Sulphuric acid

Toxicological overview

Key Points

Kinetics and metabolism

- A key toxicokinetic consideration of sulphuric acid inhalation is where is the respiratory tract the aerosols are deposited
- Once in the lung, sulphate from sulphuric acid is rapidly absorbed into the blood stream

Health effects of acute exposure

- The major routes of exposure are by ingestion, inhalation, dermal or ocular exposure
- Irritant and corrosive to all tissues with which it comes into contact
- Inhalation may cause burning or choking, sore throat, irritation of nose and eyes, cough and chest tightness. In severe cases pulmonary oedema may occur hours or days after exposure
- Ingestion can cause immediate burns to the mouth, throat, larynx, oesophagus and stomach, resulting in oedema, airway obstruction and difficulty in clearing bronchial secretions. Symptoms may include salivation, dysphagia, intense thirst, nausea, vomiting, haemorrhage, diarrhoea and abdominal pain. Shock, collapse, acute renal failure and death may arise
- Ocular or dermal exposure causes erythema, lacrimation, conjunctivitis, photophobia, or irritation, erythema or burns, respectively

Health effects of chronic exposure

- Chronic inhalation may lead to chemical pneumonitis, bronchitis, changes in lung function and dental decay
- Few data on the toxicity of sulphuric acid following chronic ingestion
- Limited mutagenicity data are available but it is predicted that it does not have mutagenic potential
- Inorganic acid mists containing sulphuric acid are carcinogenic to humans. Sulphuric acid or sulphuric acid solutions are not considered to be carcinogenic

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Toxicological Overview

Summary of Health Effects

Concentrated sulphuric acid is highly corrosive to all tissues with which it comes in contact.

Single, high exposures to sulphuric acid by inhalation, ingestion or dermal routes may be fatal.

There is sufficient evidence that occupational exposure to strong, inorganic–acid mists containing sulphuric acid is carcinogenic in humans [1]. Inhalation of sulphuric acid mists may cause an increase in upper respiratory tract neoplasms such as cancer of the larynx. This classification is for inorganic acid mists containing sulphuric acid only and does not apply to sulphuric acid or sulphuric acid solutions [2].

Severe lung damage (pulmonary oedema) may occur after a single short term exposure. Symptoms of which include coughing and shortness of breath and can be delayed until hours or days after the exposure. These symptoms are aggravated by physical exertion [3].

Sulphuric acid is considered not to be a developmental toxicant.

Its toxicity is due to effects at the site of initial contact, and systemic effects in mammals are not likely following exposure by any route [4].

Sulphuric acid is not considered as an allergen by skin contact in humans [5]. Occupational exposure to sulphuric acid may, however, result in dermatitis [3].

Kinetics and metabolism

Sulphuric acid is a direct irritant that results in adverse effects at the site of contact. The effects of sulphuric acid are a result of pH change rather than the liberation of sulphate ions [4].

The key toxicokinetic consideration following inhalation is where in the respiratory tract sulphuric acid aerosols deposit. Factors affecting this include environmental conditions, especially relative humidity (which affects aerosol size), and physiological factors such as breathing rate, depth of breathing, and type of breathing, e.g., mouth, nose, or oro-nasal. Once in the lung, the sulphate from sulphuric acid has been shown to be rapidly absorbed into the blood stream [4].

The sulphate anion becomes part of the pool of sulphate anions in the body, and is excreted in the urine. It is therefore unlikely to accumulate in the body [3].

Sources and route of human exposure

The main routes of exposure to sulphuric acid are via ingestion, inhalation, dermal or ocular exposure.

Domestically, exposure may occur from lead-acid batteries, preparations for unblocking drains or from entering areas of farmland treated with sulphuric acid before it has degraded.

Sulphuric acid in not persistent and is quickly neutralised in the environment. This means that the hazards associated with this chemical rapidly decrease from the time of application [4].

Health Effects of Acute / Single Exposure

Human Data

General toxicity

Sulphuric acid is corrosive to all tissues with which it comes in contact, and can cause systemic effects after severe exposures by inhalation, ingestion or topical application. The severity of injury depends on the concentration of the sulphuric acid solution and the duration of exposure [3].

