SUMMARY OF DATA FOR CHEMICAL SELECTION

OCTACHLORONAPHTHALENE

2234-13-1

BASIS OF NOMINATION TO THE CSWG

The nomination of octachloronaphthalene to the CSWG is based on exposure potential as a persistent organic pollutant and suspicion of potential carcinogenicity for this polychlorinated aromatic hydrocarbon. Dr. Elizabeth Weisburger, a member of the American Conference of Governmental Industrial Hygienists (ACGIH) TLV Committee as well as the Chemical Selection Working Group (CSWG), provided a list of 281 chemical substances with ACGIH recommended TLVs for which there were no long-term studies cited in the supporting data and no designations with respect to carcinogenicity. She presented the list to the Chemical Selection Planning Group (CSPG) for evaluation as chemicals which may warrant chronic testing; it was affirmed at the CSPG meeting held on August 9, 1994, that the 281 "TLV Chemicals" be reviewed as a Class Study. As a result of the class study review, octachloronaphthalene is presented as a candidate for testing by the National Toxicology Program because of:

- potential for general population exposures based on environmental occurrence and by bioaccumulation in the food chain
- evidence of occupational exposures based on TLV and other literature documentation
- suspicion of carcinogenicity and lack of chronic toxicity data.

Sources of human exposure to octachloronaphthalene are mainly general (consumer); but the exposure potential is not well defined because of a lack of specific information on pollutant levels in environmental media and food chain products. Although U.S. annual production has reportedly declined in recent years and octachloronaphthalene is no longer commercially manufactured in bulk, it continues to be produced for research and other small scale purposes. This chemical is not listed in the National Occupational Exposure Survey (NOES) database.

No information on genetic toxicity of octachloronaphthalene was identified. Suspicion of carcinogenicity is based on structural similarity to other highly chlorinated organic compounds, such as polychlorinated biphenyls (PCBs). Estrogen-mimicking effects have been associated

Prepared for NCI by Technical Resources International, Inc. under Contract No. NO1-CB-50511 (11/95; rev. 8/96)

with some of these highly lipophilic, bioaccumulating compounds. Octachloronaphthalene is of interest as a member of the chlorinated class of persistent organic pollutants (POPs) for which information relating biological activity and structure is sought.

SELECTION STATUS

ACTION BY CSWG: 12/6/95

Studies Requested:

- Estrogenic activity screen
- Induction of P450 studies

Priority: High

Rationale/Remarks:

- Widespread exposure due to previous production
- Inadvertent formation from incineration of products (e.g., cars and wires) containing octachloronaphthalene
- Suspect endocrine disruptor

INPUT FROM GOVERNMENT AGENCIES/INDUSTRY:

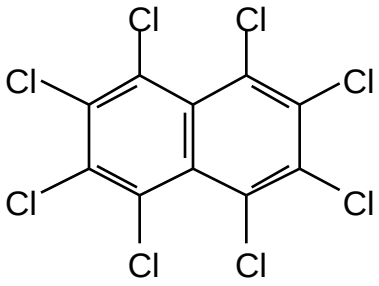
Dr. John Walker, Executive Director of the TSCA Interagency Testing Committee (ITC), was contacted at the Environmental Protection Agency (EPA) for information on the total annual production level of octachloronaphthalene; and Dr. Walker reported that there were no data for 1989 (Walker, 1995a). He also provided a summary of actions of the TSCA ITC on this chemical (see Regulatory Status section).

Prepared for NCI by Technical Resources International, Inc. under Contract No. NO1-CB-50511 (11/95; rev. 8/96)

CHEMICAL IDENTIFICATION

CAS Registry No.:	2234-13-1
Chemical Abstract Name:	Naphthalene, octachloro- (8CI, 9CI)
Synonyms and Trade Names:	Octachloronaphthalene; 1,2,3,4,5,6,7,8-octachloronaphthalene; perchloronaphthalene; Perna; Halowax 1051; OCN
Structural Class:	Polychlorinated naphthalene; polychlorinated bicyclic aromatic hydrocarbon

Structure, Molecular Formula and Molecular Weight:



$C_{10}Cl_8$ Mol. wt.: 403.74

Chemical and Physical Properties:

