Naphthalene: Environment tier II assessment

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Preface

This assessment was carried out by staff of the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) using the Inventory Multi-tiered Assessment and Prioritisation (IMAP) framework.

The IMAP framework addresses the human health and environmental impacts of previously unassessed industrial chemicals listed on the Australian Inventory of Chemical Substances (the Inventory).

The framework was developed with significant input from stakeholders and provides a more rapid, flexible and transparent approach for the assessment of chemicals listed on the Inventory.

Stage One of the implementation of this framework, which lasted four years from 1 July 2012, examined 3000 chemicals meeting characteristics identified by stakeholders as needing priority assessment. This included chemicals for which NICNAS already held exposure information, chemicals identified as a concern or for which regulatory action had been taken overseas, and chemicals detected in international studies analysing chemicals present in babies' umbilical cord blood.

Stage Two of IMAP began in July 2016. We are continuing to assess chemicals on the Inventory, including chemicals identified as a concern for which action has been taken overseas and chemicals that can be rapidly identified and assessed by using Stage One information. We are also continuing to publish information for chemicals on the Inventory that pose a low risk to human health or the environment or both. This work provides efficiencies and enables us to identify higher risk chemicals requiring assessment.

The IMAP framework is a science and risk-based model designed to align the assessment effort with the human health and environmental impacts of chemicals. It has three tiers of assessment, with the assessment effort increasing with each tier. The Tier I assessment is a high throughput approach using tabulated electronic data. The Tier II assessment is an evaluation of risk on a substance-by-substance or chemical category-by-category basis. Tier III assessments are conducted to address specific concerns that could not be resolved during the Tier II assessment.

These assessments are carried out by staff employed by the Australian Government Department of Health and the Australian Government Department of the Environment and Energy. The human health and environment risk assessments are conducted and published separately, using information available at the time, and may be undertaken at different tiers.

This chemical or group of chemicals are being assessed at Tier II because the Tier I assessment indicated that it needed further investigation.

For more detail on this program please visit: www.nicnas.gov.au.

Disclaimer

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Acronyms & Abbreviations

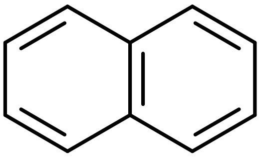
Rationale

This assessment considers the environmental risks associated with the industrial uses of naphthalene. This chemical is the simplest member of a large group of organic chemicals that are collectively identified as ‘polycyclic aromatic hydrocarbons (PAH)’. The Tier I environmental assessments of PAHs on the Inventory found that they all require further assessment. These assessments also indicated that the environmental risk profile of naphthalene is distinctly different from other PAHs. The Tier II environmental risk assessment of naphthalene has, therefore, been conducted separately.

This assessment also provides reference information for environmental assessments of substances on the Inventory that are composed of mixtures of potentially hazardous polycyclic organic chemicals, including PAHs. They include substances obtained by distillation of coal tar such as creosote (CAS RN 8001-58-9), creosote oil (CAS RN 61789-28-4), and distillates, coal tar, naphthalene oils (CAS RN 84650-04-4). The risks to human health from industrial uses of these complex mixtures of PAHs and other polycyclic organic chemicals have already been assessed in the IMAP Human Health Tier II assessment of coal tar distillates (NICNAS, 2015) and other assessments.

Chemical Identity

Synonyms	naphthalin white tar tar camphor

Structural Formula	
Molecular Formula	$C_{10}H_8$
Molecular Weight (g/mol)	128.17
SMILES	c12c(cccc1)cccc2

Physical and Chemical Properties

The physical and chemical property data for naphthalene were retrieved from the Hazardous Substances Bata Bank (HSDB) of the United States National Library of Medicine (HSDB, 2019) and a peer-reviewed research publication (Růžička, et al., 2005):

Physical Form	solid
Melting Point	80.2°C
Boiling Point	217.9°C
Vapour Pressure	10.92 Pa (25°C)
Water Solubility	31 mg/L (25°C)
Ionisable in the Environment?	no
log K_{ow}	3.3

Naphthalene is a solid that readily sublimes into the vapour phase under ambient conditions (HSDB, 2019). This property is a functional requirement for non-industrial uses of naphthalene as a fumigant. The vapour pressure for naphthalene at 25°C presented above is for the solid substance (Růžička, et al., 2005).

