Fabrication of Nanomaterial Embedded Molecularly Imprinted Polymer-Based Sensors and its Electrochemical Applications

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Molecular imprinting technology is a creative method that enables synthetic biorecognition gaps to imitate real biological derivatives like antibodies, receptors, enzymes, etc. After removing the target analyte, synthetic cavities enable the recognition and selective rebinding of the template. In this case, molecular imprinting technology offers biosimilar receptors with higher specific affinities and better stability than natural receptors and biomolecules [1]. Although stable and durable MIPs seem relatively easy to create to achieve maximum efficiency, some optimization parameters should be considered, such as appropriate functional monomer and crosslinker [2]. The optimization process can vary based on the polymerization technique. In addition, the structure of the polymeric matrices and the type of bond contact between the template and the polymer are two important factors in MIPs. It was reported that template monomer interactions are realized through non-covalent interactions such as van der Waals forces, hydrogen bonds, and dipolar interactions [1, 2]. Among them, MIP-based electrochemical sensors have a significant place because, with MIPs, it is possible to overcome the lack of selectivity issue in electrochemical sensors.

Nanomaterials, famous for their prominent electron transfer capacity and specific surface area, are increasingly employed in modifications of MIP sensors. Unlike traditional electrochemical sensors, nanomaterials-based MIP sensors have excellent sensing and recognition capabilities. MIP is an appropriate substrate for electrochemical sensors owing to its binding sites, which match the target analytes' functional groups and spatial structure. However, the irregular shapes and slow electron transfer rate of MIP limit the sensitivity and conductivity of electrochemical sensors.

Nanomaterial-based MIP sensors and miniature electrochemical transducers have proven their practicality by successfully detecting target analytes in situ. Their superior chemical and physical stability, low-cost manufacturing, high selectivity, and fast response have made nanomaterial-based MIPs an exciting field of research. The studies on electrochemical nanomaterial-based MIP sensors to identify pharmaceuticals, heavy metals, hormones, enzymes, and biomarkers have shown promising results. These sensors have been successfully used in biological fluids (serum and urine samples) and pharmaceutical samples, demonstrating their real-world applicability.

MIP-based electrochemical sensors and miniature electrochemical transducers can detect target analytes in situ. Thanks to superior chemical and physical stability, low-cost manufacturing, high selectivity, and fast response, MIPs have recently become an interesting field. The increase in environmental awareness and stricter regulation for the use of chemicals and economic competitiveness are challenging the scientific community and industry to explore greener strategies in their processes, preventing pollution and reducing waste while maximizing the efficiency of the processes, and that can only be achieved by the application of the green chemistry and engineering principles. Molecular imprinting has much to gain in applying these green tools since new alternative solvents and clean technologies, combined with computational tools, can optimize both the polymer and the process.

References

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