Sulphuric acid produces superficial coagulation burns (which may be self-limiting) and destruction of surface epithelium and submucosa [6]. Sulphuric acid is a direct-acting toxicant and neurological effects other than subjective symptoms and reflex response to pain are not likely following exposure to sulphuric acid by any route [4].

Inhalation

The degree and severity of respiratory effects are influenced by factors such as the physical state and particle size of the aerosol, deposition site, concentration and humidity [4]. Asthmatics appear to be at particular risk from pulmonary effects [1]. Young children may also be at increased risk due to greater uptake on a mg/kg/body weight basis.

Sulphuric acid is not very volatile at 20°C [7] and so workplace exposures to harmful concentrations are primarily to mists or aerosols produced on spraying.

Sulphuric acid is corrosive and can cause severe irritation or corrosive damage if inhaled. Symptoms may include burning and choking sensations, sore throat [7], irritation of eyes and nose, cough, and chest tightness [6].

Dyspnoea and stridor due to laryngeal oedema may also follow exposure [6].

Severe lung damage may occur, with life-threatening accumulation of fluid (pulmonary oedema). The symptoms of pulmonary oedema include coughing and shortness of breath and can be delayed until hours or days after the exposure. These symptoms are aggravated by physical exertion [3].

Ingestion

Sulphuric acid is corrosive and will cause immediate burns on ingestion to the mouth, throat, oesophagus and the stomach (including antral ulceration and perforation). The larynx may also be burned causing oedema, airway obstruction and difficulty clearing bronchial secretions. In severe case extensive areas of the gastrointestinal tract may be involved [6].

Symptoms may include salivation, dysphagia (difficulty swallowing), intense thirst, nausea, vomiting, haemorrhage and haematemesis, diarrhoea and retro-sternal and abdominal pain [3, 6].

In addition, ingestion may result in metabolic acidosis, shock, collapse, hypotension, acute renal failure and disseminated intravascular coagulation (DIC) [6].

Small amounts of acid which may enter the lungs during ingestion or vomiting (aspiration) can cause serious lung injury and death [3].

Dermal / ocular exposure

Sulphuric acid and sulphuric acid mists are corrosive and can cause severe irritation with symptoms including erythema (redness) and pain. Other signs may be present, including corneal damage, blepharospasm, lacrimation, conjunctivitis, palpebral oedema and photophobia [6]. Severe deep burns to eyes may occur and cause permanent damage, including blindness [7].

Milder dermal exposures (generally to concentrations less than 10%) may occur without irritation [4]. Concentrated sulphuric acid can cause severe irritation and burns which may result in permanent scarring or, when extensive (>50%), death. In one case considered, a man was splashed over the face and body with a solution containing sulphuric acid, receiving second-degree burns over 60% of his body and third-degree burns over 20% of his body before dying 5 days later from the extensive burns and chemical damage to the respiratory tract [4].

High mist or aerosol concentrations may cause erythema, irritation and burns to the skin if contact is prolonged [3].

Delayed effects following an acute exposure

Pulmonary oedema with increasing breathlessness, wheeze, hypoxia and cyanosis may take up to 36h to develop [6]. This is aggravated by physical effort and so rest and medical observation are therefore essential [7].

In an industrial incident, a worker who experienced injury to the upper airways from sulphuric acid fumes was normal for most lung function tests at a 6-week follow-up [3]. In another industrial incident, a 40-year old worker who was accidentally sprayed in the face with sulphuric acid and had experienced acute respiratory symptoms had permanent pulmonary damage which was characterized by chronic cough, difficulty breathing, reduced respiratory performance, and bronchiectasis with fibrosis and emphysema developing within a 7-18 month period [4].

Health Effects of Chronic / Repeated Exposure

Human Data

General toxicity

Sulphuric acid is a direct irritant that results in adverse effects at the site of contact.

