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A REVIEW ON FUNGAL DEGRADATION OF TEXTILE DYE EFFLUENT

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ABSTRACT

Among pollution causing various industries, textile industry creates a major attention by environmentalists due to consumption of large volume of water, dyes and chemicals for various processing of textiles. Textile effluents contain carcinogenic aromatic amines, dyes, organic and inorganic materials. Removal of colored compounds from textile industry effluents by biological methods is currently available. Recent promising research works on biological decolorization of textile effluent have showed that variety of microorganisms and plants capable of decolorizing wide range of anionic and cationic dyes. This review article deals with the dye removing efficiency of fungi through biodegradation and biosorption mechanism.

Key words: Biodecolorization, Fungal decolorization, Dye removing efficiency.

INTRODUCTION

Environmental pollution is caused by release of various chemicals as a consequence of industrial progress which has now become a persistent environmental contaminant. Due to rapid industrialization and urbanization a lot of chemicals including dyes, pigments and aromatic molecular structural compounds were extensively used for several industrial applications such as textiles, printing, pharmaceuticals, food, toys, paper, plastic and cosmetics are manufactured and used in day-to-day life[1]. Textile dyes were classified as azo, diazo, cationic, basic, anthraquione and metal complex based, depending on thenature of their chemical structure[2]. There are more than 100,000 commercially available dyes with over 7 x 10^5 tons of dyestuff produced annually[3,4]. Around 8000 chemical products associated with the dyeing process are listed in the Colour Index (Society of Dyers and Colourists 1976). Chemical structure of the dyes was resistant to fading on exposure to light, water and many chemicals[5].

Discharge of colored effluents from dye manufacturing units and textile processing industries was produced by various textile industry process. The production of high amount of effluents mixes into water leading to pollution of aquatic systems and represent major environmental problems[7]. Color was one of the most obvious indicators of water pollution and discharge of highly colored synthetic dye effluents can damage the receiving water bodies[8-15]. Colored wastewaters associated with the reactive azo dye constitute approximately 30% of the total dye market.

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EXPERIMENTAL

Reviews of literature

- This paper crtically analyse the various recent research works on fungal degradation of dyes and dye effluent, which were associated as pollutants to solve the dangerous water pollution and save the future.

White-rot fungi are those organisms that are able to degrade lignin, the most complex structural polymer found in woody plants[16]. The most widely studied white-rot fungus, in regards to xenobiotic degradation, is *Phanerochaete chrysosporium*. This fungus is capable of degrading dioxins, polychlorinated biphenyls (PCBs) and other chloro-organics[17,18]. Other whiterot fungi also decolorize dyes, e.g. *Coriolus versicolo*, *Trametes versicolor*[19,20] *Pleurotus ostreatus*[21] and *Coriolopsis polysona*[22].

Meanwhile, there are various other fungi, such as *Umbelopsis isabellina* and *Penicillium geastrivous*[23], *Aspergillus foetidus* and *Rhizopus oryzae*[24] which can also decolorize and/or adsorb dyes. Fungal decolorization is a promising alternative to replace or supplement present treatment processes.

Using Remazol Brilliant Blue R (RBBR), strains of terrestrial white rot (WRF) and marine fungi (MF) were screened for efficient decolorization. Dye degradation potential of selected strains was studied with chemically different dyes (azo, anthraquinone, heterocyclic, triphenylmethane). *Irpex lacteus* and *Pleurotus ostreatus* (WRF) efficiently degraded dyes from all groups whereas less efficient and selective degradations were observed with *Dactylospora haliotrepha* and *Aspergillus ustus* (MF). Seawater salinity often reduced decolorization efficiency of WRF but increased decolorization ability of MF. In soil/lacteus removed 77% of RBBR used at 150 µg/g within 6 weeks. The work presents fungi as suitable candidates to be applied to re-mediation of dye-contaminated water and soil[25-37].

Totally 19 isolates of Aspergillus strains were isolated from the environment samples collected from Meerut egions, Meerut, India. Different parameters such as various carbon source, nitrogen source, temperature, pH and salinity concentrations were optimized for decolorization oftextile dye Orange 3R byusing fugal isolates. Aspergillus strain (MMF3) showed maximum dye decolorization of 96% at the end of 5th day under optimum condition and found to be more efficient in dye decolorization. All parameters studied in this paper were found to be effective for all isolates. The results reported here warrant further investigation to establish the usefulness of these isolates for ioremediation and biodegradation application suchas waste water treatment. High decolorization extent and facile conditions show the potential for this fungal strain to be used in the biological treatment of dyeing mill effluents[38].

