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Abstract

Toxicity Mechanisms of Mixtures of Anionic and Non-Ionic Surfactants †

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1. Introduction

In recent years, several toxicological studies concerning pollutants have focused on the joint toxicological assessment of co-pollutants, revealing that multiple interactions between toxics can appear and need to be described. In the case of surfactants, while individual studies of them can provide valuable information, they may not reflect real-world exposure to multiple surfactants at once. Synergistic or antagonistic effects stem from the combined toxicity of surfactants, meaning that combined effects are greater or lower than the sum of the individual effects [1,2].

In this work, we study the joint toxicity effects of anionic and non-ionic surfactants to bacteria microcrustaceans *Daphnia magna*. The type of action (concentration addition or response addition) and the possible related antagonistic or synergistic toxic effects are described.

2. Materials and Methods

Surfactants: Anionic surfactant ether carboxylic derivatives (EC-$R_{12\text{-}14}E_3$, EC-$R_{12\text{-}14}E_{10}$, and EC-R_8E_8) and amine-oxide-based non-ionic surfactants (AO-R_{14}, AO-R_{12}, and AO-$_{Cocoamido}$) (supplied by Kao Corporation S.A., Tokyo, Japan) were used. Individual and binary mixtures (1:1) of the surfactants were tested. Toxicity tests: Toxicity was tested using microcrustaceans *D. magna* and according to the guideline UNE-EN ISO 6341 [3].

3. Results

The toxicity test of binary mixtures (1:1) reveals that concentration addition can be expected for mixtures of the most toxic surfactants from the same family (EC-EC-$R_{12\text{-}14}E_{10}$ + EC-$R_{12\text{-}14}E_3$, and AO-R_{14} + AO-R_{12}), whereas response addition can be expected for the mixture EC-EC-R_8E_8 + EC-$R_{12\text{-}14}E_3$. Antagonism effects, less toxic than the expected, were identified for mixtures including $AO_{\text{-}Cocoamido}$, but a synergism effect was identified for the mixture of EC-EC-$R_{12\text{-}14}E_3$ + AO-R_{14}.

4. Conclusions

- Antagonisms effects were identified for some mixtures of ether carboxylic derivatives and amine-oxide-based surfactants.
- Mixtures showing antagonism effects are preferred for the selection of surfactants in the formulation of more eco-friendly products.

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References

1. Ríos, F.; Lobato-Guarnido, I.; Fernández-Serrano, M. Antagonistic toxic effects of surfactants mixtures to bacteria Pseudomonas putida and marine microalgae Phaeodactylum tricornutum. *Toxics* **2023**, *11*, 344. [CrossRef] [PubMed]
2. Ríos, F.; Fernández-Arteaga, A.; Lechuga, M.; Fernández-Serrano, M. Ecotoxicological characterization of surfactants and mixtures of them. In *Toxicity and Biodegradation Testing*; Bidoia, E., Montagnolli, R., Eds.; Humana Press: New York, NY, USA, 2018.
3. *UNE-EN ISO 6341*; Water Quality—Determination of the Inhibition of the Mobility of Daphnia Magna Straus (Cladocera, Crustacea)—Acute Toxicity Test (ISO 6341:2012). Ente Nazionale Italiano di Unificazione (UNI): Milano, Italy, 2013.