Nonylphenols: Environment tier II assessment

05 February 2016

CAS Registry Numbers: 84852-15-3, 90481-04-2, 68081-86-7, 11066-49-2, 104-40-5, 25154-52-3, 54181-64-5.

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

Acronyms & Abbreviations

Grouping Rationale

This Tier II assessment considers the environmental risks associated with industrial uses of seven substances comprised of one or more isomers of nonylphenol. These substances have been assessed as a group due to their structural similarities and as the UVCBs in this group are likely to be constitutionally similar. In addition, much of the available ecotoxicity data does not specify the identity of the “nonylphenol” test substance.

The main industrial use for nonylphenols is as intermediates in the production of other chemical substances, such as nonylphenol ethoxylate surfactants. The most significant potential pathway for emission of nonylphenols to the environment is as the result of degradation of these surfactants, which are produced on a large scale for use in consumer products, such as detergents. This use pattern results in release of nonylphenol ethoxylate surfactants into sewage treatment systems where biodegradation can further release nonylphenols into treated effluent and biosolids (de Oude, 1992).

This indirect environmental emission pathway for nonylphenols will be considered during the group assessment of nonylphenol ethoxylate surfactants on the Inventory. The group assessment of nonylphenol ethoxylate surfactants will consider the risks arising from the parent surfactant chemicals in the latter group, and the cumulative effects of their common nonylphenol degradants.

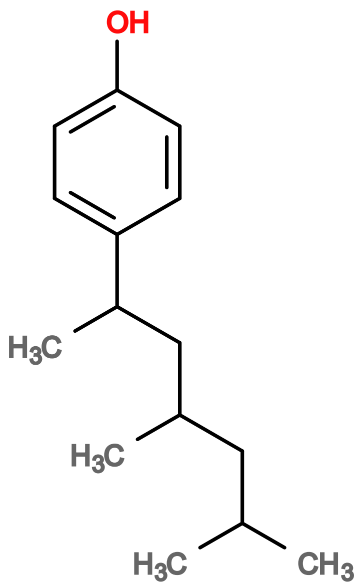
Chemical Identity

Nonylphenol is produced through the alkylation of phenol with nonene. The industrial scale manufacture of nonene is achieved through the oligomerisation of propene. This manufacturing process results in a mixture of branched nonene isomers and technical nonylphenol is therefore a mixture of highly branched nonylphenol isomers. Linear nonylphenol is produced only for laboratory research (APERC, 2016).

The use of an acid catalyst in the production of nonylphenol results in predominant substitution by the branched nonyl group at the *para*- (4-) position of the phenol ring. Hence, branched *para*-substituted nonylphenol isomers are the predominant isomers formed by industrial production methods. In technical nonylphenol mixtures, branched *para*-nonylphenol isomers generally constitute at least 90% of the final product (APERC, 2016).

Branched-chain Isomers

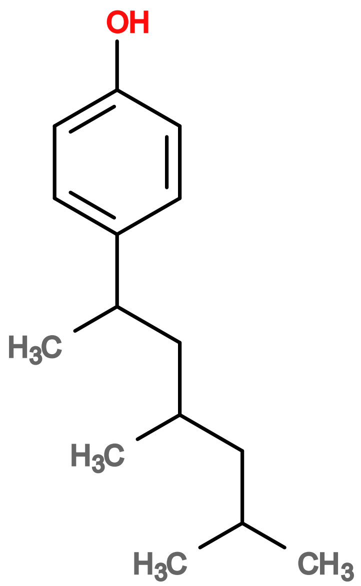
The substance represented by CAS RN 84852-15-3 is a mixture of branched-chain isomers of 4-nonylphenol. Representative chemical identity information is provided. This chemical is often incorrectly identified as one of the two straight-chain nonylphenol substances, CAS RN 25154-52-3 or CAS RN 104-40-5 (US EPA, 2010).