Sulphuric acid can be corrosive to all tissues with which it comes in contact, and can cause systemic effects after inhalation, ingestion or topical exposures. The severity of injury depends on the concentration of the sulphuric acid and the duration of exposure [3].

Inhalation

Inhalation of sulphuric acid mist will cause severe irritation of the lungs (chemical pneumonitis) and in severe cases may cause pulmonary oedema. Repeated exposure to lower concentrations of the mist may lead to damage to the lining of the throat in the region of the larynx [6].

The degree and severity of respiratory effects are influenced by factors such as the physical state and particle size of the aerosol, deposition site, concentration and humidity [4]. Asthmatics may be at particular risk from pulmonary effects [1, 4]. In addition, infants and young children may be at risk due to their increased exposure and uptake on a mg/kg/body weight basis.

Bronchitis and changes in lung function have been noted after long term exposure to sulphuric acid mists [4]. In one study of workers, a slight increase in bronchitis was noted after exposure to sulphuric acid aerosols at an average concentration of 1.4 mg m^{-3} for up to 40 years. There were no effects on lung function noted [4]. In another study of workers exposed for an average of 12.2 years, a small decrease in forced vital capacity (FVC) was observed in workers exposed to an average sulphuric acid aerosol concentration of 0.21 mg m^{-3} compared to workers exposed to an average concentration of 0.1 mg m^{-3}. No other significant changes in lung function tests were noted [4].

Sulphuric acid mists can attack tooth enamel leading to an increased risk of dental caries [7]. Exposures to high concentrations (up to 16 mg m^{-3}) cause dental erosion. Etching of teeth may occur after a few weeks exposure, progressing to erosion after a few months exposure [3].

Ingestion

There is little human data on the effects of chronic or repeated oral ingestion of sulphuric acid in humans.

Dermal / ocular exposure

High mist or aerosol concentrations may cause erythema, irritation and burns to the skin if contact is prolonged [3]. Repeated exposure to low concentrations of mists or aerosols can cause dermatitis [3]. Sulphuric acid is not considered as an allergen by skin contact in humans [5]. There is insufficient data on the effects in humans after chronic ocular exposure.

Genotoxicity

Only limited data are available to assess the mutagenicity of sulphuric acid.

Negative results were obtained in assays for gene mutation in bacteria using Salmonella typhimurium and Escherichia coli, both in the presence and absence of an exogenous metabolic activation system [5].

Positive results were reported in assays in mammalian cells to investigate clastogenicity. These were believed to be as a consequence of low pH, rather than any inherent mutagenicity. It is well established that such conditions may give artefactual positive results [6].

There were no experimental *in-vivo* data available. However, sulphuric acid will dissociate into hydrogen ions and sulphate ions which can be predicted to be without mutagenic potential.

Carcinogenicity

There is sufficient evidence that occupational exposure to strong-inorganic–acid mists containing sulphuric acid is carcinogenic [1]. Inhalation of sulphuric acid mists may cause an increase in upper respiratory tract cancers such as cancer of the larynx, resulting from chronic irritant effects on this tissue.

The IARC classification as a known human carcinogen is for inorganic acid mists containing sulphuric acid only and does not apply to sulphuric acid or sulphuric acid solutions [2].

Environmental concentrations of sulphuric acid are generally much lower than those found in occupational settings and are unlikely to result in respiratory tract cancers [4].

Reproductive and developmental toxicity

There are limited environmental data on the reproductive toxicity of sulphuric acid. In one study, no effects on the developing foetus were seen in rabbits or mice exposed by inhalation of sulphuric acid aerosols during gestation [4].

It is a point-of-contact toxicant, and it is unlikely that sulphuric acid would reach germ cells, cross the placenta, or be excreted into breast milk after exposure by any route (e.g., inhalation, oral, dermal, or ocular). On contact with tissues sulphuric acid dissociates into hydrogen and sulphate ions. Hydrogen ions are responsible for the toxic effects to tissue, which occur only at the point of contact with sulphuric acid [4].

Sulphuric acid is considered not to be a developmental toxicant.

References

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This document will be reviewed not later than 3 years or sooner if substantive evidence becomes available.