



Material Safety Data Sheet

according to 1907/2006/EC, Article 31

DATE: 23.07.2013

1. Identification of substance and of the company/undertaking

1.1 Product identifier

Substance Name: Silver (powder)

Not classified

EC No.: (EINECS) 231-131-3

REACH Registration No.: NA

CAS No.: 7440-22-4

1.2 Relevant identified uses of the substance and uses advised against

Relevant identified uses:

Application of the substance / the preparation: antibacterial agent applied in cleaning and protective preparations, cosmetics.

- *Sector of Use category:* Industrial use (SU3), Professional use (SU22).
- *Chemical Product category:* Biocidal products (PC8), Washing and cleaning products (including solvent based products) (PC35), Cosmetics, personal care products (PC39).
- *Process category:* Use in closed batch and other processes (synthesis) where opportunity for exposure arises (PROC4).
- *Environmental Release category:* Formulation of preparations (ERC2)
- *Article category:* Antibacterial cleaning fluid (TARIC CODE 38)

Uses advised against: Consumer use (SU21), Manufacture of food products (SU4)

Reasons why uses advised against: The use of powder by the general public and in food products is advised against due to the high risk of human and environmental exposure.

1.3 Details of the supplier of the Safety Data Sheet

Manufacturer/Supplier: NA

Street address/P.O. Box: NA

Country ID/Postcode/Place: NA

Telephone number: NA

Email address of competent person for the SDS: NA

National Contact: NA

1.4 Emergency telephone number

Opening hours: NA



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2. Hazards identification

2.1 *Classification of the substance*

2.1.1 *Classification according to Regulation (EC) No 1272/2008 [CLP]*

Silver as such is not classified.

2.1.1.1. *Self classification*

- According to generally available data, hazardous to the aquatic environment of silver (>99.9%) in powder form (< 1 mm)¹ was identified as: Aquatic Acute 1, H400 (M-Factor = 1), Aquatic Chronic 1, H410 (M-Factor = 10)

- Irritant 2²: H315

Therefore, it is possible to suggest for silver nanoparticles and for the aquatic environment following classification:

Risk Phrase: Very toxic to aquatic organisms may cause long-term adverse effects in the aquatic environment.

Hazard Codes: “category acute 1”³

Hazard statement code: H400, H410

In case of silver nanoparticles it should be also taken under account, that:

- Any very fine metal particles (nanopowder) may cause eye irritation (suggested: hazard category: “Eye Irrit. 2”, hazard statement code: H319).
- Any very fine metal particles (nanopowder) may cause respiratory irritation (suggested: hazard category: “STOT SE 3”, hazard statement code: H335).
- Any very fine metal particles (nanopowder) may cause skin irritation (suggested: hazard category: “Skin Irrit. 2”, hazard statement code: H315).

2.1.2 *Classification according to Directive 67/548/EEC*

Classification: N; R50-53: dangerous for the environment

2.1.3 *Additional information*

Any additional information

2.2 *Label elements*

Labelling according to Regulation (EC) No 1272/2008 [CLP]

Hazard pictograms:

Suggested pictograms :



GHS09



GHS07

Signal word:

Suggested signal word GHS09: Warning.

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Hazard statements:

Suggested hazard statements:

Very toxic to aquatic life (H400).

Very toxic to aquatic life with long lasting effects (H410).

Causes serious eye irritation (H319).

May cause respiratory irritation (H335).

Causes skin irritation (H315).

Precautionary statement

Avoid release to the environment (P273).

Wear protective gloves/protective clothing/eye protection (P280).

Avoid breathing dust (P261).

Store in a well-ventilated place. Keep container tightly closed (P403 + P233).

2.2 Other hazards

Nano Ag, as a powder, during handling can form dust. To measure this parameter, dustiness is measured. According to the value reported in section 9, the dustiness class established by the software Stoffenmanager nano⁴ is medium (lowest possible value in the software).