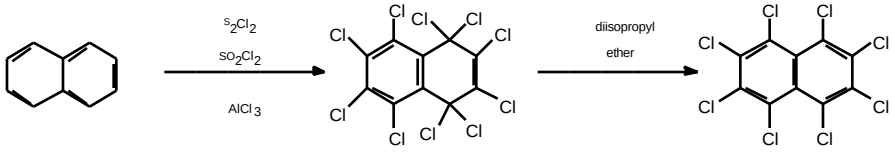
Description:	Pale yellow wax-like solid (ACGIH, 1993)
Melting Point:	197.5°C (Lide, 1995)
Boiling Point:	410°C (ACGIH, 1993)
Specific Gravity:	2.0 @ 20°C (ACGIH, 1993)
Vapor Pressure:	< 1 torr @ 20°C (ACGIH, 1993)
Solubility:	Insoluble in water; slightly soluble in alcohol; soluble in acetone; very soluble in benzene, carbon tetrachloride, chloroform and ligroin (ACGIH, 1993; STN International, 1995; Lide, 1995)
Reactivity:	Nonflammable solid (ACGIH, 1993)

Technical Products and Impurities: Octachloronaphthalene synthesized in a research laboratory according to the method reported by Brinkman and Reymer (1976) was reported to be ≥ 95% pure (Belfroid *et al.*, 1994). Octachloronaphthalene was typically available in Halowaxes (mixtures of congener polychlorinated naphthalenes) in technical grade (Imagawa & Yamamoto, 1994).

Prepared for NCI by Technical Resources International, Inc. under Contract No. NO1-CB-50511 (11/95; rev. 8/96)

EXPOSURE INFORMATION

Production and Producers: Octachloronaphthalene can be synthesized by the chlorination of naphthalene with chlorine gas in the presence of a catalyst. Jakobsson and coworkers (1992) described the synthesis of octachloronaphthalene (3) from naphthalene (1) by the following reaction sequence in which the intermediate, decachloro-1,4-dihydronaphthalene (2) was dissolved in diisopropyl ether and refluxed for 10 to 36 hours producing a yield of octachloronaphthalene of 81%.



(1) (2) (3)

Octachloronaphthalene is listed in the EPA's TSCA Inventory (STN International, 1995). However, according to Safe (1993), polychlorinated naphthalenes (PCNs) are no longer produced. When in commercial production, octachloronaphthalene was an important component of PCN products marketed under trade names such as Halowaxes, Nibren waxes, Seekay waxes, and Clonacire waxes. Brinkman and Reymer (1976) reported that Halowax 1051 was composed of approximately 90 wt. % of octachloronaphthalene with approximately 10 wt. % of hexachloronaphthalene. Several companies produced commercial PCNs, including Koppers Chemical Co., Halochem, Prodelec, Bayer, and ICI. Annual production figures are unavailable, but production of these PCNs was estimated to have peaked at under 2,300 tons (4,600,000 lbs.) in 1972 (Safe, 1993).

Use Pattern: Octachloronaphthalene has been used as a component of PCN waxes and impregnants; in protective coatings, such as electrical insulating and fire-resistant materials; in water repellants; in wood preservatives; as a lubricant additive; and as a reactant/chemical intermediate in organic synthesis (Lewis, 1993; Safe, 1993). Although no longer in large scale commercial production, it continues to be used as a starting material/chemical intermediate in the synthesis of other naphthalene derivatives in chemical research laboratories (Matthews, 1990; Jakobsson *et al*., 1992).

Prepared for NCI by Technical Resources International, Inc. under Contract No. NO1-CB-50511 (11/95; rev. 8/96)

Human Exposure: Octachloronaphthalene is not listed in the National Occupational Exposure Survey (NOES) database. Occupational exposures to octachloronaphthalene and PCN mixtures, such as Halowaxes, which contain octachloronaphthalene have been reported; the exposed workers were involved in the production or uses of the PCNs. The principal route of exposure was reportedly the inhalation of hot vapors (Safe, 1993). Occupational dermatoses caused by dermal exposures to octachloronaphthalene have also been reported. This chemical is among the more highly chlorinated PCNs which have been documented as chloroacnegens (Birmingham, 1991).

Another potential source of exposure to octachloronaphthalene is through bioconcentration in the food chain. Fish-eating sectors of the general population may be exposed to low levels of PCNs in fish taken from polluted bodies of water. However, little information was found in the available literature on the extent of bioconcentration of this highly lipophilic chemical in fish and other dietary sources. Opperhuizen *et al.* (1985) reported that most PCNs bioaccumulate rapidly, with uptake and elimination rates comparable to those of chlorinated benzenes and biphenyls. However, they reported observing an absence of accumulation of octachloronaphthalene in female guppies which might be explained by reduced bioavailability of the compound due to its very low water solubility and steric factors affecting membrane permeability and influencing its uptake.

