Santalol and related substances: Human health tier II assessment

12 December 2019

Chemicals in this assessment

Chemical Name in the Inventory	CAS Number
2-Penten-1-ol, 2-methyl-5-(2-methyl-3-methylenebicyclo[2.2.1]hept-2-yl)-, [1.alpha.,2.alpha.(Z),4.alpha.]-(-)-	77-42-9
2-Penten-1-ol, 5-(2,3-dimethyltricyclo[2.2.1.02,6]hept-3-yl)-2-methyl-, [R-(Z)]-	115-71-9
Santalol, acetate	1323-00-8
Santalol, phenylacetate	1323-75-7
Oils, sandalwood	8006-87-9
Santalol	11031-45-1
Butanoic acid, 2-methyl-5-(2-methyl-3-methylenebicyclo[2.2.1]hept-2-yl)-2-pentenyl ester	67633-98-1
Butanoic acid, 5-(2,3-dimethyltricyclo[2.2.1.02,6]hept-3-yl)-2-methyl-2-pentenyl ester	67633-99-2

Chemical Name in the Inventory	CAS Number
Sandalwood, extract	84787-70-2

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

Sandalwood oil (CAS No. 8006-87-9) is a volatile oil obtained from steam distillation of the heartwood of the plant *Santalum album* L (commercially known as the East Indian sandalwood). The oil has a long history of use in religious rituals, folk medicine and as an insect repellent. In recent years, almost all sandalwood oil traded internationally as East Indian sandalwood oil (Burdock and Carabin, 2008; Galleria Chemica). Sandalwood oil is also identified with the CAS No. 84787-70-2 for sandalwood extract (SCCS, 2012; CosIng; REACH).

Alpha-santalol (CAS No. 115-71-9) and beta-santalol (CAS No. 77-42-9) are sesquiterpenoids that are the major constituents in sandalwood oil, and are responsible for the distinctive woody odour. Commercial sandalwood oil contains about 7–60 % of alpha-santalol and 7–33 % beta-santalol depending on the species (Burdock and Carabin, 2008; Science Direct).

Santalol (CAS No. 11031-45-1) is the generic name for a commercial product consisting of mixed alpha- and beta-santalol isomers, obtained via fractional distillation of sandalwood oil (Bhatia et al., 2008a). Most of the available studies are conducted using the chemical ‘santalol’, without specifying the exact composition of isomers in the mixture.

The international (ISO) standard for sandalwood oil states a minimum free alcohol content (calculated as santalol) of 90 % (Burdock and Carabin, 2008). The ISO standard states that the majority of currently available trade oils, reportedly from *S. album*, contain approximately 50–80 % santalols (SCCS, 2012). The minor constituents reported in the oil include approximately 6 % sesquiterpene hydrocarbons (mostly alpha- and beta-santalenes and epi-beta-santalene with small amounts of alpha- and beta-curcumenes, which are possibly beta-farnesene and dendrolasin). Other minor constituents reported include unspecified amounts of dihydro-beta-agarofuran, santene, teresantol, borneol, teresantalic acid, tricycloekasantalal, santalone and santanol (Burdock and Carabin, 2008).

The esters of santalol: santalyl acetate (CAS No. 1323-00-8), santalyl phenylacetate (CAS No. 1323-75-7), alpha-santalyl butyrate (CAS No. 67633-99-2) and beta-santalyl butyrate (CAS No. 67633-98-1) are also included in this assessment, as they are expected to be hydrolysed into santalol and the corresponding acids. The corresponding carboxylate ions produced by ester hydrolysis in vivo are expected to have low toxicity.

Import, Manufacture and Use

Australian

No specific Australian use, import, or manufacturing information has been identified for santalol. However sandalwood oil has reported non-industrial use in Australia in therapeutic products (TGA, 2007).

International

The following international uses have been identified through Galleria Chemica; the European Commission Cosmetic Ingredients and Substances (CosIng) database; the United States (US) Personal Care Products Council International Nomenclature of Cosmetic Ingredients (INCI) Dictionary, the US Household Products Database (HPD); the US National Library of Medicine's Hazardous Substances Data Bank (HSDB) and other sources (International Fragrance Association (IFRA) Transparency List and the joint FAO/WHO expert committee on food additives (JECFA)).

All chemicals in this group, except santalyl phenylacetate (CAS No. 1323-75-7) have reported cosmetic use in perfumes or as fragrance ingredients.

Santalol as the main component of sandalwood oil has reported domestic use in detergents and household cleaners (Bhatia et al., 2008a).

All chemicals in this group, except alpha-santalyl butyrate (CAS No. 67633-99-2) and beta-santalyl butyrate (CAS No. 67633-98-1) have reported non-industrial use as food additives.

