Preliminary study on entrapment of biomass of extensive studied fungal species for environmental applications : color removal as an example

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Introduction

There are more than 10,000 dyestuffs are available for various commercial purpose, most of them are difficult to biodegrade due to their complex aromatic molecular structure and synthetic origin (Clarke 1980). A Large amount of structurally diverse dyestuffs are used for textile dyeing as well as other industrial applications (Zollinger 1991). During processing, up to 15 % of the used dyestuffs are released into the process water (Zollinger 1991). Coloured industrial effluents not only produce visual pollution, but it is major thread to ecological and public health. Some of the dyes are either toxic or mutagenic and carcinogenic due to the presence of metals, chlorides, etc. in their structure (Crini 2006; Fu 2001, Aksu 2005). Conventional treatments of textile effluents are ineffective, costly, complicated or associated with other problems (Robinson 2001). In recent year, colour removal from wastewaters through adsorption, particularly biosorption, has emerged as a promising technology. The most commonly used adsorbent for color removal is activated carbon, but it require energy for activation, So it is not economically viable, Moreover it cannot degrade the synthetic dyes (Yeh 1995). Biological methods are simple and cost effective option to deal for dye biodegradation (Haug 1991, Spadora 1992). *Phanerochaete chrysosporium* sp of the fungus is the most extensively studied white-rot fungus for various environmental applications. It is a model organism for lignin and xenobiotic biodegradation studies. This organism is able to transform a wide range of organic compounds due to their extracellular, nonspecific ligninolytic enzymes such as lignin peroxides (LiP), manganese peroxidase (MnP) and laccases as well as hydrogen-producing oxidases (Chivukula 1995; Bumpus 1988).

Due to these reasons, it is very good organism for various environmental applications, But commercial application of dried microbial cells in the powdered form has been hindered by operational limitations (see in figure 1-3) associated with their physical characteristics, such as small particle size with low density, poor mechanical strength and low rigidity, solid/liquid separation, difficulty in separation of microbial cells after biosorption, mass loss during separation and small particle size, which make difficult to use in the batch and continuous systems (McHale et al.,1994). These problems can be solved by entrapment/ immobilization of microbial cells using natural or synthetic polymers. Natural polymers such as alginate, chitosan, chitin, and cellulose derivatives have been mostly used as the matrix for the immobilization of the microbial cells via entrapment (Aloysius et al., 1999). The white-rot fungus *Phanerochaete chrysosporium* has been reported to be the potential biosorbent for textile dyes. In the present work, decolorization of commercial textile dye *Disperse Yellow 211*, by immobilized *P. chrysosporium* was investigated as an example. The purpose of the present study is to evaluate feasibility of entrapment of biosorbent. The colour removal by entrapped *P. chrysosporium* is taken as an example to demonstrate the feasibility of entrapment of this biomass for overcoming the operational problems.

Materials and methods

Immobilization of fungal biomass

The white-rot fungus used in the study was *P. chrysosporium* which was obtained from the Institute of Microbiology Technology, Chandigarh, India. Lyophilized culture of fungus was brought in laboratory and stored at 4 ^{0}C. Fungus was cultivated in the potato dextrose agar medium, and mass cultivation was done in patato dextrose broth. After 5- day incubation at 30 $\pm 1^0$C in an incubator shaker (160 rpm), the mycelia pellets were collected by filtration and then oven dried at temperature of 50 ^{0}C for the period of 12 hour. After that, these dried mycelia were crushed to powder form and directly immobilized.A 2% (w/v) of sodium alginate was prepared in hot distilled water (60 ^{0}C). After cooling, 0.5 g of mycelia (dry weight) was mixed with 40 ml sodium alginate solution (w/v). The mixture was dropped into 0.2M $CaCl_2$ solution with a burette and gentle stirred to avoid aggregation of the beads. The resultant beads of 4mm in diameter were cured in 0.2M $CaCl_2$ solution at 4 ^{0}C for to complete gellation (Wu 2007). After keeping them overnight in the $CaCl_2$ solution, the beads were rinsed with double distilled water.

