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Research Article

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Microfluidic Nanoparticle Based Lab-On-A-Chip Devices for the Detection of Dopamine

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Abstract

Dopamine is a neurotransmitter compound that is produced in the substantial ventral typical area and hypothalamus of the brain. Dysfunction of the dopamine system has been implicated in different nervous systems. A novel integrated Lab-on-a-chip device using PDMS and glass plate has been successfully designed, fabricated, and tested for various concentrations of dopamine.

For the separation of dopamine and ascorbic acid mixture, the working electrode of the Lab-on-a-Chip device was modified by coating with Au- nanocomposite particles, which separates dopamine and ascorbic acid.

1. Introduction

Dopamine (DA) plays an impartment role in reward and movement regulation in the brain. In the reward pathway, DA production occurs in the general tag mental (VTM), in the nerve cell bodies. From there it is released into the nucleus acumens and performed cortex. In the ViVO, the concentration of (DA) in VITA is 4.8 ± 1.5 n m, while in the red nucleus, it is 0.5±1.5 nm [1]. The pathway for motor function is different. In this pathway, the substantial cell bodies are responsible for the production and discharge of DA into the striatum DA plays multiple junctions in the brain. Present Address: Soolini University Solan, India reported the role of DA in the modulation of behavior and cognition volumetry movement, motivation, punishment, and award, inhibition of prolaction productions, sleep, dreaming mood, attention, working memory, and learning [2, 3]. DA can be a precursor in the biosynthesis of other related catecholamines such as Norephenphinephirine and epinephrine. Norepinephrine is synthesized from DA Beta-hydroxyls in the presence of L- ascorbic acid and molecular oxygen. Norepinephrine then acted by the enzyme phenylethanolamine. Normethyl transferase with S-adenosyl. L-methiomine[SAMe] is a cofactor to produce epinephrine.

The biosynthesis of DA and other catecholamines can be limited by the action of the enzyme tyrosine by hydroxylase (TH) [4]. Therefore, regulating the mechanism of TH could be promising for improving gene therapy approach and other treatment modalities [5]. After the synthesis of DA, it is incorporated into synaptic DA, it is incorporated into synaptic vesicles by the action of vesicular monoamine transportation 2(VMAT2) where it is stated DA is discharged by exocytosis into the cell membrane and dumped into the synapse. In the synthesis, DA binds to either postsynaptic or presynaptic DA receptors on both. Thisbabd regardless of the receptor gene rates and electric potential in the presynaphic [6]. In the case of postsynaptic DA receptors, the signal is proportional to the post-synaptic neuron. In contrast, in the case of the [presynaptic DA receptors, the signal can either excite the presynaptic cell on inhibit it. Presynaptic receptors with an inhibitory potential also known as autoreceptors inhibit the synthesis and release of neurotransmitters and thus function to maintain normal levels of DA.

After carrying out its synaptic function, DA is taken out again into the cytosol by presynaptic cells through the action of either high-efficiency DA transporters(DAT) or low-affinity plasma membrane monoamine transporters, once in the synaptic neuron, amphetamine exercises a reverse influence on the the action of DA transporters (DAT) and focus DA molecules out of storage vesicles and into the dynamic gap [6]. The DA transporter is a sodium-coupled symport or protein responsible for modeling the concentration of extraneuronal DA in the brain [7]. The DA is now in the cytosol and is repacked into vesicles by the action of vesicular transport VMAT2 [8].