Sandalwood oil has additional reported non-industrial use in therapeutic products to treat stomach pains, vomiting and gonorrhoea (HSDB).

Restrictions

Australian

East Indian sandalwood oil and *S. album* are approved for non-industrial use (active and excipient) in listable medicines in Australia (TGA, 2007).

International

The chemicals in this group are not specifically restricted internationally.

Existing Worker Health and Safety Controls

Hazard Classification

The chemicals are not listed on the Hazardous Chemical Information System (HCIS) (Safe Work Australia).

Exposure Standards

Australian

No specific exposure standards are available.

International

No specific exposure standards are available.

Health Hazard Information

Limited data are available for santalol. Unless specified for alpha-santalol, most studies conducted using santalol do not indicate the exact composition and are more often a blend. Studies for sandalwood oil are generally assumed to be for the East Indian sandalwood oil. No data are available for the esters, but data from the parent alcohol and corresponding acids are considered as suitable analogues for systemic effects.

Toxicokinetics

Cyclic terpenoid primary alcohols are oxidised (via beta-oxidation and cleavage of the side chain) to yield carboxylic acid metabolites. These metabolites will conjugate with glucuronic acid and are excreted primarily via the urine, and to a minor extent in the faeces (Adams et. al., 1996; JECFA 2003a).

Following absorption, santalol is detoxified via conjugation with glucuronic acid then excreted in the urine. For rabbits administered repeated oral doses of santalol, a metabolite was formed by the loss of an isoprene (C5) unit from the parent compound (Adams et. al., 1996).

In an inhalation study, mice were exposed to sandalwood oil at 50–108 mg/m^3 for 1 hour. Low concentrations of alpha-santalol (6.1 ng/mL) and beta-santalol (5.3 ng/mL) were detected in the serum (Bhatia et al., 2008a).

Santalyl esters are expected to hydrolyse to santalol and the corresponding carboxylic acids (specifically acetic acid, butanoic acid and phenylacetic acid), then conjugated with glucuronic acid and excreted as urinary metabolites. Hydrolysis is catalysed

by carboxylesterases or esterases, in particular beta-esterases in the liver. Phenylacetic acid is distributed throughout the human body and excreted as the urinary conjugates of glutamine and taurine within 24 hours. Conjugation of phenylacetic acid is dose-dependent and species-specific (Adams et al., 1996; JECFA, 2003a; JECFA, 2003b).

Acute Toxicity

Oral

Based on the available data for santalol and sandalwood oil in rats, the chemicals in this group have low acute toxicity following oral exposure.

The reported median lethal dose (LD50) values are:

- alpha-santalol, 3800 mg/kg bw (Galleria Chemica); and
- sandalwood oil, 5580 mg/kg bw (Burdock and Carabin, 2008).

Dermal

Based on the available data for santalol and sandalwood oil in rabbits, the chemicals in this group have low acute toxicity following dermal exposure.

The reported dermal LD50 values are:

- alpha-santalol, >5000 mg/kg bw (Galleria Chemica); and
- sandalwood oil, >5000 mg/kg bw (Burdock and Carabin, 2008).

Inhalation

No specific acute inhalation toxicity studies are available.

In an inhalation study to investigate the sedative effects of several fragrance compounds and essential oils (see **Toxicokinetics**), female Swiss mice were exposed to sandalwood oil at an approximate concentration range of 50–180 mg/m^3 for 1 hour. A 40 % decrease in motility compared with untreated controls was observed (Burdock and Carabin, 2008).

Corrosion / Irritation

Respiratory Irritation

Most essential oils may cause mucous membrane irritation following exposure, and there is risk of aspiration from both the essential oil and from hydrocarbons or emulsifiers added to the products (HSDB).

Skin Irritation

Limited data are available for santalol. Based on the available study in humans, santalol is not expected to be a strong skin irritant at concentrations up to 20 %. Sandalwood oil when applied undiluted was considered to be a skin irritant in vitro, but not in humans. Based on the weight of evidence, the chemicals are not likely to be strong skin irritants.

In an acute dermal study in rabbits (n=6), skin irritation was observed following a single neat application of santalol. No other details are available (Bhatia et al., 2008a).

In an in vitro skin irritation study (OECD TG 439: Reconstructed human epidermis test method), 30 µL sandalwood extract was applied topically to the EpiDerm TM tissue for 60 minutes at 37 degrees. The negative control was phosphate buffer saline (PBS), and the positive control was 5 % sodium dodecyl sulfate. At the end of exposure period, the test substance was washed from the epidermis surface with saline, and the rinsed tissues were subjected to a 42-hour post-treatment incubation period. Cell viability was measured using an MTT assay. The mean viability of the test system was 6.5 % (compared to 100 % negative control and 4.6 % positive control), and; therefore, the chemical was considered an irritant (REACHa).

