Sulfuric acid, mercury(2+) salt (1:1): Human health tier II assessment

03 July 2015

CAS Number: 7783-35-9

Preface

This assessment was carried out by staff of the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) using the Inventory Multi-tiered Assessment and Prioritisation (IMAP) framework.

The IMAP framework addresses the human health and environmental impacts of previously unassessed industrial chemicals listed on the Australian Inventory of Chemical Substances (the Inventory).

The framework was developed with significant input from stakeholders and provides a more rapid, flexible and transparent approach for the assessment of chemicals listed on the Inventory.

Stage One of the implementation of this framework, which lasted four years from 1 July 2012, examined 3000 chemicals meeting characteristics identified by stakeholders as needing priority assessment. This included chemicals for which NICNAS already held exposure information, chemicals identified as a concern or for which regulatory action had been taken overseas, and chemicals detected in international studies analysing chemicals present in babies' umbilical cord blood.

Stage Two of IMAP began in July 2016. We are continuing to assess chemicals on the Inventory, including chemicals identified as a concern for which action has been taken overseas and chemicals that can be rapidly identified and assessed by using Stage One information. We are also continuing to publish information for chemicals on the Inventory that pose a low risk to human health or the environment or both. This work provides efficiencies and enables us to identify higher risk chemicals requiring assessment.

The IMAP framework is a science and risk-based model designed to align the assessment effort with the human health and environmental impacts of chemicals. It has three tiers of assessment, with the assessment effort increasing with each tier. The Tier I assessment is a high throughput approach using tabulated electronic data. The Tier II assessment is an evaluation of risk on a substance-by-substance or chemical category-by-category basis. Tier III assessments are conducted to address specific concerns that could not be resolved during the Tier II assessment.

These assessments are carried out by staff employed by the Australian Government Department of Health and the Australian Government Department of the Environment and Energy. The human health and environment risk assessments are conducted and published separately, using information available at the time, and may be undertaken at different tiers.

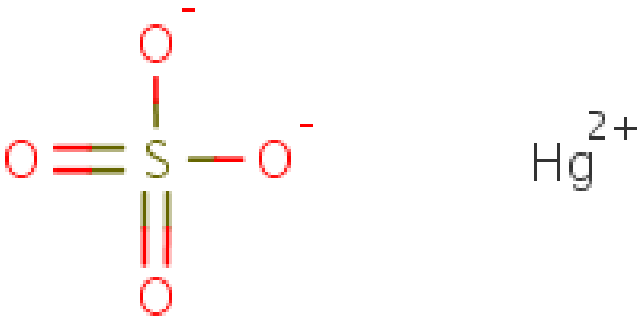
This chemical or group of chemicals are being assessed at Tier II because the Tier I assessment indicated that it needed further investigation.

For more detail on this program please visit:www.nicnas.gov.au

Disclaimer

Acronyms & Abbreviations

Chemical Identity

Synonyms	mercuric sulfate mercury (II) sulfate mercury disulfate
Structural Formula	
Molecular Formula	H2O4S.Hg
Molecular Weight (g/mol)	296.65
Appearance and Odour (where available)	White granules or crystalline powder; or colourless rhombic crystals; with no odour
SMILES	O=S1(=O)O{-}.[Hg]{2+}.O{-}1

Import, Manufacture and Use

Australian

Under a previous mandatory call for information by NICNAS (1999), the chemical was listed as imported and/or manufactured in Australia, with a total reported volume of <100 kg. The use was not reported.

International

The following international uses have been identified through Galleria Chemica; the Substances and Preparations in Nordic countries (SPIN) database; the United States (US) Environmental Protection Agency's (EPA) Aggregated Computer Toxicology Resource (ACToR); and the US National Library of Medicine's Hazardous Substances Data Bank (HSDB).

The chemical has reported commercial use as an electrolyte for primary (non-rechargeable) batteries.

The chemical has reported site-limited uses:

- as a catalyst; and

- in extracting gold and silver from roasted pyrites, when combined with sodium chloride.

The chemical has reported non-industrial uses as a:

- water treatment agent; and
- colouring agent for wine and barbital.

