FlashNote

Spatial Localization of Microplastics Resultant Tissue Responses with MALDI TIMS Imaging

MALDI TIMS Imaging enables label-free detection of low-abundance microplastics in whole-body tissue sections while simultaneously revealing localized molecular responses to environmental exposure.

Why it matters

Microplastics are emerging environmental contaminants that have been detected in food, water, and biological systems. Understanding where these particles accumulate and how tissues respond to exposure remains a significant analytical challenge. Conventional techniques such as fluorescence microscopy, Raman spectroscopy, or pyrolysis-based methods either require labeling, provide limited molecular information, or lack spatial context.

MALDI Mass Spectrometry Imaging offers a label-free alternative by directly analyzing molecules within tissue sections. However, the detection of low-abundance exogenous compounds remains challenging due to spectral complexity and interference from endogenous biomolecules. In this study, trapped ion mobility spectrometry (TIMS) was integrated with MALDI Imaging to improve molecular specificity and enable confident localization of polystyrene microplastics within whole-body mouse tissue sections.

Outcome

Using MALDI TIMS Imaging on a timsTOF fleX platform and SCiLS™ Lab software, researchers of the University of California, Davis, US successfully detected and localized orally administered polystyrene (PS) microplastics throughout whole-body murine tissue sections without chemical labeling or sample modification. TIMS added an additional dimension of separation that distinguished microplastic-derived ions from the complex biological background and significantly improved confidence in analyte assignment.

Comparison of TIMS-enabled and TIMS-disabled acquisitions revealed that ion mobility separation was essential for resolving PS-related signals and visualizing their spatial distribution across organs including the stomach, liver, heart, and intestines. Without TIMS, microplastic-associated signals appeared diffuse and difficult to interpret.

Beyond localization, MALDI TIMS Imaging enabled simultaneous investigation of organ-specific molecular responses. Regions exhibiting microplastic accumulation also showed distinct lipid remodeling patterns, linking environmental exposure to localized biological effects within a single experiment. The study demonstrates how MALDI TIMS Imaging can support emerging fields such as spatial toxicology, environmental health research, and the investigation of other low-abundance exogenous compounds.

For more details, see the original publication by Vargas *et al.*

Key Highlights

- **Label-free microplastic detection**: Spatial localization of polystyrene microplastics directly in whole-body tissue sections without fluorescent tags, extraction, or pyrolysis.
- **TIMS-enhanced specificity**: Ion mobility separation distinguishes microplastic-derived ions from endogenous tissue signals and improves confidence in molecular assignment.
- **Whole-body visualization**: Simultaneous mapping of microplastic accumulation across multiple organs within a single tissue section.
- **Exposure and response in one workflow**: Correlates microplastic localization with tissue-specific lipid remodeling and molecular changes.
- **Broad applicability**: Extensible to other low-abundance exogenous compounds, including environmental contaminants, nanoparticles, and drug metabolites.

References

Vargas KA, Parkhurst AL, Hsu M-F, Hou C, Haj FG, Neumann EK (2026). *Spatial Detection of Microsphere Polystyrene Plastics and Molecular Remodeling within a Full-Body Mouse with MALDI Trapped Ion Mobility Mass Spectrometry Imaging*. Angew. Chem. Int. Ed. **65**, e6528604. https://doi.org/10.1002/anie.6528604

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"TIMS provided the molecular specificity needed to confidently distinguish microplastic-derived signals from complex biological background, allowing us to visualize both exposure and tissue response within the same experiment."

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