Undiluted sandalwood oil was slightly irritating when applied on backs of hairless mice, and was irritating following occlusive application to intact or abraded rabbit skin for 24 hours. No further details are available (Opdyke, 1979).

Eye Irritation

No data are available for santalol. The available in vitro study for sandalwood extract indicates that the substance is not likely to be a strong eye irritant. Therefore, hazard classification is not warranted.

In an in vitro eye irritation study (OECD TG 437: Bovine corneal opacity and permeability test method), 0.75 mL of undiluted sandalwood extract (TFS plantation-grown Indian sandalwood oil, *Santalum Album*) was applied to the epithelial surface of cattle corneae and incubated for 10 minutes at 32 degrees in a horizontal position. After rinsing with saline, the corneae were incubated for a further 2 hours at 32 degrees in a vertical position. The negative control was minimal essential medium (MEM), and the positive control was 100 % ethanol. The calculated mean in vitro irritation score (IVIS) was 3.5 (IVIS >55 is regarded as serious eye damage). The oil was not considered to be corrosive or a severe irritant (REACHa).

Observation in humans

In a pre-study for a human maximisation test, no skin irritation was observed when santalol was tested (occlusive) at 20 % in petrolatum on the backs of 5 healthy male volunteers for 48 hours (Bhatia et al., 2008a).

In a 24-hour human patch test, undiluted sandalwood oil was not irritating to the skin when tested in 18 subjects. In a 48-hour closed patch test, sandalwood oil at 10 % concentration in petrolatum was not irritating in humans (Burdock and Carabin, 2008).

Sensitisation

Skin Sensitisation

Limited data are available in animal studies; however, many sensitisation human health studies are available (see **Observations in humans**). Considering the widespread number of cases, sandalwood oil and the major component santalol are recommended for hazard classification. This classification does not apply to the esters in this group.

In a guinea pig maximisation test, 'mild sensitisation' was observed following exposure to alpha-santalol at 10 % concentration (vehicle not stated). No further details are available (Bhatia et al., 2008b).

In 2 open epicutaneous test (OET), guinea pigs (n=6–8/group) were induced with 0.1 mL alpha-santalol at 20 % concentration (vehicle not stated), once a day for 21 days. The animals were challenged on days 21 and 35 with 0.0025 mL alpha-santalol at the minimal irritating concentration and some lower non-irritating concentrations (exact concentrations not stated). No sensitisation reactions were observed to the chemical with induction at 20 % (Bhatia et al., 2008b).

In an in vitro screening test (*Bacillus subtilis* Rec assay in H17 and M45 strains) for detection of delayed allergic contact dermatitis, the specific activity in spore Rec assay was determined. The specific activity value of sandalwood oil was 0.2 (allergic is >1) and; therefore, it was classified as non-allergic (Burdock and Carabin, 2008).

Quantitative Structure Activity Relationship (QSAR) modelling for the identified hydrocarbon minor constituents of sandalwood oil (alpha- and beta-santalenes and beta-farnesene) using the Organisation for Economic Cooperation and Development (OECD) Toolbox (version 4.2) did not indicate any structural alerts for skin sensitisation.

Observation in humans

The EU Scientific Committee on Consumer Safety (SCCS) has categorised both alpha- and beta-santalol as an 'established contact allergen in humans'. This is based on 11 to 100 positive test reactions reported in humans. The isoforms are considered as 1 as they are often not differentiated in reports. Sandalwood oil is also considered an established contact allergen in humans due to its content of 'well-known allergenic compounds (santalols)' (SCCS, 2012).

In a human maximisation test, santalol at 20 % in petrolatum was applied to 25 male volunteers for 5 alternate days, at 48-hour periods. The test sites were pre-treated (occlusively) with sodium lauryl sulfate (SLS) at 5 % for 24 hours. After a 10-day non-treatment period, the patients were challenged for 48 hours. No sensitisation was observed (Bhatia et al., 2008a).

Many human diagnostic patch tests are available for exposure to santalol (alpha or beta isomer not specified) at 1 %, 2 %, 5 % and 10 % in petrolatum. Positive results were observed in some of these patients, with the incidence in the range of 0.0071–1.53 % in tested patients. In 2 closed patch tests, santalol at 0.05–0.5 % in base cream or in 99 % ethanol was applied to the back, the forearm, and the inner upper arm of patients (n=214 and 427) up to 48 hours. Positive results were observed in 15 out of 427 patients (with 10 more being questionable), and in 3 out of 214 patients (with 6 being questionable) (Bhatia et al., 2008a).