Naphthalene is a neutral organic chemical that is moderately soluble in water. The moderately high octanol-water partition coefficient (K_{ow}) for this chemical indicates that it is lipophilic.

Import, Manufacture and Use

Australia

Naphthalene is produced on an industrial scale by distillation of tar feedstocks. It is produced in Australia from coal tar by a single manufacturer located in Newcastle, New South Wales (Koppers Australia, 2018).

Naphthalene is reported to be used as an additive in fuel, lubricants and surface coating products. It also has reported site-limited uses as a dye dispersant and blocking agent in textile processing, as a water reducer in plasterboard manufacture, and as an additive in fragrance formulations (NICNAS, 2015).

According to industry information, naphthalene is used as an industrial intermediate in the manufacture of printing inks, coatings, sealants and marine and automotive aftermarket products such as waxes and polishes.

There are non-industrial uses of naphthalene in Australia which include use as an insecticide and fumigant in moth repellents, use as a plant growth regulator, and use in veterinary chemical products (APVMA, 2007; NICNAS, 2015).

International

The majority of the global production volume of naphthalene is used for the manufacture of phthalic anhydride (CAS RN 85-44-9). This reactive chemical is predominantly used as an intermediate in the production of phthalate ester plasticisers that are used in polyvinyl chloride (PVC) plastics. Naphthalene is also used as an intermediate in the manufacture of azo dyes, surfactants and dispersants, tanning agents, the insecticide carbaryl (CAS RN 63-25-2), and alkylnaphthalene solvents (for carbonless copy paper) (European Chemicals Bureau, 2003; NICNAS, 2015).

Environmental Regulatory Status

Australia

Emissions of polycyclic aromatic hydrocarbons from combustion and thermal processes are subject to reporting under the Australian National Pollutant Inventory (NPI). Facility operators that burn over 400 tonnes of fuel or use over 60 000 megawatt hours of electricity (excluding lighting and motive purposes) per year are required to estimate and report their annual emissions of PAHs. Emissions from diffuse sources, such as lawn mowers and wood heaters, are also periodically estimated by state environment authorities (National Pollutant Inventory, 2019). Emissions of naphthalene resulting from industrial uses of this chemical are not currently required to be reported under the NPI.

Naphthalene is identified as an aquatic toxicant in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality and default guideline values (DGV) for this chemical have been derived (ANZG, 2018). The DGVs for naphthalene and other toxicants provide a tool that water quality managers can use to help ensure that chemical stressors do not exceed harmful levels in waterways. The 95% species protection DGV for naphthalene in freshwater is 16 micrograms per litre (µg/L). The 95% species protection DGV for naphthalene in marine waters is 70 µg/L and the 99% species protection DGV is 50 µg/L. The 99% DGV is recommended for *slightly to moderately disturbed* marine ecosystems (ANZG, 2018).

United Nations

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

OECD

Naphthalene is listed as an OECD High Production Volume (HPV) chemical (OECD, 2009). It is produced in volumes greater than 1000 tonnes per year in at least one member country of the OECD. Naphthalene has been sponsored for assessment under the Cooperative Chemicals Assessment Programme (CoCAP) and a Screening Information Data Sheet (SIDS) Initial Assessment Report (SIAR) has been published (OECD, 2003). The chemical was considered to be a low priority for further environmental risk assessment, except when it used for a specific industrial use involving the manufacture of grinding wheels.

