Australian Government

Department of Health and Aged Care
Australian Industrial Chemicals Introduction Scheme

Carbamic acid, butyl-, 3-iodo-2-propynyl ester (IPBC)

Evaluation statement

22 December 2022

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AICIS evaluation statement

Subject of the evaluation

Carbamic acid, butyl-, 3-iodo-2-propynyl ester (IPBC)

Chemical in this evaluation

Name	CAS registry number
Carbamic acid, butyl-, 3-iodo-2-propynyl ester	55406-53-6

Reason for the evaluation

Evaluation Selection Analysis indicated a potential environmental risk.

Parameters of evaluation

The chemical is listed on the Australian Inventory of Industrial Chemicals (the Inventory). This evaluation considers the environmental risks associated with the industrial use of 3-iodo-2-propynyl butylcarbamate (IPBC).

IPBC has been assessed for the risk to the environment according to the following parameters:

- Default domestic introduction volumes of 100 tonnes (t) per annum
- Industrial uses listed in the 'Summary of Use' section
- Exposure to aquatic environments and soil via release to stormwater and sewage treatment plants (STPs) as a result of consumer and commercial uses.

Summary of evaluation

Summary of introduction, use and end use

The chemical (IPBC) may be used as a fungicide and preservative in the following industrial products according to international use data:

- Adhesive and sealant products
- Apparel and footwear care products
- Arts, crafts and hobby products
- Lubricant and grease products
- Personal care products - limited environmental release
- Paint and coating products
- Plastic and polymer products
- Fabric, textile and leather products not covered by other end uses
- Ink, toner and colourant products
- Automotive care products

- Cleaning and furniture care products
- Extractive products not covered by other end uses
- Paper products
- Personal care products not covered by other end uses.

There is no information available on the volumes of IPBC in use in Australia. Data from international jurisdictions indicate that it is registered for industrial use in the European Union (EU) at 10–100 tonnes annually. Total use volume in the Nordic countries (Norway, Sweden, Finland, and Denmark) was 5–512 tonnes per year per country since 2001. IPBC is used in the USA at 20–46 t/year (2017–2020), in Canada at 0–1 t/year, and in Japan at 1–1 000 t/year.

Environment

Summary of environmental hazard characteristics

According to domestic environmental hazard thresholds and based on the available data the chemical is:

- Not Persistent (Not P)
- Not Bioaccumulative (Not B)
- Toxic (T).

Environmental hazard classification

The chemical (IPBC) satisfies the criteria for classification according to the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) for environmental hazards as follows. This does not consider classification of physical hazards and health hazards:

Environmental Hazard	Hazard Category	Hazard Statement
Hazardous to the aquatic environment (acute / short-term)	Aquatic Acute 1	H400: Very toxic to aquatic life
Hazardous to the aquatic environment (long-term)	Aquatic Chronic 1	H410: Very toxic to aquatic life with long lasting effects

Summary of environmental risk

The chemical (IPBC) is a synthetic preservative and biocide. It is used as a preservative in a wide range of consumer and commercial products, including personal care products. It is also used as a film preservative in paints and coatings.

The chemical is not persistent in the environment and has a low potential for bioaccumulation. It is very toxic to aquatic life across all trophic levels, and to terrestrial plants. However, at typical environmental concentrations, IPBC readily degrades into a less harmful substance in waters and soils. While IPBC poses a risk to aquatic ecosystems if emitted in high concentrations, the rapid degradation of the chemical and the resulting reduction in toxicity are expected to mitigate the risk to the environment.

Diffuse releases of IPBC occur to surface waters and soils both directly and indirectly. Direct releases occur through the leaching of treated building facades during rainfall events, while the use of some products containing IPBC, such as personal care products, results in indirect releases via STP. The environmental concentrations of IPBC in waters and soils from both diffuse pathways is expected to be below levels of concern.

Point source releases of IPBC at high concentrations, such as the observed releases from paint manufacturers internationally, have the potential to cause adverse effects in the environment if released without treatment. However, as these releases are expected to occur below concentrations that may affect STP function, STP treatment is expected to reduce the concentrations of these IPBC releases to concentrations below levels of concern.

Conclusions

The conclusions of this evaluation are based on the information described in this statement.

The Executive Director is satisfied that the identified environmental risks can be managed within existing risk management frameworks. This is provided that all requirements are met under environmental, workplace health and safety and poisons legislation as adopted by the relevant state or territory.

Note: Obligations to report additional information about hazards under *Section 100* of the *Industrial Chemicals Act 2019* apply.

Supporting information

Rationale

This evaluation considers the environmental risks associated with the industrial uses of IPBC. This chemical is used as a fungicide and preservative (including film preservative), in personal care products, paints and coatings, textiles, paper, ink, and construction products.

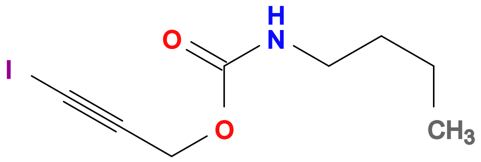
The evaluation selection analysis (ESA) of IPBC found that the industrial use of the substance may be of concern to the environment based on the high toxicity of the chemical to aquatic organisms and potential emissions to surface waters in the treated effluent discharged from sewage treatment plants (STP). This assessment will evaluate the potential for emissions of the chemical to the environment in Australia and whether risk reduction measures are required for industrial uses of this chemical.