3. Composition/information on ingredients

3.1 Substances

Identification name	Index number in CLP Annex VI	CAS number	Weight %
Silver (>99.9%)	Not classified	7440-22-4	≥ 20
Paraffin based additive	Not classified. Not toxic.	Trade secret	≤ 20

3.2 Mixtures

NA

4. First aid measures

4.1 Description of first aid measures

Following inhalation: Remove victim to fresh air and keep at rest in a position comfortable for breathing. If required, provide artificial respiration. Seek immediate medical advice.

Following skin contact: No health effect expected. Wash with plenty of soap and water. If skin irritation occurs get medical advice/attention.

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Following eye contact: Do not allow victim to rub eye(s). Rinse cautiously with lukewarm, gently flowing water for several minutes, while holding eye(s) open. Remove contact lenses, if present and easy to do. Continue rinsing. If irritation persists, immediately obtain medical attention. Do not attend to manually remove anything stuck to the eye.

Following ingestion: If irritation or discomfort occurs, seek medical treatment.

Self-protection of the first aider: The first responder should wear appropriate personal protection devices, at least a mask to avoid inhalation of powder in air.

4.2 *Most important symptoms and effects, both acute and delayed*

1. Nausea, vomiting
2. Cough
3. Itchy and watery eyes.
4. Skin irritation or ulceration.
5. The most common health effects associated with prolonged exposure to silver are the development of a characteristic, irreversible pigmentation of the skin (argyria) and/or the eyes (argyrosis). The affected area becomes bluish-gray or ash gray and is most prominent in areas of the body exposed to sunlight⁵.

4.3. *Indication of any immediate medical attention and special treatment needed*

No further relevant information available.

5. Fire fighting measures

5.1 *Extinguishing media:*

Suitable extinguishing media: Fire extinguishing powder, dry sand.

Unsuitable extinguishing media: Do not use direct water streams on fire where molten metal is present.

5.2 *Special hazards arising from the substance or mixture:*

Hazardous combustion products: Combustion of silver powder may cause the release of toxic metal oxide fume.

5.3 *Advice for fire-fighters:*

Wear self-contained respirator.

Wear fully protective impervious suit.



6. Accidental release measures

6.1 *Personal precautions, protective equipment and emergency procedures:*

Wear protective equipment. Keep unprotected persons away. Ensure adequate ventilation. Close-fitting safety goggles may be necessary in some circumstances to prevent eye contact with dust or fume.

6.1.1 *For non-emergency personnel:*

Leave affected area.

6.2. *Measures for environmental protection:*

Clean up in a way that doesn't disperse the powder into air.
Do not allow product to reach sewage system or any water course.
Inform respective authorities in case of seepage into water course or sewage system.
Do not allow material to be released to the environment without proper governmental permits.

6.3. *Measures for cleaning/collecting:*

Powder should be mechanically cleaned up in a way that doesn't disperse it into air.
Treat or dispose of waste material in accordance with all local, regional, and national requirements

6.4. *Additional information:*

See Section 7 for information on safe handling
See Section 8 for information on personal protection equipment.
See Section 13 for disposal information.

7. Handling and storage

7.1 *Precaution for safe handling:*

Protective measures:

Measures to prevent fire: Keep away from heat/sparks/open flames/hot surfaces.

Measures to prevent aerosol and dust generation: Ensure good ventilation/exhaustion at the workplace. Use appropriate filters (HEP > H13).

Measures to protect the environment: Keep container tightly sealed. It does react with Sulfur in the air, forming silver tarnish; Ag₂S (silver Sulfide).

Advice on general occupational hygiene: Avoid inhalation and contact with skin, eyes and clothing. Avoid prolonged or repeated exposure. Always practice good personal hygiene.

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No special precautions are necessary if used correctly.

7.2 Conditions for safe storage, including any incompatibilities:

Technical measures and storage conditions:

Store in closed container, preferable under inert environment.

Do not store together with acids.

Do not store together with alkalis (caustic solutions).

Packaging materials: No special packaging materials requirements.

Requirements for storage rooms and vessels: NE.

