1:2 Lead(2+) salts of medium-chain carboxylic acids: Environment tier II assessment

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CAS Registry Numbers: 7319-86-0, 15773-52-1, 15773-55-4, 301-08-6, 93981-67-0, 84852-34-6, 93965-29-8.

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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

Grouping Rationale

This Tier II assessment considers the environmental risks associated with the industrial uses of the lead(2+) salts of seven closely related carboxylic acids:

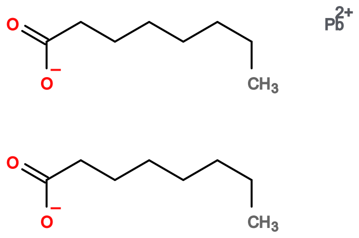
Octanoic acid, lead(2+) salt (Lead dioctanoate)
Decanoic acid, lead(2+) salt (Lead didecanoate)
Dodecanoic acid, lead(2+) salt (Lead dilaurate)
Hexanoic acid, 2-ethyl-, lead(2+) salt (Lead bis(2-ethylhexanoate))
Isooctanoic acid, lead(2+) salt (Lead diisooctanoate)
Isodecanoic acid, lead(2+) salt (Lead diisodecanoate)
Isoundecanoic acid, lead(2+) salt (Lead diisoundecanoate))

The parent carboxylic acids for these salts are all medium-chain (C_{6-12}) fatty acids. The acids include naturally occurring straight-chain fatty acids and synthetically produced fatty acids with branched chains. The lead(2+) salts of these acids are a subset of a large class of industrially important metal salts of fatty acids collectively identified as metallic soaps. This subset of metallic soaps is of definite chemical composition based on their Chemical Abstracts Service chemical names and formulae as listed in the Australian Inventory of Chemical Substances (the Inventory). The entries on the Inventory specify the ratio of lead(2+) to carboxylic acid in these salts as 1:2.

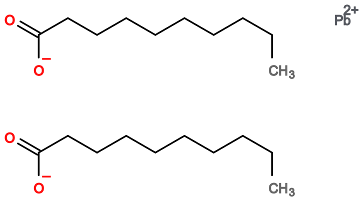
The risk assessment of these chemicals has been conducted as a group because all seven substances are well-defined lead salts of structurally and chemically similar medium-chain fatty acids. Although these salts are sparingly soluble in water, they can all potentially release toxic lead(2+) ions which provides a common source of toxicity for each of these substances. Furthermore, the potential environmental exposure pathways for chemicals in this group are similar based on specific industrial uses as driers in coating products such as paints, lacquers and varnishes. Based on these considerations, the chemicals in this group are each expected to have generally similar environmental fate and ecotoxicity profiles.

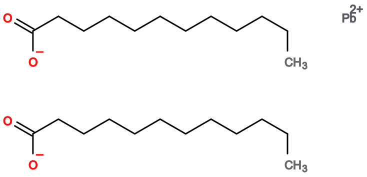
The chemicals in this group are related to the chemicals assessed as part of the Lead Salts of Medium-Chain Carboxylic Acids group. Both groups of chemicals are structurally similar, but they may have some minor compositional differences. Although they have been assessed as separate groups, persons interested in the chemicals assessed here should also consider those assessed under the Lead Salts of Medium-Chain Carboxylic Acids group assessment.

Chemical Identity

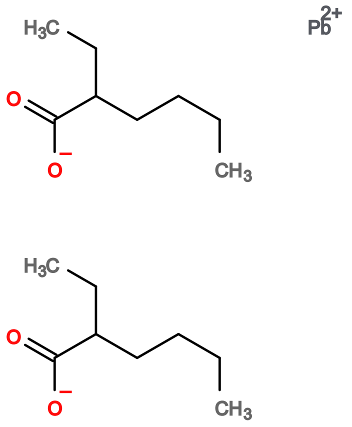
CAS RN	7319-86-0
Chemical Name	Octanoic acid, lead(2+) salt
Synonyms	Lead dioctanoate Lead dicaprylate Lead(2+) dioctanoate
Structural Formula	
Molecular Formula	$C_{16}H_{30}O_4Pb$
Molecular Weight (g/mol)	493.61
SMILES	[Pb++].CCCCCCCC(=O)[O-].CCCCCCCC(=O)[O-]

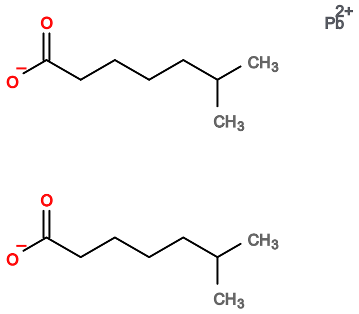
CAS RN	15773-52-1

Chemical Name	Decanoic acid, lead(2+) salt
Synonyms	Lead didecanoate Lead dicaprate Lead(2+) didecanoate
Structural Formula	
Molecular Formula	$C_{20}H_{38}O_4Pb$
Molecular Weight (g/mol)	549.71
SMILES	[Pb++].CCCCCCCCCC(=O)[O-].CCCCCCCCCC(=O)[O-]

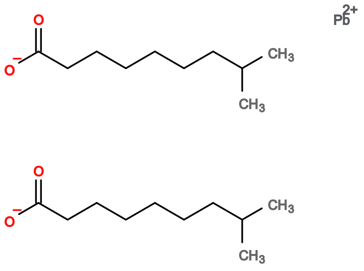
CAS RN	15773-55-4
Chemical Name	Dodecanoic acid, lead(2+) salt
Synonyms	Lead dilaurate Lead(2+) didodecanoate
Structural Formula	

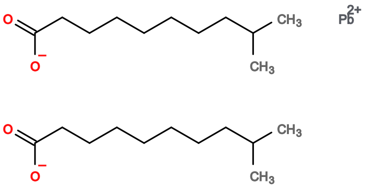
Molecular Formula	$C_{24}H_{46}O_4Pb$
Molecular Weight (g/mol)	605.82
SMILES	[Pb++].CCCCCCCCCCCC(=O)[O-].CCCCCCCCCCCC(=O)[O-]

CAS RN	301-08-6
Chemical Name	Hexanoic acid, 2-ethyl-, lead(2+) salt
Synonyms	Lead bis(2-ethylhexanoate) Lead(2+) bis(2-ethylhexanoate)
Structural Formula	
Molecular Formula	$C_{16}H_{30}O_4Pb$
Molecular Weight (g/mol)	493.61
SMILES	[Pb++].CCCCC(CC)C(=O)[O-].CCCCC(CC)C(=O)[O-]

