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RIFM fragrance ingredient safety assessment, 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate, CAS Registry Number 65405-72-3

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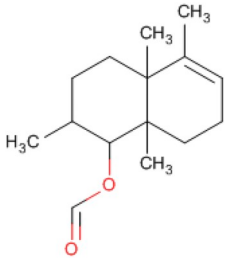
Version: 032318. This version replaces any previous versions.
Name: 1,2,3,4,4a,7,8,8a-Octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate
CAS Registry Number: 65405-72-3



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)

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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 under the limits 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 use of this material under current conditions is supported by existing information.
1,2,3,4,4a,7,8,8a-Octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate was evaluated for genotoxicity, repeated dose toxicity, reproductive toxicity, local respiratory toxicity, phototoxicity/photoallergenicity, skin sensitization, and environmental safety. Data show that 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate is not genotoxic. The skin sensitization endpoint was completed by utilizing the non-reactive Dermal Sensitization Threshold (DST). The repeated dose, developmental and reproductive, and local respiratory toxicity endpoints were completed using the TTC (Threshold of Toxicological Concern) for a Cramer Class II material (0.009 mg/kg/day, 0.009 mg/kg/day, and 0.47 mg/day, respectively). The phototoxicity/photoallergenicity endpoint was completed based on UV spectra along with data on 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate. The environmental endpoints were evaluated; 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate 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, 2004a; RIFM, 2014a)

Repeated Dose Toxicity: No NOAEL available. Exposure is below the TTC.

Developmental and Reproductive Toxicity: No NOAEL available. Exposure is below the TTC.

Skin Sensitization: No safety concerns at current, declared use levels; exposure is below the DST.

Phototoxicity/Photoallergenicity: Not phototoxic/photoallergenic. (UV Spectra, RIFM DB; RIFM, 1982b; RIFM, 1982a)

Local Respiratory Toxicity: No NOAEC available. Exposure is below the TTC.

Environmental Safety Assessment

Hazard Assessment:

Persistence: Critical Measured Value: 0% (OECD 302C) (RIFM, 2004b)
Bioaccumulation: Screening-level: 655.1 L/kg (EPI Suite v4.1; US EPA, 2012a)
Ecotoxicity: Critical Measured Value: 48-h *Daphnia magna* EC50: 0.9 mg/L (RIFM, 2014d)
Conclusion: Possibly 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: 48-h *Daphnia magna* EC50: 0.9 mg/L (RIFM, 2014d)
RIFM PNEC is: 0.18 µg/L
- Revised PEC/PNECs (2015 IFRA VoU): North America and Europe: < 1

1. Identification

1. **Chemical Name:** 1,2,3,4,4a,7,8,8a-Octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate
2. **CAS Registry Number:** 65405-72-3
3. **Synonyms:** 1-Naphthalenol, 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-, formate; Oxyoctaline formate; 2,4a,5,8a-Tetramethyl-1,2,3,4,4a,7,8,8a-octahydronaphthalen-1-yl formate; 1,2,3,4,4a,7,8,8a-Octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate
4. **Molecular Formula:** $C_{15}H_{24}O_2$
5. **Molecular Weight:** 236.55
6. **RIFM Number:** 5801
7. **Stereochemistry:** Isomer not specified. Four stereocenters and 16 total stereoisomers possible.

2. Physical data

1. **Boiling Point:** 284.44 °C (EPI Suite)
2. **Flash Point:** 132 °C (closed cup) (Givaudan)
3. **Log K_{OW}:** log Pow = 5.2, 5.3, and 5.7 (RIFM, 2008), 4.77 (EPI Suite)
4. **Melting Point**: 74.53 °C (EPI Suite)
5. **Water Solubility:** 2.359 mg/L (EPI Suite)
6. **Specific Gravity:** 1.03000 to 1.03500 @ 25 °C*
7. **Vapor Pressure:** 0.000813 mm Hg @ 20 °C (EPI Suite 4.0), 0.00151 mm Hg @ 25 °C (EPI Suite)
8. **UV Spectra:** No absorbance between 290 and 500 nm; molar absorption coefficient is below the benchmark (1000 L $mol^{-1} \cdot cm^{-1}$)
9. **Appearance/Organoleptic:** Colorless to pale yellow liquid with woody, green odor.