Storage class: NA

Further information on storage conditions

Keep container tightly sealed.

Store in cool, dry conditions in well sealed containers.

7.3. Specific end-uses:

Silver powder used for preparation of cleaning product.

8. Exposure controls and personal protection

8.1 Control parameters

Occupational exposure limits values: (<http://limitvalue.ifa.dguv.de>)

Substance	Silver, metallic
CAS No.	7440-22-4

Country	Limit value - Eight hours		Limit value - Short term	
	ppm	mg/m ³	ppm	mg/m ³
<u>Australia</u>		0,1		
<u>Austria</u>		0,01 inhalable aerosol		
<u>Belgium</u>		0,1		
<u>Canada - Ontario</u>		0,1		
<u>Canada - Québec</u>		0,1		
<u>Denmark</u>		0,01		0,02
<u>European Union</u>		0,1		
<u>France</u>		0,1		
<u>Germany (AGS)</u>		0,1 inhalable aerosol		0,8 inhalable aerosol (1)

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Germany (DFG)		0,1 inhalable aerosol		0,8 inhalable aerosol
Hungary		0,1		0,4
Italy		0,1		
New Zealand		0,1		
Poland		0,05		
Singapore		0,1		
South Korea		0,1		
Spain		0,1		
Sweden		0,1		
Switzerland		0,1 inhalable aerosol		0,8 inhalable aerosol
The Netherlands		0,1		
USA - NIOSH		0,01		
USA - OSHA		0,01		
United Kingdom		0,1		
	Remarks			
European Union	Bold-type: Indicative Occupational Exposure Limit Values [2,3] and Limit Values for Occupational Exposure [4] (for references see <u>bibliography</u>)			
France	Italic type: Indicative statutory limit values			
Germany (AGS)	15 minutes average value			
Germany (DFG)	Long term exposure level			
Poland	Silver dust and fume: Limit value - Eight hours 0.05 mg/m ³			

Information on monitoring process:

PN-EN 14042:2004: „Powietrze na stanowiskach pracy. Przewodnik użytkowania i stosowania procedur do oceny narażenia na czynniki chemiczne i biologiczne”.

8.2 *Exposure controls*

8.2.1 *Appropriate engineering controls:*

- Keep away from heat.
- Work in ventilated enclosures (e.g., glove box, laboratory hood, process chamber) equipped with high-efficiency particulate air filters (Section 7.1).
- Where operations cannot be enclosed, use adequate ventilation to maintain the concentration of silver dust in working environment below the exposure limit(s) outlined in Section 8.1 of this Safety Data Sheet.
- Provide local exhaust ventilation (e.g., capture hood, enclosing hood) equipped with HEPA filters and designed to capture the contaminant at the point of generation or release.
- Supply sufficient replacement air to make up for air removed by the exhaust system.
- Provide safety equipment such as eyewash fountains, first aid kits and safety showers.

Substance/mixture related measures to prevent exposure during identified uses: NA.



Structural measures to prevent exposure: Provide hand washing facilities and information that encourages the use of good hygiene practices. Prohibit dry sweeping or use of compressed air or portable blowers or fans for clean up. Use wet wiping and vacuum cleaners equipped with HEPA filters. Damp cleaning methods with soap or cleaning oils is preferred. Work area should be cleaned at the end of each work shift (at a minimum).

Organisational measures to prevent exposure: Avoid work procedures producing dusts. Minimise the number of exposed workers and the duration and intensiveness of the exposure.

Technical measures to prevent exposure: Properly operating chemical fume hood designed for hazardous chemicals and having proper face velocity between 0.4 and 0.6 m/sec (80-120 feet/minute). Constant velocity hoods are a better design than compensating hoods.

Filtering cabinet connected to ventilation system to the outside. General ventilation of laboratory environment.

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

8.2.2.1 Eye and face protection: If eye contact while using product may be anticipated, wear appropriate safety glasses with side shields or chemical goggles as described by European Standard EN166.

