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A Microbial Fuel Cell Equipped with a Denitrifying Biocathode Effectively Degrades the Toxic Carbon Tetrachloride

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ABSTRACT

Carbon tetrachloride (CT) is one of the toxic chlorinated solvents frequently observed at many contaminated sites. While a number of bioreactors have been developed for CT reduction, reduction using a biologically active cathode (biocathode) within a microbial fuel cell (MFC) is a novel and potentially cost-effective approach. Biocathodes harness the capacity of specific microorganisms to accept electrons from a solid surface (cathode). High-rate oxygen reduction without a platinum catalyst has been accomplished using biocathodes, as well as reduction of chlorinated groundwater pollutants. An advantage of such a process would be the oppotunity for electrical energy recovery from the treatment process. The aim of this work was to design and operated a MFC equipped with a denitrifying biocathode (MFC-DN) in the perspective of carbon tetrachloride reduction from polluted effluents.

The MFC-DN consisted of two plexiglass cubic chambers of 3 cm. Each electrode compartment was filled with small graphite cubes (3 mm x 3mm). The anode and cathode compartments were separated by a proton exchange membrane (Nafion 117). The anode chamber was loaded of 12 mL of biocatalyst (enriched inoculum, E-In) that was cultured in an acetate-ferric citrate medium. The cathode chamber was seeded with a mixed culture of denitrifying bacteria sampled from a denitrifying lab-scale reactor acclimated to CT. A synthetic wastewater containing potassium buffer salts, Na_2CO_3, and KNO_3 was fed to the cathode chamber. The CT concentration within the cathode of the MFC-DN was 10 mg/L.

In the characterization experiment, the R_{int} of MFC –DN was 1450 Ω with a maximum cell voltage of 230 mV. This relatively high value of R_{int} is typical in two-chamber MFCs. The values of P_v and P_S of the MFC were 772 mW/m^3 and 23 mW/m^2, respectively, where P_S is the power density expressed on the basis of projected surface area of membrane.

During the batch operation the average voltage of the MFC-DN was 132 mV, whereas average P_v and P_S were 11 620 mW/m^3 and 35 mW/m^2. A 100% CT depletion in the cathodic liquor was observed in the first 12 h of the run, which is equivalent to a removal rate higher than 20 mg CT/(L.d). In both experiments. abiotic removal of CT by sorption to the electrode graphite cubes (anodic and cahtodic) was negligible as determined by headspace GC-FID. We can conclude that a MFC-DN shows promise for the bioelectrochemical remediation of waters polluted with CT.

Keywords: Biocathode, Carbon Tetrachloride, Microbial Fuel Cell