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Electrochemical Sensors Based on Chitosan for Sensitive Copper Detection

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The detection of heavy metals such as Cu^{2+} typically relies on expensive analytical techniques like atomic absorption spectroscopy (AAS), which limits their application in routine environmental monitoring or in-field analysis. As an alternative, electrochemical sensors functionalized with natural polymers offer low-cost, portable solutions with promising sensitivity. Among these materials, chitosan (CHI), a biocompatible, biodegradable, and chemically versatile polysaccharide derived from chitin, stands out for its ability to form functional films, especially when the degree of deacetylation (DD) is precisely controlled [1]. This study explores the functionalization of interdigitated electrode sensors using layer-by-layer (LbL) films of carboxymethylcellulose (CMC) and CHI with different conditions DD (≈55%, 75%, 95%) to detect Cu^{2+} ions. Sensors with 1, 3, and 5 bilayers were evaluated to determine the influence of film architecture on analytical performance. The best results were achieved with 3 bilayers and CHI of high DD (95%), which provided an optimal balance between film roughness and thickness. According to SEM and AFM analyses, the higher DD promoted the formation of rougher films with an isolated island-like topography [2], which can be attributed to the greater availability of $–NH_3^+$ groups, as indicated by zeta potential measurements under this deacetylation condition. The optimized sensors demonstrated a detection limit of 0.05 ppm, a linear response from 0.5 to 2.5 ppm, and excellent reproducibility (relative standard deviation = 2%). Validation using AAS yielded a relative error of 4.63%, confirming the accuracy of the electrochemical method. This work highlights the effectiveness of using chitosans with controlled DD in the fabrication of functional multilayer films, reinforcing their potential for developing affordable, portable sensors for environmental applications.

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References

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