



Short review

RIFM fragrance ingredient safety assessment, 2-acetylpyridine, CAS Registry Number 1122-62-9



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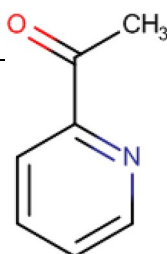
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Name: 2-Acetylpyridine
CAS Registry Number: 1122-62-9

**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

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

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PEC/PNEC - Predicted Environmental Concentration/Predicted No Effect Concentration
 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.

2-Acetylpyridine was evaluated for genotoxicity, repeated dose toxicity, reproductive toxicity, local respiratory toxicity, phototoxicity/photoallergenicity, skin sensitization, and environmental safety. Data show that 2-acetylpyridine is not genotoxic. Data on 2-acetylpyridine provide a calculated MOE > 100 for the repeated dose toxicity endpoint. The reproductive toxicity and local respiratory toxicity endpoints were evaluated using the TTC for a Cramer Class II material, and the exposure to 2-acetylpyridine is below the TTC (0.009 mg/kg/day and 0.47 mg/day, respectively). The skin sensitization endpoint was completed using the DST for non-reactive materials (900 $\mu\text{g}/\text{cm}^2$); exposure is below the DST. The phototoxicity/photoallergenicity endpoints were evaluated based on UV spectra; 2-acetylpyridine is not expected to be phototoxic/photoallergenic. The environmental endpoints were evaluated; 2-acetylpyridine 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, 2014a; RIFM, 2014b)

Repeated Dose Toxicity: (EFSA (2006)

NAOEL = 37 mg/kg/day.

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

Skin Sensitization: Not a concern for skin sensitization; the exposure is below the DST.

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: 2.7 (BIOWIN 3) (EPI Suite v4.11; US EPA, 2012a)

Bioaccumulation: Screening-level: 3.2 L/kg (EPI Suite v4.11; US EPA, 2012a)

Ecotoxicity: Screening-level: Fish LC50: 3361 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: 3361 mg/L (RIFM Framework; Salvito et al., 2002)

RIFM PNEC is: 3.361 $\mu\text{g}/\text{L}$

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

1. Identification

- Chemical Name:** 2-Acetylpyridine
- CAS Registry Number:** 1122-62-9
- Synonyms:** 2-Acetylpyridine; Ethanone, 1-(2-pyridinyl)-; Methyl-2-pyridyl ketone; 1-Pyridin-2-ylethanone; 2-Acetylpyridine
- Molecular Formula:** $\text{C}_7\text{H}_7\text{NO}$
- Molecular Weight:** 121.13
- RIFM Number:** 6696
- Stereochemistry:** No stereoisomer possible.

2. Physical data

- Boiling Point:** 188 °C (FMA Database), 199.26 °C (EPI Suite)
- Flash Point:** > 93 °C (Global Harmonized System), > 200 °F; CC (FMA Database)
- Log K_{OW} :** 0.49 (EPI Suite)
- Melting Point:** 23.03 °C (EPI Suite)
- Water Solubility:** 18680 mg/L (EPI Suite)
- Specific Gravity:** 1.080 (FMA Database)
- Vapor Pressure:** 0.367 mm Hg @ 20 °C (EPI Suite v4.0), 0.3 mm Hg @ 20 °C (FMA Database), 0.537 mm Hg @ 25 °C (EPI Suite)
- UV Spectra:** Minor absorbance between 290 and 700 nm; molar absorption coefficient is below the benchmark (1000 $\text{L mol}^{-1} \cdot \text{cm}^{-1}$)
- Appearance/Organoleptic:** Colorless liquid which yellows on exposure to air; tobacco-like aroma

3. Exposure to fragrance ingredient

- Volume of Use (Worldwide Band):** 0.1–1 metric ton per year (IFRA, 2015)
- 95th Percentile Concentration in Hydroalcohols:** 0.39% (RIFM, 2017)
- Inhalation Exposure*:** 0.000092 mg/kg/day or 0.0066 mg/day (RIFM, 2017)
- Total Systemic Exposure**:** 0.00035 mg/kg/day (RIFM, 2017)

*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

- Dermal:** Assumed 100%
- Oral:** Assumed 100%
- Inhalation:** Assumed 100%

5. Computational toxicology evaluation

- Cramer Classification:** Class II, Intermediate* (Expert Judgment)

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

*Due to potential discrepancies between 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. See Appendix for details.

2. Analogs Selected

- Genotoxicity:** None
- Repeated Dose Toxicity:** None
- Reproductive Toxicity:** None
- Skin Sensitization:** None
- Phototoxicity/Photoallergenicity:** None
- Local Respiratory Toxicity:** None
- Environmental Toxicity:** None

3. Read-across Justification: None

6. Metabolism

No relevant data available for inclusion in this safety assessment.

