Bioresource Technology 125 (2012) 291–299

Contents lists available at SciVerse ScienceDirect

Bioresource Technology

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

Microaerophilic microenvironment at biocathode enhances electrogenesis with simultaneous synthesis of polyhydroxyalkanoates (PHA) in bioelectrochemical system (BES)

S. Srikanth, M. Venkateswar Reddy, S. Venkata Mohan *

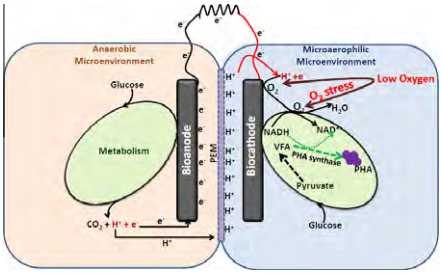
Bioengineering and Environmental Centre (BEEC), CSIR-Indian Institute of Chemical Technology (CSIR-IICT), Hyderabad 500 607, India

HIGHLIGHTS

- Microaerophilic microenvironment was evaluated as terminal electron acceptor in BES.
- Microbial accumulation of polyhydroxyalkanoates (PHA) at biocathode was observed.
- Electron losses reduced due to synergistic association between anode and biocathode.
- Gradual substrate degradation was observed due to controlled microbial metabolism.
- Redox catalytic currents and bio-electro kinetics supported the bio-electrogenesis.

GRAPHICAL ABSTRACT

Considering the microaerophilic microenvironment at biocathode in bioelectrochemical system (BES) will enhance the electrogenesis and reduce the losses due to the controlled microbial metabolism and simultaneously provides a chance to harness polyhydroxyalkanoates (PHA). The electrogenic activity (512 mV; 15.2 mW/m^2) was extended for longer periods (144 h) which might be attributed to the lowering of losses due to the controlled microbial metabolism. Growth limiting stress at cathode due to lower oxygen levels and its effective utilization by the protons and electrons coming from anode, might have diverted the microbial metabolism towards PHA synthesis instead of oxidation. PHA accumulation (19% of dry cell weight (DCW)) was observed with higher hydroxy butyrate (HB) (89%) concentration at 48th h in the cathodic biocatalyst and was re-utilized by the end of experiment. Bio-electro kinetics studied through voltammetry and Tafel analysis further supported the observed electrogenesis in microaerophilic reduction microenvironment, in terms of redox catalytic currents, Tafel slopes, exchange current densities and polarization resistance.



ARTICLE INFO

Article history:
Received 4 May 2012
Received in revised form 13 August 2012
Accepted 15 August 2012
Available online 3 September 2012

ABSTRACT

Microaerophilic microenvironment at biocathode was evaluated for electrogenesis along with the polyhydroxyalkanoates (PHA) accumulation in bio-electrochemical system (BES). The electrogenic activity (512 mV; 15.2 mW/m^2) was extended for longer periods (144 h) which might be attributed to the lowering of losses due to the controlled microbial metabolism. Growth limiting stress at cathode due to lower oxygen levels and its effective utilization by the protons and electrons coming from anode, might

Abbreviations: AO, activation overpotentials; BES, bio-electrochemical systems; C, charge (Coulumbs); COD, chemical oxygen demand; Co-polymer, poly (β-OH) butyrate-*co*-poly (β-OH) valerate, P3 (HB-*co*-HV); CP, concentration polarization; CV, cyclic voltammetry; DCW, dry cell weight; DO, dissolved oxygen; DSW, designed synthetic wastewater; E, applied voltage (V); e$^-$, electrons; ED, electron discharge; Emf, electron motive force; H$^+$, protons; I, current (mA/A); i_o, exchange current density (mA/m^2); ln i_o, logarithm of the exchange current density; MFC, microbial fuel cell; OCV, open circuit voltage (V); OL, ohmic losses; OLR, organic loading rate (Kg COD/m^3-day); PD, power density (mW/m^2); PHA, polyhydroxyalkanoates; PHB, polyhydroxy butyrate (poly(β-OH) butyrate); PHV, polyhydroxy valerate (poly(β-OH) valerate); R_{ct}, charge transfer resistance (Ω); R_p, polarization resistance (Ω); SDR, substrate degradation rate (Kg COD_R/m^3-day); TDS, total dissolved solids (mg/l); TEA, terminal electron acceptor; TEAP, terminal electron accepting process; V, voltage (V); VFA, volatile fatty acids (mg/l); α_a, electron transfer coefficient during oxidation (β_aRT/nF); α_c, electron transfer coefficient during reduction (β_cRT/nF); β_a, oxidative Tafel slope (V/dec); β_c, reductive Tafel slopes (V/dec).

* Corresponding author. Tel/fax: +91 40 27161664.
E-mail address: vmohan_s@yahoo.com (S. Venkata Mohan).

0960-8524/$ - see front matter
http://dx.doi.org/10.1016/j.biortech.2012.08.060