8.2.2.2 Skin protection: Wear chemical resistant gloves (such as latex or neoprene) and protective clothing to minimize skin contact. Substance may have drying effect on skin. Maintain good industrial hygiene. Protection recommended for workers suffering from dermatitis or sensitive skin.

Hand protection: laminated PVA gloves and polycoated Tyvek.

Other skin protection: Full protective clothing should be worn during activities with a high exposure.

8.2.2.3 Respiratory protection: In case of exposure to dust, and in any case if such exposure is above regulatory limits (see above), wear a personal respirator in compliance with national law and European Standard EN 149. Generally, a half respirator with an organic vapour cartridge and particulate filter (NIOSH type P95 or R95 filter) for up to ten times the exposure limit. A full-face piece respirator with an organic vapour cartridge and particulate filter (NIOSH P100 or R100 filter) for 50 times the exposure limit.

8.2.2.4 Thermal hazards: NIF

8.2.2 Environmental exposure controls:

Substance/mixture related measures to prevent exposure during identified uses: NIF

Structural measures to prevent exposure: Use an absorbent walk-off mat where the personnel will exit the access controlled area. Hand washing, showering, changing and cleaning clothes facilities should be provided to prevent the inadvertent contamination of other areas (including take-home) caused by the transfer on clothing and skin.



Organisational measures to prevent exposure: NE

Technical measures to prevent exposure: Filtered ventilated air before release to the outside.

9. Physical and chemical properties:

9.1 *Information on basic physical and chemical properties:*

a) Appearance:

Physical state: Solid powder (nanomaterial)

Colour: Black gray

Granulometry:

- i) Average particle size (Transmission Electron Microscope image analysis): 6.26 ± 0.05 nm (SD=1.47).
- ii) Aggregation / agglomeration (Nanoparticle Tracking Analysis): dispersion in water: average particle size 83 nm (SD 37), D10 45 nm, D50 76 nm, D90 127 nm.
- iii) Aggregation / agglomeration (Dynamic Light Scattering): dispersion in water: average particle size 123.5 nm, polydispersity: 0.15
- iv) Shape Transmission Electron Microscope image analysis: semi-spherical nanoparticles.

b) Odour: Odourless

c) Odour threshold: NA

d) pH: NA

e) Melting point: 948°C.

Remark: Melting point of classical form of silver is 961°C. In case of nanoforms, melting point can be lower, depending on particle size and morphology.

f) Initial boiling point and boiling range: 2210°C

g) Flash point: NA

h) Evaporation rate: NA

i) Flammability (solid, gas): Non-combustible solid, but potentially flammable in dust or powder⁶.

j) Upper/lower flammability or explosive limits: NIF

k) Vapour pressure: NA (solid)

l) Vapour density: NA (solid)

m) Relative density: (at 20 degrees C) 10.491 g/cm³.

n) Solubility: In water nano-Ag metal is oxidized and release ions Ag⁺. Solubility is dependent on the media conditions and chemistry (pH, organic matter, protein, etc.):



- In DI water: 20% after 24h, 50% after 120 days (initial concentration 4 mg/L Ag).⁷
- In natural water: 10% after 48h, 60% after 90 days.⁸
- o) Partition coefficient: n-octanol/water: NA
- p) Auto ignition temperature: NA
- q) Decomposition temperature: NA
- r) Viscosity: NA
- s) Explosive properties: Product does not present an explosion hazard. Explosive compounds may form when silver mixes with acetylene, ammonia, or hydrogen peroxide.
- t) Oxidising properties: NA (reducing agent).

9.2 Other Information:

u) Dustiness⁹

Ag nanopowder with SSA 20m²/g

Venturi dustiness nanoscale test at 50% relative humidity⁹

Total dustiness: D_{tot} = 1.7% (SD=0.3)

Respirable dustiness: D_{resp} 0.4% (SD=0.2)

v) Surface charge: Zeta potential in water (- 33 mV)

10. Stability and reactivity

10.1 Reactivity: NA.

10.2 Chemical stability: Decomposition will not occur if used and stored according to specifications.

10.3 Possibility of hazardous reactions: Silver may react with acetylene to form shock sensitive compounds. Shock-sensitive compounds are formed with acetylene or ammonia. Reacts with acids causing fire hazard. Contact with strong hydrogen peroxide solution cause violent decomposition to oxygen gas. Contact with ammonia may cause formation of compounds that are explosive when dry.

