Microplastic formation from a bio-based composite after ultraviolet irradiation

Niu Zhiyue[1], Catarino Ana Isabel[1], Le Gall Maelenn[2], Curto Marco[3], Demeyer Elke[4], Dhakal Hom[3], Davies Peter[2] and Everaert Gert[1]

[1] Flanders Marine Institute (VLIZ), Wandelaarkaai 7, 8400 Oostende, Belgium
E-mail: zhiyue.niu@vliz.be
[2] Marine Structures Laboratory, IFREMER, Centre de Bretagne, 29280, France
[3] Advanced Materials and Manufacturing Research Group, School of Engineering, University of Portsmouth, Portsmouth PO1 3DJ, United Kingdom
[4] Functional Thermoplastic Textiles, Centexbel, Industriepark Zwijnaarde 70, 9052 Gent, Belgium

Concerns have arisen about the environmental persistence and biological impacts of microplastic (MP, < 5 mm) in the global ocean. An important source of MP in the marine environment is originating from the degradation of petroleum-based polymers such as polypropylene (PP) induced by important weathering processes especially ultraviolet (UV) radiation. Polymers and composite materials made from a natural-sourced feedstock, like polylactic acid (PLA) known as bio-based polymers and composites, are seen as more sustainable alternatives to petroleum-based polymers because of their assumed lower environmental impacts. However, to date, few studies have focused on the microplastic formation from bio-based polymers and composites during their degradation in the marine environment. As part of the Interreg 2 Seas Mers Zeeën project SeaBioComp (seabiocomp.eu), we aimed to compare and quantify the MP formation of a newly developed bio-based composite and a reference petroleum-based polymer during artificial weathering 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 UV radiation simulating natural solar exposure of 18 months in central Europe. Dark controls (i.e. in sealed vials from the UV radiation) were incubated under the same conditions. To identify and characterise the formed MP particles (> 50 µm), we applied a combination of fluorescence microscopy, infrared technology (µFT-IR) and image analysis. We observed that 263 ± 285 PP MPs and 14 ± 9 SR-PLA MPs were formed in UV treated samples, while 3 ± 4 PP MPs and 7 ± 3 SR-PLA MPs were formed in dark control samples. As such, UV irradiation, equivalent to 18-month solar 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.

Keywords: Microplastic formation; Bio-based polymer; Ultraviolet; Plastic pollution; SeaBioComp