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Microplastics and Nanoplastics in Drinking Water: Quantification and Polymer Identification

The analysis of microplastics and nanoplastics presents an emerging challenge for human health and environmental safety because of their dimensional, chemical, and morphological heterogeneity. Recent European legislation, including Regulation (EU) 2023/2055 and Directive (EU) 2020/2184, underscores the urgent need for reliable analytical methods to detect and characterise these contaminants.

Assessing the occurrence of microplastics and nanoplastics in real drinking-water samples is essential for estimating human exposure through water consumption. This work presents a method for quantifying microplastics in drinking water according to ISO 16094, together with a novel method for identifying and quantifying nanoplastics. The proposed approach combines dielectrophoresis (DEP) with Raman spectroscopy to concentrate and analyse nanoplastics without complex sample preparation. DEP uses non-uniform electric fields to trap and concentrate polymer particles, with electrode geometry playing a key role in trapping efficiency. Raman spectroscopy subsequently enables the chemical identification and quantitative analysis of the concentrated particles, as well as the investigation of surface modifications, such as oxidation, and other nanoscale effects. Dielectrophoretic preconcentration addresses the principal analytical challenge of obtaining sufficiently intense Raman spectra at low nanoplastic concentrations.

The method comprises four main stages: preparation of nanoplastic dispersions in deionised water at different concentrations; particle confinement in a DEP cell equipped with quadrupole electrodes; Raman spectroscopic analysis of the trapped particles; and application of the method to a real drinking-water sample. Certified polystyrene nanospheres ranging from 60 nm to 800 nm and polydisperse nanoplastics representative of environmental samples were analysed. The approach enabled the rapid identification of particles with different sizes and polymer compositions while revealing surface phenomena associated with decreasing particle size.

The geometry and characteristics of the electrodes were optimised through numerical simulations to improve preconcentration efficiency. The optimised configuration was subsequently implemented and used to determine the method's limits of detection and quantification. For certified 200 nm polystyrene nanoparticles, the limit of detection was 0.44 µg/mL and the limit of quantification was 1.33 µg/mL.

These results demonstrate that the combined Raman–DEP approach is suitable for the physicochemical characterisation of nanoplastics in aqueous samples.

References

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