Analysis of Organics in Water Using Boron-Doped Diamond Electrodes

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The determination of organics in aqueous solutions is an important environmental issue in water and wastewater treatment monitoring. It is also a key requirement for the monitoring of several industrial processes. For that purpose, direct electrochemical oxidation might enable a simple and fast method. In many cases, however, the direct oxidation of organic species in aqueous solutions using simple metal or carbon electrode is not possible because the high potentials required usually result in the oxidation of water. Boron-doped diamond electrodes exhibit a wide potential window of water stability, low background currents and high stability under strongly oxidizing conditions and permit investigations of previously inaccessible chemistries. In this report, a boron-doped diamond electrode was used for the electrochemical determination of glucose and ethanol in water and an organic additive, commonly used in copper electro deposition baths.

Boron-doped diamond films fabrication is described in reference [1]. Electrochemical measurements were made in a conventional three-electrode cell using an Ag/AgCl reference electrode. The variation in the oxidation current for glucose and ethanol at a diamond electrode is plotted in Figure 1 as a function of the chemical oxygen demand (COD). The COD is defined as the amount of oxygen equivalents consumed in the oxidation of the organic compound. The measurement was performed by measuring the current at a potential of +2.15 V in a 0.05 M K_2SO_4 solution containing various glucose and ethanol compositions respectively. A linear relationship is obtained for glucose and ethanol concentrations up to 0.2 and 0.06 g/L respectively. The plots of Figure 1 may be used as a calibration curve to determine glucose and ethanol concentration respectively.

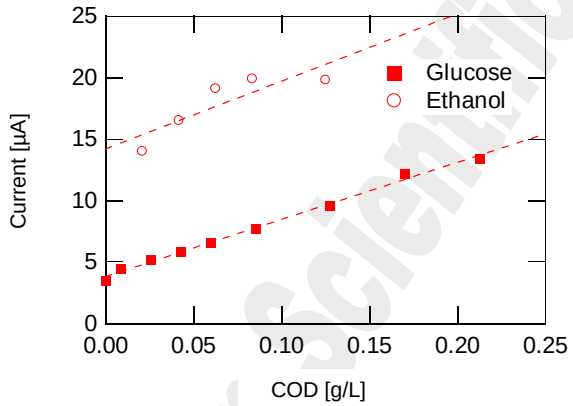

Figure 1
Amperometric measurements performed on a boron-doped diamond electrode in a 0.05 M K_2SO_4 solution containing various glucose and ethanol concentrations

Organic additives are commonly used in plating electrolytes for improving deposit performance. A successful plating process requires close monitoring of their respective concentrations. Figure 2 compares cyclic voltammograms measured at 100 mV/s on a platinum and diamond electrode in a copper electrolyte without additive (0.24 M $CuSO_4$, 1.8 M H_2SO_4). The working potential window for diamond, up to +2.5 V is considerably wider than the one on platinum where water decomposition occurs at potentials more anodic than +1.5 V. In addition, a much smaller background current density is observed on diamond compared to platinum. In Figure 3, voltammograms are shown on the diamond electrode for the same electrolyte containing 300 mg/L polyethylene glycol (PEG), 1 mg/L disodium (bis(3-sulfopropyl)) (SPS) and several concentrations of diethyl safranine azo dimethyl aniline (JGB). A plot of the current plateau measured at +1.7 V electrode as a function of the JGB concentration shows a linear dependence within the concentration range studied.

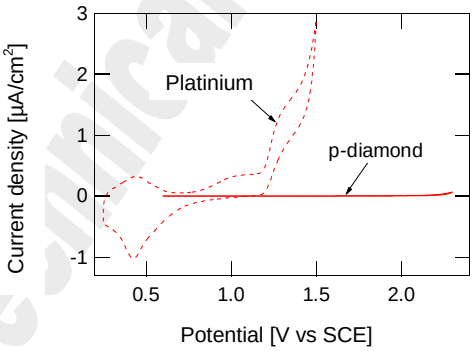

Figure 2
Voltammograms measured on platinum and boron-doped diamond of a 0.24 M $CuSO_4$ / 1.8 M H_2SO_4 electrolyte

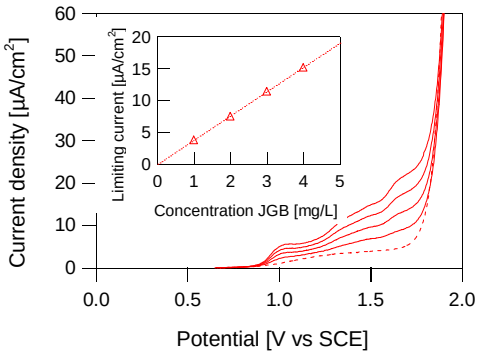

Figure 3
Voltammograms measured on a boron-doped diamond electrode of a 0.24 M $CuSO_4$ / 1.8 M H_2SO_4 electrolyte containing 300 mg/L PEG, 1 mg/L SPS and various JGB concentrations

The present investigation demonstrates the advantages of boron-doped diamond electrodes for the determination of organic additives contained in plating electrolytes and organics in water. The results hold promise for COD analysis in water using diamond electrodes.

[1] D. Gandini, P.A. Michaud, I. Duo, E. Mahé, W. Hänni, A. Perret, "New Diamond and Frontier Carbon Technology", Ed. MYU Tokyo, JP, 9/5 (1999) 303