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RIFM fragrance ingredient safety assessment, ethyl laurate, CAS Registry Number 106-33-2

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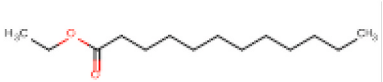

Name: Ethyl laurate

CAS Registry Number: 106-33-2

Abbreviation/Definition List:

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(*continued*)

2-Box Model - A RIFM, Inc. proprietary *in silico* tool used to calculate fragrance air exposure concentration
AF - Assessment Factor
BCF - Bioconcentration Factor
CNIH – Confirmation of No Induction in Humans test. A human repeat insult patch test that is performed to confirm an already determined safe use level for fragrance ingredients (Na et al., 2021)
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; Safford et al., 2015a; Safford et al., 2017; Comiskey et al., 2017) compared to a deterministic aggregate approach
DEREK - Derek Nexus is an *in silico* tool used to identify structural alerts
DRF - Dose Range Finding
DST - Dermal Sensitization Threshold
ECHA - European Chemicals Agency
ECOSAR - Ecological Structure-Activity Relationships Predictive Model
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
Perfumery - In this safety assessment, perfumery refers to fragrances made by a perfumer used in consumer products only. The exposures reported in the safety assessment include consumer product use but do not include occupational exposures
QRA - Quantitative Risk Assessment
QSAR - Quantitative Structure-Activity Relationship
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.

Ethyl laurate was evaluated for genotoxicity, repeated dose toxicity, reproductive toxicity, local respiratory toxicity, phototoxicity/photoallergenicity, skin sensitization, and environmental safety. Data show that ethyl laurate is not genotoxic. Data on read-across analog methyl laurate (CAS # 111-82-0) provide a calculated Margin of Exposure (MOE) > 100 for the repeated dose toxicity and reproductive toxicity endpoints. Data from read-across analog methyl hexadecanoate (CAS # 112-39-0) provided ethyl laurate a No Expected Sensitization Induction Level (NESIL) of 2400 μg/cm^2 for the skin sensitization endpoint. The phototoxicity/photoallergenicity endpoints were evaluated based on ultraviolet/visible (UV/Vis) spectra; ethyl laurate is not expected to be phototoxic/photoallergenic. The local respiratory toxicity endpoint was evaluated using the threshold of toxicological concern (TTC) for a Cramer Class I material, and the exposure to ethyl laurate is below the TTC (1.4 mg/day). The environmental endpoints were evaluated; ethyl laurate was found not to be Persistent, Bioaccumulative, and Toxic (PBT) as per the International Fragrance Association (IFRA) Environmental Standards, and its risk quotients, based on its current volume of use in Europe and North America (i.e., Predicted Environmental Concentration/Predicted No Effect Concentration [PEC/PNEC]), are <1.

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Human Health Safety Assessment

Genotoxicity: Not genotoxic.	(RIFM, 2013b; RIFM, 2014)
Repeated Dose Toxicity: NOAEL = 333.33 mg/kg/day.	OECD (2013)
Reproductive Toxicity: NOAEL = 1000 mg/kg/day.	OECD (2013)
Skin Sensitization: NESIL = 2400 μg/cm^2.	RIFM (2018)
Phototoxicity/ Photoallergenicity: Not expected to be phototoxic/ photoallergenic.	(UV/Vis Spectra; RIFM Database)

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

Environmental Safety Assessment

Hazard Assessment:

Persistence: Critical Measured Value: 63% (OECD 301B)	ECHA REACH Dossier: Butyl Decanoate; ECHA (2019)
Bioaccumulation: Screening-level: 114.9 mg/L	(EPI Suite v4.11; US EPA, 2012a)
Ecotoxicity: Critical Ecotoxicity Endpoint: 48-h *Daphnia magna* EC50: 0.09 mg/L for read-across material butyl decanoate (CAS # 30673-36-0)	ECHA REACH Dossier: Butyl Decanoate; ECHA (2019)

