

Electrochemical Synthesis of Inorganic and Organic Compounds with Boron Doped Diamond Electrodes

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For several years, electrochemical properties of synthetic, polycrystalline, in-situ boron-doped and nitrogen/boron co-doped diamond films have been studied. Electrically conducting, boron doped diamond coatings of about 0.1 to 1 μm thickness on 1 $\text{m}\Omega\text{cm}$ p-Si plates, on Nb- and most recently also on Ti- and Zr-sheets (DiaChem®-Electrodes) have shown outstanding electrochemical properties with the largest window ever seen. It permits the total oxidation to carbondioxide and water of up to now all tested organic compounds as well as some inorganics like cyanides and ammonia even before oxygen revolution. [1] The reactivity can be associated with the production of hydroxyl radicals at the electrode surface.

This hydroxyl radical formation allows also the production of very strong oxidants like chlorine [2], ozone[2], hydrogen peroxide, persulfate [3,4], chromium (III-VI) and even silver (I-II) at high purity and especially high yield. Recently, it could also be shown that specific organics can be produced with high selectivity at interesting yield.

Chlorine can be produced in a loop controlled system in concentrations of 0.02 to 10 ppm in water with remaining chloride-ion concentrations starting from some ppm up to 500 ppm for disinfection of drinking and swimming pool water. BDD/Si electrodes showed also the highest yield for the chlorine production, in comparison to platinum and DSA's, in highly concentrated salt solutions up to 18 g/l.

Ozone can be produced and may be produced also in a loop-controlled system in near future with BDD/Si electrodes for the production of fully disinfected water for the pharmaceutical and food industry. Ordinary pem-cells equipped with BDD/Si electrodes show an increased production level of a factor of 2 compared to actual cells working with PbO_2 electrodes. The supplementary advantages of BDD/Si are: any use of a battery remaining a constant potential, any influence if water disappears as well as no fouling at all.

Persulfuric acid can be produced with at least a five time higher efficiency with almost any metallic contamination

somewhat higher quality than with platinum electrodes. See Table I.

Phenol can be oxidized to benzoquinone with only a very small amount of intermediates like hydroquinone and catechol. In non-optimized conditions the linear decreasing phenol concentration at a constant current density reveals a linear increasing of benzoquinone concentration even if more than 60 % of phenol has been transformed. See figure 1.

There is no consumption of BDD/Si-electrode at all throughout all tested cases.

References

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Electrodes	H2SO4 mol/l	Current density A/m2	Current efficiency
p-Diamond	1.0	300	47 %
p-Diamond	7.5	2'000	64 %
p-Diamond	7.5	2'000	75 %
Platinum	1	10'000	5 %
Platinum	7.5	10'000	76 %

Table I. Typical current density and current efficiency for platinum and p-diamond electrodes for the production of peroxy-disulfuric acid

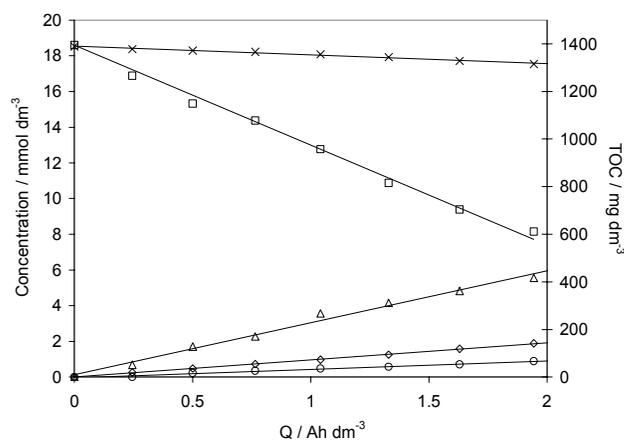


Fig. 1 Variation of the concentration of: (□) phenol, (Δ) benzoquinone, (◇) hydroquinone, (○) catechol, and (×) TOC during the electrolyses of phenol on boron-doped diamond anode. Electrolyte: 1M HClO_4 ; initial phenol concentration=20 mM; $T=25^\circ\text{C}$; $i=5 \text{ mA cm}^{-2}$, anode potential $E=2.5 \pm 0.1 \text{ V vs. SHE}$.