Environmental Occurrence: Octachloronaphthalene has been identified as a pollutant in air (including workplace atmospheres), soil and water. Van Dell and coworkers (1994) studied the formation and destruction of products of incomplete combustion (PICs), including octachloronaphthalene, resulting from the combustion of polyethylene and *o*-chlorobenzene. Taylor and coworkers (1994) identified octachloronaphthalene as a component of chlorinated waste solids produced by the pyrolysis of trichloroethylene under incinerator conditions. Octachloronaphthalene has also been reported to be among some chlorinated aromatic hydrocarbons formed during the high temperature pyrolysis of hexachlorobenzene as a waste treatment process (Calaminus *et al.*, 1993). Nakano and coworkers (1993) have reported measuring octachloronaphthalene in municipal incinerator flue gases and circulating water; and Aittola and coworkers(1994) described octachloronaphthalene emissions in flue gases from metallurgical processes (used in car shredding for metal reclamation) as a potentially serious environmental concern.

Prepared for NCI by Technical Resources International, Inc. under Contract No. NO1-CB-50511 (11/95; rev. 8/96)

According to Safe (1993), who cites identifications of PCNs in birds of prey in Britain and the Netherlands, in a drainage ditch in Florida, and in sediments from the San Francisco Bay, these compounds are not routinely measured in analytical studies of extracts of environmental samples. Thus, although commercial production of octachloronaphthalene has been reduced, this chemical continues to be generated (e.g., as a PIC), and, as a result of its hydrophobicity (lipophilicity), has potential to persist and bioaccumulate following its formation in or release to the environment.

Regulatory Status: The ACGIH-recommended threshold limit value-time-weighted average (TLV-TWA) is 0.1 mg/m^3 with a skin notation and a threshold limit value–short-term exposure limit (TLV-STEL) of 0.3 mg/m^3 with a skin notation (ACGIH, 1993). The OSHA permissible exposure limit (PEL) is also 0.1 mg/m^3 over an eight-hour work shift with a skin notation (ACGIH, 1993).

The following actions have been taken by the TSCA Interagency Testing Committee (ITC) on octachloronaphthalene (Walker, 1995b).

- A dossier (I-05) was completed in September, 1977.
- Octachloronaphthalene was added to the *Priority Testing List* in the 2nd Report and was designated for carcinogenicity, mutagenicity, teratogenicity, other chronic effects, environmental effects testing, and epidemiology study as part of a substructure-based class study (chlorinated naphthalenes).
- It was removed from the *Priority Testing List* in the 10th Report because EPA had responded to the ITC's recommendation by telling the public why testing was not implemented.

Prepared for NCI by Technical Resources International, Inc. under Contract No. NO1-CB-50511 (11/95; rev. 8/96)

EVIDENCE FOR POSSIBLE CARCINOGENIC ACTIVITY

Human Data: No epidemiological studies or case reports investigating the association of exposure to octachloronaphthalene and cancer risk in humans were identified in the available literature.

Octachloronaphthalene has been reported to cause systemic intoxication following percutaneous absorption. According to Birmingham (1991) signs of intoxication and target organ effects caused by dermally absorbed chlorinated naphthalenes include chloracne, hepatitis and peripheral neuritis. He described chloroacnegens as causative agents of pigmentary abnormalities characterized by hypermelanosis, an increase in melanin in the epidermis. Safe (1993) reported the following symptoms in humans resulting from exposures to PCNs usually by inhalation of hot vapors: rashes or chloracne, jaundice, weight loss, yellow atrophy of the liver, and in extreme cases, death.

Animal Data: No 2-year carcinogenicity studies of octachloronaphthalene in animals were identified in the available literature.

Accidental poisoning of cattle in New York State in 1941 was traced to the use of PCNs as high pressure lubricants in feed pelleting machines. Toxicity was manifested as hyperkeratosis, excess lacrimation and salivation, anorexia and depression, and decreased plasma vitamin A (Safe, 1993). The mammalian toxicology of PCNs, including octachloronaphthalene has not been well studied, according to Safe (1993). However, mixture- and structure-dependent biochemical and toxic responses are expected to resemble those reported for polychlorinated biphenyls (PCBs) and other toxic halogenated aromatic hydrocarbons (HAHs). According to Jakobsson and coworkers (1992) toxicological studies of PCN product mixtures indicate that toxicity increases with the degree of chlorination.

