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Release of microplastics from a bio-based composite after ultraviolet irradiation

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The dependence on petroleum-based polymers such as polypropylene (PP) has led to a series of environmental issues, including the persistence of microplastic (MP), i.e. plastic particles smaller than 5 mm in diameter, in the global ocean. Polymers made from a natural-sourced feedstock, like polylactic acid (PLA), known as bio-based polymers, are seen as more sustainable alternatives to petroleum-based polymers. However, our knowledge remains limited about their degradation rates and fate in the marine environment. Studies have provided evidence of the release of MP from larger debris under ultraviolet (UV) radiation in laboratory conditions. However, quantitative evidence of MP formation, i.e. observation, identification and enumeration of MPs formed after UV radiation, is limited. Indeed, only a few studies have assessed the disintegration of bio-based polymers and their capacity to form MPs. As part of the Interreg 2 Seas Mers Zeeën project SeaBioComp (seabiocomp.eu), we aim to compare, quantify and characterise the MP formation of a newly developed bio-based composite (i.e. bio-based polymers integrated with synthetic or natural fibres) and a reference petroleum-based polymer during their degradation under UV radiation. To do so, we exposed 3D printed cylinders (1 x 1 x 1 cm) of self-reinforced PLA (SR-PLA) and PP respectively, immersed in natural seawater, to accelerated UV radiation for 1,368 h, simulating about 18 months of natural solar exposure in central Europe. Dark controls (i.e. in sealed vials from the UV) were incubated in the same conditions also for 1,368 h. To identify, characterise and quantify the formed MPs, we used a combination of fluorescent microscopy, infrared technology (μFT-IR) and image analysis. We observed 263 ± 285 PP MPs (> 50 μm) and 14 ± 9 SR-PLA MPs in UV-weathered samples, while 3 ± 4 PP MPs and 7 ± 3 SR-PLA MPs in dark control samples. 1,368 h UV exposure accelerated the MP formation of PP ($P < 0.05$, Kruskal-Wallis) but not SR-PLA ($P = 0.29$, Kruskal-Wallis), suggesting that the bio-based composite SR-PLA is more resistant to releasing MPs than the reference petroleum-based polymer. We anticipate that our results will contribute to assessing the sustainability of future bio-based polymers and composites applications and to supporting a transition process to more sustainable plastic materials.