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# TOXICITY MECHANISMS OF MIXTURES OF ANIONIC AND NON-IONIC SURFACTANTS

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## 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 can appear on the combined toxicity of surfactants, meaning that the combined effects are greater or lower than the sum of the individual effects [1].

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 antagonistic or synergistic toxic effects related are described.

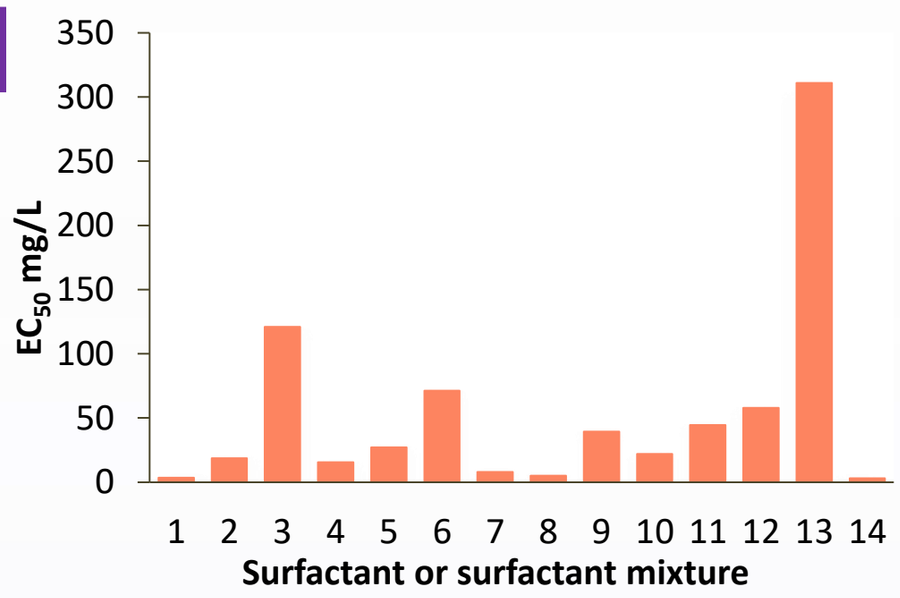
## MATERIALS & METHODS

- **Surfactants:** anionic surfactant ether carboxylic derivatives and amine-oxide-based non-ionic surfactants supplied by Kao Corporation S.A., Tokyo, Japan). 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 [2].

| n | Surfactant | Character | Chemical name |
|---|---|---|---|
| **1** | EC-$R_{12\text{-}14}E_3$ | Anionic | Laureth-4 carboxylic acid |
| **2** | EC-$R_{12\text{-}14}E_{10}$ | Anionic | Capryleth-9 carboxylic acid |
| **3** | EC-$R_8E_8$ | Anionic | Laureth-11 carboxylic acid |
| **4** | AO-$R_{14}$ | Non-ionic | Myristyl dimethyl amine oxide |
| **5** | AO-$R_{12}$ | Non-ionic | Lauryl dimethyl amine oxide |
| **6** | AOP-$_{Cocoamido}$ | Non-ionic | Cocoamidopropyl dimethyl amine oxide |

## RESULTS

| n | Mixture A + B | $TU_{mix}$ | $TU_r$ | Type of action |
|---|---|---|---|---|
| **7** | 1 + 3 | 1.19 | 1.03 | Response adition |
| **8** | 1 + 2 | 0.86 | 1.19 | Concentration addition |
| **9** | 2 + 3 | 1.21 | 1.15 | Antagonism (less than additive) |
| **10** | 4 + 5 | 1.12 | 1.57 | Concentration addition |
| **11** | 4 + 6 | 1.76 | 1.22 | Antagonism (less than additive) |
| **12** | 5 + 6 | 1.47 | 1.38 | Antagonism (less than additive) |
| **13** | 3 + 6 | 3.47 | 1.59 | Antagonism (less than additive) |
| **14** | 1 + 4 | 0.55 | 1.22 | Synergism (more than additive) |




- Simple additivity (concentration addition) is characterized by 0.8 < $Tu_{mix}$ < 1.2, while $Tu_{mix} \leq 0.8$ indicates synergism (more than additive) and $Tu_{mix} \geq 1.2$ represents antagonism (les tan additive) [1].
- $Tu_r \approx 1$, response addition can be expected [1].

**Model of Toxic Units**

$$TU_{mix} = TU_A + TU_B = \frac{[A]}{EC_{50A}} + \frac{[B]}{EC_{50B}}$$

$$\text{If } TU_A > TU_B \; TU_r = 1 + \frac{TU_B}{TU_A}$$

$$\text{If } < TU_B \; TU_r = 1 + \frac{TU_A}{TU_B}$$

## 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.

## REFERENCES

**[1]** Ríos, F., Lechuga, M., Lobato-Guarnido, I., Fernández-Serrano, M., 2023. Antagonistic toxic effects of surfactants mixtures to bacteria Pseudomonas putida and marine microalgae *Phaeodactylum tricornutum*. Toxics, 11 (344).

**[2]** UNE-EN ISO 6341, 2013 .Water quality –Determination of the inhibition of the mobility of *Daphnia magna Straus* (*Cladocera, Crustacea*)- Acute toxicity test (ISO6341:2012).