Several subchronic studies of PCNs in animals have been reported (ACGIH, 1993).

- Sikes *et al* (1952) fed hexa- and octachloronaphthalene to cattle for up to 30 days. They observed that liver injury and hyperkeratosis were the principal manifestations of toxicity and that greater toxicity for octachloronaphthalene was attributed to the higher degree of chlorination.
- Bell (1953) reported no sign of hyperkeratosis in cows following administration of PCNs and lesser toxicity with octa- than hexachloronaphthalene; but administration in a suspension, with less gastrointestinal bioavailability than the solutions used by Sikes and coworkers, may have been the reason for the disparity in results.
- Repeatedly exposing animals to fumes of molten PCNs resulted in systemic poisonings characterized by acute yellow atrophy of the liver, according to Deichmann (1981).

Prepared for NCI by Technical Resources International, Inc. under Contract No. NO1-CB-50511 (11/95; rev. 8/96)

Short-Term Tests: No *in vitro* or *in vivo* tests for genetic toxicity of octachloronaphthalene were identified in the available literature.

Other Biological Effects: Commercial Halowax PCNs, including octachloronaphthalene and PCN congeners chloro-substituted in three of four lateral (2,3,6, or 7) positions, have been reported to be inducers of microsomal enzymes. According to Safe (1993) octachloronaphthalene is reported to significantly induce rat hepatic microsomal aryl hydrocarbon hydroxylase (AHH) activity.

Structure/Activity Relationships: Octachloronaphthalene is a compound structurally related to polychlorinated biphenyls (PCBs) and belongs to the aromatic organochlorine class of compounds (also known as endocrine disruptors) marked by estrogen-mimicking effects. Both the United States and Europe are seeking information on estrogenic chemicals in an effort to set research and testing priorities (Anon., 1995). A example of this estrogenic effect was reported by Sewall and coworkers (1995). Thyroid hyperplasia and hypertrophy and elevated thyroid-stimulating hormone levels were induced when 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) was administered biweekly to female Sprague-Dawley rats for 30 weeks at average daily equivalent doses of 0.1-125 ng/kg/day. The authors hypothesized that TCDD appears to alter thyroid function via a secondary mechanism, namely increased excretion of thyroxine-glucuronide resulting from TCDD induction of uridine diphosphate-glucuronosyltransferase.

Nine compounds, structurally similar to octachloronaphthalene were screened for relevant information associating these related chemicals with a carcinogenic or mutagenic effect. No information was found on the mutagenicity or carcinogenicity for three of these structurally related compounds: decachlorobiphenyl (CAS RN 2051-24-3); perfluoronaphthalene CAS RN 313-72-4); and decachloro-1,4-dihydronaphthalene (CAS RN 14396-29-3). Toxicity information relevant to the mutagenicity or carcinogenicity of the remaining structurally related compounds is briefly summarized below and highlighted in Table 1.

- The National Toxicology Program (NTP) reported that octachlorodibenzo-p-dioxin and hexachlorobenzene were non-mutagenic in an Ames/*Salmonella* assay (metabolic activation not specified) (NTP, 1995). In another study, octachlorodibenzo-p-dioxin was non-mutagenic in an Ames/Salmonella assay without metabolic activation (Seiler, 1973).

Prepared for NCI by Technical Resources International, Inc. under Contract No. NO1-CB-50511 (11/95; rev. 8/96)

- Hexachlorobenzene induced various tumors in several studies in rats, mice, and hamsters (Cabral *et al*., 1977; Cabral *et al*., 1979; Arnold *et al*., 1985)

- An IARC Working Group reported that there is sufficient evidence that hexachlorobenzene is carcinogenic in mice and hamsters (IARC, 1979)

- Cumulative liver damage has been noted as a health hazard associated with exposures to tetrachloronaphthalene (Plog, 1988).

- Drinker and coworkers reported that hepatic hypertrophy and granulocytosis along with occasional mitotic figures were observed when rats were exposed to a mixture of trichloronaphthalene and tetrachloronaphthalene at an average concentration of 11 mg/m^3 for 16 hours/day for a total of 1,232 hours (for approximately 2.5 months) (ACGIH, 1993).

