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Decolorization of textile dyes and their effluents using white rot fungi

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Abstract

The ability of four different species of white rot fungi i.e. *Coriolus versicolor*, *Termetomyces* sp, *Pleurotus ostreatus* and *Schizophyllum commune* to remove azo dyes from aqueous solutions were evaluated in batch culture under laboratory conditions. *C. versicolor* found to be was the most efficient colour removing species for the three dyes investigated. Maximum removal capacity of *C. versicolor* for acid green, disperse red and basic orange was 98, 76 and 61 % respectively. Glucose as the carbon source in growth medium was more suitable for the decolouration of dyes in comparison with starch at the same concentration. Preliminary studies indicate that *C. versicolor* has the potential to remove colour from aqueous solutions and may be used as an efficient biological agent for the decolouration of dyes in industrial effluents.
Keywords: White rot fungi**,** decolorization Azo dyes.

Introduction

The two major sources of dye release into the environment are the textile and dyestuff manufacturing industries (Nigam *et al*. 1996). Existing physical/chemical technologies for colour removal are very expensive and commercially unattractive (Emrah, *et al*, 2007). Biological processes provide an alternative to existing technologies because they are more cost-effective, environmentally friendly, and do not produce large quantities of sludge (Azmi *et al*. 1998).

Synthetic dyes are not uniformly susceptible to biodegradation in conventional biological waste water treatment processes because of their resistance to microbial Azo dyes, which are used extensively in many industries, are the largest class with a wide variety of colours and structure. White-rot fungi are attractive organisms for use in the decontamination of pollutant sites. They are capable of mineralizing a wide variety of toxic xenobiotics (Knapp and Newby 1999), are ubiquitous in natural environments and have the potential to oxidize substrates with low solubility because the key enzymes involved in the oxidation of several pollutants are extra cellular (Reddy 1995). According to Kim *et al*. (1995), the effectiveness of decolorization depends on the structure and complexity of each dye. Relatively small structural differences can markedly affect decolorization. These differences are presumably due, at least in part, to electron distribution and charge density, although satiric factors may also contribute (Kumarasamy *et. al* 2006).

Synthetic dyes are used extensively in textile and leather dyeing, paper printing, colour photography and as additives in petroleum products. With the growing use of a variety of dyes, pollution by the dye-waste water is becoming increasingly serious (Campos *et al.*, 2001). Azo dyes are the largest class of commercially produced dyes having wide spread usage in textile, food and cosmetic industries. (Nigam, 1996) Over 100.000 dyes are commercially available with $7x10^5$ tons of dyestuffs being produced annually (Campos *et al.*, 2001 and Zollinger, 1987). Inefficiency in the dyeing process results in 50 % of all dyestuffs being directly lost to wastewater, which ultimately finds its way into the environment (Zollinger, 1987). These dyes pose mutagenic, carcinogenic and toxic hazards (Meyer, 1981; Holme, 1984; Bhatt, *et al* 2000 and Balan, *et al* 2001). Textile industry in Pakistan is the major source of release of effluent dyes into the environment.

Chemical, biological and physicochemical methods, including reverse osmosis, have been used for colour removal, all of which however are relatively expensive (Mcmullan, *et al*. 2001). In addition, they are not always successful due to the wide diversity of colored effluents. (Verma, *et al* .2003). Therefore, there is a need to develop alternative and cost-effective treatment processes for colored effluents.

Some bacterial and fungal species have been reported that are capable of biodegradation of dyes (Capelari 1997; Novotný *et al*., 2000; Novotný *et al*., 2001; Kasinath *et al*., 2003). . There is,

however, no single species capable of biodegradation of all kinds of dyes. The present study reports preliminary findings on the removal of azo dyes from solutions using white rot basidiomycetes.

Materials and Methods

Chemicals Azo dyes, C.I acid green 20, C.I. disperse red 17 and C.I. basic orange 1 (Fig. 1) were the products of Applied Chemistry Research Center of PCSIR Laboratories Complex Lahore, Pakistan.