Canada

Naphthalene was categorised as not Persistent (not P), not Bioaccumulative (not B), and Inherently Toxic to the Environment (iT) during the Categorization of the Canadian Domestic Substances List (DSL) (Environment and Climate Change Canada, 2019). It is also listed under Schedule 1 (the Toxic Substances List) of the *Canadian Environmental Protection Act 1999* (CEPA) (Government of Canada, 2018).

European Union

Naphthalene has undergone the full registration process for use in the European Union (EU) under the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) legislation (REACH, 2019). The chemical is currently listed on the Public Activities Coordination Tool (PACT) as appropriate for informal hazard assessment and/or risk management option analysis under the SVHC Roadmap. This listing is based on factors which include exposure of workers, high (aggregated) tonnage use, high risk characterisation ratio (RCR), and other exposure/risk based concerns (ECHA, 2018a).

Naphthalene was previously listed on the European Biocidal Products Directive (98/8/EC) as an ingredient in product type 19 - chemical pest attractants and repellents (PT 19: repellents and attractants). The Directive aimed to remove trade barriers between member states and to ensure a harmonized high degree of protection for man and the environment from the use of biocidal products. It was repealed with the introduction of the Biocidal Products Regulation (BPR). Since July 2008, naphthalene has not been permitted to be supplied to the market in the EU in this product type (ECHA, 2018b).

Naphthalene is also listed in Annex II of the EU Pollutant Release and Transfer Register (PRTR) which requires information on naphthalene emissions to be reported. The thresholds triggering a reporting requirement are 100 kg/year for release to air and 10 kg/year for release to water or land (European Environment Agency, 2006).

United States of America

Naphthalene is listed on the United States Environmental Protection Agency (US EPA) Chemical Substance Inventory, established under the Toxic Substances Control Act 1976 (TSCA 1976) (US EPA, 2018). This inventory lists all existing chemical substances manufactured, processed, or imported in the United States that do not qualify for an exemption or exclusion under TSCA 1976. Naphthalene is currently registered as ‘active’ on the Chemical Substance Inventory, which indicates that it has recently been manufactured, imported or processed by industry in the USA (US EPA, 2019).

Naphthalene is listed under the Clean Air Act 1990 (US EPA, 1990a), the Clean Water Act 1972 (US EPA, 1972), and the Resource Conservation and Recovery Act 1976 (US EPA, 1976). These acts regulate air emissions from stationary and mobile sources, discharges of pollutants into waters, and provide authority to control hazardous wastes from ‘cradle-to-grave’.

Environmental Exposure

Naphthalene is emitted to the environment by natural processes and from human activities. In urban areas, the dominant source of naphthalene emissions to the atmosphere is vehicle exhausts.

Naphthalene and other PAHs are generated by the incomplete combustion of organic matter and large quantities of these chemicals are emitted into the environment from bushfires and other combustion processes. In Canada, it has been estimated that 2000 tonnes of PAHs are released into the atmosphere from forest fires annually. This source accounted for 47% of total PAH emissions in Canada (Environment Canada, 1994).

In urban areas, vehicle exhaust is the dominant source of naphthalene emitted to the atmosphere (Batterman, et al., 2012). Naphthalene is a component of gasoline and diesel fuels. Although the majority of naphthalene in fuel is combusted during use, 0.4% of the initial quantity of naphthalene in diesel is not combusted and is emitted in the exhaust. However, the majority of naphthalene in diesel exhaust is produced pyrosynthetically by combustion of the fuel itself (Rhead and Pemberton, 1996). Approximately 620 milligrams (mg) of naphthalene is produced for every kilogram of diesel fuel that is combusted (Nelson, 1989). Non-industrial uses of naphthalene as a household fumigant will also contribute to cumulative emissions of the chemical in urban areas.

Point source emissions of naphthalene to the atmosphere are possible from plants that produce or use the chemical. According to data collected by the US EPA, 230 mg of naphthalene are emitted to air for every kilogram of naphthalene produced or stored (US EPA, 1990b). In Australia, industry implements control measures to reduce emissions to the atmosphere from these sources (Koppers Australia, 2018).

