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Short Review

RIFM fragrance ingredient safety assessment, theaspirane, CAS Registry Number 36431-72-8

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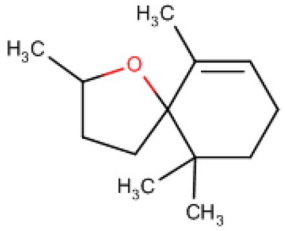
Version: 091318. This version replaces any previous versions.
Name: Theaspirane
CAS Registry Number: 36431-72-8



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Abbreviation/Definition List:

2-Box Model - A RIFM, Inc. proprietary *in silico* tool used to calculate fragrance air exposure concentration
AF - Assessment Factor
BCF - Bioconcentration Factor
Creme RIFM Model - The Creme RIFM Model uses probabilistic (Monte Carlo) simulations to allow full distributions of data sets, providing a more realistic estimate of aggregate exposure to individuals across a population (Comiskey et al., 2015, 2017; Safford et al., 2015a, 2017) compared to a deterministic aggregate approach
DEREK - Derek Nexus is an *in silico* tool used to identify structural alerts
DST - Dermal Sensitization Threshold
ECHA - European Chemicals Agency
EU - Europe/European Union
GLP - Good Laboratory Practice
IFRA - The International Fragrance Association
LOEL - Lowest Observable Effect Level
MOE - Margin of Exposure
MPPD - Multiple-Path Particle Dosimetry. An *in silico* model for inhaled vapors used to simulate fragrance lung deposition
NA - North America
NESIL - No Expected Sensitization Induction Level
NOAEC - No Observed Adverse Effect Concentration
NOAEL - No Observed Adverse Effect Level
NOEC - No Observed Effect Concentration
NOEL - No Observed Effect Level
OECD - Organisation for Economic Co-operation and Development
OECD TG - Organisation for Economic Co-operation and Development Testing Guidelines
PBT - Persistent, Bioaccumulative, and Toxic
PEC/PNEC - Predicted Environmental Concentration/Predicted No Effect Concentration
QRA - Quantitative Risk Assessment
REACH - Registration, Evaluation, Authorisation, and Restriction of Chemicals
RfD - Reference Dose
RIFM - Research Institute for Fragrance Materials
RQ - Risk Quotient
Statistically Significant - Statistically significant difference in reported results as compared to controls with a $p < 0.05$ using appropriate statistical test
TTC - Threshold of Toxicological Concern
UV/Vis spectra - Ultraviolet/Visible spectra
VCF - Volatile Compounds in Food
VoU - Volume of Use **vPvB** - (very) Persistent, (very) Bioaccumulative
WoE - Weight of Evidence

The Expert Panel for Fragrance Safety* concludes that this material is safe as described in this safety assessment.
This safety assessment is based on the RIFM Criteria Document (Api et al., 2015), which should be referred to for clarifications.

Each endpoint discussed in this safety assessment includes the relevant data that were available at the time of writing (version number in the top box is indicative of the date of approval based on a 2-digit month/day/year), both in the RIFM database (consisting of publicly available and proprietary data) and through publicly available information sources (e.g., SciFinder and PubMed). Studies selected for this safety assessment were based on appropriate test criteria, such as acceptable guidelines, sample size, study duration, route of exposure, relevant animal species, most relevant testing endpoints, etc. A key study for each endpoint was selected based on the most conservative endpoint value (e.g., PNEC, NOAEL, LOEL, and NESIL).

*The Expert Panel for Fragrance Safety is an independent body that selects its own members and establishes its own operating procedures. The Expert Panel is comprised of internationally known scientists that provide RIFM with guidance relevant to human health and environmental protection.

Summary: The existing information supports the use of this material as described in this safety assessment.

