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Low Cost Layer by Layer Construction of CNT/Chitosan Flexible Paper-Based Electrodes: A Versatile Electrochemical Platform for Point of Care and Point of Need Testing

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Abstract: Modification of cellulosic paper with carbon nanotubes (CNT) was studied for the development of electronic and analytical devices. Interesting results were published by using a CNT aqueous solution and the capillary forces of filter paper to make conductive tracks, supercapacitors, potentiometric electrodes and chemometric sensors. In this report, we show for the first time an electrochemical characterization of CNT-CS-SDS paper electrodes constructed with an ink containing optimized proportions of multi-wall CNT, chitosan (CS) and sodium dodecyl sulfate (SDS), and we compared our data with CNT-SDS paper electrodes constructed with a previously reported ink. We achieved better reversibility ($\Delta E = 131 \pm 14$ mV, CVs) and reproducibility (RSD = 3.63 %) with CNT-CS-SDS paper electrodes, when compared to CNT-SDS paper electrodes ($\Delta E = 249 \pm 7$ mV; RSD = 6.8 %) used as controls. When electrodes were fold at 90° angle, CNT-CS-SDS paper electrodes showed lower RSD than CNT-SDS paper electrodes, 8.43 % and 21.5 % respectively. These results are in concordance with SEM analysis indicating a dense CS film in CNT-CS-SDS paper electrodes. As a proof of concept, we determine dopamine concentration by DPV in the presence of ascorbic and uric acids, the limit of detection calculated was 6.32 µM. Moreover, a bismuth-film was prepared by *in situ* plating of Bi into CNT-CS-SDS paper electrodes. ASV allowed us to detect Pb in the presence of Bi (10–200 ppb) with a limit of detection of 6.74 ppb.

Keywords: Bismuth · Carbon Nanotubes · Disposable · Electrochemistry · Paper Electronics

1 Introduction

Since the discovery in the early Egypt (2400 BC) and China (1000 BC), when the first book appeared, paper and its derivatives have composed a variety of devices or other manufactured products and it is commonly used for writing, printing, drawing and packaging. At the first part of the 20th century, scientists have explored paper materials for chemical separation of many compounds. In 1940's, Martin and colleagues [1] started with one of the first approaches in paper chromatography and in 1950's zone electrophoresis in paper was introduced [2,3]. Later, of paper capabilities by the scientific community was principally determined for the development of single use and low cost devices [7].

Cellulose paper is a very attractive material for several reasons: (i) it is biodegradable, abundant, easily available, lightweight and easy to process, therefore is inexpensive [8] (ii) paper has the ability to let liquid substances pass through its hydrophobic matrix without the aid of external forces [9]. For analytical applications, paper material is always a good choice since colorimetric, fluorescence and electrochemical sensing can be successfully performed