

Electrochemical Detection of Serotonin Using a Microfluidic Device Integrating Vertically Aligned CNTs

Fernando C. Moraes, Ivana Cesarino, Renato S. Lima,
Emanuel Carrilho, Sergio A. S. Machado
*Instituto de Química de São Carlos, Universidade de São Paulo,
C.P. 780, 13560-970, São Carlos, SP, Brazil
fcmoraes@hotmail.com*

A promising platform for rapid, simple, direct, and sensitive electrochemical determination of neurotransmitter was developed. The method was applied to detection of serotonin standards. It is related to integration of vertically aligned single-walled carbon nanotubes (SWCNTs) in glass/PDMS (Poly-dimethylsiloxane) electrochemical microfluidic devices, increasing thus the sensing area and improving the mass transport. Microfluidic platforms with integrated electrochemical detectors have advantages include: low cost, chemical stability, automation capacity, and easy microfabrication. Also this device allows good analytical frequency and high values of reproducibility. In addition, the presence of vertically aligned carbon nanotubes in the microdevice improves the analytical response due to the fast electronic transfer, electrocatalysis, and high sensitivity, showing the suitability of the method.

The fabrication of the microdevices involved the following main steps: i) sputtering deposition of the electrodes (Ti/Au) on a flat glass bottom; ii) molding of the PDMS microchannels by soft lithography; iii) sealing of the glass/PDMS device irreversibly; and iv) immobilizing of the SWCNTs in-situ over the working electrode. The SWCNT alignment step comprised the mixture of 1.0 mg functionalized SWCNTs with 500 μL of $1.0 \mu\text{mol L}^{-1}$ ssDNA (single stranded DNA) solution. The mixture was sonicated and then centrifuged at 7000 rpm; each process took 45 min. Finally the supernatant solution was collected and then pumped into the microfluidic channel until reached the detection zone on work electrode.

The electrochemical assays were carried out using an Autolab PGSTAT30 coupled a flow system powered with two external syringe pumps. The morphological characteristics of the electrodes were examined by atomic force microscopy.

In order to maximize the analytical signal, the electrochemical parameters such as work potential, carrier and sample flow rate and injection time were investigated in $100 \mu\text{mol L}^{-1}$ of serotonin solution in 0.1 mol L^{-1} PBS (pH 6.0). Using the optimal parameters values (work potential at +0.4 V; injection time at 5 sec; carrier and sample flow rate at 5.0 and $30 \mu\text{L min}^{-1}$, respectively) an analytical response for the microdevices were carried out using chronoamperometry. The use of vertically aligned SWCNTs influenced remarkably the sensitivity: limits-of-detection to serotonin standards were 11.8 and 0.2 nmol L^{-1} employing Au and Au/ssDNA/SWCNT as working electrodes, respectively. In addition, the analytical sensitivity value to Au/ssDNA/SWCNT ($4.54 \text{ nA}/\mu\text{mol L}^{-1}$) was almost three times higher regarding to that obtained by Au electrode ($1.33 \text{ nA}/\mu\text{mol L}^{-1}$). The low detection limit archived for the microdevice confirming the suitability of this methodology to determinate serotonin in biological fluids.