Theaspirane was evaluated for genotoxicity, repeated dose toxicity, reproductive toxicity, local respiratory toxicity, phototoxicity/photoallergenicity, skin sensitization, and environmental safety. Data from theaspirane show that it is not genotoxic. Data on read-across analog 1-oxaspiro [4.5]deca-3,6-diene, 2,7-dimethyl-10-(1-methylethyl)- (CAS # 89079-92-5) provide a calculated MOE > 100 for the repeated dose toxicity endpoint. The reproductive and local respiratory toxicity endpoints were evaluated using the TTC for a Cramer Class III material, and the exposure to theaspirane is below the TTC (0.0015 mg/kg/day and 0.47 mg/day, respectively). The skin sensitization endpoint was completed using the DST for non-reactive materials (900 μg/cm^2); exposure is below the DST. The phototoxicity/photoallergenicity endpoints were evaluated based on UV spectra; theaspirane is not expected to be phototoxic/photoallergenic. The environmental endpoints were evaluated; theaspirane was found not to be PBT as per the IFRA Environmental Standards, and its risk quotients, based on its current volume of use in Europe and North America (i.e., PEC/PNEC), are < 1.

Human Health Safety Assessment

Genotoxicity: Not genotoxic.	(RIFM, 2016b; RIFM, 2017)
Repeated Dose Toxicity: NOAEL = 167 mg/kg/day.	RIFM (1993)
Reproductive Toxicity: No NOAEL available. Exposure is below the TTC.	
Skin Sensitization: No safety concerns at current, declared use levels.	RIFM (1998)
Phototoxicity/Photoallergenicity: Not expected to be phototoxic/photoallergenic.	(UV Spectra, RIFM Database)
Local Respiratory Toxicity: No NOAEC available. Exposure is below the TTC.	

Environmental Safety Assessment

Hazard Assessment:	
Persistence: Screening-level: 2.3 (BIOWIN 3)	(EPI Suite v4.11; US EPA, 2012a)
Bioaccumulation: Screening-level: 67.19 L/kg	(EPI Suite v4.11; US EPA, 2012a)
Ecotoxicity: Screening-level: Fish LC50: 0.9799 mg/L	(RIFM Framework; Salvito et al., 2002)
Conclusion: Not PBT or vPvB as per IFRA Environmental Standards	
Risk Assessment:	
Screening-level: PEC/PNEC (North America and Europe) < 1	(RIFM Framework; Salvito et al., 2002)
Critical Ecotoxicity Endpoint: Fish LC50: 0.9799 mg/L	(RIFM Framework; Salvito et al., 2002)
RIFM PNEC is: 0.0009799 μg/L	

- **Revised PEC/PNECs (2015 IFRA VoU):** North America and Europe: not applicable; cleared at screening-level

1. Identification

1. **Chemical Name:** Theaspirane
2. **CAS Registry Number:** 36431-72-8
3. **Synonyms:** 1-Oxaspiro [4.5]dec-6-ene, 2,6,10,10-tetramethyl-; 1-Oxaspiro-2,6,10,10-tetramethyl [4.5]dec-6-ene; 2,6,10,10-Tetramethyl-1-oxaspiro [4.5]dec-6-ene; Spiroxide; 1-Oxaspiro-(4,5)-2,6,10,10-tetramethyl-6-decene; 1-ｵｷｻｽﾋﾟﾛ-2,6,10,10-ﾃﾄﾗﾒﾁﾙ-ｽﾋﾟﾛ[4,5] -6-ﾃﾞｾﾝ; Theaspirane
4. **Molecular Formula:** $C_{13}H_{22}O$
5. **Molecular Weight:** 194.32
6. **RIFM Number:** 5031
7. **Stereochemistry:** Isomer not specified. Two stereocenters and 4 total stereoisomers possible.

2. Physical data

1. **Boiling Point:** 237.39 °C (EPI Suite)
2. **Flash Point:** 65 °C (GHS)
3. **Log K_{ow}:** 4.79 (EPI Suite)
4. **Melting Point**: 39.41 °C (EPI Suite)
5. **Water Solubility:** 3.796 mg/L (EPI Suite)
6. **Specific Gravity:** Not Available
7. **Vapor Pressure:** 0.0351 mm Hg @ 20 °C (EPI Suite v4.0), 0.0591 mm Hg @ 25 °C (EPI Suite)
8. **UV Spectra:** Minor absorbance between 290 and 700 nm; molar absorption coefficient is below the benchmark (1000 L mol^{-1} · cm^{-1})
9. **Appearance/Organoleptic:** Not Available

3. Exposure

1. **Volume of Use (worldwide band):** 0.1–1 metric ton per year (IFRA, 2015)
2. **95**th **Percentile Concentration in Hydroalcoholics:** 0.0010% (RIFM, 2016a)
3. **Inhalation Exposure*:** 0.0000018 mg/kg/day or 0.00012 mg/kg/day (RIFM, 2016a)
4. **Total Systemic Exposure**:** 0.00014 mg/kg/day (RIFM, 2016a)

*95th percentile calculated exposure derived from concentration survey data in the Creme RIFM aggregate exposure model (Comiskey et al., 2015; Safford et al., 2015a; Safford et al., 2017; and Comiskey et al., 2017).

