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Construction of an integrated enzyme system consisting azoreductase and glucose 1-dehydrogenase for dye removal

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HIGHLIGHTS

- ▶ NADH regeneration system was created by azoreductase and glucose 1-dehydrogenase.
- ▶ 1 U azoreductase:10 U glucose 1-dehydrogenase was the most suitable enzyme ratio.
- ▶ Artificial neural network could satisfactory fit for integrated enzyme system.
- ▶ All variables have strong effects on dye removal of integrated enzyme system.
- ▶ Batch results indicated integrated enzyme system was potential for dye removal.

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ABSTRACT

Azo dyes are toxic and carcinogenic and are often present in industrial effluents. In this research, azoreductase and glucose 1-dehydrogenase were coupled for both continuous generation of the cofactor NADH and azo dye removal. The results show that 85% maximum relative activity of azoreductase in an integrated enzyme system was obtained at the conditions: 1 U azoreductase:10 U glucose 1-dehydrogenase, 250 mM glucose, 1.0 mM NAD^+ and 150 μM methyl red. Sensitivity analysis of the factors in the enzyme system affecting dye removal examined by an artificial neural network model shows that the relative importance of enzyme ratio between azoreductase and glucose 1-dehydrogenase was 22%, followed by dye concentration (27%), NAD^+ concentration (23%) and glucose concentration (22%), indicating none of the variables could be ignored in the enzyme system. Batch results show that the enzyme system has application potential for dye removal.

1. Introduction

Industrial wastewater such as effluents from dye and textile industries has become a great concern (Yang et al., 2011b). Dyes are complex aromatic compounds and recalcitrant. Some dyes are toxic, carcinogenic and harmful to human health (Forgacs et al., 2004). In addition, dyes could be highly visible at low concentration (1 mg/L), which could cause an aesthetic pollution and disturbance to the aquatic ecosystem for reduction of oxygen levels (Vimonses et al., 2010). Treatment of dye-based effluents remains to be a challenge for environmental scientists. Therefore, many different treatment methods have been developed and employed for dye removal, including chemical precipitation, reverse osmosis, ozonation, and membrane filtration. High operational costs and secondary sludge generation have hindered applications of these methods (Yang et al., 2012).

Biotreatment offers an economical and environmentally friendly alternative for color removal in textile effluents (Chacko and Subramaniam, 2011). Microorganisms being capable of adapting a variety of environmental conditions are selected to degrade and mineralize dyes (Cai et al., 2012; Chi et al., 2009; Khalid et al., 2009; Saratale et al., 2009; Singh et al., 2012). In the studies of biological degradation of dyes, an effort has been made in order to identify, isolate and test the enzymes responsible for the decolorization. Enzyme-based methods have been developed for the detoxication of organic pollutants in the recent years. These treatments have a minimal impact on ecosystems, as they present no risk of biological contamination and reduce the possible chances for the release of exogenous genes from engineered bacteria into

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