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: 48-h *Daphnia magna* EC50: 0.09 mg/L for read-across material butyl decanoate (CAS # 30673-36-0)	ECHA REACH Dossier: Butyl Decanoate; ECHA (2019)

RIFM PNEC is: 0.018 μg/L

- Revised PEC/PNECs (2015 IFRA VoU): North America and Europe <1

1. Identification

1. **Chemical Name:** Ethyl laurate
2. **CAS Registry Number:** 106-33-2
3. **Synonyms:** Dodecanoic acid, ethyl ester; Ethyl dodecylate; Ethyl dodecanoate; 脂肪酸(C = 9~24)アルキル(C = 1~12)エステル; Ethyl laurate
4. **Molecular Formula:** $C_{14}H_{28}O_2$
5. **Molecular Weight:** 228.38 g/mol
6. **RIFM Number:** 431
7. **Stereochemistry:** Stereoisomer not specified. No stereocenter present and no stereoisomer possible.

2. Physical data

1. **Boiling Point:** 281.15 °C (EPI Suite)
2. **Flash Point:** >93 °C (Globally Harmonized System), >200 °F; CC (Fragrance Materials Association [FMA])
3. **Log K_{OW}:** 5.78 (EPI Suite)
4. **Melting Point**: 25.16 °C (EPI Suite)
5. **Water Solubility:** 0.4128 mg/L (EPI Suite)
6. **Specific Gravity:** Not Available
7. **Vapor Pressure:** 0.00536 mm Hg at 20 °C (EPI Suite v4.0), 0.003 mm Hg at 20 °C (FMA), 0.00874 mm Hg at 25 °C (EPI Suite)
8. **UV Spectra:** No significant absorbance between 290 and 700 nm; the molar absorption coefficient is below the benchmark (1000 L mol^{-1} • cm^{-1})
9. **Appearance/Organoleptic:** A colorless, slightly oil liquid that has an oily-fatty, somewhat leafy and flower-petal-like, mild odor with a trace of a fruity undertone

3. Volume of use (worldwide band)

1. 1–10 metric tons per year (IFRA, 2015)

4. Exposure to fragrance ingredient (Creme RIFM aggregate exposure model v1.0)

1. **95**th **Percentile Concentration in Fine Fragrance:** 0.0095% (RIFM, 2017)
2. **Inhalation Exposure*:** 0.00028 mg/kg/day or 0.020 mg/day (RIFM, 2017)
3. **Total Systemic Exposure**:** 0.0012 mg/kg/day (RIFM, 2017)

*95th percentile calculated exposure derived from concentration survey data in the Creme RIFM Aggregate Exposure Model (RIFM, 2015; Safford et al., 2015; 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 V. 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 (RIFM, 2015; Safford et al., 2015; Safford et al., 2017; and Comiskey et al., 2017).

5. Derivation of systemic absorption

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

6. Computational toxicology evaluation

1. **Cramer Classification:** Class I, Low

Expert Judgment	Toxtree v3.1	OECD QSAR Toolbox v4.2
I	I	I

2. Analogs Selected:
   a. **Genotoxicity:** None
   b. **Repeated Dose Toxicity:** Methyl laurate (CAS # 111-82-0)
   c. **Reproductive Toxicity:** Methyl laurate (CAS # 111-82-0)
   d. **Skin Sensitization:** Methyl hexadecanoate (CAS # 112-39-0)
   e. **Phototoxicity/Photoallergenicity:** None
   f. **Local Respiratory Toxicity:** None
   g. **Environmental Toxicity:** Butyl Decanoate (CAS # 30673-36-0)
3. Read-across Justification: See Appendix below

7. Metabolism

No relevant data available for inclusion in this safety assessment.

7.1. Additional References

None.

8. Natural occurrence

Ethyl laurate is reported to occur in the following foods by the VCF*:

Apple fresh (*Malus* species)	Tequila (*Agave tequilana*)
Beer	*Mangifera* species
Cheese, various types	Rum
Cocoa	Whisky
Coconut (*Cocos nucifera* L.)	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. This is a partial list.