Additional References:

None.

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

2-Acetylpyridine is reported to occur in nature in the following*:

Beef
 Beer
 Cabbage (*Brassica oleracea*)
 Coffee
 Lamb and mutton
 Licorice (*Glycyrrhiza* species)
 Maize (*Zea mays* L.)
 Malt
 Pork
 Whiskey

*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.

8. REACH Dossier

Pre-registered for 2010; no dossier available as of 01/13/19.

9. Conclusion

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

10. Summary

10.1. Human health endpoint summaries

10.1.1. Genotoxicity

Based on the current existing data, 2-acetylpyridine does not present a concern for genotoxicity.

10.1.1.1. Risk assessment. 2-Acetylpyridine was assessed at the highest concentration of 1212 µg/mL (10 mM) in the BlueScreen assay and found negative for both cytotoxicity (positive: < 80% relative cell density) and genotoxicity, with and without metabolic activation (RIFM, 2015). 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 2-acetylpyridine 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 method. *Salmonella typhimurium* strains TA98, TA100, TA1535, TA1537, and *Escherichia coli* strain WP2uvrA were treated with 2-acetylpyridine 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, 2014a). Under the conditions of the study, 2-acetylpyridine was not mutagenic in the Ames test.

The clastogenic activity of 2-acetylpyridine 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 2-acetylpyridine in Eagle's minimal essential medium with HEPES buffer at concentrations up to 1212 µg/mL (10 mM) in the presence and absence of metabolic activation (S9 mix) for 4 h and in the absence of metabolic activation for 24 h. 2-Acetylpyridine did not induce binucleated cells with micronuclei when tested up to the maximum concentration in either the presence or absence of an S9 activation system (RIFM, 2014b). Under the conditions of the study, 2-acetylpyridine was considered to be non-clastogenic in the *in vitro* micronucleus test.

Based on the data available, 2-acetylpyridine does not present a concern for genotoxic potential.

Additional References: None.

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

10.1.2. Repeated dose toxicity

The MOE for 2-acetylpyridine is adequate for repeated dose toxicity endpoint at the current use level.

10.1.2.1. Risk assessment. There are sufficient repeated dose toxicity data on 2-acetylpyridine. In a subchronic toxicity study (non-GLP compliant and non-guideline) 10 Albino rats/sex/dose were orally administered 2-acetylpyridine through gavage at doses of 0 (control: propylene glycol), 37, 110, 330, and 1000 mg/kg/day for 91 days (6 days/week). No treatment-related effects were reported for mortality, clinical signs, bodyweight gain, food consumption, clinical chemistry, and urinalysis at any dose level. Slight anemia due to decreased erythrocyte counts (statistical significance not reported) was reported in males at ≥ 330 mg/kg/day and in females at 110 mg/kg/day and 330 mg/kg/day. At doses ≥ 330 mg/kg/day, increased hematopoietic activity in the spleen of both sexes and centrilobular hepatocyte hypertrophy in the liver were reported along with female bile duct epithelium proliferation at 1000 mg/kg/day. Based on a decrease in erythrocytes and increased hematopoietic activity in the spleen of both the sexes, the NOAEL for systemic toxicity was considered to be 37 mg/kg/day (EFSA, 2006; WHO, 2006).

Therefore, the MOE can be calculated by dividing the NOAEL in mg/kg/day for 2-acetylpyridine by the total systemic exposure in mg/kg/day, 37/0.00035 or 105714.

In addition, the total systemic exposure to 2-acetylpyridine (0.35 µg/kg bw/day) is below the TTC (9 µg/kg bw/day) for the repeated dose toxicity endpoint of a Cramer Class II material at the current level of use.

Additional References: Posternak and Vodoz, 1975.

Literature Search and Risk Assessment Completed On: 01/13/19.

10.1.3. Reproductive toxicity

There are insufficient reproductive toxicity data on 2-acetylpyridine or on any read-across materials. The total systemic exposure to 2-acetylpyridine is below the TTC for the reproductive toxicity endpoint of a Cramer Class II material at the current level of use.

10.1.3.1. Risk assessment. There are insufficient reproductive toxicity data on 2-acetylpyridine or on any read-across materials that can be used to support the reproductive toxicity endpoint. The total systemic exposure to 2-acetylpyridine (0.35 µg/kg bw/day) is below the TTC (9 µg/kg bw/day; Kroes et al., 2007; Laufersweiler et al., 2012) for the reproductive toxicity endpoint of a Cramer Class II material at the current level of use.

Additional References: Posternak and Vodoz, 1975.

Literature Search and Risk Assessment Completed On: 12/14/18.

