



Australian Government

Department of Health, Disability and Ageing

Australian Industrial Chemicals Introduction Scheme

Phosphorodithioic acid, mixed O,O-bis(2-ethylhexyl and iso-Bu and iso-Pr) S-[3a,4,5,6,7,7a-hexahydro-4,7-methano-1H-inden-5(or 6)-yl] esters

Evaluation statement (EVA00212)

30 September 2026

Draft



Table of contents

Contents

AICIS evaluation statement (EVA00212).....	4
Subject of the evaluation.....	4
Chemical in this evaluation	4
Reason for the evaluation	4
Parameters of evaluation	4
Summary of evaluation	5
Summary of introduction, use and end use.....	5
Environment.....	5
Proposed means for managing risk.....	6
Environment.....	6
Conclusions	6
Supporting information	7
Chemical identity	7
Relevant physical and chemical properties	10
Introduction and use	11
Australia.....	11
International	11
Existing Australian regulatory controls	11
Environment.....	11
International regulatory status.....	12
United Nations.....	12
European Union	12
Environmental exposure	12
Environmental fate	12

Predicted environmental concentration (PEC)	16
Environmental effects	16
Effects on aquatic life	16
Effects on terrestrial Life.....	18
Effects on sediment dwelling life.....	18
Endocrine effects.....	18
Predicted no-effect concentration (PNEC).....	18
Categorisation of environmental hazard.....	18
Persistence	18
Bioaccumulation	18
Toxicity	18
Environmental risk characterisation	19
References	20

AICIS evaluation statement (EVA00212)

Subject of the evaluation

Phosphorodithioic acid, mixed O,O-bis(2-ethylhexyl and iso-Bu and iso-Pr) S-[3a,4,5,6,7,7a-hexahydro-4,7-methano-1H-inden-5(or 6)-yl] esters

Chemical in this evaluation

CAS name	CAS number
Phosphorodithioic acid, mixed O,O-bis(2-ethylhexyl and iso-Bu and iso-Pr) S-[3a,4,5,6,7,7a-hexahydro-4,7-methano-1H-inden-5(or 6)-yl] esters	255881-94-8

Reason for the evaluation

Evaluation selection analysis indicated a potential risk to environment.

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 uses of the chemical.

The risks posed to the environment associated with the industrial uses of the chemical have been evaluated according to the following parameters:

- Industrial uses listed in the 'Summary of introduction, use and end use' section
- Expected emission to sewage treatment plants (STPs), surface waters, soil and air following industrial uses

The chemical is an *unknown or variable composition, complex reaction products or biological materials* (UVCB) substance. It is comprised of various constituents containing isopropyl (ip), isobutyl (ib) or 2-ethylhexyl (eh) alkyl chains. The UVCB can have constituents with six different combinations of alkyl substituents (see **Chemical identity**). These are referred to in this evaluation as:

- ip-ip constituents
- ip-ib constituents
- ib-ib constituents
- ip-eh constituents
- ib-eh constituents
- eh-eh constituents.

Summary of evaluation

Summary of introduction, use and end use

There is limited available information on the introduction, use and end use of the chemical in Australia.

International use information indicates that the chemical is used in volumes of 10–100 tonnes per year in Europe. The chemical is primarily used as an extreme pressure and anti-wear additive in hydraulic fluids and other lubricants and greases. These products are also used in vehicles and machinery and in processes at industrial sites and in commercial applications.

Environment

Summary of environmental hazard characteristics

Based on the information presented in this evaluation statement and according to the environmental hazard thresholds stated in the Australian Environmental Criteria for Persistent, Bioaccumulative and/or Toxic Chemicals, the chemical is:

- Persistent (P)
- Bioaccumulative (B)
- Toxic (T).

Environmental hazard classification

The chemical satisfies the criteria for classification according to the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) for environmental hazards as follows (UNECE 2017). This evaluation does not consider classification of physical 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

Based on the uses, expected exposure pathways and partitioning properties of the chemical, all environmental compartments may be exposed to the chemical. Use in hydraulic fluids and other lubricants and oils from vehicles, machinery, aircraft and industrial equipment may result in releases to the air, water and soil compartments. Releases to water will also result in the chemical partitioning to the sediment compartment.

Studies on the UVCB chemical indicate that the chemical is persistent and toxic according to domestic thresholds. Information on bioaccumulation is primarily derived from studies on certain constituents. There is insufficient information available to categorise 2-ethylhexyl containing constituents. However, available bioaccumulation information indicates

ip-ip, ib-ib and ip-ib constituents are bioaccumulative according to domestic thresholds. Therefore, as the chemical is a UVCB that is known to contain at least the ip-ip and ib-ib constituents, it is categorised as a persistent, bioaccumulative and toxic (PBT) substance.

