Author's Accepted Manuscript

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PII: S0039-9140(18)30476-4
DOI: https://doi.org/10.1016/j.talanta.2018.05.015
Reference: TAL18655

To appear in: *Talanta*

Received date: 10 February 2018
Revised date: 30 April 2018
Accepted date: 2 May 2018

Cite this article as: Stefano Cinti, Roberto Cusenza, Danila Moscone and Fabiana Arduini, Paper-based synthesis of Prussian Blue Nanoparticles for the development of whole blood glucose electrochemical biosensor, *Talanta,* https://doi.org/10.1016/j.talanta.2018.05.015

Paper-based synthesis of Prussian Blue Nanoparticles for the development of whole blood glucose electrochemical biosensor

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ABSTRACT

Nowadays, environmentally friendly synthesis pathways for preserving the environment and minimizing waste are strongly required. Herein, we propose filter paper as a convenient scaffold for chemical reactions. To demonstrate this novel approach, Prussian Blue Nanoparticles (PBNPs) were synthesized on filter paper by utilizing a few μL of its precursors without external inputs, i.e. pH, voltage, reducing agents, and without producing waste as well. The functional paper, named "Paper Blue", is successfully applied in the sensing field, exploiting the reduction of hydrogen peroxide at low applied potential. The eco-designed "Paper Blue" was combined with wax- and screen-printing to manufacture a reagentless electrochemical point-of-care device for diabetes self-monitoring, by using glucose oxidase as the biological recognition element. Blood glucose was linearly detected for a wide concentration range up to 25 mM (450 mg/dL), demonstrating its suitability for management of diabetes and glucose-related diseases. The Paper Blue-based biosensor demonstrated a correlation coefficient of 0.987 with commercial glucose strips (Bayer Contour XT). The achieved results demonstrated the effectiveness of this approach, which is also extendible to other (bio)systems to be applied in catalysis, remediation, and diagnostics.

Graphical Abstract

Keywords: biosensor; paper-based; Prussian Blue Nanoparticles; screen-printed electrodes; point-of-care; whole blood

1. Introduction

Paper is establishing itself as one of the most intriguing materials of the 21th century, being adopted in various fields, as paper is used in applications such as building batteries, amplifying nucleic acids, remediating pollution, and fabricating low-cost diagnostics, etc [1-4]. Among its valuable features, paper is inexpensive, lightweight, abundant, locally producible, biodegradable, and recyclable [5,6]. These features make paper an ideal sustainable material since i) environmentally, paper minimizes waste production, and can be easily burned, ii) economically, replacing plastic with paper lowers production costs (at laboratory scale) by 50% [7], and iii) socially [8] paper can improve quality of life and safety, i.e. portable diagnostics.

Although both filter, copy, and glossy papers satisfy the above listed features, filter paper is the majorly exploited one because of its easily funtionalizable 3D cellulosic network. The functionalized paper can be tailored depending on research interests, i.e. energy, printed electronics, remediation, sensing. Even if various paper-based analytical devices have been reported in literature, an interesting approach involving the use of paper has been reported in