In a 6-year (1976–1981) patch test study conducted by the mid-Japan contact dermatitis research group (MJDCRG), patients with facial dermatoses were tested with various fragrance materials. Among these patients, 327 were tested with a mixture of alpha and beta santalol at 1 %, 2 % and 10 % in petrolatum and yielded positive reactions in 2, 2, and 5 patients (0.6 %, 0.6 % and 1.5 % incidence), respectively (Bhatia et al., 2008b). No effects were observed when these patients were further irradiated with fluorescent lamps (365 nm; 3 J/cm^2) to test for phototoxicity and photoallergy (Bhatia et al., 2008a)

In several phototoxicity and photoallergy tests, patients with suspected contact dermatitis were photopatch tested with cosmetic and toiletry ingredients. No photoallergic reactions were observed with santalol at 2 % and 5 % in petrolatum (Bhatia et al., 2008a).

There are many clinical studies available on skin sensitisation reactions to sandalwood oil, with *Santalum album* wood oil (CAS No. 84787-70-2) reported in most studies. Overall, the incidence of positive reactions was in the range of 0.4–1.8 %, for exposure to 2 % sandalwood oil in tested patients. Higher incidences were observed in patients with suspected allergies or pre-sensitised to other allergens in the European baseline series (Fragrance Mix) (Burdock and Carabin, 2008; SCCS, 2012).

Repeated Dose Toxicity

Oral

No data are available for the chemicals in this group.

Santalol is predicted to metabolise to innocuous products. When evaluated as a flavouring agent, the joint FAO/WHO expert committee on food additives (JECFA) has concluded that santalol (alpha and beta) and santalyl acetate are not likely to present a safety concern at the current estimated levels of intake (JECFA, 2003a).

Sandalwood oil is approved by the United States (US) Flavor and Extract Manufacturer's Association (FEMA) as generally recognised as safe (GRAS) for use in food as a flavouring ingredient (Adams et al., 1996).

Repeat dose oral toxicity studies with acetic acid, butanoic acid and phenylacetic acid show that these metabolites are not likely to cause serious damage to health from repeat exposure (NICNASa; NICNASb; REACHb). In a combined repeat dose/reproductive and developmental toxicity study, the no observed adverse effect level (NOAEL) for phenylacetic acid in Wistar rats was >1000 mg/kg bw/day (REACHb).

Dermal

No data are available.

Inhalation

No data are available.

Genotoxicity

No specific genotoxicity studies on santalol are available. Based on in vitro results for sandalwood oil, the chemicals are not likely to be genotoxic.

Santalum album oil was not mutagenic in a bacterial reverse mutation test (OECD TG 471) with strains of *Salmonella typhimurium* (TA97, TA1535, TA98 and TA100) at 0.05–5 µL/plate, with and without metabolic activation (REACHa).

Santalum album oil was not genotoxic in the *Bacillus subtilis* Rec assay using H17 Rec+ and M45 Rec-, with or without metabolic activation (Burdock and Carabin, 2008).

A study examining the effects of sandalwood essential oil in human breast adenocarcinoma (MCF-7) and non-tumorigenic breast epithelial (MCF-10A) cells showed that the oil induced DNA single- and double-strand breaks in both cell lines. The MCF-7 cells were unable to repair the damage and; therefore, the oil was selectively cytotoxic towards this cell line (Ortiz et al., 2016).

Santalyl acetate and santalyl phenylacetate were evaluated by the European Food Safety Authority (EFSA) and the Panel concluded that they do not ‘give rise to concern with respect to genotoxicity’ (EFSA, 2013). The metabolites acetic acid, butanoic acid and phenylacetic acid were not considered to be genotoxic in in vitro studies (NICNASa; NICNASb; REACHb).

Carcinogenicity

No specific carcinogenicity studies on santalol are available.

Several academic studies have reported the chemopreventive properties of alpha-santalol on tumour development in several strains of mice and in in vitro studies.

A 30-week study was conducted to investigate effects of alpha-santolol on ultraviolet-B (UVB) radiation-induced skin tumour development, and UVB-caused induction of epidermal ornithine decarboxylase (ODC) activity in female hairless SKH-1 mice. Topical application of the chemical at 5 % w/v in acetone showed chemopreventive effects against a 2-stage carcinogenesis model consisting of 7,12-dimethylbenz(a)anthracene (DMBA) initiated and 12-O-tetradecanoylphorbol-13-acetate (TPA) promoted skin tumour development. Alpha-santalol was observed to decrease tumour incidence and multiplicity, suggesting chemopreventive effects against UVB-induced tumour initiation, tumour promotion and complete carcinogenesis. The chemical also inhibited UVB-induced epidermal ODC activity (Dwivedi et al., 2006). Studies reported by the same group have also demonstrated anti-tumour activity of alpha-santalol at 5 % w/v on DMBA/TPA models in CD-1 and SENCAR mice (Dwivedi et al., 2006).

