Identification of the reactive species involved in the photocatalytic degradation of PE microplastics

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Abstract

Microplastics (MPs, = 1 mm – 5 mm) are present in the ocean and cause health issues to the biota that consumes them. Recently, it was found that MPs are transferred throughout the tropic chain up to humans. Formerly, it was assumed that the ocean behaves as MPs' reservoir. Now, it is known that MPs are released back into the atmosphere, cycling through the earth like global biogeochemical cycles. Since all the MPs present in the ocean were first produced in upstream processes, reducing MPs inputs through management before their introduction to aquatic ecosystems is the best option to protect the ocean. Photocatalysis is a water treatment process that can be used to reduce MPs pollution. By photocatalysis, MPs can be transformed into CO2 and H2O. However, photocatalysis is a complex process that involves the generation of charge carriers ($h+$, e-) and oxygen reactive species, ROS (OH, O2–) that can be or not involved in the degradation mechanism. Thus, to increase the possibility of using photocatalysis for MPs pollution remediation purposes, the species involved in the degradation of MPs should be identified. In this research, we investigated the role of charge carriers and ROS in the photocatalytic degradation of polyethylene (PE) MPs using C,N-TiO2. Tert-butanol, isopropyl alcohol (IPA), Tiron, and Cu(NO3)2 were used as OH, $h+$, O2–, and $e–$ scavenger, providing information regarding their role in MPs removal. Our results revealed that forming free OH through the pathways involving the charge carrier $e–$ plays an essential role in PE degradation. Furthermore, the degradation behaviors observed when $h+$ and O2– were removed from the reaction system suggest that these species can also perform the initiating step of degradation. The information obtained here will allow setting the reaction conditions to maximize MPs removal from polluted water.

Keywords: microplastics, polyethylene, photocatalysis, charge carriers, ROS, TiO2, water treatment

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