Chemical identity

Chemical identity information for IPBC and its main expected environmental degradant, PBC (CAS RN 76114-73-3) are presented below.

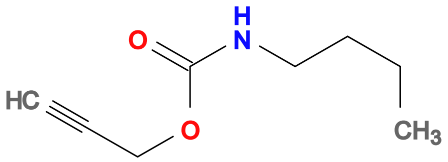
The chemical (IPBC) belongs to a large family of carbamate biocides. The target organisms of these biocides are dependent on the selection of *N*-substituent and *O*-substituent present on either side of the carbamate group, which has given rise to carbamate insecticides, herbicides, and fungicides.

The mode of action of these pesticides is also variable. Carbamate insecticides are generally *N*-methyl carbamates that inhibit acetylcholinesterase (AChE). The *N*-substituent is typically an aromatic moiety in carbamate herbicides, or a benzimidazole moiety in carbamate fungicides such as carbendazim (CAS RN 10605-21-7) (Machemer and Pickel 1994). IPBC is a carbamate ester of 3-iodo-2-propynol, bearing a butyl substituent on the nitrogen atom, however, the toxic mode of action of IPBC is not well understood. It has been proposed that IPBC affects cell membrane permeability in fungi (FRAC 2022):

Chemical name	Carbamic acid, butyl-, 3-iodo-2-propynyl ester
CAS No.	55406-53-6
Synonyms	3-iodo-2-propynyl butylcarbamate IPBC iodopropynyl butylcarbamate (INCI name) Iodocarb 3-iodoprop-2-yn-1-yl butylcarbamate 3-iodo-2-propynyl *N*-butylcarbamate carbamic acid, N-butyl-, 3-iodo-2-propyn-1-yl ester
Structural formula	
Molecular formula	$C_8H_{12}INO_2$
Molecular weight (g/mol)	281.09
SMILES	CCCCNC(=O)OCC#CI

Related chemical

The chemical (IPBC) degrades to carbamic acid, butyl-, 2-propynyl ester, or propargyl butylcarbamate (PBC), in the environment. As such, the physical and chemical properties, and the environmental fate and hazards of PBC are relevant to the environmental risk assessment of IPBC. The chemical identity and properties of PBC are detailed below:

Chemical name	Carbamic acid, butyl-, 2-propynyl ester
CAS No.	76114-73-3
Synonyms	propargyl butylcarbamate (PBC) prop-2-yn-1-yl butylcarbamate 2-propynyl *N*-butylcarbamate butylcarbamic acid propargyl ester
Structural formula	
Molecular formula	$C_8H_{13}NO_2$
Molecular weight (g/mol)	155.19
SMILES	CCCCNC(=O)OCC#C

Relevant physical and chemical properties

Measured physical and chemical properties for IPBC were obtained from the registration dossier for 3-iodo-2-propynyl butylcarbamate submitted under the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) legislation in the European Union (REACHa n.d.), and from the PubChem compound summary for 3-iodo-2-propynyl butylcarbamate (NCBI n.d.). Measured physical and chemical properties for PBC were obtained from the REACH dossiers for carbamic acid, N-butyl-, 2-propyn-1-yl ester (REACHb n.d.; REACHc n.d.). The Henry's Law constants for both chemicals were calculated (calc.) from the experimental (exp.) values for water solubility and vapour pressure using EPISuite (US EPA 2017):

Chemical	IPBC	PBC
Physical form	Solid	Liquid
Melting point	66°C (exp.)	-2°C (exp.)
Boiling point	Decomposition before boiling	224°C (exp.)
Vapour pressure	0.0038 Pa (20°C, exp.)	4.7 Pa (20°C, exp.)
Water solubility	168 mg/L (20°C, exp.)	4900 mg/L (20°C, exp.)
Henry's law constant	6.36×10^{-3} Pa·m^3/mol (20°C, calc.)	0.148 Pa·m^3/mol (20°C, calc.)
Ionisable in the environment?	No	No
pKa	-	-
log K_{ow}	2.81 (25°C, exp.)	1.9 (25°C, exp.)

The chemical (IPBC) is an off white solid that melts at 66°C. It is moderately soluble in water. It has a low volatility from water and when in the solid form.

Its degradation product (PBC) is a liquid at ambient temperature. It is moderately volatile, and readily soluble in water.

Introduction and use

Australia

No specific Australian introduction volume information has been identified.

The chemical has a reported use as a preservative in baby wipes (NICNAS 2013).

The chemical has non-industrial uses in Australia. It is an approved active constituent in pesticides by the Australian Pesticides and Veterinary Medicines Authority (APVMA). Four IPBC-containing products are approved for use by the APVMA for the protection of freshly sawn timber from sapstain and mould, for the dressing of pruning wounds in fruit orchards, and for the prevention of fungal disease in grapevine (APVMA).

International

Available information indicates that IPBC is an antifungal preservative (biocide) and film preservative added to many personal care products, paints and coatings, construction products, cleaning products, and other products worldwide (NCBI; Nordic Council of Ministers; REACHa; US NIEHS).

The chemical (IPBC) is used as a preservative internationally in both leave-on and rinse-off cosmetic and personal care products. The typical IPBC concentration in these products ranges from 0.005 to 0.1%. IPBC is present in some products at concentrations 0.1–5%, with the majority below 0.5%. IPBC is also used in personal care products that are primarily disposed of to landfill (wipes, nail polish).

