Environmental profile of Propylparaben

12237 Chemicals in the Environment

Due: 1 May 2024

Group 21

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Executive Summary

There were two tests conducted on the toxicity of propylparaben in the laboratory. The group began with a luminescence test on *Vibrio fischeri*, assessing its diminishing population within two consecutive time intervals of 10 minutes.

Following the standardized bacteria test, the group moved onto algal testing and used the same compound on the unicellular *Raphidocelis Subcapitata*. Here, a selected window of 96 hours dictated the results - with a special caveat. Acetone in this case brought forth the chlorophyll required to measure visible light emitted by the organism.

After collecting the data in both experiments, the group generated concentration-response curves using RStudio. With the statistical computing software, we were able to model each given point's uncertainty, along with the concentration of propylparaben required to attain 10 and 50 percent of the final change in luminescence.

The conclusion is that propylparaben falls under the least stringent of EU CLP classifications. Its primary environmental hazard is to the endocrine system. It is not a persistent substance, is moderately mobile in soil, and is not bioaccumulative, according to its K_{OW}. Its existing abundance in the world is lower than the predicted no-effect concentration, making the current situation a safe one.

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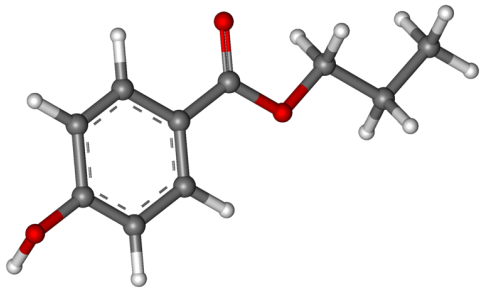

Introduction

Propylparaben's present yearly production volume within the European Economic Area falls between 100 and 1000 tonnes (ECHA). It appears in foods as a processing aid, but also can be seen in human body cosmetics. Its most functional aspect is exploited by pharmaceutical companies worldwide, that of resistance to microbes. One of seven parabens derived synthetically from para-hydroxybenzoic acid, propylparaben is amidst growing concern of disrupting the human endocrine system.

The risk assessment of chemicals is beneficial for legislators who will use judgments to restrict a chemical or authorize its use completely. Living in the twenty-first century raises additional concerns about how long the compound has already been in the environment, as companies which produce chemicals as their sole source of livelihood are not a novelty. This paper does not begin to explore the nature of propylparaben's interaction with one, two, five, or *twenty* other chemicals in a site of action.

With adequate information on the physical properties of propylparaben and its testing on living creatures, others can decide if the known benefits it may offer certain members of the human population are worth the estimated cost on aquatic life. It may initially be surprising that here on Earth, a vast majority of life lives on soil and sediment, yet standards of evaluation have become comparatively more advanced in water.

Hazard Identification

As a pure substance, propylparaben is not volatile (compared to the volatile benzene: 94.8 mm Hg at 25 °C (Daubert, 1989), formaldehyde: 3.890 mm Hg at 25 °C (Boublik, 1984), and toluene: 28.4 mm Hg at 25 °C). With a Henry's constant value less than $3*10^{-7}$, propylparaben is less volatile than water (*Note 1*). The gas film regulates its transition between liquid and vapor, according to K_H.

The species is often protonated in neutral surroundings, as its pK_a generally characterizes as a weak acid. It can be thought of to have medium mobility in soil, with K_{OC} in 150-500 (*Note 1*).

Although possible due to its structure, hydrolysis happens too slow to make an observable difference. Photolysis halves the concentration of propylparaben at a decent rate, compared to that of benzene: 16.9 days (Hustert K *et al,* 1981). Propylparaben is readily biodegradable according to OECD 301F, where it apparently achieved 60% theoretical oxygen consumption.

There is no experimental evidence surrounding a bioconcentration factor of propylparaben, meaning the only reasonable estimate is based on $\log K_{OW}$. Using an equation for fish by Veith *et al*. (1979), the risk due to this is moderate, and certainly well below GHS's threshold of 500. Furthermore, the compound fails to attain a REACH rating of "potentially bioaccumulative", as $\log K_{OW} > 4$.

