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Screen-printed electrode based on *Apis mellifera* beeswax modified with Printex 6L carbon@chitosan/Au for sensing of folic acid

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Abstract

The present work reports the development of a highly sensitive electrochemical platform, constructed using screen printed electrode based on *Apis mellifera* beeswax (SPWE) – employed as substrate – modified with Printex 6L Carbon (P6LC) at Chitosan (Chi) plus electrodeposited Au, and its application for Folic acid (FA) detection and recovery and real samples, since it is a crucial vitamin for regular physiological functions, as well as, is essential for DNA and RNA formation [1]. The beeswax utilization emerges from the necessity of ecofriendly materials and the possibility of beeswax reutilization for SPWE manufacturing, making it an interesting alternative for application in species detection systems [2]. The electrode was named as SPWE/P6LC@Chi/Au. For the electrodes production, the beeswax is melted on plates with thickness of 0.1 cm, being the graphite ink, applied on its surface. The graphite ink was studied by cyclic voltammetry (CV) with 1.0 mmol L^{-1} (KCl 0.1 mol L^{-1}) Fe $(CN)^{3-/4}$ in different proportions of graphite powder (G)/varnish glass (VG) (w/w), being: 50% G/50% VG, 60% G/40% VG and 70% G/30% VG. Also, a study varying the number of graphite ink layers (two, three and four layers) was carried out by CV. The same wax was reused three times, and tests made by CV were carried out, resulting in electrochemical profiles that demonstrated stability, with a decay of 6,2% in current. The electrochemical characterization was performed by CV with 1.0 mmol L^{-1} (KCl 0.1 mol L-1) $Fe(CN)^{3-/4}$ as supporting electrolyte for the reversibility parameters. The electrode with 3 ink layers and a proportion of 70% graphite:30% varnish, obtained the best results in terms of reversibility parameters, reaching

values of electroactive real area of 90.8%; i /i= 1.04; ΔEp= 139.3 mV e K0=1.68x10^{-3} cm s^{-1} and therefore was used for further electrochemical analysis. The kinetic study was made by CV in the potential range of 5 to 100 mV s^{-1}, obtaining R^2 values of 0.99271 and 0.98993 for the anodic and cathodic linearity, respectively. The stability of the system was tested by chronoamperometry for 4.5 h, presenting a current deviation of 0.16 µA. For FA detection (2x10^{-4} mol L^{-1} at BR buffer, pH 6.0) at SPWE/P6LC@Chi/Au sensor, DPV was carried out and the obtained current response was 7.8 µA. This sensor, when compared with other platform (SPWE), had an increase in the electrochemical sensitivity of 84%. An analytical curve was realized in the linear range of 0.025 – 0.75 µmol L^{-1} of FA at BR buffer pH 6.0, and LOD= 0.00945 µmol L^{-1} was obtained, with mean recovery rates of FA in female urine of 101.7%, demonstrating the detectability, sensibility and accuracy of SPWE/P6LC@Chi/Au, making it a viable alternative for FA detection in real samples.

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