*http://www.thegoodscentscompany.com/data/rw1015231.html#tophyp, retrieved 9/15/2017.

3. Exposure

1. **Volume of Use (worldwide band):** 10–100 metric tons per year (IFRA, 2015)
2. **95th Percentile Concentration in Hydroalcoholics:** 0.042% (RIFM, 2015b)
3. **Inhalation Exposure*:** 0.00050 mg/kg/day or 0.036 mg/day (RIFM, 2015b)
4. **Total Systemic Exposure**:** 0.0015 mg/kg/day (RIFM, 2015b)

*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 II, Intermediate (Expert Judgment)

Expert Judgment	Toxtree v 2.6	OECD QSAR Toolbox v 3.2
II*	III	I

*Due to potential discrepancies with the current *in silico* tools (Bhatia et al., 2015), the Cramer Class of the target material was determined using expert judgment based on the Cramer decision tree (Cramer et al., 1978). See Appendix below for further details.

2. Analogs Selected:
   a. **Genotoxicity**: None
   b. **Repeated Dose Toxicity:** None
   c. **Developmental and Reproductive Toxicity:** None
   d. **Skin Sensitization:** None
   e. **Phototoxicity/Photoallergenicity:** None
   f. **Local Respiratory Toxicity**: None
   g. **Environmental Toxicity:** None
3. Read-across Justification: None

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)

1,2,3,4,4a,7,8,8a-Octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate is not reported to occur in food by the VCF*.

*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 that contains 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

Available; accessed 03/19/18.

10. Summary

10.1. Human health endpoint summaries

Based on the current existing data and use levels, 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate does not present a concern for genetic toxicity.

10.1.1. Genotoxicity

10.1.1.1. Risk assessment. 1,2,3,4,4a,7,8,8a-Octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate was assessed in the BlueScreen assay and found negative for both cytotoxicity and genotoxicity, with and without metabolic activation (RIFM, 2015a). The mutagenic activity of 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate 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 pre-incubation methods. *Salmonella typhimurium* strains TA1535, TA1537, TA98, TA100, and TA102 were treated with 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate in ethanol at concentrations up to 5000 μg/plate. No increases in the mean number of revertant colonies were observed at any tested dose in the presence or absence of S9 (RIFM, 2004a). Under the conditions of the study, 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate was not mutagenic in the Ames test.

The clastogenic activity of 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate 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 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate in dimethyl sulfoxide (DMSO) at concentrations up to 2635 μg/mL in the presence and absence of metabolic activation (S9) for 3 and 24 h 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate did not induce binucleated cells with micronuclei when tested up to cytotoxic levels in either non-activated or S9-activated test systems (RIFM, 2014a). Under the conditions of the study, 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate was considered to be non-clastogenic in the *in vitro* micronucleus test.

Based on the available data, 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate does not present a concern for genotoxic potential.

Additional References: None.

Literature Search and Risk Assessment Completed On: 8/28/2017.

10.1.2. Repeated dose toxicity

There are insufficient repeated dose toxicity data on 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate. The total systemic exposure to 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate is below the TTC for the repeated dose toxicity endpoint of a Cramer Class II material at the current level of use.

10.1.2.1. Risk assessment. There are no repeated dose toxicity data on 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate or any read-across materials that can be used to support the repeated dose toxicity endpoint. The total systemic exposure to 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate (1.5 μg/kg/day) is below the TTC (9 μg/kg bw/day; Kroes et al., 2007) for the repeated dose toxicity endpoint of a Cramer Class II material at the current level of use.

Additional References: None.

