

Gallium Arsenide (GaAs, CAS 1303-00-0)
Cal/OSHA HEAC draft summary, last revised 4/29/2010

Properties

MW 144.6; Dark Gray Cubic Crystal; Density 5.3; Melting Point 1238 C; Solubility: < 1 mg/ml in water, <1 mg/ml in DMSO, 95% in ethanol, methanol, and acetone, soluble in hydrochloric acid.

Sources and Exposures

Used to manufacture semiconductor, transistors, solar cells, lasers, LEDs, and other electronic devices. Handled as solid and potentially processed to generate inhalable particulate. ACGIH TLV documentation 2005 states absorption via inhalation is more efficient than ingestion. Appears the respirable fraction presents the greatest exposure route of concern.

Overview

Inhaled GaAs reported (Webb, 1984) dissociation resulting in arsenic in blood and gallium retained in lungs. reported metabolized to a trivalent arsenic compounds thus have been associated with cancer. Also elemental gallium believed to displace zinc in enzymes used in heme synthesis.

Summary

No human epi/chronic studies found. Female rats lung cancer NOAEL 0.1 mg/M3 (NTP 2000). Rat developmental NOAEL 10 mg/M3 and mice developmental effects seen at lowest dose of 10 mg/M3 (NOAEL), but was not significant until next dose of 37 mg/M3 (Mast, 1990). Mice maternal pulmonary toxicity LOAEL 10 mg/M3 (lowest dose in study). Pulmonary effects appear most sensitive endpoint in animals – hyperplasia, alveolar epithelial hyperplasia chronic active inflammation, proteinosis, and alveolar metaplasia.

Carcinogenicity

Arsenic trioxide compounds believed to be carcinogens and are believed to be formed post GaAs absorption. IARC 2004 classified the GaAs carcinogenic to humans because arsenic inorganic compound classification. ACGIH 2005 TLV classified GaAs as A3 confirmed animal carcinogen with unknown relevance to humans. GaAs not listed separately from arsenic (inorganic compounds) as being known to cause cancer on Proposition 65 list.

NTP 2000 reported GaAs not mutagenic in Salmonella typhimurium, with or without S9 metabolic activation enzymes, and no increase in the frequency of micronucleated erythrocytes was observed in peripheral blood of male or female mice exposed to GaAs by inhalation for 14 weeks. Doses were 0, 0.01, 0.1 and 1 mg/M3, 6 hours/day, 5 days/week for 105 weeks. No evidence of carcinogenic activity in male F344/N rats or male/female B6C3F mice exposed to GaAs; clear evidence in female F344/N rats at the 1 mg/M3 dose. There were increases in alveolar/bronchiolar neoplasms and mononuclear cell leukemia.

Reproductive and Developmental

No human studies identified. A Rat developmental NOAEL of 10 mg/M3, Mast et al 1990, was based on decreased weight and skeletal variations. In mice no NOAEL was determined because effects were seen at all doses (lowest dose 10 mg/M3).

Pulmonary

NTP 2000 2-yr inhalation of 1 um GaAs particles produced various alveolar hyperplasia: rats at 0.01 mg/M3 and mice at 0.1 mg/M3.

Other

Grant & Schuman, 1993 found photophobia and blindness in rats give lethal doses of gallium salts. Bingham et al, 2001 found no cases of photophobia or blindness in humans following exposure to GaAs.

Flora 1996 found inhibited delta-aminolevulinic acid dehydratase activity in blood, reduced glutathione levels and increase zinc protoporphyrin levels after 50 to 200 mg/kg 5 days/wk 3 weeks oral administration to rats. Goering et al, 1988 heme biosynthesis appears to be due to the gallium component, which may displace the zinc cofactor from the enzyme. Bingham et al 2001 found oral GaAs less toxic than intratracheal in rats, altered hepatic enzyme function (increase in serum aspartate aminotransferase activity gamma-glutamyltranspeptidase, and hepatic malondialdehyde, GaAs had a moderate effect on liver function compared to immunologic or hematologic systems.

Burns et al, 1994 found GaAs suppresses function of all cell types involved with the immune response in mice. Burns & Munson 1993b found GaAs inhibited production of interleukins in mice. Burns et al 1991 immunosuppression caused by GaAs appears to be due mainly to the arsenic component.

Measurement

NIOSH 7303 (elements by inductively-coupled plasma) has lowest LOQ for arsenic at 0.075 ug. Thus, a sample of 480 minutes at 2 L/minute provides a LOQ of about 0.04 ug/M3. Gallium by this same analysis has a similar limit of quantification. An IH could analyze for arsenic or gallium and with their almost identical atomic weights multiply the result by two for comparison to the GaAs exposure limit. Thus, the NIOSH method LOQ of 0.04 ug/M3 would actually be 0.02 ug/M3.

Current Limits and Risk Levels

- No current Cal/OSHA limits for gallium arsenide. The existing Cal/OSHA PEL for *arsenic and inorganic arsenic compounds* is 0.01 mg/M3. Action Level of 0.005 mg/M3 for applicable general industries under the substance-specific standard, section 5214, except agriculture, pesticide application and wood preservative use.
- Arsenic and inorganic compounds (as As) TLV 1990: 0.01 mg/M3, lung cancer.
- Gallium Arsenide TLV 2004: 0.0003 mg/M3 respirable particulate, to protect against pulmonary inflammation, potential adverse reproductive effects and lung cancer.

Assumptions and Estimates

Rat lung hyperplasia appears to be most sensitive endpoint at 0.01 mg/M3. Adjusting for interspecies variation (10) and subchronic dosing (3) results in an exposure limit of 0.0003 mg/M3.

Recommendation

The HEAC recommends a PEL of 0.0003 mg/M3 to protect against possible lung (hyperplasia) observed as the most sensitive endpoint in rats. Exposures at this PEL should avoid risk of cancer observed in female rats and developmental effects in rats and mice seen at higher doses.

References

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