9. REACH dossier

HYPERLINK "https://echa.europa.eu/registration-dossier/-/registered-dossier/26612" \o "https://echa.europa.eu/registration-dossier/-/registered-dossier/26612"Available; accessed 11/03/21.

10. Conclusion

The maximum acceptable concentrations[a] in finished products for ethyl laurate are detailed below.

IFRA Category[b]	Description of Product Type	Maximum Acceptable Concentrations[a] in Finished Products (%)[c]
1	Products applied to the lips (lipstick)	0.18
2	Products applied to the axillae	0.055
3	Products applied to the face/body using fingertips	1.1
4	Products related to fine fragrances	1.0
5A	Body lotion products applied to the face and body using the hands (palms), primarily leave-on	0.26
5B	Face moisturizer products applied to the face and body using the hands (palms), primarily leave-on	0.26
5C	Hand cream products applied to the face and body using the hands (palms), primarily leave-on	0.26
5D	Baby cream, oil, talc	0.087
6	Products with oral and lip exposure	0.61
7	Products applied to the hair with some hand contact	2.1
8	Products with significant ano-genital exposure (tampon)	0.087
9	Products with body and hand exposure, primarily rinse-off (bar soap)	2.0
10A	Household care products with mostly hand contact (hand dishwashing detergent)	7.2
10B	Aerosol air freshener	7.2
11	Products with intended skin contact but minimal transfer of fragrance to skin from inert substrate (feminine hygiene pad)	0.087
12	Other air care products not intended for direct skin contact, minimal or insignificant transfer to skin	No Restriction

Note: [a]Maximum acceptable concentrations for each product category are based on the lowest maximum acceptable concentrations (based on systemic toxicity, skin sensitization, or any other endpoint evaluated in this safety assessment). For ethyl laurate, the basis was the subchronic reference dose of 3.33 mg/kg/day, a predicted skin absorption value of 10%, and a skin sensitization NESIL of 2400 μg/cm^2.
[b]For a description of the categories, refer to the IFRA RIFM Information Booklet (https://www.rifm.org/downloads/RIFM-IFRA%20Guidance-for-the-use-of-IFRA-Standards.pdf).
[c]Calculations by Creme RIFM Aggregate Exposure Model v3.1.4.

11. Summary

11.1. Human health endpoint summaries

11.1.1. Genotoxicity

Based on the current existing data, ethyl laurate does not present a concern for genotoxicity.

11.1.1.1. Risk assessment. Ethyl laurate was assessed in the BlueScreen assay and found positive for both cytotoxicity (positive: <80% relative cell density) and genotoxicity without metabolic activation but negative with metabolic activation (RIFM, 2013a). BlueScreen is a human cell-based assay for measuring the genotoxicity and cytotoxicity of chemical compounds and mixtures. Additional assays were considered to fully assess the potential mutagenic or clastogenic effects of the target material.

The mutagenic activity of ethyl laurate 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 method. *Salmonella typhimurium* strains TA98, TA100, TA1535, TA1537, and *Escherichia coli* strain WP2uvrA were treated with ethyl laurate in ethanol 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, 2013b). Under the conditions of the study, ethyl laurate was not mutagenic in the Ames test.

The clastogenic activity of ethyl laurate 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 ethyl laurate in ethanol at concentrations up to 2280 μg/mL in the dose range (DRF) study; micronuclei analysis was conducted at concentrations up to 100 μg/mL in the presence and absence of S9 for 4 h and in the absence of metabolic activation for 24 h. Ethyl laurate did not induce binucleated cells with micronuclei when tested up to cytotoxic levels in either the presence or absence of an S9 activation system (RIFM, 2014). Under the conditions of the study, ethyl laurate was considered to be non-clastogenic in the *in vitro* micronucleus test.

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

Additional References: None.

Literature Search and Risk Assessment Completed On: 12/07/20.

11.1.2. Repeated dose toxicity

The MOE for ethyl laurate is adequate for the repeated dose toxicity endpoint at the current level of use.