Due to their persistence, PBT chemicals have the potential to become widely dispersed environmental contaminants. Once in the environment, persistent chemicals that are also highly bioaccumulative pose an increased risk of accumulating in exposed organisms, and of causing adverse effects. They may also biomagnify through the food chain resulting in very high internal concentrations in higher trophic levels and vulnerable species. As persistent and bioaccumulative chemicals may accumulate and remain in environmental biota over long periods, it is difficult to predict their adverse effects. A safe environmental exposure level cannot be derived for PBT chemicals.

Since the chemical has PBT characteristics, there are potential significant long-term risks to the environment from the manufacture, import and use of the chemical. Given these characteristics, there is a risk to the environment that requires management (see **Proposed means for managing risks**).

Proposed means for managing risk

Environment

Recommendation to Department of Climate Change, Energy, the Environment and Water (DCCEEW)

It is recommended that the chemical be scheduled under the Industrial Chemical Environmental Management (Register) Act 2021 (ICEMR Act), with application of appropriate risk management measures to minimise release to the environment from its introduction and use.

In making the scheduling decision, consideration should be given to the following:

- The chemical is persistent, bioaccumulative and toxic (PBT) according to the domestic PBT criteria. A safe environmental exposure level cannot be derived for PBT chemicals.
- The chemical has known or potential use in products and end uses as listed in the 'Summary of introduction, use and end use' section.

Conclusions

The Executive Director proposes to be satisfied that the identified risks to the environment from the introduction and use of the industrial chemical can most likely be managed.

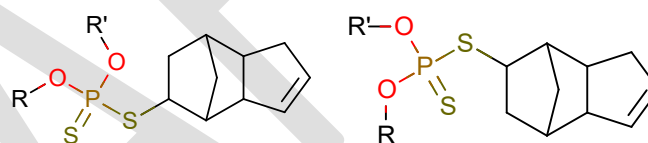
Note:

1. Obligations to report additional information about hazards under section 100 of the *Industrial Chemicals Act 2019* apply.
2. You should be aware of your obligations under environmental, workplace health and safety and poisons legislation as adopted by the relevant state or territory.

Supporting information

Chemical identity

CAS number	255881-94-8
CAS name	Phosphorodithioic acid, mixed O,O-bis(2-ethylhexyl and iso-Bu and iso-Pr) S-[3a,4,5,6,7,7a-hexahydro-4,7-methano-1 <i>H</i> -inden-5(or 6)-yl] esters
Molecular formula	Unspecified
Associated names	S-(tricyclo[5.2.1.0 ^{2,6}]deca-3-en-8(or 9)-yl) O-(2-ethylhexyl or isobutyl or isopropyl) O'-(2-ethylhexyl or isobutyl or isopropyl) phosphorodithioate
Molecular weight (g/mol)	-
SMILES (canonical)	-
Representative structures	



R/R' = isopropyl, isobutyl, 2-ethylhexyl

Additional chemical identity information

The chemical is a UVCB. It contains an organothiophosphate group comprising of two oxygen and two sulfur atoms linked to a central phosphorous atom. One sulfur atom is linked to the norbornane component of a dihydrocyclopentadiene group, the position of which varies, as specified in the names of the constituents ("5(or 6)-yl"). The two oxygens are linked to either isopropyl (ip), isobutyl (ib) or 2-ethylhexyl (eh) chains (structures shown in Figure 1). The UVCB can have constituents with six different combinations of alkyl substituents. For each of these combinations two different regioisomers are possible (Table 1).

Table 1: Details of the UVCB constituents

Constituents abbreviation	Constituent Name	CAS Numbers	Molecular formula	Molecular weight (g/mol)
ip-ip	S-(tricyclo[5.2.1.0 ^{2,6}]deca-3-en-8(or 9)-yl) O-isopropyl O'-isopropyl phosphorodithioate	2869089-91-6 and 2869089-92-7	C ₁₆ H ₂₇ O ₂ PS ₂	346.5
ip-ib	S-(tricyclo[5.2.1.0 ^{2,6}]deca-3-en-8(or 9)-yl) O-isopropyl O'-isobutyl phosphorodithioate	Unknown	C ₁₇ H ₂₉ O ₂ PS ₂	360.6
ib-ib	S-(tricyclo[5.2.1.0 ^{2,6}]deca-3-en-8(or 9)-yl) O-isobutyl O'-isobutyl phosphorodithioate	2869089-93-8 and 2869089-94-9	C ₁₈ H ₃₁ O ₂ PS ₂	374.5
ip-eh	S-(tricyclo[5.2.1.0 ^{2,6}]deca-3-en-8(or 9)-yl) O-isopropyl O'-2-ethylhexyl phosphorodithioate	Unknown	C ₂₁ H ₃₇ O ₂ PS ₂	416.7
ib-eh	S-(tricyclo[5.2.1.0 ^{2,6}]deca-3-en-8(or 9)-yl) O-isobutyl O'-2-ethylhexyl phosphorodithioate	Unknown	C ₂₂ H ₃₉ O ₂ PS ₂	430.7
eh-eh	S-(tricyclo[5.2.1.0 ^{2,6}]deca-3-en-8(or 9)-yl) O-2-ethylhexyl O'-2-ethylhexyl phosphorodithioate	2869089-95-0 and 2869089-96-1	C ₂₆ H ₄₇ O ₂ PS ₂	486.8

The chemical contains ip-ip and ib-ib constituents at concentrations $\geq 0.1\%$ (w/w), with ip-ip constituents reportedly 'largely exceeding' 0.1% (w/w) (ECHA 2021a). No other information on the relative concentrations of constituent classes in the UVCB chemical was identified (ECHA 2021a).