CAS RN	93981-67-0
Chemical Name	Isooctanoic acid, lead(2+) salt
Synonyms	Lead diisooctanoate Lead(2+) bis(6-methylheptanoate)
Structural Formula	
Molecular Formula	$C_{16}H_{30}O_4Pb$
Molecular Weight (g/mol)	493.61
SMILES	CC(C)CCCCC(=O)[O-].CC(C)CCCCC(=O)[O-].[Pb++]

CAS RN	84852-34-6
Chemical Name	Isodecanoic acid, lead(2+) salt
Synonyms	Lead diisodecanoate Lead(2+) bis(8-methylnonanoate)

Structural Formula	
Molecular Formula	$C_{20}H_{38}O_4Pb$
Molecular Weight (g/mol)	549.71
SMILES	CC(C)CCCCCCC(=O)[O-].CC(C)CCCCCCC(=O)[O-].[Pb++]

CAS RN	93965-29-8
Chemical Name	Isoundecanoic acid, lead(2+) salt
Synonyms	Lead diisoundecanoate Lead(2+) bis(9-methyldecanoate)
Structural Formula	
Molecular Formula	$C_{22}H_{42}O_4Pb$
Molecular Weight (g/mol)	577.77

SMILES	CC(C)CCCCCCCC(=O)[O-].CC(C)CCCCCCCC(=O)[O-].[Pb++]

Physical and Chemical Properties

There is only limited information available on the physical properties of the chemicals addressed in this group assessment. Lead 2-ethylhexanoate has been described as a white solid with plastic properties (Nora and Koenen, 2012), while lead dilaurate has been referred to as a white powder (Weast, 1976). The lead(2+) salts of other fatty acids in this group are all expected to be solids under ambient conditions based on the typical properties of metallic soaps (Nora and Koenen, 2012).

The metallic soaps of divalent (2+) metal ions are well known to be only sparingly soluble in water (Nora and Koenen, 2012). A number of studies of the solubility of various divalent metallic soaps show the lead(2+) soaps typically dissociate in water to release lead(2+) ions and fatty acids in the form of carboxylate mono-anions. These studies also clearly demonstrate that the water solubility of metallic soaps decreases as the length of the fatty acid carbon chain increases. Additionally, these studies have shown that the lead(2+) salts are typically the least soluble of the divalent metal salts of fatty acids (Hunter and Liss, 1976; Mauchauffee, et al., 2008).

Solubility products (K_{sp}s), which are a quantitative measure of the position of the solubility equilibrium, are available for lead dioctanoate, lead didecanoate and lead dilaurate (Hunter and Liss, 1976; Mauchauffee, et al., 2008). All measurements were obtained at an ionic strength of 0.1 M (NaCl). The values for lead dioctanoate and lead didecanoate (a) were obtained at 20°C, while those for lead didecanoate (b) and lead dilaurate were obtained at 25°C. The concentrations of lead(2+) ions at saturation (at 20°C) for lead dioctanoate and lead didecanoate (a) were reported by the authors (Mauchauffee, et al., 2008). The lead(2+) ion concentrations at saturation (at 25°C) for lead didecanoate (b) and lead dilaurate were calculated using an activity coefficient of 0.586 M, as used in the original study (Hunter and Liss, 1976):

Chemical	Lead dioctanoate	Lead didecanoate	Lead dilaurate
K_{sp}	1.58×10^{-11}	(a) 8.51×10^{-17} (b) 3.16×10^{-13}	5.01×10^{-16}
Lead(2+) Concentration at Saturation	36.05 mg/L	(a) 1.34 mg/L (b) 15.18 mg/L	1.77 mg/L

No quantitative water solubility data have been identified for the other salts in this group. However, based on the observed trend in solubility for metallic soaps, all remaining chemicals are expected to have solubility greater than that of lead dilaurate (di-C_{12}) as these salts are of saturated carboxylic acids with chain lengths less than C_{12}.

Import, Manufacture and Use

Australia

A survey conducted in 2005 reported that lead bis(2-ethylhexanoate) and lead dioctanoate were being used in surface coatings and inks in Australia (Australian Government, 2005). However, a subsequent mandatory call for information revealed that lead bis(2-ethylhexanoate) was used in industrial surface coatings at a volume of one tonne in 2003, declining to 20 kg in 2004. No use was reported in 2005. Lead dioctanoate was not used in Australia in the years 2003-05 (Commonwealth of Australia, 2006; NICNAS, 2007).

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

International

Lead bis(2-ethylhexanoate) and lead dioctanoate have been reported to be used internationally in paints. Lead bis(2-ethylhexanoate) appears to be predominantly used in paints for motor vehicles. The reported use pattern of lead dioctanoate was less specific, with use in paints, lacquers and varnishes identified. However, the chemical was also reported to be used as a catalyst and dyeing auxiliary in the early 2000s (Nordic Council of Ministers, 2013; UNEP, 2011).

Sweden and Denmark reported use of lead bis(2-ethylhexanoate) in 2011. Data available for the preceding decade show a reduction in the volume and number of preparations containing lead bis(2-ethylhexanoate). Lead dioctanoate has also been used in multiple Nordic countries to varying degrees over the past decade. Lead dilaurate and lead diisodecanoate were also reported to be used in Nordic countries in the early 2000s, but no use has been reported since 2003. The use pattern of these chemicals is not specified (Nordic Council of Ministers, 2013).

Lead diisooctanoate was identified as a low-production chemical in the European Union under the superseded *Regulation 793/93 on the Evaluation and Control of the Risks of Existing Substances*. Low-production volume chemicals were defined as chemicals introduced to the European Union at a volume between 10 and 1000 tonnes per annum in the 1990s (Allanou, et al., 1999; European Commission, 2013). However, this chemical – along with all others in this group – is only pre-registered under the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) legislation. Therefore, it can be assumed that these chemicals are not currently being used at a volume greater than 100 tonnes per annum in the European Union (ECHA, 2014b; 2014c).

No data were available for the use of lead didecanoate and lead diisoundecanoate. These chemicals do not appear to be used industrially in Canada and have not been introduced for an industrial use at a volume greater than 100 kg per annum in Sweden since its records began in 1992 (Environment Canada, 2013a; KemI, 2014).

Environmental Regulatory Status

Australia

Lead and lead compounds are subject to reporting under the Australian National Pollutant Inventory (NPI). Under the NPI, emissions of lead and lead compounds are required to be reported annually by facilities that use or emit more than 10 tonnes of lead or lead compounds, burn more than 2000 tonnes of fuel, consume more than 60 000 megawatt hours of electricity (excluding lighting and motive purposes), or have an electricity rating of 20 megawatts during a reporting year (Australian Government Department of the Environment, 2013a). Emissions may be intentional, accidental or incidental releases arising through industrial processes. Additionally, emissions of lead and lead compounds from diffuse sources, such as lawn mowers and wood heaters, are also periodically estimated by state environment authorities. Diffuse emissions data are updated much less frequently than facility data (Australian Government Department of the Environment, 2013b).

