Mercury elemental (metallic elemental mercury, mercury vapor)

Updated: October 2019

CAS No. 7439-97-6

There are three classes of mercury: metallic elemental mercury (quicksilver, Hg^0), inorganic mercurial salts (e.g., Hg_2Cl_2, Hg^+, $HgCl_2$, Hg^{+2}), and organic mercurials (e.g., methylmercury, phenylmercury). Adverse effects from exposure to mercury differ depending on the form and the route of exposure. This article focuses on elemental mercury.

Metallic mercury occurs as a part of the Earth's natural geochemistry, comprising 50 llg/kg of the Earth's crust. It is 62nd in order of abundance. It is found in the form of the sulfide, as cinnabar ore, which has an average mercury content of 0.1-4%; it is also present in the form of geodes of liquid mercury and as impregnated schist or slate. The major source of atmospheric mercury is suggested to be degassing of the Earth's crust and the oceans [IARC].

Mercury is a naturally occurring metal. It is the only metal on earth which is liquid at room temperatures. Metallic mercury is the pure form of mercury. It is a shiny, silver white, odorless liquid, much heavier than water [ATSDR_1].

Neither liquid mercury nor mercury vapor has an odor and thus, chemical odor provides no warning of hazardous concentrations [ATSDR_1].

Most of the metallic mercury on the market is 4N material (99.99% mercury) [IARC].

Usage and exposure:

Human exposure to mercury has a very long history. Several thousand years ago in China, an inorganic mercury compound (mercury sulfide) was used to prepare red dye pigment vermilion, which is a brilliant red ore, namely cinnabar. Inorganic mercury compounds have also been used in medical applications since ancient Egypt. In modern history, almost all of those applications have gradually disappeared. However, mercury compounds have been used as skin ointments to treat skin infection, and in developing

countries, they have been applied to the treatment of skin sores from syphilis. Mercury compounds have been used as laxatives and also added to teething powders as calomel (mercurous chloride). Historical industrial mercury poisoning, "mad hatter" was a result of the use of mercuric nitrate to treat the fur used in production of high quality felt hats. Inorganic mercuric compounds were also used worldwide as antiseptic preservatives, mercurochrome (dibromohydroxymercurifluorescein), and preservative antibacterial agents as phenylmercury compounds. More recently, young women have used skin lightening products and cosmetics, which contain inorganic mercury compounds [Jung-Duck Park].

Mercury has the properties of low viscosity, high density, high electrical conductance, and a reflective surface, for which it is used widely in scientific devices, electrical equipment, and industry, including in thermometers, barometers, batteries, electrical switches and relays, mercury lamps, solders, semiconductor solar cells, catalysts, preservatives, electroplating, pharmaceuticals, and chloroalkali production [Jung-Duck Park].

A major use of mercury is as a cathoAde in the electrolysis of sodium chloride solution to produce caustic soda and chlorine gas [IARC].

Metallic mercury is used in oral thermometers, barometers, sphygmomanometers (devices used to test blood pressure), wall thermostats for heating and cooling, fluorescent light bulbs/tubes, some batteries, electric light switches, some indoor gas meter regulators (in houses built before the 1960’s), and for a variety of other purposes [ATSDR_1].

Another use of liquid metallic mercury is in the extraction of gold from ore concentrates or from recycled gold articles [IARC].

Mercury vapor is the commonest form to which workers are exposed in industries such as mining and processing of cinnabar ore and the chloralkali industry, where brine is electrolyzed in mercury cells in which the cathode is a flowing sheet of liquid mercury. The manufacture and use of liquid mercury-containing instruments constitute another source of occupational exposure to mercury vapor through breakage, spillage or careless handling. Dental personnel are exposed to mercury vapors through the preparation of dental amalgams [IARC].

Persons whose skin or clothing is contaminated with liquid mercury can contaminate response personnel by direct contact or off-gassing vapor and

can also contaminate equipment leading to a risk of chronic exposure for response personnel [ATSDR].

Routs of exposure:

Inhalational exposure is the most typical route of elemental mercury toxicity [CDC].

Inhaled mercury vapor is readily absorbed, at a rate of approximately 80%, in the lungs, and quickly diffused into the blood and distributed into all of the organs of the body. Absorbed elemental mercury is oxidized to the mercuric form (Hg^{++}) in the red blood cells and tissues, a process that takes several minutes. Elemental mercury is in an uncharged monoatomic form, which is highly diffusible and lipid soluble. Elemental mercury can cross the blood-brain barrier and blood-placenta barrier as well as the lipid bilayers of cellular and intracellular organellar membranes. Though elemental mercury vapor is rapidly oxidized to ionic mercury, it remains as vapor in the blood for a short time, which is long enough for a significant amount of mercury vapor to penetrate the blood-brain barrier before it is oxidized. Mercury molecules can then be oxidized and accumulate in the brain. The oxidized form will not effectively cross the blood-brain barrier. Notably, elemental mercury can pass through the mucosa and connective tissue of the nasal cavity, and from there it can be transported to the brain via the nerve cells of the olfactory system, namely the olfactory pathway [Jung-Duck Park].

