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Development of a Low-cost Paper-based Electroanalytical Device for the Detection of Caffeine

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Paper-based electroanalytical devices are more attractive than any other analytical techniques for determining the caffeine (CAF) content in different applications to assess the quality of food and pharmaceuticals due to the simplicity, portability, sensitivity, stability, and low-cost nature of the devices. This research employed a paper based and commercially available polyurethane varnish to develop the hydrophobic pattern to generate the hydrophilic detection zone in which the sample is spiked. The electrode system having three electrodes, was fabricated on the detection zone for the electrochemical detection of caffeine using cyclic voltammetry (CV). The working electrode was modified with anthraquinone and showed electrocatalytic activity towards the oxidation reaction of caffeine. Throughout the study, unmodified carbon paste electrodes (UMCPEs) and silver plates served as counter and pseudo-reference electrodes respectively. The pH, scan rate, and modifier concentration were optimized to improve the analytical performance. Under optimum conditions, the calibration plot that was obtained between peak current and the caffeine concentration showed a good correlation with a correlation coefficient as high as 0.99, over the concentration range from 0.1 mM to 1.0 mM, having a detection limit (LoD), quantification limit (LoQ) and sensitivity (S) of 4 µM, 0.4 mM and 5.0 x 10^{-4} A mM^{-1} respectively. The electrochemical analysis demonstrated the applicability and reliability of this method since the calculated precision, accuracy, detection, and quantification limits (LoD and LoQ) fall within the acceptable range for monitoring caffeine levels in various samples. The low-cost nature, high sensitivity, and good linearity further support its potential as an effective analytical method for caffeine determination.

Keywords: *anthraquinone, caffeine, cyclic voltammetry, paper-based, polyurethane varnish*