11.1.2.1. Risk assessment. There are insufficient repeated dose toxicity data on ethyl laurate. Read-across material methyl laurate (CAS # 111-82-0; see Section VI) has sufficient data to support the repeated dose toxicity endpoint. In an OECD 422 and GLP compliant subchronic toxicity study, 12 Crj: CD(SD)/sex/dose were orally administered methyl laurate at the doses of 0, 250, 500, and 1000 mg/kg/day for 45–55 days. Starting 2 weeks prior to mating, the treatment duration in males was 45 days, and in females was 55 days. Doses for the main study were determined based on the absence of treatment-related effects in a 2-week dose range finding (DRF) study with doses of 0, 250, 500, 750, and 1000 mg/kg/day. Like the DRF study, no treatment-related adverse effects were observed during the main study in any dose group. Hence, based on the absence of treatment-related adverse effects at the highest test dose, the NOAEL for repeated dose toxicity was considered to be 1000 mg/kg/day (OECD, 2013).

A default safety factor of 3 was used when deriving a NOAEL from the OECD 422 studies (ECHA, 2012). The safety factor has been approved by the Expert Panel for Fragrance Safety*.

Thus, the derived NOAEL for the repeated dose toxicity data is 1000 mg/kg/day/3 or 333.33 mg/kg/day.

Therefore, the ethyl laurate MOE for the repeated dose toxicity endpoint can be calculated by dividing the methyl laurate NOAEL in mg/kg/day by the total systemic exposure to ethyl laurate, 333.33 mg/kg/day/0.0012 mg/kg/day, or 277775.

In addition, the total systemic exposure to ethyl laurate (1.2 μg/kg/day) is below the TTC (30 μg/kg/day; Kroes et al., 2007) for the repeated dose toxicity endpoint for a Cramer Class I material at the current level of use.

Section X provides the maximum acceptable concentrations in finished products, which take into account skin sensitization and application of the Quantitative Risk Assessment (QRA2) described by Api et al. (RIFM, 2020b) and a subchronic reference dose (RfD) of 3.33 mg/kg/day.

Derivation of subchronic RfD:

The RIFM Criteria Document (Api et al., 2015) calls for a default MOE of 100 (10 × 10), based on uncertainty factors applied for inter-species (10 ×) and intraspecies (10 ×) differences. The subchronic RfD for ethyl laurate was calculated by dividing the lowest NOAEL (from the Repeated Dose and Reproductive Toxicity sections) of 333.33 mg/kg/day by the uncertainty factor, 100 = 3.33 mg/kg/day.

*The Expert Panel for Fragrance Safety is composed of scientific and technical experts in their respective fields. This group provides advice and guidance.

Additional References: Longland et al., 1977; Schon et al., 1955; RIFM, 1957.

Literature Search and Risk Assessment Completed On: 11/25/20.

11.1.3. Reproductive toxicity

The MOE for ethyl laurate is adequate for the reproductive toxicity endpoint at the current level of use.

11.1.3.1. Risk assessment. There are no reproductive toxicity data on ethyl laurate. Read-across material methyl laurate (CAS # 111-82-0; see Section VI) has sufficient reproductive toxicity data that can be used to support the reproductive toxicity endpoint. In an OECD 422/GLP study, groups of 12 Crj:CD (SD) rats/sex were administered test material methyl laurate via oral gavage at doses of 0, 250, 500, or 1000 mg/kg/day in corn oil. Males were dosed for 45 days (14 days pre-mating, 14 days mating, and a subsequent 17 days), while females were dosed for 41–45 days (14 days pre-mating, mating, and gestation, until lactation day 3). In addition to systemic toxicity parameters, the reproductive toxicity parameters were also assessed. There were no treatment-related

adverse effects observed on fertility effects, litter parameters, or the development of pups. Thus, the NOAEL for fertility and developmental toxicity was considered to be 1000 mg/kg/day, the highest dose tested (OECD, 2013). **Therefore, the ethyl laurate MOE for the reproductive toxicity endpoint can be calculated by dividing the methyl laurate NOAEL in mg/kg/day by the total systemic exposure to ethyl laurate, 1000 mg/kg/day/0.0012 mg/kg/day, or 833333.**

In addition, the total systemic exposure to ethyl laurate (1.2 μg/kg/day) is below the TTC (30 μg/kg/day; Kroes et al., 2007; Laufersweiler et al., 2012) for the reproductive toxicity endpoint for a Cramer Class I material at the current level of use.