The chemical is likely synthesised through an electrophilic addition reaction of the corresponding phosphorodithioic acid ester (where isopropyl, isobutyl or 2-ethylhexyl groups are present) and dicyclopentadiene (Wu et al. 2022) (Figure 1). The unselective reaction on either side of the dicyclopentadiene double bond leads to the "5(or 6)-yl" regioisomers described above.

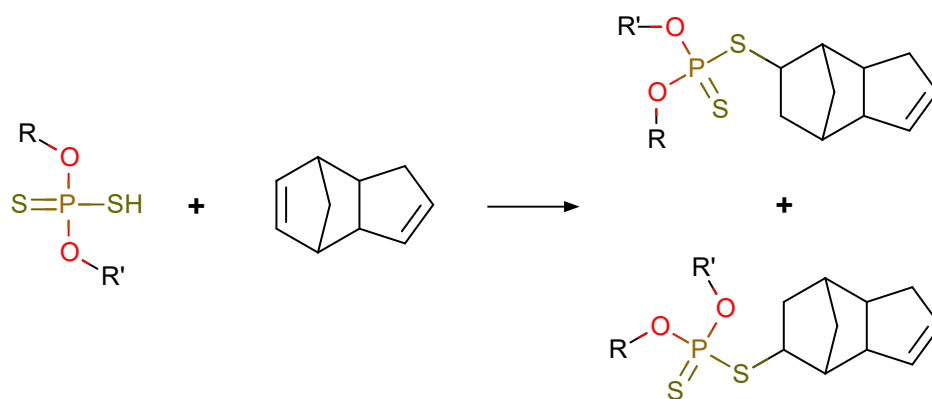


Figure 1: General reaction scheme to produce the chemical. An electrophilic addition reaction occurs between the corresponding phosphorodithioic acid precursor and dicyclopentadiene (CAS number 77-73-6). R/R' groups are any combination of the following: isopropyl, isobutyl or 2-ethylhexyl groups.

While the resulting UVCB chemical could contain other reaction byproducts, based on the CAS name of the chemical, it is expected to be predominantly composed of the six combinations of di-alkyl substituents.

Relevant physical and chemical properties

Measured physical and chemical properties for the UVCB chemical were retrieved from the lead registration dossier for the chemical submitted under REACH legislation in the European Union (EU) and from the ECHA reports for the chemical (ECHA 2021a; ECHA n.d.). In the absence of experimental data physicochemical properties were calculated for the constituents (US EPA 2017) with values for the lowest molecular weight (ip-ip constituents) and highest molecular weight (eh-eh constituents) reported:

Chemical	UVCB chemical	ip-ip constituents	eh-eh constituents
Physical form	liquid	-	-
Melting point	-37°C (exp.)	2°C (calc.)	90°C (calc.)
Boiling point	> 200°C (exp.)	380°C (calc.)	480°C (calc.)
Vapour pressure	10.8 Pa at 20°C (exp.)	0.00338 Pa (calc.)	2.74x10 ⁻⁶ Pa (calc.)
Water solubility	1.4 mg/L at 20°C (exp.)	0.050 mg/L (exp.)	<4x10 ⁻⁷ mg/L (calc.)
Henry's law constant	Range: 19–327 Pa·m ³ /mol (calc.)	19 Pa·m ³ /mol (calc.)	327 Pa·m ³ /mol (calc.)
Ionisable in the environment?	No	No	No
log K_{ow}	5.5–7.9 at 26°C, pH 6 (exp.)	6.1 (calc.)	11 (calc.)
log K_{oc}	-	4.6 (calc.)	7.3 (calc.)

Some experimental endpoints are available for the UVCB chemical. The calculated physiochemical properties for the constituents obtained using EPISuite (US EPA 2017) indicate most physiochemical properties vary significantly from measured values. Therefore, the experimental values may have limited relevance to the physiochemical properties of the UVCB.

The calculation methods used to predict the physicochemical properties of the constituents cannot distinguish between the different regioisomers. As such, only one value has been estimated for each constituent for each property.

As the constituents increase in chain length, the calculated physiochemical properties indicate that the volatility decreases from slightly volatile (ip-ip) to very slightly volatile (eh-eh). Additionally, calculated physiochemical properties indicate that all constituents are very slightly soluble in water (US EPA 2017). Calculated log K_{ow} values (6.1 (ip-ip)–11.0 (eh-eh)) are higher than measured values (5.5–7.9) for the UVCB (ECHA n.d.).

The Henry's law constant values calculated using the bond method range from 19 (ip-ip) to 327 Pa·m³/mol (eh-eh).

