Bioelectrochemical systems for coupled wastewater treatment and energy production

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In a world where the global population, annual worldwide energy demand and consumption of fossil fuels are steadily increasing, employing a cheap, environmentally friendly, and unlimited energy source from renewable feedstocks is one of the main challenges for humanity today, as is the transition to energy and environmentally sustainable alternatives. The fish processing industry produces considerable volumes of wastewater characterised by a high concentration of organics that are suitable for recovery and valorisation, including proteins and fatty acids, and pollutants. Downstream the recovery processes, the organic content is still high, and further treatments are necessary. In this context, the use of **Bio-Electrochemical Systems** (BESs) could be considered with simultaneous production of energy or hydrogen and treatment of wastewater.

The aim of the present work is evaluating the efficiency and potentiality of an innovative tubular BES systems with slip-casted ceramic membranes serving as separator in degrading organic pollutants from fish industry effluents while enhancing both energy and fuels production. The systems feature a high-surface-area carbon felt anode and a carbon cloth cathode coupled with a brush-painted catalytic ink. Such design was chosen for its scalability, robustness, and compatibility with low-cost fabrication methods. The cells were tested under fed-batch mode and different experimental conditions. Several analytical techniques, i.e. polarization experiments, Electrochemical Impedance Spectroscopy (EIS), Cyclic Voltammetry (CV) and Total Organic Carbon (TOC), were employed for cells characterization. System performance was notably influenced by a range of parameters: specifically, the degree of biofilm formation and the extent of anode surface availability were found to play a pivotal role in improving organic substrate degradation, overall treatment performance and both fuels and power production. The findings contribute to the advancement of BES technologies as viable alternatives for sustainable wastewater management and energy production.

Keywords: *Bio-electrochemical systems, fish industry wastewater, Microbial Fuel Cells, Microbial Electrolytic Cells, energy production, hydrogen.*

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