Restrictions

Australian

There is a general entry for mercury in Schedule 7 of the *Poisons Standard—the Standard for the Uniform Scheduling of Medicines and Poisons* (SUSMP).

'MERCURY **except**:

(a) when separately specified in this Schedule;

(b) when included in Schedule 2, 4 or 6;

(c) in preparations containing 0.01 per cent or less of mercury in organic form as a preservative;

(d) mercury (metallic) in scientific instruments;

(e) dental amalgams; or

(f) in a sealed device, for therapeutic use, which prevents access to the mercury' (SUSMP, 2015).

Schedule 7 chemicals are described as 'Substances with a high potential for causing harm at low exposure and which require special precautions during manufacture, handling or use. These poisons should be available only to specialised or authorised users who have the skills necessary to handle them safely. Special regulations restricting their availability, possession, storage or use may apply' (SUSMP, 2015).

International

The chemical is listed on the following (Galleria Chemica):

- United Nations Minamata Convention on mercury 'to protect human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds';
- Rotterdam Convention Annex III—Chemicals subject to the prior informed consent procedure (under the entry 'Mercury compounds, including inorganic mercury compounds, alkyl mercury compounds and alkyloxyalkyl and aryl mercury compounds');
- Council of Europe Resolution ResAP(2008)1 on requirements and criteria for the safety of tattoos and permanent make-up (PMU), Table 3—Maximum allowed concentrations of impurities in products for tattoos and PMU (limit of 0.2 ppm of mercury);
- Annex XVII to the REACH Regulations. Mercuric sulphate is covered by the entry for inorganic compounds of mercury—Mercury compounds 'Shall not be placed on the market, or used, as substances or in mixtures where the substance or mixture is intended for use:

  (a) to prevent the fouling by micro-organisms, plants or animals of

  - the hulls of boats,
  - cages, floats, nets and any other appliances or equipment used for fish or shellfish farming,
  - any totally or partly submerged appliances or equipment;

  (b) in the preservation of wood;

  (c) in the impregnation of heavy-duty industrial textiles and yarn intended for their manufacture;

  (d) in the treatment of industrial waters, irrespective of their use';
- Health Canada List of prohibited and restricted cosmetic ingredients (The Cosmetic Ingredient ‘Hotlist’);
- European Union (EU) Cosmetics Regulation 1223/2009 Annex II—List of substances prohibited in cosmetic products (under the entry 'Mercury and its compounds, except those special cases included in Annex V');

- Association of Southeast Asian Nations (ASEAN) Cosmetic Directive Annex II, Part 1: List of substances which must not form part of the composition of cosmetic products (under the entry 'Mercury and its compounds except those special cases included in Annex VI, Part 1');
- New Zealand Cosmetic Products Group Standard—Schedule 4: Components cosmetic products must not contain (under the entry 'Mercury and its compounds, except those special cases included in Schedule 7'); and
- Council of Europe Resolution AP (92) 2 on control of aids to polymerisation for plastic materials and articles—Limits for finished articles (limit of 0.005 mg/kg for mercury compounds (as Hg)).

Existing Work Health and Safety Controls

Hazard Classification

The chemical is not specifically listed on the Hazardous Substances Information System (HSIS) (Safe Work Australia). However, the chemical is covered under the following entry in the HSIS: Mercury, inorganic compounds with the exception of mercuric sulphide and those specified elsewhere in HSIS.

The following risk phrases for human health are applicable for the chemical:

- T+; R26/27/28 (acute toxicity)
- R33 (cumulative effects)

Exposure Standards

Australian

No specific exposure standards are available for the chemical.

The entry for 'Mercury, inorganic divalent compounds (as Hg)' applies to mercuric sulfate and has an exposure standard of 0.025 mg/m^3 (0.003 ppm) time-weighted average (TWA).

International

The following exposure standards are identified (Galleria Chemica).

