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A Comparison of Two Fabrication Methods of Carbon Fiber Microelectrodes and Their Ability to Detect Catecholamines

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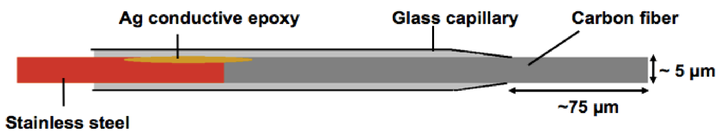
Abstract

Carbon fiber microelectrodes (CFMs) have been widely used as sensors to detect neurotransmitters, including catecholamines in animal models for the study of their role in brain function and behavior. A very common method of fabricating CFMs is by encasing a 7µM-diameter fiber in a glass tube and melting the glass to create a tight seal. While this method is simple and inexpensive, it is extremely easy to damage the CFMs. Also, when performing experiments *in vivo*, the electrode cannot be permanently implanted in the animal. We are interested in designing a new CFM composed of a broader material that can be permanently implanted. In this study, we fabricate a new CFM composed of fused silica and compare its catecholamine-detecting capabilities to the original glass-encased CFM.

Introduction

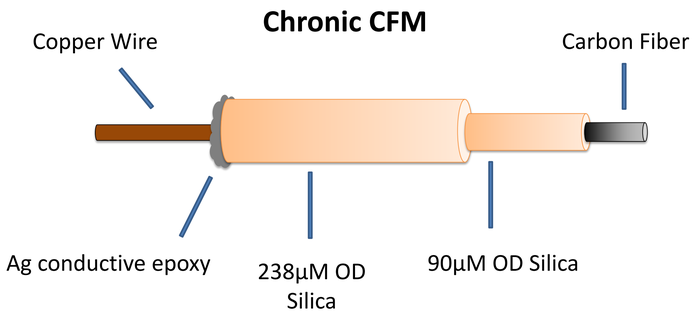
- Carbon fiber microelectrodes (CFMs) used to detect catecholamines, such as dopamine (DA) or norepinephrine (NE) *in vivo*. [1]
- Common CFMs composed of carbon fiber and glass casing: easy to make but fragile.
  - Pros: inexpensive, easy to make, simple to test
  - Cons: cannot be permanently implanted, repeated tests in animals can cause trauma and inaccurate data.

Glass Encased CFM



- Chronic implant electrodes are composed of fused silica – broader material
  - Pros: less fragile, permanently implantable, causes less trauma to animal target regions
  - Cons: longer fabrication process, more difficult to fabricate.
- Catecholamine detection may be affected by the type of CFM used.

Chronic CFM



[2] Paul Phillips, Nature Method

Methods

Acute Electrode Fabrication

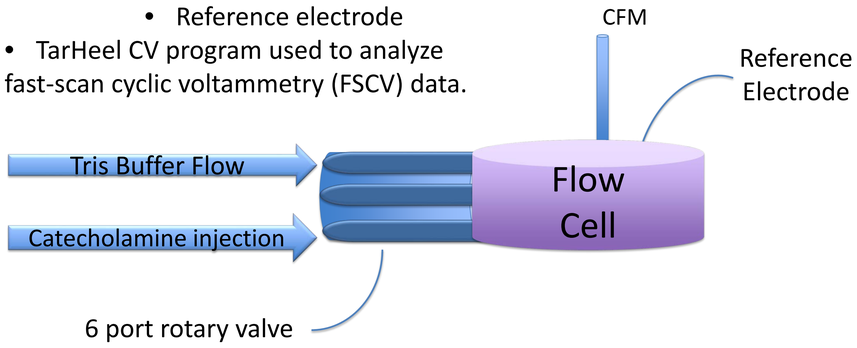
- T-650 PAN carbon fibers are aspirated into glass capillary (1 mm diameter, 10 cm length).
- Capillary is marked at halfway point and loaded into glass microelectrode puller (Narishige PE-22). Capillary position is adjusted so the capillary is pulled at the midpoint.
- Glass is melted against carbon fiber to ensure good seal.
- CFMs placed under light microscope and cut to 70-120 µM length.

