Detection of Microplastics and Nanoplastics in Blood-Relevant Matrices for Scalable Routine Testing

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1. Blood as a Clinically Relevant Matrix for MNP Assessment

Microplastics and nanoplastics (MNPs) have been detected in human blood and other tissues, raising concerns about systemic exposure and potential health effects. Blood represents a clinically relevant matrix for evaluating systemic exposure, as circulating particles may interact with immune, vascular, and neurological systems. Despite this importance, no widely deployable method currently exists for scalable, routine measurement of MNP burden in blood.

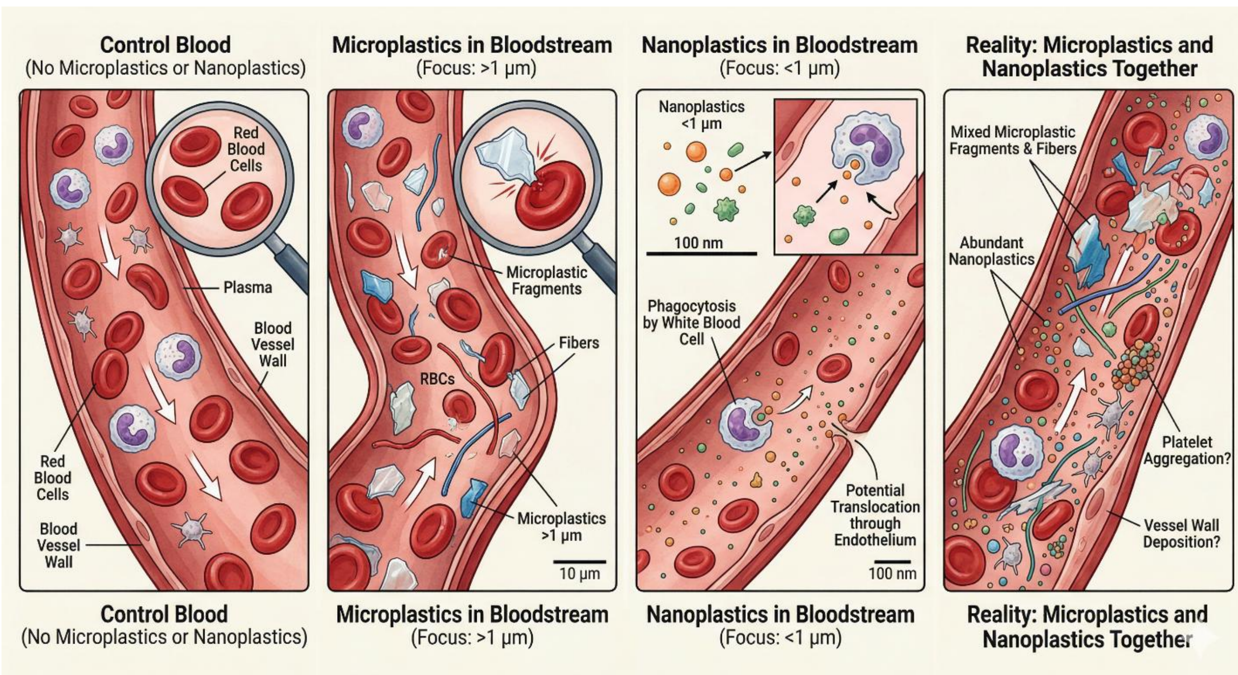

Figure 1. Conceptual representation of microplastic and nanoplastic behavior in blood-relevant environments.
Control blood (left) demonstrates baseline cellular and plasma structure. Microplastics (>1 µm) are typically present as irregular fragments and fibers, interacting with circulating components. Nanoplastics (<1 µm) exhibit distinct behavior, including higher dispersion, potential cellular interactions, and increased surface-area–driven activity. In real-world conditions (right), microplastics and nanoplastics coexist, forming heterogeneous systems with mixed particle types, spatial distributions, and potential interactions with vascular and immune components. This schematic highlights the complexity of particle behavior in biological matrices and the importance of detection approaches that capture heterogeneous, non-uniform particulate systems.

2. Evidence of Microplastics and Nanoplastics in Human Blood

Key human studies have established the presence of MNPs in blood:

- Leslie et al. (2022) provided the first quantitative evidence using pyrolysis-GC/MS, detecting polymers (PET, PS, PE, PMMA) at a mean concentration of ~1.6 µg/mL in 77% of samples from 22 healthy volunteers.
- Brits et al. (2024) quantified micro- and nanoplastics in 68 anonymized blood samples via pyrolysis-GC/MS, reporting quantifiable levels in 25% of samples (mean ~1.07 µg/mL).
- Lee et al. (2024) used imaging/spectroscopy to detect MPs in 88.9% of 36 healthy adults (mean 4.2 particles/mL), with higher levels associated with plastic food container use and altered coagulation markers.
- Yang et al. (2023) identified 9 polymer types (up to 184 µm) in blood from cardiac surgery patients, with changes observed pre- vs. post-surgery.
- Marfella et al. (2024) and Zhang et al. (2025) linked higher MNP burdens in blood and plaques to increased cardiovascular risk and major adverse cardiac events.

These studies confirm systemic circulation of MNPs but rely on destructive, low-throughput methods ill-suited for routine or longitudinal testing.

3. Limitations of Current Approaches

Current methods (Raman, µFTIR, pyrolysis-GC/MS) are time-intensive, equipment-heavy, and often destructive or contamination-prone, limiting scalability for blood matrices. A non-destructive, image-based framework that captures emergent optical patterns offers a promising alternative for higher-throughput analysis.

4. Preliminary Findings in Simulated Blood Matrices

In this report, simulated blood matrices were evaluated across microplastic and nanoplastic conditions using standardized optical imaging and computational analysis. Samples were prepared under controlled conditions and assessed at defined timepoints using a non-destructive imaging workflow.

Across conditions, samples appeared visually similar to the naked eye. However, reproducible differences in optical structure were observed, including variations in spatial heterogeneity, aggregation behavior, and temporal evolution. These differences were consistent with particle-associated interactions within the matrix rather than uniform background effects. Notably, nanoplastic conditions demonstrated earlier and more pronounced spatial organization compared to microplastic conditions at comparable low concentrations, supporting a surface-area–dependent interaction mechanism.

Computational analysis focuses on emergent optical patterns rather than direct particle counting, enabling detection of both microplastic and nanoplastic-associated signals in intact liquid samples. This approach avoids destructive processing steps and is compatible with scalable workflows.

5. Toward Scalable Blood-Based Monitoring

These results demonstrate the feasibility of detecting microplastics and nanoplastics in blood-relevant matrices using a non-destructive, image-based framework. The ability to generate reproducible signals supports future development of scalable approaches for assessing systemic exposure and enables potential integration into routine monitoring, longitudinal studies, and clinical research. Such platforms could complement urine-based methods and provide a comprehensive picture of MNP exposure dynamics.

References

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