A study identified that alpha-santalol caused G2/M phase cell cycle arrest to decrease cell viability, indicating that this mechanism contributes to the overall tumour-preventive efficacy of the chemical (Zhang et al., 2010)

Reproductive and Developmental Toxicity

No data are available.

Risk Characterisation

Critical Health Effects

The critical health effects for risk characterisation for santalol and sandalwood oil include:

- local effects (skin sensitisation).

Santalyl acetate, santalyl phenylacetate, alpha-santalyl butyrate and beta-santalyl butyrate do not have any critical health effects for risk characterisation.

Public Risk Characterisation

While specific Australian use information is not available, the chemicals in this group have reported international uses as fragrance ingredients in cosmetic and domestic products. Considering the range of products that may contain the chemicals, the main route of public exposure is expected to be through the skin, inhalation from products applied as aerosols, and potential oral exposure from lip and oral hygiene products.

Available studies in humans show that sandalwood oil and the major component santalol have potential to cause skin sensitisation especially to individuals with allergies or pre-sensitised to other allergens (see **Skin sensitisation**).Human data for these chemicals was evaluated by the SCCS and the chemicals were not considered to be among the more common fragrance allergens. They were not included on the list of common allergens that require labelling in cosmetic products regardless of their widespread use (SCCS, 2012). Therefore, the risk of skin sensitisation following exposure to products containing these chemicals as fragrance ingredients is expected to be low.

Occupational Risk Characterisation

During product formulation, dermal exposure might occur, particularly where manual or open processes are used. These could include transfer and blending activities, quality control analysis, and cleaning and maintaining equipment. Worker exposure to the chemicals at lower concentrations could also occur while using formulated products containing the chemicals. The level and route of exposure will vary depending on the method of application and work practices employed.

Given the critical local health effect, the chemicals could pose an unreasonable risk to workers unless adequate control measures to minimise dermal exposure are implemented. The chemicals should be appropriately classified and labelled to ensure that a person conducting a business or undertaking (PCBU) at a workplace (such as an employer) has adequate information to determine the appropriate controls.

The data available support an amendment to the hazard classification in the HCIS (Safe Work Australia) (refer to **Recommendation** section).

NICNAS Recommendation

Assessment of the chemicals are considered to be sufficient provided that risk management recommendations are implemented and all requirements are met under workplace health and safety and poisons legislation as adopted by the relevant state or territory.

Regulatory Control

Work Health and Safety

The chemicals are recommended for classification and labelling aligned with the Globally Harmonized System of Classification and Labelling of Chemicals (GHS) as below. This does not consider classification of physical hazards and environmental hazards.

Note: The recommended classification does not apply to the esters santalyl acetate (CAS No. 1323-00-8), santalyl phenylacetate (CAS No. 1323-75-7), alpha-santalyl butyrate (CAS No. 67633-99-2) and beta-santalyl butyrate (CAS No. 67633-98-1).

From 1 January 2017, under the model Work Health and Safety Regulations, chemicals are no longer to be classified under the Approved Criteria for Classifying Hazardous Substances system.

Hazard	Approved Criteria (HSIS)[a]	GHS Classification (HCIS)[b]
Sensitisation	Not Applicable	May cause an allergic skin reaction - Cat. 1B (H317)

[a] Approved Criteria for Classifying Hazardous Substances [NOHSC:1008(2004)].

[b] Globally Harmonized System of Classification and Labelling of Chemicals (GHS) United Nations, 2009. Third Edition.

[*] Existing Hazard Classification. No change recommended to this classification

Advice for consumers

Products containing the chemicals should be used according to the instructions on the label.

Advice for industry

Control measures

Control measures to minimise the risk from dermal exposure to the chemicals should be implemented in accordance with the hierarchy of controls. Approaches to minimise risk include substitution, isolation and engineering controls. Measures required to eliminate, or minimise risk arising from storing, handling and using a hazardous chemical depend on the physical form and the manner in which the chemicals are used. Examples of control measures that could minimise the risk include, but are not limited to:

- health monitoring for any worker who is at risk of exposure to the chemicals, if valid techniques are available to monitor the effect on the worker's health;
- minimising manual processes and work tasks through automating processes;
- work procedures that minimise splashes and spills;
- regularly cleaning equipment and work areas; and
- using protective equipment that is designed, constructed, and operated to ensure that the worker does not come into contact with the chemicals.

Guidance on managing risks from hazardous chemicals are provided in the *Managing risks of hazardous chemicals in the workplace—Code of practice* available on the Safe Work Australia website.