Literature Search and Risk Assessment Completed On: 09/08/17.

10.1.3. Developmental and reproductive toxicity

There are insufficient developmental and reproductive toxicity data on 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate or any read-across materials. The total systemic exposure to 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate is below the TTC for the developmental and reproductive toxicity endpoints of a Cramer Class II material at the current level of use.

10.1.3.1. Risk assessment. There are no developmental or reproductive toxicity data on 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate or any read-across materials that can be used to support the developmental or reproductive toxicity endpoints. The total systemic exposure to 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate (1.5 μg/kg/day) is below the TTC (9 μg/kg bw/day; Kroes et al., 2007; Laufersweiler et al., 2012) for the developmental and reproductive toxicity endpoints of a Cramer Class II material at the current level of use.

Additional References: None.

Literature Search and Risk Assessment Completed On: 09/08/17.

10.1.4. Skin sensitization

Based on the available data and the application of DST; 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate does not present a safety concern for skin sensitization under the current, declared levels of use.

10.1.4.1. Risk assessment. The chemical structure of 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate indicates that it would not be expected to react significantly with skin proteins (Roberts et al., 2007; Toxtree 2.5.0; OECD toolbox v3.1). In a guinea pig maximization test and open epicutaneous test (OET), this material was reported to be a non-sensitizer (RIFM, 1978c; RIFM, 1978d). Acting conservatively, due to limited data, the reported exposure was benchmarked utilizing the non-reactive 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 acceptable concentration for 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate which presents no appreciable risk for skin sensitization based on the non-reactive DST.

Additional References: RIFM, 1978a; RIFM 1971; RIFM, 1982a; RIFM, 1978b.

Literature Search and Risk Assessment Completed On: 9/26/14.

10.1.5. Phototoxicity/photoallergenicity

	Phototoxicity	Photoallergenicity
Step 1: UV benchmark (1000 L mol^{-1} · cm^{-1})	**Below**	
Step 2: Study data	**Sufficient**	**Sufficient**
Step 3: Exposure benchmark		
Step 4: Read-across		
Step 5: Generate data		

Based on the available UV absorption spectra and existing *in vivo*

Table 1
Acceptable concentrations limits for 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate based on non-reactive DST.

IFRA Category[a]	Description of Product Type	Acceptable Concentrations in Finished Products	Reported 95th Percentile Use Concentrations in Finished Products
1	Products applied to the lips	0.07%	0.00%
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%	0.04%
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%	0.00%
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%	0.01%
10	Household care products with mostly hand contact	2.70%	0.1%
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.

study data, 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate would not be expected to present a concern for phototoxicity or photoallergenicity.

10.1.5.1. Risk assessment. The available UV absorption spectra for 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate indicate no absorbance between 290 and 500 nm. The corresponding molar absorption coefficient is well below the benchmark of concern for phototoxicity and photoallergenicity (Henry et al., 2009). Phototoxicity of 10% 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate in ethanol plus 2% DMSO was evaluated in Himalayan white spotted guinea pigs; there were no observed reactions (RIFM, 1982b). Photoallergenicity of 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate in ethanol was evaluated in Himalayan white spotted guinea pigs; there were no skin reactions after induction with 1% or 10% test material and challenge with 10% test material (RIFM, 1982a). Based on lack of absorbance and the *in vivo* study data, 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate would not be expected to present a concern for phototoxicity or photoallergenicity.

10.1.5.2. UV spectra analysis. The available UV absorption spectra for 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate indicate no absorbance between 290 and 500 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: 08/23/17.

10.1.6. Local Respiratory Toxicity

The margin of exposure could not be calculated due to lack of appropriate data. The exposure level for 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate 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 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate. Based on the Creme RIFM Model, the inhalation exposure is 0.036 mg/day. This exposure is 13.1 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.

*As per Carthew et al., 2009; #57336, Cramer Class II materials default to Cramer Class III.

Additional References: None.

Literature Search and Risk Assessment Completed On: 09/11/2017.