Mercuric sulfate (mercury as inorganic compounds) has an:

- exposure limit of 0.02–0.05 mg/m^3 TWA in different countries such as Canada (Alberta, British Columbia, Quebec, Saskatchewan), Germany, Ireland, Japan, Malta, Mexico, Singapore, Spain, Sweden, the United Kingdom and the USA (California); and
- a short-term exposure limit (STEL) of 0.075 mg/m^3 in Canada (Saskatchewan).

Health Hazard Information

When data for the chemical being assessed are not available, health hazard information for mercuric chloride (CAS No. 7487-94-7) has been included in this report where appropriate. Similar to the chemical being assessed, mercuric chloride is an inorganic divalent mercury compound and therefore is considered to be a suitable analogue to assess the systemic effects of this chemical.

The IMAP reports on (elemental) mercury (NICNAS, 2015a) and (organic) phenylmercury compounds (NICNAS, 2015b) complement this report.

Toxicokinetics

Mercury is a naturally occurring element and can exist as elemental, inorganic or organic forms, commonly as salts. Mercuric sulfate is an inorganic mercury salt (ATSDR, 1999).

Oral absorption of inorganic mercury compounds is 2–38 %. The mechanism of absorption from the gastrointestinal tract might involve binding to biological molecules (e.g. proteins), or simple diffusion. Data on absorption through inhalation are lacking, although in dogs it has been estimated to be approximately 40 %. Direct dermal absorption of inorganic mercury compounds, or indirect dermal absorption of their vapour, is not expected to be high (ATSDR, 1999; WHO, 2003).

Following absorption, inorganic mercury compounds are distributed to most organs, but their low lipid solubility reduces their access to the brain or foetus, which requires crossing the blood–brain barrier or placental–foetal barrier, respectively. In mice administered radiolabelled mercury as mercuric chloride as a single oral dose at 0.2–20 mg/kg bw, the liver and kidneys had the highest accumulation 14 days after exposure; mercury accumulation in the brain was significantly lower, but mercury levels in the brain persisted for longer than in other organs (ATSDR, 1999; WHO, 2003).

Inorganic mercury compounds are rapidly converted to mercury (II) ions upon absorption, and can be metabolised further via oxidation-reduction cycling. Parenteral administration (by means other than through the digestive tract, e.g. injection) of mercuric chloride in rats and mice resulted in exhaled metallic mercury vapour; homogenates of liver and kidneys from animals also released mercury vapour (ATSDR, 1999; WHO, 2003).

Inorganic mercury compounds can be excreted via the urine and faeces; faeces is the main pathway following short-term exposure and the urine is the main pathway following long-term exposure. Excretion can also occur to a lesser extent via lung exhalation or secretion in saliva, sweat or breast milk. The half-life for elimination of inorganic mercury was reported to be approximately two days from the lungs, 2–28 days from blood, approximately 20 days from the brain and 1–2 months from the whole body (ATSDR, 1999; WHO, 2003).

Acute Toxicity

Oral

The chemical is covered under the HSIS listing for 'Mercury, inorganic compounds with the exception of mercuric sulphide and those specified elsewhere in HSIS' and classified as hazardous with the risk phrase ‘Very toxic if swallowed’ (T+; R28) (Safe Work Australia). The available data for mercuric sulfate support this classification.

The following oral median lethal dose (LD50) values were available (RTECS):

- 57 mg/kg bw in rats; and
- 25 mg/kg bw in mice.

Oral LD50 values of 25.9 to 77.7 mg mercury/kg bw were reported in rats exposed to mercuric chloride. 'Haematological, hepatic, and renal effects were reported in rats and/or mice administered sublethal single doses of mercuric chloride' (ATSDR, 1999; WHO, 2003).

In humans exposed to mercuric chloride, the lethal oral dose was estimated to be 10–42 mg mercury/kg bw based on nine deaths following oral ingestion (ATSDR, 1999) (see ***Observation in humans*** section).

Dermal

The chemical is covered under the HSIS listing for 'Mercury, inorganic compounds with the exception of mercuric sulphide and those specified elsewhere in HSIS' and classified as hazardous with the risk phrase ‘Very toxic in contact with skin’ (T+; R27) (Safe Work Australia). The available data for mercuric sulfate are not sufficient to recommend an amendment of this classification.

