Monitoring the Breakdown of Plastic Materials Under Ultraviolet and Visible Light

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The accumulation of plastic waste in landfills and especially in water systems is a pressing environmental concern. Every year, roughly 8 million tons of plastic waste escapes into the oceans, which over time can then break down into microplastics, less than a quarter inch in size, that are consumed by ocean wildlife. The plastic degradation can occur by mechanical means, but energy absorbed from sunlight is also involved in the breakdown of plastic materials. If the efficiency of this degradation was increased, solar energy could be used to eliminate plastic waste and regenerate fuels or chemical feedstocks.

In this study, films of four commonly used polymer materials (high-density polyethylene, linear low-density polyethylene, polypropylene, and polystyrene) were exposed to UV and visible light radiation to study how light can be used to degrade plastics. During exposure times of 2 – 3 weeks, the samples were periodically monitored by infrared (IR) spectroscopy to obtain information on structural changes occurring within the polymers. The IR spectra showed the growth of a new IR vibration from carbon-oxygen double bonds, indicating that bonds in the polymer material were breaking and then reacting with molecular oxygen or water in the air. The vibrational band became more intense with continued irradiation as well as when left in the dark. Raman spectroscopy has also been utilized to better understand the pathway of photo-degradation. Overall, the results were much more dramatic when using high-energy UV light compared to visible light.

Additional studies are underway to synthesize a solid-state photocatalyst that is better able to absorb visible light. A system currently under investigation is an iron-doped zinc oxide nanoparticle supported on a layered silicate clay. The nanoparticles were synthesized sono-chemically and characterized by scanning electron microscopy. Preliminary studies will incorporate the hybrid material into a polymer film and determine if the rate of degradation under visible light irradiation is enhanced. In future work, filters would be created out of the clay material with the aim of removing microplastic pollution from water samples and then using visible light for photo-degradation of the plastics. Ultimately, this would allow solar energy to be used to reduce or recycle plastic waste.