10.4 Conditions to avoid:

Avoid wet atmosphere.

Avoid dust generation and incompatibles.



10.5 Incompatible materials: Acids, Bases. I.e. Acetylene, ammonia, strong hydrogen peroxide solutions, strong acids, oxalic acid, tartaric acid, bromoazide, chlorine trifluoride, and ethyleneimine.

10.6 Hazardous decomposition products: Metal oxide fume.

Toxicological information

11.1 Information on toxicological effects

Acute toxicity

*Cytotoxicity*¹⁰

Method: In vitro - human C3A hepatocyte cell line. The supernatants were analysed to assess lactate dehydrogenase (LDH) release from cells (as described in¹¹).

Species: C3A human hepatocyte cell line cultured in M2279 liquid medium supplemented with additives.

Routes of exposure: nanoparticles of 35 nm added to liquid medium.

Effective Dose: LC50 = 50 µg/ml (31.25 µg/cm²)

Exposure time: 24 h

Results: Ag nanoparticles located within the cells.

Current in vitro studies have shown that Ag NPs have potential to induce cytotoxicity in cells derived from a variety of organs, with concentrations variable from 10 µg/mL, also depending on cell lines¹². Sub-cytotoxic concentrations can generate genotoxic effects, especially for uncoated particles.⁸

In vitro and in vivo inhalation studies:

In vivo inhalation exposure of rats and mice for 28¹³ and 14 days¹⁴ did not cause appreciable toxic effects up to an exposure of 1.9E7 particles/m³.

In vivo oral ingestion studies :

Oral lethal dose (LD) :

Guinea pig¹⁵: LD >5 gm/kg.

Mouse¹⁵: LD¹⁵ >10 gm/kg

Mouse¹⁶: LD50 = 100 mg/kg

Rats¹⁷ LD50 > 5000 mg/kg.

Chronic toxicity



Absorption of silver compounds by ingestion, inhalation or through broken skin can cause argyria, a permanent bluish-grey discoloration of the skin, conjunctiva and mucous membranes. Exposure limits based on the value above which development of argyria can be expected was found to be the intake of 0.9 g of silver over the whole lifetime¹⁸.

In vivo oral ingestion studies :

Human study of oral ingestion of 0.6 mg/day for four months of the 10 nm long nanosilver particles did not indicated negative effect on the seven human patients¹⁹.

Rats

It was established that for nano-Ag oral NOAEL was 30 mg/kg/day and for bulk Ag NOEL reached 63.5 mg/kg/day²⁰.

Oral exposure of rats to 222 mg silver/kg/day in drinking water for 37 weeks resulted in growth depression and shortened lifespan. Also observed were granular silver deposits in the eyes²¹. Enlargement of the left ventricle of the heart was observed in rats receiving drinking water containing 635-660 mg silver/day for life. Histological examination showed slight thickening of the basement membranes of kidney glomeruli in the absence of severe renal lesions. Deposition of silver granules was observed in the skin, eyes, and several internal organs²¹.

Skin corrosion/irritation: Powder: irritant effect

Serious eye damage/irritation: Powder: irritant effect

Respiratory or skin sensitisation: No sensitizing effects known.

Germ cell mutagenicity: NIF

Carcinogenicity: Tumorigenic effects have been observed on tests with laboratory animals (examples in Table below).

Reproductive toxicity: Information on the developmental and reproductive toxicity in humans following inhalation exposure to silver was unavailable. There was no decrease of fertility in male rats exposed for life to drinking water containing 635-660 mg silver/day as either silver nitrate or silver chloride²¹.