The dermal LD50 for mercuric sulfate was reported to be 625 mg/kg bw in rats (RTECS).

Inhalation

The chemical is covered under the HSIS listing for 'Mercury, inorganic compounds with the exception of mercuric sulphide and those specified elsewhere in HSIS' and classified as hazardous with the risk phrase ‘Very toxic by inhalation’ (T+; R26) (Safe Work Australia). No data are available to support or revise this classification.

Observation in humans

For a 70 kg adult, the lethal oral dose of mercuric chloride was estimated to be 10–42 mg mercury/kg bw. Nine deaths have been reported following oral ingestion of mercuric chloride at 29–50 mg mercury/kg bw. Death is caused primarily by shock, cardiovascular failure, acute kidney failure and gastrointestinal damage (ATSDR, 1999).

Neurotoxicity was also reported in a man who ingested a lethal dose (details not provided) of mercuric chloride. He had blurred vision and seizures prior to death, and brain abscesses were observed at autopsy. Poisoning by mercuric chloride can result in respiratory effects such as rales and pulmonary oedema; cardiovascular effects such as altered electrocardiogram; gastrointestinal effects such as ulceration (of the lips, tongue, pharynx, and gastrointestinal tract), abdominal pain, nausea, vomiting and diarrhoea; jaundice, enlarged liver and altered liver enzymes; and skeletal muscle breakdown (ATSDR, 1999).

Studies regarding dermal exposure to inorganic mercury compounds are limited. In a case study, a 27-year-old woman was reported to have died following insertion of an 8.75 g mercuric chloride tablet into her vagina. The cause of death was not reported, but she experienced vomiting and diarrhoea prior to death. Swelling, ulceration and necrosis of the gastrointestinal lining, as well as severe kidney damage, were observed at autopsy. In

children exposed to mercuric chloride after their nappies had been rinsed with a solution containing the chemical, increased heart rate and blood pressure, as well as skin inflammation and peeling were reported (ATSDR, 1999).

Corrosion / Irritation

Corrosivity

No data are available for the chemical.

Although mercuric chloride is classified as hazardous with the risk phrase 'Causes burns' (C; R34) in the HSIS (Safe Work Australia), no data are available to evaluate this classification. Therefore, this classification is not considered relevant for read across to mercuric sulfate.

Sensitisation

Skin Sensitisation

No data are available.

Repeated Dose Toxicity

Oral

Mercuric chloride is classified as hazardous with the risk phrase 'Toxic: Danger of serious damage to health by prolonged exposure if swallowed' (T; R48/25) in the HSIS (Safe Work Australia). However, inorganic mercury compounds are not classified for repeated dose oral toxicity. In the absence of any data for mercuric sulfate, but considering the similar structure and metabolism of mercuric chloride, this classification is also supported for mercuric sulfate (see **Recommendation** section).

An oral reference dose (RfD) of 0.3 µg/kg bw/day was reported for mercuric chloride based on autoimmune effects reported in rat studies and correction factors adopted to extrapolate the data to humans (US EPA IRIS). Three studies from the entire inorganic mercury database used to derive the oral RfD were provided as an example in the US EPA IRIS report. In other repeated dose studies, renal toxicity was the primary effect. Neurotoxicity has also been observed following chronic exposure to inorganic mercury compounds, and these effects might be related to cumulative toxicity of mercury in the brain (see **Other Health Effects: Neurotoxicity** section).

Male and female brown Norway rats (n = 6–20/group) were administered mercuric chloride at 0, 100, 250, 500, 1000 or 2000 µg/kg bw/day, three times per week for eight weeks. An extra group was administered 50 µg/kg bw/day mercuric chloride three times per week for 12 weeks. Immune responses were reported in all treated animals compared with controls, with changes in the antiserum profile observed in the kidneys of treated animals. Protein in the urine (proteinuria) was reported at doses ≥100 µg/kg bw/day, which caused reduced blood albumin levels in all animals treated at those doses and death in many affected animals. Nephrosis (kidney tubule damage) was reported in animals exposed to high doses (not specified) (US EPA IRIS).

