# Silver and its salts

| CAS number: | 7440-22-4 (silver, metal) |
| --- | --- |
| Synonyms: | — |
| Chemical formula: | Ag |

Workplace exposure standard (retained)

| TWA: | **0.1 mg/m3 (silver, metal)**  **0.01 mg/m3 (silver salts)** |
| --- | --- |
| STEL: | **—** |
| Peak limitation: | **—** |
| Notations: | **—** |
| IDLH: | **10 mg/m3 as Ag** |
| **Sampling and analysis**: The recommended value is quantifiable through available sampling and analysis techniques. | |

## Recommendation and basis for workplace exposure standard

A TWA of 0.1 mg/m3 for metallic silver and 0.01 mg/m3 for soluble silver salts is recommended to protect for permanent skin and mucous membrane discolouration in exposed workers.

## Discussion and conclusions

Silver is used in the production of alloys, jewellery, tableware, photographic, medical materials and electronics.

The critical effect of exposure is a permanent generalised or localised grey-blue discolouration of the skin, eyes and mucous membranes (argyria).

Workplace studies from different industries indicate a threshold for argyria above 0.1 mg/m3 as metallic silver and 0.04 mg/m3 as soluble silver salts (ACGIH, 2018; DFG, 1996; SCOEL, 1993). A review of human cases from ingestion or injection of colloidal silver suggests that chronic ingestion of a total of 1.4 to 3.8 g of silver over several months is required to elicit argyria.

The TWA of 0.1 mg/m3 for elemental silver and 0.01 mg/m3 for soluble silver salts are recommended to be retained. This recommendation is based on the weight of evidence of thresholds for the development of argyria from occupational exposure to airborne metallic and soluble silver and retention of 25 per cent dose in humans following inhalation. The TWA for both silver and its salts is the same as the occupational exposure limits derived by ACGIH (2018) and DFG (1996, 2002). The TWA derived by SCOEL (1993) is also the same as the retained SWA TWA.

## Recommendation for notations

Not classified as a carcinogen according to the Globally Harmonized System of Classification and Labelling of Chemicals (GHS).

Not classified as a skin sensitiser or respiratory sensitiser according to the GHS.

There are insufficient data to recommend a skin notation.

# Appendix

### Primary sources with reports

| Source Year set Standard |
| --- |
| SWA 1991 TWA: 0.1 mg/m3 (silver, metal); 0.01 mg/m3 (silver salts) |
|  |
| ACGIH 2001 TLV-TWA: 0.1 mg/m3 (silver, metal); 0.01 mg/m3 (silver salts) |
| Grouped assessment of elemental Ag and soluble Ag compounds. TLV-TWA intended to protect for permanent grey-blue skin and mucous membrane discolouration (argyria).  Summary of information:  TLV-TWA of 0.1 mg/m3 elemental Ag is based on lack of argyria from occupational exposures at 0.1 mg/m3 and 25% lung retention following inhalation. Exposure at this concentration is expected to result in maximum total ingestion of 1.5 g after 25 yr, which is lower than the amount required to produce generalised argyria. Ag salts are considered more toxic than elemental Ag; therefore, a TWA of 0.01 mg/m3 is expected to be protective of argyria from soluble salts (derivation for salts not discussed).  Human data:   * Upper respiratory tract irritation in reclamation workers at 0.039–0.378 mg/m3 (8 h/d, 1‑10 yr): * granular Ag deposits in conjunctiva and cornea, * no radiographic abnormalities in chest * 25% of inhaled dose accumulated in liver 2–6 d following exposure in volunteer study * Blood levels of 0.011 µg/mL in 80% of photographic workers exposed on average at 0.001–0.1 mg/m3 * No cases of argyria reported in polishers occupationally exposed at 0.1 mg/m3 * 12 cases of argyria reported in electronics workers exposed at 1–2 mg/m3 during varnish spraying * Review of occupational hygiene data from photographic industry associated occupational exposures to AgNO3 above 1 mg/m3 with development of generalised argyria and 0.1 mg/m3 with slight localised discolouration of mucous membranes * Argyria may occur after total ingestion of ~1.4–3.8 g over several months * Exposed polishers showed increased densities in lung radiographs * Overexposure to heated Ag vapour caused pulmonary oedema.   Animal data:   * LD50 (AgNO3): 50 mg/kg (mice); LDLO (Ag2O): 2,820 mg/kg (rats) * Reduced bw gain following dermal application of 2 mL dose (0.24 M) of AgNO3 (guinea pigs): * 1% of dose absorbed (no further details provided) * Ocular argyria, increased mortality and reduced bw at 222 mg/kg/d AgNO3 in repeat dose drinking water study (mice, 37 wk): * mortality began after 23 wk * Ventricular hypertrophy at 89 mg/kg/d AgNO3 in oral dose study (rats, 9 mo): * no effect on fertility or spermatogenesis * Accumulation in brain in drinking water study (mice, 4 mo, dose not specified) * Development of local fibrosarcomas at injection/implantation site using colloidal or metallic Ag in carcinogenicity studies (rats, dose and duration not specified): * study concludes relevance of these findings to humans is uncertain * Rate of systemic absorption from lungs: 1 µg/cm2/d (dogs), after 225 d, 77% of dose in liver * Binds DNA, but is non-mutagenic *in vitro* in bacteria; clastogenic in Chinese hamster ovarian cells: * no *in vivo* genotoxicity data presented.   Insufficient data to recommend a TLV-STEL or notations for carcinogenicity, skin absorption or sensitisation. |
| DFG 1996 MAK: 0.1 mg/m3 (silver, metal); 0.01 mg/m3 (silver salts) |
| Summary of additional information:  MAK of 0.1 mg/m3 for elemental Ag adopted from ACGIH (1980) TLV-TWA recommendation. MAK (1973) of 0.01 mg/m3 for Ag salts based on workplace studies that reported no incidences of argyria while operating under air concentrations below 0.01 mg/m3 for Ag salts, value is retained based on more recent occupational studies, which confirm this level of protection.  Human data:   * Argyria in 17/27 workers exposed at 0.04–0.35 mg/m3 to Ag compounds (median duration: 8.1 yr) * 29% incidence of ocular argyria in reclamation workers (n=27) exposed to Ag halide salts and Ag2O; average annual exposure estimated at 0.01–0.2 mg/m3:   + no changes in kidney or eye function compared to control group * No incidences of argyria in workers (n=50) exposed exclusively to metallic Ag dust at 0.003–0.54 mg/m3: * 8 workers exposed to silver salts (n=23) at 0.001–0.310 mg/m3 developed local argyria in eyes, skin and mucous membranes * No argyria in workers (n= 30–40, 20 yr) exposed on average at 0.01 mg/m3.   Animal data:   * Non-carcinogenic based chronic subcutaneous injection study with dose groups 1.75 and 2.45 mg per animal (rats, n=30, 1 time/wk, 10 mo): * 6/30 rats had local sarcomas, 1: leukaemia, 1: carcinoma on the jaw * survival was not reduced compared to controls during the last phase of 835 d.   Insufficient data to recommend notations for carcinogenicity, skin absorption or sensitisation. |
| SCOEL 1993 TWA: 0.1 mg/m3 (silver, metal) |
| Summary of additional information:  Weight of evidence of workplace studies (also cited in ACGIH, 2018 and DFG, 1996) indicate threshold for argyria of 0.2–0.5 mg/m3 as total Ag dust. An UF of 2–5 was applied to this threshold to account for the absence of extended analytical determinations to arrive to the recommended TWA of 0.1 mg/m3 as total Ag dust.  Available data does not warrant derivation of a STEL. |
| OARS/AIHA NA NA |
| No report. |
| HCOTN NA NA |
| No report. |