Chronic Electrode Fabrication

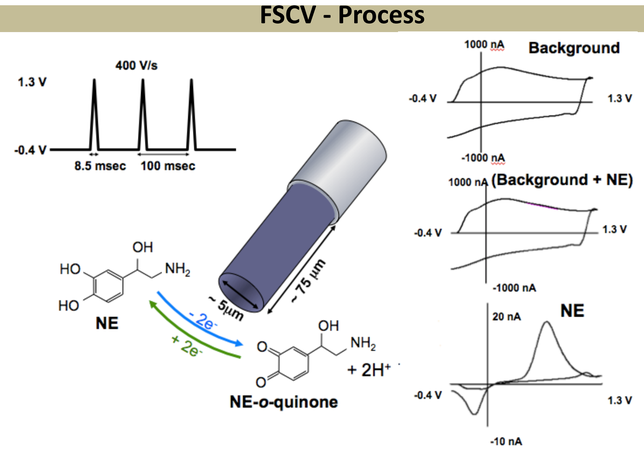
- T-650 PAN carbon fibers (>3cm length) are loaded into 90µM diameter fused silica capillary while submerged in isopropanol.
- One end of the silica capillary is coated with two-component epoxy and attached to a 238µM diameter silica capillary.
- The other end of the 90µM capillary is coated with Ag epoxy and the carbon fiber is cut to 75-125µM.
- The tip of the 238µM capillary is coated with silver conducted epoxy and a copper wire is attached.

Flow Cell

- Flow cell analysis mimics in vivo environment to test efficacy of CFM at detecting catecholamines.
- Components include:
  - Tris buffer composed of salts and Tris (pH 7.4)
  - 1µM catecholamine solution (DA or NE)
  - Carbon Fiber Microelectrode
  - Reference electrode
- TarHeel CV program used to analyze fast-scan cyclic voltammetry (FSCV) data.



FSCV - Process



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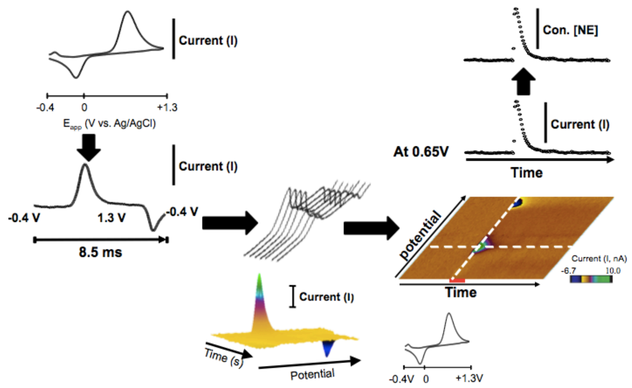
Methods (continued)

FSCV – Data Analysis



Results

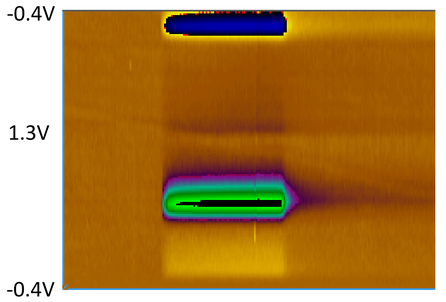


Figure 1: Color plot of DA. The x-axis is time (s), the y-axis is applied potential to the electrode (V) and the current is coded by pseudocolor (nA).

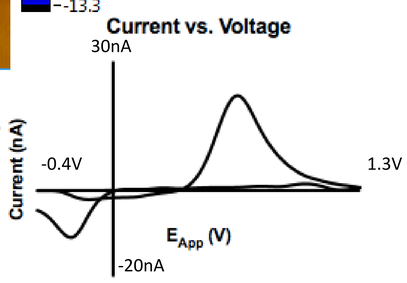


Figure 2: Background-subtracted cyclic voltammograms of dopamine at glass-encased CFM.

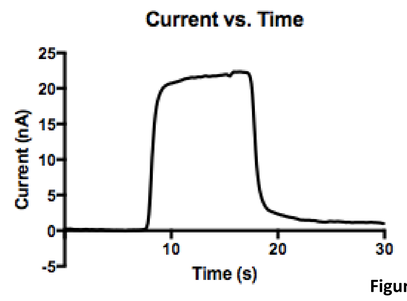


Figure 3: Dynamic response of oxidative peak current to 10-sec injection of DA.

References

[1]Wakabayashi K. T. et al. Application of fast-scan cyclic voltammetry for the in vivo characterization of optically evoked dopamine in the olfactory tubercle of the rat brain. *Analyst*, 2016

[2]Paul Phillips et al. Chronic microsensors for longitudinal, subsecond dopamine detection in behaving animals. *Nat Meth*, 2010

Acknowledgements

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