Abstract

[Project Information]

Project Title : Analysis of Biological Effect of Polymer Molecules and Their Degradation Products for Designing Biosafety Materials

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[Abstract]

Polymeric materials are utilized in various fields such as packaging, textiles, agricultural materials, and medical applications, making them indispensable in modern society. However, due to post-use and environmental aging, they break down or undergo physical fragmentation, becoming micro-particles (microplastics) that are widely present in the natural environment. These particles are exposed to ecosystems, particularly aquatic ones, and may have various biological impacts on flora and fauna.

This study aims to deepen the understanding of the biological toxicity of polymers and to establish reliable toxicity testing methods and material design guidelines. Experiments were conducted to elucidate the effects and mechanisms of chemical substances generated from the degradation of polymers, such as polycaprolactone (PCL), on *Daphnia magna*, an environmental indicator species. Furthermore, reliable toxicity testing methods for insoluble molecules were established, and an integrated model of toxicity mechanisms considering physical degradation, chemical degradation, and additive leaching was constructed based on the experimental results.

In toxicity tests using polystyrene microbeads of different sizes, simulating physical degradation, it was found that the particle size that is easily taken up by organisms changes depending on their developmental stage. Additionally, the shape of the particles was suggested to influence toxicity. In comparisons of the properties and toxicity of PCL polymers, oligomers, and monomers, simulating chemical degradation, it was found that polymers, being insoluble, accumulated in the digestive tract and exhibited toxicity, whereas soluble oligomers and monomers did not accumulate in the body and had lower toxicity. Furthermore, in the toxicity evaluation of the additive carbodiimide, gene

expression analysis indicated the induction of endoplasmic reticulum stress, suggesting that the high reactivity of carbodiimide cross-links proteins and imposes stress on cells.

These findings suggest the necessity of evaluating microplastic risks from multiple perspectives, including particle size, specific gravity, dispersion state, and the life history of organisms, rather than just the type of substance. Additionally, it was revealed that conventional standard toxicity tests do not capture all effects, and the results of this study are expected to contribute to the design of environmentally friendly polymer materials through the establishment of new toxicity indicators and testing methods.

[References]

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