Abstract No: PO-13

Ultrafast, simultaneous detection of neurotransmitters and heavy metals at four-bore carbon-fiber microelectrodes using fast-scan cyclic voltammetry

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Progressive deterioration of brain cells leads to devastating neurological disorders such as Parkinson's and Alzheimer's. Despite the efforts taken by scientists, the pharmaceutical industry, and medical professionals to develop medicines that slow down the progression of the disease, these have become a major global concern. It is known that the etiology of these diseases is multifactorial; however, it is not fully understood yet. In addition to the currently available knowledge of some risk factors such as aging, the fundamentals of some other vital factors remain hidden due to the incompetence of existing methods. In particular, the contribution of heavy metals and the role of co-transmission on these illnesses haven't been explored experimentally in real time yet. Therefore, in this study, we fabricated the fastest four-bore carbon-fiber microelectrode (CFM) that can perform real time, simultaneous measurements of heavy metals and neurotransmitters with a temporal resolution of 100 ms. We used fast-scan cyclic voltammetry (FSCV) as our electrochemical measuring tool to perform fast measurements. Each bore in our novel electrode contains a single carbon-fiber (diameter of 5-7 µm) that acts as a single electrode. We characterized our sensor with dopamine (DA), serotonin (5-HT), ascorbic acid (AA), and Cu^{2+} ions in tris buffer using FSCV. To the best of our knowledge, this is the first time reporting simultaneous measurements of four analytes using FSCV. Interestingly, we find that the sensitivity of CFMs towards Cu^{2+} ions increases in the presence of DA and AA; this may be presumably due to the increased surface-active sites on the secondary film formed by DA, AA, and their products catalyzing the surface adsorption of Cu^{2+} ions. Additionally, we find that 5-HT detection with a bare electrode is not feasible in the presence of Cu^{2+} ions. Most likely, it is because the active sites are already occupied by Cu^{2+} ions, thus, leaving no room for the adsorption of 5-HT molecules. This finding is fundamentally novel and will provide an excellent platform for surface modification strategies for multi-bore CFMs to perform in vivo experiments.

Keywords: Carbon-fiber, FSCV, Metals, Microelectrodes, Multi-bore, Neurotransmitters

Acknowledgment
This work was supported by the start up grant (Florida Institute of Technology).