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Comparison of Analytical Methods to Determine Phthalates Release from Macroplastic and Presence in Seawater

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Plastic pollution is a global issue of growing concern because of the large amount of waste ending up into terrestrial and aquatic ecosystems, primarily due to inefficient methods of end-of-life treatment. Biodegradable plastics, capable of being decomposed into harmless compounds by microorganisms, are promoted as an eco-friendly alternative to fossil-based polymers. However, environmental impact of these materials is a matter of intense debate, due to the limited knowledge of the release and decomposition of the chemicals they contain and how living species are affected by biodegradable plastic waste.

Since phthalates and other additives are generally not chemically bound to the polymers, a degradation experiment under natural environmental conditions was set up to evaluate the presence of phthalates and the release in natural seawater. Three biodegradable plastic films with similar weight and shape, made up of poly(lactic acid) and poly(butylene adipate-co-terephthalate) samples were immersed in marine water for 120 days, one exposed to heat and sunlight, the other one shielded from UV light.

The biobag samples were found to contain phthalic acid esters as additives, whether low molecular weight as dimethyl phthalate, diethyl phthalate, benzyl butyl phthalate and dibutyl phthalate, or high molecular weight including di-2-ethylhexyl phthalate and di-n-octyl phthalate. Phthalates are considered as hazardous endocrine disrupting compounds, able to induce toxic effects in humans and aquatic animals. Quantification of these chemicals in examined biobags was performed by means of HPLC-DAD and resulted in concentrations in the µg/g range across all samples.

Results of ^{1}H-NMR analysis of seawater samples after the degradation experiment showed that phthalates leaching occurred in one of the DARK samples; however, quantification through HPLC was not achieved due to the low concentration or modification of chemical structure of phthalate esters through photo- or thermal degradation. Diverse factors can affect phthalate structure in aquatic environments, such as hydrolysis, photolysis and biodegradation, therefore a comprehensive analysis of which degradation mechanisms are involved in biodegradable plastic decomposition is crucial to assess how and at which concentration additives and breakdown products can harm living species.