**95th percentile calculated exposure; assumes 100% absorption unless modified by dermal absorption data as reported in Section IV. It is derived from concentration survey data in the Creme RIFM aggregate exposure model and includes exposure via dermal, oral, and inhalation routes whenever the fragrance ingredient is used in products that include these routes of exposure (Comiskey et al., 2015; Safford et al., 2015a; Safford et al., 2017; and Comiskey et al., 2017).

4. Derivation of systemic absorption

1. **Dermal:** Assumed 100%
2. **Oral:** Assumed 100%
3. **Inhalation:** Assumed 100%

5. Computational toxicology evaluation

1. **Cramer Classification:** Class III, High

Expert Judgment	Toxtree v 2.6	OECD QSAR Toolbox v 3.2
III	III	III

2. **Analogs Selected**:
   a. **Genotoxicity:** None
   b. **Repeated Dose Toxicity:** 1-Oxaspiro [4.5]deca-3,6-diene, 2,7-dimethyl-10-(1-methylethyl)- (CAS # 89079-92-5)
   c. **Reproductive Toxicity:** None
   d. **Skin Sensitization:** None
   e. **Phototoxicity/Photoallergenicity:** None
   f. **Local Respiratory Toxicity:** None
   g. **Environmental Toxicity:** None
3. Read-across Justification: See Appendix below

6. Metabolism

Not considered for this risk assessment and therefore not reviewed except where it may pertain in specific endpoint sections as discussed below.

7. Natural occurrence (discrete chemical) or composition (NCS)

Theaspirane is reported to occur in the following foods by the VCF*:
Black choke berry juice (*Aronia melanocarpa* Ell.)
Cherimoya (*Annona cherimolia* Mill.)
Grape (*Vitis* species).
Passion fruit (*Passiflora* species).
Quince, marmelo (*Cydonia oblonga* Mill.)
Raspberry, blackberry, and boysenberry.
Sherry.
Starfruit (*Averrhoa carambola* L.)
Tea.
Wine.

*VCF Volatile Compounds in Food: database/Nijssen, L.M.; Ingen-Visscher, C.A. van; Donders, J.J.H. (eds). – Version 15.1 – Zeist (The Netherlands): TNO Triskelion, 1963–2014. A continually updated database containing information on published volatile compounds that have been found in natural (processed) food products. Includes FEMA GRAS and EU-Flavis data.

8. IFRA standard

None.

9. REACH dossier

Pre-registered for 2010; no dossier available as of 04/18/18.

10. Summary

10.1. Human health endpoint summaries

10.1.1. Genotoxicity

Based on the current existing data, theaspirane does not present a concern for genetic toxicity.

10.1.1.1. Risk assessment. Theaspirane was assessed in the BlueScreen assay and found positive for cytotoxicity (positive: < 80% relative cell density) and negative for genotoxicity, with and without metabolic activation (RIFM, 2013). BlueScreen is a screening assay that assesses genotoxic stress through human-derived gene expression. Additional assays were considered to fully assess the potential mutagenic or clastogenic effects of the target material.

The mutagenic activity of theaspirane has been evaluated in a bacterial reverse mutation assay conducted in compliance with GLP regulations and in accordance with OECD TG 471 using the standard plate incorporation and preincubation methods. *Salmonella typhimurium* strains TA98, TA100, TA1535, TA1537, and *Escherichia coli* WP2uvrA were treated with theaspirane in dimethyl sulfoxide (DMSO) at

concentrations up to 5000 μg/plate. No increases in the mean number of revertant colonies were observed at any tested concentration in the presence or absence of S9 (RIFM, 2016b). Under the conditions of the study, theaspirane was not mutagenic in the Ames test.

