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Microbial fuel cell: Critical factors regulating bio-catalyzed electrochemical process and recent advancements

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ABSTRACT

Microbial fuel cells (MFC) are bio-catalyzed electrochemical hybrid systems which function by converting chemical energy to electrical energy through a cascade of redox reactions in the presence of biocatalyst. The research on MFC has been intensified in the last few years due to its inherent ability to produce sustainable energy from renewable organic waste. The current review depicts an overview on the fundamental operational mechanism of MFC encompassing electromotive force, electron delivery, electron transfer, losses encountered during operation, etc. The specific function of physical, biological and operational factors on the bioelectrogenic activity is elaborated. In addition, the strategies to regulate the process towards enhancing the performance of the system have been discussed. The potential applications of MFC for energy generation, waste remediation and value added product recovery have also been elaborated.

Contents

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1. Introduction

Microbial fuel cell (MFC) is a bio-catalyzed electrochemical system which can directly convert chemical energy from an organic substrate to electrical energy through a cascade of redox reactions [1–7]. The microbial metabolism is linked via electron donating and accepting conditions through the artificially introduced electrodes (anode and cathode), that induces the development of potential difference which acts as a net driving force for bioelectrogenic activity [8–11]. MFC can utilize a wide range of soluble or dissolved complex organic wastes/wastewater and renewable biomass as substrate that further offers the dual benefits of renewable energy generation in the form of bioelectricity with simultaneous waste/pollutant remediation, which makes the process eco-friendly [12–14]. MFC is gaining profound interest and importance in the present bioenergy research due to its innate potential and sustainable nature. Reports on MFCs were sparsely noticed from 1994, however considerable impact is being noticed since 2003 (Fig. 1) [15]. The citations also increased rapidly in the recent years indicating the relevance and importance of the research on MFC. Studies on MFC using wastewater were more focused since 2004 and it was evident that wastewater is a potential substrate for bioelectricity generation. Research on MFC could pave a way in the field of renewable energy generation that could answer several complex environmental pollution problems and the energy crisis with a unified approach [5,6,10]. Apart from harnessing power, MFC has documented other applications viz., bioelectrochemical treatment system (waste remediation), bioelectrochemical system (bioelectrosynthesis of various value added products) and microbial electrolytic cell (H_2 production at lower applied potential) [6,7].

MFCs are featured simple, yet governed by various crucial parameters that regulate their performance. In an MFC, there exists a need to depend on several factors like physical, physico-chemical, chemical, biological, electrochemical, etc., which will essentially influence the rate of microbial electron transfer and power output [13]. Physical factors that significantly govern the MFC performance are of vital importance in MFC. The reactor configuration influences the biocatalyst activity and various

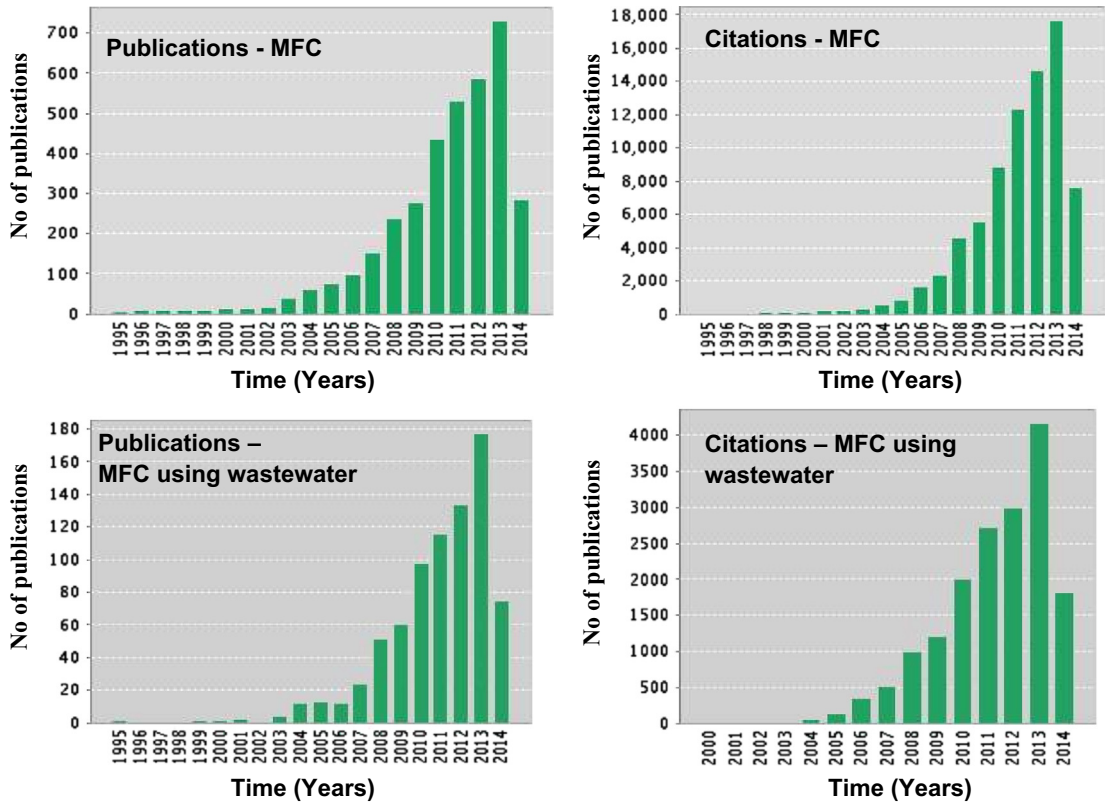

Fig. 1. Scientometric evaluation of the microbial fuel cell (MFC) research pertaining to the publications and citations (ISI Web of Knowledge; Keywords: microbial fuel cell and wastewater (as on 25th May 2013)).