Bioresource Technology 124 (2012) 23–28

Contents lists available at SciVerse ScienceDirect

Bioresource Technology

journal homepage: www.elsevier.com/locate/biortech

Use of non-native phenazines to improve the performance of *Pseudomonas aeruginosa* MTCC 2474 catalysed fuel cells

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HIGHLIGHTS

- Addition of non-native phenazines improved the *Pseudomonas aeruginosa* 2474 catalysed MFC.
- Native phenazines inhibited microbial growth and MFC power generation.
- With Cu^{2+}-GECE (anode) in oxychloraphin supplemented MFC, power output was 7.8 mW/m^2.

ARTICLE INFO

Article history:
Received 26 May 2012
Received in revised form 5 August 2012
Accepted 10 August 2012
Available online 17 August 2012

Keywords:
Microbial fuel cell
Phenazines
Electrode
Open circuit potential
Power density

ABSTRACT

One of the bottlenecks to performance of microbial fuel cells (MFC) has been the low electron transfer from bacterial cell membrane or membrane organelle to anode. In this study, the effect of phenazines, a class of secondary metabolites was examined on the power generation in *Pseudomonas aeruginosa* MTCC 2474 catalysed MFC with graphite electrodes. Different metal salt-doped graphite epoxy composite electrodes (MS-GECE) were tested in phenazine supplemented MFC. With Cu^{2+}-GECE as anode in oxychloraphin and tubermycin supplemented MFC, power density generated was 7831 ± 112.5 and 2096.5 ± 11.8 μW/m^2 respectively. However, the addition of native phenazines (pyocyanin and pyorubin) which are normally produced by the bacteria was not very helpful in performance of the MFC. Also, the addition of these phenazines inhibited the growth of bacteria as well. Thus, choice of an appropriate secondary metabolite can have a positive influence as a mediator of electron transfer in the working of MFCs.

1. Introduction

Microbial fuel cells (MFCs) are devices to generate electricity using microorganisms as catalysts to oxidise any suitable substrate. For sustainable power generation microorganisms will have to capture electrons from the substrate and divert them both for their metabolic needs as well as to an anode with reasonable efficacy. MFCs can be classified into two groups depending on how electrons are transferred from the microorganisms to the anode: in mediator-using MFCs electron shuttles or mediators are added to the system, while in mediator-less MFCs no extraneous mediators are added. Typical synthetic exogenous mediators used for enhancing the electron transfer rate in MFC are dyes such as neutral red (Park and Zeikus, 2000), methylene blue (Ieropoulos et al., 2005), 2-hydroxy-1,4-naphthoquinone (HNQ) (Tokuji and Kenji, 2003) and metallorganics such as Fe(III)EDTA (Vega and Fernandez, 1987). In mediator-less MFCs, the microorganisms typically employ electrochemically active membrane-associated cytochromes, conductive pili or secreted redox-mediating molecules that facilitate electron transfer. Examples of such microorganisms include metal reducing bacteria *Geobacter metallireducens* (Bond and Lovley, 2003), *Rhodoferax ferrireducens* (Chaudhuri and Lovley, 2003), *Shewanella putrefaciens* (Kim et al., 2002), *Clostridium butyricum* (Park et al., 2001) and *Aeromonas hydrophila* (Pham et al., 2003 and Ustak et al., 2007). For example, in a consortium of *Alcaligenes faecalis, Enterococcus faecium* and *Pseudomonas aeruginosa* secreted soluble redox shuttles are important for power generation (Rabaey et al., 2004).

Whenever there is a high internal resistance leading to low electron transfer rates from the bacterial catalysts to the anode the power generated in MFCs is vastly reduced (Park and Zeikus, 2003). Direct electron transfer between a membrane-bound redox proteins and an electrode is hindered by the peptide chain adjoining the active redox centre of the protein (Kim et al., 1999). In such a scenario, addition of exogenous mediators could be helpful. However, such a solution can have some inherent disadvantages. Toxicity and instability of the added mediators can limit their applications in MFCs (Gill et al., 2003 and Jang et al., 2004). One possible solution could be to use native electron shuttles produced

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http://dx.doi.org/10.1016/j.biortech.2012.08.034