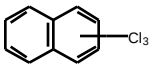
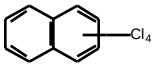
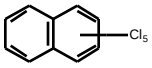
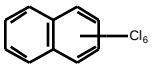
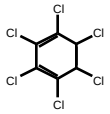
- Repeated exposure of rats to an average concentration of 8.8 mg/m^3 of a mixture of pentachloronaphthalene and hexachloronaphthalene for up to 4.5 months produced severe liver injury, jaundice with some fatality; the liver showed a marked fatty degeneration and centrolobular necrosis (ACGIH, 1993).

- Halowax 1014 (20 percent tetrachloronaphthalene, 40 percent pentachloronaphthalene, 40 percent hexachloronaphthalene) induced aryl hydrocarbon hydroxylase (AHH) and 7-ethoxyresorufin O-deethylase (EROD) in chicken or eider embryos exposed via the yolk sac (Engwall *et al.*, 1994).

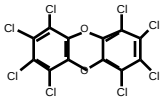
- Octachlorodibenzo-p-dioxin induced marked increases in EROD activity and cytochrome P-450 levels and fatty vacuolization of the liver (Safe and Phil, 1993).

Prepared for NCI by Technical Resources International, Inc. under Contract No. NO1-CB-50511 (11/95; rev. 8/96)

Table 1. Summary of Information on Octachloronaphthalene and Two Structurally Related Compounds

Chemical [CAS Reg. No.]	Carcinogenicity Data	Mutagenicity Data
Octachloronaphthalene [2234-13-1]	NDF	NDF
Trichloronaphthalene [1321-65-9]  Tetrachloronaphthalene [1335-88-2] 	*possible precarcinogenic process* hepatic hypertrophy, granulocytosis and occasional mitotic figures observed in rats (ACGIH, 1993)	NDF
Pentachloronaphthalene [1321-64-8]  Hexachloronaphthalene [1335-87-1] 	*possible precarcinogenic process* severe liver injury with some fatality, fatty degeneration and centrilobular necrosis observed in rats (ACGIH, 1993)	NDF
Hexachlorobenzene [118-74-1] 	*oral*: increase in hepatomas, liver hemangendothelioma, thyroid alveolar adenomas, and unspecified tumors in hamsters (Cabral *et al*., 1977) increase in hepatocellular tumors in Swiss mice (Cabral *et al*., 1979) increase in parathyroid adenomas, adrenal pheochromocytomas, and liver neoplastic nodules in Sprague-Dawley rats (also treated transplacentally) (Arnold *et al*., 1985) An IARC Working Group reported that there is sufficient evidence that hexachlorobenzene is carcinogenic	negative for mutation in *S. typhimurium* (NTP, 1995)

Prepared for NCI by Technical Resources International, Inc. under Contract No. NO1-CB-50511 (11/95; rev. 8/96)

	in mice and hamsters (IARC, 1979)	
Octachlorodibenzo-*p*-dioxin [3268-87-9] 	*oral*: no hepatocellular tumors when given in diets containing 0.25, 0.5, or 1 percent for up to 37 weeks to male and female $B6C3F_1$ mice and Osborne Mendel rats (42 weeks observation) (IARC, 1977) *topical*: no skin tumors with applications of 0.2, 3 or 80 mg/kg in 0.2 ml acetone 3/wk for 60 weeks in male and female Swiss-Webster mice (1 male and 1 female developed unspecified subcutaneous tumors) (IARC, 1977)	negative for mutation in *S. typhimurium* strains G46, TA1530, and TA1531 without S9; doubtful results in strains TA1532 and TA1534 without metabolic activation (Seiler, 1973); negative for mutation in *S. typhimurium* (NTP, 1995)

Prepared for NCI by Technical Resources International, Inc. under Contract No. NO1-CB-50511 (11/95; rev. 8/96)

REFERENCES

ACGIH (1993) *Documentation of Threshold Limit Values and Biological Exposure Indices*, 6th ed., Vol. II, Cincinnati, OH, American Conference of Governmental Industrial Hygienists, pp. 745-746, 1141-1142, 1170-1171, 1511-1512, 1624-1625

Aittola, J.-P., Paasivirta, J., Vattulainen, A., Sinkkonen, S., Koistinen J. & Tarhanen, J. (1994) Formation of chloroaromatics at a metal reclamation plant and efficiency of stack filter in their removal from emission. *Organohalogen Compd.*, **19**(Dioxin '94), 321-324 [Abstract: CA122,247005]

