Development of a Sustainable Sensor Based on Carbon Paste and Reductive NADES for the Detection of Emerging Contaminants

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The carbon paste electrode (CPE) is a widely used material in electrochemical analysis due to its low cost, ease of preparation, wide potential window, renewability, good stability, and low ohmic resistance [1]. Its performance and environmental friendliness can be further enhanced by modifying the composite with natural deep eutectic solvents (NADES), which are biodegradable, non-toxic, sustainable, and allow for tunable density and viscosity [2]. In this study, an electrochemical sensor was developed using carbon paste in which part of the mineral oil was replaced with reductive natural deep eutectic solvents (NADES). The NADES composed of choline chloride, citric acid, and water (in a molar ratio of 2:1:5) showed the best performance when replacing 10% of the binder, resulting in improved cohesion of the composite. FTIR characterization confirmed the formation of new hydrogen bonds between the precursors. Scanning electron microscopy (SEM) revealed a more compact and organized surface in the CPE/NADES10% electrode, with fewer interstitial spaces between the graphite layers. Electrochemical analysis using hydroquinone as a probe indicated a ~25% increase in anodic current relative to cathodic current, suggesting a catalytic effect. Citric acid molecules at the electrode–solution interface can act as proton acceptors during electrochemical oxidation processes of organic molecules that are pH-dependent., following a proton coupled electron transfer mechanism (PCET). These results demonstrate the potential of this approach for developing more sustainable and selective electrochemical sensors for target analytes.

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