In brown Norway rats (number and sex not specified) administered 0 or 3000 µg/kg bw/day mercuric chloride in the diet for up to 60 days, 4/5 rats fed mercuric chloride had an immune response in kidney glomeruli by day 15 and 5/5 rats had an immune response in kidney glomeruli by day 60. Mild proteinuria was reported in 3/5 rats fed mercuric chloride. There were no immune responses or altered urinary protein levels in control rats (US EPA IRIS).

Brown Norway rats (n = 1 for control and n = 5 for treated, sex not specified) and Lewis rats (n = 2 for treated, sex not specified) were administered mercuric chloride at 0 or 3 mg/kg bw/day by oral gavage, twice per week for up to 60 days. Two brown Norway rats treated with mercuric chloride died between study days 30 and 40. In the remaining brown Norway rats, there was an immune response in kidney glomeruli; morphological changes in the small intestine (ileum) and colon; and immunoglobulin (IgA and IgG) deposits in the gastrointestinal lining, compared with no changes observed in the one control brown Norway rat and treated Lewis rats (US EPA IRIS).

Fischer 344 (F344) rats (n = 10/sex/dose) were administered mercuric chloride by oral gavage at 0, 0.312, 0.625, 1.25, 2.5 or 5 mg/kg bw/day five days per week for 26–27 weeks. Kidney weights were significantly increased in rats that received mercuric chloride at doses ≥0.625 mg/kg bw/day. In treated males (dose/s not specified) granular kidneys (indicative of organ damage), and enlarged thyroids and parathyroids were reported. A significantly increased incidence of nephropathy was reported in exposed males at the 1.25 or 5 mg/kg bw/day dose and females at 5 mg/kg bw/day (NTP, 1993). A no observed adverse effect level (NOAEL) of 0.312 mg/kg bw/day can be derived from this study based on the kidney effects seen at 0.625 mg/kg bw/day.

The $B6C3F_1$ mice (n = 10/sex/dose) were administered mercuric chloride by oral gavage at 0, 1.25, 2.5, 5, 10 or 20 mg/kg bw/day, five days per week for 26–27 weeks. Increased incidence and severity of kidney tubule damage were reported in mice at ≥5 mg/kg bw/day (NTP, 1993). An NOAEL of 2.5 mg/kg bw/day can be derived from this study based on the kidney effects seen at 5 mg/kg bw/day.

Dermal

No data are available for the chemical.

Although mercuric chloride is classified as hazardous with the risk phrase 'Toxic: Danger of serious damage to health by prolonged exposure in contact with skin' (T; R48/24) in the HSIS (Safe Work Australia), no data are available to evaluate this classification. Therefore, this classification is not considered relevant for read across to mercuric sulfate. However, mercuric sulfate has a hazard classification for acute dermal toxicity.

Inhalation

No data are available.

Genotoxicity

Mercuric chloride is classified as hazardous—Category 3 mutagenic substance—with the risk phrase 'Possible risk of irreversible effects' (Xn; R68) in the HSIS (Safe Work Australia). However, inorganic mercury compounds are not classified for genotoxicity in the HSIS. In the absence of any data for mercuric sulfate, but considering the similar structure and metabolism to mercuric chloride, this classification is also supported for mercuric sulfate (see **Recommendation** section).

The World Health Organization (WHO) report (2003) states that 'There is convincing evidence that inorganic mercury compounds can interact with and damage DNA *in vitro*. Data from *in vitro* studies indicate that inorganic mercury compounds may induce clastogenic effects in somatic cells, and some positive results have also been reported in *in vivo* studies'.

