Canadian Water Quality Guidelines for the Protection of Aquatic Life

IPBC

IPBC (3-iodo-2-propynyl butylcarbamate (CAS number 55406-53-60 and molecular formula $C_8H_{12}INO_2$) is a carbamate compound (Konasewich and Quintin 1994) commonly used as a pesticide with various purposes, an industrial fungicide in paints and adhesives, an antimicrobial in metal-working fluids and on canvas and cordage, and as an antisapstain (Szenasy and Bailey 1996). It is a white crystalline powder with a specific odour. IPBC is highly soluble in organic solvents (e.g., acetone and benzyl alcohol) (Bioassay Systems Corporation 1982) and is moderately soluble in water (156 $mg \cdot L^{-1}$ at 20°C) (Konasewich and St. Quintin 1994). IPBC has a low vapour pressure: <0.002 Pa at 20°C and 0.007 Pa at 30°C (USEPA 1997). The log octanol–water coefficient (log K_{ow}) has been estimated at 2.81 (MRI 1990). IPBC is not likely to complex or absorb with suspended solids or sediments and is more likely to remain in the dissolved phase (Szenasy and Bailey 1996).

IPBC has received full registration in Canada for use as a material preservative in paints, adhesives, caulking, etc., and temporary full registration for use as an antisapstain wood preservative and joining wood preservative (M. Raphael 1998, Pest Management Regulatory Agency, Ottawa, pers. com.). IPBC was used in antisapstain formulations, primarily Kop-Coat NP-1 (7.6% IPBC), at 60% of mills surveyed in British Columbia in 1996 (Environment Canada 1998a). In 1996, lumber mills used 36 020 kg a.i. of IPBC for antisapstain purposes, reduced from the 47 540 kg used in 1993 (Environment Canada 1998a).

The mode of action of carbamate insecticides is primarily through acetylcholinesterase inhibition (Ecobichon 1991). The mode of action of IPBC, a fungicide and antimicrobial ingredient, however, is not clearly known, but may be linked to iodine toxicity (D. Nye 1998, Troy Corporation, Newark, New Jersey, pers. com.). The primary hydrolysis metabolite, propargyl butyl carbamate (PBC), has no iodine and is approximately 1000 times less toxic to fish and invertebrates than IPBC. Although iodine is an essential element, it is considered toxic at higher concentrations. Elemental iodine (I_2) is corrosive to exposed membranes and likely interferes with the permeability of the cell membranes and denatures proteins (Bowen, 1979; Santone and Prowis 1991).

The fate of IPBC in aquatic environments depends largely on physicochemical processes, particularly hydrolysis, rather than biotransformation processes. Microbial degradation is insignificant, due to the antimicrobial properties of IPBC (Schiefer 1990). EPL Bio-Analytical Services Inc. (1990a) reported IPBC to be hydrolytically stable at pH 5 with no signs of degradation, but at pH 7 the half-life was reported to be 139 d, and at pH 9, 0.947 d. Hydrolysis may be the main route of dissipation in aquatic environments, despite the dependence on alkalinity for catalyzation (USEPA 1997). Volatilization is not likely a significant dissipation route (Agriculture Canada et al. 1989), due to IPBC's low vapour pressure and its moderate solubility in water.

As IPBC is not known to be naturally occurring, all IPBC in the environment is expected to be from anthropogenic sources. Sources could include spills and other unpermitted discharges, permitted discharges from commercial facilities using the chemical, and discharges from products treated with IPBC (Henderson 1992). A sampling study initiated by the Fraser River Action Plan (FRAP) was abandoned following repeated sampling attempts at three separate mills using Kop-Coat NP-1, because IPBC concentrations in effluent samples were too low for accurate detection. The on-site dilution study performed used samples spiked with Kop-Coat NP-1 to determine dilution recoveries. IPBC recovery was unaffected by dilution with river water; recoveries reflected those anticipated by dilution calculations with distilled water. Although IPBC may be present at the effluent outfalls, dilution in sizable receiving waters would cause rapid dissipation (Szenasy 1998). Soil and water analysis near a leaking holding dike of a Kop-Coat NP-1 spill found no detectable IPBC where levels were expected to be 760 $mg \cdot L^{-1}$ (Koppers Company Inc. 1987).

Table 1. Water quality guidelines for IPBC for the protection of aquatic life (Environment Canada 1998b).

Aquatic life	Guideline value ($\mu g \cdot L^{-1}$)*
Freshwater	1.9*
Marine	NRG†

*Interim guideline.

