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Efficient Treatment of Azo Dye Wastewater with Simultaneous Energy Generation by Microbial Fuel Cell

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Abstract : The textile industry consumes a substantial amount of water throughout the processing and production of textile fabrics. The water eventually turns into wastewater, where it acts as an immense damaging nuisance due to its dye content. Wastewater streams contain a percentage ranging from 2.0% to 50.0% of the total weight of dye used, depending on the dye class. The management of dye effluent in textile industries presents a formidable challenge to global sustainability. The current focus is on implementing wastewater treatment technology that enable the recycling of wastewater, reduce energy usage and offset carbon emissions. Microbial fuel cell (MFC) is a device that utilizes microorganisms as a bio-catalyst to effectively treat wastewater while also producing electricity. The MFC harnesses the chemical energy present in wastewater by oxidizing organic compounds in the anodic chamber and reducing an electron acceptor in the cathodic chamber, thereby generating electricity. This research investigates the potential of MFCs to tackle this challenge of azo dye removal with simultaneously generating electricity. Although MFCs are well-established for wastewater treatment, their application in dye decolorization with concurrent electricity generation remains relatively unexplored. This study aims to address this gap by assessing the effectiveness of MFCs as a sustainable solution for treating wastewater containing azo dyes. By harnessing microorganisms as biocatalysts, MFCs offer a promising avenue for environmentally friendly dye effluent management. The performance of MFCs in treating azo dyes and generating electricity was evaluated by optimizing the Chemical Oxygen Demand (COD) and Hydraulic Retention Time (HRT) of influent. COD and HRT values ranged from 1600 mg/L to 2400 mg/L and 5 to 9 days, respectively. Results showed that the maximum open circuit voltage (OCV) reached 648 mV at a COD of 2400 mg/L and HRT of 5 days. Additionally, maximum COD removal of 98% and maximum color removal of 98.91% were achieved at a COD of 1600 mg/L and HRT of 9 days. Furthermore, the study observed a maximum power density of 19.95 W/m3 at a COD of 2400 mg/L and HRT of 5 days. Electrochemical analysis, including linear sweep voltammetry (LSV), cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS) were done to find out the response current and internal resistance of the system. To optimize pH and dye concentration, pH values were varied from 4 to 10, and dye concentrations ranged from 25 mg/L to 175 mg/L. The highest voltage output of 704 mV was recorded at pH 7, while a dye concentration of 100 mg/L yielded the maximum output of 672 mV. This study demonstrates that MFCs offer an efficient and sustainable solution for treating azo dyes in textile industry wastewater, while concurrently generating electricity. These findings suggest the potential of MFCs to contribute to environmental remediation and sustainable development efforts on a global scale.

Keywords : textile wastewater treatment, microbial fuel cell, renewable energy, sustainable wastewater treatment
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