Environmental Fate

Partitioning

Naphthalene is expected to partition primarily to the atmosphere or soil after it is released into the environment.

Naphthalene is a volatile and moderately lipophilic neutral organic chemical that is moderately soluble in water. In surface waters, naphthalene is present in the form of a dissolved solute, in micelles, or absorbed to dissolved or colloidal organic matter (Kirso and Irha, 1998). The Henry's Law constant for the chemical is 46.8 Pa-m^3/mole, which indicates that it is moderately to highly volatile from water and moist soil (HSDB, 2019).

The mean organic carbon normalised adsorption coefficient in soil (K_{oc}) for naphthalene is 871 L/kg based on measurements in seventeen US soils (Howard, 1989). This moderately high value for K_{oc} indicates that naphthalene has a moderate binding affinity for the organic components of soil. The chemical is, therefore, expected to have low mobility in the terrestrial compartment except in sandy soils with low organic carbon content. Based on the mean K_{oc} value, naphthalene is also expected to have a strong tendency to absorb to sediments and to suspended solids in the water compartment (HSDB, 2019).

Calculations with a standard multimedia partitioning (fugacity) model assuming equal and continuous emission of naphthalene to the air, water and soil compartments (Level III approach) predict that the majority of the chemical will partition to soil (86.6%) and water (11.5%) with minor amounts partitioning to air (0.9%) and sediment (1.0%) (US EPA, 2011). Assuming 100% release of naphthalene into air, the fugacity model predicts that 90% of the chemical will partition to the atmosphere. The latter release scenario is considered more likely for industrial uses of this chemical in Australia.

Degradation

Naphthalene is rapidly degraded in the atmosphere and in aerobic surface waters and sediments by natural processes.

Naphthalene is rapidly oxidised in the atmosphere by reactions with hydroxyl radicals. The half-life for indirect photo-oxidation of this chemical is in the range of 2.96 to 29.6 hours and is based on the measured rate of reaction with hydroxyl radicals in air. Direct photolysis in air is not expected to be an important dissipation pathway for naphthalene based on estimated photolysis half-lives in the range of 71 to 550 days (Howard, et al., 1991).

Naphthalene is mineralised under aerobic conditions in surface waters and sediments by microbial degradation. The rate of mineralisation is variable and may not be well predicted by laboratory screening tests. For example, the inherent biodegradability of naphthalene was evaluated using the modified MITI test (OECD 302C), which showed very limited biodegradation (2%) of the chemical over 28 days (NITE, 2017). However, multiple tests using natural surface waters and sediments have demonstrated the potential for rapid biodegradation of naphthalene under more realistic exposure conditions (Howard, 1989). The estimated half-lives for aerobic biodegradation of naphthalene in unacclimated surface water is in the range from less than one day to 20 days. Biodegradation of naphthalene is slower under anaerobic conditions and longer half-lives are estimated for degradation under these conditions (25–258 days) (Howard, et al., 1991). Based on the weight of evidence, naphthalene is considered to be rapidly biodegradable in aquatic ecosystems.

The rate of biodegradation of naphthalene in soil is also variable. However, the chemical is not expected to persist in the soil compartment based on estimated half-lives for biodegradation in the range from 17 to 48 days (Howard, et al., 1991). The chemical is also expected to dissipate from moist soil by volatilization.

Bioaccumulation

Naphthalene has a low to moderate potential to bioconcentrate in fish.

The highest reported bioconcentration factor (BCF) for naphthalene in fish is 895–999 L/kg for sheepshead minnow (*Cyprinodon variegatus*) (Jonsson, et al., 2004). This BCF value is less than the domestic categorisation criterion for bioaccumulation (BCF ≥ 2000 L/kg). The octanol-water partition coefficient for naphthalene (log K_{ow} = 3.3) is also less than the domestic categorisation threshold for bioaccumulation hazards in aquatic organisms (log $K_{ow} \geq 4.2$).