The *Uniform Paint Standard* of the *Poisons Standard 2013* (Cwlth) recommends that lead and lead compounds be limited to 0.1% of the non-volatile content of all paints manufactured and sold in Australia (measured as elemental lead) (Commonwealth of Australia, 2013). In addition, use of lead bis(2-ethylhexanoate) and lead dioctanoate in industrial surface coatings or inks in Australia at concentrations greater than 0.1% of the non-volatile content is prohibited without prior assessment under the NICNAS (NICNAS, 2014a; 2014b).

United Nations

No chemicals in this group are currently identified as a Persistent Organic Pollutant (UNEP, 2001), ozone depleting substance (UNEP, 1985), or hazardous substance for the purpose of international trade (UNEP, 1998).

The United Nations Environment Programme (UNEP), in partnership with the World Health Organization (WHO), has established the Global Alliance to Eliminate Lead Paint. The alliance primarily supports actions in developing nations to reduce and phase-out lead use in paints (UNEP, 2011).

OECD

No chemicals in this group have been sponsored for assessment under the Cooperative Chemicals Assessment Programme (CoCAP) (OECD, 2013).

Canada

Lead bis(2-ethylhexanoate) was categorised as Persistent (P), not Bioaccumulative (not B), and Inherently Toxic to the Environment (iT_E) by Environment Canada during the Categorization of the Domestic Substances List (DSL) (Environment Canada, 2013c). A subsequent screening assessment is yet to be completed (Environment Canada, 2013b).

The remaining chemicals in this group are not currently listed on the DSL (Environment Canada, 2013a).

Lead in most paint products available to consumers in Canada is limited to 90 mg/kg (0.009% w/w) of the non-volatile content under the *Surface Coating Materials Regulations* of the *Canada Consumer Product Safety Act 2010*. Exempted products which contain more than 90 mg/kg lead must be appropriately labelled (Government of Canada, 2005).

European Union

All chemicals in this group have been pre-registered, but have not yet undergone the full registration process, under the REACH legislation (ECHA, 2014d). Therefore, no chemicals in this group are currently identified as a Substance of Very High Concern in the European Union.

However, it is noted that all other lead compounds currently registered under the REACH legislation (for example, mixed C_{16-18} lead carboxylates (CAS RN 91031-62-8)) have been identified as Substances of Very High Concern due to their reproductive toxicity, and are currently included on the Candidate List for Eventual Inclusion in Annex XIV (the Authorisation List) to REACH (ECHA, 2013).

United States of America

Select industries in the United States of America (USA), including most mining, utilities and manufacturing facilities, must report emissions of lead and lead compounds to the United States Environmental Protection Agency (US EPA) if the facility manufactures or processes more than 25 000 pounds of lead compounds (approximately 11 tonnes) per annum. Reporting is also required if the facility otherwise uses more than 10 000 pounds (approximately 4.5 tonnes) in a reporting year (US EPA, 2012; 2014a; 2014b).

Most paint products containing lead, as well as toys and furniture painted using such products, are prohibited in the USA if the lead content exceeds 0.009% w/w of the non-volatile paint content under the *Consumer Product Safety Improvement Act 2008*. Exempted products which contain more than 0.009% w/w lead must be appropriately labelled (United States Government, 2008).

Environmental Exposure

Based on the available data, the principal industrial use of lead bis(2-ethylhexanoate) and lead dioctanoate is in industrial coatings, such as paints, lacquers and varnishes. Metallic soaps are known to be used as driers in coatings containing drying oil components, with lead soaps typically used at a concentration of 0.5% w/w lead (non-volatile content) (Australian Government Department of the Environment, 2014; Bielman, 1993). However, the use of these chemicals in industrial coatings in Australia at concentrations resulting in greater than 0.1% w/w lead (non-volatile content) is prohibited, without prior assessment under the

NICNAS (NICNAS, 2014a; 2014b). Therefore, current industrial use of these chemicals as driers in surface coatings in Australia is expected to be limited.

The extent of use of the remaining chemicals in this group in Australia is unclear. Based on the use information available for lead bis(2-ethylhexanoate) and lead dioctanoate, international data and the chemical similarity of the substances addressed in this group assessment, the remaining chemicals are assumed to also primarily be used in industrial coating products. However, the restrictions recommended for lead compounds in paints under the *Uniform Paint Standard*, and an increased awareness of the environmental and human health concerns of lead pollution, are expected to similarly limit current uses of these chemicals in industrial coating products in Australia.

If used in industrial coating products in Australia, the primary source of environmental exposure for the chemicals in this group is expected to be release of soluble lead(2+) ions from the cured coating. A range of studies have highlighted the potential for lead to be released from intact coatings (Barnes and Davis, 1996; Beauchemin, et al., 2011; Davis and Burns, 1999). Chips and dust from coatings containing lead can also result in environmental exposure of lead compounds. A small proportion may also be released to sewer, surface water or soil during application and disposal of excess product (OECD, 2009).

Environmental Fate

Dissolution, Speciation and Partitioning

The behaviour of the lead(2+) ion is strongly dependent on the chemistry of the environmental compartment into which it is released.

The metallic soaps are salts of weak acids and dissolution of these substances in water therefore results in hydrolysis. Hydrolysis of the fatty acid conjugate base results in the formation of the corresponding fatty acid. The extent to which this reaction occurs is dependent on the properties of the acid and the pH of the aquatic environment. At neutral pH, fatty acids are predominantly in the conjugate base (anionic) form. For the metal ion, hydrolysis is a result of dissociation of hydrogen ions from water molecules coordinated to the metal ion. In the case of lead(2+) ions, coordinated water is only weakly acidic and the predominant form of the dissolved metal ion in pure water at neutral pH is the simple hydrated lead(2+) di-cation (Mauchauffee, et al., 2008).

However, in environmental waters, lead(2+) ions are expected to undergo a range of additional reactions and they can therefore exist as a variety of different chemical species. The speciation chemistry of lead(2+) ions in environmental waters is complex and strongly dependent on water chemistry, especially pH and the presence of complexing anions. For example, at pH levels lower than 7, the simple hydrated lead(2+) di-cation is the dominant species of ionic lead (ANZECC, 2000b). However, at pH levels greater than 7, the speciation of ionic lead is dominated by the formation of carbonate complexes, such as $PbCO_3$ (US EPA, 1999). These carbonate complexes have low solubility and the precipitation of lead(2+) salts becomes important under alkaline conditions. In seawater, lead(2+) is complexed by chloride ions. These complexes account for more than 90% of the speciation of ionic lead in seawater (ANZECC, 2000b).