Summary of evaluation of the CMR properties:

Silver tumorigenic data¹⁵

Route/ Organism	Dose	Effect
Implant/ mouse	lowest published toxic dose: 11 gm/kg	Equivocal tumorigenic agent by RTECS criteria. Tumorigenic: Tumors at site of application.
Implant/	lowest published toxic dose:	Equivocal tumorigenic agent by RTECS criteria.

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rat	2,400 mg/kg	Tumorigenic: Tumors at site of application
Multiple/ rat	lowest published toxic dose: 330 mg/kg/43 week- intermittent	Equivocal tumorigenic agent by RTECS criteria. Tumorigenic: Tumors at site of application.

STOT-single exposure: NIF

STOT-repeated exposure: NIF

Aspiration hazard: NIF

Additional toxicological information: To the best of our knowledge the acute and chronic toxicity of this substance is not fully known.

Oxidative stress was measured with GSH/GSSG ratio and Lipid peroxidation. GSH oxidation was observed from 25 µg/mL both after 6h and 24h exposure, but no Lipid peroxidation was observed. Gene expression showed oxidative stress, inflammatory response, and DNA damage in A549 cells from 25 µg/mL after 48h, while some signs of stress started to be seen already at 10 µg/mL.



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12. Ecological information:

12.1 Toxicity

Do not allow material to be released to the environment without proper governmental permits.

Acute (short term) toxicity:

Fish¹⁰:

Method: In vitro.

Species: *Trout hepatocytes*

Routes of exposure: Primary trout hepatocytes were cultured in Sigma Medium 199 supplemented with additives. Nanoparticles of 35 nm added to liquid medium.

Effective Dose: LC50: 1000 µg/ml (625 µg/cm²)

Exposure time: 24 h

Results: Ag nanoparticles located within the cells.

Different studies shows a lethal concentration (96h LC50) of 90 µg/L nano Ag (10 nm size) for *Pimephales promelas*²², and of 1.4µg/L in *Japanese medaka*²³, while effects on development of early life stages of different species ranging from 0.5¹³ µg/L in Japanese medaka and 180 µg/L²⁴ Ag (96h EC50) for *Danio rerio*. The studies used different Ag NPs (coated/uncoated, different size).

Crustacea³

Method: OECD guideline number 202 (acute immobilization test), M4 media

Species: *Daphnia magna*

Routes of exposure: nanoparticles with different diameter (see Table below) were dispersed in distilled deionized water (400 mg/L).

Effective Dose: Average Effective-concentration values (EC) see in table below.

Exposure time: 48 h

Results: all examined nanoparticles were toxic to *Daphnia magna*. Presented toxicity was related to the chemical characteristics and agglomeration of the nanoparticles. Unlike the control groups that exhibited normal swimming, the *Daphnia* exposed to each type of nanosilver showed at least one type of abnormality (erratic swimming, migration to the bottom of the beaker or the water surface). The lowest concentrations caused 100% mortality (LC), the median effective concentrations (EC50) and the highest concentrations that did not cause any mortality (NLEC) of *Daphnia* after 48 hours are presented in Table below. The mortality in the control groups was less than 5% for all the tests.

Average Effective-concentration values (EC), of different nanoparticles for <i>Daphnia magna</i> neonates during 48 h ³
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Sample	EC [mg/L]	LC	EC50	NLEC
nAg1. Maximum particle diameter of 16 nm; 36% between 7 and 9 nm . CMD (count median diameter) 7.32 nm. No agglomeration was observed.		0.006	0.004	0.002
nAg2. Maximum particle diameter of 129 nm; 65% between 1 and 13 nm. CMD = 6.47 nm. No agglomeration was observed.		0.003 25	0.002	0.001
nAg3. Maximum diameter of 161 nm: 86% between 1 and 45 nm. CMD = 17.97 nm. Strong agglomeration was observed. About 70% of the aggregates had diameters from 25 to 100 nm, while most of the others had diameters from 100 to 250 nm.		0.275	0.187	0.1

Another acute studies on daphnia species showed that 48h LC50 concentrations ranged from 0.004 to 0.030 mg/L Ag, depending on particle size (smaller particles more toxic)¹². Exposure with Humic Acid (HA) to 0.050 mg/L Ag caused 90% mortality with 0 HA, while 10 mg/L HA decreased toxicity to 50%, and 20 mg/L HA decreased effect to ~ 15%²⁵.