The chemical (IPBC) is also used in cleaning and washing agents, including automotive care products, cleaning wipes, surface cleaners, and toilet cleaners. It is used in leather treatment products and shoe polish.

The chemical is used as a preservative and film preservative in surface coatings, construction products, and arts, crafts, and hobby products. This use encompasses paints, primers, lacquers and varnishes, adhesives and binding agents, sealants and fillers, surface treatment products, corrosion inhibitors, lubricants and additives, and various materials used for construction. IPBC is used in these products at concentrations ranging from 0.1 to 15%, with the majority below 1%.

The chemical is also used to preserve wood, cans, textiles, rubber, plastics, (metal) cutting fluids, oil recovery drilling mud/packer fluids, paper, and ink. It may be applied to heating, ventilation, and air conditioning (HVAC) ducts to prevent microbial growth.

Data from international jurisdictions may include industrial and non-industrial uses of IPBC. IPBC is registered under REACH for use in the European Economic Area (EEA) at up to 100 tonnes annually (REACHa n.d.). This registration volume does not include biocidal uses regulated under the Biocidal Products Regulation (BPR) (ECHAa). However, some of these uses, including uses in “Product Type 6” (Preservatives for products during storage) and "Product Type 13” (Working or cutting fluid preservatives), are categorised as industrial uses in Australia. IPBC has been used in the Nordic countries (Norway, Sweden, Finland, and Denmark) at 5–512 tonnes per year per country since 2001 (Nordic Council of Ministers n.d.). These volumes are total introduction volumes per country and include uses not registered under REACH. IPBC was used in the USA at 20–46 t/year between 2017 and 2020, according to data extracted from the 2020 Toxics Release Inventory Factsheet for IPBC (US EPAa). IPBC is used in Canada at 0–1 t/year (OECD), and in Japan at 1–1 000 t/year (NITE).

Existing Australian regulatory controls

Public

The chemical is listed in the *Poisons Standard, Standard for the Uniform Scheduling of Medicines and Poisons (SUSMP)* (TGA 2022) as follows:

Schedule 5

‘3-IODO-2-PROPYNYL BUTYL CARBAMATE (Iodocarb) in preparations containing 10 per cent or less of 3-iodo-2-propynyl butyl carbamate **except**:

a) in aqueous preparations not for cosmetic use containing 10 per cent or less 3-iodo-2-propynyl butyl carbamate; or

b) in cosmetic preparations (other than aerosolised preparations) containing 0.1 per cent or less of 3-iodo-2-propynyl butyl carbamate.'

Schedule 6

'3-IODO-2-PROPYNYL BUTYL CARBAMATE (Iodocarb) **except**:

a) when included in Schedule 5;

b) in aqueous preparations not for cosmetic use containing 10 per cent or less of 3-iodo-2-propynyl butyl carbamate (Iodocarb); or

c) in cosmetic preparations (other than aerosolised preparations) containing 0.1 per cent or less of 3-iodo-2-propynyl butyl carbamate.'

Environment

The chemical IPBC is not subject to specific environmental regulatory controls.

International regulatory status

United Nations

The chemical (IPBC) is not currently identified as a Persistent Organic Pollutant (POP) (UNEP 2001), ozone depleting substance (UNEP 1987), or hazardous substance for the purpose of international trade (UNEP & FAO 1998).

Canada

The Canadian Council of Ministers of the Environment has set an interim long term concentration threshold of 1.9 micrograms per litre (µg/L) for IPBC in the Water Quality Guidelines for the Protection of Aquatic Life (CCME).

European Union

The chemical (IPBC) is approved for use as a biocide under the EU Biocidal Products Regulation ((BPR, Regulation (EU) 528/2012)) for three product types: preservative for products during storage (PT06), wood preservatives (PT08), working or cutting fluid preservatives (PT13) (ECHAa).

The chemical (IPBC) is being reviewed for use as a biocide under the EU Biocidal Products Regulation ((BPR, Regulation (EU) 528/2012)) for the following product types: film preservatives (PT07), fibre, leather, rubber, and polymerised materials preservatives (PT09), construction material preservatives (PT10) (ECHAa).

Restrictions on the use of IPBC as a preservative in cosmetics are listed in the Cosmetic Products Regulation, Annex V. IPBC is not to be used in oral and lip products, body lotion and body cream, and products for children under 3 years of age (except in bath products / shower gels and shampoos). The IPBC concentration must not exceed 0.01% in leave-on products, 0.02% in rinse-off products, and 0.0075% in deodorants and anti-perspirants (EC).

Environmental exposure

The chemical (IPBC) is a synthetic chemical and the occurrence of this substance in the environment stems exclusively from human activity. Industrial uses of IPBC are expected to result in both direct and indirect releases into surface waters and soils.

The chemical is also used as a dry-film preservative in paints, coatings, and other construction materials. During this use, IPBC continuously leaches to the top layer of treated surfaces over time to provide long-term protection from microbial degradation. During rainfall events, IPBC is washed off treated building surfaces to become a component of building run-off (Bollmann et al. 2014; Bollmann et al. 2017; Burkhardt et al. 2012). The building run-off containing this chemical is then discharged directly onto soil and into surface waters through the stormwater drainage systems. These sources may contribute to cumulative diffuse emissions of IPBC into the environment.

