MOF-derived carbon material modified electrodes for electrochemical detection of heavy metals and glucose

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Abstract

The development of advanced materials for electrochemical sensing has become a key research topic in addressing environmental and health-related challenges. Among the emerging materials for sensing applications, Metal-Organic Frameworks (MOFs), a class of hybrid crystalline materials characterized by high surface area, well-defined porosity, and tunable chemical functionality, are very promising candidates. The peculiar structural properties make MOFs attractive for the detection of a wide range of analytes, due to their ability to interact selectively with target species. Nevertheless, their poor intrinsic conductivity limits their direct application in electrochemical devices. To overcome this issue, MOFs can be thermally converted into conductive carbon-based materials through pyrolysis. This transformation preserves the hierarchical architecture and porosity of the original frameworks while enhancing electrical conductivity and stability.

In this work, MOF-derived carbon-based materials obtained from two different precursors, ZIF8 and MIL101(Fe), were synthesized and used to modify glassy carbon electrodes (GCEs) by a straightforward drop-casting method. Electrochemical characterization by Cyclic Voltammetry (CV) and Electrochemical Impedance Spectroscopy (EIS) confirmed an enhancement in electron transfer properties of GCEs after modification. The ZIF8-derived carbon material was employed for the electrochemical detection of heavy metal ions such as cadmium (Cd^{2+}) and lead (Pb^{2+}) using Differential Pulse Anodic Stripping Voltammetry (DPASV), achieving limits of detection of 0.05 µM for Cd^{2+} and 0.007 µM for Pb^{2+}. The MIL101(Fe)-derived carbon material was used for glucose detection via amperometric measurements, reaching a limit of detection of 0.05 mM.

The combination of porous structure, surface accessibility, and improved charge transport supports the potential use of MOF-derived carbon-based materials in the development of reliable and efficient sensors for applications in environmental monitoring.

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