Algae/aquatic plants

Ag NP caused decrease of photosynthetic efficiency of *R. subcapitata* at high concentration (i.e. ~21 mg/L, 4.5h EC50)¹⁴, while *Lemna minor* showed significant effect on growth already at 5 µg/L at 14d, with a EC50 at 14d ~ 20 µg/L²⁶.

Bacteria

Method: In vitro. LUMISTOX DIN EN ISO 11348-3

Species: marine bacteria *Vibrio fischeri*

Routes of exposure: water with 20,4% sucrose with 5/0,5/ 0,05/0,005 ppm of Ag nanoparticles

Effective Dose: ND

Exposure time: 30 min

Results: NOEL and NLEC at least 5ppm of Ag nanoparticles

The exposure of soil to sludge containing low concentration of silver NPs (0.14 mg Ag/kg soil) cause decrease of enzymatic activity (around 27% minimum) and biomass (35%) of bacteria²⁷.

Chronic (long term) toxicity

Fish: Only one study showed that 14d exposure to *Cyprionodon variegatus* at 2.9 µg/L in adults caused only proliferation of epithelial tissue in gills, decreasing significantly at day 35.²⁸

Algae/aquatic plants: NIF

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12.2 Persistence and degradability

Abiotic degradation: Ag NPs in wastewater²⁹ and in soil³⁰ tend to be transformed in AgS in presence of different levels of S.

Physical- and photo-chemical elimination: NA

Biodegradation: NA

12.3 Bioaccumulation potential

Partition coefficient n-octanol/water: NA

Bioconcentration factor (BCF): ND

12.4 Mobility in soil

Known or predicted distribution to environmental compartments: ND

Surface tension: NA

Adsorption/desorption: NA

12.5 Results of PBT and vPvB assessment: NA

12.6 Other adverse effects: NIF

12.7 Additional information:

Because of its colloidal properties, it is expected that nanosilver binds to complexing and sorbing agents present in soil, suspended matter of sediment.

13. Disposal considerations

13.1 Waste treatment methods

Within the present knowledge of the supplier, silver is not regarded as hazardous waste. However because it's hazardous to the aquatic environment, nanosilver waste can be classified as hazardous for aqueous environment: H 14 'Ecotoxic'³¹. Therefore this material and its container must be disposed of in a safe way. Empty containers or liners may retain some product residues. Avoid dispersal of split material and runoff and contact with soil, waterways, drains and sewers.

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13.1.1 Product/packaging disposal:

Product

The generation of waste should be avoided or minimised wherever possible. Disposal of this product, solutions and any by-products should at all times comply with the requirements of environmental protection and waste disposal legislation and any regional local authority requirements. Consult state, local or national regulations to ensure proper disposal.

Packaging

The generation of waste should be avoided or minimised wherever possible. Waste packaging should be recycled. Incineration or landfill should only be considered when recycling is not feasible. Consult state, local or national regulations to ensure proper disposal.

13.1.2 Waste treatment-relevant information: Consult state, local or national regulations to ensure proper disposal.

13.1.3 Sewage disposal-relevant information: The literature shows that nanosilver in model wastewaters treatment plants is almost entirely converted in Ag_2S^{19} . In addition, according to simulations, the highest concentration expected in effluents for more stable coated Ag is $< 0.24 \mu\text{g/L}^{32}$. Disposal via wastewater treated in a common wastewater treatment plant is preferred to disposal via landfill.

13.1.4 Other disposal recommendations: There are no specific informations about disposal of wastes containing nanosilver. However, it is suggested to avoid release of solid material into the environment.

