SULFURIC ACID

CAS number: 7664-93-9

Synonyms: Sulphuric acid, hydrogen sulfate, matting acid, oil of vitriol, vitriol brown oil

Chemical formula: H_2SO_4

Workplace exposure standard (amended)

TWA: **0.1 mg/m^3**

STEL: **—**

Peak limitation: **—**

Notations: **—**

IDLH: **15 mg/m^3**

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/m^3 is recommended to protect for adverse lung effects including in individuals with pre-existing respiratory disease and, the potential for laryngeal cancer in exposed workers.

Discussion and conclusions

Sulfuric acid is commonly manufactured and used in the manufacture of chemicals, detergents, dyes, explosives and fertilisers. It is the acid in lead acid batteries and used in metal cleaning and electroplating.

Critical effects of exposure are in the lungs. Sulfuric acid is corrosive and irritating and affects tracheobronchial clearance, inducing pulmonary function changes. It has the potential to cause laryngeal cancer and in individuals with pre-existing respiratory disease, decrements in pulmonary function..

Acute exposure to sulfuric acid aerosols can alter the tracheobronchial clearance mechanisms of inhaled particles via alterations in the phagocytic response. Short term, transient reduced lung clearance rates are observed in volunteers at 0.1 mg/m^3, with clearance rates slowed at 1 mg/m^3 (ACGIH, 2018; AIOH, 2015). Asthmatics constitute a sensitive subpopulation with the threshold concentration producing decrements in pulmonary function at 0.35 to 0.45 mg/m^3 in asthmatic adults (ACGIH, 2018). Exposure at 0.2 mg/m^3 can cause coughing or sneezing; while 0.5 mg/m^3 is reported to cause sneezing, irritated nose, cough, runny nose and dry nose (AIOH, 2015). Exposure *via* inhalation at 0.35 mg/m^3 caused changes in respiration rate in human subjects which is likely to be a reflex reaction to an irritant stimulus (ACGIH, 20018). An association with laryngeal cancer and workers exposed to strong inorganic acid mists containing sulfuric acid is reported in epidemiological studies. A threshold mechanism based on acidity is acknowledged. Regardless, no studies in humans were identified where occupational exposures is solely to sulfuric acid and data from carcinogenicity studies in experimental animals are inadequate (ACGIH, 2018; HCOTN 2003).

Slight histologic and functional changes are reported to occur in the lungs of non-human primates chronically exposed at 0.5 to 2.4 mg/m^3 (ACGIH, 2018). Dose-related changes and significant cell proliferation to laryngeal cells is observed in rats exposed at 0.5 and 1.0 mg/m^3; with effects at 0.2 mg/m^3 considered minimal (AIOH, 2015).

Given this information, protection for irritation effects and the potential for development of mucociliary clearance changes may likely protect for the reported adverse effects. Therefore, exposure maintained below 0.1 mg/m^3 will provide sufficient protection for changes in tracheobronchial clearance mechanisms, altered pulmonary function in non-asthmatics and asthmatics and for possible adverse consequences for the respiratory tract epithelium. A TWA of 0.1 mg/m^3 as recommended by AIOH (2015) and DFG (1999) is recommended. The data do not support a STEL as the TWA is considered sufficiently protective.

Recommendation for notations

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

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

There is insufficient data to recommend a skin notation.

APPENDIX

Primary sources with reports

Source	Year set	Standard
SWA	***1991***	***TWA: 1 mg/m³; STEL: 3 mg/m³***
Based on ACGIH 1991 TLV.		
ACGIH	***2004***	***TLV-TWA: 0.2 mg/m³***

TLV-TWA recommended to minimise central airway effects such as clearance and pulmonary function changes, potential for decrements in pulmonary function in individuals with pre-existing respiratory disease and, potential for laryngeal cancer associated with exposure to sulfuric acid aerosols.

Summary of data:

Evidence basis for the TWA:

- Highly irritating in terms of dermal exposure and rapidly injurious to eyes and mucous membranes of respiratory tract and can etch teeth
- Slight histologic and functional changes occurred in lungs of non-human primates chronically exposed at 0.5 -2.4 mg/m^3
- Acute exposure to aerosols can alter tracheobronchial clearance mechanisms of inhaled particles as demonstrated in clearance studies in animal and human subjects:
  - low concentrations tended to accelerate clearance; high concentrations tend to slow tracheobronchial clearance
  - mucociliary clearance is an important mechanism by which inhaled insoluble particles and microbes are removed from the conducting airways and daily exposure to low levels may produce alterations in bronchial mucociliary clearance transport
- In general, single exposure of resting or exercising healthy human subjects at ≤1 mg/m^3 found to produce no changes in pulmonary function
- Exposure to sub-micron particles can produce non-specific airway hyper-responsiveness, a central feature of asthma
- Strong evidence individuals with pre-existing respiratory disease, such as asthma, are more susceptible *via* inhalation than non-asthmatic individuals:
  - changes in pulmonary function occurred after acute aerosol exposure in a concentration range of 300-450 µg/m^3 in adult asthmatics
- Most effects of exposure to aerosols and potential for development of mucociliary clearance changes can be reduced and eliminated in many exposed persons if exposure is kept <0.25 mg/m^3
- Carcinogenicity evidence is contradictory and contains re-evaluations of original studies with varying conclusions:
  - no human studies where occupational exposures is solely to sulfuric acid
  - most exposures occur in the presence of other inorganic acids or metals such as nickel and chromium.