Introduction and use

Australia

Limited Australian use, import or manufacturing information has been identified.

Ingredient information via safety data sheets (SDS) indicates that the chemical may be present in lubricant products, such as automotive oil, available for purchase in Australia.

International

Available information indicates that the chemical is used internationally as an extreme pressure and anti-wear additive in lubricants and greases.

The chemical has an estimated use value in Europe of 10-100 tonnes per year (tonnes/year) (ECHA 2021a; ECHA n.d.). Estimated use volumes for Sweden (6.7 tonnes/year), Finland (1.2 tonnes/year), Denmark (0.4 tonnes/year) and Norway (0.1 tonnes/year) are reported on the Substances in Preparations in Nordic Countries (SPIN) database (SPIN n.d.).

In Europe, the chemical is primarily used as an extreme pressure and anti-wear additive in hydraulic fluids and other lubricants and greases. These products are also used in vehicles and machinery and in processes at industrial sites and in commercial applications. Relevant industries include the mineral oil and fuel industry, and the aerospace and defence industries. Lubricants containing the chemical may be applied to work pieces or equipment as part of their reported use in open systems (ECHA 2021a). No consumer use has been identified for the chemical.

The chemical is potentially used as a replacement for zinc (dialkyl)dithiophosphates - ZDDP) such as phosphorodithioic acid, O,O-bis(mixed isobutyl, 2-ethylhexyl, isopropyl) esters, zinc salt (CAS number 85940-28-9) (Mang et al. 2011). ZDDPs are primarily used as an extreme pressure and anti-wear additive in lubricants and grease, specifically in Type HM mineral oil-based hydraulic fluids, where their typical concentrations are $\leq 1.0\%$. Type HM fluids are the largest category of mineral-oil based hydraulic fluids and are used in high pressure uses where component wear is a concern. Small amounts are expected to be eventually discharged to drain or partition with separated oil in any subsequent emulsion-splitting process. Most used oil is reclaimed for use as fuel oil (OECD 2004).

Existing Australian regulatory controls

Environment

The industrial use of the chemical is not subject to any specific national environmental regulations.

International regulatory status

United Nations

The chemical 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 and FAO 1998).

European Union

The chemical has been identified as a Substance of Very High Concern (SVHC) under the REACH legislation, due to PBT properties (ECHA 2021b). It has been recommended for inclusion in Annex XIV (the authorisation list) (ECHA 2025).

Environmental exposure

The main industrial use of the chemical is as an extreme pressure and anti-wear additive in hydraulic fluids and other lubricants and greases. Leakages of hydraulic fluids and other lubricants and greases from vehicles, machinery, aircraft and industrial equipment are expected to be the main contributors to environmental releases of the chemical. These releases may affect the air, water and soil compartments. If the chemical is released to water, the chemical will partition to the sediment.

Likely emissions of chemicals used in lubricant products to the environment are detailed in emission scenario documents for these use patterns (OECD 2004; OECD 2020). Accidental spills and inappropriate disposal may occur and are expected to result in low releases of this chemical to wastewater (OECD 2004). Standard exposure scenarios for these use patterns also indicates that the chemical may be combusted at the end of use along with the oil containing it.

In Australia, the Product Stewardship for Oil (PSO) Scheme incentivises the management, collection and re-refining of used oil. The scheme aims to reduce the use of virgin oils while reducing the environmental harms of improperly disposed oil (DCCEEW 2025). Collection of oils under this scheme is expected to reduce the likelihood of oils, and chemicals in oil, being released to the environment through improper disposal methods.

The consumer disposal of motor oil in Australia is limited (an average of 4% of households reporting disposal, to a maximum of 6.9% in the ACT, (Aither 2013)). This suggests that DIY users of oil may make up a small portion of all users of vehicle maintenance products, and that the vast majority of vehicle maintenance is performed through professional mechanic services. It also indicates that releases from any consumer uses should be minimal. In addition, in Europe, only professional uses are listed for the chemical, indicating that consumer use in automotive lubricant applications is not likely (ECHA 2021a).

Environmental fate

Partitioning

The chemical may be present in all environmental compartments due to release or partitioning processes in the environment. The chemical is a neutral organic chemical with intrinsic constituents that are very slightly soluble in water and moderately to highly volatile

based on calculated physicochemical properties. The Henry's law constant (19–327 Pa·m³/mol) for the smallest (ip-ip) and largest (eh-eh) constituents of the UVCB chemical indicates that the chemical will be moderately to highly volatile from water and moist soil. All constituents are lipophilic, with calculated log K_{OW} values >6.1, and measured data for the UVCB chemical (log K_{OW} 5.5-7.9) indicating that the chemical is also lipophilic. Calculated carbon soil adsorption coefficient (log K_{OC}) for the constituents ranges from 4.6 (ip-ip) to 7.3 (eh-eh), with measured log K_{OC} values varying from 5.57 to >5.63 depending on the constituent that is measured (ECHA 2021a). As all constituents have log K_{OC} values indicating that they will be immobile in soil and will preferentially adsorb to phases in the environment with high organic carbon content (including sediment and soil), the chemical will also have the same partitioning behaviour.