Virtually no elemental mercury is absorbed from the gastrointestinal tract or by the skin. Mercury crosses the placenta and can be transferred to infants via breast milk [ATSDR].

Elemental mercury from ingestion is poorly absorbed, at less than 0.01% of the dose, in the gastrointestinal tract. In the case of accidental swallowing of elemental mercury such as from breakage of a thermometer, systemic toxicity is rare and generally not expected [Jung-Duck Park].

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With time after exposure, the greater proportion of the body burden of mercury is found in the kidney. Urine and feces are the main pathways of excretion, although a small amount of inhaled mercury can be eliminated in the breath,

sweat, and saliva. The excretion of elemental mercury is dose-dependent and biphasic: initially rapid, then followed by slow excretion. The biological half-life of mercury is estimated to be approximately 30 to 60 days in the body. The half-life of mercury in the brain is not entirely clear, but is estimated to be as long as approximately 20 years. [Jung-Duck Park].

An urinary mercury concentration ≥ 10 ug/L or a total whole blood mercury concentration ≥ 10 ug/L is an unusual level of exposure for a person with no known occupational exposure to mercury [CDC].

Target organ:

The primary organs of mercury deposition following inhalation exposure to elemental mercury vapor are the brain and kidney [Jung-Duck Park].

Health hazards:

Acute Exposure

Symptoms of acute toxicity following high-level exposure to mercury vapor occur within hours of the exposure.

Respiratory system - acute exposure to high levels of elemental mercury vapor can cause chemical pneumonitis. Within a few hours of exposure, dyspnea, chest pain, and dry cough develop, often associated with fever, chills, and headache. Symptoms might resolve or gradually progress to pulmonary edema, respiratory failure, and death. The acute mercury-induced lung damage usually resolves completely, but some cases of diffuse pulmonary fibrosis, restrictive lung disease, and chronic respiratory insufficiency, have been reported [ATSDR_1].

Cardiovascular - acute inhalation of high levels of elemental mercury vapor can cause tachycardia and hypertension [ATSDR_1].

CNS - acute inhalation of mercury vapor may produce CNS effects such as headache, weakness, and visual disturbances [ATSDR_1].

Kidney - Owing to the accumulation of mercury in the kidneys, acute renal failure, indicated by proteinuria, haematuria and oliguria, are commonly reported [Public Health England].

Gastrointestinal effects - metallic taste, salivation, dysphagia, abdominal cramps, diarrhea, and nausea have been reported following inhalation of large

amounts of elemental mercury vapor. Oral and dermal exposures to elemental mercury are not normally associated with GI symptoms [ATSDR_1].

Dermal - dermal reactions associated with dermal contact with liquid elemental mercury or the vapor are rare. Acrodynia (or pink disease) is associated with hypersensitivity to mercury absorbed from vapor inhalation or dermal exposure. Symptoms of acrodynia include abnormal redness of the skin, followed by peeling of skin on the hands, nose, and soles of the feet [ATSDR_1].

Chronic Exposure

Repeated or continuous exposure to elemental mercury can result in accumulation of mercury in the body and permanent damage to the nervous system and kidneys. Classic symptoms of poisoning include neuropsychiatric effects, renal impairment, and oropharyngeal inflammation [ATSDR_1].

The neuropsychiatric effects include tremor, anxiety, emotional lability, forgetfulness, insomnia, anorexia, erethism (abnormal irritation, sensitivity, or excitement), fatigue, and cognitive and motor dysfunction. Although less common, neuromuscular changes (weakness, muscle atrophy, and muscle twitching) and polyneuropathy (paresthesias, stocking-glove sensory loss, hyperactive tendon reflexes, slowed sensory and motor nerve conduction velocities) have also been reported [ATSDR_1].

Nephrotoxicity including proteinuria and increased urinary enzyme excretion were observed following chronic occupational exposure to elemental mercury, as well as stomatitis, sore gums and ulceration of the oral mucosa [Public Health England].

The International Agency for Research on Cancer (IARC) has classified elemental mercury and inorganic mercury compounds as category 3 carcinogens, not classifiable as to carcinogenicity to humans [Public Health England].

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