Additional References: None.

Literature Search and Risk Assessment Completed On: 12/07/20.

11.1.4. Skin sensitization

Based on the existing data and read-across material methyl hexadecanoate (CAS # 112-39-0), ethyl laurate is considered a skin sensitizer with a defined NESIL of 2400 μg/cm^2.

11.1.4.1. Risk assessment. Limited skin sensitization studies are available for ethyl laurate. Based on the existing data and read-across material methyl hexadecanoate (CAS # 112-39-0; see Section VI), ethyl laurate is considered a skin sensitizer. The chemical structures of these materials indicate that they would not be expected to react with skin proteins (Roberts et al., 2007; Toxtree v3.1.0; OECD Toolbox v4.2). In a local lymph node assay (LLNA), read-across material methyl hexadecanoate was found to be sensitizing with an EC3 value of 10.35% (2588 μg/cm^2) based on linear regression (RIFM, 2002). In a guinea pig open epicutaneous test (OET), it was reported that ethyl laurate did not show skin sensitization reactions (Klecak, 1985). In a human maximization test, no skin sensitization reactions were observed with the target material, ethyl laurate, when tested at 12% (8280 μg/cm^2) in petrolatum (RIFM, 1973). In a Confirmation of No Induction in Humans test (CNIH) with 2.1% (2480 μg/cm^2) of read-across material methyl hexadecanoate in 1:3 ethanol:diethyl phthalate (1:3 EtOH:DEP), no reactions indicative of sensitization were observed in any of the 103 volunteers (RIFM, 2018).

Based on the available data on read-across material methyl hexadecanoate, summarized in Table 1, ethyl laurate is considered to be a skin sensitizer with a defined NESIL of 2400 μg/cm^2. Section X provides the maximum acceptable concentrations in finished products, which take into account skin sensitization and application of the Quantitative Risk Assessment (QRA2) described by Api et al. (RIFM, 2020b) and a subchronic RfD of 3.33 mg/kg/day.

Table 1
Data summary for methyl hexadecanoate as read-across material for ethyl laurate.

LLNA Weighted Mean EC3 Value μg/cm^2 (No. Studies)	Potency Classification Based on Animal Data[a]	Human Data			
		NOEL-CNIH (Induction) μg/cm^2	NOEL-HMT (Induction) μg/cm^2	LOEL[b] (Induction) μg/cm^2	WoE NESIL[c] μg/cm^2
2588 [1]	Moderate	2480	NA	NA	2400

NOEL = No observed effect level; CNIH = Confirmation of No Induction in Humans test; HMT = Human Maximization Test; LOEL = lowest observed effect level; NA = Not Available.

[a] Based on animal data using classification defined in ECETOC, Technical Report No. 87, 2003.

[b] Data derived from CNIH or HMT.

[c] WoE NESIL limited to 2 significant figures.

Additional References: None.

Literature Search and Risk Assessment Completed On: 12/21/20.

11.1.5. Phototoxicity/photoallergenicity

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

11.1.5.1. Risk assessment. There are no phototoxicity studies available for ethyl laurate in experimental models. UV/Vis absorption spectra indicate no significant absorption 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 the lack of absorbance, ethyl laurate does not present a concern for phototoxicity or photoallergenicity.

11.1.5.2. UV spectra analysis. UV/Vis absorption spectra (OECD TG 101) were obtained. The spectra indicate no significant 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} • cm^{-1} (Henry et al., 2009).

Additional References: None.

Literature Search and Risk Assessment Completed On: 12/04/20.

11.1.6. Local Respiratory Toxicity

The MOE could not be calculated due to a lack of appropriate data. The exposure level for ethyl laurate is below the Cramer Class I TTC value for inhalation exposure local effects.

