



# Sulphuric Acid

## Toxicological Overview

### Key Points

#### Kinetics and metabolism

- a key toxicokinetic consideration of sulphuric acid inhalation is where in the respiratory tract the aerosols are deposited

#### Health effects of acute exposure

- inhalation may cause irritation of the respiratory tract and eyes, lacrimation, rhinorrhoea, cough and chest tightness
- severe lung damage may follow acute exposure
- ingestion can cause 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, vomiting, haemorrhage, haematemesis, diarrhoea and abdominal pain
- ocular exposure may cause blepharospasm, lacrimation, conjunctivitis, photophobia, glaucoma or corneal damage; dermal exposure may cause irritation or burns

#### Health effects of chronic exposure

- chronic inhalation may lead to chemical pneumonitis, bronchitis, changes in lung function and dental decay
- inorganic acid mists which may contain sulphuric acid are carcinogenic to humans

## 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.

Inhalation of strong inorganic acid mists which may include sulphuric acid causes cancer of the larynx; evidence suggests exposure is also associated with lung cancer in humans.

Inhalation may cause irritation of the respiratory tract and eyes, lacrimation, rhinorrhoea, cough and chest tightness. Severe lung damage which may include chemical pneumonia, congestion, fibrosis, bronchiectasis and inflammation can occur after a single short-term 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, vomiting, haemorrhage, haematemesis, diarrhoea and abdominal pain. Circulatory collapse, metabolic acidosis, hypoxia, respiratory failure, acute renal failure, haemolysis and disseminated intravascular coagulation, and death may arise.

Ocular exposure may cause pain, blepharospasm, lacrimation, conjunctivitis, photophobia, palpebral oedema, glaucoma, cataracts and corneal damage. Exposure to concentrated sulphuric acid may result in chemical burns which are destructive. Dermal exposure may cause irritation, erythema or burns; extensive chemical burns following sulphuric acid exposure may be fatal.

Sulphuric acids toxicity is largely due to effects at the site of initial contact, though systemic effects may be observed and include circulatory collapse, metabolic acidosis, hypoxia, respiratory failure, acute renal failure, haemolysis and disseminated intravascular coagulation.

Sulphuric acid is not considered to be a developmental toxicant.

Sulphuric acid is not considered as an allergen by skin contact in humans.

## 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 [1].

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, eg mouth, nose or oro-nasal. Once in the lung, the sulphate from sulphuric acid has been shown to be rapidly absorbed into the bloodstream [1].

Following ingestion, sulphuric acid will be diluted and buffered by the contents of the gastrointestinal (GI) tract [2]. Sulphuric acid is not absorbed by the GI tract; however, it will disassociate and the released sulphite anions will be absorbed and enter the body's electrolyte pool [2]. There is no data on dermal absorption of sulphuric acid aerosol or liquid [3].

## Sources and Route of Human Exposure

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

Sulphuric acid is used in the production of phosphate fertiliser, phosphoric acid and batteries; it is also used in chemical synthesis [4]. It is used in metal extraction, refinement and processing (notably including cleaning), and has direct uses in other industries (including paper and pulp) [4]. Sulphuric acid is a liquid at room temperature; however, due to industrial processes involving the acid it may form mists on condensation of vapours or atomisation of the liquid [5]. Sulphuric acid may form mists in conjunction with other strong inorganic acids [6]. Workers may be exposed to these mists through inhalation, dermal and oral routes [6]. A workplace exposure limit (WEL) for sulphuric acid mists has been set in the UK, to protect workers from their harmful effects. The long-term WEL (8-hour time weighted average reference period) for sulphuric acid mists is 0.05 mg/m<sup>3</sup> [7].

The general public could be exposed to sulphuric acid in lead-acid batteries or in the use of cleaning products (such as acidic drain unblockers) [1].

Sulphuric acid is not persistent and is quickly neutralised in the environment. On contact with soil or water it is expected to dissociate into sulphate and become part of the natural sulphur cycle [8]. Therefore, hazards associated with this chemical reduce rapidly from the time of application [1].

## Health Effects of Acute/Single Exposure

### Human data

#### General toxicity

The toxicity of sulphuric acid is defined by its ability to increase local H<sup>+</sup> ion concentration and relatively small amounts of sulphuric acid are required to achieve this [2].

#### Inhalation

Sulphuric acid is corrosive and can cause severe irritation or corrosive damage if inhaled. Symptoms may include local eye and respiratory tract irritation, intense coughing, lacrimation, rhinorrhoea and chest tightness [1, 3]. Severe lung damage, such as chemical pneumonia, fibrosis, bronchiectasis, congestion and inflammation, has been reported following inhalation of sulphuric acid mists [1]. Blackening of the teeth has also been reported [3].

A worker developed acute respiratory distress syndrome (ARDS) after industrial exposure to sulphuric acid fumes, he later developed a lung abscess [9]. Following treatment, lung functions test were normal at 6-weeks post-exposure [9].

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 [1]. Asthmatics appear to be at particular risk from pulmonary effects [10].