†No recommended guideline.

Water Quality Guideline Derivation

The interim Canadian water quality guideline for IPBC for the protection of freshwater life was developed based on the CCME protocol (CCME 1991). For more information, see the supporting document (Environment Canada 1998b).

Freshwater Life

Acute toxicity data were found for six species of fish, ranging from a 96-h LC_{50} of 0.067 mg a.i.·L^{-1} for rainbow trout *(Oncorhynchus mykiss)* (Springborn Laboratories 1990) to a 96-h LC_{50} of 1.9 mg P-100·L^{-1} for coho salmon embryos *(O. kisutch)* (Farrell et al. 1998). Chronic toxicity data were found for only one fish species, the fathead minnow *(Pimephales promelas).* Embryos were exposed to technical grade IPBC in a flow-through system <24 h post-fertilization and were observed for survival at hatch (5 d) and for reduced larval weight and length at 35 d (Springborn Laboratories Inc. 1992). The 5-d LOEC for hatch survival was 0.057 mg·L^{-1}, while the 35-d LOEC for reduced weight gain and growth (length) was 0.019 mg·L^{-1}.

The toxicity of IPBC to invertebrates is represented by two species, *Daphnia magna* and *Hyalella azteca*, ranging from a 48-h LC_{50} of 0.04 mg P-100·L^{-1} (Farrell et al. 1998) to a 24-h LC_{50} of 1.419 mg a.i.·L^{-1} (Inversek Research International 1989), both for *D. magna*.

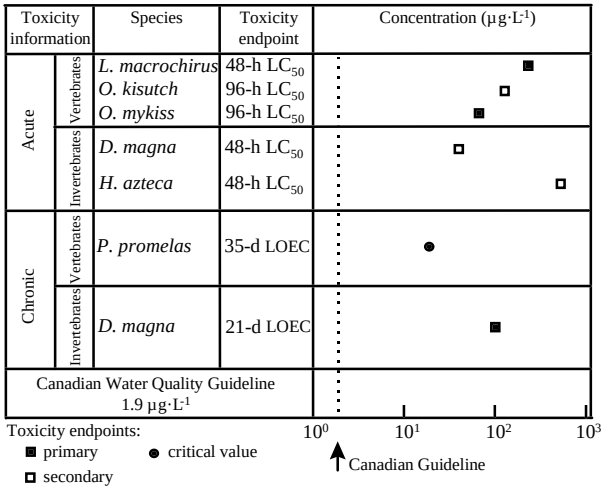

Figure 1. Select freshwater toxicity data for IPBC.

The only plant study located was an exposure of *Chlorella pyreniodosa* in a static replacement system. IPBC was algistatic at 0.5 mg·L^{-1} and algicidal at 1.0 mg·L^{-1} (United States Testing Company Inc. 1988). This study, however, was ranked as unacceptable.

The lowest concentration causing a toxic effect was the 35-d LOEC of 0.019 mg a.i.·L^{-1} for fathead minnows (Springborn Laboratories Inc. 1992). The guideline was derived by multiplying this LOEC by a safety factor of 0.1 (CCME 1991). This calculation results in an interim water quality guideline for IPBC of 1.9 µg·L^{-1} (0.0019 mg·L^{-1}) for the protection of freshwater life

References

Agriculture Canada, Health and Welfare Canada, Environment Canada, Department of Fisheries and Oceans, and Canadian Forestry Service. [1989?]. Discussion document on anti-sapstain chemicals. Draft copy.

Bioassay Systems Corporation. 1982. Acute dermal toxicity study performed on 100% polyphase. Project number 11100. Performed for Troy Chemical Corporation Inc.: Newark, NJ. BSC, Woburn, MA. (Cited in Henderson 1992.)

Bowen, H.J.M. 1979. Environmental chemistry of the elements. Academic Press Inc., New York.

CCME (Canadian Council of Ministers of the Environment). 1991. Appendix IX—A protocol for the derivation of water quality guidelines for the protection of aquatic life. (April 1991). In: Canadian water quality guidelines, Canadian Council of Resource and Environment Ministers. 1987. Prepared by the Task Force on Water Quality Guidelines. [Updated and reprinted with minor revisions and editorial changes in Canadian environmental quality guidelines, Chapter 4, Canadian Council of Ministers of the Environment, 1999, Winnipeg.]

Ecobichon, D.J. 1991. Toxic effects of pesticides. In: Casarett and Doull's. Toxicology: The basic science of poisons, 4th ed., M.O. Amdur, J. Doull, and C.D. Klaassen, eds. McGraw-Hill, New York.