In addition to complexation by simple inorganic anions, lead(2+) is complexed by organic matter in environmental waters. These complexes are of great significance for the environmental fate of lead(2+) because they account for the majority of dissolved lead in natural freshwater at pH values in the range 5 to 9 (ANZECC, 2000b). Further, the partitioning of lead(2+) from the water phase onto clay particles, particulate humic substances, and iron, aluminium and manganese (oxy)hydroxides have all been identified as important mechanisms controlling the concentration of lead in natural waters. In sediments, the speciation of lead will be dominated by complexes with humic substances and by the formation of relatively insoluble lead sulfides (ANZECC, 2000b).

The partitioning behaviour of lead in soil has a complex dependence on soil properties, but is mainly determined by pH and clay content. A detailed review of measured partition coefficients for sorption from water onto soil (K_Ds) conducted by the US EPA identified values for lead(2+) in the range of 150 L/kg to 44 580 L/kg. The adsorption of lead on soil generally increases with increasing soil pH (US EPA, 1999). Lead is typically considered relatively immobile in soil (UNEP, 2010).

Biotransformation

The organic components of the salts in this group are biodegradable both as the lead(2+) salts and as the free fatty acids.

A ready biodegradation study on lead bis(2-ethylhexanoate), conducted in accordance with OECD Test Guideline (TG) 301C, found the chemical to undergo 98% degradation in 28 days (LMC, 2013; NITE, 2014).

The fatty acid components of the chemicals in this group will undergo relatively rapid biodegradation in the environment. Available experimental data from studies conducted in accordance with standard test guidelines demonstrate that dodecanoic acid (lauric acid), 2-ethylhexanoic acid and octanoic acid are all readily biodegradable (63-73% degradation in 15 days, OECD TG 301D; 99% degradation in 28 days, OECD TG 301E; and >60% degradation in 10 days, OECD TG 301D, respectively) (ECHA, 2014a; 2014e; 2014f). Decanoic acid (C_{10}) is expected to undergo biodegradation at rate which is similar to lauric acid (C_{12}) and octanoic acid (C_8). The available biodegradation data for short-chain isocarboxylic acids suggest that the biodegradation potential of the remaining chemicals in this group should not be expected to differ significantly from that of their straight-chain analogues (LMC, 2013).

Bioaccumulation

Chemicals in this group will release lead(2+) ions, which bioaccumulate in most organisms.

The lead(2+) ions released from these chemicals may pose a bioaccumulation hazard depending on the bioavailability of the metal ion under the prevailing exposure conditions. Conventional measures of bioaccumulation as applied to organic chemicals are not appropriate for metal ions. These measures do not consider the potential for metals to accumulate in specific tissues, the physiological mechanisms available to organisms to regulate internal metal concentrations, and the influence of environmental factors (US EPA, 2007). Nevertheless, lead and lead compounds are globally acknowledged to pose a significant bioaccumulation concern (UNEP, 2010; 2014).

The fatty acid components of the chemicals in this group are not expected to pose a bioaccumulation hazard. The straight-chain fatty acids of the chemicals in this group are dietary fatty acids which are naturally ubiquitous in the environment and organisms, and their storage in body tissues is an essential biological process which is regulated by homeostatic controls (NRC, 2005). The extent to which the branched fatty acids are similarly metabolised and stored in organisms is unclear. However, the structural properties and degradability of these chemicals suggest limited potential for bioaccumulation. The chemical characteristics of these fatty acids are similar to those of anionic surfactants, which are generally considered not to be bioaccumulative (Konnecker, et al., 2011).

Transport

The chemicals in this group and their ionic components have a low potential for long-range transport.

The lead(2+) salts of fatty acids are ionic solids that do not partition to the atmospheric compartment, where long-range transport typically occurs. The fatty acid constituents of these salts are rapidly biodegradable and therefore not subject to long-range transport. The ionic lead components of these salts may have some limited mobility in water due to complexation by dissolved organic matter, but lead released into water and onto soil will eventually become bound to sediment or soil particles (UNEP, 2010).

Predicted Environmental Concentration (PEC)

A PEC was not calculated for the chemicals or their ionic components addressed under this assessment.

Historically, lead compounds in paint have been a significant source of lead in the environment. Further, surfaces previously coated with preparations containing high concentrations of lead compounds continue to release lead to the environment (Davis and Burns, 1999; UNEP, 2011). However, the release of lead compounds from current industrial use of the chemicals in this group is expected to be limited largely due to the general decline in the use of lead in paints and limits placed on the acceptable concentration of lead compounds in coating products used in Australia.

The most significant source of potential environmental emissions of lead compounds from paint is expected to be associated with the release of lead during the lifetime, and end-of-life disposal, of coated articles. Studies which have considered the release of lead from outdoor surfaces have found water runoff from surfaces painted between 1994 and 1999 to contain an average of 8.4 micrograms per litre (µg/L) of lead (Davis and Burns, 1999). While some runoff water may pass into sewers, a proportion can be expected to be released directly to surface waters or soil. At the end of their useful life, coated articles are expected to be disposed to landfill. This should not be expected to result in significant environmental exposure due to the immobility of lead in soil.

Environmental Effects

No ecotoxicity data specific to the chemicals addressed under this assessment are available. However, it is expected that the environmental effects of sparingly soluble lead(2+) salts of fatty acids will be determined principally by the release of lead(2+) ions into the environment. Lead is recognised to be a highly toxic environmental contaminant (UNEP, 2010; 2014). The effects assessment of the chemicals in this group has therefore primarily focused on the extensive body of information regarding the ecotoxicity of lead and inorganic lead compounds.

Effects on Aquatic Life

Bioavailable forms of lead(2+) are very toxic to aquatic life in short and long term exposures.

Toxicity of lead(2+)

The speciation of lead(2+) is strongly dependent on water chemistry, which can have a dramatic effect on the bioavailability and therefore toxicity of lead. For example, lead(2+) is more toxic to freshwater species in soft water than hard water. Toxicity is also higher in acidic freshwater when compared to alkaline freshwater. However, toxicity is lower to marine species than for freshwater species (ANZECC, 2000b). These factors and their effects should be noted when evaluating the toxicity of lead(2+) salts.

