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Development of a Multi-Modal Spectroscopic Approach for Characterizing Inhalable Airborne Microplastics

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Despite extensive research on microplastics (MPs), the physicochemical characteristics of airborne MPs (AMPs), particularly in the inhalable size fraction (<10 μm), remain poorly understood. This knowledge gap is primarily due to the lack of analytical techniques capable of effectively identifying and characterizing AMPs within the vast number of atmospheric aerosol particles.

To address these challenges, this study developed a novel single-particle analytical approach for characterizing inhalable AMPs. The method integrates fluorescence microscopy, Raman microspectrometry (RMS), optical photothermal Fourier transform infrared (O-PTIR) spectroscopy, and scanning electron microscopy with energy-dispersive X-ray spectrometry (SEM/EDX). Fluorescence microscopy enables efficient screening of potential AMP particles among atmospheric aerosols. RMS and O-PTIR, as complementary vibrational spectroscopic techniques, provide detailed insights into chemical functional groups, molecular composition, and the mixing state of AMPs in the 1–10 μm size range. SEM/EDX further reveals morphological characteristics and elemental compositions at the single-particle level. The combined use of these techniques overcomes individual analytical limitations, enabling a comprehensive physicochemical characterization of inhalable AMPs.

Results indicate the presence of thousands of AMPs per cubic meter in the ambient air. Furthermore, significant differences in chemical functional groups between standard plastic references and aged AMPs highlight the impact of environmental aging on MP physicochemical properties. These findings provide critical insights into the nature of inhalable AMPs in ambient aerosols, with important implications for both human health and climate change.