Environment Canada. 1998a. 1996 BC antisapstain chemical inventory summary report, April 1998. Environment Canada, Pacific and Yukon Region, Vancouver.

———. 1998b. Water quality guidelines for the protection of freshwater life for 3-iodo-2-propynyl butyl carbamate (IPBC). Supporting document. Environment Canada, Environmental Quality Branch, Ottawa. Unpub. draft doc.

EPL Bio-Analytical Services, Inc. 1990. Aqueous hydrolysis of P-100. Laboratory Project Number 147-001. Submitted to Troy Chemical Corporation, Newark, NJ.

Farrell, A.P., E. Stockner, and C.J. Kennedy. 1998. A study of the lethal and sublethal toxicity of Polyphase P-100, an antisapstain fungicide containing 3-iodo-2-propynyl butyl carbamate (IPBC), on fish and aquatic invertebrates. Arch. Environ. Contam. Toxicol. 35:472–478.

Henderson, N.D. 1992. A review of the environmental impact and toxic effects of IPBC. Prepared for Environmental Protection Division, British Columbia Ministry of Environment, Lands, and Parks. Victoria, BC.

Inveresk Research International. 1989. Polyphase P-100 determination of acute toxicity (LC_{50}) to *Daphnia* (48 h, static). Prepared by Inveresk Research International, Musselburgh, Scotland. IRI Report No. 5609. Prepared for Troy Chemical Company, Newark, NJ.

Konasewich, D.E., and O.N.C. St. Quintin. 1994. Antisapstain wood protection recommendations for design and operation. Prepared for Environment Canada and BC MELP. Envirochem Special Projects Inc., North Vancouver, BC.

Koppers Company Inc. 1987. Report: NP-1. Spill data example. Koppers Company Inc., Pittsburgh. (Cited in Henderson 1992.)

MRI. 1990. Analysis of Polyphase P-100 octanol/water partition coefficient (63-11). Final eport. MRI Project No. 9555-F(01). Prepared for Troy Chemical Corporation, Newark, NJ. MRI, Kansas City, MO.

Santone, K.S., and G. Prowis. 1991. Mechanisms of and tests for injuries. In: Handbook of pesticide technology, Vol. 1. General principles, W.J. Hayes, Jr., and E.R. Laws, Jr., eds. Academic Press Inc., New York.

Schiefer, H.B. 1990. Anti-sapstain chemicals: A critical evaluation. Prepared for BC Stakeholder Forum on Sapstain Control. Toxicology Research Centre, Saskatoon, SK.

Springborn Laboratories Inc. 1990. Troysan Polyphase P-100—Acute toxicity to rainbow trout *(Oncorhynchus mykiss)* under flow-through conditions. SLI Report No. 90-03-3261. Prepared for Troy Chemical Company, Newark, NJ.

———. 1992. Troysan Polyphase P-100—Toxicity to fathead minnow *(Pimephales promelas)* embryos and larvae. SLI Report No. 92-1-4057. Prepared for Troy Chemical Company, Newark, NJ.

Szenasy, E. 1998. Assessing the potential impact of the antisapstains DDAC and IPBC, chemicals of concern in the Fraser River. FRAP Report No. 1998-07. Fraser River Action Plan, Environment Canada, Environmental Conservation Branch, Vancouver.

Szenasy, E., and H. Bailey. 1996. Appendix 2: Report by EVS Environmental Consultants. In: Anti-sapstain chemical technical review. Prepared by Aquatic Environmental Sciences, Envirochem Special Projects Inc., EVS Environment Consultants and Frido Consulting. Prepared for the Subcommittee on Anti-sapstain Chemical Waste Control Regulation Amendments of the BC Stakeholder Forum on Sapstain Control. Vancouver.

United States Testing Company Inc. 1988. Polyphase P-100—Algistatic/algicidal MIC vs. Chlorella. Report No. EO60906A. Prepared for Troy Chemical Company, Newark, NJ.

USEPA (U.S. Environmental Protection Agency). 1997. R.E.D. facts: 3-iodo-2propynyl butylcarbamate (IPBC). USEPA, Prevention, Pesticides and Toxic Substances, Washington, DC.

Reference listing:

Canadian Council of Ministers of the Environment. 1999. Canadian water quality guidelines for the protection of aquatic life: IPBC. In: Canadian environmental quality guidelines, 1999, Canadian Council of Ministers of the Environment, Winnipeg.

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