure Limits - Limits For Air Contaminants - Skin	Skin Designation	X
n-butanol	US - Vermont Permissible Exposure Limits Table Z-1-A Final Rule Limits for Air Contaminants - Skin	Skin Designation	X
n-butanol	US - Washington Permissible exposure limits of air contaminants - Skin	Skin	X
n-butanol	US - Minnesota Permissible Exposure Limits (PELs) - Skin	Skin Designation	X
n-butanol	US - Hawaii Air Contaminant Limits - Skin Designation	Skin Designation	X
n-butanol	US OSHA Permissible Exposure Levels (PELs) - Skin	Skin Designation	X

Section 12 - ECOLOGICAL INFORMATION

Refer to data for ingredients, which follows:

N-BUTANOL:

TITANIUM(IV) BUTOXIDE:

■ DO NOT discharge into sewer or waterways.

TITANIUM(IV) BUTOXIDE:

■ Prevent, by any means available, spillage from entering drains or watercourses.

N-BUTANOL:

- Fish LC50 (96hr.) (mg/l): 1910- 1940
- Daphnia magna EC50 (48hr.) (mg/l): 1983
- Algae IC50 (72hr.) (mg/l): 650
- log Kow (Prager 1995): 0.88
- log Kow (Sangster 1997): 0.84
- log Pow (Verschueren 1983): 0.88
- Half- life Soil - High (hours): 168
- Half- life Soil - Low (hours): 24
- Half- life Air - High (hours): 87.7
- Half- life Air - Low (hours): 8.8
- Half- life Surface water - High (hours): 168
- Half- life Surface water - Low (hours): 24
- Half- life Ground water - High (hours): 1296
- Half- life Ground water - Low (hours): 48
- Aqueous biodegradation - Aerobic - High (hours): 168
- Aqueous biodegradation - Aerobic - Low (hours): 24
- Aqueous biodegradation - Anaerobic - High (hours): 1296
- Aqueous biodegradation - Anaerobic - Low (hours): 96
- Aqueous biodegradation - Removal secondary treatment - High (hours): 99%
- Aqueous biodegradation - Removal secondary treatment - Low (hours): 31%
- Photooxidation half- life water - High (hours): 104000
- Photooxidation half- life water - Low (hours): 2602
- Photooxidation half- life air - High (hours): 87.7
- Photooxidation half- life air - Low (hours): 8.8

log Kow: 0.88

Koc: 71.6

Half-life (hr) air: 5-52

Half-life (hr) H2O surface water: 2.4-3022

Henry's atm m³ /mol: 5.57E-06

BOD 5 if unstated: 1.1-2.04,33%

COD: 1.9,92%

ThOD: 2.594

Fish: LD100 (24 h): 1.4 g/L

Fish LC50 (96 h): 1.91g/L

Toxicity invertebrate: cell mult. inhib.8-650mg/L

Bioaccumulation: not sig

Nitrif. inhib.: 50% inhib at 8200mg/L

Effects on algae and plankton: cell mult. inhib.100-875mg/L

Degradation Biological: sig

processes Abiotic: RxnOH*

TITANIC ACID:

■ Metal-containing inorganic substances generally have negligible vapour pressure and are not expected to partition to air. Once released to surface waters and moist soils their fate depends on solubility and dissociation in water. Environmental processes (such as oxidation and the presence of acids or bases) may transform insoluble metals to more soluble ionic forms. Microbiological processes may also transform insoluble metals to more soluble forms. Such ionic species may bind to dissolved ligands or sorb to solid particles in aquatic or aqueous media. A significant proportion of dissolved/ sorbed metals will end up in sediments through the settling of suspended particles. The remaining metal ions can then be taken up by aquatic organisms.

When released to dry soil most metals will exhibit limited mobility and remain in the upper layer; some will leach locally into ground water and/ or surface water ecosystems when soaked by rain or melt ice. Environmental processes may also be important in changing solubilities.

Even though many metals show few toxic effects at physiological pHs, transformation may introduce new or magnified effects.

A metal ion is considered infinitely persistent because it cannot degrade further.

The current state of science does not allow for an unambiguous interpretation of various measures of bioaccumulation.

The counter-ion may also create health and environmental concerns once isolated from the metal. Under normal physiological conditions the counter-ion may be essentially insoluble and may not be bioavailable.

Environmental processes may enhance bioavailability.

