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High-Throughput Microplastic Detection and Identification Using Integrated Darkfield Imaging and Raman Spectroscopy

Stanford scientists have developed a two-step microscopy and spectroscopy platform that detects and chemically identifies microplastics and other small contaminants in biological tissue and liquid samples far faster than existing methods, cutting sample processing from hours to minutes.

Microplastic contamination of human tissue, blood, saliva, and drinking water is an emerging public health concern, yet current analytical tools are too slow or too expensive for routine use at scale. Standard Raman spectroscopy, the gold standard for chemically identifying polymer particles, requires scanning every point of a sample one at a time, and advanced alternatives rely on costly specialized hardware that limits broad adoption. Researchers at Stanford addressed this bottleneck by pairing two complementary techniques in a single workflow. The system first uses darkfield microscopy, a low-cost imaging method, to rapidly scan a tissue slice or liquid sample and automatically pinpoint the locations of candidate contaminant particles using computer vision. A confocal Raman microscope then collects spectra only at those identified locations, delivering chemical identification of each particle against standard polymer databases without the need to scan the full sample. The result is a platform that can analyze cubic-centimeter tissue volumes at one-micrometer precision at throughputs orders of magnitude higher than conventional Raman workflows, using standard sample preparation and existing laser hardware. By combining commodity darkfield optics with existing confocal Raman instruments under a unified software layer, this technology offers microscopy manufacturers, Raman instrument vendors, and biomedical and environmental testing labs a cost-effective path to turnkey microplastic analysis workflows that make large-scale

biospecimen and water-monitoring studies practical for the first time.

Stage of Development
Proof of Concept

Applications

- Rapid microplastic and nanoplastic detection in human tissue, blood, and saliva
- Biomedical research on plastic exposure and bioaccumulation
- Water quality and environmental contamination monitoring
- Pharmaceutical, food, and beverage quality control
- Forensic and consumer product safety testing

Advantages

- Reduces sample processing from hours to minutes
- Analyzes cubic-centimeter tissue volumes at micrometer precision
- Significantly lower cost than competing methods (OPTIR, CARS, SRS)
- Uses standard sample preparation on quartz or gold substrates
- Compatible with any Raman laser wavelength
- Modular design that can be retrofitted onto existing microscopy and Raman systems
- Works with established polymer and contaminant spectral databases
- Scalable to continuous liquid-flow configurations for water monitoring

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