CAS RN	84852-15-3
Chemical Name	Phenol, 4-nonyl-, branched
Synonyms	branched 4-nonylphenol branched *para*-nonylphenol
Representative Structural Formula	
Molecular Formula	$C_{15}H_{24}O$
Molecular Weight (g/mol)	220.35

Representative SMILES	c1(C(C)CC(C)CC(C)C)ccc(O)cc1

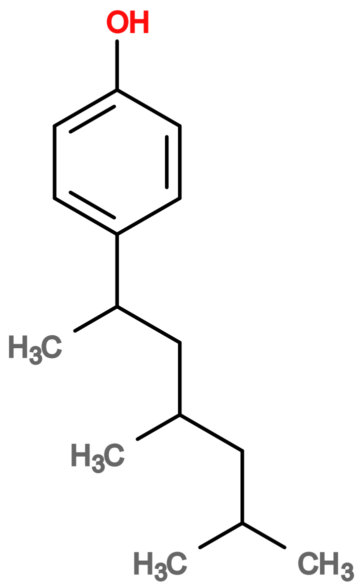
The substance represented by CAS RN 90481-04-2 is a mixture of branched-chain isomers of nonylphenol. The substitution pattern is not specified in the chemical name. However, as discussed above, industrial production of nonylphenol generally results in at least 90% branched *para*-nonylphenol. Representative chemical identity information is provided for this isomer.

As CAS RN 84852-15-3 refers specifically to the branched *para*-nonylphenol isomer, CAS RN 90481-04-2 is rarely used. CAS RN 84852-15-3 is considered more representative of nonylphenols produced and used on an industrial scale (APERC, 2016).

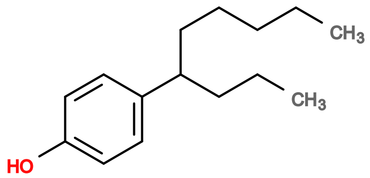
CAS RN	90481-04-2
Chemical Name	Phenol, nonyl-, branched
Synonyms	branched nonylphenol
Representative Structural Formula	
Molecular Formula	$C_{15}H_{24}O$
Molecular Weight (g/mol)	220.35
Representative SMILES	c1(C(C)CC(C)CC(C)C)ccc(O)cc1

The substance represented by CAS RN 68081-86-7 is a mixture of isomers from the alkylation of phenol with nonene. The substitution pattern and branching structure of the alkyl chain is not specified in the chemical name. However, as discussed above, industrial production of nonylphenol generally results in at least 90% branched *para*-nonylphenol. Representative chemical identity information is provided for this isomer.

This CAS RN is rarely used as CAS RN 84852-15-3 is considered more representative of nonylphenols produced and used on an industrial scale (APERC, 2016).

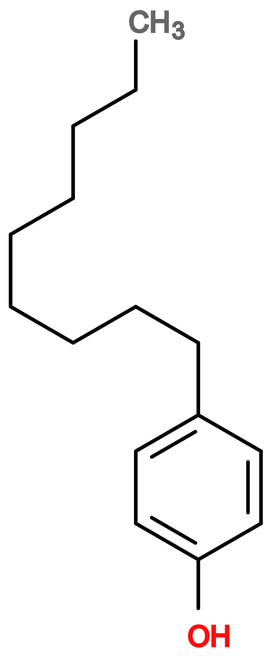
CAS RN	68081-86-7
Chemical Name	Phenol, nonyl derivatives
Synonyms	nonyl phenol derivatives
Representative Structural Formula	
Molecular Formula	$C_{15}H_{24}O$
Molecular Weight (g/mol)	220.35
Representative SMILES	c1(C(C)CC(C)CC(C)C)ccc(O)cc1

The substance represented by CAS RN 11066-49-2 is a mixture of isononylphenol isomers (APERC, 2013). Representative chemical identity information is provided.

CAS RN	11066-49-2
Chemical Name	Phenol, isononyl-
Synonyms	isononylphenol
Representative Structural Formula	
Molecular Formula	$C_{15}H_{24}O$
Molecular Weight (g/mol)	220.35
Representative SMILES	c1(C(CCC)CCCCC)ccc(O)cc1

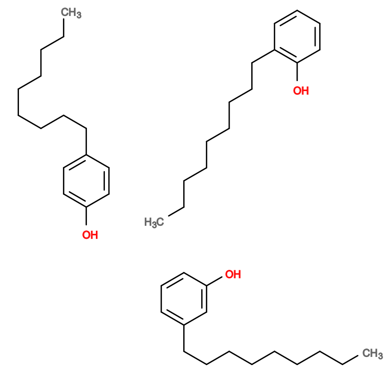
Straight-chain Isomers

CAS RN	104-40-5
Chemical Name	Phenol, 4-nonyl-
Synonyms	4-nonylphenol *para*-nonylphenol
Structural Formula	