Personal protective equipment should not solely be relied upon to control risk and should only be used when all other reasonably practicable control measures do not eliminate or sufficiently minimise risk. Guidance in selecting personal protective equipment can be obtained from Australian, Australian/New Zealand or other approved standards.

Obligations under workplace health and safety legislation

Information in this report should be taken into account to help meet obligations under workplace health and safety legislation as adopted by the relevant state or territory. This includes, but is not limited to:

- ensuring that hazardous chemicals are correctly classified and labelled;
- ensuring that (material) safety data sheets ((M)SDS) containing accurate information about the hazards (relating to both health hazards and physicochemical (physical) hazards) of the chemicals are prepared; and
- managing risks arising from storing, handling and using a hazardous chemical.

Your work health and safety regulator should be contacted for information on the work health and safety laws in your jurisdiction.

Information on how to prepare an (M)SDS and how to label containers of hazardous chemicals are provided in relevant codes of practice such as the *Preparation of safety data sheets for hazardous chemicals—Code of practice* and *Labelling of workplace hazardous chemicals—Code of practice*, respectively. These codes of practice are available from the Safe Work Australia website.

A review of the physical hazards of these chemicals has not been undertaken as part of this assessment.

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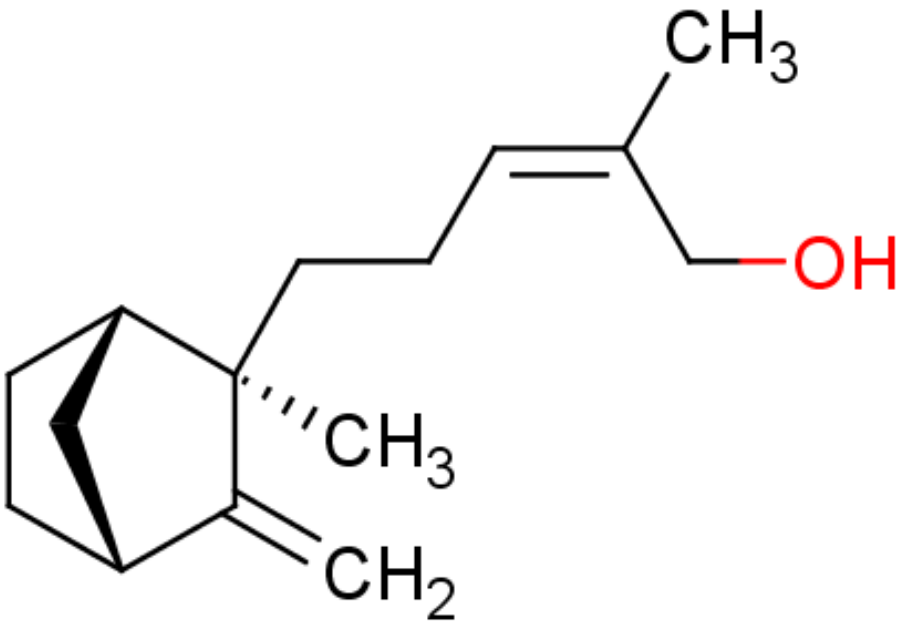
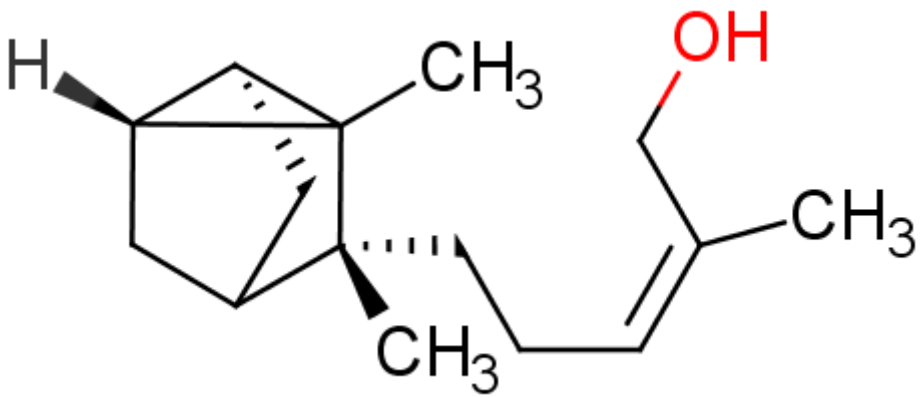
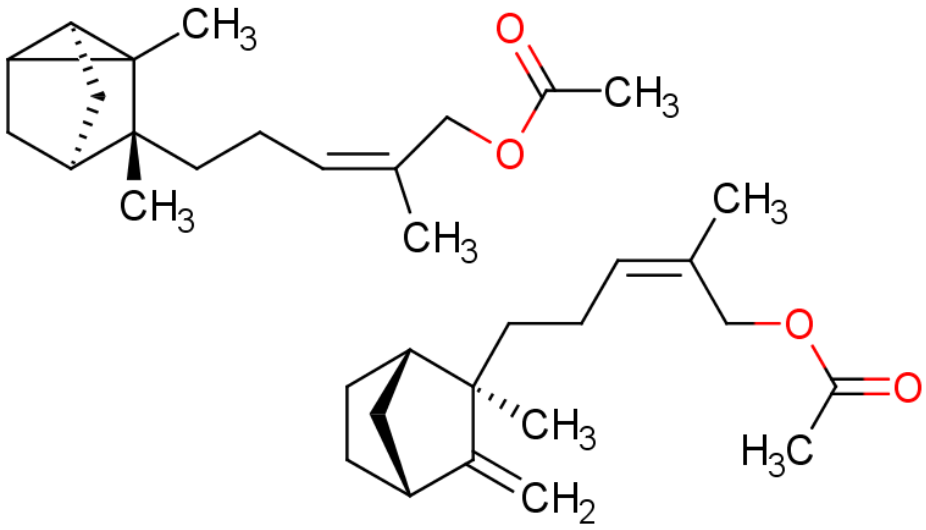
Last Update 12 December 2019