Fungal cultures

Four white rot fungi basidiomycetes fungi, namely *Coriolus versicolor*, *Termetomyces Pleurotus ostreatus* and were used in the present investigation. *Coriolus versicolor* was obtained through the courtesy of Dr. J. D. Reid, National Research Council of Canada, and Prairie Regional Laboratory, Saskatoon, Saskatchewan, Canada. Other species were local isolates. Stock cultures of these fungi were maintained on potato dextrose agar at 4•C and periodically subculture.

Culture conditions

White rot basidiomycetes were tested for their decolorization ability under uniform conditions. Azo dyes at a concentration of 100 ppm were added to liquid medium containing 2.0 g KH_2PO_4; 0.4 g Mg SO_4. $7H_2O$; 0.3 g Ca $Cl_2.H_2O$ and 0.4 g yeast extract in one-liter double distilled water. Glucose and starch (1%) were used as the carbon source. Glucose was additionally tested at concentrations ranging from 2.5 to 25 g/l. Mycelial inoculation was carried out in 250 ml Erlenmeyer flasks containing 100 ml of the above medium. The culture medium flasks containing dyes without fungal mycelial inoculum were used as a blank. The cultures were incubated at 30 ^oC on a rotary shaker at 150 rpm. Any change in the colour intensity was measured at intervals of 3, 5 and 7 days.

Analytical methods

Reduction in colour intensity was determined spectrophotometricallry by monitoring the absorbance at the wavelength maxima for acid green, dispersed red, basic orange respectively 620, 540 and 480 nm after 3,5 and 7 days. Results were recorded as the mean of decolorization for three replicate cultures. Mean values of parameters studied were analyzed by the Duncan Multiple Range Test (DMR).

Results & Discussion

All the four different species of white rot fungi tested for their ability to remove acid green 20 azo dye from aqueous solutions were noted to decolorize the dye within the first three days of incubation (Fig. 2).

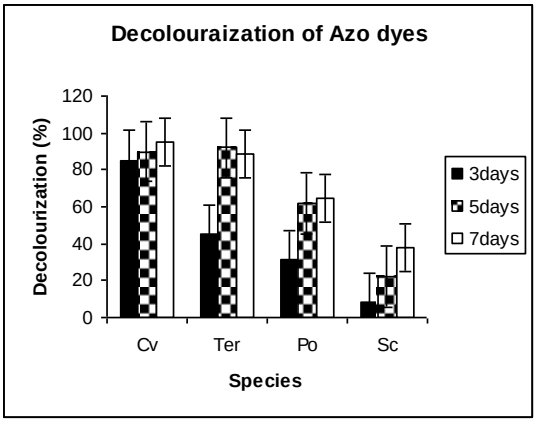

Fig.2: Decolorization of the azo dye acid green by different species of white rot fungi. *C.V. =Coriolus Versicolor*; *Ter. =Termetomyces* sp; P.o= *Pleurotus Ostreatus*; *SC Schizophyllum commune* (P<0.05 ANOVA test)

However, much variation in the efficiency of colour reduction was observed. *C. versicolor*

Carbon source	Decolorization (%)		
	3d	5d	7d
Glucose Starch	85.0	90.7	97.1
	38.5	42.1	47.3

Table 1: Effect of carbon source on the Decolorization of the acid green azo dye by C. versicolor in 3, 5 and 7 days.