Naphthalene is metabolised and excreted by fish predominately as one polar metabolite (Reichert and Varanasi, 1982). The study monitored the accumulation of orally administered naphthalene in the tissues of English sole(*Parophrys vetulus*) and observed rapid excretion of the chemical when feeding was stopped. The primary metabolite was identified as 1,2-dihydronaphthalene-1,2-diol (CAS RN 7234-04-0). A combination of moderate BCF values and established detoxification processes indicate that naphthalene has a low potential for biomagnification in aquatic life.

In mammals, naphthalene is readily metabolised and excreted as 1-naphthol (CAS RN 90-15-3) or 1,2-dihydronaphthalene-1,2-diol (NICNAS, 2015). Based on its toxicokinetics in mammals, naphthalene is unlikely to biomagnify in terrestrial food webs.

Transport

Naphthalene is unlikely to undergo long range transport based on its short half-life in air.

Predicted Environmental Concentration (PEC)

A PEC was not calculated for naphthalene. The quantity of this chemical released to the environment as a result of its industrial uses are expected to be negligible compared to the quantities that are emitted from other anthropogenic sources and natural sources.

Environmental concentrations of naphthalene are strongly dependent on proximity to urban and industrial areas. For example, the measured ambient air concentrations of naphthalene in the rural areas of Sweden is in the range of 3–98 ng/m^3 (UNEP, 1998). Near urban and industrial areas, the measured concentrations were in the range of 9–193 ng/m^3. Naphthalene concentrations in air of up to 22 400 ng/m^3 have been detected 100 m downwind from a coking coal plant in the USA (UNEP, 1998). Naphthalene has also been detected in roadside soil exposed to vehicle exhaust in Brisbane, Australia. The highest detected level of naphthalene in river water in Norway was 2.09 nanograms per litre (ng/L) (UNEP, 1998).

Environmental Effects

Effects on Aquatic Life

Naphthalene causes acute toxic effects in aquatic organisms by a non-polar narcosis mode of action (ECHA, 2008).

Acute toxicity

The following measured median lethal concentration (LC50) and median effective concentration (EC50) values for freshwater model organisms across three trophic levels were obtained from a review of PAH toxicity data conducted by the National Institute for Public Health and the Environment (Verbruggen, 2012) in the Netherlands:

Taxon	Endpoint	Method
Fish	96 h LC50 = 1.6 mg/L	Experimental *Oncorhynchus mykiss* Flow through mortality test
Invertebrates	48 h EC50 = 1.66 mg/L	Experimental *Daphnia magna* Static, immobility test
Algae	4 h EC50 = 2.82 mg/L	Experimental *Nitzschia palea* Static, photosynthetic assimilation of ^{14}C

Chronic toxicity

The following 10% lethal effect concentration (LC10), 10% effect concentration (EC10), and no-observed-effect-concentration (NOEC) values were obtained from the review of PAH toxicity data conducted by the National Institute for Public Health and the Environment (Verbruggen, 2012):

Taxon	Endpoint	Method
Fish	27 d LC10 = 0.02 mg/L	Experimental *Oncorhynchus mykiss* Flow through, post hatch mortality (early life exposure)
Invertebrates	7 d EC10 = 0.514 mg/L	Experimental *Ceriodaphnia dubia* Renewal, reproductive toxicity observed

Taxon	Endpoint	Method
Algae	24 h NOEC = 1.2 mg/L	Experimental *Scenedesmus subcapitata* Growth inhibition

Effects on Terrestrial Life

Naphthalene has low acute toxicity to mammals exposed by inhalation or ingestion.

The acute toxicity of naphthalene in mammals is species specific. The acute median lethal dose (LD50) for rats is > 2000 mg/kg body-weight (bw), but 533–710 mg/kg bw in mice (European Chemicals Bureau, 2003). Toxic effects by inhalation were observed in rats exposed to naphthalene vapour concentrations of 0.4 mg/L (OECD TG 403, (NICNAS, 2015)), but no mortality was observed. The exposure concentrations in these studies far exceed any environmental concentrations that are likely as a result of known industrial uses of this chemical and they are not considered to be environmentally relevant.