The following acute median lethal concentrations (LC50s) and median effective concentration (EC50) for model organisms across three trophic levels for lead (CAS RN 7439-92-1) were reported in the Registration Dossier for the chemical under the European Union REACH legislation (ECHA, 2014g). All studies were conducted on freshwater species using soluble salts of lead(2+):

Taxon	Endpoint	Method
Fish	96 h LC50 = 108 µg Pb/L	Experimental *Pimephales promelas* (Fathead minnow) ASTM Method; Flow through $CaCO_3$ = 43.9 mg/L, pH = 7.4
Invertebrates	48 h LC50 = 73.6 µg Pb/L	Experimental *Ceriodaphnia dubia* (Water flea) US EPA Method; Semi-static $CaCO_3$ = 16.4 mg/L, pH = 5.7

Taxon	Endpoint	Method
Algae	48 h EC50 = 23.1 µg Pb/L	Experimental *Pseudokirchneriella subcapitata* (Green algae) OECD TG 201; Static $CaCO_3$ = 24 mg/L, pH = 7.3 Reduced growth rate observed

The chronic toxicity of lead(2+) to freshwater and marine species was critically evaluated for the compilation of water quality trigger values for environmental contaminants in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Only studies that considered the complex relationship between water chemistry and toxicity were considered, and no-observed effect concentration (NOEC) equivalent values were derived (ANZECC, 2000b). The equivalent NOEC values available for sensitive freshwater fish and invertebrate species are reported below, along with an effective concentration for 10% of the test population (EC10) value for algae as reported in the Registration Dossier for lead under the European Union REACH legislation (ANZECC, 2000b; ECHA, 2014g):

Taxon	Endpoint	Method
Fish	NOEC = 5.65 µg Pb/L	Experimental *Lepidomeda vittatus* (Little Colorado spinedace) $CaCO_3$ = 30 mg/L
Invertebrates	NOEC = 19.5 µg Pb/L	Experimental *Daphnia magna* (Water flea) $CaCO_3$ = 30 mg/L
Algae	48 h EC10 = 4.5 µg Pb/L	Experimental *Pseudokirchneriella subcapitata* (Green algae) OECD TG 201; Static $CaCO_3$ = 24 mg/L, pH = 7.3 Reduced growth rate observed

Toxicity of medium-chain fatty acids

Apart from octanoic acid, the medium-chain fatty acid constituents of these chemical have only low to moderate toxicity to aquatic life in short and long term exposures.

The following acute LC50 values and EC50 values for model freshwater organisms across three trophic levels for (a) 2-ethylhexanoic acid (CAS RN 149-57-5), (b) octanoic acid (CAS RN 124-07-2), (c) lauric acid (CAS RN 143-07-7) and (d) decanoic acid (CAS RN 334-48-5) were reported in the databases included in the OECD QSAR Toolbox and the Robust Test Summaries submitted to the US EPA under the High Production Volume Challenge Program (LMC, 2013; US EPA, 2001). Additional available toxicity values similarly reflect low to moderate ecotoxicity for these medium-chain fatty acids (LMC, 2013; NITE, 2014):

Taxon	Endpoint	Method
Fish	(a) 96 h LC50 = 70 mg/L	Experimental *Pimephales promelas* (Fathead minnow) APHA Method 231; Static
	(b) 96 h LC50 = 22 mg/L	Experimental *Lepomis macrochirus* (Bluegill) US EPA Method; Static
	(c) 96 h LC50 = 5 mg/L	Experimental *Oryzias latipes* (Japanese medaka) OECD TG 203
Invertebrates	(a) 48 h LC50 = 85.4 mg/L	Experimental *Daphnia magna* (Water flea) EU Method; Static
	(b) 48 h EC50 = 550 mg/L (c) 48 h EC50 = 3.6 mg/L	Experimental *Daphnia magna* (Water flea) OECD TG 202 Decreased mobility observed
Algae	(a) 72 h EC50 = 49.3 mg/L	Experimental *Desmodesmus subspicatus* (Green algae) DIN 38412 L9; Static Reduced growth rate observed

Taxon	Endpoint	Method
	(b) 72 h EC50 = 31 mg/L (d) 72 h EC50 = 5.9 mg/L	Experimental *Pseudokirchneriella subcapitata* (Green algae) OECD TG 201 Reduced growth rate observed

The following chronic NOEC and EC10 values for model organisms across two trophic levels for (a) 2-ethylhexanoic acid, (b) octanoic acid, (c) lauric acid and (d) decanoic acid were reported in the databases included in the OECD QSAR Toolbox and the Robust Test Summaries submitted to the US EPA under the High Production Volume Challenge Program (LMC, 2013; US EPA, 2001):

Taxon	Endpoint	Method
Invertebrates	(a) 21 d NOEC = 25 mg/L (c) 21 d NOEC = 0.47 mg/L (d) 21 d NOEC = 0.20 mg/L	Experimental *Daphnia magna* (Water flea) OECD TG 211 Reproductive toxicity observed
Algae	(a) 72 h EC10 = 31.9 mg/L	Experimental *Desmodesmus subspicatus* (Green algae) DIN 38412 L9; Static Reduced growth rate observed
	(b) 72 h NOEC = 0.07 mg/L (c) 72 h NOEC = 3.4 mg/L (d) 72 h NOEC = 0.97 mg/L	Experimental *Pseudokirchneriella subcapitata* (Green algae) OECD TG 201 Reduced growth rate observed

Effects on Sediment-Dwelling Life

Bioavailable forms of lead(2+) are very toxic to sediment-dwelling organisms.

Toxicity of lead(2+)

The toxicity of lead to sediment-dwelling organisms has been summarised in the rationale and background information to the Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Exposure to sediment contaminants for benthic organisms is assumed to principally involve pore waters (ANZECC, 2000c). The available NOEC value equivalents for select sediment-dwelling organisms (corrected to a $CaCO_3$ concentration of 30 mg/L) include a NOEC of 5.1 micrograms of lead per litre (µg Pb/L) for the amphipod *Gammarus pseudolimnaeus* and a NOEC of 28 µg Pb/L for the midge *Tanytarsus dissimilis* (ANZECC, 2000b). However, toxicity is highly dependent on sediment chemistry, which is complex and depends on a range of variable environmental parameters such as dissolved oxygen, pH and the geochemistry of sediment particles (ANZECC, 2000c). In particular, the presence of natural organic matter and the formation of sulfides will affect lead bioavailability. These factors must also be considered when determining the toxicity of lead(2+) to sediment-dwelling species.

Toxicity of medium-chain fatty acids

No suitable data were available to evaluate the effects of the fatty acid constituents of these chemicals on sediment-dwelling organisms. However, the release of lead(2+) ions to the sediment compartment is expected to dominate ecotoxicity concerns for these salts.

Effects on Terrestrial Life

Bioavailable forms of lead(2+) are toxic to terrestrial organisms.

Toxicity of lead(2+)

The toxicity of lead to terrestrial organisms has been summarised in Schedule B5c of the *National Environment Protection (Assessment of Site Contamination) Measure 1999* (Cwlth). Lead is strongly adsorbed to organic matter in soil and therefore bioavailability is typically limited. Mean NOEC values for terrestrial invertebrates range from 129 milligrams of lead per kilogram of soil (mg Pb/kg soil) for the earthworm *Dendrobaena rubida* to 1797 mg Pb/kg soil for the springtail *Fautrix candida*. Plants are also susceptible to lead toxicity, with mean NOEC values in a range from 50 mg Pb/kg soil for barley (*Hordeum vulgare*) to 546 mg Pb/kg soil for the Loblolly pine (*Pinus taeda*). Reproductive toxicity and impaired growth are listed as the most common toxic effects (Commonwealth of Australia, 1999).

