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Probing Nanoparticle-Driven Sample Preparation Strategies: Unlocking Ultra-Sensitive Bioanalytical Detection

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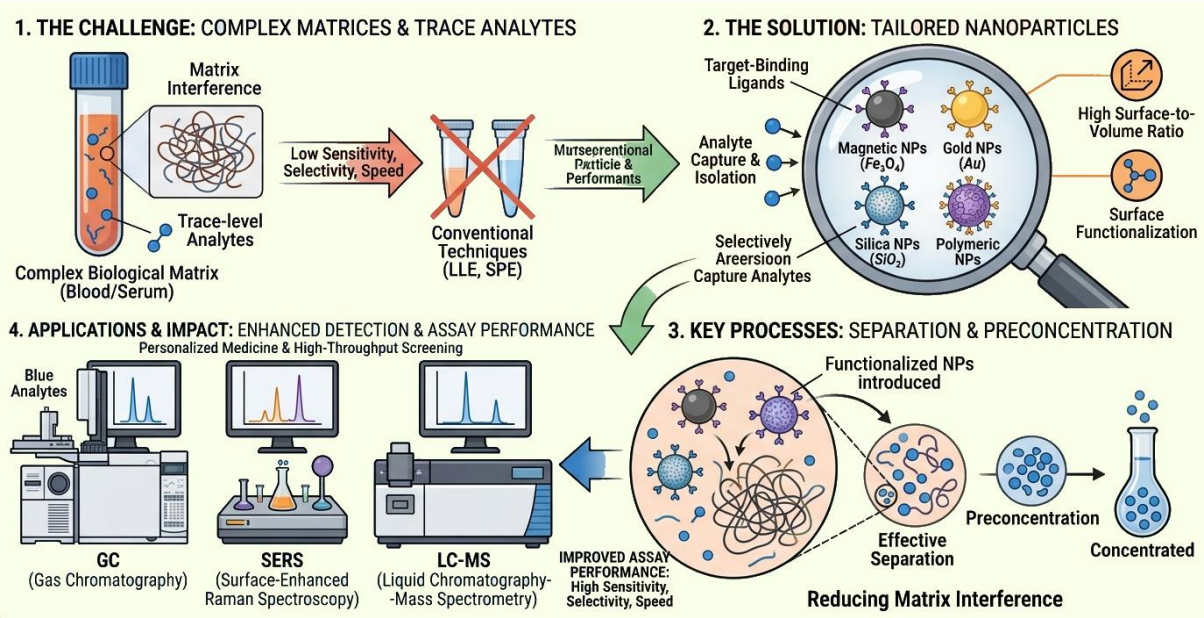
GRAPHICAL ABSTRACT



Abstract

The development of bioanalytical research now depends heavily on nanoparticles, especially when it comes to improving sample preparation techniques. The sensitivity, selectivity, and speed of conventional techniques like liquid-liquid extraction and solid-phase extraction are frequently lacking,

particularly when examining trace-level analytes in intricate biological matrices. A solution is provided by nanoparticle-based methods, which enhance analyte capture and isolation by utilizing special physicochemical characteristics such as high surface-to-volume ratios and surface functionalization capabilities. Gold, magnetic, silica, and polymeric nanoparticles are among the many varieties that have demonstrated great promise in a variety of analytical systems. While reducing matrix interference, these tailored nanoparticles enable effective target molecule separation, preconcentration, and detection. The ability to adapt is further demonstrated by their interoperability with cutting-edge instruments like GC, SERS, and LC-MS. With the expansion of high-throughput screening and customized medicine, bioanalytical needs are only increasing. Nanoparticle-based methods provide a reliable, scalable, and creative means to improve assay performance. In order to demonstrate the exciting potential of nanoparticles in preparation of samples for enhanced bioanalytical sensitivity, this review summarizes recent developments, real-world applications, and prospective viewpoints in the field.

Keywords: Nanoparticles, Bioanalytical Sensitivity, Magnetic Solid-Phase Extraction, Nanoparticle-based sample preparation techniques

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