Development of Polymer-based Chemical Sensor to Study the Impact of Polymer Concentration and Freeze-Thaw Cycle on the Detection of Gallic Acid

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A simple, inexpensive and efficiently sensitive sensor for voltammetric detection of gallic acid (GA) has been fabricated with 0.1% and 1.0% w/v of polyvinyl alcohol (PVA). Electrode responses were evaluated for the oxidation of 10 to 50 μM GA at bare glassy carbon electrode, a GCE modified electrochemically with PVA and PVA/MWCNT/GCE, PVA/ZnO/GCE, PVA/MWCNT/ZnO/GCE composites by solvent casting method. The PVA/GCE at 0.1% (w/v) has proven to be the best electrochemical sensor among the four electrochemical modified electrode as it has increased oxidative current to 26 folds as compared to a bare GCE. PVA/GCE 0.1% (w/v) has detected GA in the lowest concentration range of 50 μM with a high sensitivity of $11.03 \pm 1.61 \mu\text{A}$ as compared to bare GCE with 0.43 μA . The PVA/GCE 0.1% (w/v) modified chemical sensor has shown more pronounced current sensitivity of $21.85 \pm 1.14 \mu\text{A}$ after 5 freeze-thaw cycles, an effective casting method in this study. Freeze-thaw cycle method has strengthened PVA hydrogels enhancing the current sensitivity for the detection of GA to 51 folds as compared to bare GCE and 1.98 folds as compared to PVA/GCE (without freeze-thaw cycle). Satisfactory precision was obtained for PVA/GCE 0.1% (w/v) (without freeze thaw cycle) with %RSD of 15.58 whereas, %RSD for PVA/GCE 0.1% (w/v) (with 5 freeze-thaw cycle) was 5.24. Under optimal conditions, the polymer based electrochemical sensor PVA/GCE displayed a linear range to GA in the concentration of 1.6×10^{-6} to $4.9 \times 10^{-5} \text{ mol L}^{-1}$ with a detection limit of $4.95 \times 10^{-7} \text{ mol L}^{-1}$.

Keywords: Electrochemical modified electrode, freeze-thaw cycle, gallic acid, PVA hydrogel, square wave voltammetry

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