Toxicity of medium-chain fatty acids

Limited data are available in regards to the toxicity of medium-chain fatty acids to terrestrial organisms. The toxicity of lauric acid is low, with dietary LC50 values greater than 5620 mg/L available for the birds *Colinus virginianus* and *Anas platyrhynchos*, and low-observed effect level (LOEC) values for a variety of mosquitoes (*Culex* sp.) ranging from 64.1 mg/L to 200 mg/L. No-observed effect level (NOEL) values for mosquitoes (*Aedes aegypti* and *Culex* sp.) ranging from 14.4 mg/L to 46.1 mg/L were also available for octanoic acid (LMC, 2013).

Predicted No-Effect Concentration (PNEC)

The primary environmental effects of the chemicals in this group are expected to be caused by the release of lead(2+) ions.

In place of the PNECs for aquatic and sediment compartments for this ionic component, the trigger values published for lead in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality have been used. These values represent thresholds above which further assessment of potential toxicity may be required to ensure environmental quality. Although they were not developed for risk assessment purposes, they nevertheless provide important reference values for evaluating the risks posed by anthropogenic emissions of lead to the Australian environment. For freshwater ecosystems with low water hardness (30 mg/L $CaCO_3$), a high reliability trigger value for protection of 95% of species has been determined to be 3.4 µg Pb/L. The equivalent value for protection of marine species is 4.4 µg Pb/L. For the sediment compartment, the trigger value is 50 mg Pb/kg, dry weight (ANZECC, 2000a).

In place of a PNEC for the soil compartment for lead(2+), the added contaminant limit published for lead in the *National Environment Protection (Assessment of Site Contamination) Measure 1999* (Cwlth) has been used. This value represents the level above which further investigation or evaluation is required after considering naturally occurring background levels. For soil where the contaminant has been present for less than two years, the contaminant limit for protection of 99% of species is 110 mg added Pb/kg soil (Commonwealth of Australia, 1999).

Categorisation of Environmental Hazard

It is not currently possible to categorise the environmental hazards of metals and other inorganic chemicals according to standard persistence, bioaccumulation and toxicity (PBT) hazard criteria. These criteria were developed for organic chemicals and do not take into account the unique properties of inorganic substances and their behaviour in the environment and biota (UNECE, 2007; US EPA, 2007). Therefore, environmental hazard categorisation according to domestic PBT criteria has only been performed for the organic components of the chemicals in the 1:2 Lead(2+) Salts of Medium-Chain Carboxylic Acids group, as presented below.

Persistence

Not Persistent (Not P). Based on results obtained from various biodegradation studies which indicate rapid and ultimate biodegradation of medium-chain fatty acids, the organic components of all chemicals in this group are categorised as Not Persistent.

Bioaccumulation

Not Bioaccumulative (Not B). Based on the structural properties and degradability of the medium-chain fatty acids, as well as the essential biological functions of some of the acids, the organic components of all chemicals in this group are categorised as Not Bioaccumulative.

Toxicity

Lead dioctanoate

Toxic (T). Based on the available chronic ecotoxicity value for algae, the organic component of lead dioctanoate is categorised as Toxic.

All remaining chemicals

Not Toxic (Not T). Based on available acute ecotoxicity values greater than 1 mg/L, and chronic ecotoxicity values greater than 0.1 mg/L, the organic components of all chemicals in this group, except for lead dioctanoate, are categorised as Not Toxic.

Summary

The organic component of octanoic acid, lead(2+) salt is categorised as:

- Not P
- Not B
- T

The organic components of decanoic acid, lead(2+) salt; dodecanoic acid, lead(2+) salt; hexanoic acid, 2-ethyl-, lead(2+) salt; isooctanoic acid, lead(2+) salt; isodecanoic acid, lead(2+) salt; and isoundecanoic acid, lead(2+) salt are all categorised as:

- Not P
- Not B
- Not T

An environmental hazard categorisation for the inorganic lead(2+) component of the chemicals in this group has not been assigned for the reasons discussed above. Nevertheless, there is an international consensus that bioavailable forms of lead are highly toxic to the environment and that lead bioaccumulates in most organisms (UNEP, 2010; 2014).

Risk Characterisation

Risk quotients (RQs) have not been calculated for these chemicals.

The chemicals in this group contain lead(2+) ions, which can be released into the environment from industrial applications. Anthropogenic emissions of lead to the environment are acknowledged to be of concern, both domestically and internationally, due to the bioaccumulation properties and high toxicity of bioavailable forms of lead. Environmental contamination by lead is of particular concern because high exposure to lead compounds can cause neurological defects and reproductive toxicity across a range of organisms, including humans, plants and animals (UNEP, 2010; 2014).

However, the release of lead to the environment in Australia from industrial uses of chemicals in this group is expected to be limited in volume and diffuse in nature. Available use data suggests that the contribution of lead from current industrial uses of lead salts of medium-chain fatty acids to total environmental lead loads is comparatively small. Domestic restrictions on the lead content in surface coatings and international trends to reduce lead in paint have dramatically reduced the consumption of these lead salts for their main industrial use as driers in coatings. The risks from lead released from articles to which lead-containing industrial coating products have been applied are expected to decline further as lead salts of medium-chain fatty acids are finally phased out of use.

Key Findings

The main industrial use of chemicals in the 1:2 Lead(2+) Salts of Medium-Chain Carboxylic Acids group is expected to be in industrial coatings. Lead bis(2-ethylhexanoate) and lead dioctanoate have previously been used in paints and other coating products both domestically and internationally. However, available information from domestic and international sources indicates that the use of lead(2+) salts of medium-chain fatty acids in these products has largely been phased out in developed countries.

The principal environmental concern for industrial uses of lead(2+) salts of medium-chain fatty acids is the potential for release of soluble forms of ionic lead from articles on which industrial coatings have been used. This poses a concern because lead and lead compounds are considered to be highly significant environmental contaminants. However, the potential for lead to be released to the environment due to current use of the chemicals in this group in paints and other coating products is expected to be greatly reduced compared to historic emissions.

The chemicals in this group are considered to pose a low and declining risk to the environment based on the expected limited contribution to total anthropogenic lead emissions from current uses of industrial coating products containing lead based driers, and the phase out of use of these chemicals in industrial coating products. No further assessment of the environmental risks of these chemicals is currently required.

The organic components of the chemicals in the 1:2 Lead(2+) Salts of Medium-Chain Carboxylic Acids group are not PBT substances according to domestic environmental hazard criteria.

