National Toxicology Program
U.S. Department of Health and Human Services

Indium Phosphide 22398-80-7

DRAFT REPORT

SUPPORT FOR CHEMICAL NOMINATION AND SELECTION
PROCESS OF THE NATIONAL TOXICOLOGY PROGRAM

NIEHS CONTRACT NO. NO1-ES-85218

EXECUTIVE SUMMARY OF DATA

INDIUM PHOSPHIDE
(22398-80-7)

November 7, 1988

Submitted to:

National Toxicology Program
National Institutes of Health
Building 31, Room 2B-55
Bethesda, Maryland 20205

Submitted by:

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Overview for Indium Phosphide

Nomination History: Indium phosphide was nominated to the NTP for toxicity and carcinogenicity testing by NIEHS based on its use in the electronics industry, its potential acute toxicity, and lack of toxicity data.

Physical and Chemical Properties: Brittle, metallic mass with a melting point of 1070°C. No information was found on its solubility in water or organic solvents. It is slightly soluble in mineral acids.

Production, Uses, and Exposure: The TSCA Inventory reported three companies as domestic producers of indium phosphide in 1977. One of these reported less than 1,000 pounds; the other two did not report production. No other information on the domestic production or importation of indium phosphide was available. Indium phosphide is used in semiconductor devices, injector lasers, and solar cells. It has been proposed to replace silicon in microchips. Indium phosphide is not listed in the NOES data base. The ACGIH has not recommended a TLV for indium phosphide but has recommended a TLV of 0.1 mg/m^3 for indium and its compounds.

Regulatory Status: No information was found on the regulatory status of indium phosphide.

Toxicological data:

Human - No information on toxicological effects in humans was found.

Animal - A 12% increase in the collagen content of lungs was observed in mice which were exposed by inhalation to indium phosphide. No other information on the toxicological effects of indium was found.

Genotoxicity: No information was found.

Structure-activity Relationships: In general, indium compounds (for example, indium oxide, indium chloride, and indium nitrate) are highly toxic by intravenous, intraperitoneal, and subcutaneous routes of administration.

CEC Review: The CEC recommended indium phosphide for stability studies, toxicity studies, including immunotoxicity, and carcinogenicity testing with a moderate priority. The recommendation was contingent on obtaining additional information on production and use, and the reusults of the stability studies to be performed by NTP.

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Indium Phosphide

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NTP EXECUTIVE SUMMARY OF DATA WORKING DRAFT

INDIUM PHOSPHIDE*

I. Chemical and Physical Information
- A. Synonyms: Indium monophosphide
- B. CAS No.: 22398-80-7
- C. Molecular Formula: InP
- D. Structural Formula: In-P
- E. Molecular Weight: 145.80
- F. Physical Properties:
  1. Physical State: Brittle metallic mass (Windholz, 1983)
  2. Melting Point: 1070°C (Windholz, 1983)
  3. Boiling Point: No information was found.
  4. Flash Point: No information was found.
  5. Vapor Pressure: No information was found.
  6. Specific Gravity: No information was found.
  7. Refractive Index: No information was found.
  8. Solubility in Water: No information was found.
  9. Solubility in Organic Solvents: No information was found.
  10. Log Octanol/Water Partition Coefficient: No information was found.
  11. Henry's Law Constant: No information was found.
  12. Other: Slightly soluble in mineral acids (Hawley, 1981)

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*The National Institute of Environmental Health Sciences (NIEHS) nominated indium phosphide for toxicity and carcinogenicity testing.

II. Production/Use/Exposure/Environmental/Regulatory Data

A. Production

1. Manufacturing Process

Indium phosphide is manufactured by direct combination of the highly purified elements at high temperatures under controlled conditions (Kirk-Othmer, 1981). A rapid synthesis of indium phosphide using elemental indium and red phosphorus under high pressure was recently reported (Adamski and Ahern, 1985). Starting materials other than the purified elements apparently can be used to make indium phosphide (Windholz, 1983), including highly purified trimethyl indium [Chemistry and Industry (London), 1983]. Phosphine can also be combined with elemental indium to form indium phosphide by a reactive sputtering process (Kirk-Othmer, 1982).

2. Volume

The public portion of the Toxic Substances Control Act Chemical Substance Inventory (TSCA Inventory) reported three companies as domestic producers of indium phosphide. One of these reported production of less than 1000 pounds, and the other two did not report production volumes for 1977 (USEPA, 1988a).

The Chemical Economics Handbook (CEH) did not report domestic production for indium phosphide (CEH, 1988).

The U.S. International Trade Commission (USITC) did not report domestic production of indium phosphide for the years 1983 to 1985 (USITC, 1984, 1985, 1986).

The TSCA Inventory reported the importation by one company of less than 1000 pounds of indium phosphide in 1977 (USEPA, 1988a).

No import data on indium phosphide were reported by the CEH (CEH, 1988).

The U.S. Department of Commerce (USDOC) did not report the importation of indium phosphide for the years 1983 and 1984 (USDOC, 1984, 1985).

