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Simultaneous co-metabolic decolourisation of azo dye mixtures and bio-electricity generation under thermophillic (50 °C) and saline conditions by an adapted anaerobic mixed culture in microbial fuel cells

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HIGHLIGHTS

- ▶ Effective decolourisation of azo dye mixtures in microbial fuel cells.
- ▶ Concomitant electricity generation.
- ▶ Dye decolourisation under thermophillic and saline conditions.
- ▶ Azo dye adapted mixed microbial cultures and co-substrate molasses for dye removal.

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ABSTRACT

In this study, azo dye adapted mixed microbial consortium was used to effectively remove colour from azo dye mixtures and to simultaneously generate bio-electricity using microbial fuel cells (MFCs). Operating temperature (20–50 °C) and salinity (0.5–2.5% w/v) were varied during experiments. Reactor operation at 50 °C improved dye decolourisation and COD removal kinetic constants by approximately 2-fold compared to the kinetic constants at 30 °C. Decolourisation and COD removal kinetic constants remained high (0.28 h^{-1} and 0.064 h^{-1} respectively) at moderate salinity (1% w/v) but deteriorated approximately 4-fold when the salinity was raised to 2.5% (w/v). Molecular phylogenetic analysis of microbial cultures used in the study indicated that both un-acclimated and dye acclimated cultures from MFCs were predominantly comprised of Firmicutes bacteria. This study demonstrates the possibility of using adapted microbial consortia in MFCs for achieving efficient bio-decolourisation of complex azo dye mixtures and concomitant bio-electricity generation under industrially relevant conditions.

1. Introduction

Microbial fuel cells are regarded as a promising new technology for wastewater treatment due to their capability to convert the chemical energy of contaminants to biogenic electrical energy (Popov et al., 2012). Hitherto, the use of MFCs for degradation of xenobiotic compounds has not been explored extensively.

Azo dyes are extensively used as colouring agents in textile, leather and paper industries due to their chemical stability and lightfast properties. It is estimated that up-to 50% of the azo dyes used in colour industry are not bound to their substrate and hence, discharged as highly coloured effluent. Apart from the aesthetic deterioration of the receiving water bodies, some azo dyes and their biotransformation metabolites have been shown to be toxic and carcinogenic to organisms in the natural environment including humans (Manu and Chaudhari, 2003). The chemical stability of azo dyes makes them resistant to natural degradation processes and therefore, causes disposal problems in colour industry. Advanced oxidation (e.g. UV/Fenton), physicochemical (e.g. adsorption) and biological processes or a combination of previously mentioned methods are usually used to treat colour industry wastewater and to meet the regulatory discharge limits (Banat et al., 1996). Capital costs for biological wastewater treatment processes are 5–20 times less compared to advanced oxidation methods and the running costs are 3–10 times less (Marco et al., 1997). However, azo dyes go through conventional activated sludge systems unchanged and therefore, considered as xenobiotic pollutants with a major contribution to environmental toxicity (Ozkan-Yucel and Gokcay, 2010).

Colour industry wastewater often contains mixtures of azo dyes with a vast chemical structural diversity. Moreover, during textile wet processing, large amounts of sodium sulphate decahydrate

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