

Mechanistic Investigation of Microplastic Generation Due to Surface Wear

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Plastic litter in the environment undergoes various degradation processes, including surface wear caused by mechanical forces. While most of the published literature focuses on the photodegradation and biodegradation of plastic materials, less attention has been given to the mechanical processes that result in the fragmentation of plastics. Thus, this study examines the generation of microplastics (MPs) from plastic litter subjected to surface wear in the environment. Specifically, the fragmentation of new high-density polyethylene (HDPE), low-density polyethylene (LDPE) pellets, and photodegraded LDPE pellets was investigated using a custom-designed dry sand-rubber wheel abrasion tester. The tests simulated the fragmentation of plastic litter caused by vehicle traffic on roadways, under varying surface abrasion conditions and vehicle speeds. The abundance and size distribution of resulting MPs were analyzed using micro Fourier Transform Infrared Spectroscopy. Results showed that higher surface abrasion (40 grit) produced a greater number of MPs from all tested plastics. A lower vehicle speed (25 mph) generated more MPs compared to a higher speed (70 mph). This difference is attributed to the longer contact time between the tire and the plastic surface at lower speeds, leading to increased surface abrasion. Moreover, to better understand how the microstructural properties of plastics and their environmental weathering influence their potential to release MPs, the surface wear resistance of various new and weathered plastic materials including HDPE, LDPE, styrene-butadiene rubber (SBR), and polystyrene (PS) sheets was evaluated using an Erichsen abrasion tester. The surface wear resistance of new plastics was ranked in the following order: LDPE, HDPE > PS > SBR. Photodegradation significantly reduced the wear resistance of LDPE and PS, although its influence on HDPE and SBR was minimal. Additionally, a scratch test was conducted to assess the materials' resistance to surface damage under controlled loads. The test was performed using a linear tribometer with a normal force of 15 N, and scratch characteristics were analyzed through profilometry analysis. This is an ongoing study and data analysis and interpretation are expected to be completed by the end of April. This study provided fundamental insights about MP generation from plastic litter due to surface wear.