3. Producers and Importers

Producers

The following companies have been listed as domestic

producers of indium phosphide:

Apache Chemicals, Inc. (SRI International, 1984)
Seward, IL

CERAC Inc. (USEPA, 1988a)
Milwaukee, WI

Crystal Specialties Los Angeles, CA	(USEPA, 1988a)
Eagle-Picher Industries, Inc. Miami, OK	(SRI International, 1987)
Great Western Inorganics Jefferson, CO	(USEPA, 1988a)

Importers

The following company was listed as an importer of indium phosphide in 1977:

Metalspecialties, Inc. Fairfield, CT	(USEPA, 1988a)

4. Technical Product Composition

No information regarding the technical product composition was located; however, electronic grade indium phosphide is manufactured from the highly purified elements (Kirk-Othmer, 1981). In addition, it is expected that a high level of purity would be desirable for electronic applications. The above suggest that most of the indium phosphide produced is of very high purity.

B. Use

Indium phosphide (electronics grade) is used in semiconductor devices, injector lasers, and experimental solar cells [Hawley, 1981; Chemistry and Industry (London), 1983; Chemical and Engineering News, 1978]. It has been predicted that indium phosphide-containing materials may replace the silicon used in microchips [Chemistry and Industry (London), 1983].

C. Occupational Exposure

No information regarding occupational exposure was found. Indium phosphide is not listed in the National Occupational Exposure Survey (NOES), which was conducted by the National Institute for Occupational Safety and Health (NIOSH) during the years 1981 to 1983 (NIOSH, 1985).

The American Conference of Governmental Industrial Hygienists (ACGIH) has not recommended an exposure limit value for indium phosphide, but has recommended a threshold limit value (TLV) of 0.1 mg/m^3 for indium and its compounds (ACGIH, 1986, 1987). The TLV is a recommendation, not a binding standard. It is based primarily on the character and severity of injury from indium salts, particularly the pulmonary effects observed in rats exposed daily by inhalation to indium sesquioxide (In_2O_3) at

concentrations ranging from 24 to 97 mg/m^3 (Leach et al., 1961, as cited in ACGIH, 1986).

D. Consumer Exposure

No information was found.

E. Environmental Data

No information was found.

F. Regulatory Status

No federal regulations concerning indium phosphide were located (Bureau of National Affairs, 1988).

Indium phosphide is not subject to reporting under Title III of the Superfund Amendments and Reauthorization Act (SARA) of 1986 according to the Title III List of Lists (USEPA, 1988b). The List of Lists covers SARA Section 302 Extremely Hazardous Substances, Reportable Quantity ("RQ") Hazardous Substances of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), SARA Section 313 Toxic Chemicals, and Hazardous Wastes of the Resource Conservation and Recovery Act of 1976 (RCRA).

The Interagency Testing Committee (ITC) has not reviewed indium phosphide (USEPA, 1988c).

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III. Toxicological Effects

A. Human Data

1. Acute: No information was found.
2. Epidemiological Evidence/Case Reports: No information was found.
3. Absorption/Distribution/Metabolism/Elimination: No information was found.
4. Carcinogenicity/Chronic: No information was found.
5. Teratogenicity and Reproductive Effects: No information was found.

B. Animal Data:

There was information on only one study regarding the toxicity of indium phosphide in animals. According to the National Institute of Environmental Health Sciences (NIEHS, 1987), the Russian study by Brakhnova et al. (1977) found a 12% increase in the collagen content of lungs after mice were exposed by inhalation to indium phosphide. (Only the title of this study was provided by Chemical Abstracts, and a translation has not been obtained.)

1. Acute: No information was found.
2. Absorption/Distribution/Metabolism/Elimination: No information was found.
3. Prechronic: No information was found.
4. Carcinogenicity/Chronic: No information was found.
5. Teratogenicity and Reproductive Effects: No information was found.

C. Genotoxicity: No information was found.

D. Other Relevant Information: It is difficult to predict the potential toxicity of indium compounds on the basis of the available toxicity data. Stokinger (1981) reported that "depending on the route of administration and compound type, indium is one of the more toxic of metals." Administration of In_2O_3 dust by inhalation to rats for 3 months produced pulmonary inflammation. However, it was practically nontoxic when administered in the diet for 3 months to rats. Administration of indium chloride ($InCl_3$) in the feed to rats caused slight growth depression at 2.4%, and marked growth depression at 4% over a 3-month period. A single intratracheal dose of indium antimonide (InSb) induced no gross or histological signs of toxicity in rats during a 9-month observation period.

E. Structure-Activity Relationships: The National Toxicology Program (NTP) has not tested any compounds containing indium (NTP CHEMTRACK, 1988). Additional information from other sources was not found.