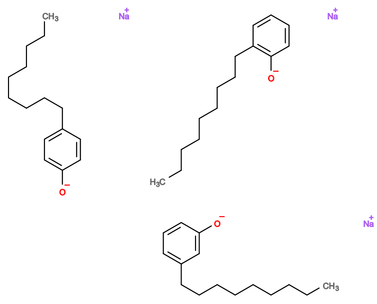
	
Molecular Formula	$C_{15}H_{24}O$
Molecular Weight (g/mol)	220.35
SMILES	c1(O)ccc(CCCCCCCCC)cc1

The CAS RN for this substance was previously used to identify all isomers of nonylphenol. However, this has subsequently been revised (APERC, 2013). Now, the substance represented by CAS RN 25154-52-3 is recognised as a mixture of nonylphenol isomers substituted at the *ortho*- (2-), *meta*- (3-) and *para*- (4-) positions with linear nonyl (C_9) chains (US EPA, 2010).

CAS RN	25154-52-3
Chemical Name	Phenol, nonyl-
Synonyms	nonylphenol
Structural Formula	

	
Molecular Formula	$C_{15}H_{24}O$
Molecular Weight (g/mol)	220.35
SMILES	c1(O)c(CCCCCCCCC)cccc1 c1(O)ccc(CCCCCCCCC)cc1 c1(O)cc(CCCCCCCCC)ccc1

The substance represented by CAS RN 54181-64-5 is a mixture of 1:1 sodium salts of linear chain nonylphenols substituted at the *ortho*- (2-), *meta*- (3-) and *para*- (4-) positions.

CAS RN	54181-64-5
Chemical Name	Phenol, nonyl-, sodium salt
Synonyms	sodium nonylphenolate
Structural Formula	
Molecular Formula	$C_{15}H_{23}NaO$

Molecular Weight (g/mol)	242.33
SMILES	c1([O-])c(CCCCCCCCC)cccc1.[Na+] c1([O-])ccc(CCCCCCCCC)cc1.[Na+] c1([O-])cc(CCCCCCCCC)ccc1.[Na+]

Physical and Chemical Properties

The physical and chemical property data below were retrieved from the European Union Risk Assessment Report for 4-Nonylphenol (Branched) and Nonylphenol (ECB, 2002). It was not reported which isomer(s) of nonylphenol were used in the associated studies. Representative values have been selected, noting that the composition and purity of a given test substance may influence the reported physical and chemical properties:

Physical Form	liquid
Pour Point	-8°C (exp.)
Boiling Point	> 290°C decomposes (exp.)
Vapour Pressure	0.3 Pa (exp.)
Water Solubility	11 mg/L (exp.)
Ionisable in the Environment?	no
log K_{ow}	4.48 (exp.)

Import, Manufacture and Use

Australia

Branched 4-nonyl phenol (CAS RN 84852-15-3) has reported uses in spray adhesive products and nonylphenol (CAS RN 25154-52-3) has reported uses in surface coating products.

No specific Australian use, import, or manufacturing information has been identified for the other chemicals in this group.

International

According to industry information, the production of straight chain nonylphenols is generally considered to be not industrially significant. These isomers are typically produced only for research use (APERC, 2013). The most industrially relevant substance is reported to be the branched 4-nonylphenol (CAS RN 84852-15-3) (US EPA, 2010). The following information is expected to primarily relate to this substance.

Nonylphenols are used internationally as industrial intermediates in the production of other chemicals. Traditionally, they have primarily been used in the production of nonylphenol ethoxylates. In the 1990s, approximately 55–60% of nonylphenols produced in the European Union (EU) were used to manufacture nonylphenol ethoxylates (ECB, 2002). Nonylphenol ethoxylates were widely used as surfactants in a range of products until the early to mid-2000s, when concerns regarding their potential to degrade to nonylphenols in the environment resulted in a significant phase down of their use. No information was identified to indicate the current proportion of nonylphenols used in the manufacture of nonylphenol ethoxylates.

Other uses of nonylphenols include use as monomers in the production of phenol/formaldehyde resins, as intermediates in the production of tri(4-nonylphenyl) phosphite (a polymer stabiliser), in the manufacture of phenolic oximes (used in the extraction of copper from ore), and as catalysts in the curing of epoxy resins (ECB, 2002; US EPA, 2010).