Indirect source emissions of IPBC into the environment include “down the drain” disposal of IPBC-containing products. Some IPBC-containing products, such as personal care products, will be washed down drains during typical use, while some paint and adhesive residues may be improperly disposed of down drains. Products that are washed “down the drain” are expected to be treated in municipal STPs.

Factories that manufacture or formulate products containing IPBC, such as those formulating paints, cutting fluids, and personal care products, may release IPBC in wastewater. These wastewaters will be also treated in industrial and municipal STPs.

Once in STP, the removal of IPBC will occur depending on specific degradation and partitioning processes. IPBC that is not removed during these processes will be released to rivers or oceans in STP effluent. As some IPBC may adsorb to STP sludge, application of STP biosolids to land may be considered an exposure route for soil organisms (Struijs 1996).

Non-industrial uses of IPBC are also expected to contribute to emission sources into the environment. IPBC-containing products are registered with the Australian Pesticides and Veterinary Medicines Authority (APVMA) for use as antifungal and anti-sapstain agent on freshly sawn timber, in fruit orchards, and in vineyards. Release from these sources will occur to soil, surface waters, and possibly groundwater. The extent of release from non-industrial sources cannot be accurately quantified.

Environmental fate

Partitioning

The chemical (IPBC) is expected to partition to the water and soil compartments when released into the environment.

The chemical (IPBC) is an organic chemical that is neutral in the environmental pH range (pH = 4–9), is moderately soluble in water, and has low volatility. The Henry’s Law constant of 6.36×10^{-3} Pa·m^3/mol suggests that it will be very slightly volatile from water and moist soil. IPBC has moderate lipophilicity with a log K_{OW} value of 2.81. Reported organic carbon adsorption coefficients (K_{OC}) of 61–309 L/kg, depending on the type of soil, indicate it will have medium to high mobility in soil. IPBC adsorption does not appear to be highly correlated with soil organic matter content, clay content or cation exchange capacity, although differences in relative adsorption between soils may be related to differences in the extent of test item degradation (ECHAb; REACHa). In a monitoring study of biocides in surface waters, a significant proportion of the detected IPBC was found in suspended particulate (i.e., attached to particles in the water) rather than in the dissolved state (Paijens et al. 2020; Paijens et al. 2021).

Calculations with a standard multimedia partitioning (fugacity) model assuming equal and continuous distributions to the water and soil compartments (Level III output), predict that IPBC will mostly partition to water (65.3–66.1%, depending on K_{OC}), some will remain in soil (33.8–34.6%), and negligible quantities will partition to sediment (<0.1%). Following release to surface waters in STP effluent, calculations with a fugacity model with sole release to the water compartment predict that IPBC will mostly remain in water (99.9%), and very small quantities will partition to sediment (0.1%) (US EPA 2017).

IPBC is expected to degrade into propargyl butylcarbamate (PBC) and iodine species in the environment through abiotic and microbial processes. Fugacity modelling suggests that the partitioning of the PBC degradant between the environmental compartments will be similar to the partitioning of IPBC.

Degradation

The chemical IPBC is expected to undergo rapid primary degradation at environmentally relevant concentrations in water/sediment systems, and in soil. The primary degradation product, PBC, is expected to undergo further degradation.

Biodegradation studies on IPBC and PBC have been hindered by the toxicity of the chemicals to micro-organisms (Carbajo et al. 2015; REACHa). Degradation of IPBC and PBC in ready biodegradability screening tests in water, following OECD Test Guidelines (TG) 301 B and 301 F for IPBC, and OECD TG 301 F for PBC, reached 0 to 5% after 28 days. It is likely that the high concentrations of test materials (15–100 mg/L) in these tests had an inhibitory effect on the biosolids (REACHa; REACHb).

Degradation studies performed at environmentally relevant concentrations indicate the chemical is unlikely to persist in the environment. An inherent biodegradability test (OECD TG 302 B, modified Zahn-Wellens/EMPA Test) showed that IPBC degrades rapidly into propargyl butylcarbamate (PBC) in water. The biodegradation process was monitored by specific analysis of IPBC and the degradation product PBC in the aqueous phase and in the biosolids, rather than Dissolved Organic Carbon (DOC) removal. The ratio of inoculum to test material was higher than recommended in the guidelines to avoid a toxic effect of IPBC on the biosolids at higher concentrations, with an initial IPBC concentration of 1 mg/L. In the aqueous phase, the IPBC concentration decreased to 0.9–1.5% of the nominal value within two hours of incubation. In these samples, 85–89% of the maximum theoretical amount of the degradation product PBC were detected. The concentration of PBC in the water phase continuously decreased during the test period and was below the limit of quantification (LOQ) of 0.01 mg/L after 21 days of incubation. No significant amounts of IPBC or PBC were found in the biosolids (REACHa).

Another laboratory study was performed to investigate the biodegradation of IPBC in anaerobic conditions in a water/sediment system. IPBC underwent rapid primary degradation with a half-life of 1.5 hours. The major identified degradation product was PBC, which also degraded with a half-life of 11.5 days (REACHa).