2. Lab-On-A-Chip Fabrication

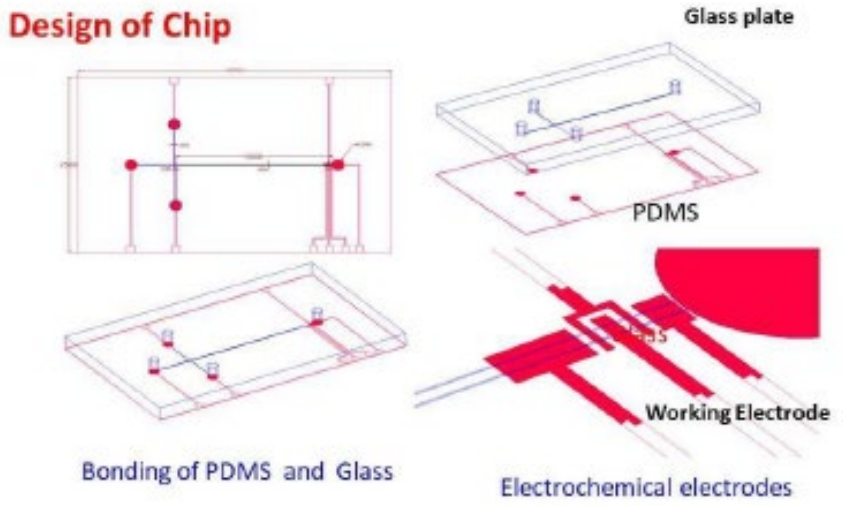

Figure 1: Design of Lab-on-a-Chip with Electrochemical Detection Electrodes and Glass Bonding

Figure 1 shows the design of a Lab-on-a-chip consisting of PDMS in which microchannels are produced for the transportation of samples and regents and a flat glass plate on which electrodes are fabricated for power supply connection... Figure 2 shows the schematic diagram with the actual dimensions of the lab-on-a-chip, it also shows the integrated electrodes for supplying voltages for the detection of dopamine and other chemicals. Microchannels in PDMS were fabricated using micro molding process [9]. Silicon wafer with patterned with photoresist was used as a mold master to have a relatively thick structure of microchannels for transporting samples and reagents. We used an ultra-thick photoresist SU-8 [10].

After the patterning, PDMS was poured into the mold master to have a thick structure of microchannels for the transportation of samples and reagents [11]. After the patterning PDMS was poured into the mold master, and then cured PDMS, peeled off from the master. On the glass plate, the electrodes were fabricated for high voltage supply to electrodes and also on the detection electrode through the pre-designed mask for electrodes [12]. PDMS is known as one of the most attractive materials for microfluidic devices [13]. Another attractive feature of PDMS is due to its spontaneous adhesion to the smooth surface [14]. Figure 2 also shows the electrochemical detection and glass bonding. To provide the necessary electric field needed. Figure 2 also shows the design of a lab-on-a-chip with electrochemical detection and metallic electrodes on the flat glass plate for bonding [15, 16].

