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Abstract

Colorimetric and Visual Determination of Hydrogen Peroxide and Glucose by Applying Paper-Based Closed Bipolar Electrochemistry †

Elmira Rafatmah [1] and Bahram Hemmateenejad [2,*]

[1] Shiraz University, Shiraz, Iran; e.rafatmah@yahoo.com
[2] Shiraz University, Shiraz, Iran
* Correspondence: hemmatb@shirazu.ac.ir
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Abstract: Paper-based bipolar electrochemical (P-BPEs) assays have attracted a lot of attention due to their low preparation cost, self-pumping property of paper, being portable. The dominant reporting method in the introduced P-BPEs is electrochemiluminescence (ECL). ECL limits the infield application of this type of paper-based sensor as they need an expensive photon-counting compartment. Therefore, the development of a colorimetric method instead of ECL can be a promising feature. In the present study, the electrodeposition of Prussian Blue (PB) on the paper fibers has been introduced which has been used directly as a colorimetric method for the reporting cell of P-BPE. This disposable P-BPE biosensor is used for the determination of glucose. The closed bipolar electrochemical cell is fabricated on a small part of paper using a laser printing-based process for paper hydrophobization. The bipolar and driving electrodes are provided by pressing the writing pencil HB on the paper. The required reagent solutions are injected and dried in anodic, and cathodic bipolar cells. For determination purposes, the defined portion of deionized water and analyte solution is injected into the reporting and sensing cells respectively. By the connection of the driving electrodes to the power supply, anodic and cathodic reactions will take place around the bipolar electrode. Finally, the image of the devices is captured by a smartphone camera or by a digital scanner, and they are used for image analysis and sensing (Figure 1). The mechanism of sensing glucose is the oxidation of the analyte in the sensing cell using glucose oxidase followed by reduction of the produced H_2O_2 by application of an external potential (10.0 V). This causes the oxidation of $K_4Fe(CN)_6$ in the presence of Fe(II) ions and subsequent formation of PB particles in the reporting cell. The intensity of the blue color in the reporting cell is used as a visual and colorimetric signal that can be digitally read using a scanner or digital camera. The parameters affecting the performance of the device were optimized using experimental design and chemometrics modeling. The P-BPE represents a very wide response range that extends from 0.1 mmol.L^{-1} to 4.0 mol.L^{-1} in the case of hydrogen peroxide, and from 0.1 to 50 mmol.L^{-1} in the case of glucose. The limit of detections for hydrogen peroxide and glucose are 4.9 µmol.L^{-1} and 70 µmol.L^{-1} respectively.

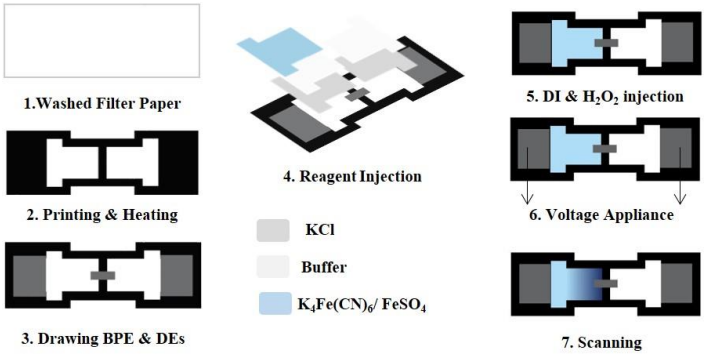

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Figure 1. Schematic diagram for fabrication of P-BPE sensor based on colorimetric sensing.

Keywords: bipolar electrochemistry; central composite design; image analysis; paper-based microfluidic

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