The substance is not very toxic, as there is no EC_{50}/LC_{50} less than 1 mg/L. Toxicity data seem to be affecting crustaceans most, as understood from the driving force behind aquatic classification, EC_{50} = 0.25 mg/L. Similarly, CLP classifies propylparaben as Aquatic Chronic 3, because of the NOEC value for an OECD 211 test on *Daphnia Magna* and degradability status. It is not a PBT

nor a vPvB compound, because half-life data falls on the order of several days (in plasma and water).

In a modified ISO Standard 11348-3 at DTU, a test exploiting similarities in sensitivity to propylparaben between the bacterium *Vibrio Fischeri* and fish during a period of three days, the EC_{50} value was 14.58 mg/L. This was less toxic than findings which already existed, but the hypothesis is that natural deviation caused 10-minute samples to be unexpectedly lesser in growth than 20-minute samples. Methodology was different, but on the other hand, the correction factor may have changed due to a fluctuation in readings for the control group.

Both this test and another were assessed using fluorescence as a metric. In the other test (which took place at the same location), ISO Standard 8692 guided an algae test to an EC_{50} value of 25.495, once again showing less toxicity than the rest of public knowledge on the species (Madsen et al., 2001). The conventional value fell outside of the newly discovered EC_{50}'s 95% confidence interval, and there is a leading explanation for this - REACH regulation has retracted their use of the 2004 procedure in favor of the existing and annotated 2012 version, which could have led to erroneous results.

Hazard Assessment

From the table above, the $PNEC = 5\ \mu g/L$. The assessment factor is 50 by data for two trophic levels, to normalize the lowest available LC_{50}/EC_{50}/NOEC. The predicted concentration in freshwater is 1.2 µg/L, although (insufficient) indications from surface water in Brazil suggest this is a conservative guess (Galinaro *et al,* 2015). From there, $HAZARD\ QUOTIENT = 0.24$, which exempts the compound from risk of effect in the environment.

This is not an evenly distributed chemical worldwide, as Europe has banned it from food, while the USA continues to use it there as an antimicrobial agent. It is concerning that despite lacking toxicity, the compound may offer behavioral changes to an individual by way of hijacking enzyme functions, for instance in conjunction with estrogen. In terms of the spheres, it would appear that propylparaben is most abundant in aquatic scenarios, followed by soil, and least in air, followed by its low volatility.

References

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Appendices

Data on hazard	
Name of compound	**Propylparaben (IUPAC name: propyl 4-hydroxybenzoate)**
CAS-no.	**94-13-3**
Smiles notation	**O=C(OCCC)c(ccc(O)c1)c1**
Physical-chemical parameters	
Structural formula	**$C_{10}H_{12}O_3$**
Molecular weight (g/mol)	**180.20 g/mol [PubChem - Compound Summary for CID 7175]**
Melting Point	**95-98°C [PubChem – Compound Summary for CID 7175]**
Boiling Point	**271°F at 1 mmHg [NIH, 1992]**
Water solubility (mg/l)	**500 mg/L (25°C) [ECHA, 2024]** **5.00 x 10^2 mg/L (25°C) [PubChem - Yalkowsky et al, 2010]**

Vapor pressure (atm) or (Pa)	**0 – 0.046 Pa (20-50°C) [ECHA, 2024]**
logK_{ow}	**2.8 (20°C) [ECHA, 2024]** **3.04 [PubChem – Hansch et al, 1995]**
Henry's constant (atm*m^3/mol)	**4.3 x 10^{-9} [PubChem – Compound Summary for CID 7175]**
K_{oc}	**286.6 (20°C) [ECHA, 2024]** **158 L/kg [CompTox – predicted from OPERA model]**
pK_a	**8.46 (20°C) [ECHA, 2024]** **7.91 [check XI, 7.16]**
Distribution	
Volatilisation from aquatic solution	**The Henry's constant is less than 3*10^{-7}, so the compound is less volatile than water.**
Bioaccumulation potential	**QSAR log (Kow) 3.57 [EPIWIN, 1994]** **BCF (fish, estimated): 76.6**
Mobility	**LogPow: 2.94 [Fisher Scientific Company, 2022]**
Degradation	
Biodegradation	**Aerobic biodegradability: 91.5% ThOD** **Anaerobic biodegradability: 18% ThGP** **[Madsen et al, 2001] Note: OECD 301F**

