Single-Walled Carbon Nanotubes Based Optical Fiber Sensors for Electroanalytical Determination of Dopamine

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***Abstract*: In this paper, the Single-Walled Carbon Nanotubes (SWCNTs) as sensitive nanostructured material has been considered for the development of an optoelectronic sensor. It can perform chemical detection in water. The fabricated sensor has been employed which involves single wavelength reflectance measurements in a reflectometric system. The high sensitivity and good stability of steady state signal, as well as the good responce dynamics in case of toluene detection confirm the potentiality of SWCNTs which is to be employed in water environment.**

***Index Terms*: Optical fiber sensors, single-walled carbon nanotubes (SWCNTs), toluene detection.**

I. INTRODUCTION

There are two groups of carbon nanotubes, multi-wall carbon nanotubes (MWNTs) and single-wall carbon nanotubes (SWCNTs). Carbon nanotubes (CNTs), consist of sheet of graphite rolled into cylinder. The SWCNTs consist of a single graphite sheet rolled seamlessly, defining a cylinder of 1-2 nm diameter. MWCNTs consist of several layers of graphite sheets rolled into cylinders with one cylinder inside another. Theoretical calculations have predicted that this material will behave either as a metal or semiconductor depending on its size and lattice helicity. SWCNTs have low resistivity of 100-200 cm μΩ.cm comparable with a high-quality carbon fiber with a resistivity of approximately 100 cm μΩ.cm [9]. The SWCNTs remain stable at high temperature in the chemical reaction and can carry electrical current densities up to 109 GA/cm^2.

CARBON nanotubes have been studied intensively due to their importance as building blocks in nanotechnology. Based on carbon nanotubes a number of chemical sensors have been proposed in the recent years, especially for Volatile Organic Compound (VOC), H_2, H_2O, and NH_3 detection in gaseous environments [1]. No straight forward information is achievable about the analytes present in the test environment, due to their low selectivity against given chemical species. Pattern recognition method is very useful in these cases. To enhance the discrimination capability of the whole hybrid system the correlation between data obtained by complementary transducers is used. Single-Walled Carbon Nanotubes (SWCNTs) are considered as highly sensitive materials for the development of high-performance Volatile Organic Compound (VOC) Silica Optical Fiber (SOF) sensors [2], [3].

II. PRINCIPLES AND METHODS

Thin films of SWCNTs are deposited in the form of sensitive nano structured materials onto the distal end of standard Silica Optical Fiber (SOF). The sensing principle of proposed configuration includes the changes of the complex dielectric constant and thickness of sensitive overlay as a result of the chemical adsorption of a given analyte [3]. This leads to change in the reflectance at the fiber-overlay interface. By lighting optical fiber sensing interface the interrogation of the toluene sensor has been carried out and the amount of reflected power [3] is continuously monitored. The super luminescent diode is operating at a wavelength of 1310 nm. The ratio between the signal reflected at the sensing interface and the one corresponding to the amount of power emitted by the source is given by

$$I = k * R \qquad (1)$$

Where k is a constant and R is the film reflectance. To test the sensing performance in toluene detection in the proposed SWCNTs-based sensor, it has been kept in a Pyrex beaker containing pure water. Toluene in test environment is simulated by successive injections in the chamber of the volume of the target analyte. These are chosen so as to obtain the desired concentration.

The lifetime of the SWCNTs-modified depended on oxidation of dopamine because of fouling of the electrode surface due to the adsorption of oxidation products.

III. EXPERIMENTAL RESULT

At different SWCNTs modified electrodes, namely SWCNTs / Graphite electrode, SWCNTs / Pt electrode, SWCNTs/Au electrode and SWCNTs/GC electrode, fig.1 gives CVs of 100 ppm dopamine in 0.2 M phosphate buffer having pH 7.5. The scan rate is 50 mV/s. SWCNTs-modified glassy carbon electrode was chosen for the electrochemical study of dopamine. The Electro-chemical behaviour of SWCNTs-modified glassy carbon electrode gave better peak current of dopamine.

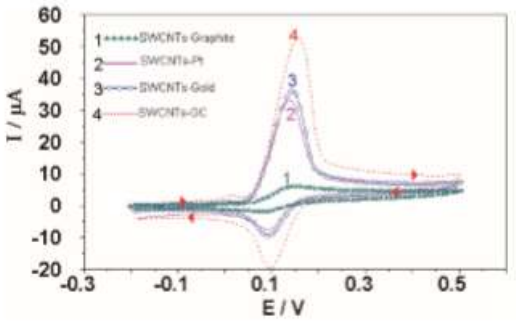

Fig. 1: 100 ppm dopamine in 0.2 M phosphate buffer pH 7.5 scan rate 50 mV/s at different SWCNTs-modified electrode, (1) SWCNTs/Graphite electrode, (2) SWCNTs/Pt electrode, (3) SWCNTs/Au electrode and (4) SWCNTs/GC electrode

The stability of the deposited SWCNTs sensitive layer within an aqueous environment is investigated. Then the toluene detection measurement in water was performed. An Silica Optical Fiber (SOF) sensor is coated by 12 monolayers of SWCNTs (approx. 24 nm each). The sensing performance against toluene in air was tested already [3]. It is inserted in a beaker containing pure water and then left for several days inside it. With each toluene injection, when the interaction between analyte molecules and sensitive overlay takes place there results in decrease of the reflectance. The carbon nanotube-based Silica Optical Fiber (SOF) sensor provides complete recoveries of the steady-state value of uncontaminated water. It demonstrates the excellent desorption features. As the test chamber is not perfectly thermo-stated there is a slight drift in the sensor base line due to thermal changes. Further analyses are going on to assess its stability over long periods. An approximation of the influence of the noise on sensor response has been given. This is done by calculating the noise effect on the sensor output in steady-state levels with respect to the absence of analyte within the chamber.

IV. CONCLUSION

In this research paper, the electro-chemical behavior of oxidation of dopamine at the Single-Walled Carbon Nanotubes (SWCNTs)-modified electrode was done. It is a diffusion-controlled process. Peak currents at differential pulse voltammetry is increased with the concentrations of dopamine. The detection limit was 0.023 ppm, and the minimum current to detection dopamine was 0.035µA.

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