In vitro studies using mercuric chloride produced mainly positive results (ATSDR, 1999; WHO, 2003):

- positive results in *Bacillus subtilis* rec-assay;
- negative results in an Ames test in *Salmonella typhimurium* strains;
- dose-dependent increases in chromosomal aberrations and sister chromatid exchanges (SCE) in Chinese hamster ovary (CHO) cells;
- marginal to marked DNA damage (conversion into single-stranded form) in mouse or rat fibroblasts treated with 50 or 10 µM mercuric chloride, respectively;
- positive results in alkaline elution assays (DNA single-strand breaks) in CHO cells, and rat and mouse embryo fibroblasts;
- spindle disturbances in Indian muntjak fibroblasts and human lymphocytes;
- a weak mutagenic response with metabolic activation in mouse lymphoma L5178Y cells treated at 4.4 and 5.9 µg mercury/mL, doses approaching levels that cause severe cytotoxicity;
- cell transformation in Syrian hamster cells;
- SCE and chromosomal aberrations in human lymphocytes;
- inhibition of DNA repair mechanisms; and
- binding to chromatin in rat fibroblasts and CHO cells.

Assays with negative results were reported as not suitable for detecting the mutagenic potential of heavy metals (ATSDR, 1999).

In vivo studies with mercuric chloride produced mainly positive results for genotoxicity (ATSDR, 1999; WHO, 2003):

- in Swiss albino mice administered a single oral dose of mercuric chloride at 2.2, 4.4 or 8.9 mg mercury/kg bw, there was a dose-dependent increase in chromosome aberrations (primarily chromatid breaks) in bone marrow cells, as well as an increased percentage of aberrant cells (details not available);
- in Swiss mice (n = 3–4/group) exposed to mercuric chloride by a single intraperitoneal (i.p.) injection at 0.7, 1.5, 3.0 or 4.4 mg mercury/kg bw, there were no chromosomal aberrations in bone marrow cells harvested 12, 24, 36 or 48 hours after administration;
- in rats orally exposed to mercuric chloride at 0.18–1.8 µg mercury/kg bw/day for 12 months, there was a dose-dependent increase in dominant lethal mutations, as evidenced by increased incidence of embryonic loss;
- female (101 × C3H)F_1 mice treated with a single i.p. injection of mercuric chloride at 1.5 mg mercury/kg bw had a dominant lethal effect (details not available); and
- no increase in chromosomal aberrations in mouse spermatogonia or Syrian hamster oocytes following administration of a single dose of mercuric chloride at ≥4.4 mg mercury/kg bw via the parenteral route.

Carcinogenicity

No data are available for the chemical. The data available for mercuric chloride are insufficient to derive a conclusion on the carcinogenicity of the chemical. The WHO report (2003) states that 'There is no credible evidence that exposure of humans to either elemental mercury or inorganic mercury compounds results in cancer'. The International Agency for Research on Cancer (IARC) has reported that 'there is inadequate evidence in humans for the carcinogenicity of mercury and mercury compounds' (IARC, 1993).

The National Toxicology Program (NTP) report (1993) for mercuric chloride also concluded that there was some evidence for carcinogenicity in male F344 rats, but equivocal evidence in female F344 rats and male B6C3F1 mice, and no evidence in female B6C3F1 mice.

In a two-year study, F344 rats (n = 50/sex/dose) were administered mercuric chloride by oral gavage at 0, 2.5 or 5 mg/kg bw/day five days per week for 103–104 weeks. In high-dose male rats, there was a significant increased incidence of squamous cell papillomas of the forestomach and thyroid follicular cell carcinomas, compared with controls. Significant treatment-related non-neoplastic lesions included increased severity of nephropathy in male rats; increased incidence of inflammation in the nasal mucosa of all treated rats; parathyroid gland hyperplasia and increased heart mineralisation in male rats (NTP, 1993).

In a two-year study, B6C3F1 mice (n = 50/sex/dose) were administered mercuric chloride by oral gavage at 0, 5 or 10 mg/kg bw/day five days per week for 103–104 weeks. No significant neoplastic changes were reported. Significant non-neoplastic lesions included increased severity of nephropathy in all treated male mice and increased incidence and severity of nephropathy in all treated female mice (NTP, 1993).

Reproductive and Developmental Toxicity

No data are available for the chemical. The limited data available for mercuric chloride are insufficient to derive a conclusion on reproductive and developmental toxicity of the chemical.