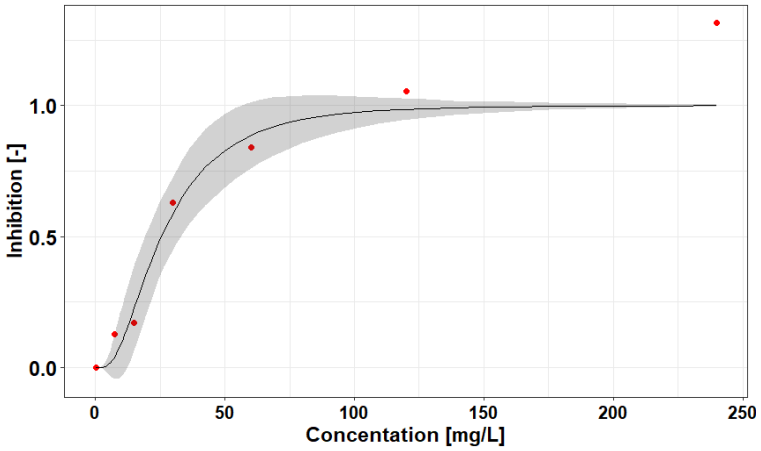
Photolysis		**Absorbs light with wavelength >290 nm (PubChem – Compound Summary for CID 7175)** **Aqueous photolysis half-life of 2.5 days [Fang H et al, 2013]**	
Hydrolysis		**"Hydrolysis is not relevant in regard to abiotic degradation due the rapid biodegradability of the substance." [ECHA]**	
Ecotoxicity			
Fish	**>1- ≤ 10 mg/L**	**LOEC**	**2500 µg/L (7 d-LOEC growth)** **9000 µg/L (7 d-LOEC growth)** **[Yamamoto et al, 2011; Dobbins et al, 2009]**
		LC_{50}	**5-10 mg/L (48 h) [Fisher Scientific Company, 2022] (Note: Leuciscus Idus)**
Crustaceans, daphnids	**>0.1- ≤ 1 mg/L**	**NOEC**	**0.25 mg/L (Fraunhofer IME, 2019)**
	>1- ≤ 10 mg/L	**LOEC**	**2000 µg/L (10 d-LOEC growth)**
	>10- ≤ 100 mg/L	**EC_{50}**	**15.4 mg/L (8.0-32.3) (48 h) [Madsen et al, 2001]**
Algae	**>1- ≤ 10 mg/L**	**NOEC**	**7400 µg/L (72 h-NOEC)**

	>10- ≤ 100 mg/L		**11,000 µg/L (72 h-NOEC)**
		EC_{50}	**15 (15-16) (72 h) [Madsen et al, 2001]**
Labeling			
Environmental labeling			**ED (endocrine-disrupting) [ECHA]**
Europe / USA / Other			**USA: 4,500-225,000 kg (2002) [Pubchem] Note: Non-confidential production volume**

REPORTING SCHEME FOR THE VIRTUAL ALGAL TEST

Student no.	s236965
Student name	Yannis Shoemaker
Team no.	21

Question	**Answer**
What is the purpose of the experiment?	The purpose of our algae test was to quantify the effect of propylparaben in aqueous solution on the division of a planktonic, green, freshwater species named *Raphidocelis Subcapitata.* Part of this was ensuring we account for experimental uncertainty by including confidence intervals of our findings. Ultimately, we aimed to understand their

	inhibition by generating growth curves from 24h and 96h and adding to existing literature.
List the average growth rate of the control group	Average growth rate of controls: 1.522 d^{-1}
Insert a copy of the concentration-response curve obtained	
List the EC_{10} and EC_{50} (with confidence intervals) you obtained	EC_{10} = 10.277 mg/L $[4.773\text{-}15.781]_{95\%}$ EC_{50} = 25.495 mg/L $[19.115\text{-}31.875]_{95\%}$
Does the EC_{50}-value obtained indicate that your compound is more toxic towards algae than found in the literature (e.g. in the USEPA Ecotox database)?	Our EC_{50} value does not indicate that propylparaben is more toxic towards algae than found in the literature. Our value was greater than the 16 mg/L (*OECD TG 201,* 2012) and 15 mg/L (*Madsen et al, 2001*), but lower than 36 mg/L (*Yamamoto et al, 2011*). We tested the same organism they did in their laboratory.