#### Ingestion

Sulphuric acid is corrosive and irritating to the upper GI tract on oral exposure [2]. Ingestion of corrosives can cause immediate burns to the mouth, throat, oesophagus and the stomach. Ulceration of the stomach may be sufficient to cause perforation. The larynx may also be burned causing oedema, airway obstruction and difficulty clearing bronchial secretions. In severe cases extensive areas of the GI tract may be involved [11].

Symptoms following ingestion of corrosive substances may include salivation, dysphagia, vomiting, haemorrhage and haematemesis, and abdominal pain [11]. Systemic effects, including circulatory collapse, metabolic acidosis, hypoxia, respiratory failure, acute renal failure, haemolysis and disseminated intravascular coagulation, may arise [11].

Aspiration following the ingestion of corrosive materials may lead to stridor and respiratory complications [11].

#### Dermal/ocular exposure

Concentrated sulphuric acid is corrosive and irritating to the skin [2]. Corrosives can produce superficial coagulation burns (which may be self-limiting) and destroy surface epithelium and submucosa [11]. Large or prolonged dermal exposures to corrosive substances may result in systemic effects [11]. When extensive (body coverage >50%), chemical burns from sulphuric acid may be fatal [1].

In one case, a man splashed over the face and body with a solution containing sulphuric acid developed second-degree burns over 60% of his body and third-degree burns over 20% of his body. He died 5 days later from the extensive burns and chemical damage to the respiratory tract [1]. There is no evidence that sulphuric acid can cause systemic effects by entering undamaged skin [3].

When diluted, sulphuric acid may not be irritant or corrosive to the skin [2]. The threshold for irritation appears to be 2.5%; however, 10% has been tolerated without irritation [2].

Concentrated sulphuric acid is also corrosive and irritating to the eyes [2]. Ocular exposure to corrosives may result in pain, blepharospasm, lacrimation, conjunctivitis, palpebral oedema, photophobia, glaucoma, cataracts and corneal damage [1, 11]. Eye damage has been reported as a result of contact with sulphuric acid from car batteries [1]. No effects on the eyes were reported for healthy volunteers exposed to sulphuric acid at 1.58 mg/m<sup>3</sup> as respirable aerosol for 1 hour, while minor eye irritation was reported in asthmatics exposed to 1.0 mg/m<sup>3</sup> for the same duration [2].

#### Delayed effects following an acute exposure

Pulmonary oedema with increasing breathlessness, wheeze, hypoxia and cyanosis may take up to 36 hours to develop [11].

In an 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 characterised by chronic cough, difficulty in breathing, reduced respiratory performance and bronchiectasis with fibrosis and emphysema developing within a 7–18-month period [1].

## Health Effects of Chronic/Repeated Exposure

### Human, animal and in-vitro data

#### 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 industrial bronchitis [11].

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 [1]. Asthmatics may be at particular risk from pulmonary effects [1, 10].

Bronchitis and changes in lung function have been noted after long-term exposure to sulphuric acid mists [1]. 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<sup>3</sup> for up to 40 years. There were no effects on lung function noted [1]. 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<sup>3</sup> compared to workers exposed to an average concentration of 0.1 mg/m<sup>3</sup>. No other significant changes in lung function tests were noted [1].

Chronic occupational exposure to sulphuric acid mists has been shown to cause dental erosion [12]. An average of 5 years' occupational exposure to sulphuric acid is associated with etching of the teeth; however, etching has been observed following 3–4 months' exposure [1].

#### Ingestion

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

#### Dermal/ocular exposure

Repeated contact with dilute sulphuric acid can cause skin desiccation, ulceration and chronic purulent inflammation around the nails. Sulphuric acid is not considered to be a skin allergen in humans [4].

There is insufficient data on the effects in humans after chronic ocular exposure.

#### Genotoxicity

Only limited data is 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 [4]. Positive results were given in a Chinese hamster ovary

chromosomal aberrations assay; however, this was shown to be due to the effects of low pH [2].

The International Agency for Research on Cancer (IARC) has evaluated the potential for mists from strong inorganic acids to cause cancer [6]. IARC concluded that while it is plausible that inhalation of these mists may cause localised low pH and as a result DNA damage and increased cancer risk, the evidence supporting DNA damage induction or any other mechanism as the cause of observed cancers is weak [6].

There is no experimental in-vivo data available.

### Carcinogenicity

In a 2012 evaluation IARC classified strong inorganic acid mists as carcinogenic to humans (group 1) [6]. It should be noted that this classification concerns mists of strong inorganic acids that may include sulphuric acid but are not limited to sulphuric acid [6]. The evaluation states that strong inorganic acid mist exposure causes cancer of the larynx and that there are positive associations between exposure and lung cancer [6].

Environmental concentrations of sulphuric acid are generally much lower than those found in occupational settings and are unlikely to result in respiratory tract cancer [1].

### Reproductive and developmental toxicity

There is limited environmental data on the reproductive toxicity of sulphuric acid. In one study, no effects on the developing fetus were seen in rabbits or mice exposed by inhalation of sulphuric acid aerosols during gestation [1].

As a point-of-contact toxicant it is unlikely that sulphuric acid would reach germ cells, cross the placenta or be excreted into breast milk after exposure by any route. 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 [1].

Sulphuric acid is not considered to be a developmental toxicant.

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