The clastogenic activity of theaspirane was evaluated in an *in vitro* micronucleus test conducted in compliance with GLP regulations and in accordance with OECD TG 487. Human peripheral blood lymphocytes were treated with theaspirane in DMSO at concentrations up to 877 μg/mL in the presence and absence of metabolic activation (S9) for 3 h and in the absence of metabolic activation for 24 h. Theaspirane did not induce binucleated cells with micronuclei when tested up to cytotoxic concentrations in either the presence or absence of an S9 activation system (RIFM, 2017). Under the conditions of the study, theaspirane was considered to be non-clastogenic in the *in vitro* micronucleus test.

Based on the data available, theaspirane does not present a concern for genotoxic potential.

Additional References: None.

Literature Search and Risk Assessment Completed On: 05/20/18.

10.1.2. Repeated dose toxicity

The margin of exposure for theaspirane is adequate for the repeated dose toxicity endpoint at the current level of use.

10.1.2.1. Risk assessment. There are insufficient repeated dose toxicity data on theaspirane. Read-across material, 1-oxaspiro [4.5]deca-3,6-diene, 2,7-dimethyl-10-(1-methylethyl)- (CAS # 89079-92-5; see Section V) has sufficient repeated dose toxicity data that can be used to support the repeated dose toxicity endpoint. A GLP 28-day oral gavage subchronic toxicity study was conducted in CD strain rats. Groups of 5 rats/sex/dose were administered 1-oxaspiro [4.5]deca-3,6-diene, 2,7-dimethyl-10-(1-methylethyl)- (Neocaspirene) via oral gavage at doses of 0, 10, 100, or 500 mg/kg/day in maize oil for 4 weeks. One male and 1 female rat from the control group were found dead on day 2 of the study, and 1 female rat from the high-dose group was euthanized on the same day. At necropsy, ruptures of the esophagus associated with accidental dosing was noted as the factor contributing to the death of all 3 rats. As this occurred early in the study, these animals were replaced. At 500 mg/kg/day, statistically significant findings included a decrease in bodyweight gain during weeks 1–2 (males only), a decrease in the mean cell volume and mean cell hemoglobin (males only), an increase in the plasma activity of 5′-nucleotidase (females only), an increase in the plasma activity of alanine aminotransferase (males only), and an increase in the serum protein concentration (males only). Although there were no changes in the total serum protein concentration among female animals, there was a statistically significant increase in α2-globulin and β-globulin in high-dose females. An increase in the activity of 5′-nucleotidase is generally associated with hepatobiliary disease when seen in parallel with an increase in alkaline phosphatase activity, but there was no evidence to support this. Statistically significant increases in the absolute and relative liver weights were observed among animals of the highest dose group. The increase in the relative liver weights extended to males of the mid-dose group. The absolute and relative kidney weights were statistically significantly increased among males of the highest dose group. Enlargement of the liver and kidneys was observed in male rats dosed at 500 mg/kg/day, and pallor of these organs was noted in a few male and female rats dosed at 100 and 500 mg/kg/day. In all high-dose male rats, the cytoplasm of the epithelial cells of the proximal tubules contain eosinophilic hyaline droplets, and in 2 of these rats, this accumulation was associated with degeneration of the epithelial cells. In addition, 3 out of 5 male rats treated at 100 mg/kg/day showed accumulation of hyaline droplets within the renal tubular epithelium. These changes were not apparent in female rats. The kidney changes in males were consistent with documented changes of α-2u-globulin nephropathy, which is species-specific to male rats in response to treatment with some hydrocarbons. This effect is not considered a hazard to human health (Lehman-McKeeman and Caudill, 1992; Lehman-McKeeman et al., 1990). All high-dose animals exhibited hypertrophy of hepatocytes, which may be associated with the increased serum proteins, since it is synthesized in the liver; therefore, the increased plasma concentration is most likely related to the increased liver weights. Since there were no histopathological or clinical chemistry evidence of liver degeneration or necrosis, the liver weight increases were considered to be adaptive (Hall et al., 2012). The NOAEL for systemic toxicity was considered to be 500 mg/kg/day, the highest dose tested (RIFM, 1993).

A default safety factor of 3 was used when deriving a NOAEL from a 28-day study. The safety factor has been approved by the Expert Panel for Fragrance Safety*.