11.1.6.1. Risk assessment. There are no inhalation data available on ethyl laurate. Based on the Creme RIFM Model, the inhalation exposure is 0.020 mg/day. This exposure is 70 times lower than the Cramer Class I TTC value of 1.4 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: 12/15/20.

11.2. Environmental endpoint summary

11.2.1. Screening-level assessment

A screening-level risk assessment of ethyl laurate 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, ethyl laurate 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 is > 1). Noting that the initial screening-level assessment (Tier 1) determined the PEC/PNEC to be > 1, the assessment was refined (Tier 2 and Tier 3) using the more specific model ECOSAR, which provides chemical class-specific ecotoxicity estimates (see the Risk Assessment Refinement section below).

A screening-level hazard assessment using EPI Suite v4.11 (US EPA, 2012a) did not identify ethyl laurate 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).

11.2.2. Risk assessment

Based on the current Volume of Use (2015), ethyl laurate presents a risk to the aquatic compartment in the screening-level assessment.

11.2.3. Key studies

11.2.3.1. Biodegradation. No data available.

11.2.3.2. Ecotoxicity. No data available.

11.2.3.3. Other available data. Ethyl laurate has been registered for REACH, with no additional information available at this time.

Additional data is available for the read-across material butyl decanoate (CAS # 3073-36-0) (ECHA, 2019):

The ready biodegradability of the test material was evaluated using the CO_2 evolution test according to the OECD 301B guideline. Biodegradation of 63% was observed after 56 days.

The *Daphnia magna* acute immobilization test was conducted according to the OECD 202 guidelines under static conditions. The 48-h EC50 value based on geometric mean measured concentration was reported to be 0.09 mg/L (95% CI: 0.08–0.14 mg/L).

The algae growth inhibition test was conducted according to the OECD 201 guidelines under static conditions. The 72-h EC50 value based on geometric mean measured concentration for growth rate was

	LC50 (Fish) (mg/L)	EC50 (*Daphnia*) (mg/L)		EC50 (Algae) (mg/L)	AF	PNEC (μg/L)	Chemical Class
RIFM Framework Screening-level **(Tier 1)**	0.16				1000000	0.00016	
ECOSAR Acute Endpoints **(Tier 2)** v2.0	0.191	0.264		0.062			Esters
ECOSAR Acute Endpoints **(Tier 2)** v2.0	0.076	0.061		0.193	10000	0.0061	Neutral Organic SAR (Baseline toxicity)
	Tier 3: Measured Data (including read-across data)						
	LC50	EC50		NOEC	AF	PNEC	Comments
Fish							
Daphnia		0.09			5000	0.018	
Algae		0.731					

reported to be 0.731 mg/L (95% CI: 0.679–0.793 mg/L).

11.2.4. Risk assessment refinement

The screening-level assessment was refined (Tier 2 and Tier 3) using more a more specific model (ECOSAR provides chemical class-specific ecotoxicity estimates). In the case of the present safety assessment, Tier 2 and Tier 3 refinement determined the PEC/PNEC ratio to be < 1. As explained in the screening-level assessment section above, Tier 1 utilizes the material's regional volume of use, log Kow, and molecular weight only. Tier 2 and Tier 3 use lower uncertainty factors and more specific estimates, and Tier 3 includes measured data as well.

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

Endpoints used to calculate PNEC are underlined.

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

Exposure	Europe (EU)	North America (NA)
Log K_{ow} Used	5.78	5.78
Biodegradation Factor Used	1	1
Dilution Factor	3	3
Regional Volume of Use Tonnage Band	<1	1–10
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 0.018 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: 12/12/20.

