Electrochemical and Spectroelectrochemical Investigations of Cytochrome c at Optically Transparent Diamond Thin-Film Electrodes - S. Haymond, Z. Cvackova, J. Butler, Y. Show, and G. Swain (Michigan State University)

No other material shows as much versatility as an electrode as does electrically conducting diamond. The material can be used in electroanalysis to provide sensitive detection of analytes with superb precision and stability; high current density electrolysis (1-10 A/cm^2) in aggressive solution environments without any microstructural or morphological degradation; and spectroelectrochemistry as an optically transparent electrode.

We recently demonstrated that boron-doped diamond thin-film electrodes are quite responsive for horse heart cytochrome c without any pretreatment or activation procedure (1). Heterogeneous electron transfer rate constants in the mid to high 10^{-3} cm/s range are typical for the H-terminated surface. The voltammetric peak currents change linearly with the concentration and, importantly, there is no electrode fouling. The results, observed for a hydrogen-terminated and uncharged surface, raise some interesting questions about the necessary surface interactions of the protein for relatively rapid electrode kinetics.

Figure 1 shows cyclic voltammetric i-E curves for a 100 µM solution of cytochrome c containing 50 mM NaCl and 1 mM Tris at pH 7. The potential was initially scanned negatively from 0.30 to –0.20 V at 0.020 V/s. Data are presented for scans between 1 and 15 at an acid-washed, rehydrogenated microcrystalline (10 ppm) diamond electrode. A well defined voltammetric response is observed that is stable with cycling.

Diamond also functions remarkably well as an optically transparent electrode in the UV/Vis (2,3). UV/Vis and IR electrochemical difference spectra (transmission mode) were measured for cytochrome c using optically transparent diamond electrodes. A free-standing, mechanically polished, boron-doped diamond disk (380 µm thick and 8 mm in diameter) served as the optically transparent electrode (OTE) for the UV/Vis spectroelectrochemical measurements. The OTE for the IR measurements consisted of a diamond thin film (2 µm thick) deposited on an undoped Si wafer. The electrochemical difference spectra measured at diamond OTEs are in good agreement with spectroelectrochemical studies of the protein reported for conventional OTEs (e.g., ITO and Au minigrid).

The presentation will discuss (i) the voltammetric measurements of cytochrome c at both boron-doped microcrystalline and nanocrystalline diamond films, and (ii) spectroelectrochemical investigations of the protein using diamond OTEs in both the UV/Vis and IR regions of the spectrum.

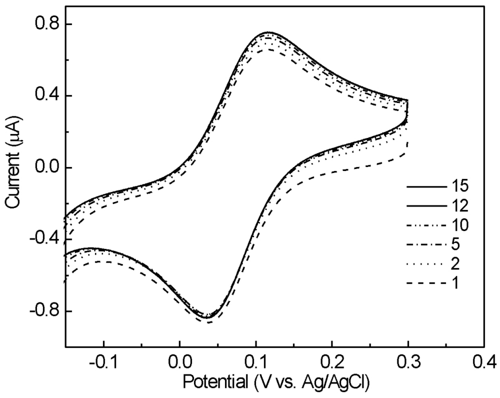

Figure 1. Demonstration of the cyclic voltammetric response stability for cytochrome c at a microcrystalline boron-doped diamond electrode. The numbers in the legend represent the scan number. Electrode area = 0.2 cm^2.

References

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