Both IPBC and PBC degrade rapidly in soil at 22°C. A laboratory study was performed to investigate the aerobic soil metabolism of IPBC at temperatures of 22°C and 5°C. The initial IPBC concentration was 1 mg/kg of soil. IPBC rapidly degraded in soil at 22°C with a half-life of 2.13 hours. The primary soil metabolite was propargyl butyl carbamate (PBC). PBC further degraded in soil at 22°C with a half-life of 4.30 days. IPBC degradation was slowed at 5°C, resulting in a soil half-life of 8.60 hours. The rate of PBC degradation decreased to a greater extent than that of IPBC as temperature decreased from 22 to 5°C. Fourteen days after treatment, greater than 60% of the applied ^{14}C had been mineralized to $^{14}CO_2$ at 22°C whereas less than 5% had been mineralized at 5°C. IPBC and PBC degradation in soil is expected to be primarily microbially mediated but nonbiological processes may be involved (Juergensen et al. 2000; REACHa).

In another study performed according to OECD TG 217, with an initial IPBC concentration of 10 mg/kg soil, IPBC degraded rapidly in soil with a half-life of 1.05 days. However, the fast degradation in the beginning of the two-phase degradation kinetics was followed by a phase with a nearly constant residual IPBC concentration of 0.013 mg/kg soil (Bollmann et al. 2017).

Samples from soils impacted by IPBC spills of 700–2000 mg/L had undetectable quantities of IPBC (Detection limit 10 mg/L) 28 days following the incident, further supporting the rapid degradation of IPBC in soil (Juergensen et al. 2000).

The chemical (IPBC) was found to be hydrolytically stable in sterile aqueous solutions at ambient temperatures at pH 5 and 7 (ECHAb; REACHa). Conflicting observations were made for IPBC hydrolysis at pH 9: while a short half-life <1 day was measured in one study (REACHa), others reported long half-lives >200 days at this pH (ECHAb).

The chemical (IPBC) may undergo phototransformation in the solid state but appears to be stable to irradiation in water. No phototransformation was observed in sterilised aqueous buffer solution at pH 7 and natural pond water at pH 8.5 within 3 days of continuous irradiation (ECHAb). The decomposition rate of IPBC in wood slices dipped in an IPBC solution reached 25 to 60% after 25 to 50 days of irradiation (ECHAb ; Lee et al. 1991). A comparative study of the photodegradation of four organoiodine wood preservatives in ethanol solution and impregnated into wood showed that IPBC was the most stable to irradiation (Lee et al. 1991).

Both IPBC and PBC are rapidly degraded in the atmosphere by reactions with photogenerated hydroxyl radicals. Atmospheric oxidation modelling indicates that both chemicals have half-lives of approximately 5 hours (US EPA 2017).

Bioaccumulation

The chemical (IPBC) is not expected to bioaccumulate in organisms.

The measured log K_{OW} for IPBC is below the domestic threshold for bioaccumulation potential. A bioconcentration factor (BCF) of < 4.5 L/kg in fish has been reported for this chemical (Juergensen et al. 2000), which indicates a low potential to bioaccumulate. The calculated biotransformation half-life of IPBC normalised to 10 g fish is 23 minutes (US EPA 2017).

Environmental transport

The chemical (IPBC) is unlikely to undergo long-range environmental transport.

The chemical (IPBC) is not persistent in the aquatic environment or in soil and is therefore not expected to undergo long-range transport in water or contaminate groundwaters.

The chemical (IPBC) has a short calculated atmospheric half-life (5 hours), which limits the potential to undergo long-range transport through the atmosphere in the vapour phase. A calculated logarithmic octanol-air coefficient (log K_{OA}) of 9.25 (US EPA 2017) indicates a potential for IPBC to be transported on aerial particles. IPBC was detected in the gas phase in Arctic air samples at a Norwegian background station. However, local contamination sources from the use of the chemical as a wood preservative and uses in cosmetics and personal care products could not be excluded (Röhler et al. 2020; Röhler et al. 2021).

Predicted environmental concentration (PEC)

The estimated environmental concentration of IPBC in inland surface waters is 0.38 micrograms per litre (µg/L), and the PEC in STP influent waters is 150 µg/L, based on international monitoring data. The PEC in soils amended with STP biosolids is 0.11 mg/kg soil dry weight (dw), based on default assumptions on use volumes and release.

No domestic environmental monitoring data were identified. Standard exposure modelling assuming a default introduction volume of 100 tonnes per year, 100% release to sewers, and 68% mitigation within STPs, gives calculated IPBC concentrations of 18 µg/L in STP effluents (Struijs 1996).

However, modelled data appear to be an overestimate based on international STP effluent monitoring data. IPBC has been detected in surface waters, including STP influents and effluents, in several studies conducted in Sweden, France, Switzerland, the Netherlands, and the USA (Guardian et al. 2021; Morasch et al. 2010; NORMAN ; Norstöm 2009; Paijens et al. 2021). While the concentration of IPBC was frequently below the limit of detection, IPBC was detected in surface waters on at least one occasion in each of these studies, at concentrations up to 0.38 µg/L in an STP effluent in Switzerland (Morasch et al. 2010).

The chemical (IPBC) was detected at high concentrations in the influent water to the treatment plants at two paint industries in Sweden (150 and 32 µg/L). The effluent waters from these companies also contained IPBC but at much lower levels, respectively 0.032 and 0.22 µg/L, indicating removal efficiencies of >99% within STPs. The presence of IPBC was monitored at another potential point source, a landfill. IPBC was present at a concentration of 35 nanograms per litre (ng/L) in the landfill leachate prior to treatment but the concentration was below the limit of detection of 10 ng/L after biological treatment (Norstöm 2009).