Modelling was also used to estimate partitioning following release to sewers from calculated physical and chemical properties (Struijs 2014). For the most water-soluble component, ip-ip, it is estimated to partition into biosolids (57% for primary treatment and 85% for secondary treatment) and partly remain in water in STPs. A significant proportion of the chemical emitted to surface waters in STP effluents is estimated to further partition to sediment (86% for ip-ip). All other constituents have higher partitioning to sediment (98% for eh-eh). The constituents may be emitted into the soil compartment through the application of biosolids from STP processes where they are expected to remain mostly in soil due to low mobility.

Fugacity modelling following emission to all compartments indicates that for the ip-ip constituent, it will partition into soils (72%) and sediment (19%), with minor partitioning into water (9%) and negligible amounts into air (<0.1%) (US EPA 2017). As all other constituents are less volatile, similar partitioning behaviour is expected for these constituents. Additionally, partitioning is similar when the constituents are modelled for emission to the water compartment only.

Degradation

The chemical is persistent in the environment.

Based on slow hydrolysis rates and experimental ready biodegradation data on the chemical, the chemical is persistent in water. There are no measured half-life data for degradation of this chemical in sediment or soil. The chemical is not expected to be persistent in air based on its calculated half-life.

Abiotic degradation in water

Hydrolysis of the chemical is slow to negligible in environmentally relevant conditions.

A half-life greater than 1 year was estimated at pH 9 by a laboratory study conducted according to the Organisation for Economic Cooperation and Development (OECD) Test Guideline (TG) 111 (ECHA 2021a). A separate test at elevated temperatures (50–70 °C) under Good Lab Practice (GLP) conditions at pH 7 indicates that the substance is unlikely to hydrolyse at environmentally relevant temperatures, with a half-life greater than 60 days (ECHA 2021a; ECHA n.d.).

No data on photodegradation in water were identified.

Biodegradability in water

The chemical was found to be not readily or inherently biodegradable in experimental studies.

All biodegradation studies have nominal concentrations of the chemical above the solubility limit, except the OECD TG 309 study.

Ready biodegradability tests have been conducted with the UVCB chemical under OECD TG 301C and 301D conditions. Overall, all available ready biodegradation test results indicate that the chemical is not readily biodegradable. In the 301C study, the chemical had a biodegradation of 0% (based on BOD measurement) (ECHA 2021a). In the first OECD 301D study from 1987, a degradation of 2% based on oxygen demand was reported (ECHA 2021a). In a modified and extended OECD 301D study from 2011, degradation of the chemical did not reach pass levels. After 28 days, 12% degradation was observed in the replicate with test substance only, while 7% degradation was observed in the replicate with test substance and silicone oil. Higher degradation was observed in replicates with silicone oil and an added emulsifier. The degradation levels in the emulsifier replicates are likely to be an overestimate of actual degradation due to the significant oxygen consumption in the negative control under similar conditions (ECHA 2021a). Even though the reported degradation is an overestimate in some conditions, the pass threshold was not reached in any replicates.

Biodegradation of the ip-ip constituents was investigated in an OECD TG 309 study. Concentrations of the test material were monitored for 91 days at 12 °C in surface water from a river in Germany. Initial concentrations were 10 µg/L and 50 µg/L. Insignificant differences between the tests in river water and the sterile controls indicate that limited biodegradation occurred in the test. No radiolabelling was applied, limiting further analysis of the test results. Given the low number of degradants formed and insignificant differences between river water and sterile control, disappearance of the test material was attributed to dissipation processes rather than biodegradation (ECHA 2021a).

Other compartments

No degradation data were identified for the sediment and soil compartments.

All constituents of the chemical are expected to degrade quickly in the atmosphere through reaction with photogenerated hydroxyl radicals and ozone. Calculations performed assuming a typical hydroxyl radical concentration of 1.5×10^6 molecules/cm³ resulted in half-lives of 0.54–0.62 hours, while an ozone concentration of 7×10^{11} molecules/cm³ resulted in a half-life of 1.4 hours (US EPA 2017).

Bioaccumulation

Some constituents of the chemical are bioaccumulative in fish. Experimental and calculated bioconcentration factors (BCFs) are above Australian categorisation thresholds for bioaccumulation in aquatic organisms (DCCEEW 2022).

Experimental studies of the octanol-water partitioning coefficient using the HPLC method (OECD TG 117) indicate that the log K_{OW} for the UVCB chemical ranges between 5.5 to 7.9 (ECHA n.d.).