The derived NOAEL for the repeated dose toxicity data is 500/3 or 167 mg/kg/day.

Therefore, the theaspirane MOE for the repeated dose toxicity endpoint can be calculated by dividing the 1-oxaspiro [4.5]deca-3,6-diene, 2,7-dimethyl-10-(1-methylethyl)- NOAEL in mg/kg/day by the total systemic exposure to theaspirane, 167/0.00014, or 1192857.

In addition, the total systemic exposure to theaspirane (0.14 μg/kg/day) is below the TTC (1.5 μg/kg bw/day; Kroes et al., 2007) for the repeated dose toxicity endpoint of a Cramer Class III material at the current level of use.

Additional References: None.

Literature Search and Risk Assessment Completed On: 05/12/18.

10.1.3. Reproductive toxicity

There are insufficient reproductive toxicity data on theaspirane or on any read-across materials. The total systemic exposure to theaspirane is below the TTC for the reproductive toxicity endpoint of a Cramer Class III material at the current level of use.

10.1.3.1. Risk assessment. There are no reproductive toxicity data on theaspirane or on any read-across materials that can be used to support the reproductive toxicity endpoint. The total systemic exposure to theaspirane (0.14 μg/kg bw/day) is below the TTC (1.5 μg/kg bw/day; Kroes et al., 2007; Laufersweiler et al., 2012) for the reproductive toxicity endpoint of a Cramer Class III material at the current level of use.

Additional References: None.

Literature Search and Risk Assessment Completed On: 08/01/18.

10.1.4. Skin sensitization

Based on the existing data and the application of DST, theaspirane does not present a concern for skin sensitization under current, declared levels of use.

10.1.4.1. Risk assessment. The chemical structure of this material indicates that it would not be expected to react with skin proteins (Roberts et al., 2007; Toxtree 2.6.13; OECD toolbox v4.2). In a guinea pig maximization test, no reactions indicative of sensitization were observed with 100% and 25% theaspirane at challenge (RIFM, 1998). Acting conservatively, due to the insufficient data, the reported exposure was benchmarked utilizing the non-reactive Dermal Sensitization Threshold (DST) of 900 μg/cm^2 (Safford, 2008; Safford et al., 2011; Safford et al., 2015b; Roberts et al., 2015). The current exposure from the 95th percentile concentration is below the DST for non-reactive materials when evaluated in all QRA categories. Table 1 provides the maximum acceptable concentrations for theaspirane that present no appreciable risk for skin sensitization based on the non-reactive DST. These concentrations are not limits; they represent acceptable concentrations based on the DST approach.

Additional References: None.

Table 1
Maximum acceptable concentrations for theaspirane that present no appreciable risk for skin sensitization based on non-reactive DST.

IFRA Category[a]	Description of Product Type	Maximum Acceptable Concentrations in Finished Products Based on Non-Reactive DST	Reported 95th Percentile Use Concentrations in Finished Products
1	Products applied to the lips	0.07%	0.00%[b]
2	Products applied to the axillae	0.02%	0.00%[b]
3	Products applied to the face using fingertips	0.41%	0.00%[b]
4	Fine fragrance products	0.39%	0.00%[b]
5	Products applied to the face and body using the hands (palms), primarily leave-on	0.10%	0.00%[b]
6	Products with oral and lip exposure	0.23%	0.01%
7	Products applied to the hair with some hand contact	0.79%	0.00%[b]
8	Products with significant ano-genital exposure	0.04%	No Data[c]
9	Products with body and hand exposure, primarily rinse-off	0.75%	0.00%[b]
10	Household care products with mostly hand contact	2.70%	0.00%[b]
11	Products with intended skin contact but minimal transfer of fragrance to skin from inert substrate	1.50%	No Data[c]
12	Products not intended for direct skin contact, minimal or insignificant transfer to skin	Not Restricted	0.05%

Note.
[a] For a description of the categories, refer to the IFRA/RIFM Information Booklet.
[b] Negligible exposure (< 0.01%).
[c] Fragrance exposure from these products is very low. These products are not currently in the Creme RIFM Aggregate Exposure Model.

Literature Search and Risk Assessment Completed On: 06/06/18.