In 2010, demand for nonylphenols in the United States of America (USA) was reported to exceed 170 000 tonnes (US EPA, 2010). This is consistent with use data from the EU, which indicate current use volumes for branched 4-nonylphenol, which is known to be the most widely produced nonylphenol, are in the range 10 000 to 100 000 tonnes per annum (ECHA, 2015a; US EPA, 2010).

Import data from the EU indicate that most nonylphenols used in the EU are produced locally. In 2012, it was reported that production of nonylphenols in China is approximately 50 000 tonnes per annum (Mao, et al., 2012). Therefore, global annual production volumes appear to continue to be significant and potentially exceed 200 000 tonnes.

Environmental Regulatory Status

Australia

The use of the chemicals in this group is not subject to any specific national environmental regulations.

United Nations

None of the chemicals in this group are 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

Nonylphenol (CAS RN 25154-52-3) and branched 4-nonylphenol (CAS RN 84852-15-3) were identified as High Production Volume (HPV) chemicals by the OECD in 2004 and 2007. This indicates that these chemicals were used at more than 1000 tonnes per annum in at least one member country or region (OECD, 2004).

Both of these chemicals have been sponsored for assessment under the Cooperative Chemicals Assessment Programme (CoCAP) by the Netherlands. The 12th Screening Information Dataset (SIDS) Initial Assessment Meeting (SIAM 12) found that both chemicals were candidates for further work (OECD, 2001).

The remaining chemicals in this group have not been sponsored for assessment under CoCAP (OECD, 2013).

Canada

Nonylphenols are listed on Schedule 1 of the *Canadian Environmental Protection Act 1999* (the Toxic Substances List) (Environment Canada, 2013a). Use of nonylphenols has been phased down in Canada since 2004, with most users of nonylphenols required to prepare and implement pollution prevention plans. The majority have met risk management objectives by eliminating the use of these chemicals (Environment Canada, 2014).

One chemical (nonyl phenol derivatives, CAS RN 68081-86-7) was categorised as not Persistent (not P), Bioaccumulative (B), and Inherently Toxic to the Environment (iT_E) by Environment Canada during the Categorization of the Domestic Substances List (DSL) (Environment Canada, 2013b). Two chemicals in this group (sodium nonylphenolate, CAS RN 54181-64-5 and branched nonylphenol, CAS RN 90481-04-2) were not listed on the DSL (Environment Canada, 2013d). The remaining four chemicals in this group were categorised as not P, not B, and iT_E (Environment Canada, 2013b).

European Union

All chemicals in this group are subject to export notification procedures and prior informed consent notification for imports under Regulation No 649/2012 of the European Parliament and of the Council. Importers and exporters of the chemical must notify relevant authorities before transportation of the substance (European Commission, 2012).

Nonylphenol (CAS RN 25154-52-3) is prohibited for use in the EU at concentrations equal to or greater than 0.1% in most cleaning products, or in textile and leather processing, metal working, manufacturing of pulp and paper, cosmetic products and other personal care products under Annex XVII (List of Restrictions) to the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) legislation (ECHA, 2014). Branched 4-nonylphenol (CAS RN 84852-15-3) is currently listed on the Community Rolling Action Plan for evaluation under the REACH legislation based on potential for high environmental exposure (ECHA, 2015c).

Branched 4-nonylphenol (CAS RN 84852-15-3) is currently registered for use in the EU under the REACH legislation. The remaining chemicals in this group have been pre-registered, but have not yet undergone the full registration process (ECHA, 2015a; 2015d).

United States of America

The United States Environmental Protection Agency (US EPA) published an Action Plan for Nonylphenol and Nonylphenol Ethoxylates in 2010. Significant New Use Rules (SNURs) were subsequently proposed for nonylphenol (CAS RN 25154-52-3), 4-nonylphenol and branched 4-nonylphenol, prohibiting new uses without prior approval (US EPA, 2015).

Environmental Exposure

Based on international data, the industrially relevant nonylphenols in this group are expected to be used predominantly as intermediates in the manufacture of other chemicals, or in a manner which results in the chemical being bound in an inert matrix. Environmental release of nonylphenols from use in these industrial applications is expected to be limited, resulting only from processes such as rinsing of manufacturing equipment.