10.2. Environmental endpoint summary

10.2.1. Screening-level assessment

A screening-level risk assessment of 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate 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, 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate was identified as a fragrance material with the 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 v4.1 identified 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate as possibly persistent but not 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 v4.1). Data on persistence and bioaccumulation are reported below and summarized in the Environmental Safety Assessment section prior to Section 1.

10.2.2. Risk assessment

Based on current VoU (2015), 1,2,3,4,4a,7,8,8a-octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate presents a risk to the aquatic compartment in the screening-level assessment.

10.2.3. Key studies

10.2.3.1. Biodegradation. RIFM, 2004b**:** The inherent biodegradability of the test material was determined by the Manometric Respirometry Test according to the OECD 302C method. Under the conditions of the study, no biodegradation was observed after 42 days.

RIFM, 2003**:** The Ready Biodegradability of the test material was determined by the Manometric Respirometry Test according to the OECD 301F method. The test material underwent no biodegradation after 35 days in the test conditions.

10.2.3.2. Ecotoxicity. RIFM, 2014c**:** A *Daphnia magna* immobilization test was conducted according to the OECD 202 method. The 48-h EC50 was reported to be 0.9 mg/L.

RIFM, 2014d**:** An algae growth inhibition test was conducted according to the OECD 201 method. The 72-h EC50 was reported to be > 3.16 mg/L.

10.2.3.3. Other available data. 1,2,3,4,4a,7,8,8a-Octahydro-2,4a,5,8a-tetramethyl-1-naphthyl formate has been pre-registered for REACH with no additional data at this time.

10.2.4. 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*) (mg/L)	EC50 (Algae) (mg/L)	AF	PNEC (μg/L)	Chemical Class
RIFM Framework Screening-level **(Tier 1)**	0.1927			1,000,000	0.0001927	
ECOSAR Acute Endpoints **(Tier 2)** ***Ver 1.11***	0.759	1.172	0.322	10,000	0.0322	Esters
ECOSAR Acute Endpoints **(Tier 2)** ***Ver 1.11***	0.628	0.460	0.988			Neutral Organics
Tier 3: Measured Data						
	LC50	EC50	NOEC	AF	PNEC	Comments
Fish						
Daphnia		>3.16				
Algae		0.9		5000	0.18	

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

Exposure	Europe (EU)	North America (NA)
Log K_{ow} Used	5.3	5.3
Biodegradation Factor Used	0	0
Dilution Factor	3	3
Regional Volume of Use Tonnage Band	1–10	1–10
Risk Characterization: PEC/PNEC	**< 1**	**< 1**

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

The RIFM PNEC is 0.18 μg/L. The revised PEC/PNECs for EU and NA are < 1; therefore, the material does not present a risk to the aquatic environment at the current reported volumes of use.

Literature Search and Risk Assessment Completed On: 9/7/17.

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.

Conflicts of interest

The authors declare that they have no conflicts of interest.

Appendix

Explanation of Cramer Classification:

Due to potential discrepancies with the current *in silico* tools (Bhatia et al., 2015), the Cramer Class of the target material was determined using expert judgment based on the Cramer decision tree (Cramer et al., 1978).

Q1 Normal constituent of the body? No
Q2 Contains functional groups associated with enhanced toxicity? No
Q3 Contains elements other than C, H, O, N, and divalent S? No
Q5 Simply branched aliphatic hydrocarbon or a common carbohydrate? No
Q6 Benzene derivative with certain substituents? No
Q7 Heterocyclic? No
Q16 Common terpene? (see Cramer et al., 1978 for detailed explanation) No
Q17 Readily hydrolyzed to a common terpene? No
Q19 Open chain? No
Q23 Aromatic? No
Q24 Monocarbocyclic with simple substituents? No
Q25 Cyclopropane (see explanation in Cramer et al., 1978)? No
Q26 Monocycloalkanone or a bicyclo compound? Yes, Class II (Intermediate Class)

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