Human data:

- Study in humans exposed at 0.35-5 mg/m^3 via facemask; <1 mg/m^3 could not detect odour, taste or irritation that were detected at 3 mg/m^3.
- Inhalation study of the ability to alter clearance of insoluble particles from the lung, non-asthmatic and asthmatic volunteers exposed to aerosols and tracheobronchial clearance of radioactively-tagged Fe_2O_3 particles inhaled just prior to or after acid aerosol exposure examined:

Source	Year set	Standard

- transient acceleration of clearance occurred after 1 h exposure at 100 µg/m^3
- transient slowing of clearance occurred after 1 h exposure at 1,000 µg/m^3

- In contrast to study above, a different study found healthy, young, exercising adults, exposed at 1,000 µg/m^3 resulted in a speeding of the bronchial clearance mechanism; solubility of particles used may account for difference
- Exercising adult asthmatic volunteers exposed at 100 and 450 µg/m^3; reduction in FEV_1 and specific airway conductance in asthmatic subjects after exposure at 450 µg/m^3 but not at 100 µg/m^3
- Association of respiratory cancers with exposure to aerosols examined in many studies; quality of data questioned due to exposure discrepancies and difficulty in interpreting due to confounders
- Increased incidence of laryngeal cancer initially reported in 1,165 steel workers, with average exposure concentration of ~2 mg/m^3 in pickling operations; SMR dropped from 1.56 to 1.36 when controlled for smoking
- Nested case-control study of tumours associated with the URT on workers employed since 1950:
  - cohort consisted of 2,678 men with known exposure to sulfuric acid, 367 individuals with possible exposure and 1,356 unexposed
  - mortality rates compared with the national population using person-years method
  - among those known to be exposed, overall mortality <national population (SMR = 0.92)
  - mortality specifically from cancer of the larynx (SMR = 0.48) and lung (SMR 0.98) < national population
  - concluded risk of mortality from respiratory cancer to be low if exposure <1 mg/m^3.

Animal data:

- Series of reports on studies on chronically exposed monkeys:
  - authors found hyperplasia and hypertrophy of the bronchial epithelium at 0.4 mg/m^3
  - authors concluded exposure to acid mist at ~0.4 mg/m^3, regardless of particle size, capable of inducing slight but detectable deleterious effects on pulmonary structures or in pulmonary function in non-human primates
- Study examined pulmonary clearance in rabbits exposed for 1–4 h/d up to 14 d:
  - exposure at 0.05 mg/m^3 for 4 h/d resulted in significant reduction in pulmonary clearance half time, meaning acceleration of clearance
  - 0.1 mg/m^3 for 2 h/d also resulted in significant reduction in pulmonary clearance half time
- Study on rabbits chronically exposed to submicronic mist at 0 or 250 µg/m^3; bronchial responsiveness assessed at 4, 8 and 12 mo:
  - relative to controls, exposed rabbits showed decreased mucociliary clearance, decreased airways diameter, increased secretory cell count, and increased bronchial reactivity
  - airway hyper-responsiveness is a central feature of asthma, chronic exposure may be associated with obstructive airway disease
  - epidemiology studies said to have not addressed this in occupational settings.

Insufficient data to assign a skin or sensitiser notation or recommend a TLV-STEL.

Source	Year set	Standard
DFG	***1999***	***MAK: 0.1 mg/m³***

MAK based on alterations in mucociliary clearance in humans, considered the most sensitive end-point.

Summary of additional data

Evidence used as basis of MAK value.

- In humans, mucociliary clearance rate consistently reduced at ≥0.3 mg/m³; refers to studies cited by ACGIH
- Coughing reported during exposures with heavy exercise at 0.38 mg/m³ and throat irritation at 0.45 mg/m³
- Calculations demonstrate an expected significant reduction in the pH of the mucous after exposure at ≥ 0.3 mg/m³
- Not possible to make a statement as to the effects on humans of long-term exposure
- MAK set at 0.1 mg/m³.

SCOEL	***2007/2012***	***TWA: 0.05 mg/m³***

Summary of additional data:

Human data:

- Several acute studies indicate no adverse respiratory tract effects in lung function or bronchial reactivity testing on single exposure at ~0.5 mg/m³
- Repeated exposure data from humans are of limited value, mainly because of historical difficulties in measuring airborne concentrations
- Cites IARC (1992) "*There is sufficient evidence that occupational exposure to strong-inorganic-acid mists containing sulphuric acid is carcinogenic* " The presumed mechanism by which laryngeal cancer manifests in observed groups of workers is chronic inflammation of the epithelium in this region, caused by the acidity of aerosols.