12. Literature Search*

- **RIFM Database:** Target, Fragrance Structure-Activity Group materials, other references, JECFA, CIR, SIDS
- **ECHA:** https://echa.europa.eu/
- **NTP:** https://ntp.niehs.nih.gov/
- **OECD Toolbox:** https://www.oecd.org/chemicalsafety/risk-assessment/oecd-qsar-toolbox.htm
- **SciFinder:** https://scifinder.cas.org/scifinder/view/scifinder/scifinderExplore.jsf
- **PubMed:** https://www.ncbi.nlm.nih.gov/pubmed
- **National Library of Medicine's Toxicology Information Services:** https://toxnet.nlm.nih.gov/
- **IARC:** https://monographs.iarc.fr
- **OECD SIDS:** https://hpvchemicals.oecd.org/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:** https://www.nite.go.jp/en/chem/chrip/chrip_search/systemTop
- **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 11/03/21.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome. RIFM staff are employees of the Research Institute for Fragrance Materials, Inc. (RIFM). The Expert Panel receives a small honorarium for time spent reviewing the subject work.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.fct.2022.113099.

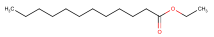
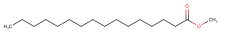
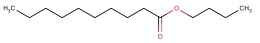
Appendix

Read-across Justification

Methods

The read-across analogs were identified using RIFM fragrance materials chemical inventory clustering and read-across search criteria (RIFM, 2020a). These criteria follow the strategy for structuring and reporting a read-across prediction of toxicity as described in Schultz et al. (2015) and are 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, 2017).

- 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 material 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, oncologic classification, ER binding, and repeat dose categorization predictions were generated using OECD QSAR Toolbox v4.2 (OECD, 2018).
- Developmental toxicity was predicted using CAESAR v2.1.7 (Cassano et al., 2010).
- Protein binding was predicted using OECD QSAR Toolbox v4.2 (OECD, 2018), and skin sensitization was predicted using Toxtree.
- The major metabolites for the target material and read-across analogs were determined and evaluated using OECD QSAR Toolbox v4.2 (OECD, 2018).
- To keep continuity and compatibility with *in silico* alerts, OECD QSAR Toolbox v4.2 was selected as the alert system.

	Target Material	Read-across Material	Read-across Material	Read-across Material
Principal Name	Ethyl laurate	Methyl laurate	Methyl hexadecanoate	Butyl decanoate
CAS No.	106-33-2	111-82-0	112-39-0	30673-36-0
Structure				

	LC50 (Fish) (mg/L)	EC50 (*Daphnia*) (mg/L)	EC50 (Algae) (mg/L)	AF	PNEC (μg/L)	Chemical Class
RIFM Framework Screening-level **(Tier 1)**	2.974			1000000	0.002974	

Similarity (Tanimoto Score)		0.86		0.5
Read-across Endpoint		• Repeated Dose Toxicity • Reproductive Toxicity	• Skin Sensitization	• Environmental
Molecular Formula	$C_{14}H_{28}O_2$	$C_{13}H_{26}O_2$	$C_{17}H_{34}O_2$	$C_{14}H_{28}O_2$
Molecular Weight (g/mol)	228.376	214.349	270.457	228.37
Melting Point (°C, EPI Suite)	−10.00	5.20	30.00	25.16
Boiling Point (°C, EPI Suite)	271.00	267.00	324.49	281.15
Vapor Pressure (Pa at 25 °C, EPI Suite)	1.17	0.55	6.27E-03	1.17
Log K_{OW} (KOWWIN v1.68 in EPI Suite)	5.71	5.41	9.05E-03	5.71
Water Solubility (mg/L, at 25 °C, WSKOW v1.42 in EPI Suite)	4.13E-01	8.84E-01	7.38	4.13E-01
J_{max} (μg/cm^2/h, SAM)	1.162	2.456	0.00	1.162
Henry's Law (Pa·m^3/mol, Bond Method, EPI Suite)	4.01E+02	3.02E+02	9.38E+02	4.01E+02
Repeated Dose Toxicity				
Repeated Dose (HESS)	• Not categorized	• Not categorized		
Reproductive Toxicity				
ER Binding (OECD QSAR Toolbox v4.2)	• Non-binder, non-cyclic structure	• Non-binder, non-cyclic structure		
Developmental Toxicity (CAESAR v2.1.6)	• Non-toxicant (good reliability)	• Non-toxicant (moderate reliability)		
Skin Sensitization				
	• No alert found		• No alert found	