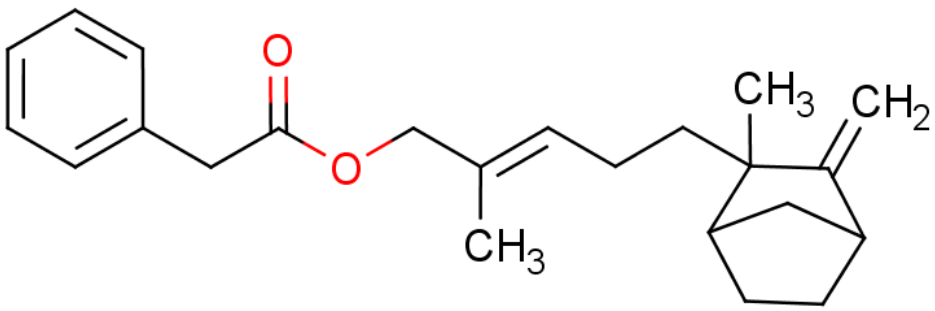
Chemical Identities

Chemical Name in the Inventory and Synonyms	**2-Penten-1-ol, 2-methyl-5-(2-methyl-3-methylenebicyclo[2.2.1]hept-2-yl)-, [1.alpha.,2.alpha.(Z),4.alpha.]-(-)-** beta-santalol 2-methyl-5-(2-methyl-3-methylene-2-norbornyl)-2-penten-1-ol
CAS Number	77-42-9
Structural Formula	

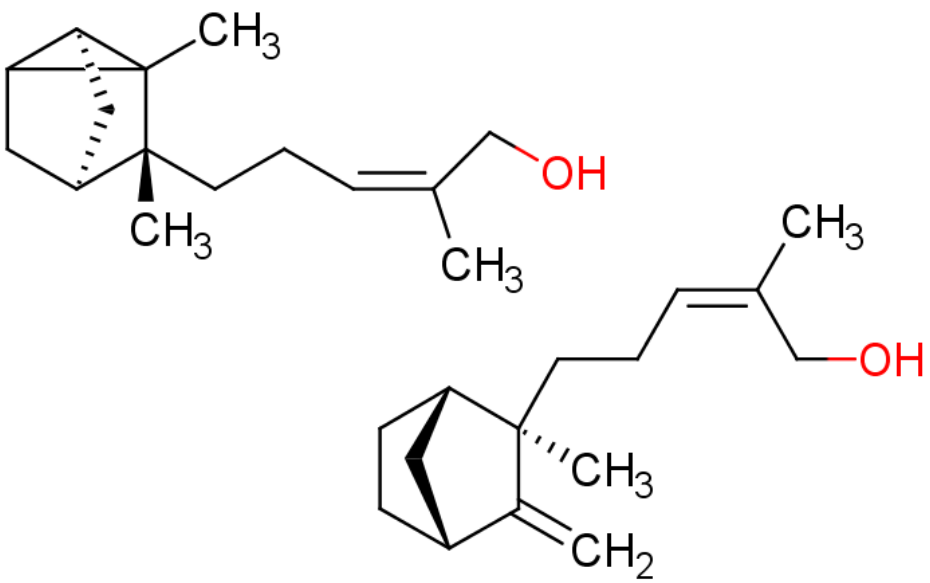
	
Molecular Formula	C15H24O
Molecular Weight	220.35

Chemical Name in the Inventory and Synonyms	**2-Penten-1-ol, 5-(2,3-dimethyltricyclo[2.2.1.02,6]hept-3-yl)-2-methyl-, [R-(Z)]-** alpha-santalol (Z)-alpha-santalol -(2,3-dimethyltricyclo(2.2.1.0(2,6))hept-3-yl)-2-methyl-2-penten-1-ol
CAS Number	115-71-9
Structural Formula	
Molecular Formula	C15H24O
Molecular Weight	220.35