Animal data:

- Groups of 15 female rats exposed nose-only for 6 h/d, 5 d/wk for up to 28 d at 0, 0.3, 1.38, and 5.52 mg/m³ (MMAD 0.62, 0.83, and 0.94 µm respectively):
  - histopathological examinations identified no lesions in the lungs or nasal passages, significant exposure-related changes found in the larynx
  - epithelial metaplasia in the larynx observed at all exposure levels
  - changes seen at 0.3 mg/m³ considered slight and regarded as an adaptive response; observations suggest there may be a risk of respiratory tract epithelial changes following longer-term repeated exposure at 0.3 mg/m³ which are of concern when viewed in the context of observations of laryngeal cancer
- Refers to inhalation study in rabbits as cited by ACGIH (2018) with exposure at 0.25 mg/m³ (250 µg/m³) and decreased mucociliary clearance, decreased airways diameter, increased secretory cell count and increased bronchial reactivity:
  - similar results obtained when rabbits exposed at 0.125 mg/m³ for 2 h/d for 1 yr; no further information
- No clear NOAEC from animal studies:
  - evidence of various respiratory tract effects in rats, rabbits and monkeys on repeated exposure to concentrations in the range 0.125-0.38 mg/m³.

TWA basis:

- Considering the data presented, coupled with concern for potential human carcinogenicity, concludes long-term exposure should be maintained below 0.1 mg/m³ to provide sufficient protection of possible adverse consequences for the respiratory tract epithelium

Source	Year set	Standard
		• Recommends an TWA limit of 0.05 mg/m^3 that will satisfy this condition • Recommends sampling the inhalable fraction.
OARS/AIHA	***NA***	***NA***
No report.		
HCOTN	***2003***	***Not assigned***
Review of the carcinogenic potential of strong inorganic acid mists containing sulfuric acid. Concludes it is known to be carcinogenic to humans and that these acid mists act as non-stochastic genotoxic carcinogens i.e. expected to exhibit a threshold. Summary of data: • The epidemiological data evaluated in the review showed an association between exposure to strong inorganic acid mists containing sulfuric acid and laryngeal cancer • Association with laryngeal cancer found in various industries and occupations in which workers may be exposed to strong inorganic acid mists containing sulfuric acid • Data from carcinogenicity studies in experimental animals are inadequate • No evidence for mutagenicity or genotoxicity involved in cancer mechanisms; most likely, a reduction of the pH is one of the biological mechanisms, by which strong inorganic acid mists containing sulfuric acid exerts its carcinogenic effect.		

Secondary source reports relied upon

Source		Year	Additional information
AIOH	✓	2015	• Recommends a TWA of 0.1 mg/m^3 (inhalable aerosol fraction); evidence provided as the basis includes that cited by primary sources, summarised as follows: o in humans, non-malignant respiratory effects exist at 1-3 mg/m^3 o short-term reduced lung clearance rates in volunteers observed at 0.1 mg/m^3 o threshold of perception for individuals unaccustomed to mist exposure is ~0.02-0.05 mg/m^3; 0.1 mg/m^3 is clearly perceptible; 0.2 mg/m^3 can cause coughing or sneezing • Exposure at ~0.5 mg/m^3 reported to cause sneezing, irritated nose, cough, runny nose and dry nose • Chronic effects (dose-related changes and significant cell proliferation to laryngeal cells) noted in rats exposed at 0.5 and 1.0 mg/m^3; effects at 0.2 mg/m^3 were minimal; 28 d inhalation study • STEL not warranted.
NICNAS	✓	2015	• Corrosive or irritating to the skin, eyes, gastrointestinal and respiratory tracts at concentrations >10%.
IARC	✓	1992	• Classified strong acid mists containing sulfuric acid as known to be carcinogenic to humans (Category 1).

Carcinogenicity — non-threshold based genotoxic carcinogens

Is the chemical mutagenic?	No

The chemical is not a non-threshold based genotoxic carcinogen.

Notations

Source	Notations
SWA	—
HCIS	—
NICNAS	—
EU Annex	NA
ECHA	—
ACGIH	Carcinogenicity – A2
DFG	Carcinogenicity – 4
SCOEL	—
HCOTN	Carcinogenicity – category 1A
IARC	Carcinogenicity – Group 1 (strong acid mist)
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

Insufficient data to assign a skin notation.

IDLH

Is there a suitable IDLH value available?	Yes

Additional information

Molecular weight:	98.07
Conversion factors at 25°C and 101.3 kPa:	1 ppm = 4.01 mg/m^3; 1 mg/m^3 = 0.25 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* on the ACGIH website.

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