Anon. (1995) Environment and health: U.K., U.S., Denmark study estrogenic chemicals. *Chemical Week*, **157**(5), 33 (August 9, 1995)

Arnold, D.L., Moodie, C.A., Charbonneau, S.M., Grice, H.C., McGuire, P.F., Bryce, F.R., Collins, B.T., Zawidzka, Z.Z., Krewski, D.R., Nera, E.A. & Munro, I.C. (1985) Long-term toxicity of hexachlorobenzene in the rat and the effect of dietary vitamin A. *Food Chem. Toxicol.*, **9**, 779-793

Belfroid, A., Meiling, J., Sijm, D., Hermens, J., Seimen, W. and van Gestel, K. (1994) Uptake of hydrophobic halogenated aromatic hydrocarbons from food by earthworms *(Eisenia andrei)*. Arch. Environ. Contam. Toxicol., **27**,260-265

Bell, W.B. (1953) Relative toxicity of chlorinated naphthalenes in bovine hyperkeratosis (X-Disease). *Vet. Med.*, **48**,135-140, 146 [cited in ACGIH (1992)]

Birmingham, D.J. (1991) Occupational dermatoses. In: Clayton, G.D. & Clayton, F.E., *Patty's Industrial Hygiene and Toxicology*, 4th ed., Part A, New York, John Wiley & Sons, Inc., p. 272

Brinkman, U.A.Th. and Reymer, H.G.M. (1976) Polychlorinated naphthalenes. *J. Chromatog.*, 127:203-243

Cabral, J.R.P., Shubik, P., Mollner, T. & Raitano, F. (1977) Carcinogenic activity of hexachlorobenzene in hamsters. *Nature*, **269**, 510-511

Cabral, J.R.P., Mollner, T., Raitano, F. & Shubik, P. (1979) Carcinogenic activity of hexachlorobenzene in hamsters. *Int. J. Cancer*, **23**, 47-51

Calaminus, B., Trouve, G. & Delfosse, L. (1993) Experimental study of the quantitative conversion of hexachlorobenzene during high temperature pyrolysis. *J. Anal. Appl. Pyrolysis*, **27**(2), 281-292 [Abstract: CA120,85738]

Deichmann, W.B. (1981) Halogenated cyclic hydrocarbons. In: Clayton, G.D. & Clayton, F.E, eds., *Patty's Industrial Hygiene and Toxicology*, 3rd ed., Vol. 2B, New York, John Wiley & Sons, pp. 3669-3684 [cited in ACGIH (1993)]

Engwall, M., Brunström, B. & Jakobsson, E. (1994) Ethoxyresorufin *O*-deethylase (EROD) and aryl hydrocarbon dehydroxylase (AHH)-inducing potency and lethality of chlorinated naphthalenes in chicken (*Gallus domesticus*) and eider duck (*Somateria mollissima*) embryos. *Toxicology*, **68**,37-42

IARC (1977) *IARC Monographs on the Evaluation of Carcinogenic Risk to Humans*, Vol. 15, *Some Fumigants, the Herbicides 2,4-D and 2,4,5-T, Chlorinated Dibenzodioxins and Miscellaneous*

Prepared for NCI by Technical Resources International, Inc. under Contract No. NO1-CB-50511 (11/95; rev. 8/96)

Industrial Chemicals, Lyon, France, International Agency for Research on Cancer, 354 pp.

IARC (1979) *IARC Monographs on the Evaluation of Carcinogenic Risk to Humans*, Vol. 20, *Some Halogenated Hydrocarbons*, Lyon, France, Internatioal Agency for Research on Cancer, 609 pp.