Recommendations

The seven chemicals in the 1:2 Lead(2+) Salts of Medium-Chain Carboxylic Acids group are not prioritised for further assessment under the IMAP framework.

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 octanoic acid, lead(2+) salt; decanoic acid, lead(2+) salt; dodecanoic acid, lead(2+) salt; hexanoic acid, 2-ethyl-, lead(2+) salt; isooctanoic acid, lead(2+) salt; isodecanoic acid, lead(2+) salt; and isoundecanoic acid, lead(2+) 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 octanoic acid, lead(2+) salt; decanoic acid, lead(2+) salt; and dodecanoic acid, lead(2+) salt (lead dilaurate) was conducted based on the data available from the solubility studies conducted by Hunter and Liss (1976) and Mauchauffee et al. (2008), and the ecotoxicological data identified in this assessment (ECHA, 2014g; LMC, 2013). These chemicals are classified as Acute Aquatic Category 1 because the calculated maximum lead(2+) ion concentrations at saturation, derived from the available K_{sp} values, exceed all acute toxicity values for lead identified in this assessment for aquatic species. Based on this classification, and the global consensus that lead(2+) bioaccumulates in aquatic organisms, these chemicals are also classified as Chronic Aquatic Category 1 according to the GHS classification strategy for metals and metal compounds (UNECE, 2007).

Based on the chemical structures of hexanoic acid, 2-ethyl-, lead(2+) salt; isooctanoic acid, lead(2+) salt; isodecanoic acid, lead(2+) salt; and isoundecanoic acid, lead(2+) salt, these chemicals are all considered to be more soluble than lead dilaurate. Therefore, these chemicals will be considered more toxic than lead dilaurate under the GHS. However, lead dilaurate has been classified under the highest environmental hazard categories available. Therefore, these more soluble chemicals have been classified under the same aquatic hazard categories as lead dilaurate.

It is preferable to classify the hazard posed by metals and metal compounds using the findings of a study conducted in accordance with the OECD Transformation and Dissolution protocol (UNECE, 2007). Therefore, should a study conducted in accordance with this protocol suggest a lower hazard classification is warranted for any of the chemicals assessed here, these chemicals may be reclassified as appropriate.

References

Allanou R, Hansen BG and van der Bilt Y (1999). *Public Availability of Data on EU High Production Volume Chemicals*. European Chemicals Bureau, Ispra, Italy. http://esis.jrc.ec.europa.eu.

ANZECC (2000a). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Environment and Conservation Council, Sydney, Australia. http://www.environment.gov.au.

ANZECC (2000b). 8.3 Toxicants. In: Australian and New Zealand Environment and Conservation Council, ed. *Australian and New Zealand guidelines for fresh and marine water quality: Volume 2 - Aquatic ecosystems - rationale and background information*. Canberra, Australia.

ANZECC (2000c). 8.4 Sediment Quality Guidelines. In: Australian and New Zealand Environment and Conservation Council, ed. *Australian and New Zealand guidelines for fresh and marine water quality: Volume 2 - Aquatic ecosystems - rationale and background information*. Canberra, Australia.

Australian Government (2005). *Lead in Australia*. Australian Government, Canberra, Australia. http://www.chem.unep.ch.

Australian Government Department of the Environment (2013a). *NPI substance list and thresholds*. Australian Government Department of the Environment, Canberra, Australia. Accessed 11 March at http://www.npi.gov.au.

Australian Government Department of the Environment (2013b). *Understanding NPI data*. Australian Government Department of the Environment, Canberra, Australia. Accessed 11 March at http://www.npi.gov.au.

Australian Government Department of the Environment (2014). *Lead alert facts: Lead in auto paints*. Australian Government Department of the Environment, Canberra, Australia. Accessed 4 June at http://www.environment.gov.au.

Barnes GL and Davis AP (1996). Dissolution of Lead Paint in Aqueous Solutions. *Journal of Environmental Engineering,* **122**(7), pp 663.

Beauchemin S, MacLean LCW and Rasmussen PE (2011). Lead speciation in indoor dust: a case study to assess old paint contribution in a Canadian urban house. *Environmental Geochemistry and Health,* **33**(4), pp 343.

Bielman J (1993). Driers. In: Drummond R, Foxton J and Samios J, ed. *Surface coatings. Raw materials and their usage*. The New South Wales University Press, Sydney, Australia.

Commonwealth of Australia (1999). *National Environment Protection (Assessment of Site Contamination) Measure 1999*.

Commonwealth of Australia (2006). *No. C 01, Tuesday 3 January 2006: Chemical Gazette*. Commonwealth of Australia, Canberra, Australia. http://www.nicnas.gov.au.

Commonwealth of Australia (2013). *Poisons Standard 2013*. Poisons Standard. Enacted on 23 August 2013.

Davis AP and Burns M (1999). Evaluation of lead concentration in runoff from painted structures. *Water Research,* **33**(13), pp 2949.

ECHA (2013). *Candidate List of Substances of Very High Concern for Authorisation*. European Chemicals Agency, Helsinki, Finland. Accessed 17 March at http://echa.europa.eu.

ECHA (2014a). *2-Ethylhexanoic acid*. European Chemicals Agency, Helsinki, Finland. Accessed 4 June at http://apps.echa.europa.eu.

ECHA (2014b). *Registered Substances*. European Chemicals Agency, Helsinki, Finland. Accessed 9 May at http://echa.europa.eu.

ECHA (2014c). *Substances to be registered*. European Chemicals Agency, Helsinki, Finland. Accessed 1 May at http://echa.europa.eu.

ECHA (2014d). *Pre-registered substances*. European Chemicals Agency, Helsinki, Finland. Accessed 1 May at http://echa.europa.eu.

ECHA (2014e). *Lauric acid*. European Chemicals Agency, Helsinki, Finland. Accessed 4 June at http://apps.echa.europa.eu.

ECHA (2014f). *Octanoic acid*. European Chemicals Agency, Helsinki, Finland. Accessed 4 June at http://apps.echa.europa.eu.

ECHA (2014g). *Lead*. European Chemicals Agency, Helsinki, Finland. Accessed 29 May at http://apps.echa.europa.eu.

Environment Canada (2013a). *Search Engine for Chemicals and Polymers*. Environment Canada, Gatineau, Canada. Accessed 1 May at http://www.ec.gc.ca.

Environment Canada (2013b). *Status of Prioritized Substances*. Environment Canada, Gatineau, Canada. Accessed 1 May at http://www.ec.gc.ca.

Environment Canada (2013c). *Search Engine for the Results of DSL Categorisation*. Environment Canada, Gatineau, Quebec, Canada. Accessed 21 November 2013 at http://www.ec.gc.ca.

European Commission (2013). *ESIS*. European Commission, Brussels, Belgium. Accessed 12 April at http://esis.jrc.ec.europa.eu/index.php?PGM=dat

Government of Canada (2005). *Surface Coatings Materials Regulations*. Enacted on 19 April 2005.