Chemicals released from processes such as cleaning of manufacturing equipment may enter sewage treatments plants (STPs) in waste water. Depending on degradation and partitioning processes of chemicals in STPs, some fraction of the quantity of chemicals in waste water entering STPs can be emitted to the air compartment, to rivers or oceans in treated effluent, or to soil through application of biosolids to agricultural land. Based on the high lipophilicity of nonylphenols, approximately 20% of the total volume of these chemicals entering a typical STP may be removed by adsorption to sludge, which may be applied to land as biosolids (Struijs, 1996). Hence, emissions of nonylphenols to both environmental surface waters and soils are considered as part of this assessment.

Environmental Fate

Partitioning

The chemicals in this group are expected to partition between water and sediment, or remain in soil, when released from industrial uses.

Nonylphenols are neutral organic chemicals that are only slightly to moderately soluble in water, with moderate volatility (ECB, 2002). A Henry's Law constant of 0.11 Pa-m^3/mol, available for nonylphenol (CAS RN 25154-52-3), indicates moderate volatility from water and moist soil (LMC, 2013). The log K_{ow} value available demonstrates high lipophilicity, which suggests limited mobility in soil. This is supported by the estimated soil adsorption coefficients (log K_{oc} > 3.6) for nonylphenols (US EPA, 2008).

Calculations with a standard multimedia partitioning (fugacity) model assuming equal and continuous distributions to air, water and soil compartments (Level III approach) predict that nonylphenols will mainly partition to the soil compartment (approximately 60%), with minor partitioning to the sediment compartment and water compartment (approximately 20% each) (US EPA, 2008). Nonylphenols are expected to remain in the soil compartment if released solely to soil (US EPA, 2008). With sole release to the water compartment, nonylphenols are expected to partition equally between the water and sediment compartments (US EPA, 2008).

Degradation

The chemicals in this group are expected to undergo degradation in the environment.

The biodegradation of technical nonylphenol (assumed to be branched) has been observed to be 62% in 28 days in a study conducted in accordance with OECD Test Guideline (TG) 301 F using inocula from STP receiving predominantly municipal waste, but the 10 day window was not met (ECB, 2002). Other studies have determining varying degrees of biodegradation, from 0% to 53% (ECB, 2002). The biodegradability of nonylphenols is known to vary across isomers (Lu and Gan, 2014). However, the abovementioned study, conducted with technical nonylphenol, is expected to be representative of the isomers typically found in the environment. Previous assessments of nonylphenols have suggested that nonylphenols have not passed other ready biodegradation tests because local microbial populations require acclimation to the substance, resulting in a lag phase.

However, soil studies testing the biodegradation of radio-labelled nonylphenols for durations up to 150 days have indicated that, while concentrations of the parent compound can fall dramatically, less than 10% of the parent chemical undergoes complete mineralisation (Dettenmaier and Doucette, 2007; Kouloumbos, et al., 2008; Shan, et al., 2011). Further studies have identified a stable nitrophenol metabolite in soil/sludge and sediment matrices at levels up to 40% of applied nonylphenol (De Weert, et al., 2009; Kouloumbos, et al., 2008; Telscher, et al., 2005; Zhang, et al., 2009). Varying levels of eventual degradation of this metabolite were observed.

In the atmosphere, nonylphenols are predicted to undergo rapid photo-oxidation by hydroxyl radicals (half life = 2.5 hours) (US EPA, 2008).

Bioaccumulation

The chemicals in this group have a moderate potential to bioconcentrate in aquatic organisms.

Experimental data demonstrate moderate potential for nonylphenols to bioconcentrate in fish. The highest available whole body bioconcentration factor (BCF) for fish is 1200–1330 L/kg, although this value was based on total radioactivity and may include measurement of metabolites. Other studies conducted using various fish species have determined mean whole body BCF values between 220 and 741 L/kg (ECB, 2002). Conversely, bioconcentration values as high as 3300 L/kg have been estimated for mussels (ECB, 2002). However, mussels are recognised as being particularly susceptible to bioconcentration of chemicals due to their feeding behaviour and limited mobility. This results in exposure to the chemical through the water column and sediment, including direct contact and/or resuspension (Zaldivar, et al., 2011). Therefore, values for mussels may not provide a representative measure of general bioconcentration potential.