10.1.5. Phototoxicity/photoallergenicity

Based on the available UV/Vis spectra, theaspirane would not be expected to present a concern for phototoxicity or photoallergenicity.

10.1.5.1. Risk assessment. There are no phototoxicity studies available for theaspirane in experimental models. UV/Vis absorption spectra indicate minor absorbance between 290 and 700 nm. The corresponding molar absorption coefficient is below the benchmark of concern for phototoxicity and photoallergenicity (Henry et al., 2009). Based on lack of significant absorbance in the critical range, theaspirane does not present a concern for phototoxicity or photoallergenicity.

10.1.5.2. UV spectra analysis. UV/Vis absorption spectra (OECD TG 101) for theaspirane were obtained. The spectra indicate minor absorbance in the range of 290–700 nm. The molar absorption coefficient is below the benchmark of concern for phototoxic effects, 1000 $L\,mol^{-1} \cdot cm^{-1}$ (Henry et al., 2009).

Additional References: None.

Literature Search and Risk Assessment Completed On: 03/27/18.

10.1.6. Local Respiratory Toxicity

The margin of exposure could not be calculated due to lack of appropriate data. The exposure level for theaspirane is below the Cramer Class III TTC value for inhalation exposure local effects.

10.1.6.1. Risk assessment. There are no inhalation data available on theaspirane. Based on the Creme RIFM Model, the inhalation exposure is 0.00012 mg/day. This exposure is 3916.7 times lower than the Cramer Class III TTC value of 0.47 mg/day (based on human lung weight of 650 g; Carthew et al., 2009); therefore, the exposure at the current level of use is deemed safe.

Additional References: None.

Literature Search and Risk Assessment Completed On: 12/15/16.

10.2. Environmental endpoint summary

10.2.1. Screening-level assessment

A screening-level risk assessment of theaspirane was performed following the RIFM Environmental Framework (Salvito et al., 2002), which provides 3 tiered levels of screening for aquatic risk. In Tier 1, only the material's regional VoU, its log K_{ow}, and its molecular weight are needed to estimate a conservative risk quotient (RQ), expressed as the ratio Predicted Environmental Concentration/Predicted No Effect Concentration (PEC/PNEC). A general QSAR with a high uncertainty factor applied is used to predict fish toxicity, as discussed in Salvito et al. (2002). In Tier 2, the RQ is refined by applying a lower uncertainty factor to the PNEC using the ECOSAR model (US EPA, 2012b), which provides chemical class–specific ecotoxicity estimates. Finally, if necessary, Tier 3 is conducted using measured biodegradation and ecotoxicity data to refine the RQ, thus allowing for lower PNEC uncertainty factors. The data for calculating the PEC and PNEC for this safety assessment are provided in the table below. For the PEC, the range from the most recent IFRA Volume of Use Survey is reviewed. The PEC is then calculated using the actual regional tonnage, not the extremes of the range. Following the RIFM Environmental Framework, theaspirane was identified as a fragrance material with no potential to present a possible risk to the aquatic environment (i.e., its screening-level PEC/PNEC < 1).

A screening-level hazard assessment using EPI Suite v4.11 (US EPA, 2012a) did not identify theaspirane as possibly persistent or bioaccumulative based on its structure and physical–chemical properties. This screening-level hazard assessment considers the potential for a material to be persistent *and* bioaccumulative *and* toxic, or very persistent *and* very bioaccumulative as defined in the Criteria Document (Api et al., 2015). As noted in the Criteria Document, the screening criteria applied are the same as those used in the EU for REACH (ECHA, 2012). For persistence, if the EPI Suite model BIOWIN 3 predicts a value < 2.2 and either BIOWIN 2 or BIOWIN 6 predicts a value < 0.5, then the material is considered potentially persistent. A material would be considered potentially bioaccumulative if the EPI Suite model BCFBAF predicts a fish BCF ≥ 2000 L/kg. Ecotoxicity is determined in the above screening-level risk assessment. If, based on these model outputs (Step 1), additional assessment is required, a WoE-based review is then performed (Step 2). This review considers available data on the material's physical–chemical properties, environmental fate (e.g., OECD Guideline biodegradation studies or die-away studies), fish bioaccumulation, and higher-tier model outputs (e.g., US EPA's BIOWIN and BCFBAF found in

EPI Suite v4.11).

