Application of the SSbD framework to biocidal nanocoatings: gaps and steps towards its implementation

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1. Introduction

The Safe and Sustainable by Design (SSbD) Framework has the aim to facilitate the design and development of chemicals and materials to be safe and sustainable through research and innovation initiatives. The framework considers the intrinsic hazards of a chemical or material, environmental and human safety during production, use and disposal as well as environmental sustainability through life cycle assessments. The result of the assessments provides a score that indicates the level of SSbD [1]. The SSbD framework is currently in the development and testing phase, and presently, there are no specific approaches available for specific groups of chemicals or materials. In particular it is unclear how functional and societal benefits can be included within the SSbD Framework. Biocides, for instance, are being used for the protection of living organisms against infectious diseases. Nevertheless, their impact may extend beyond controlling the intended harmful organisms, potentially affecting humans and non-target organisms in the environment. Biocides are also being promoted to achieve several United Nations Sustainable Development Goals, however, it is so far not possible to consider this within the SSbD [2]. Thus, due to the dual nature of biocides—offering benefits and carrying negative effects caused by their nature as being toxic to target organisms— a specific SSbD approach considering their functionality is crucial for evaluating their safety and sustainability alongside societal benefits. Sudheshwar et al. (2023) also suggested SSbD should place greater emphasis on the material and chemical functionality and their practical advantages [3]. An approach therefore needs to be developed to incorporate the benefits derived from the use of biocidal products into the general SSbD framework.

2. Materials and Methods

First, the data and methodological challenges to apply the current SSbD framework to biocidal products was assessed considering hazard assessment, environmental and human safety during production, use and disposal as well as environmental life cycle assessment in this phase. Secondly, to examine the benefits of using biocides, we considered methodological approaches that can be integrated into the SSbD framework, along with a discussion. The overview of the study can be seen in Figure 1.

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Figure 1: Overview of the study

3. Results

Some of the gaps observed were based on data requirements. To give some examples from Step 1, for instance, certain hazard classes identified in SSbD Step 1 are not currently recognized as hazard classes under CLP, indicating a misalignment between the two classification systems. Not having clear classifications, along with missing data and difficulty in figuring out classifications, creates significant obstacles. Our analysis underscores the demand for a high level of expertise in both the assessment and conclusive determination of hazard classes. The study also emphasizes the need for a good understanding of data generation due to the complex information involved. Problems also arise in getting and assessing literature data because of a lack of tools and the complicated nature of the information. The prevalence of technical and lengthy reports further adds to the intricacies encountered in navigating these classification challenges. Our discussion also includes the possible methodological differences that can be followed in Step 2, and 3. The second important point is that, even though the benefits of biocides are considered in The Biocidal Products Regulation [4], the benefits for society are not yet considered in SSbD. This may not only be applicable to biocides but also to other chemicals/materials. Thus, the functionality of the assessed chemical/material plays an important role within the SSbD Framework. We developed several criteria to be considered within the SSbD framework to account for functionality and follow a holistic approach. While a more comprehensive approach is needed for the biocides that are already on the market, a more simplified approach is needed for the early design stage of biocidal coatings due to limitation of the data. As many data are required to complete an SSbD assessment, this is obviously not possible for the materials at an early state of innovation.

4. Conclusion

In summary, our investigation addresses data limitations, complexity, and various methodological approaches for Biocidal-Spesific SSbD Framework. Moreover, the oversight of societal benefits in SSbD has led us to develop criteria for a holistic approach through the integration of benefit assessment.

5. References

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