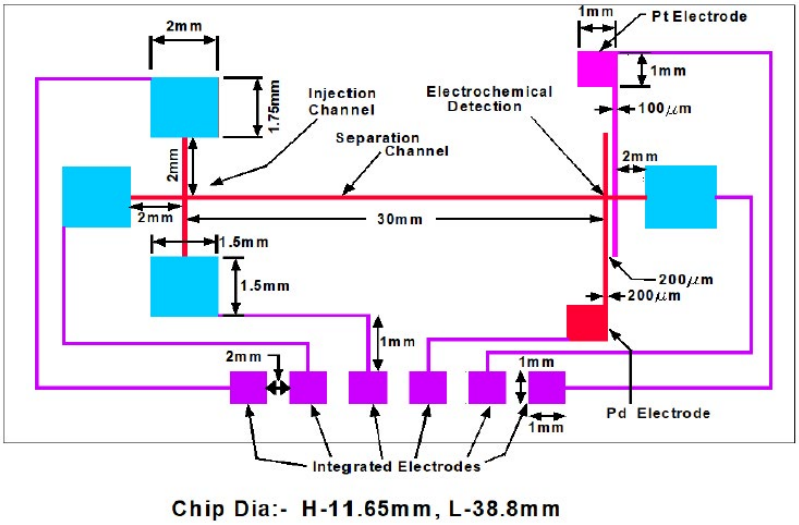

Figure 2: Schematic Layout of CE/EC

3. Results and Discussions

To provide the necessary electric field needed for the electrophoresis process and bonding pads were provided for gold metallization using a sputtering method for electrochemical detection [17-19]. Figure 3 shows the schematic diagram of integrated electrodes for supplying electric field, PDMS channels, and Working electrodes of the lab-on-a-chip device. Figure 4 shows the measuring jig fabricated in our workshop for electrochemical detection. Figure 5(a) shows the photograph of microchannels fabricated in PDMS whereas Figure 5 (b) shows the photograph of electrodes fabricated on the flat glass plate. Figure 6 shows the photograph of a complete integrated lab-on-a-chip bonded together channels part on PDMS and electrode part fabricated on a glass plate in the presence of Plasma.