Biomagnification of nonylphenols in aquatic organisms appears to be limited. Various field studies have indicated that nonylphenol concentrations are lower in fish compared to primary feeders (ECB, 2002; Takeuchi, et al., 2009). Some studies have determined Biomagnification Factors (BMFs) greater than one, indicating biomagnification, in bird/fish prey relationships. Hu et al. (2005) found nonylphenol concentrations in herring gulls to be higher than concentrations in prey (catfish, bartail flathead and white flower croaker), with BMF values between 1.15 and 1.51. In a study also investigating biomagnification in herring gulls, Staniszewska et al. (2014) found mean BMF values between 1 and 4 (maximum 15) when comparing muscle and liver concentrations with those of herring, flounder and cod. However, it is difficult to interpret the results of these studies, as herring gulls often scavenge and dietary nonylphenol may derive from multiple sources. In the absence of further information, these studies are not considered to provide a sufficient weight of evidence in favour of biomagnification of nonylphenols.

Bioaccumulation also appears significant in sediment-dwelling organisms. A 56 day Biota Sediment Accumulation Factor (BSAF) of 24 g carbon/g lipid has been determined for the worm *Lumbriculus variegatus*. The ingestion of sediment was identified as a key exposure pathway in this study. Subsequent field studies for the same species determined BSAF values between 39 and 55 g carbon/g lipid (Croce, et al., 2005). Similar values have been obtained in additional studies (Hecht, et al., 2004; Maenpaa and Kukkonen, 2006). Compared to BSAF values for other organic chemicals, these values appear to indicate significant bioaccumulation potential for nonylphenols in this species (Croce, et al., 2005).

Transport

The chemicals in this group are not expected to undergo long-range transport.

Nonylphenols are readily sorbed to soil and sediment, which is expected to limit their potential to undergo long-range transport in the environment. Although the substances are also soluble in water and moderately volatile, nonylphenols have a relatively short primary half life in water and are rapidly degraded in the atmosphere. No environmental monitoring data were identified to indicate presence in remote areas.

Predicted Environmental Concentration (PEC)

Predicted environmental concentrations were estimated for the chemicals in this group based on available Australian environmental monitoring information.

Standard exposure modelling for the release of chemicals to surface water in STP effluents was used to calculate riverine environmental concentrations (Struijs, 1996). In accordance with the IMAP Framework, a default value of 100 tonnes is allocated for each chemical in this group as the volume that is imported and/or manufactured in Australia annually (NICNAS, 2013). Assuming that the majority of nonylphenols are used as an intermediate in industrial processes, 5% of the introduced quantity of each chemical is estimated to be released to STPs nationwide. Based on these standard calculations, 75% of nonylphenols in waste water entering STP are predicted to be removed as a result of volatilisation, partitioning to sludge, and biodegradation. The resultant PECs for the riverine compartment was calculated to be 1.06 µg/L for each chemical in this group.

These values are supported by measured environmental concentrations of nonylphenols in Australia. However, it is noted that interpretation of these studies can be difficult due to the range of isomers present in the technical mixtures of nonylphenols, and the potential for nonylphenol to be derived from degradation of chemicals which are not in this group (such as nonylphenol ethoxylates). One study has considered levels of nonylphenols at various STPs in South-East Queensland. Branched nonylphenol was reported in effluent at concentrations ranging from 0.056 to 0.34 µg/L (Tan, et al., 2007). Similar studies, also conducted in South-East Queensland, report effluent concentrations of 4-nonylphenol in the range of 0.10 to 2.9 µg/L (Leusch, et al., 2005; Ying, et al., 2009).

Biosolid samples from 13 STPs around Australia have been found to contain 0.35 to 513 mg/kg 4-nonylphenol (Langdon, et al., 2011). Concentrations of 4-nonylphenol in soils subject to long-term biosolid application have been noted to decrease sharply with soil depth internationally (Xia, et al., 2010), consistent with potential rapid primary degradation as outlined above.

Environmental Effects

Effects on Aquatic Life

The chemicals in this group are expected to cause toxic effects at low concentrations in aquatic organisms across multiple trophic levels.

In many of the available data, chemical identity was poorly characterised. Where not otherwise indicated, the test substance was simply referred to as “nonylphenol”.

