Bioresource Technology 119 (2012) 362–372

Contents lists available at SciVerse ScienceDirect

Bioresource Technology

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

Acid azo dye remediation in anoxic–aerobic–anoxic microenvironment under periodic discontinuous batch operation: Bio-electro kinetics and microbial inventory

S. Venkata Mohan [a,*], P. Suresh Babu [a], K. Naresh [a], G. Velvizhi [a], Datta Madamwar [b]

[a] Bioengineering and Environmental Centre (BEEC), CSIR-Indian Institute of Chemical Technology (CSIR-IICT), Hyderabad 500 607, India
[b] BRD School of Biosciences, Sardar Patel University, Satellite Campus, Vallabh Vidyanagar 388 120, India

HIGHLIGHTS

- ▶ C.I. Acid black 10B degradation was studied in periodic discontinuous batch operation.
- ▶ Anoxic–aerobic–anoxic microenvironment showed good removal of azo dye.
- ▶ Azo-reductase and dehydrogenase activity were monitored during dye degradation.
- ▶ Tafel analysis and bioprocess parameters correlated well with dye removal.
- ▶ Presence of specific organism capable of dye degradation was observed.

ARTICLE INFO

Article history:
Received 26 April 2012
Received in revised form 24 May 2012
Accepted 24 May 2012
Available online 1 June 2012

Keywords:
Sequencing batch reactor
Dehydrogenase activity
Cyclic voltammeter
Wastewater treatment
Tafel analysis

ABSTRACT

Functional behavior of anoxic–aerobic–anoxic microenvironment on azo dye (C.I. Acid black 10B) degradation was evaluated in a periodic discontinuous batch mode operation for 26 cycles. Dye removal efficiency and azo-reductase activity (30.50 ± 1 U) increased with each feeding event until 13th cycle and further stabilized. Dehydrogenase activity also increased gradually and stabilized (2.0 ± 0.2 μg/ml) indicating the stable proton shuttling between metabolic intermediates providing higher number of reducing equivalents towards dye degradation. Voltammetric profiles showed drop in redox catalytic currents during stabilized phase also supports the consumption of reducing equivalents towards dye removal. Change in Tafel slopes, polarization resistance and other bioprocess parameters correlated well with the observed dye removal and biocatalyst behavior. Microbial community analysis documented the involvement of specific organism pertaining to aerobic and facultative functions with heterotrophic and autotrophic metabolism. Integrating anoxic microenvironment with aerobic operation might have facilitated effective dye mineralization due to the possibility of combining redox functions.

1. Introduction

Synthetic dyes are aromatic organic colorants, which have potential industrial applications. Generally, dyes are classified based on their chemical and application classes. Among the chemical class, the azo dyes are more versatile and accounts to be more than half of the annual dye production. These dyes are characterized by the presence of diazotized amine coupled to an amine or a phenol and contain one or more azo linkages which are extensively used in industries such as textile, food, cosmetics, leather tanning and plastic for colorization (Chun et al., 2006; Ong et al., 2010). Azo dyes are also used in simple diazotization reaction during synthesis (Telke et al., 2008). About 10–90% of unfixed dyes during the dying process get discharged through the effluents (Abadulla et al., 2000). Release of these dyes into environment causes adverse impact on the aquatic ecosystem both physically and chemically. Azo dyes are also considered to be toxic to the aquatic biota and are reported to be carcinogenic to the humans (Yahagi et al., 1975).

Dye bearing effluents are typically characterized by residual color, excess salts and low biodegradability (high COD with relatively low BOD), which requires treatment prior to their discharge. The overall cost, regeneration, secondary pollutants, interference by other wastewater constituents and residual sludge generation associated with physico-chemical methods limits their usage in spite of their efficiency in dye removal (Davies et al., 2005; Venkata Mohan et al., 2002, 2005a). Alternatively, biological processes are considered to be advantageous compared to the physico-chemical methods due to their eco-friendly nature (Davies et al., 2005; Katuri

* Corresponding author. Tel./fax: +91 40 27191664.
E-mail address: vmohan_s@yahoo.com (S. Venkata Mohan).

0960-8524/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.biortech.2012.05.125