(*continued on next page*)

(*continued*)

	Target Material	Read-across Material	Read-across Material	Read-across Material
Protein Binding (OASIS v1.1)				
Protein Binding (OECD)	• No alert found		• No alert found	
Protein Binding Potency	• Not possible to classify according to these rules (GSH)		• Not possible to classify according to these rules (GSH)	
Protein Binding Alerts for Skin Sensitization (OASIS v1.1)	• No alert found		• No alert found	
Skin Sensitization Reactivity Domains (Toxtree v3.1.0)	• No skin sensitization reactivity domain alerts were identified.		• No skin sensitization reactivity domain alerts were identified.	
Environmental Toxicity				
BIOWIN 3	• 3.311			• 3.311
ECOSAR (96-h Fish LC50) for esters in mg/L	• 0.191			• 0.191
ECOSAR (48-h *Daphnia* LC50) for esters in mg/L	• 0.264			• 0.264
ECOSAR (96-hr algae LC50) for esters in mg/L	• 0.062			• 0.062
Metabolism				
Rat Liver S9 Metabolism Simulator and Structural Alerts for Metabolites (OECD QSAR Toolbox v4.2)	See Supplemental Data 1	See Supplemental Data 2	See Supplemental Data 3	N/A

Summary

There are insufficient toxicity data on ethyl laurate (CAS # 106-33-2). 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, methyl laurate (CAS # 111-82-0), methyl hexadecanoate (CAS # 112-39-0), and butyl decanoate (CAS # 30673-36-0) were identified as a read-across analog with sufficient data for toxicological evaluation.

Conclusions

- Methyl laurate (CAS # 111-82-0) was used as a read-across analog for the target material ethyl laurate (CAS # 106-33-2) for the reproductive toxicity and repeated dose toxicity endpoints.
  - o The target material and the read-across analog are structurally similar and belong to a class of saturated esters.
  - o The target material and the read-across analog share a C12 straight saturated acid branch.
  - o The key difference between the target material and the read-across analog is that the target material has an ethanol branch, whereas the read-across analog has a methanol branch. The read-across analog contains the structural features of the target material that are relevant to this endpoint and is expected to have equal or greater potential for toxicity as compared to the target material.
  - o The similarity between the target material 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 material 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 material and the read-across analog.
  - o The target material 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.
- Methyl hexadecanoate (CAS # 112-39-0) was used as a read-across analog for the target material ethyl laurate (CAS # 106-33-2) for the skin sensitization endpoint.
  - o The target material and the read-across analog are structurally similar and belong to a class of saturated esters.
  - o The target material and the read-across analog share a C12 straight saturated acid branch.
  - o The key difference between the target material and the read-across analog is that the target material has an ethanol branch, whereas the read-across analog has a methanol branch. The read-across analog contains the structural features of the target material that are relevant to this endpoint and is expected to have equal or greater potential for toxicity as compared to the target material.
  - o The similarity between the target material 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 material 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 material and the read-across analog.
  - o The target material and the read-across analog are expected to be metabolized similarly, as shown by the metabolism simulator.
- Butyl decanoate (CAS # 30673-36-0) was used as a read-across analog for the target material ethyl laurate (CAS # 106-33-2) for the environmental toxicity endpoint.
  - o The target material and the read-across analog are structurally similar and belong to a class of saturated esters.
  - o The target material and the read-across analog share a C12 straight saturated acid branch.
  - o The key difference between the target material and the read-across analog is that the target material has an ethanol branch, whereas the read-across analog has a methanol branch. The read-across analog contains the structural features of the target material that are relevant to this endpoint and is expected to have equal or greater potential for toxicity as compared to the target material.
  - o The similarity between the target material 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 material and the read-across analog are sufficiently similar to enable comparison of their toxicological properties.
  - o According to the ECOSAR and BIOWIN models, structural predictions for the ecotoxicological endpoint are consistent between the target material and the read-across analog.

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