Acute toxicity

The following measured median lethal concentration (LC50) and median effective concentration (EC50) values for model organisms across three trophic levels were reported in the European Union Risk Assessment Report for 4-Nonylphenol (Branched) and Nonylphenol (ECB, 2002):

Taxon	Endpoint	Method
Fish	96 h LC50 = 0.128 mg/L	Experimental *Pimephales promelas* (Fathead minnow) Flow through
Invertebrates	48 h EC50 = 0.085 mg/L	Experimental *Daphnia magna* (Water flea) Static
	96 h EC50 = 0.069 mg/L	Experimental *Ceriodaphnia dubia* (Water flea) Static Test substance: CAS RN 84852-15-3
Algae	72 h EC50 = 0.323 mg/L	Experimental *Scenedesmus subspicatus* (Green algae) Test substance: CAS RN 25154-52-3 Reduced growth rate observed

Taxon	Endpoint	Method
	96 h EC50 = 0.41 mg/L	Experimental *Selenastrum capricornutum* (Green algae) Test substance: CAS RN 84852-15-3 (95% 4-nonylphenol) Reduced cell growth observed

Chronic toxicity

The following no-observed-effect-concentration (NOEC) and effective concentration for 10% of the test population (EC10) values for model organisms across three aquatic trophic levels were reported in the European Union Risk Assessment Report for 4-Nonylphenol (Branched) and Nonylphenol (ECB, 2002):

Taxon	Endpoint	Method
Fish	28 d NOEC = 0.0595 mg/L	Experimental *Lepomis macrochirus* (Bluegill) Flow-through Mortality observed
	33 d NOEC = 0.0074 mg/L	Experimental *Pimephales promelas* (Fathead minnow) Flow through Test substance: CAS RN 84852-15-3 Decreased survival of embryos
Invertebrates	21 d NOEC = 0.024 mg/L	Experimental *Daphnia magna* (Water flea) Static Test substance: 91.8% nonylphenol, 86.1% 4-nonylphenol Decreased survival of offspring

Taxon	Endpoint	Method
Algae	72 h EC10 = 0.0251 mg/L	Experimental *Scenedesmus subspicatus* (Green algae) Test substance: CAS RN 25154-52-3 Reduced growth rate observed

Studies considering the effects of nonylphenol on Australian species have also been conducted. Holdway et al. (2008) found that 24 hour exposure to nonylphenols reduced fertility in the Australian rainbowfish (*Melanotaenia fluviatilis*). A NOEC of 0.05 mg/L was determined.

Nonylphenols are known to have endocrine activity and cause toxic effects in the reproductive systems of organisms. The chemical binds to the (o)estrogen receptor and mimics the effects of naturally occurring (o)estrogen (Environment Canada, 2002). Some isomers of nonylphenol are more (o)estrogenic than others (Lu and Gan, 2014; Uchiyama, et al., 2008).

In fish, the presence of (o)estrogen induces the release of vitellogenin, which normally plays a role in egg production. The ability for exposure to nonylphenols to significantly increase blood vitellogenin levels in fish in a dose-dependent manner has been well established (ECB, 2002; Environment Canada, 2002). In male fish, the (o)estrogenic activity of nonylphenols manifests in changes in testicular structure (including the development of testis-ova) and reduced testes size (ECB, 2002; Environment Canada, 2002).

In water fleas (*Daphnia* sp.), exposure to nonylphenols has been found to reduce the elimination of testosterone metabolites in a dose-dependent manner. It has been hypothesised that reduced elimination of testosterone metabolites contributes to observed reproductive toxicity, including a decrease in the number of offspring produced and a increase in deformed offspring born to exposed animals (ECB, 2002).

Effects on Sediment-Dwelling Life

Nonylphenols can cause toxic effects in sediment-dwelling organisms.

A 14 d NOEC of 20.1 mg/kg dry weight is available for the midge *Chironomus tentans* (Environment Canada, 2002).

Effects on Terrestrial Life

Nonylphenols can cause toxic effects in terrestrial organisms.

Chronic ecotoxicity values have been obtained for nonylphenols for the springtail *Folsomia fimetaria* and the earthworm *Aporrectodea caliginosa*. Both studies considered reproductive toxicity and obtained a 21 d EC10. In *F. fimetaria*, the value was 23.6 mg/kg soil, while in *A. caliginosa* the value was 3.44 mg/kg soil (Environment Canada, 2002).

Similar to aquatic organisms, (o)estrogenic activity as a result of nonylphenol exposure has also been observed in reptilian, avian and mammalian cells (Environment Canada, 2002).