Naphthalene has non-industrial uses as an insecticide and insect repellent and concentrated exposure to naphthalene in the vapour phase in indoor exposure situations is toxic to invertebrates (Gervais, et al., 2010). It is also toxic to some invertebrates exposed in soil. For example, the median lethal concentration for the soil-dwelling invertebrate, *Folsomia candida*, exposed to naphthalene is 11.2 mg/kg soil (Droge, et al., 2006).

Predicted No-Effect Concentration (PNEC)

PNECs for naphthalene have not been calculated.

The DGVs published for naphthalene in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality provide suitable alternative water quality standards for the protection of aquatic ecosystems and they should be used when aquatic exposure to naphthalene is a significant concern (ANZG, 2018).

Categorisation of Environmental Hazard

The categorisation of the environmental hazards of naphthalene according to domestic environmental hazard thresholds is presented below (EPHC, 2009; NICNAS, 2017):

Persistence

Not Persistent (Not P). Based on the rapid photo-oxidation of naphthalene in air and the rapid biodegradation of the chemical in surface waters and sediments, it is categorised as Not Persistent.

Bioaccumulation

Not Bioaccumulative (Not B). Based on low to moderate bioconcentration factors in fish and evidence of rapid elimination of the chemical and its major metabolite from fish, naphthalene is categorised as Not Bioaccumulative.

Toxicity

Toxic (T). Based on available chronic ecotoxicity endpoint values below 0.1 mg/L, naphthalene is categorised as Toxic.

Summary

Naphthalene is categorised as:

- Not P
- Not B
- T

Risk Characterisation

Risk quotients (RQs) have not been calculated for this chemical.

The emission of naphthalene to the environment in Australia from its known industrial uses is expected to be negligible compared with other anthropogenic emission sources and natural emissions. It will partition to the air or soil compartment depending on the route of release. The chemical is not expected to persist in either compartment as it is rapidly degraded by natural processes. It has a low potential to biomagnify in aquatic and terrestrial food webs and has moderate toxicity to aquatic life.

Key Findings

Naphthalene is produced in Australia and has identified industrial uses as an additive to fuel and lubricants. Emissions from these industrial uses are negligible compared to emissions resulting from vehicle exhaust and natural sources.

Naphthalene is rapidly degraded in the environment under aerobic conditions and has a low to moderate potential to bioconcentrate in fish. Natural detoxification mechanisms in higher order organisms limit the potential for biomagnification of naphthalene in food webs. The chemical has moderate aquatic toxicity and it has been identified as an aquatic toxicant in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality. There are default guideline values available for naphthalene which can be used by water quality managers where it is necessary to manage the environmental impacts of this toxicant on aquatic ecosystems.

The chemical is not a PBT substance according to domestic environmental hazard criteria.

Recommendations

No further assessment of this chemical under the IMAP framework is required.

Environmental Hazard Classification

In addition to the categorisation of environmental hazards according to domestic environmental thresholds presented above, the classification of the environmental hazards of naphthalene according to the third edition of the United Nations' Globally Harmonised System of Classification and Labelling of Chemicals (GHS) is presented below (UNECE, 2009):

Hazard	GHS Classification (Code)	Hazard Statement
Acute aquatic	Category 2 (H401)	Toxic to aquatic life

Hazard	GHS Classification (Code)	Hazard Statement
Chronic aquatic	Category 2 (H411)	Toxic to aquatic life with long-lasting effects

The classification of the aquatic hazards of naphthalene was performed based on the aquatic toxicity data presented in this assessment. The long-term aquatic hazards of naphthalene were classified considering the weight of evidence on environmental persistence which indicates that this chemical is rapidly degraded in aquatic ecosystems (UNECE, 2009).

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