Ecotoxicity

Ingredient	Persistence: Water/Soil	Persistence: Air	Bioaccumulation	Mobility
titanium(IV) butoxide	LOW		LOW	HIGH
n-butanol	LOW	MED	LOW	HIGH

Section 13 - DISPOSAL CONSIDERATIONS

US EPA Waste Number & Descriptions

A. General Product Information

Corrosivity characteristic: use EPA hazardous waste number D002 (waste code C)

B. Component Waste Numbers

When n-butanol is present as a solid waste as a discarded commercial chemical product, off-specification species, as a container residue, or a spill residue, use EPA waste number U031 (waste code I).

Disposal Instructions

All waste must be handled in accordance with local, state and federal regulations.

! Legislation addressing waste disposal requirements may differ by country, state and/ or territory. Each user must refer to laws operating in their area. In some areas, certain wastes must be tracked.

A Hierarchy of Controls seems to be common - the user should investigate:

- Reduction
- Reuse
- Recycling
- Disposal (if all else fails)

This material may be recycled if unused, or if it has not been contaminated so as to make it unsuitable for its intended use. If it has been contaminated, it may be possible to reclaim the product by filtration, distillation or some other means. Shelf life considerations should also be applied in making decisions of this type. Note that properties of a material may change in use, and recycling or reuse may not always be appropriate.

DO NOT allow wash water from cleaning equipment to enter drains. Collect all wash water for treatment before disposal.

- Recycle wherever possible.
- Consult manufacturer for recycling options or consult Waste Management Authority for disposal if no suitable treatment or disposal facility can be identified.
- Treat and neutralize at an approved treatment plant.
- Treatment should involve: Neutralization with suitable dilute acid followed by: Burial in a licensed land-fill or Incineration in a licensed apparatus (after admixture with suitable combustible material).
- Decontaminate empty containers. Observe all label safeguards until containers are cleaned and destroyed.

Section 14 - TRANSPORTATION INFORMATION

DOT:

Symbols: None Hazard class or Division: 8

Identification Numbers: UN3267 PG: III

Label Codes: 8 Special provisions: IB3, T7, TP1, TP28

Packaging: Exceptions: 154 Packaging: Non- bulk: 203

Packaging: Exceptions: 154 Quantity limitations: 5 L

Passenger aircraft/rail:

Quantity Limitations: Cargo 60 L Vessel stowage: Location: A aircraft only:

Vessel stowage: Other: 40, 52

Hazardous materials descriptions and proper shipping names:

Corrosive liquid, basic, organic, n.o.s.

Air Transport IATA:

ICAO/IATA Class: 8 ICAO/IATA Subrisk: None

UN/ID Number: 3267 Packing Group: III

Special provisions: A3

Cargo Only

Packing Instructions: 820 Maximum Qty/Pack: 60 L

Passenger and Cargo Passenger and Cargo

Packing Instructions: 818 Maximum Qty/Pack: 5 L

Passenger and Cargo Limited Quantity Passenger and Cargo Limited Quantity

Packing Instructions: Y818 Maximum Qty/Pack: 1 L

Shipping Name: CORROSIVE LIQUID, BASIC, ORGANIC, N.O.S.

*(CONTAINS TITANIUM(IV) BUTOXIDE)

Maritime Transport IMDG:

IMDG Class: 8 IMDG Subrisk: None

UN Number: 3267 Packing Group: III

EMS Number: F-A , S-B Special provisions: 223 274

Limited Quantities: 5 L

Shipping Name: CORROSIVE LIQUID, BASIC, ORGANIC, N.O.S.(contains titanium(IV) butoxide)

Section 15 - REGULATORY INFORMATION



REGULATIONS

ND

Ingredient CAS % de minimus concentration
n-butanol 71-36-3 1.0

ND

Ingredient CAS RQ
n-butanol 71-36-3 5000 lb (2270 kg)

titanium(IV) butoxide (CAS: 5593-70-4) is found on the following regulatory lists;

"Canada Domestic Substances List (DSL)", "OECD Representative List of High Production Volume (HPV) Chemicals", "US DOE Temporary Emergency Exposure Limits (TEELs)", "US Toxic Substances Control Act (TSCA) - Inventory"
Regulations for ingredients

n-butanol (CAS: 71-36-3) is found on the following regulatory lists;

