Bioresource Technology 127 (2013) 37–43

Contents lists available at SciVerse ScienceDirect

Bioresource Technology

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

Development of an activated carbon-packed microbial bioelectrochemical system for azo dye degradation

Arely Cardenas-Robles, Eduardo Martinez, Idelfonso Rendon-Alcantar, Carlos Frontana, Linda Gonzalez-Gutierrez *

Centro de Investigación y Desarrollo Tecnológico en Electroquímica, Parque Tecnológico Querétaro Sanfandila, 76703 Sanfandila, Pedro Escobedo, Qro., Mexico

HIGHLIGHTS

- ▶ The biodegradation rate of azo dyes is increased when an electric field is applied.
- ▶ Activated carbon in the bioelectrochemical reactor regulates both pH and open circuit potential.
- ▶ Synergistic effect of electrical and biological parameters reduce the residence time of the reactor.
- ▶ Growth of microorganisms increases in response to the applied current.

ARTICLE INFO

Article history:
Received 10 February 2012
Received in revised form 4 August 2012
Accepted 20 September 2012
Available online 27 September 2012

Keywords:
Bioelectrochemical system
Azo dyes
Activated carbon
Current stimulated biodegradation

ABSTRACT

A microbial bioelectrochemical reactor (BER) was employed for the degradation of azo dyes without the use of an external electron donor, using activated carbon (GAC) as a redox mediator. Contribution of pH values, open circuit potential (OCP), dye concentration and applied current were individually studied. A batch system and an upflow fixed bed bioreactor were built for analyzing the effect of the applied current on biodegradation of the azo dye Reactive Red 272. The presence of GAC (20% w/v) regulated both pH and OCP values in solution and led to a removal efficiency of 98%. Cyclic voltammetry results indicate a dependence of the electron transfer mechanism with the concentration of the azo compound. With these results, a continuous flow reactor operating with $J = 0.045$ mA cm^{-2}, led to removal rates of 95% (±3.5%) in a half-residence time of 1 hour.

1. Introduction

Azo dyes (R–N═N–R) are used by textile and other industries worldwide, resulting in the generation of wastewaters containing azo compounds at concentrations of 100–500 mg L^{-1} (Sponza and Işik, 2004). These dyes are degraded only slowly, remain visible and are toxic to the aquatic life even in small concentrations (Mondal, 2008).

Biodegradation of azo dyes can be carried out in anaerobic environments, in which the chromophore azo bond (–N═N–) is chemically reduced; however, this process generates side products which are even more toxic than the azo compounds (e.g. aromatic amines) (Kandelbauer and Guebitz, 2005). In order to degrade the reduced products, an aerobic process can be used and therefore, the complete degradation of azo compounds requires a combination of anaerobic and aerobic stages (van der Zee and Villaverde, 2005; Mezohegyi et al., 2007).

The anaerobic biodegradation of azo dyes is slow due to limitations in the electron transfer process. Some electron donors used were glucose, volatile fatty acids and ethanol (Dos Santos et al., 2004; Dafale et al., 2008), and antraquinone-2,6-disulfonate (AQDS), riboflavin, humic substances, among others were used as redox mediators (van der Zee and Cervantes, 2009). Activated carbon can also be used as redox mediator since it contains different functional groups (active sites) capable of being reduced and oxidized (van der Zee et al., 2003; Mezohegyi et al., 2007; Gonzalez-Gutierrez et al., 2009).

Biodegradation processes can also be enhanced by the application of an electric current, since some microorganisms can take electrons from an electrochemical process. Some applications include the reduction and biodegradation of some organic substances and reduction of nitrate and uranium (VI) (Zhang et al., 2004; Strycharz et al., 2008; Aulenta et al., 2010). Either single strain cultures or mixed consortia of microorganisms, especially anaerobes, are electrochemically active (Carmona-Martinez et al., 2011; Rosenbaum et al., 2011), but the mechanism of the stimulation of the degradative processes by an electrical current applied to a bioprocess, has not been completely elucidated.

* Corresponding author. Tel.: +52 442 2116034.
E-mail addresses: vicky01@rocketmail.com, lgonzalez@cideteq.mx (L. Gonzalez-Gutierrez).

0960-8524/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.biortech.2012.09.066