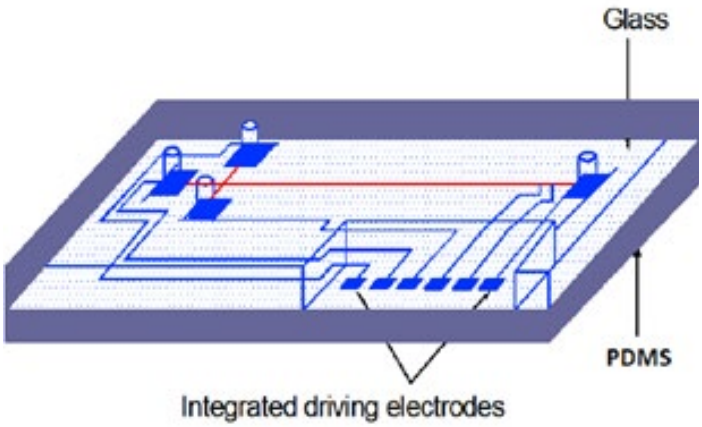

Figure 3: Schematic Diagram of Integrating Electrodes of Lab-on-a-Chip

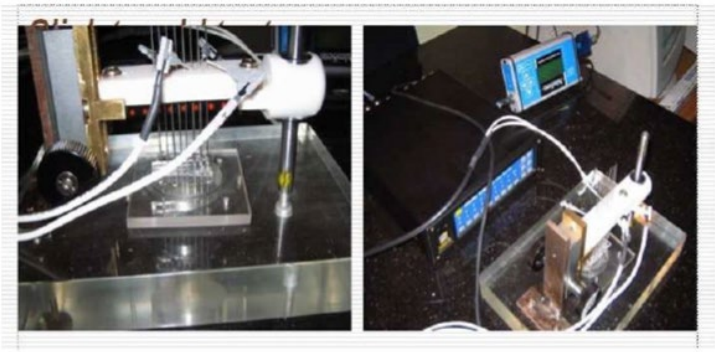

Figure 4: A jig Fabricated for testing of Lab-on-a- Chip

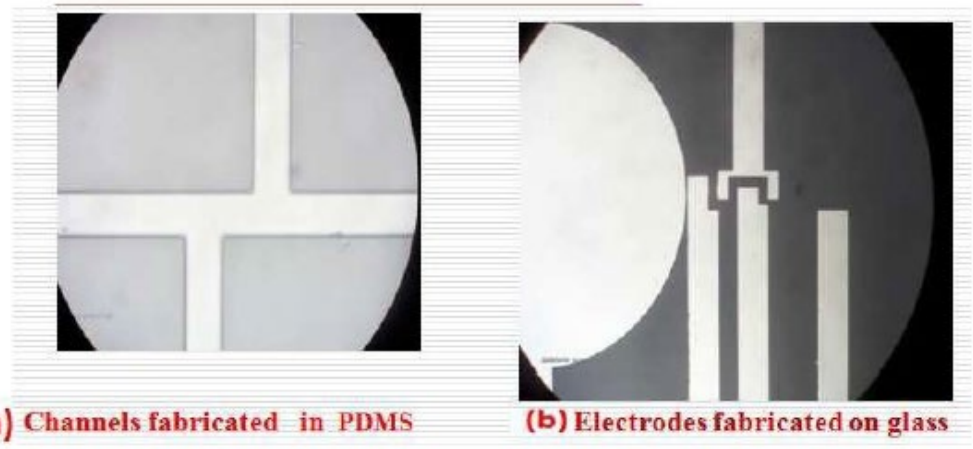

Figure 5: Photographs of Integrated Lab-on-a-Chip Fabricated (a) Micro-Channels Fabricated in PDMS (b) Detection Electrodes Fabricated on a Flat Glass Plate

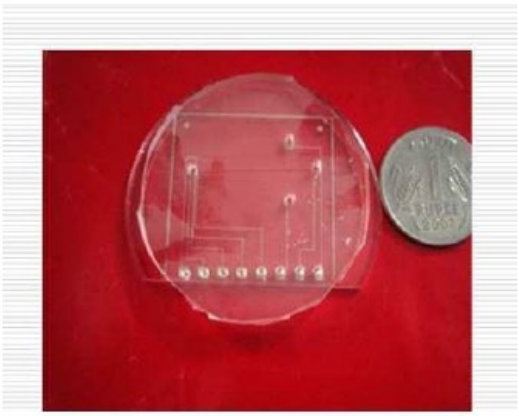

Figure 6: Complete Photograph of Integrated Lab-on-a-Chip Fabricated

Microchannels were cleaned with deionized water before use the lan- 0n-a-chip device fabricated we tested dopamine. The results are shown in Figure 7, We observed from this graph that with the increase of the dopamine concentration, its peak is increased (Figure 7 a). A calibration curve is also obtained for dopamine which is shown in Figure 7b. We conclude from here that our lab-on-a-chip fabricated is detecting various concentrations of dopamine. The response of dopamine was measured using the Voltametry technique [20]. From the above experiment, we can not separate dopamine and ascorbic acid, thus we are not sure that the peak which we have obtained in Figure 7 is pure dopamine or a mixture of dopamine and ascorbic acid because peaks of these two are nearly obtained at the same peak. To confirm this a minimal area of (250 microns to X500 microns) on the working electrode was coated with PEDOT Au-nanocomposite particles by electro-polymerization which is shown in Figure 8. The nanocomposite-modified electrode was demonstrated. Now this modified electrode was incorporated with the lab-on-a-chip device and tested the mixture of ascorbic acid and dopamine mixture. Figure 9 has two curves A and B. Curve is of nonmodified electrode and curve B is a modified electrode with Au- nanocomposite particles. In Figure 9 Curve A we have ascorbic acid (AA)and dopamine peak (DA) side by side, whereas Figure 9 Curve B shows only the peak of dopamine.