Measured steady-state BCFs for common carp (*Cyprinus caprio*) were determined in an OECD TG 305C study in flow through conditions with a mixture of constituents of the chemical: ip-ip, ib-ib and eh-eh in a 1:1:1 ratio, at a low exposure concentration of 50 µg/L and a high exposure concentration of 500 µg/L. Hydrogenated castor oil (HCO-30) was used

as a dispersant at concentrations 20 times the test concentration. A steady state was reached within 6 weeks of exposure for both concentrations. The following lipid-normalised steady-state BCFs were obtained:

- ip-ip: 2,340 L/kg (high exposure)
- ip-ip: 3,794 L/kg (low exposure)
- ib-ib: 816 L/kg (high exposure)
- ib-ib: 2,403 L/kg (low exposure)
- eh-eh: below limit of quantification in fish
 - <5 L/kg (high exposure)
 - <49 L/kg (low exposure)

Measured BCFs at the higher concentration are systematically lower than the lower concentration. It is unknown whether HCO-30 dispersant fully solubilised the constituents at the high exposure concentrations. Undissolved material would be less bioavailable and result in underestimated BCF values from the high exposure test. Consequently, the low-exposure BCFs of 2,403 L/kg and 3,794 L/kg for the ib-ib and ip-ip constituents, respectively, are considered most reliable and indicative of likely bioaccumulation levels in the environment.

Measured BCFs in fish for ip-ip and ib-ib constituents are above 2,000 L/kg. Read-across indicates that BCFs for the ip-ib constituents will also exceed 2,000 L/kg, as their structures are intermediate between the ip-ip and ib-ib constituents. These results for the ip-ip, ip-ib and ib-ib constituents are above Australian categorisation thresholds for bioaccumulation (DCCEEW 2022).

Calculated BCF values for fish according to the Arnot-Gobas model (with and without biotransformation) for the six constituents of the UVCB are above 2,000 L/kg for the ip-ip, ib-ib and ip-ib constituents, and below 2,000 L/kg for the ip-eh, ib-eh and eh-eh constituents. All calculated BAFs for all constituents are above 2,000 L/kg, indicating a potential for all constituents to bioaccumulate in biota from all trophic levels (US EPA 2017). Predictions from the Arnot-Gobas model are highly uncertain for chemicals with log Kow values > 9. The calculated log Kow values for the eh-ip (8.6), eh-ib (9.04), and eh-eh (11.0) constituents are either close to or exceed log Kow = 9, indicating that there is significant uncertainty in the bioaccumulation predictions. Insufficient information is available to categorise the ip-eh, ib-eh, and eh-eh constituents as bioaccumulative.

No bioaccumulation data in terrestrial or air-breathing organisms were identified. All constituents have the potential to bioaccumulate in air-breathing organisms based on calculated partitioning coefficients for air ($\log K_{OA} > 6$) and water (low $K_{OW} > 2$).

Environmental transport

No evidence of long-range transport was found for the chemical. Most of the chemical is expected to partition into sediment/soil, where it will be immobile.

No environmental monitoring studies were identified for the chemical. Monitoring data in remote regions of the world far from sources of release are not available.

The chemical is not expected to undergo long-range transport in air. The chemical has a short predicted atmospheric half-life of 0.54–0.62 hours (US EPA 2017). The chemical may adsorb to particulate matter, and the sorbed fraction may be resistant to atmospheric oxidation. The sorbed fraction is predicted to be between 5% (ip-ip) and 93% (eh-eh), increasing with increasing molecular weight (US EPA 2017).

Predicted environmental concentration (PEC)

No Australian or international monitoring data are available for the chemical.

The chemical has been identified in this evaluation as a PBT substance. It is not currently possible to derive a safe environmental exposure level for the chemical. Therefore, the environmental risks for this chemical cannot be characterised in terms of a risk quotient (RQ). As such, a predicted environmental concentration (PEC) has not been calculated.

Environmental effects

Effects on aquatic life

The chemical causes adverse effects in aquatic organisms, particularly aquatic invertebrates.

Standard ecotoxicity tests conducted according to internationally recognised test guidelines are available. Ecotoxicity data were identified in the following sources:

- REACH registration dossiers (ECHA n.d.)
- Annex XV report (ECHA 2021a).

The chemical is not readily soluble in water, and some of the identified studies were performed in saturated solutions or with the assistance of solubilising agents. The ecotoxicity tests were performed using the UVCB chemical as the test material. However, due to expected differences in water solubilities of constituents in this UVCB and removal of undissolved materials in some tests, the composition of the tested material was likely to be different to the composition of the UVCB. The most water-soluble constituents (such as ip-ip) are expected to be overrepresented in these tests.

Acute toxicity

The following measured median lethal concentration (LC50) and median effective concentration (EC50) values for freshwater model organisms across three trophic levels were retrieved from the above sources:

Taxon	Endpoint	Method
Fish	96 h LC50 = 2.9–10.9 mg/L*	<i>Oncorhynchus mykiss</i> (Rainbow trout) Measured concentrations Acetone used as solubiliser OECD TG 203
Invertebrate	48h EC50 = 0.12 mg/L	<i>Daphnia magna</i> (Water flea) Mobility Nominal concentrations OECD TG 202
Algae	72 h EC50 > 0.23 mg/L	<i>Desmodesmus subspicatus</i> (Green algae) Growth rate Measured concentrations OECD TG 201

* Denotes an endpoint greater than the water solubility of the chemical

In the acute fish study reported above, the LC50 could not be accurately determined due to differences in the start and end concentrations of the test material. However, the results show that the LC50 is above the solubility limit of the chemical.