### Secondary source reports relied upon

| Source |  | Year | Additional information |
| --- | --- | --- | --- |
| NICNAS |  | 2018 | * Tier I: not assessed. |
| US EPA |  | 1991 | * Not classifiable as carcinogenic in humans based on inadequate experiments with animals * Available animal studies used implantation methods of solid silver, which resulted in local fibrosarcomas, but did not indicate substance-specific carcinogenicity (also cited in ACGIH, 2018). |
| US NIOSH |  | 1994 | * IDLH for Ag (metal dust and soluble compounds) based on acute oral toxicity data in humans and animals. |

### Carcinogenicity — non-threshold based genotoxic carcinogens

| Is the chemical mutagenic? | Insufficient data |
| --- | --- |
| Is the chemical carcinogenic with a mutagenic mechanism of action? | No |
| **The chemical is not a non-threshold based genotoxic carcinogen.** |  |

## Notations

| Source | Notations |
| --- | --- |
| SWA | — |
| HCIS | NA |
| NICNAS | — |
| EU Annex | NA |
| ECHA | NA |
| ACGIH | — |
| DFG | — |
| SCOEL | — |
| HCOTN | NA |
| IARC | NA |
| US NIOSH | NA |

NA = not applicable (a recommendation has not been made by this Agency); — = the Agency has assessed available data for this chemical but has not recommended any notations

### Skin notation assessment

| Calculation |
| --- |
| Insufficient data to assign a skin notation. |

### IDLH

| Is there a suitable IDLH value available? | Yes |
| --- | --- |

## Additional information

| Molecular weight: | 107.8682 |
| --- | --- |
| Conversion factors at 25°C and 101.3 kPa: | 1 ppm = Number mg/m3; 1 mg/m3 = Number ppm |
| This chemical is used as a pesticide: |  |
| This chemical is a biological product: |  |
| This chemical is a by-product of a process: |  |
| A biological exposure index has been recommended by these agencies: | ACGIH  DFG  SCOEL |

## Workplace exposure standard history

| Year | Standard |
| --- | --- |
| Click here to enter year |  |

## References

American Conference of Industrial Hygienists (ACGIH®) (2018) TLVs® and BEIs® with 7th Edition Documentation, CD-ROM, Single User Version. Copyright 2018. Reprinted with permission. See the [*TLVs® and BEIs® Guidelines section*](http://www.acgih.org/tlv-bei-guidelines/policies-procedures-presentations) on the ACGIH website.

Deutsche Forschungsgemeinschaft (DFG) (1973) Silber – MAK value documentation, German language edition.

Deutsche Forschungsgemeinschaft (DFG) (1996) Silber – MAK value documentation, German language edition.

Deutsche Forschungsgemeinschaft (DFG) (2002) Silber – MAK value documentation, German language edition.

EU Scientific Committee on Occupational Exposure Limits (SCOEL) (1993) Recommendation from the Scientific Committee on Occupational Exposure Limits for metallic silver. SCOEL/SUM/25B.

US National Institute for Occupational Safety and Health (NIOSH) (1994) Immediately dangerous to life or health concentrations – Silver (metal dust and soluble compounds, as Ag).

US Environmental Protection Authority (US EPA) (1991) Integrated Risk Information System (IRIS) Chemical Assessment Summary – Silver.