Molecularly imprinted polymer-based electrochemical sensor for detecting low molecular weight compounds

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Molecularly imprinted polymers (MIPs) are synthetic materials formed through polymerisation in the presence of a template molecule. They are designed to contain specific binding sites that match the shape, size, and functional groups of that molecule. Often described as 'plastic antibodies', MIPs can replicate the molecular recognition abilities of natural antibodies, offering both high selectivity and affinity [1]. Unlike biological receptors, MIPs are more stable, resistant to harsh environmental conditions, and less expensive to produce. Given these advantages, these polymers can be utilised for detecting low-molecular-weight compounds, such as food contaminants, drugs, and environmental pollutants [2, 3]. MIP preparation typically involves (i) self-assembly of functional monomers with the template molecule in solution, (ii) chemical or electrochemical polymerisation forming a rigid polymer network, and (iii) template removal to create selective binding cavities [3].

In this study, electrochemical sensors based on polypyrrole-based molecularly imprinted polymers (MIPs) were developed for the selective detection of low-molecular-weight compounds, including L-tryptophan [2], melamine [3], and salicylic acid. The MIPs were prepared by electropolymerizing a pre-polymeric solution containing pyrrole as the functional monomer and the target template molecules. The polymer layers were deposited directly onto the surfaces of graphite electrodes and screen-printed carbon electrodes using an amperometric method. Following polymerisation, the template molecules were removed through an extraction procedure, leaving behind specific binding sites within the polymer matrix. As a control, non-imprinted polymer (NIP) electrodes were prepared under the same conditions, but without the addition of the template.

The properties of all polypyrrole films were evaluated using cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS). The interactions between the template molecules and the polymer layers were assessed by comparing the oxidation peak currents obtained through differential pulse voltammetry (DPV). The results, along with the calculated apparent imprinting factors, demonstrate that the designed MIPs are suitable for developing electrochemical sensors for the detection of low-molecular-weight molecules.

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References

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