Hunter KA and Liss PS (1976). Measurement of the Solubility Products of Various Metal Ion Carboxylates. *Journal of Electroanalytical Chemistry,* **73**, pp 347.

KemI (2014). *KemI-stat*. Swedish Chemicals Agency (Swedish: Kemikalieinspektionen), Sundbyberg, Sweden. Accessed 1 May at http://apps.kemi.se.

Konnecker G, Regelmann J, Belanger S, Gamon K and Sedlak R (2011). Environmental properties and aquatic hazard assessment of anionic surfactants: Physico-chemical, environmental fate and ecotoxicity properties. *Ecotoxicology and Environmental Safety,* **74**, pp 1445.

LMC (2013). *The OECD QSAR Toolbox for Grouping Chemicals into Categories*, v 3.1. Laboratory of Mathematical Chemistry, University "Prof. Dr. Assen Zlatarov", Burgas, Bulgaria. Available at http://oasis-lmc.org.

Mauchauffee S, Meux E and Schneider M (2008). Determination of the Solubility Products in Water at 20°C of 32 Metallic Carboxylates. *Industrial and Engineering Chemistry Research,* **47**, pp 7533.

NICNAS (2007). *Lead Compounds in Industrial Surface Coatings and Inks*. National Industrial Chemical Notification and Assessment Scheme, Sydney, Australia. http://www.nicnas.gov.au.

NICNAS (2014a). *AICS Listing: CAS Number 301-08-6*. National Industrial Chemical Notification and Assessment Scheme, Sydney, Australia. Accessed 21 May at http://www.nicnas.gov.au.

NICNAS (2014b). *AICS Listing: CAS Number 7319-86-0*. National Industrial Chemical Notification and Assessment Scheme, Sydney, Australia. Accessed 21 May at http://www.nicnas.gov.au.

NITE (2014). *Japan Chemicals Collaborative Knowledge Database*. National Institute of Technology and Evaluation, Tokyo, Japan. Accessed 19 March at http://www.safe.nite.go.jp.

Nora A and Koenen G (2012). Metallic Soaps. In: Bellussi G, Bohnet M, Bus J, Drauz K, Faulhammer H, Greim H, Jackel K-P, Karst U, Klaffke W, Kleeman A, Laird T, Meier W, Mukherjee J, Ottow E, Qiao G, Roper M, Sundmacher K, Ulber R, van Dyk B, von Heimburg J, Wagermann K and Wietelmann U, ed. *Ullmann's Encyclopedia of Industrial Chemistry*. Wiley.

Nordic Council of Ministers (2013). *Substances in Preparations in Nordic Countries (SPIN)*. Chemical Group, Nordic Council of Ministers, Copenhagen, Denmark. Downloaded 9 November 2012. Available at http://www.spin2000.net.

NRC (2005). Dietary Fats: Total Fat and Fatty Acids. In: National Research Council, ed. *Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein and Amino Acids (Macronutrients)*. The National Academies Press, Washington DC, USA.

OECD (2009). *Emission Scenario Documents on Coating Industry (Paints, Lacquers and Varnishes)*. Organisation for Economic Cooperation and Development, Paris, France. http://search.oecd.org.

OECD (2013). *OECD Existing Chemicals Database*. Organisation for Economic Cooperation and Development, Paris, France. Accessed 13 November 2013 at http://webnet.oecd.org.

Standards Australia (1998). *AS 4361: Guide to lead paint management*. Standards Australia, Sydney, Australia.

UNECE (2007). *Annex 9: Guidance on Hazards to the Aquatic Environment*. United Nations Economic Commission for Europe, Geneva, Switzerland. http://www.unece.org.

UNECE (2009). *Globally Harmonised System of Classification and Labelling of Chemicals (GHS), 3rd Revised Edition*. United Nations Economic Commission for Europe, Geneva, Switzerland. Accessed 12 November 2013 at http://www.unece.org

UNEP (1985). *The Vienna Convention for the Protection of the Ozone Layer and its Montreal Protocol on Substances that Deplete the Ozone Layer*. United Nations Environment Programme, Ozone Secretariat, Nairobi, Kenya. Accessed 12 November 2013 at http://ozone.unep.org.

UNEP (1998). *The Rotterdam Convention on the Prior Informed Consent procedure for Certain Hazardous Chemicals and Pesticides in International Trade*. United Nations Environment Programme, Secretariat of the Rotterdam Convention, Châtelaine, Switzerland. Accessed 12 November 2013 at http://www.pic.int.

UNEP (2001). *The Stockholm Convention on Persistent Organic Pollutants*. United Nations Environment Programme, Secretariat of the Stockholm Convention, Châtelaine, Switzerland. Accessed 12 November 2013 at http://www.pops.int.

UNEP (2010). *Final review of scientific information on lead*. United Nations Environment Programme, Nairobi, Kenya. http://www.unep.org.

UNEP (2011). *Operational Framework for the Global Alliance to Eliminate Lead Paint*. United Nations Environment Programme, Naroibi, Kenya. http://www.unep.org.

UNEP (2014). *Lead and Cadmium*. United Nations Environment Programme, Nairobi, Kenya. Accessed 5 March at http://www.unep.org.

United States Government (2008). *Consumer Product Safety Improvement Act of 2008*. CPSIA. Enacted on 14 August 2008.

US EPA (1999). *Understanding Variation in Partition Coefficient, Kd, Values - Volume II: Review of Geochemistry and Available Kd Values for Cadmium, Cesium, Chromium, Lead, Plutonium, Radon, Strontium, Thorium, Tritium (3H), and Uranium*. United States Environmental Protection Agency, Washington DC, USA. http://www.epa.gov.

US EPA (2001). *Robust Summaries and SIDS Dossier for: 2-Ethylhexanoic acid*. United States Environmental Protection Agency, Washington DC, USA. http://www.epa.gov.

US EPA (2007). *Framework for Metals Risk Assessment*. United States Environmental Protection Agency, Washington DC, USA. http://www.epa.gov.

US EPA (2012). *Is My Facility's Six-Digit NAICS Code a TRI-Covered Industry?* United States Environmental Protection Agency, Washington DC, USA. Accessed 17 April at http://www2.epa.gov.

US EPA (2014a). *Basics of TRI Reporting*. United States Environmental Protection Agency, Washington DC, USA. Accessed 3 April at http://www2.epa.gov.

US EPA (2014b). *TRI-Listed Chemicals*. United States Environmental Protection Agency, Washington DC, USA. Accessed 3 April at http://www2.epa.gov.

Weast RC (ed) (1976). *CRC Handbook of Chemistry and Physics* (57th edition). CRC Press, Cleveland, USA.

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