Optimizing Microplastic Analysis through Comparative FTIR and Raman Spectroscopy: Addressing Challenges in Environmental Degradation Studies

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Abstract

Polymer degradation presents numerous challenges in the analysis of microplastics, particularly when examining environmental samples. This degradation process includes several mechanisms such as photo-oxidation, which is driven by sunlight exposure; mechanical fragmentation caused by physical stresses; and biological degradation through the action of microorganisms. These processes result in a diverse array of degradation products. Moreover, the rate and extent of polymer degradation vary significantly with environmental conditions and interactions with other environmental factors. These complexities are compounded by technical barriers in the analytical processes and a pressing need for a deeper understanding of various degradation methods.
In our study to expand the Fourier-Transform Infrared (FTIR) spectroscopy database, we systematically collected and analyzed larger particles visually identified as plastics. Utilizing a Bruker Tensor 27 FTIR equipped with an Attenuated Total Reflection (ATR) module, we recorded spectra within the range of 400-4000 cm-1. Samples with spectra that did not match those in the existing database were earmarked for further analysis using Raman spectroscopy with a Reinshaw inVia Raman microscope, equipped with a 633 nm laser. The Raman spectra were captured at 50X magnification, incorporating 5 - 10 accumulations at a 5% laser power setting.

The study addresses the challenge of classifying plastic particles using Fourier-Transform Infrared (FTIR) spectroscopy, particularly those that FTIR could not definitively classify due to potential degradation. By employing Raman spectroscopy for these ambiguous samples, we successfully identified them as polyethylene (PE), polyethylene terephthalate (PET), and polyvinyl chloride (PVC). This comparative analytical approach not only enriched the FTIR database but also significantly enhanced the precision of data interpretation, especially for samples sourced from environmental contexts.
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