Goldschmidt 2026 Abstract
https://doi.org/10.46427/gold2026.38110

From Bulk Plastics to Nanoplastics: Photochemical Degradation of Conventional and Biodegradable Plastic Mulch Films

SHAMSUNNAHAR SUCHANA, ELSA BAXTER, JINGYUN ZHENG, MANON KELLER, PEDRO MENA-GIRALDO, STEPHANE BAYEN AND NATHALIE TUFENKJI

McGill University

The widespread use of polyethylene mulch films in agriculture has contributed to increasing plastic accumulation in crop soils. Biodegradable mulch films are promoted as sustainable alternatives; however, both conventional and biodegradable polymers undergo environmental weathering that transforms bulk plastics into smaller particles and dissolved organic chemicals. Although biodegradable materials are designed to mineralize, soil environments often limit oxygen availability, light penetration, and moisture, potentially leading to incomplete degradation and the formation of macroplastics (>5 mm), microplastics (5 mm-1 μm), nanoplastics (<1 μm), and soluble intermediates such as oligomers and monomers. While photodegradation-driven changes in bulk polymer properties are relatively well understood, the formation and fate of nanoplastics and soluble intermediates from biodegradable polymers remain poorly constrained. Here, we investigated the photochemical degradation of conventional polyethylene (PE) and biodegradable poly(butylene adipate-co-terephthalate) (PBAT) mulch films under simulated solar irradiation equivalent to approximately 4.5 months of summer exposure in Montreal, Canada. Optical photothermal infrared (O-PTIR) microspectroscopy, pyrolysis-gas chromatography-mass spectrometry (Py-GC/MS), and high-resolution liquid chromatography-mass spectrometry (LC-HRMS) were used to characterize polymer transformation, evaluate chemical modification of released particles, and quantify nanoplastics and soluble degradation intermediates. Photodegradation produced clear oxidative changes in surface chemistry and functional groups for both mulch types. Conventional PE films generated nanoplastics that accumulated progressively, whereas PBAT-derived nanoplastics underwent continued hydrolysis and photolysis, indicating secondary transformation pathways that likely promote conversion into soluble intermediates. Non-targeted chemical analysis showed evolving chemical features in PBAT over time, whereas PE degradation products showed comparatively limited temporal variability. Additionally, increasing amounts of soluble PBAT-derived monomers were quantified during degradation. These contrasting behaviors suggest different degradation mechanisms between conventional and biodegradable polymers. Overall, this study provides nanoscale and molecular-level insight into the weathering of agricultural plastics, demonstrating that polymer composition governs the partitioning of degradation products between particulate and dissolved phases and thereby influences the environmental fate and persistence of agricultural plastics.