Predicted No-Effect Concentration (PNEC)

Based on the presented data, fish are most sensitive to the chronic toxic effects of nonylphenols. Therefore, the results from the 33 d fish chronic toxicity test were used to derive an aquatic PNEC. The PNEC for the chemicals in this group is calculated to be

0.074 µg/L, based on the 33 d NOEC of 0.0074 mg/L and an assessment factor of 100. A conservative assessment factor of 100 was selected as although chronic ecotoxicity data are available across three aquatic trophic levels, nonylphenols have moderate bioaccumulation potential in aquatic organisms.

Insufficient data are available to calculate a PNEC for nonylphenols for the sediment or soil compartments.

Categorisation of Environmental Hazard

The categorisation of the environmental hazards of phenol, 4-nonyl-, branched; phenol, nonyl-, branched; phenol, nonyl derivatives; phenol, isononyl-; phenol, 4-nonyl-; phenol, nonyl-; and phenol, nonyl-, sodium salt according to domestic environmental hazard thresholds is presented below (EPHC, 2009; NICNAS, 2013):

Persistence

Not Persistent (Not P). Based on the results of the ready biodegradation study available for a commercial nonylphenol mixture, all chemicals in this group are categorised as Not Persistent.

Bioaccumulation

Not Bioaccumulative (Not B). Based on BCF values in fish less than 2000 L/kg, all chemicals in this group are categorised as Not Bioaccumulative.

It should be noted that available data nevertheless indicate moderate potential for bioaccumulation in aquatic organisms, and possible biomagnification in piscivorous birds.

Toxicity

Toxic (T). Based on the available aquatic toxicity data, which demonstrate acute toxicity values below 1 mg/L and chronic toxicity values below 0.1 mg/L, all chemicals in this group are categorised as Toxic.

Summary

Phenol, 4-nonyl-, branched; phenol, nonyl-, branched; phenol, nonyl derivatives; phenol, isononyl-; phenol, 4-nonyl-; phenol, nonyl-; and phenol, nonyl-, sodium salt are categorised as:

- Not P
- Not B
- T

Risk Characterisation

Based on the PEC and PNEC values determined above, the following Risk Quotient (RQ = PEC ÷ PNEC) has been calculated for the chemicals in this group for release into rivers:

PEC (µg/L)	PNEC (µg/L)	RQ

PEC (µg/L)	PNEC (µg/L)	RQ
1.06	0.074	14.32

An RQ greater than 1 indicates that the chemical may pose an unreasonable risk to the environment, as environmental concentrations may exceed levels that cause harmful effects. Further, as the chemicals in this group are all isomers and expected to have the same mode of action, the use of individual risk quotients may underestimate cumulative risk. Therefore, industrial use of nonylphenols may pose an unreasonable risk to the aquatic environment.

Insufficient data are available to characterise the risks posed by the release of these chemicals to the sediment and soil compartments.

Key Findings

The chemicals in this group are mainly used as industrial intermediates internationally, with other applications including use as catalysts in the curing of epoxy resins. Some of the chemicals in this group are used in end-use products in Australia, but the major uses are assumed to be as intermediates in the manufacture of other chemicals.

Nonylphenols are widely recognised for their potential to cause toxic effects in a range of organisms due to their ability to interfere with the normal functioning of endocrine systems. In addition, nonylphenols have moderate bioaccumulation potential in fish and may form stable degradation products in the environment.

Based on the risk quotients calculated for the chemicals in this group, industrial use of nonylphenols may pose an unreasonable risk to the aquatic environment.

Recommendations

It is recommended that all chemicals in this group be considered for assessment of environmental concerns at Tier III level under the IMAP framework. The Tier III environmental risk assessment of these chemicals will focus on outstanding areas of uncertainty in the assessment, particularly the extent of environmental exposure resulting from industrial use in Australia.

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 phenol, 4-nonyl-, branched; phenol, nonyl-, branched; phenol, nonyl derivatives; phenol, isononyl-; phenol, 4-nonyl-; phenol, nonyl-; and phenol, nonyl-, sodium salt 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 1 (H400)	Very toxic to aquatic life
Chronic Aquatic	Category 1 (H410)	Very toxic to aquatic life with long lasting effects

The classification of the aquatic hazards posed by the chemicals in this group was performed based on the ecotoxicity data presented in this assessment.

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