

### **P33: DEVELOPMENT OF SELECTIVE AND SENSITIVE ELECTROCHEMICAL SENSORS, BASED ON NOVEL CARBONACEOUS MATERIALS**

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**Abstract** – Chemical sensors has received widespread attention during the past two decades because of their rapid, accurate, reproducible, and low-cost methodologies. Carbon paste electrodes (CPEs) are suitable for a variety of applications and many works have been devoted in the development of new sensitive and selective electrode surfaces based on carbon paste. The application of novel and promising carbonaceous materials, as electrode surfaces, is an issue of great concern.

In this work, the immobilization of calf thymus dsDNA on alternatively prepared carbonaceous materials is being demonstrated. The alternatively prepared carbonaceous materials that were used was activated carbon (B), HNO<sub>3</sub> oxidized activated carbon (B5), Ag impregnated activated carbon BAX-Ag (B-Ag) and graphite oxide (GO). Electrochemical techniques (such as differential pulse voltammetry) were applied, aimed to the use of novel carbonaceous materials at electrochemical DNA sensing.

**Keywords:** Carbonaceous materials; differential pulse voltammetry; DNA sensing

#### **1. INTRODUCTION**

Carbon paste electrodes have been used in many investigations in the past 50 years [1] for electrochemical sensing and detection. Electrical conductivity of carbon comes from the graphite structure in nano and macro scale. Parallel layers of carbon atoms, linked by covalent Van Der Waals forces, form hexagonal rings dimensional layers, creating this unique structure [2].

The development of chemical sensors has received widespread attention, because of their

extensive use in environmental monitoring and clinical analysis via rapid, accurate, reproducible, and low-cost methods. The data reported in literature demonstrate that carbon paste electrodes (CPEs) are very suitable for a variety of applications and many works have thus been devoted in the development of new sensitive and selective electrode surfaces based on carbon paste as the electrode material of choice. The application of novel and promising carbonaceous materials, as electrode surfaces, is an issue of great concern. Carbon is compatible with biological tissues more than other materials used in electroanalysis and as a result has broad application in biological samples such as electrochemical DNA sensors. [3]

The present study demonstrates the immobilization of calf thymus dsDNA on alternatively prepared carbonaceous materials, using electrochemical techniques (Differential Pulse Voltammetry), aimed at electrochemical DNA sensing. The alternatively prepared carbonaceous materials, that were used, was activated carbon (B), HNO<sub>3</sub> oxidized activated carbon (B5), Ag impregnated activated carbon BAX-Ag (B-Ag) and graphite oxide (GO).

#### **2. EXPERIMENTAL**

Activated carbon used was a wood-based activated carbon BAX-1500, manufactured by Mead Westvaco, USA.

GO was prepared in the laboratory according to the modified Hummers method [4].

B carbon was oxidized with 70% (v/v) HNO<sub>3</sub> for 5 h (carbon denoted hereafter as B5). The excess of acid and the soluble products of surface oxidation were removed by washing with water at 100 °C

using a Soxhlet apparatus, until constant pH. The preparation of Ag impregnated B carbon sample (carbon denoted as B-Ag) was made according to the Tollens method [5].

Differential pulse voltammetry (DPV) were carried out using  $\mu$ Autolab potentiostat / galvanostat controlled by GPES 4.9 software (Eco Chemie, The Netherlands). The electrochemical experiments were carried out in a three electrode glass cell system with platinum wire (Metrohm, Switzerland) as counter electrode and Ag / AgCl as a reference (MF-2052 BASI, [www.BASInc.com](http://www.BASInc.com)).

Firstly, the working electrode was the unmodified carbon paste electrode (CPE), prepared by hand mixing graphite powder to mineral oil by 75/25 ratio. Then, the working electrode was prepared by hand mixing graphite powder to the alternative carbons (wood-based activated carbon, wood-based oxidized activated carbon, and wood-based Ag impregnated activated carbon as well as graphite oxide) and mineral oil by 80/20 ratio. The resulted paste was placed into a Teflon sleeve. All the electrochemical experiments were performed at ambient temperature in an electrochemical cell. The electrochemical cell was cleaned with diluted nitric acid and rinsed with sterilized double-distilled water.

The voltammetric study of the immobilization of dsDNA on the novel carbonaceous electrodes were carried out by differential pulse voltammetry, using the well studied redox reaction of  $K_3[Fe(CN)_6]$  as supporting electrolyte. Previously published results [6] are briefly referred here along with new experimental results.

### 3. RESULTS AND DISCUSSION

It must be stressed that guanine's residue oxidation signal was used to monitor the interacting ability of novel carbonaceous material with dsDNA. Experimental results show that guanine's residue oxidation peak current was increased in all of the cases of carbonaceous materials compared to the conventional CPE, Figure 1. Furthermore, as it can be seen from Figure 1, GO-CPE had greater interaction capacity than the other modified CPEs and conventional CPE in all of the studied mass concentration of dsDNA, with the exception of 50

mg/L where B5 had the better response.

Repeatable results supports that B<sub>5</sub> had greater conductivity capacity than CPE and at the same time linear response from 10 to 100  $\mu$ mol / L dsDNA.

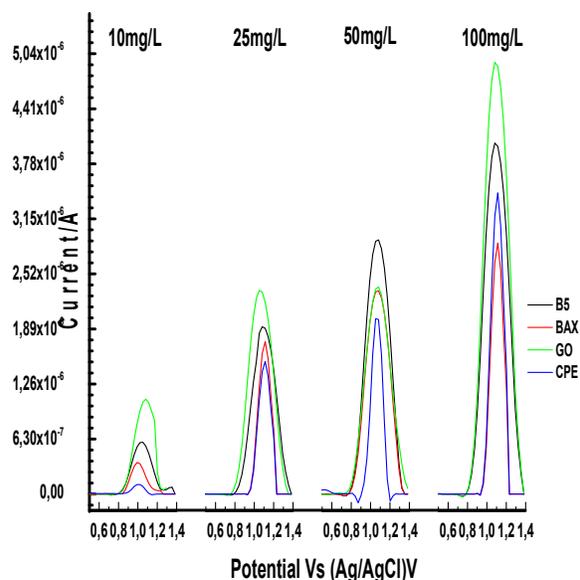


Figure 1 :DPV quantitative analysis of dsDNA.

### 4. CONCLUSIONS

To sum up, in the present work, combining the ability of activated carbon and graphite oxide to promote the adsorption and the electron-transfer reactions, a paste electrode based on these carbonaceous materials has been prepared and used for the study of dsDNA. The proposed carbonaceous materials had excellent ability to interact with dsDNA, with GO-CPE to present the greater capacity. They were found to be great electron transfer mediators, since the electrochemical results show that in most of the cases they pose reversible redox characteristics. In addition, the present results suggest that the new fabricated dsDNA modified electrode is a promising tool allowing direct quantification of DNA that can be included into future electroanalytical gene diagnosis platforms, or pharmaceutical testing, environmental and quality control, avoiding the

high cost, low sensitivity, and procedural complication.

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