14. Transport information

There are no specific recommendations. However, due to aquatic environment hazardous it is suggested:

Land transport ADR/RID (cross-border)

ADR/RID class: 9

Maritime transport IMDG

IMDG Class: 9

Air transport ICAO-TI and IATA-DGR

ICAO/IATA Class: 9

14.1 UN number: UN3077³³

14.2 UN proper shipping name: Environmentally hazardous substances, solid, n.o.s. (Silver nanopowder).



14.3 *Transport hazard class:* 9

14.4 *Packing group:* III

14.5 *Environmental hazards:* hazardous to the aquatic environment.

14.6 *Special precautions for user:* Do not let this chemical enter the environment.

14.7 *Transport in bulk according to Annex II of MARPOL 73/78 and the IBC Code:* NR

It is suggested to use a secondary seal, such tape seal, or a wire tie to prevent a removable closure from inadvertently opening during transport. The outer package should be filled with shock absorbing material that can protect the inner sample container from damage, absorb liquids that might leak from the inner container during normal events in transport, if applicable.

15. Regulatory information

15.1 *Safety, health and environmental regulations/legislation specific for the substance or mixture:*

EU Regulations:

(EC) No 1272/2008 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 2008 on classification, labelling and packaging of substances and mixtures, amending and repealing Directives 67/548/EEC and 1999/45/EC, and amending Regulation (EC) No 1907/2006 (Text with EEA relevance): Silver not listed.

Authorisations and/or restrictions on use: Not determined/listed

Authorisations: Not determined/listed

Restriction on use: For use only by technically qualified individuals.

15.1 *Chemical Safety Assessment:* Chemical Safety Assessment has not been carried out.

16. Other information

This information is based on our present knowledge. However, this shall not constitute a guarantee for any specific product features and shall not establish a legally valid contractual relationship.

Indication of changes: Non

Abbreviations and acronyms:

EC No: European Commission number

EINECS: European Inventory of Existing Commercial Chemical Substances

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REACH: Registration, Evaluation, Authorisation and Restriction of Chemicals

CAS No: Chemical Abstracts Service number

SU: Sector of Use category

PC Chemical Product category

PROC: Process category

TARIC CODE: Integrated Tariff of the European Communities

CLP regulation: Classification, Labelling and Packaging

STOT SE: Specific Target Organ Toxicity Single Exposure

STOT RE: Specific Target Organ Toxicity Repeated Exposure

HEPA: High Efficiency Particulate Air (filter)

NIOSH: National Institute for Occupational Safety and Health

OSHA: Occupational Safety and Health Administration

SD: Standard Deviation parameter

D10, D50, D90: particle diameter where that 10%, 50% and 60% of all particles are finer (smaller)

DI water: Deionized water

SSA: Specific Surface Area

NPs: Nanoparticles

CMR: Carcinogenic, Mutagenic or Toxic for Reproduction

RTECS: Registry of Toxic Effects of Chemical Substances

OECD: Organisation for Economic Co-operation and Development

ADR: Accord européen sur le transport des marchandises dangereuses par Route (European Agreement concerning the International Carriage of Dangerous Goods by Road)

RID: Règlement international concernant le transport des marchandises dangereuses par chemin de fer (Regulations Concerning the International Transport of Dangerous Goods by Rail)

IMDG: International Maritime Code for Dangerous Goods

IATA: International Air Transport Association

ICAO: International Civil Aviation Organization

GHS: Globally Harmonized System of Classification and Labelling of Chemicals

LD: Lethal dose

LD50: Lethal dose, 50 percent

LC50: Lethal concentration, 50 percent

EC50: Effective-concentration

NLEC: No Lethal Effective-concentration

NOAEL: No Observed Adverse Effect Level

NE= Not established

NA= Not applicable

NIF= No Information Found

ND= No Data

Relevant R-phrases and/or H-statements (number and full text):

H400 - Very toxic to aquatic life.

H410 - Very toxic to aquatic life with long lasting effects.

H319 - Causes serious eye irritation.

H335 - May cause respiratory irritation.



H315 - Causes skin irritation.

R50 - 53 Aquatic Acute 1, Aquatic Chronic 1

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