The chemical has been detected in stormwater runoff sourced from façade leachate from buildings during rain events. IPBC was present in two out of eight sampled rain events (Paijens et al. 2021). IPBC was detected at total concentrations of 3.6–24 ng/L (dissolved state and particles) in an underground stormwater storage pond in Paris (Paijens et al. 2020).

As the measured STP effluent concentration of 0.38 µg/L (Morasch et al. 2010) is the highest measured value of IPBC in STP effluents, surface waters, or stormwater/leachates, it is taken as the worst-case PEC for surface waters. The highest IPBC concentration in an STP influent (150 µg/L) (Norstöm 2009) is used as the PEC for wastewaters entering STPs.

Very limited monitoring data in soil are available. In one study, façade leachates and soil samples from the bottom of the façades of 17 recently built or renovated houses in Denmark were analysed for biocides. IPBC was detected in the façade leachates of some houses, but was below the detection limit of 0.9 µg/kg soil in all soil samples (Bollmann et al. 2017).

The calculated PEC in soil amended with biosolids is 0.11 mg/kg soil dw at the time of application, based on an influent concentration of 56 µg/L (calculated assuming a default introduction volume of 100 t/year and 100% release to sewer), 3% partitioning of IPBC to biosolids in STPs, typical biosolids application rates and a soil bulk density of 1 500 kilograms per cubic metre (kg/m^3) (EPHC 2009; Struijs 1996). The concentration of IPBC in soil is expected to drop rapidly after application based on half-lives of 2–9 hours in soil at 5–22°C (REACHa).

Environmental effects

The chemical (IPBC) causes long lasting toxic effects at low concentrations in aquatic organisms across multiple trophic levels. IPBC is also toxic to some terrestrial organisms, particularly plants.

Effects on Aquatic Life

Acute toxicity

Acute toxicity data are available for 15 species of freshwater, marine, and euryhaline aquatic organisms, including fish, invertebrates, and algae (Adam et al. 2009; Coors et al. 2012; Coors et al. 2014; Farrell et al. 1998; REACHa; US EPAb). The following are the most sensitive acute median lethal concentrations (LC50) for fish and invertebrates and median effect concentrations (EC50) on growth rate for algae measured after standard exposure times (96 h for fish, 48 h for invertebrates, 72 h for algae), retrieved from the REACH dossier for IPBC (REACHa) and from the literature (Farrell et al. 1998). Relevant endpoints (EC50 and the concentration at which 10% inhibition is observed, EC10) for the toxicity of IPBC to aquatic micro-organisms are also reported in the table (Carbajo et al. 2015; REACHa):

Taxon	Endpoint	Method
Fish	96h LC50 = 67 µg/L	*Oncorhynchus mykiss* (rainbow trout) mortality Flow-through conditions EPA OPP 72-1
Invertebrate	48h LC50 = 40 µg/L	*Daphnia magna* (water flea) mortality Semi-static conditions Nominal concentrations (within 30% of the measured concentrations) EPA Guidelines
Algae	72h EC50 = 53 µg/L	*Desmodesmus subspicatus* (green algae) growth rate Static conditions OECD TG 201
Aquatic micro-organisms	24h EC50 = 119 µg/L	*Tetrahymena thermophila* (ciliate) biomass Standard Operational Procedure Guideline of Protoxkit F^{TM}
STP microflora	3h EC50 = 26 mg/L 3h EC10 = 6 mg/L	STP biosolids Respiration inhibition OECD TG 209

The chemical (IPBC) is very toxic to all aquatic organisms. All acute LC50 values for fish are below 1 mg/L. The endpoints for freshwater fish range from 67 µg/L for rainbow trout (*Oncorhynchus mykiss*) to 0.43 mg/L for zebra fish (*Danio rerio*). For marine and euryhaline fish, LC50 endpoints of 0.37 mg/L for starry flounder (*Platichthys stellatus*) and 0.41 mg/L for sheepshead minnow (*Cyprinodon variegatus*) have been measured (REACHa). IPBC affects fish behaviour and physiology at sub-lethal concentrations. Detrimental effects on the olfactory response of coho salmon (*Oncorhynchus kisutch*) were observed at concentrations as low as 1.3 µg/L (electro-olfactogram amplitude EC50) (Jarrard et al. 2004).

A greater variation in the toxicity of IPBC to invertebrates is observed, with endpoints ranging from 0.023 to 2.9 mg/L. A mobility EC50 of 23 µg/L was measured for the American oyster (*Crassostrea virginica*), although after a longer exposure time (96 h instead of the standard 48 h exposure for invertebrates) (US EPAb). For freshwater invertebrates, the lowest measured endpoint is an LC50 of 40 µg/L for *Daphnia magna* (Farrell et al. 1998), although a range of toxicities were observed in different studies for this species. The least sensitive invertebrate species studied is the opossum shrimp *Neomysis mercedis* with a 48 h LC50 of 2.9 mg/L (Farrell et al. 1998), although a lower 96 h LC50 of 0.090 mg/L was measured for another species of opossum shrimp, *Americamysis bahia* (US EPAb).

The acute toxicity of IPBC to two species of freshwater algae, *Desmodesmus subspicatus* (growth rate EC50 of 53 µg/L) (REACHa), and *Raphidocelis subcapitata* (biomass EC50 of 39 µg/L) (Coors et al. 2014), are in the same range.