The WHO report (2003) states that 'Large doses of inorganic mercury compounds administered parenterally have caused embryotoxicity and teratogenicity. These effects have not been demonstrated after physiological dosing regimens or at dose levels not toxic to the mothers. No valid information is available on the reproductive toxicity of inorganic mercury compounds in humans.'

Only limited data are available for mercuric chloride. In female hamsters administered mercuric chloride at 6.2–8.2 mg mercury/kg bw by subcutaneous injection for 1–4 days, the oestrus cycle was disrupted—delayed ovarian follicle maturation and uterine cell hypertrophy, corpora lutea (follicle remnant after ovulation) form was changed and there were altered progesterone concentrations (ATSDR, 1999; WHO, 2003).

Most animal studies on mercuric chloride were conducted using routes not relevant for human exposure (e.g. i.p. injection). In male rats that received a single i.p. injection of mercuric chloride at 0.74 mg mercury/kg bw, there was degeneration of the seminiferous tubules. A single i.p. injection of mercuric chloride at 1 mg mercury/kg bw in male rats resulted in reduced pregnancies in the female rats with which they were mated. In two studies in mice, administration of a single dose of mercuric chloride to female animals by i.p. injection at 1 or 1.48 mg mercury/kg bw resulted in reduced litter sizes, reduced numbers of litters or reduced implantation sites (ATSDR, 1999; WHO, 2003).

Other Health Effects

Neurotoxicity

The chemical is covered under the HSIS listing for inorganic mercury compounds and classified as hazardous with the risk phrase 'Danger of cumulative effects' (R33) in the HSIS (Safe Work Australia). This classification is supported for the chemical.

Neurotoxicity has been reported following exposure to mercury, including oral and dermal exposure to inorganic mercury compounds from products such as teething powders, ointments and laxatives. Retention of mercury occurs in the brain to a greater extent than other organs, predisposing it to damage over time.

Although inorganic mercury compounds are less lipid soluble than organic mercury compounds (NICNAS, 2015b), following absorption, mercury ions from any source can be converted to organic forms and trapped in the brain. Similar neurological signs and symptoms have been reported irrespective of the source of mercury exposure, but these effects can vary greatly in individuals. Effects included involuntary muscle movement, loss of emotional control, sleeping problems, memory loss, peripheral nerve damage, and cognitive and motor function deficits (ATSDR, 1999; WHO, 2003).

Limited data available specifically for mercuric chloride also support the claims for neurotoxicity. A single oral dose of mercuric chloride at 0.74 mg mercury/kg bw in rats disturbed the blood-brain barrier after 12 hours of exposure, and after 11 weeks administration by oral gavage or subcutaneous injection at the same dose, neurotoxicity including uncontrolled muscle movement (ataxia) and sensory loss. In rats that received mercuric chloride at 2.2 mg mercury/kg bw for three months in the diet, reduced activity and abnormal gait were reported (WHO, 2003).

Risk Characterisation

Critical Health Effects

The critical health effects for risk characterisation include genotoxicity and cumulative effects following acute or repeated exposure from oral and dermal exposure.

Public Risk Characterisation

Given the uses identified for the chemical, it is unlikely that the public will be exposed. Hence, the public risk from this chemical is not considered to be unreasonable.

Occupational Risk Characterisation

Given the critical health effects, the chemical could pose an unreasonable risk to workers unless adequate control measures to minimise oral, dermal and inhalation exposure are implemented. The chemical should be appropriately classified and labelled to ensure that a person conducting a business or undertaking (PCBU) at a workplace (such as an employer) has adequate information to determine the appropriate controls.

The data available support a specific hazard classification for mercuric sulfate in the HSIS (Safe Work Australia), by removing it from the generic entry for inorganic mercury compounds (see **Recommendation** section).

NICNAS Recommendation

Assessment of the chemical is considered to be sufficient, provided that the recommended amendment to the classification is adopted, and labelling and all other requirements are met under workplace health and safety and poisons legislation as adopted by the relevant state or territory.

Regulatory Control

Work Health and Safety

Workers exposed to mercuric sulfate (an inorganic mercury compound) require health monitoring according to Schedule 14 of the Work Health and Safety Regulations (2011). The type of health monitoring required is: 'Demographic, medical and occupational history. Physical examination with emphasis on dermatological, gastrointestinal, neurological and renal systems. Urinary inorganic mercury' (Work Health and Safety Regulations, 2011).