Imagawa, T. & Yamamoto, Y. (1994) Determination of congener composition of Halowax using an automatic emission detector. *Bunseki Kagaku*, **43**(8), 629-633 [Abstract: CA122,177394]

Jakobsson, E., Eriksson, L. & Bergman, A. (1992) Synthesis and crystallography of 1,2,3,4,6,7-hexachloronaphthalene and 1,2,3,5,6,7-hexachloronaphthalene. *Acta Chem. Scand.*, **46**(6), 527-532

King, M.E., Shefner, A.M. and Bates, R.R. (1973) Carcinogenesis bioassay of chlorinated dibenzodioxins and related chemicals. *Environ. Health* Perspect., **5**,163-170

Lewis, R.J., Sr. (1993) *Hawley's Condensed Chemical Dictionary*, 12th ed., New York, Van Nostrand Reinhold Co., p. 583

Lide, D.R., ed. (1995) *CRC Handbook of Chemistry and Physics*, 74th ed., Boca Raton, FL, p. **3**-331

Matthews, R.S. (1990) Fluorine-19 NMR spectroscopy of polyhalonaphthalenes. Part II. Polychloropolyfluoronaphthalenes via nucleophilic fluoride dechlorination. *J. Fluor. Chem.*, **50**(3), 381-392

Nakano, T., Fujimori, K., Takaishi, Y. & Umeda, H. (1993) Isomer specific analysis of polychloronaphthalenes. *Hyogo-kenritsu Kogai Kenkyusho Kenkyu Hokoku*, **25**, 34-41 [Abstract: CA122,273566]

NTP (1995) *NTP Results Report*, Research Triangle Park, NC, National Institute of Environmental Health Sciences, National Toxicology Program

Opperhuizen, A., v. d. Velde, E.W., Gobas, F.A.P.C., Liem, D.A.K. and v.d. Steen, J.M.D. (1985) Relationship between bioconcentration in fish and steric factors of hydrophobic chemicals. Chemosphere, 14 (11-12), 1871-1896.

Plog, B.A. ed. (1988) *Fundamentals of Industrial Hygiene*, 3rd ed., Washington, DC, National Safety Council, p. 831

Safe, S.H. (1993) Chlorocarbons, -hydrocarbons (toxicology). In: Howe-Grant, M., ed., *Kirk-Othmer Encyclopedia of Chemical Technology*, 4th ed., Vol. 6, New York, John Wiley & Sons, pp. 127-139

Safe, S. and Phil, D. (1990) Polychlorinated biphenyls (PCBs), dikenzo-p-dioxins (PCDDs), dibenzofurans (PCDFs), and related compounds: Environmental and mechanistic considerations which support the development of toxic equivalency factors (TEFs). *Crit. Rev. Toxicol.*, **21**,51-88

Seiler, J.P. (1973) A survey on the mutagenicity of various pesticides. *Experientia*, **29**,622-623

Sewall, C.H., Flagler, N., Vanden Heuvel, J.P., Clark, G.C., Tritscher, A.M., Maronpot, R.M. & Lucier, G.W. (1995) Alterations in thyroid function in female Sprague-Dawley rats following chronic treatment with 2,3,7,8-tetrachlorodibenzo-*p*-dioxin. *Toxicol. Appl. Pharmcol.*, **132**,237-244

Prepared for NCI by Technical Resources International, Inc. under Contract No. NO1-CB-50511 (11/95; rev. 8/96)

Sikes, D., Wise, J.C. & Bridges, M.E. (1952) The experimental production of "X-Disease" (hyperkeratosis) in cattle with chlorinated naphthalenes and petroleum products. *J. Am. Vet. Med. Assoc.*, **121**,337-344 [cited in ACGIH (1993)]

STN International (1995) STN databases: Registry, Beilstein, CA. Columbus, OH, Chemical Abstracts Service

Taylor, P.H., Tirey, D.A., Rubey, W.A. & Dellinger, B. (1994) Detailed modeling of the pyrolysis of trichloroethene: formation of chlorinated aromatic species. *Combust. Sci. Technol.*, **101**(1-6), 75-102

Van Dell, R.D., Mahle, N.H. & Hixson, E.M. (1994) The effect of oxygen on the formation and destruction of the products of incomplete combustion from the combustion of polyethylene and *o*-dichlorobenzene. *Combust. Sci. Technol.*, **101**(1-6), 261-83

Walker, J. (1995a) A personal communication [facsimile transmittal] from John Walker, Ph.D., M.P.H. Executive Director, TSCA Interagency Testing Committee, Environmental Protection Agency, Washington, DC, to Victor Fung, Ph.D., National Cancer Institute, Division of Cancer Biology, 4/26/95

Walker, J. (1995b) Personal communication [facsimile transmittal] from John Walker, Ph.D., M.P.H. Executive Director, TSCA Interagency Testing Committee, Environmental Protection Agency, Washington, DC, to Victor Fung, Ph.D., National Cancer Institute, Division of Cancer Biology, 6/8/95