For invertebrates, two EC50 endpoints are available:

- Toxic effects were observed in *Daphnia magna* with an EC50 of 0.12 mg/L based on the number of immobile and/or floating daphnia (test reported in 1987). The EC50 is based on nominal concentrations. As concentrations decreased up to 4-fold during the test, an EC50 based on time-weighted mean concentrations would be expected to lie between 0.03 mg/L and 0.12 mg/L.
- No toxic effects were observed up to the solubility limit (OECD TG 202 test reported in 2006). A saturated solution of the UCVB chemical was used (nominal concentration 0.13 mg/L). The EC50 was determined to be > 0.077 mg/L based on mean measured test concentrations.

As the chemical is a UVCB, the conflicting results in the above tests may be due to differences in the composition of the tested materials. The EC50 of 0.12 mg/L determined in the older 1987 study is conservatively used to characterise acute effects to *Daphnia* in this evaluation.

The only available algae data is a limit test at a single measured concentration of 0.40 mg/L at the start of the test. It is unlikely that toxic effects were observed as the no observed effect concentration (NOEC) is reported as the test concentration. The concentration declined during testing, which may be due to volatilisation or adsorption of the chemical to glassware. The reported EC50 of > 0.23 mg/L is based on the geometric mean of the measured concentrations.

Daphnia magna is the most sensitive species in acute tests with an EC50 of 0.12 mg/L.

Chronic toxicity

The following measured NOEC values were retrieved for invertebrates and algae:

Taxon	Endpoint	Method
Invertebrates	21 d NOEC = 0.0018 mg/L	<i>Daphnia magna</i> (Water flea) Reproduction Time weighted mean measured concentrations Semi-static OECD TG 211
		<i>Desmodesmus subspicatus</i> (Green algae) Growth rate Measured concentrations OECD TG 201
Algae	72 h NOEC ≥ 0.23 mg/L	

Adverse effects were observed in the OECD TG 211 study within the measured concentration range: 21 d EC50 (immobilisation) = 0.046 mg/L, 21 d EC50 (reproduction) = 0.021 mg/L. The lowest observed effect concentration (LOEC) of 0.0059 mg/L was based on reproduction. As the undissolved test material was removed by centrifugation and the test was continued with the saturated solution that was obtained, it is likely that only the most

water-soluble components were present in the tested solution. The observed endpoints in this study are below the observed water solubility limit for the ip-ip constituent (0.05 mg/L).

Effects on terrestrial Life

There are no suitable data available to evaluate the effects of the chemical on terrestrial organisms.

Effects on sediment dwelling life

There are no suitable data available to evaluate the effects of the chemical on sediment dwelling organisms.

Endocrine effects

There is no available information to suggest that there are endocrine effects for the chemical.

Predicted no-effect concentration (PNEC)

The chemical has been identified as a bioaccumulative and environmentally persistent chemical. When combined, these hazard characteristics have the potential to result in a range of long-term effects on organisms exposed to the chemical, which cannot be readily identified through standard toxicity testing. For such chemicals, it is not currently possible to estimate a safe exposure concentration. Therefore, a PNEC has not been derived for the substance.

Categorisation of environmental hazard

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

Persistence

Persistent (P). Based on half-lives in water above the Australian threshold (60 days) and a lack of mineralisation in biodegradation studies, the chemical is categorised as Persistent.

Bioaccumulation

Bioaccumulative (B). The chemical is a UVCB that is known to contain ip-ip and ib-ib constituents and may contain ip-ib constituents (see **Chemical Identity**). Based on measured and calculated bioconcentration factors (BCF) in fish exceeding 2,000 L/kg for ip-ip, ip-ib and ib-ib constituents, the chemical is categorised as Bioaccumulative.

Toxicity

Toxic (T). Based on available acute ecotoxicity values below 1 mg/L and chronic ecotoxicity values below 0.1 mg/L, the chemical is categorised as Toxic.

Environmental risk characterisation

Available experimental information for the chemical indicates a lack of degradation, as well as toxic effects in aquatic organisms.

Bioaccumulation information for some of the constituents indicates that the chemical is bioaccumulative.

As the chemical is a PBT substance, no PEC or PNEC was calculated. Therefore, no risk quotient has been calculated for this chemical.

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:

- No Australian introduction information or environmental monitoring data are available for the chemical. The likelihood of environmental exposure to the chemical is unknown.
- The composition percentages of the constituents for this UVCB chemical are unknown.
- No ecotoxicity data was identified for the soil and sediment compartments, where the chemical is likely to partition to.

