Sensors for Polystyrene Nanoplastics Detection in Water Samples

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ABSTRACT

Polystyrene nanoplastics (PS-NPs) are increasingly discovered in aquatic ecosystems, posing ecological and human health problems. Identifying PS-NPs in complex environmental matrices remains difficult due to their small dimension, chemical passiveness, and existence of background interferences. Recent improvements in sensor and biosensor technologies have shown promise for improving the sensitivity, selectivity and portability of PS-NPs detection systems. However, maintaining high detection accuracy while minimizing false signals and matrix interferences remains a significant challenge. Limited selectivity, sensor fouling, and a lack of standardization across detection platforms add to the complexity of analysis. To improve recognition performance, several ways have been investigated, including surface functionalization, nanomaterial immobilization and substrate modification. These strategies seek to overcome limitations in sensitivity, repeatability, and environmental applicability. As a result, more advanced sensor platforms capable of detecting low concentrations in real time are urgently needed. This study highlights recent research on sensor and biosensor technologies used to detect PS-NPs, with a focus on the integration of nanomaterials and molecular recognition elements. Literature from Science Direct and IEEE Xplore indexed journals until June 2025 was reviewed. The findings indicate that hybrid sensor systems, particularly those employing plasmonic nanoparticles and functionalized nanostructures, are at the forefront of PS-NPs detection research. To find novel sensing methodologies, this review examines current technologies and compares their merits using recent case studies and performance analysis.

Keywords: *Sensor, Biosensor, Polystyrene, Nanoplastics*