

Safe by design assessment of a multi-component nanomaterial as anti-pest in food packaging

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1. Introduction

Insect pests can infest each year as much as 40% of the world's crop yield, resulting in substantial resource losses. Plant diseases alone incur an economic toll exceeding \$220 billion annually on a global scale (FAO 2024). Addressing this challenge calls for innovative, eco-friendly solutions, as advocated by the European Green Deal. In this context, a safe and sustainable assessment of a multi-component nanomaterial (MCNM) (i.e., bentonite nanoclays encapsulating clove essential oil) embedded into a low-density polyethylene (LDPE) film food packaging as anti-pest was carried out. This work is part of the industry-oriented H2020 SUNSHINE project, which aims to create materials in accordance with the Safe-and-Sustainable-by-Design (SSbD) framework recently proposed by the European Commission (Caldeira et al., 2022).

2. Methodology

According to the SSbD framework, the first step concerned the material safety by merging information from the literature and from experimental work performed within SUNSHINE, on: i) physico-chemical characterization of both individual components and

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MCNM; ii) hazard characteristics of the precursors for the MCNM synthesis; iii) (eco)toxicological data. Afterwards, in line with step 2 of the SSbD framework, an industrial hygiene survey to identify potential hotspots of particles emissions from MCNM production, handling, processing or maintenance and cleaning phases was developed to then design a tailored monitoring campaign for occupational exposure assessment. Moreover, as indicated in the final application/use phase of step 3 of the SSbD framework and according to Regulation (EU) N°10/2011, the potential migration of the active ingredients and of the inorganic elements constituting the MCNM was investigated from both pristine LDPE films and those after accelerated aging.

3. Results

Physico-chemical characterization showed that the thermal stability of clove essential oil encapsulated into the nanoclays was significantly increased over time with respect to the clove oil alone. This improvement was also observed in both toxicological and ecotoxicological assays. Data revealed that the encapsulation of clove essential oil lowers the overall toxicity of eugenol (i.e., the main organic compound of the essential oil). With regards to the materials safety during production/processing phases, corresponding to step 2 of the SSbD framework, three different exposure scenarios (ES) were identified from the results of the survey: ES1) extrusion of micronized mixture; ES2) pellet drying; ES3) film production on a blower. A first workplace air-monitoring campaign to monitor the extrusion step showed the first ES as the one that needs most attention regarding to the nano-sized particles release. However, awareness should be also dedicated to the other two ES with respect to the release of micrometric-sized particles. A further campaign is underway for the scale-up of the process. As far as the investigation of the potential migration of chemicals/materials from both pristine and accelerated aged MCNM-nanobased LDPE film, did not raised concerns. In details, the overall data generated on the i) overall migration, ii) specific migration and iii) inorganic elements constituting the MCNM, never exceeded the thresholds established by the Regulation N°10/2011 on plastic materials and articles intended to come into contact with food and by its amendment n°1245/2020.

4. Conclusions

Following the first steps of the SSbD framework, a safety assessment of the MCNM embedded into an LDPE film for food packaging was performed. This approach showed its usefulness for gathering information and for highlighting potential issues at an early stage of the product development. The results from this safety assessment are going to be then integrated with the application of sustainability assessment methodologies to finally achieve the Green Deal ambitions of phasing out harmful substances from the EU market.

5. References

FAO, Food and Agriculture Organization of the United Nations, <https://www.fao.org/plant-production-protection/en>, visited on 28.03.2024.

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