Decolorization assay

Stock solution of *Disperse Yellow 211* was prepared (1000 mg l^{-1}) and desired concentrations of the dye were obtained by further dilutions. From stock solution, concentration of 50 mg l^{-1} solutions was prepared by serial dilutions. The preliminary color removal experiment was done at pH 5.0 and initial concentration 50mg l^{-1} . All the experiments were performed at room temperature. pH was maintained using 0.1N HCl and NaoH. Biosorption studies were carried out in a fixed-bed column (1.6 cm in internal diameter) with the column lengths of 50 cm. Immobilized fungal beads were packed into the column (10 cm bed height). The dye solution was continuously pumped into the column. The desired flow rate was maintained (0.8 ml min^{-1}). Composite samples were taken from the effluent at pre-determined time, centrifuged at 3000rpm. Supernatant was scanned for absorbance with a UV-Visible spectrophotometer and analyzed for the residual concentration of dye in solution and percent decolorization was calculated.

Results and Discussion

The application of biosorbent in powder form suffers by operational limitations due to their physical characteristics. Such limitations can be overcome by entrapping them into beads form. A very promising biopolymer material, that offers such advantages, is alginate, a natural anionic polymer. Alginate is a linear copolymer of a-l-guluronate (G) and a-dmannuronate (M), which constitutes 10 – 40 % of the dry weight of all species of brown algae (Volesky 2003). The gelation properties of alginate can be attributed to the simultaneous binding of the divalent cations such as Ca^{2+} to different chains of a-l-guluronate blocks (G-blocks) (Veglio 1997). As a result of their configuration, it can form electronegative cavities, capable of holding the cations via ionic interactions, resulting in cross-linking of the chains into a structure resembling an “egg box” (Grant 1973). Due to its ability to form stable structures, cross-linked alginate has been used for the immobilization of biological material for various purposes, including the immobilization of material such as fungi, for the removal of color from textile (Wu 2007). There are various biopolymer are available which can entrap such adsorbent and solve above described operational limitations. The present study shows that dry biomass of *Phanerochaete chrysosporium* can be entrapped in the form of beads, which can be successfully use in column process for removal textile dye. In this study removal of Disperse Yellow 211 with entrapped biomass beads are found to 83% in above said condition.

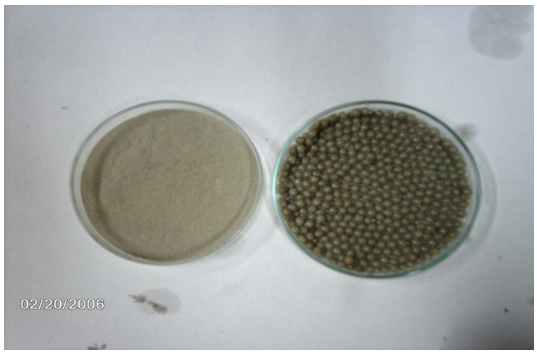

Figure 1. Entrapped and Powder form *of.* biomass (algae) (algae)

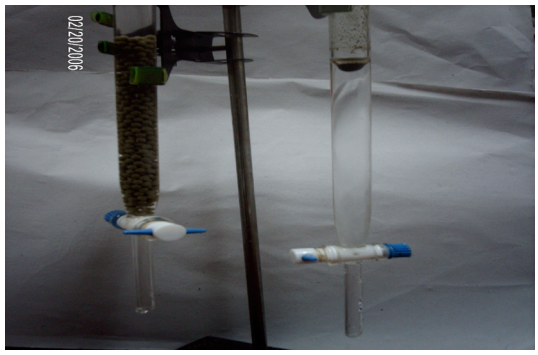

Figure 2. Entrapped and Powder form *of* Biomass in Continuous Process

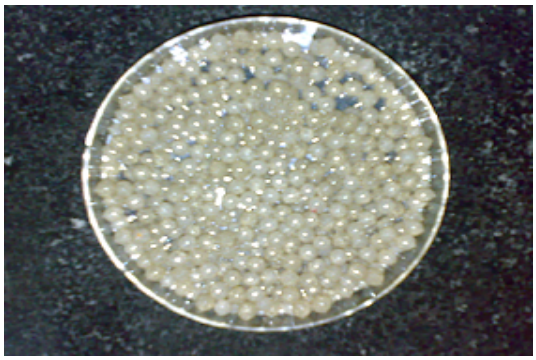
Figure 3. Entrapped biomass of *Phanerochaete Chrysosporium in the form of bead*

Conclusions

The present study concluded that entrapment of the bioadsorbent particulally biomass based can overcome the operational limitations. Thus can be use for various environmental applications. In this work a widely studied fungus species i.e. *Phanerochaete chrysosporium* was usefully used for presenting an example of entrapment and colour removal.

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