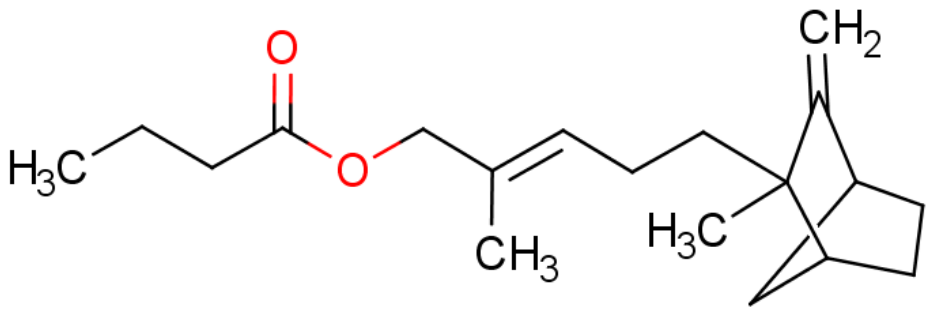
Chemical Name in the Inventory and Synonyms	**Santalol, acetate** santalyl acetate
CAS Number	1323-00-8
Structural Formula	
Molecular Formula	C17H26O2
Molecular Weight	524.78

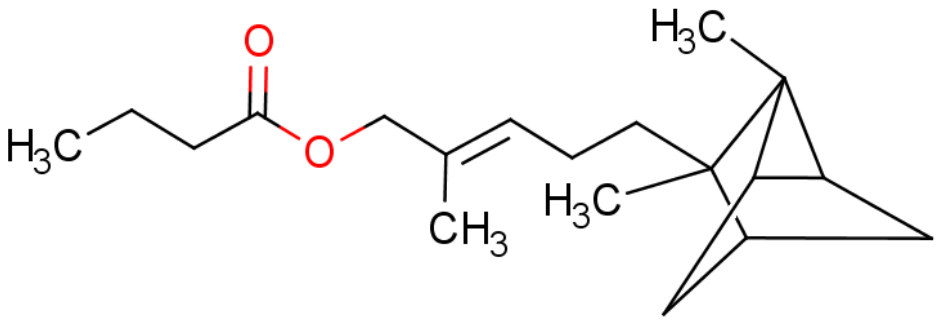
Chemical Name in the Inventory and Synonyms	**Santalol, phenylacetate** santalyl phenylacetate santalyl alpha-toluate santalol, benzeneacetate acetic acid, phenyl-, santalyl ester
CAS Number	1323-75-7
Structural Formula	
Molecular Formula	C23H30O2
Molecular Weight	338.49

Chemical Name in the Inventory and Synonyms	**Oils, sandalwood** Sandalwood oil, East Indian Santalum album oil Santalum album L
CAS Number	8006-87-9
Structural Formula	**No Structural Diagram Available**
Molecular Formula	Unspecified
Molecular Weight	Unspecified

Chemical Name in the Inventory and Synonyms	**Santalol** santalol, alpha- and beta-
CAS Number	11031-45-1
Structural Formula	

Molecular Formula	C15H24O
Molecular Weight	440.71

Chemical Name in the Inventory and Synonyms	**Butanoic acid, 2-methyl-5-(2-methyl-3-methylenebicyclo[2.2.1]hept-2-yl)-2-pentenyl ester** 2-penten-1-ol, 2-methyl-5-(2-methyl-3-methylene-2-norbornyl)-, butyrate santalyl butyrate beta-santalyl butyrate
CAS Number	67633-98-1
Structural Formula	
Molecular Formula	C19H30O2
Molecular Weight	290.44

Chemical Name in the Inventory and Synonyms	**Butanoic acid, 5-(2,3-dimethyltricyclo[2.2.1.02,6]hept-3-yl)-2-methyl-2-pentenyl ester** 5-(2,3-dimethyltricyclo(2.2.1.02,6)hept-3-yl)-2-methylpent-2-enyl butyrate alpha-santalyl butyrate
CAS Number	67633-99-2
Structural Formula	
Molecular Formula	C19H30O2

Molecular Weight	290.44

Chemical Name in the Inventory and Synonyms	**Sandalwood, extract** extract of sandalwood
CAS Number	84787-70-2
Structural Formula	**No Structural Diagram Available**
Molecular Formula	Unspecified
Molecular Weight	Unspecified

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