10.2.2. Risk assessment

Based on the current Volume of Use (2015), theaspirane presents no risk to the aquatic compartment in the screening-level assessment.

10.2.2.1. Biodegradation. No data available.

10.2.2.2. Ecotoxicity. No data available.

10.2.2.3. Other available data. Theaspirane has been pre-registered for REACH with no additional data at this time.

10.2.3. Risk assessment refinement

Ecotoxicological data and PNEC derivation (all endpoints reported in mg/L; PNECs in µg/L).

Endpoints used to calculate PNEC are underlined.

	LC50 (Fish) (mg/L)	EC50 (*Daphnia*)	EC50 (Algae)	AF	PNEC (µg/L)	Chemical Class
RIFM Framework Screening-level **(Tier 1)**	0.9799			1000000	0.0009799	

Exposure information and PEC calculation (following RIFM Environmental Framework: Salvito et al., 2002).

Exposure	Europe (EU)	North America (NA)
Log K_{ow} Used	4.79	4.79
Biodegradation Factor Used	0	0
Dilution Factor	3	3
Regional Volume of Use Tonnage Band	< 1	< 1
Risk Characterization: PEC/PNEC	**< 1**	**< 1**

Based on available data, the RQ for this material is < 1. No further assessment is necessary.

The RIFM PNEC is 0.0009799 µg/L. The revised PEC/PNECs for EU and NA are: not applicable. The material was cleared at the screening-level and therefore does not present a risk to the aquatic environment at the current reported volumes of use.

Literature Search and Risk Assessment Completed On: 05/02/18.

11. Literature Search*

RIFM Database: Target, Fragrance Structure Activity Group materials, other references, JECFA, CIR, SIDS

- **ECHA:** http://echa.europa.eu/
- **NTP:** https://ntp.niehs.nih.gov/
- OECD Toolbox
- **SciFinder:** https://scifinder.cas.org/scifinder/view/scifinder/scifinderExplore.jsf
- **PubMed:** http://www.ncbi.nlm.nih.gov/pubmed
- **TOXNET:** http://toxnet.nlm.nih.gov/
- **IARC:** http://monographs.iarc.fr
- **OECD SIDS:** http://webnet.oecd.org/hpv/ui/Default.aspx
- **EPA ACToR:** https://actor.epa.gov/actor/home.xhtml
- **US EPA HPVIS:** https://ofmpub.epa.gov/oppthpv/public_search.publicdetails?submission_id=24959241&ShowComments=Yes&sqlstr=null&recordcount=0&User_title=DetailQuery%20Results&EndPointRpt=Y#submission
- **Japanese NITE:** http://www.safe.nite.go.jp/english/db.html
- **Japan Existing Chemical Data Base (JECDB):** http://dra4.nihs.go.jp/mhlw_data/jsp/SearchPageENG.jsp
- **Google:** https://www.google.com
- **ChemIDplus:** https://chem.nlm.nih.gov/chemidplus/

Search keywords: CAS number and/or material names.

*Information sources outside of RIFM's database are noted as appropriate in the safety assessment. This is not an exhaustive list. The links listed above were active as of 08/27/2018.

Conflicts of interest

The authors declare that they have no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.fct.2019.110620.

Appendix

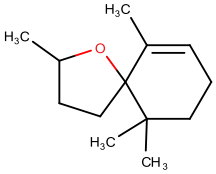
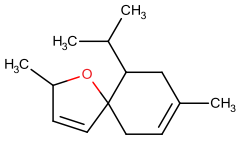
Read-across Justification

Methods

The read-across analogs were identified following the strategy for structuring and reporting a read-across prediction of toxicity as described in Schultz et al. (2015). The strategy is also consistent with the guidance provided by OECD within Integrated Approaches for Testing and Assessment (OECD, 2015) and the European Chemical Agency read-across assessment framework (ECHA, 2016).

- First, materials were clustered based on their structural similarity. Second, data availability and data quality on the selected cluster were examined. Third, appropriate read-across analogs from the cluster were confirmed by expert judgment.
- Tanimoto structure similarity scores were calculated using FCFC4 fingerprints (Rogers and Hahn, 2010).
- The physical–chemical properties of the target substance and the read-across analogs were calculated using EPI Suite v4.11 (US EPA, 2012a).