The chemical (IPBC) is moderately to highly toxic to aquatic microorganism species found in STPs. The most sensitive species tested is the ciliate *Tetrahymena thermophila*, with an EC50 (growth) of 119 µg/L after 24 h IPBC exposure. The EC50 for bioluminescence inhibition of the bacterium *Vibrio fischeri* after 30 min IPBC exposure is 3.9 mg/L (Carbajo et al. 2015). Ecotoxicity endpoints for the inhibition of total respiration of biosolids from STPs after 3 h IPBC exposure are EC50 values of 26–44 mg/L, and an EC10 of 6 mg/L (Carbajo et al. 2015; REACHa).

The primary degradation product of IPBC is PBC. Based on the available ecotoxicity data, PBC is not expected to contribute significantly to the observed toxicity of IPBC. Measured ecotoxicity endpoints across the three trophic levels for the PBC degradant suggest that it is at least 1 000 times less acutely toxic to aquatic life than IPBC. The following are the most sensitive acute median lethal concentration (LC50) for fish, and median effect concentrations (EC50) on mobility for invertebrates and growth rate for algae, measured after 96 h exposure for fish and algae and 48 h for invertebrates, retrieved from the REACH dossiers for PBC and the Biocidal Assessment Report for the use of IPBC in product-type 8 (ECHAb; REACHb; REACHc; REACHd):

Taxon	Endpoint	Method
Fish	96h LC50 = 85 mg/L (PBC)	*Oncorhynchus mykiss* (rainbow trout) mortality Flow-through conditions US EPA FIFRA 72-1
Invertebrate	48h EC50 = 54 mg/L (PBC)	*Daphnia magna* (water flea) mobility Static conditions OECD TG 202
Algae	96h EC50 > 100 mg/L (PBC)	*Raphidocelis subcapitata* (green algae) growth rate Static conditions Nominal concentrations OECD TG 201

Chronic toxicity

The following measured no-observed-effect concentrations (NOEC) for model organisms across three trophic levels were obtained from the REACH dossier for IPBC and the US EPA ECOTOX database (REACHa ; US EPAb):

Taxon	Endpoint	Method
Fish	35d NOEC = 8.4 µg/L	*Pimephales promelas* (fathead minnow) larval length and weight Flowthrough conditions EPA OPP 72-4
Invertebrates	21d NOEC = 50 µg/L	*Daphnia magna* (water flea) mortality Flowthrough conditions Nominal concentrations OECD TG 202
Algae	72h NOEC = 4.6 µg/L	*Desmodesmus subspicatus* (green algae) growth rate Static conditions Mean measured OECD TG 201

Chronic effects are observed at very low IPBC concentrations, particularly for fish and algae. Fathead minnow larvae exposed to IPBC for 35 days following egg fertilisation have significantly reduced weights and lengths at concentrations ≥ 19 µg/L (lowest observed effect concentration, LOEC) (REACHa). The growth rate of *Desmodesmus subspicatus* is affected by IPBC at concentrations ≥ 10 µg/L (LOEC) (REACHa).

Effects on terrestrial Life

The following measured endpoints were obtained from the REACH dossier for IPBC, the European Commission’s Biocidal Assessment Report for the use of IPBC in product-type 8 (PT8, wood preservatives), the US EPA ECOTOX database, and the literature (ECHAa ; Guimarães et al. 2018; REACHa; US EPAb):

Taxon	Endpoint	Method
Terrestrial plants	21d EC50 = 4.9 mg/kg soil dry weight (dw) 21d LOEC = 1.3 mg/kg soil dw	*Avena sativa* (oat) fresh weight Nominal concentrations OECD TG 208
Annelids	14d LC50 > 1 000 mg/kg soil dw 14d NOEC = 1 000 mg/kg soil dw	*Eisenia fetida* (earthworm) mortality OECD TG 207
Arthropods	28d EC10 = 16 mg/kg soil dw 28d LC10 = 12 mg/kg soil dw	*Folsomia candida* (springtail) reproduction (EC10) and mortality (LC10) OECD TG 232
Birds	8d LC50 > 5620 ppm in diet 14d LD50 = 749 mg/kg organism (org) 21d NOEL = 292 mg/kg org	*Colinus virginianus* (northern bobwhite quail) mortality
Soil micro-organisms	28d EC50 = 312 mg/kg soil dw	Soil microflora inhibition of total respiration Nominal concentrations OECD TG 217

The chemical is highly toxic to terrestrial plants, harmful to springtails, and slightly toxic/practically nontoxic to earthworms and birds.

Endocrine effects/activity

The chemical does not appear to cause adverse effects mediated by an endocrine mode of action, however, the endocrine disruption potential of IPBC is currently under assessment by ECHA (REACHa).

In a study incorporating data from in vitro assays, chemical descriptors, and biological pathways to establish toxicity profiles of human endocrine activity for 309 chemicals, IPBC showed a low to moderate potential endocrine activity in some nuclear receptor binding assays (glucocorticoid receptor, peroxisome proliferator-activated receptor, or pregnane X receptor) and assays on xenobiotic-metabolizing enzymes activity (including cytochrome P450s, aromatase). IPBC showed no significant activity in estrogen receptor, thyroid receptor, or androgen receptor binding assays (Reif et al. 2010).