"Canada - Alberta Occupational Exposure Limits", "Canada - British Columbia Occupational Exposure Limits", "Canada - Northwest Territories Occupational Exposure Limits (English)", "Canada - Nova Scotia Occupational Exposure Limits", "Canada - Ontario Occupational Exposure Limits", "Canada - Prince Edward Island Occupational Exposure Limits", "Canada - Quebec Permissible Exposure Values for Airborne Contaminants (English)", "Canada - Saskatchewan Industrial Hazardous Substances", "Canada - Saskatchewan Occupational Health and Safety Regulations - Contamination Limits", "Canada - Yukon Permissible Concentrations for Airborne Contaminant Substances", "Canada Domestic Substances List (DSL)", "Canada Ingredient Disclosure List (SOR/88-64)", "Canada National Pollutant Release Inventory (NPRI)", "Canada Toxicological Index Service - Workplace Hazardous Materials Information System - WHMIS (English)", "GESAMP/EHS Composite List - GESAMP Hazard Profiles", "IMO IBC Code Chapter 18: List of products to which the Code does not apply", "IMO MARPOL 73/78 (Annex II) - List of Other Liquid Substances", "International Council of Chemical Associations (ICCA) - High Production Volume List", "OECD Representative List of High Production Volume (HPV) Chemicals", "US - Alaska Limits for Air Contaminants", "US - California Air Toxics ""Hot Spots"" List (Assembly Bill 2588) Substances for which emissions must be quantified", "US - California Occupational Safety and Health Regulations (CAL/OSHA) - Hazardous Substances List", "US - California Permissible Exposure Limits for Chemical Contaminants", "US - California Toxic Air Contaminant List Category IV", "US - Connecticut Hazardous Air Pollutants", "US - Hawaii Air Contaminant Limits", "US - Idaho - Limits for Air Contaminants", "US - Massachusetts Oil & Hazardous Material List", "US - Michigan Exposure Limits for Air Contaminants", "US - Minnesota Hazardous Substance List", "US - Minnesota Permissible Exposure Limits (PELs)", "US - New Jersey Right to Know Hazardous Substances", "US - Oregon Permissible Exposure Limits (Z-1)", "US - Pennsylvania - Hazardous Substance List", "US - Rhode Island Hazardous Substance List", "US - Tennessee Occupational Exposure Limits - Limits For Air Contaminants", "US - Vermont Hazardous wastes which are Discarded Commercial Chemical Products or Off-Specification Batches of Commercial Chemical Products or Spill Residues of Either", "US - Vermont Permissible Exposure Limits Table Z-1-A Final Rule Limits for Air Contaminants", "US - Vermont Permissible Exposure Limits Table Z-1-A Transitional Limits for Air Contaminants", "US - Washington Discarded Chemical Products List - ""U"" Chemical Products", "US - Washington Permissible exposure limits of air contaminants", "US - Wyoming Toxic and Hazardous Substances Table Z1 Limits for Air Contaminants", "US ACGIH Threshold Limit Values (TLV)", "US Cosmetic Ingredient Review (CIR) Cosmetic ingredients found safe as used", "US Department of Transportation (DOT) List of Hazardous Substances and Reportable Quantities - Hazardous Substances Other Than Radionuclides", "US DOE Temporary Emergency Exposure Limits (TEELs)", "US EPA Carcinogens Listing", "US EPA High Production Volume Program Chemical List", "US EPA Master Testing List - Index I Chemicals Listed", "US EPA Master Testing List - Index II Chemicals Removed", "US EPCRA Section 313 Chemical List", "US Food Additive Database", "US List of Lists - Consolidated List of Chemicals Subject to EPCRA, CERCLA and Section 112(r) of the Clean Air Act", "US NIOSH Recommended Exposure Limits (RELs)", "US OSHA Permissible Exposure Levels (PELs) - Table Z1", "US RCRA (Resource Conservation & Recovery Act) - List of Hazardous Wastes", "US RCRA (Resource Conservation & Recovery Act) - Phase 4 LDR Rule - Universal Treatment Standards", "US Spacecraft Maximum Allowable Concentrations (SMACs) for Airborne Contaminants", "US Toxic Substances Control Act (TSCA) - Inventory", "US TSCA Section 4/12 (b) - Sunset Date/Status"

titanic acid (CAS: 20338-08-3) is found on the following regulatory lists;

"Canada Domestic Substances List (DSL)", "US Toxic Substances Control Act (TSCA) - Inventory"

Section 16 - OTHER INFORMATION

LIMITED EVIDENCE

- Inhalation and/or ingestion may produce health damage*.
- Cumulative effects may result following exposure*.
- Vapors potentially cause drowsiness and dizziness*.

* (limited evidence).

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- Classification of the mixture and its individual components has drawn on official and authoritative sources as well as independent review by the Chemwatch Classification committee using available literature references.

A list of reference resources used to assist the committee may be found at:
www.chemwatch.net/references.

- The (M)SDS is a Hazard Communication tool and should be used to assist in the Risk Assessment. Many factors determine whether the reported Hazards are Risks in the workplace or other settings. Risks may be determined by reference to Exposures Scenarios. Scale of use, frequency of use and current or available engineering controls must be considered.

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