- J_{max} values were calculated using RIFM's Skin Absorption Model (SAM). The parameters were calculated using the consensus model (Shen et al., 2014).
- DNA binding, mutagenicity, genotoxicity alerts, and oncologic classification predictions were generated using OECD QSAR Toolbox v4.2 (OECD, 2018).
- ER binding and repeat dose categorization were generated using OECD QSAR Toolbox v4.2 (OECD, 2018).
- Developmental toxicity was predicted using CAESAR v2.1.7 (Cassano et al., 2010), and skin sensitization was predicted using Toxtree 2.6.13.
- Protein binding was predicted using OECD QSAR Toolbox v4.2 (OECD, 2018).
- The major metabolites for the target and read-across analogs were determined and evaluated using OECD QSAR Toolbox v4.2 (OECD, 2018).

	Target Material	Read-across Material
Principal Name	Theaspirane	1-Oxaspiro [4.5]deca-3,6-diene, 2,7-dimethyl-10-(1-methylethyl)-
CAS No.	36431-72-8	89079-92-5
Structure		
Similarity (Tanimoto Score)		0.83
Read-across Endpoint		• Repeated dose toxicity
Molecular Formula	C13H22O	C14H22O
Molecular Weight	194.32	206.33
Melting Point (°C, EPI Suite)	39.41	38.65
Boiling Point (°C, EPI Suite)	237.39	256.04
Vapor Pressure (Pa @ 25 °C, EPI Suite)	7.88	3.22
Log Kow (KOWWIN v1.68 in EPI Suite)	4.79	5.03
Water Solubility (mg/L, @ 25 °C, WSKOW v1.42 in EPI Suite)	3.79	2.055
J_{max} (μg/cm^2/h, SAM)	40.9	25.072
Henry's Law (Pa·m^3/mol, Bond Method, EPI Suite)	5.01E+001	4.65E+002
Repeated dose (HESS)	Not categorized	Not categorized
Reproductive toxicity		
ER Binding (OECD QSAR Toolbox v4.2)	Non-binder, without OH or NH2 group	
Developmental Toxicity (CAESAR v2.1.6)	Toxicant (good reliability)	
Rat Liver S9 Metabolism Simulator and Structural Alerts for Metabolites (OECD QSAR Toolbox v4.2)	See Supplemental Data 1	See Supplemental Data 2

Summary

There are insufficient toxicity data on theaspirane (CAS # 36431-72-8). Hence, *in silico* evaluation was conducted to determine read-across analogs for this material. Based on structural similarity, reactivity, physical–chemical properties, and expert judgment, 1-oxaspiro [4.5]deca-3,6-diene, 2,7-dimethyl-10-(1-methylethyl)- (CAS # 89079-92-5) was identified as a read-across material with sufficient data for toxicological evaluation.

Conclusions

- 1-Oxaspiro [4.5]deca-3,6-diene, 2,7-dimethyl-10-(1-methylethyl)- (CAS # 89079-92-5) was used as a read-across analog for the target material theaspirane (CAS # 36431-72-8) for the repeated dose toxicity endpoint.
  - o The target substance and the read-across analog are structurally similar and belong to a class of heterocyclic compounds, specifically cyclic ethers. They are substituted n-hydro furans.
  - o The key difference between the target substance and the read-across analog is that the target substance is a cyclic alkene substituted tetrahydro furan, and the read-across analog is a cyclic, substituted dihydro furan. This structural difference is toxicologically insignificant.
  - o Similarity between the target substance and the read-across analog is indicated by the Tanimoto score. Differences between the structures that affect the Tanimoto score are toxicologically insignificant.
  - o The physical–chemical properties of the target substance and the read-across analog are sufficiently similar to enable comparison of their toxicological properties.
  - o According to the OECD QSAR Toolbox v4.2, structural alerts for toxicological endpoints are consistent between the target substance and the read-across analog.
  - o The target substance and the read-across analog do not have any alerts for repeated dose toxicity. Data are consistent with *in silico* alerts.
  - o The target substance and the read-across analog are expected to be metabolized similarly, as shown by the metabolism simulator.
  - o The structural alerts for the endpoints evaluated are consistent between the metabolites of the read-across analog and the target material.

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