The Fifth International Symposium on Environmental Biotechnology and Engineering
July 2016 - Buenos Aires, Argentina

Synthesis and application of graphene based electrodes in bioelectrochemical systems

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Bioelectrochemical systems (BES) allow to obtain energy from microbial metabolism. These systems are based on the ability of certain microorganisms, such as bacteria of the genus Geobacter, to form biofilms on solid surfaces, which are used as final electron acceptors of cellular respiration. Thus, these microorganisms called electrogenic, oxidize organic compounds and transfer electrons to an external acceptor which can be used as anode in an electrochemical cell. Currently, BES represent a promising approach to capture the chemical energy present in various effluents and its transformation into storable energy, such as H_2 or CH_4. In consequence, the actual costs of effluent treatments can be reduced. Additionally, there has emerged a new generation of BES aimed at various functions such as desalination, electrosynthesis and remediation of contaminated sediments. However, the development of this technology has been hampered mainly by the low rate of charge transfer to the electrodes. For this reason, various materials that are able to overcome this limitation are under study. Among these materials, graphene has aroused great interest in the area.

The aim of this work was to develop electrodes that allow the development of biofilms of electrogenic bacteria to be used in BES. Therefore, we prepared electrodes employing bidirectional carbon fabric coated with graphene. Graphene was synthesized from the reduction of graphite oxide with ascorbic acid. We performed cytotoxicity assays with this material over *Geobacter sulfurreducens* and *E. coli* JM 109 pure cultures. This material did not alter cell viability in any case. Thus, we proceeded to use the electrode as an anode in microbial electrolysis cells. For this purpose, three electrode systems were assembled using platinum wire as counter electrode and an Ag/AgCl reference electrode. We performed a first characterization of the electrodes by cyclic voltammetry and then the working electrode was polarized at 0.24 V. The electrolysis cells were inoculated 24 hours later with a pure culture of *G. sulfurreducens*. The current production was monitored by chronoamperometry at 0.24 V until a stable current was reached. The results showed that the rate of adhesion of bacteria to graphene-based electrode was similar to that of a standard graphite electrode. However, the current reached with graphene electrode during the growth phase of the biofilm was five times higher than that of the graphite electrode. The biofilms were observed by scanning electron microscopy. In conclusion, the proposed material proved to be highly efficient in the electrochemical system tested.

Keywords: Bioremediation, Bioenergy, Electrogenic biofilm, Wastewater.