References

- Aither (2013) [*Third independent review of the Product Stewardship \(Oil\) Act 2000*](#), Department of the Environment, accessed 13 Jul 2026.
- DCCEEW (Department of Climate Change, Energy, the Environment and Water) (2022) [*Australian Environmental Criteria for Persistent, Bioaccumulative and/or Toxic Chemicals*](#), DCCEEW, accessed 12 Jan 2026.
- DCCEEW (Department of Climate Change, Energy, the Environment and Water) (2025) [*Product Stewardship for Oil \(PSO\) Scheme*](#), DCCEEW, accessed 13 Jul 2026.
- ECHA (European Chemicals Agency) (2021a) [*Annex XV report*](#), European Chemicals Agency website, accessed 01 Sep 2026.
- ECHA (European Chemicals Agency) (2021b) [*AGREEMENT OF THE MEMBER STATE COMMITTEE ON THE IDENTIFICATION OF S-\(tricyclo\[5.2.1.0^{2,6}\]deca-3-en-8\(or 9\)-yl\) O-\(isopropyl or isobutyl or 2 ethylhexyl\) O-\(isopropyl or isobutyl or 2-ethylhexyl\) phosphorodithioate AS A SUBSTANCE OF VERY HIGH CONCERN under Articles 57 and 59 of Regulation \(EC\) 1907/2006*](#), European Chemicals Agency website, accessed 01 Sep 2026.
- ECHA (European Chemicals Agency) (2025) [*OPINION OF THE MEMBER STATE COMMITTEE ON THE DRAFT 12TH RECOMMENDATION OF THE PRIORITY SUBSTANCES TO BE INCLUDED IN ANNEX XIV OF THE REACH REGULATION AND THE ASSOCIATED ANNEX XIV ENTRIES*](#), European Chemicals Agency website, accessed 07 May 2026.
- ECHA (European Chemicals Agency) CHEM (n.d.) REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) registered dossier for S-(tricyclo(5.2.1.0^{2,6})deca-3-en-8(or 9)-yl O-(isopropyl or isobutyl or 2-ethylhexyl) O-(isopropyl or isobutyl or 2-ethylhexyl) phosphorodithioate, CAS No. 255881-94-8, dossier registration date: 16 Sep 1987, [European Chemicals Agency website](#), accessed 07 May 2026.
- Mang T, Braun J, Dresel W and Omeis J (2012) *Ullmann's Encyclopedia of Industrial Chemistry: Lubricants, 2. Components*, Wiley-VCH, Weinheim.
- OECD (Organisation for Economic Co-operation and Development) (1995) [*Guidance document for aquatic effects assessment*](#), OECD, accessed 07 Jan 2026.
- OECD (Organisation for Economic Co-operation and Development) (2004) [*OECD SERIES ON EMISSION SCENARIO DOCUMENTS Number 10 EMISSION SCENARIO DOCUMENT ON LUBRICANTS AND LUBRICANT ADDITIVES*](#), OECD, accessed 07 Jan 2026.
- OECD (Organisation for Economic Co-operation and Development) (2019) [*Guiding Principles and Key Elements for Establishing a Weight of Evidence for Chemical Assessment*](#), OECD, accessed 07 Jan 2026.
- OECD (Organisation for Economic Co-operation and Development) (2020) [*EMISSION SCENARIO DOCUMENT ON CHEMICAL ADDITIVES USED IN AUTOMOTIVE LUBRICANTS Series on Emission Scenario Documents No. 39*](#), OECD, accessed 07 Jan 2026.

SPIN (Substances in Perparation in Nordic Countries) (n.d.) [SPIN Database](#), SPIN website, accessed 09 Dec 2025.

Struijs J (2014) [SimpleTreat 4.1: A model to predict fate and emission of chemicals in wastewater treatment plants: Background report describing equations](#), National Institute of Public Health and the Environment (RIVM), accessed 09 Dec 2025.

UNECE (United Nations Economic Commission for Europe) (2017) [Globally Harmonized System of Classification and Labelling of Chemicals \(GHS\), Seventh Revised Edition](#), UNECE, accessed 05 Jan 2026.

UNEP (United Nations Environment Programme) (1987) [The Montreal Protocol on Substances that Deplete the Ozone Layer](#), UNEP Ozone Secretariat, accessed 06 Jan 2026.

UNEP (United Nations Environment Programme) (2001) [The Stockholm Convention on Persistent Organic Pollutants](#), UNEP Secretariat of the Stockholm Convention, accessed 06 Jan 2026.

UNEP and FAO (United Nations Environment Programme and the Food and Agriculture Organization of the United Nations) (1998) [Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade](#), UNEP and FAO, accessed 06 Jan 2026.

US EPA (United States Environmental Protection Agency) (2017) [Estimation Programs Interface \(EPI\) Suite™ for Microsoft Windows® \(Version 4.11\)](#), [Computer software], US EPA website, accessed 09 Dec 2025.

Wu Z, Yang Z, Zheng X, Kong Y, Gao C, Jiang T, Zhou X, Wu S and Zhang C (2022) [Dicyclopentadiene phosphorodithioate and preparation method thereof](#), Chinese Patent CN115141224A, China National Intellectual Property Administration.

DRAFT

