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Dissolved Black Carbon Accelerates the Photo-Degradation of Polystyrene Microplastics

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Abstract : Microplastics (MPs) can undergo the photooxidation process under ultraviolet (UV) exposure, which determines their transformation and fate in environments. The presence of dissolved organic matter (DOM) can interact with MPs and take participate in the photo-degradation of MPs. As an important DOM component, dissolved black carbon (DBC), widely distributed in aquatic environments, can accelerate or inhibit the sunlight-driven photo-transformation of environmental pollutants. However, the role and underlying mechanism of DBC in the photooxidation of MPs are not clear. Herein, the DBC (< 0.45 μm) was extracted from wood biochar and fractionated by molecular weight (i.e., <3 KDa, 3 KDa−30 KDa, 30 KDa−0.45 μm). The effects of DBC chemical composition (i.e., molecular weight and chemical structure) in DBC-mediated photo-transformation of polystyrene (PS) MPs were investigated. The results showed that DBC initially inhibited the photo-degradation of MPs due to light shielding. Under UV exposure for 6−24 h, the presence of 5 mg/L DBC decreased the carbonyl index of MPs compared to the control. This inhibitory effect of DBC was found to decrease with increasing irradiation time. Notably, DBC initially decreased but then increased the hydroxyl index with aging time, suggesting that the role of DBC may shift from inhibition to acceleration. In terms of the different DBC fractions, the results showed that the smallest fraction of DBC (<3 KDa) significantly accelerated the photooxidation of PS MPs since it acted as reactive oxygen species (ROS) generators, especially in promoting the production of $^1O_2$ and ^{3}DBC* and •OH. With the increase in molecular weight, the acceleration effect of DBC on the degradation of MPs was decreased due to the increase of light shielding and possible decrease of photosensitization ability. This study thoroughly investigated the critical role of DBC chemical composition in the photooxidation process, which helps to assess the duration of aging and transformation of MPs during long-term weathering in natural waters.

Keywords : microplastics, photo-degradation, dissolved black carbon, molecular weight, photosensitization
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