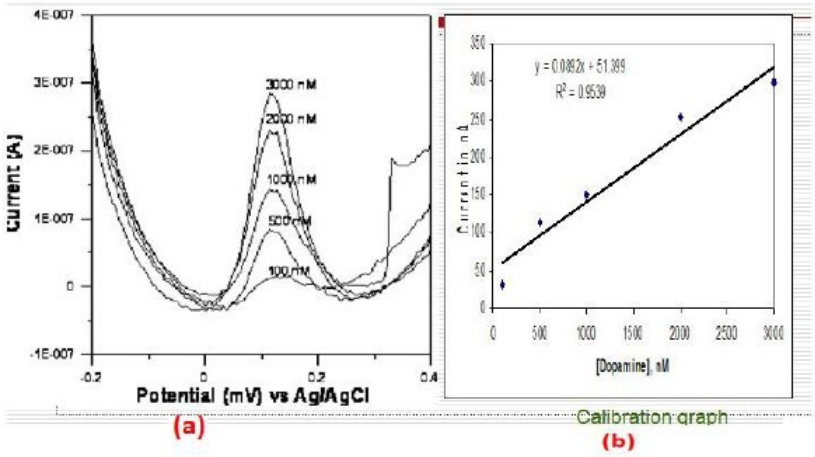

Figure 7: Concentration of Dopamine Recorded

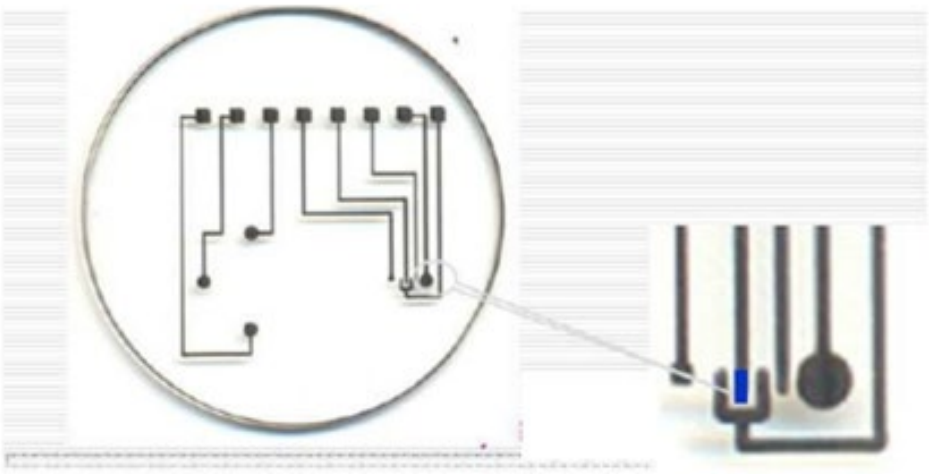

Figure 8: A Very Small Area (250 Microns To X500 Micron) In the Designed Electrode was Coated with PEDOT-Au Nanocomposite by Electron Polymerization Technique

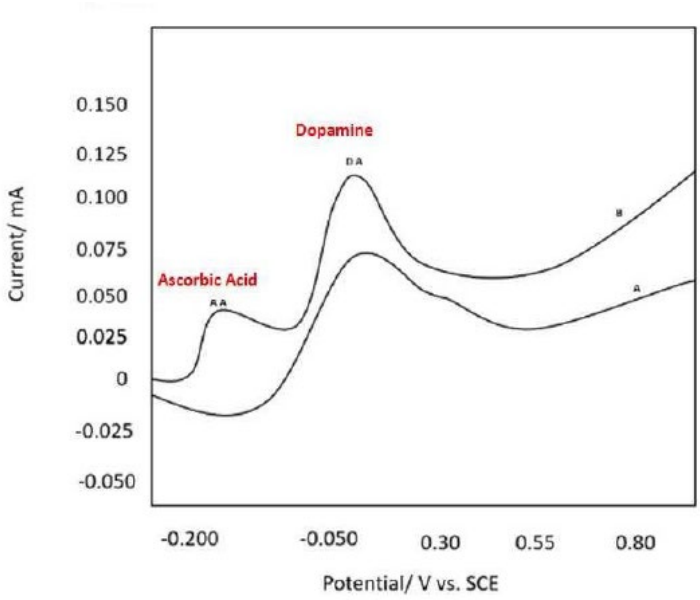

Figure 9: Separation of Ascorbic acid (AA) and Dopamine (da).

Curve A Show Non-Deposited Non-Composite Electrode Where As Curve B Shows Electrode Deposited With Au- Nanocomposite Using PEDOT Process

4. Conclusions

In the present study, we have successfully fabricated a novel lab-on-a- chip device using PDMS and glass, which can detect dopamine. We observe that with the increase the dopamine concentration the peak of dopamine is increased (Figure 8). In the second part we modified the working electrode with Au- composite nanoparticle and observed that ascorbic acid (AA) and dopamine (DA) are separated(Figure 9).

Acknowledgments

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