ELECTROCHEMICAL WATER TREATMENT WITH BORON-DOPED DIAMOND ELECTRODES

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Thin-Film Boron-Doped Diamond coatings on boron-doped silicon substrates (BDD/Si) technology by means of a large-area hot-filament CVD process has been developed extensively for use as an innovative and efficient electrode material mainly for promoting electrochemical water treatment applications.

The interesting properties of this new electroactive material, regarding electrochemical behavior from the anodic as well as cathodic point of view, the extremely high chemical and mechanical stability as well as the largest known electrochemical window are well-recognized conditions for an electrode for potential water treatment like disinfection and reduction of Chemical Oxygen Demand (COD) [1]. These electrodes, as previous tests have demonstrated, have an outstanding production capacity of strong chemical oxidizing agents in water like hydroxyl radicals. They also seem to be responsible for the electrochemical production of other strong oxidants on BDD/Si-electrodes like chlorine, ozone, peroxo-disulfates, peroxo-dicarbonates and hydrogen peroxide in many kinds of water, i.e. seawater, waste water, fresh water or even ultra pure water.

The BDD/Si-electrodes are manufactured in circular or square plates of 1 to 2 mm thickness with a resistivity ranging from 1 to 100 mΩcm, coated either on one or on both sides with BDD of 0.5 to 2 µm thickness at a resistivity of 10 to 100 mΩcm. They are used in a specially designed electrochemical cell (DiaCell®), which is part of a pilot plant operating with a tank of 1 m^3 capacity, including pump and instrumentation (see Fig. 1). To limit fouling of the electrodes, a polarity reversal is carried out in cycles depending on the concentration of pH-sensitive salts, e.g. calcium and magnesium, and/or on organic fouling at one polarity. The electrodes are self-cleanable as the fouling is dissolved on the opposite polarity electrode surface.

For disinfection demonstration, mainly three typical water qualities (pool water, ballast water, drinking water) have been evaluated. In comparison, the new BDD/Si-electrode technology has been tested together with the traditional sodium hypochlorite (NaOCl) method using different spiked microbiological populations (i.e. Legionnella, Bacteria H40, Adenovirus, E.coli, Vibrio fischerii, Pyrocystis fusiformis protozoan etc.) [2]. Total disinfectant concentrations are measured by the typical DPD (Diethyl-Para-Phenylenediamine) method. The activity of the microorganisms is analyzed by counting the colony-forming units and by bioluminescence measurements in the case of *Vibrio fischerii* bacteria and *Pyrocystis fusiformis* protozoan. Fig. 2 shows the effect on bacteria H40.

The treatment of highly organic waste water shows very interesting effectiveness and needs for rather low COD reduction to enhance the biodegradability. As is shown, for typical organics contents, i.e. benzene sulfonates, it is important to achieve electrochemical COD reductions in the range of 10-15 %, at an optimum peak of biological degradation. The actual effectiveness lies in the range of 95 to 100 % at COD concentrations of >0.5 g/l. Due to the electrochemical pretreatment with a DiaCell® at an electrical charge of approx. 10 Ah/l the biodegradability could be improved under laboratory conditions at 25°C from 0 (untreated solution) up to 4 g CO_2/dl of waste water. The biodegradability was evaluated by measuring the CO_2 content of the solution produced by multiple populations of bacteria.

References:
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2. L. Pupunat, Ph. Rychen, M. A. Fontecha-Camara, W. Haenni, B. Klaus, P. Rossi, Proceedings First International Conference on Ballast Water Management, Singapore, Nov. 2001

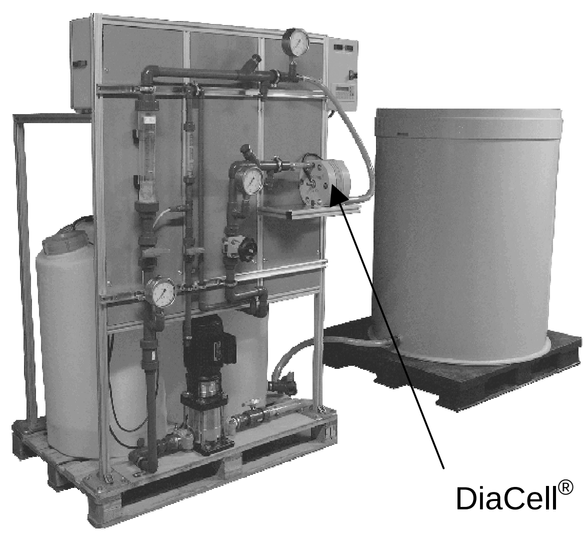

Fig. 1 The Pilot plant with the DiaCell®

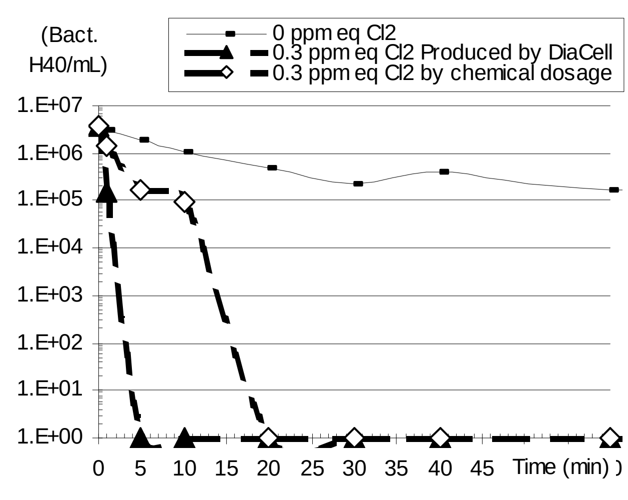

Fig. 2 Bacteria H40 inactivation after injection in a solution produced from artificial seawater through the DiaCell® and after chemical dosage