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IV. Nomination Source

A. Source: NIEHS (NIEHS, 1987)

B. Recommendations:
-Toxicity
-Carcinogenicity

C. Rationale/Remarks:
-Used in electronics industry
-Potential for acute toxicity
-Lack of chronic toxicity data

D. Priority: None given

E. Date of Nomination: June 1987

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Indium Phosphide 22398-80-7 V

Indium Phosphide

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V. Chemical Evaluation Committee Review

A. Date of Review: December 1, 1988

B. Recommendations:
-Stability studies
-Toxicity, including immunotoxicity
-Carcinogenicity

C. Priority: Moderate

D. NTP Chemical Selection Principle: 2

E. Rationale/Remarks:
-Used in electronics industry
-Potential for increased use as proposed replacement for silicon
-Potential for acute toxicity
-Exposure to inorganic compounds often causes pulmonary asthma
-Carcinogenicity testing pending results of stability studies

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Indium Phosphide 22398-80-7 VI

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VI. Board of Scientific Counselors Review

A. Date of Review: March 14, 1989

B. Recommendations:
-Stability studies
-Toxicity including immunotoxicity

C. Priority: High

D. Rationale/Remarks:
-Used in electronics industry
-Potential for increased use as replacement for silicon
-Lack of toxicity data
-Toxicity studies pending results of stability studies
-Review chemicals used in semi-conductor industry for new NTP nominations

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VII. Executive Committee Review:

A. Date of Review: May 25, 1989

B. Decision: Selected as an NTP FY 1989 priority chemical

Indium Phosphide 22398-80-7 VIII

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VIII. Information Sources

This report was prepared by a multidisciplinary team of scientists. The authors included Joseph Ward, William Jarvis, Susan Colman, Philip Howard, and Michael Neal.

The information resources used to prepare this review included the automated data bases listed below, journal articles, general references materials, and agency reports.

ON-LINE DATA BASES SEARCHED

MEDLARS

CHEMLINE	
RTECS	
HSDB	
MEDLINE	1966-Present
TOXLINE	1965-Present
TOXLIT	1981-Present
TOXLIT-65	1965-1980
CANCERLIT	1963-Present

DIALOG

NTIS	1970-Present
Occupational Safety and Health (NIOSH)	1972-Present
Federal Register	1977-Present
Chemical Industry Notes	1975-Present
PTS Prompt	1972-Present

CIS

SANSS
TSCA Inventory

OTHER

NOES
NTP CHEMTRACK
CAS ONLINE 1967-Present

SRC

TSCATS
EFDB
CABE ARCHIVES
SRC DOCUMENTS

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IX References

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USDOC. 1984. U.S. Department of Commerce. Bureau of the Census. Report Ft 135/Annual 1983.

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USEPA. 1988a. U.S. Environmental Protection Agency. Computer Printout (CIS): 1977 Production Statistics for Chemicals in the Non-Confidential Initial TSCA Chemical Substance Inventory. Washington, DC: Office of Pesticides and Toxic Substances.

USEPA. 1988b. U.S. Environmental Protection Agency. Title III List of Lists. Washington, DC: Office of Toxic Substances.

USEPA. 1988c. U.S. Environmental Protection Agency. Personal communication from Robert Brink, Executive Secretary, Interagency Testing Committee (ITC), to Philip Howard, Syracuse Research Corporation, September 8, 1988.

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LABORATORY HEALTH AND SAFETY REVIEW OF:
Indium Phosphide

Route: Inhalation

Indium phosphide is a non-combustible solid. It is incompatible with strong oxidizing agents, sulfur and strong acids. The chemical is not soluble in water, is non-volatile and odorless. It is not readily soluble in mineral acids.

Indium phosphide has neither an OSHA PEL or an ACGIH TLV. However, Indium and its compounds have an OSHA PEL of O.1mg/m (as In). The chemical may cause irritation to the skin, mucous membranes and respiratory tract. Exposure may cause damage to the lungs, liver, kidneys and heart.

In the event of inhalation or ingestion, get medical help immediately. If ingestion occurs, do NOT induce vomiting.

Specific glove type information is not available. Double gloving with gloves of dissimilar materials is to be used when handling neat chemical. Additional personal protective equipment is to include: ANSI approved safety goggles are to be worn when handling the neat chemical, ANSI approved safety glasses with side shields are to be worn at all other times. Disposable jumpsuits (e . g ., TYVEK , etc .) and NIOSH approved chemical cartridge respirators with particulate filter cartridges are to be used in conjunction with the equipment described above.

In the event of a spill, utilize appropriate personal protective equipment, as described above. In order to minimize dust formation, dampen the solid spilled material with 60-70% ethanol to pick up any remaining material. Place the absorbed material in a vapor-tight bag for disposal. Clean the spill area with strong soap and water until all traces of the material are removed. All potentially contaminated materials are to be disposed of as hazardous waste.

All waste materials potentially contaminated with test chemical must be securely packaged, labeled, double bagged and disposed of as hazardous waste in accordance with federal (EPA, RCRA, etc .), state and local regulations. Incineration is the preferred method of disposal, when possible, otherwise a licensed hazardous waste landfill site is acceptable.