10.1.4. Skin sensitization

Based on the existing data and the application of the DST, 2-acetylpyridine does not present a concern for skin sensitization under the 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 3.1.0; OECD Toolbox v4.2). No predictive skin sensitization studies are available for 2-acetylpyridine. Acting conservatively due to the absence of data, the reported exposure was benchmarked utilizing the non-reactive DST of 900 µg/cm² (Safford, 2008; Safford et al., 2011; Roberts et al., 2015; Safford et al., 2015b). 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 2-acetylpyridine that present no appreciable risk for skin sensitization based on the non-reactive DST. These levels represent maximum acceptable concentrations based on the DST approach. However, additional studies may show it could be used at higher levels.

Additional References: None.

Literature Search and Risk Assessment Completed On: 12/06/18.

Table 1

Maximum acceptable concentrations for 2-acetylpyridine 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	0.069%	1.0 × 10 ⁻⁴
2	Products applied to the axillae	0.021%	0.0053%
3	Products applied to the face using fingertips	0.41%	2.2 × 10 ⁻⁴ %
4	Fine fragrance products	0.39%	4.0 × 10 ⁻⁴ %
5	Products applied to the face and body using the hands (palms), primarily leave-on	0.10%	0.013%
6	Products with oral and lip exposure	0.23%	1.0 × 10 ⁻⁵ %
7	Products applied to the hair with some hand contact	0.79%	0.0016%
8	Products with significant ano-genital exposure	0.041%	No Data ^c
9	Products with body and hand exposure, primarily rinse-off	0.75%	0.0050%
10	Household care products with mostly hand contact	2.7%	0.014%
11	Products with intended skin contact but minimal transfer of fragrance to skin from inert substrate	1.5%	No Data ^c
12	Products not intended for direct skin contact, minimal or insignificant transfer to skin	Not Restricted	0.25%

Note: ^aFor a description of the categories, refer to the IFRA/RIFM Information Booklet.

^cFragrance exposure from these products is very low. These products are not currently in the Creme RIFM Aggregate Exposure Model.

10.1.5. Phototoxicity/photoallergenicity

Based on the available UV/Vis spectra, 2-acetylpyridine 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 2-acetylpyridine 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 the lack of significant absorbance in the critical range, 2-acetylpyridine does not present a concern for phototoxicity or photoallergenicity.

10.1.5.2. UV spectra analysis. UV/Vis absorption spectra (OECD TG 101) for 2-acetylpyridine 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 · cm⁻¹ (Henry et al., 2009).

Additional References: None.

Literature Search and Risk Assessment Completed On: 11/20/18.

10.1.6. Local respiratory toxicity

The MOE could not be calculated due to a lack of appropriate data. The exposure level for 2-acetylpyridine 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 2-acetylpyridine. Based on the Creme RIFM Model, the inhalation exposure is 0.0066 mg/day. This exposure is 71.2 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), Cramer Class II materials default to Cramer Class III for the local respiratory toxicity endpoint.

Additional References: None.

Literature Search and Risk Assessment Completed On: 12/11/18.

10.2. Environmental endpoint summary

10.2.1. Screening-level assessment

A screening-level risk assessment of 2-acetylpyridine 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, 2-acetylpyridine 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 2-acetylpyridine 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), 2-acetylpyridine does not present a risk to the aquatic compartment in the screening-level assessment.

10.2.2.1. Key studies. Biodegradation: No data available.

Ecotoxicity: No data available.

Other available data: 2-Acetylpyridine 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 $\mu\text{g/L}$)

Endpoints used to calculate PNEC are underlined.

	(mg/L)	(<i>Daphnia</i>) (mg/L)	(mg/L)			
RIFM Framework						
Screening-level (Tier 1)	<u>3361</u>			1,000,000	<u>3.361</u>	

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

Exposure	Europe (EU)	North America (NA)
Log K_{ow} Used	0.49	0.49
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 additional assessment is necessary.

The RIFM PNEC is 3.361 $\mu\text{g/L}$. 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 VoU.

Literature Search and Risk Assessment Completed On: 01/02/19.

11. 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**
- **SciFinder:** <https://scifinder.cas.org/scifinder/view/scifinder/scifinderExplore.jsf>
- **PubMed:** <https://www.ncbi.nlm.nih.gov/pubmed>
- **TOXNET:** <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/opphpv/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 05/31/19.

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

Explanation of Cramer Classification

Due to potential discrepancies between 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? Yes
- Q8. Lactone or cyclic diester? No
- Q10. 3-membered heterocycles? No
- Q11. Has a heterocyclic ring with complex substituents? No
- Q12. Heteroaromatic? Yes
- Q13. Does the ring bear any substituents? Yes
- Q14. More than one aromatic ring? No
- Q22. Common component of food? Yes, Intermediate (Class II)

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