NEW ELECTRODE MATERIALS FOR NEUROLOGICAL SOLUTES: NANOCRYSTALLINE GRAPHITE AND CARBON NANOPIPETTES

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Several new forms of carbon, specifically nanocrystalline and microcrystalline diamond and carbon nanotubes are being investigated for sensing neurological fluids, as alternatives to conventional pre-treated glassy carbon (GC) and carbon paste materials. Diamond may be much superior in terms of its stability and low capacitive background current, but exhibits slow electron transfer kinetics for redox reactions involving adsorption related analytes. Carbon nanotubes rely on defect states present within the walls for electron transfer. Although GC yet remains superior in terms of its fast electron transfer kinetics, the extensive surface pre-treatments and the fouling of its surface with time makes it unattractive for in vivo applications. Graphite could be very attractive for electrochemical detection provided one can make predominant use of its edge planes only.

We present the synthesis and electrochemical characterization of two new forms of crystalline carbon at the nanoscale, i.e., nanocrystals of graphite (NCG) and carbon nanopipettes. They are both morphological manifestations of nanocrystalline graphite.

Carbon nanopipettes are made up of a central nanotube (~10-20 nm) surrounded by helical sheets of graphite. This gives the nanopipettes an outer conical structure, with a base of about a micron, which narrows down to a tip of about 10-20 nm [1]. These nanopipettes have a central hollow core, with both ends open. We have been able to synthesize them in the form of arrays. Due to their unique morphology, the outer surfaces of the nanopipettes continuously expose edge planes of graphite, making them attractive for electrochemical nanosensors (see Fig. 1).

Similarly, NCG are 2D (or 3D) forms of graphite with grain size of 10 nm, hence have large density of edge-plane sites versus basal-plane sites. Thus, they should be particularly reactive toward electrochemical reactions involving chemisorption. Examples include redox reactions involving catechols and quinones. Electrochemical results using several biologically important analytes such as dopamine, serotonin, catechol, 4-methyl catechol, and hydroquinone support the hypothesis that nanocrystals of graphite would behave similar to edge planes of crystalline graphite. The as-synthesized material did not require any electrochemical pre-treatment; however occasionally, a one-time anodic oxidation did improve the kinetic rate for the catechol- and quinone-related electron transfer reactions. The electrochemical response of the electrodes (NCG and carbon nanopipettes) was stable even after one year of storage time. These electrodes yielded clearly resolvable peaks in the voltammograms for the analytes at concentration levels similar to those of extracellular neural fluids (See Fig. 2). These results demonstrate that the electrode material is suitable for *in vivo* biological applications.

References:

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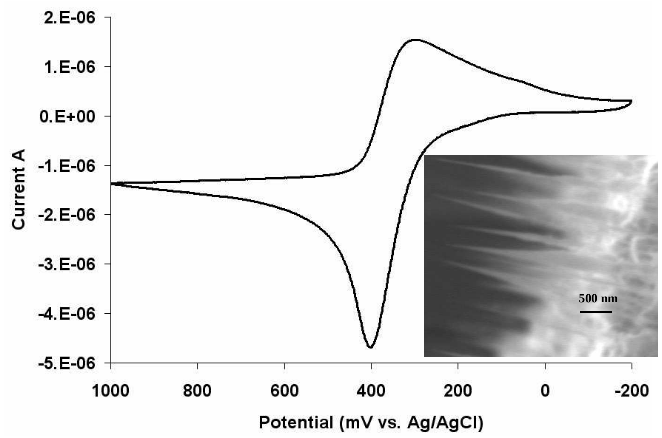

Figure 1. Cyclic Voltammetry of 1mM of Dopamine in 0.1 M KCl at 100 mV/s at an electrode with an array of nanopipettes as shown in the inset

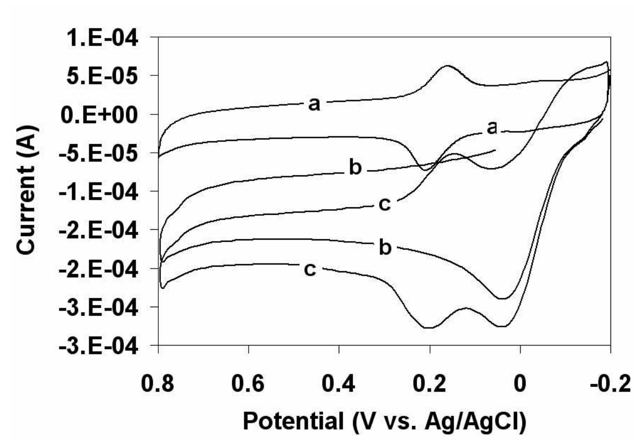

Figure 2. Cyclic Voltammetry of 10mM ascorbic acid and 0.1 mM dopamine in pH 7 phosphate buffer solution at the NCG electrode surface. a-only dopamine b-only ascorbic acid c-mixture of the two