Fabrication of a three-dimensional electrochemical paper-based device (3D-ePAD) for individual and simultaneous detection of ascorbic acid, dopamine and uric acid

Nongyao Nontawong¹, Maliwan Amatotongchai^{1*}, Wanchai Wuepchaiyaphum¹, Sanoe Chairam¹, Saichol Pimmongkol², Sirirat Panich³, Suparb Tamuang¹ and Purim Jarujamrus¹

¹Department of Chemistry and Center of Excellence for Innovation in Chemistry, Faculty of Science, Ubon Ratchathani University, Ubon Ratchathani 34190, Thailand.

²Department of Physics, Faculty of Science, Ubon Ratchathani University, Ubon Ratchathani 34190, Thailand.

³Faculty of Science and Technology, RMUTP, Bangkok 10800, Thailand.

*E-mail: maliwan.a@ubu.ac.th, amaliwan@gmail.com

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We report the development of a three-dimensional electrochemical paper-based analytical device (3D-ePAD) for the individual and simultaneous determination of ascorbic acid (AA), dopamine (DA) and uric acid (UA). The device was fabricated by alkyl ketene dimer (AKD)-inkjet printing of a circularly hydrophobic zone on filter paper for application of aqueous samples coupled with screen-printing of the electrodes on the paper which was folded underneath hydrophobic zone. A self-assembled three-electrode system, comprising a graphite paste modified with Fe₃O₄@Au-Cys/PANI was fabricated on the patterned paper by screen printed through the pre-designed transparent film slit. The three electrodes of Fe₃O₄@Au-Cys/PANI modified graphite electrodes (Fe₃O₄@Au-Cys/PANI/GFE) on the layout paper were served as the working electrode, the reference electrode, and the counter electrode, respectively. Cyclic voltammetry (CV) was used to study the electrochemical mechanism of AA, DA and UA. The results indicated that a high sensitivity towards AA, DA and UA was observed. Our results suggested that coating the working electrode with anionic surfactant, SDS (1 mM, pH 2), provides the distinguishable oxidation peak potential of AA and did not overlap with the oxidation peak of DA and UA. As a result, simultaneous determination of these three molecules in a mixture can be achieved. Examples of individual quantification of DA and UA in pharmaceutical and urine samples were demonstrated using differential pulse voltammetry (DPV). Under the optimum condition, the developed 3D-ePAD gave a linearity ranged from 20 to 1,000 µM for both DA and UA. The detection limits were 2.19 and 1.80 µM for DA and UA, respectively. There are no significant matrix interferences in the analyzed samples which can be concluded that the proposed method is suitable for the quantification of DA and UA with sufficient accuracy and precision.

Keywords: Three-dimensional electrochemical paper-based device (3D-ePAD), Gold-coated magnetite ($\text{Fe}_3\text{O}_4@\text{Au}$), Polyaniline (PANI), Ascorbic acid, Dopamine, Uric acid

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