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From Nanoparticles to Microplastics: Single-Particle ICP-MS for Particulate Pollutants

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The increasing use of engineered nanomaterials in consumer products and industrial processes, combined with the continuous fragmentation and weathering of plastic debris into micro- and nanoplastics, is contributing to a growing spectrum of anthropogenic particulate pollutants across environmental compartments. These particles span a wide range of sizes, compositions, and sources, and are present at low concentrations in complex matrices containing a mix of natural and anthropogenic particles. Understanding their fate and impact requires analytical approaches capable of characterizing particles as discrete entities, as opposed to bulk measurements.

Single-particle inductively coupled plasma mass spectrometry (sp-ICP-MS) has emerged as a powerful technique for the detection and characterization of inorganic nanoparticles, providing quantitative information on particle size, number concentration, and elemental mass. A major development in this field is the introduction of inductively coupled plasma time-of-flight mass spectrometry (ICP-TOFMS). By enabling simultaneous acquisition of the full mass spectrum for each particle, ICP-TOFMS provides multi-element fingerprints, representing a game changer in single-particle analysis. This capability allows differentiation between engineered and natural nanoparticles, identification of particle populations, and improved source attribution. It further enables the tracking of particulate pollutants across environmental systems, from combustion-derived particles in the atmosphere, to engineered TiO_2 nanoparticles in aquatic environments, and CeO_2 particles accumulating in soils, as well as the investigation of particle–cell interactions at the single-cell level.

Emerging challenges such as micro- and nanoplastics further push the boundaries of the technique. Strategies based on multi-element fingerprints, targeting metal additives used in plastic production, and particle labelling offer promising pathways for their detection and tracking.

By combining advances in instrumentation, data analysis, and interdisciplinary applications, sp-ICP-MS is evolving from a niche technique into a key tool for understanding particulate pollutants across environmental and biological systems.

[1] M. Resano, F. Vanhaecke et al., Chem. Sci., 2022, 13, 4436.
[2] A. Goodman et al., Environ. Sci.: Nano, 2025, 12, 1789