No evidence of endocrine activity in other organisms was identified. Studies on carcinogenicity and toxicity to reproduction in mice and rats did not show any significant effects of IPBC (REACHa).

Predicted no-effect concentration (PNEC)

The PNEC for aquatic organisms in this evaluation is 0.46 µg/L. The algal 72 hours NOEC value of 4.6 µg/L was used to derive the PNEC for this chemical. An assessment factor of 10 was used as there are sufficient reliable acute and chronic aquatic toxicity data available for three trophic levels.

Based on the most sensitive aquatic micro-organisms tested, the ciliate *Tetrahymena thermophila* with a 24 h biomass EC50 of 0.119 mg/L, and an assessment factor of 10, the PNEC for micro-organisms is 11.9 µg/L (EPHC 2009). However, a more representative PNEC for the microflora in STPs is obtained by considering the ecotoxicity endpoints for biosolids (EC10 = 6 mg/L), and an assessment factor of 10, leading to a PNEC for STP micro-organisms of 0.6 mg/L.

A PNEC of 98 µg/kg for soil was derived from the lowest measured endpoint for terrestrial organisms (EC50 = 4.9 mg/kg dry soil for oat), using an assessment factor of 50, as long-term toxicity tests of two trophic levels (springtail and soil micro-organisms) are available in addition to short-term ecotoxicity data across multiple trophic levels of terrestrial life (EPHC 2009).

Categorisation of environmental hazard

The categorisation of the environmental hazards of the assessed chemical according to domestic environmental hazard thresholds is presented below:

Persistence

Not Persistent (Not P). Based on measured half-lives in water and soil, IPBC is categorised as Not Persistent.

Bioaccumulation

Not Bioaccumulative (Not B). Based on measured log K_{OW} and BCF values below domestic thresholds, IPBC is categorised as Not Bioaccumulative.

Toxicity

Toxic (T). Based on available ecotoxicity values below 1 mg/L and evidence of high chronic toxicity to aquatic organisms, IPBC is categorised as Toxic.

Environmental risk characterisation

The chemical (IPBC) is very toxic to aquatic organisms, including aquatic primary producers such as algae. This toxicity is necessary for the functional use of the substance as preservative and industrial biocide, which involves controlling the growth of unicellular organisms such as bacteria, fungi, and algae. These industrial uses also have the potential to release these biocides directly or indirectly to the aquatic environment, which is of potential concern.

Based on the PEC and PNEC values determined above, the following Risk Quotients (RQ = PEC ÷ PNEC) have been calculated for release of IPBC into surface waters, STPs, and soil:

Compartment	PEC	PNEC	RQ
Surface water	0.38 µg/L	0.46 µg/L	0.83
STP micro-organisms	0.15 mg/L	0.6 mg/L	0.25
Soil (application of biosolids)	0.11 mg/kg	0.098 mg/kg	1.1

Calculated RQ values below 1 for surface waters and STP micro-organisms indicate that IPBC is not expected to pose a high risk to the environment based on estimated emissions, as environmental concentrations are below levels likely to cause harmful effects.

The chemical (IPBC) may be released to STPs as a result of the use as a preservative in consumer products. High STP influent values have also been measured at international STPs receiving industrial liquid waste, mainly from paint manufacturers. However, these influent concentrations have been observed below concentrations that may affect STP micro-organisms. High removal rates within STPs substantially reduce concentrations of IPBC in effluents and mitigate the risk to aquatic life.

The chemical (IPBC) is also released to the environmental waters and soil from the leachate of painted surfaces during rainfall events. Based on the measured concentrations of IPBC in stormwater and in affected soils, this release scenario is unlikely to pose an unreasonable risk to the environment. Additionally, IPBC degrades rapidly in the aquatic environment to form the less toxic chemical PBC, which will further reduce the risk of emissions to the environment.

The use of biosolids on agricultural land may pose a risk to soil organisms based on an RQ of 1.1. However, this RQ is based on an IPBC concentration in biosolids calculated using a default introduction volume of 100 tonnes per year with 100% release to sewer. This is expected to be a conservative upper estimate of the actual amount of IPBC reaching and partitioning to biosolids in STPs. Considering the short half-life of the chemical in soil and intermittent application of biosolids to soil, this pathway is unlikely to pose adverse effects to the environment despite the high toxicity of the chemical to terrestrial plants.

Uncertainty

This evaluation was conducted based on a set of information that may be incomplete or limited in scope. Some relatively common data limitations can be addressed through use of conservative assumptions (OECD 2019) or quantitative adjustments such as assessment factors (OECD 1995). Others must be addressed qualitatively, or on a case by case basis (OECD 2019).

The most consequential areas of uncertainty for this evaluation are:

- Monitoring studies that measure the concentrations of IPBC in Australian influents, effluents, and surface waters are not available. Additionally, studies investigating the leaching of IPBC from painted surfaces have been performed in Europe, with European weather and European paint formulations. Australian weather and paint formulated for use in Australia may differ to these European conditions. However, no information is available that suggests that use of international data is unsuitable for the purposes of this evaluation.

- The chemical (IPBC) has non-industrial uses as an antifungal agent for timber treatment, both in Australia and internationally. Consequently, the environmental monitoring data for IPBC may include releases from non-industrial sources. However, as the total IPBC concentrations are expected to be below levels of concern, further investigation into contributions from non-industrial uses are not currently needed.

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