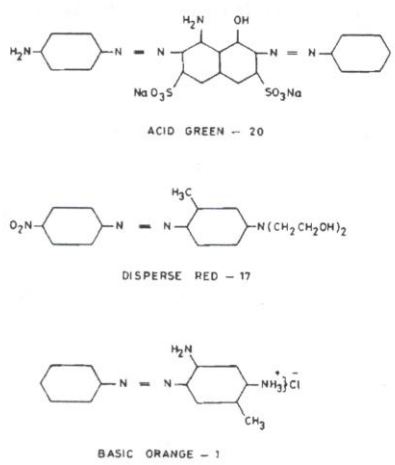

Fig.1: *Chemical structure of acid green-20, disperse red 17 and basic orange-1*

produced the highest decolorization of 86 % of the azo dye within first three days of incubation, whereas *S. commune* produced only 6 % in the same period. Higher degree of colour reduction was achieved after the incubation period of 7 days with selectively order of *C. versicolor* > *Termetomyces* sp.> *Pleurotus ostreatus* > and *S. commune*. Maximum removal of the dye during this period was 98 %, 89 %, 66% and 36 % respectively. As a result of these observations, *C. versicolor* was selected for further studies. The objective was to optimize cultural conditions for maximum removal of colours from aqueous solutions. For the purpose, *C. versicolor* was grown in culture media separately containing glucose and starch as the dye was achieved when glucose was used as the carbon source (Table 1). Decolorization of the acid green dye was almost double when glucose was present in the culture medium as compared with starch. High percentage of decolorization was due to dye adsorption by mycelium of fungi as well as reduction of dye intensity in solution because of changes caused by them (Balan *et al*., 2001). Glucose was further tested at different concentrations, ranging from 5 to 25-g/ l in order to determine its optimum concentration in the culture medium (Fig. 3).

The color reduction was found to be increased with the increase in glucose concentration from 5 to 10 g / l; beyond that concentration there was no further improvement in colour reduction. The maximum decolorization of 97 % of acid green dye by *C. versicolor* was obtained at a concentration of 10 g /l in 7 days.

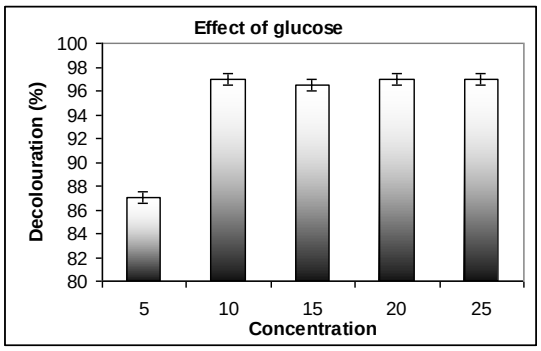

Fig.3: Effect of glucose concentration on decolouration of acid green 20 by *C. versicolor* after 7 days of incubation (P<0.05 ANOVA test)

Knapp *et al*. (1995) has also reported a continuous increase in decolorization with an increase in glucose concentration from 0.35 to 3.52 g/l. For the purpose of making a wider application of *C. versicolor* for the removal of colour from the industrial effluents, the species was further tested with two more azo dyes i.e. basic orange 1 and disperse red 17. In this study *C. versicolor* was grown in the culture media containing 10-g/l glucose and 100 ppm of each dye separately. *C. versicolor* produced decolorization of 76 and 61 %of basic orange and disperse red during 7 days of incubation, respectively, thus showing the selectivity order of acid green 20 > basic orange1 > disperse red 17 days (Fig.4).

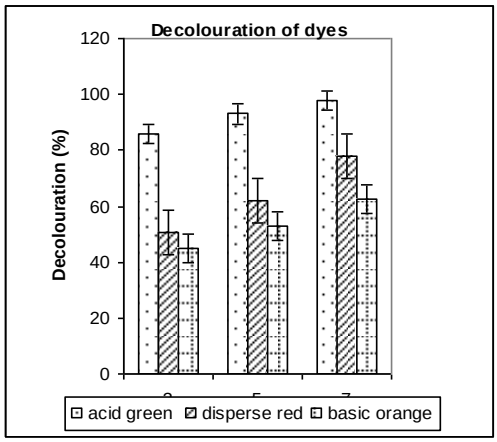

Fig.4: Mean values of decolouration of acid green 20, disperse red 17 and basic orange 1 dyes by *C.versicolor* (P<0.05 ANOVA test)

In conclusion the results presented in the present communication show that the white rot fungus *C. versicolor* has the potential to remove azo dyes from aqueous solutions. However, to apply these observations on a larger scale, further investigations are required to optimize cultural conditions such as inoculum concentration, pH of the culture medium and temperature of incubation in the presence of dyes that are indented to be decolorized.

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