The chemical is recommended for classification and labelling under the current approved criteria and adopted GHS as below. Mercuric sulfate should be listed separately to the inorganic mercury compound entry in the HSIS, to indicate the extra hazard classifications relevant to this chemical based on its structural similarity to mercuric chloride.

This assessment does not consider classification of physical and environmental hazards.

Hazard	Approved Criteria (HSIS)[a]	GHS Classification (HCIS)[b]
Acute Toxicity	Very toxic if swallowed (T+; R28)* Very toxic in contact with skin (T+; R27)* Very toxic by inhalation (T+; R26)*	Fatal if swallowed - Cat. 2 (H300) Fatal in contact with skin - Cat. 1 (H310) Fatal if inhaled - Cat. 2 (H330)
Repeat Dose Toxicity	Toxic: Danger of serious damage to health by prolonged exposure if swallowed (T; R48/25)	Causes damage to organs through prolonged or repeated exposure if swallowed - Cat. 1 (H372)
Genotoxicity	Muta. Cat 3 - Possible risk of irreversible effects (Xn; R68)	Suspected of causing genetic defects - Cat. 2 (H341)
Other Health Effects	Danger of cumulative effects (R33)*	Causes damage to organs through prolonged or repeated exposure - Cat. 1 (H372)

[a] Approved Criteria for Classifying Hazardous Substances [NOHSC:1008(2004)].

[b] Globally Harmonized System of Classification and Labelling of Chemicals (GHS) United Nations, 2009. Third Edition.

* Existing Hazard Classification. No change recommended to this classification

Advice for industry

Control measures

Control measures to minimise the risk from oral, dermal and inhalation exposure to the chemical should be implemented in accordance with the hierarchy of controls. Approaches to minimise risk include substitution, isolation and engineering controls. Measures required to eliminate, or minimise risk arising from storing, handling and using a hazardous chemical depend on the physical form and the manner in which the chemical is used. Examples of control measures that could minimise the risk include, but are not limited to:

- using closed systems or isolating operations;
- using local exhaust ventilation to prevent the chemical from entering the breathing zone of any worker;
- health monitoring for any worker who is at risk of exposure to the chemical, if valid techniques are available to monitor the effect on the worker's health;
- air monitoring to ensure control measures in place are working effectively and continue to do so;
- minimising manual processes and work tasks through automating processes;
- work procedures that minimise splashes and spills;
- regularly cleaning equipment and work areas; and
- using protective equipment that is designed, constructed, and operated to ensure that the worker does not come into contact with the chemical.

Guidance on managing risks from hazardous chemicals are provided in the *Managing risks of hazardous chemicals in the workplace—Code of practice* available on the Safe Work Australia website.

Personal protective equipment should not solely be relied upon to control risk and should only be used when all other reasonably practicable control measures do not eliminate or sufficiently minimise risk. Guidance in selecting personal protective equipment can be obtained from Australian, Australian/New Zealand or other approved standards.

Obligations under workplace health and safety legislation

Information in this report should be taken into account to help meet obligations under workplace health and safety legislation as adopted by the relevant state or territory. This includes, but is not limited to:

- ensuring that hazardous chemicals are correctly classified and labelled;
- ensuring that (material) safety data sheets ((M)SDS) containing accurate information about the hazards (relating to both health hazards and physicochemical (physical) hazards) of the chemical are prepared; and
- managing risks arising from storing, handling and using a hazardous chemical.

Your work health and safety regulator should be contacted for information on the work health and safety laws in your jurisdiction.

Information on how to prepare an (M)SDS and how to label containers of hazardous chemicals are provided in relevant codes of practice such as the *Preparation of safety data sheets for hazardous chemicals—Code of practice* and *Labelling of workplace hazardous chemicals—Code of practice*, respectively. These codes of practice are available from the Safe Work Australia website.

A review of the physical hazards of the chemical has not been undertaken as part of this assessment.

References

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