The fungal isolates *Aspergillus flavus* and *Aspergillus wentii* were evaluated for their ability to decolorize textile effluent and aqueous solution of dyes-Acid blue and yellow MGR. decolorization competence of both the strains was determined on Yeast-glucose peptone (YGP) and potato dextrose medium (PDA) containing 100 ppm of the textile dyes and 50 mL of effluent in 24 h of incubation in rotary shaker at 170 rpm at room temperature. The maximum decolorization was observed as 98.47% in effluent, 94.41% by immobilized *A. flavusin* Acid blue dye and 95.88% by immobilized *A. wentiiin* Yellow MGR dye. Free cell of *A. wemntii* was able to decolorize effluent (88.58%), Acid blue (93.05%) and Yellow MGR dye (90.48%) in PDA medium[39].

The increasing use of synthetic dyes is alarming and their discharge as textile waste may cause substantial ecological damage. Biological decolorization of dye using microorganisms is an environmentally friendly and cost-competitive alternative to chemical methods. This study involves the application of laccase obtained from *Pleurotus ostreatus*, a common fungus, in decolorization and degradation of blue HFRL dye.

This azo dye is a major constituent present in most of the textile mill effluents. The fungal cultures were inoculated and laccase was produced by solid state fermentation. The obtained enzyme was further used for dye decolorization on solid medium, liquid broth based medium and by using centre composite design. The results suggest the potential dye decolorization capacity of this fungal laccase[40].

Bioremediation using a variety of microbes for the degradation of xenobiotics seems a green solution to the problem of environmental pollution. Microbes have been gifted by nature with the ability of degrading a wide spectrum of environmental pollutants. Different fungi have the potentials to degrade complex and recalcitrant organic compounds into simpler fragments; sometimes achieving complete mineralization. We have investigated the decolorization and degradation of atriphenylmethane dye, malachite green by two fungal microorganisms, *Aspergillus flavus* and *Alternariasolani*. Both the species were able to decolorize different concentrations of malachite green (10 to 50 μM) almost completely (> 96 %) within 6 days[41].

Decolorization of azo dye red 3 BN by three fungal species *Penicillium chrysogenum*, *Aspergillus niger* and *Cladosporium sp.* has been analyzed using potato dextrose agar (PDA) medium containing 0.01% of Red 3 BN. Physico-chemical parameters like carbon source, nitrogen source, temperature, pH and inoculum volume are optimized for the decolorization Process by changing one parameter at a time. Optimal condition for *P. chrysogenum* was found to be 1% maltose 1% yeast extract, pH 8, 27^{o}C and 2% inoculums. Ideal condition for *A. niger* was found to be 1% maltose, 1% yeast extract, pH 8, 27^{o}C and 10% inoculum and that for *Cladosporium sp*. was found to be1% maltose, 1% peptone, pH 6, 37^{o}C and 10% inoculum. Extent of decolorization recorded by *P. chrysogenum* under ideal conditions was 99.56%, *A. niger* was 98.64% and that by *Cladosporium sp*. was 98.18%. The study has confirmed the potential of the above fungi in the decolorization of azo dye Red 3 BN and opened scope for future analysis of their performance in the treatment of textile effluent[42].

The biosorption potential of three fungal waste-biomasses[43] (*Acremoniumstrictum*, *Acremonium* sp. and *Penicillium* sp.) from pharmaceutical companies was compared with that of a selected biomass (*Cunninghamella elegans*), already proven to bevery effective in dye biosorption. Among the waste-biomasses, *A. strictum* was the most efficient (decolorization percentage up to 90% within 30 min) with regard to three simulated dye baths; nevertheless it was less active than *C. elegans* which was able to produce a quick and substantial decolorization of all the simulated dye baths (up to 97%within 30 min). The biomasses of *A. strictum* and *C. elegans* were then tested for the treatment of nine real exhausted dye baths. *A. strictum* was effective at acidic or neutral pH, whereas *C. elegans c*onfirmed its high efficiency and versatility towards exhausted dyebaths characterised by different classes of dyes (acid, disperse, vat, reactive) and variation in pH and ionic strength. Finally, the effect of pH on the biosorption process was evaluated to provide a realistic estimation of the validity of the laboratory results in an industrial setting. The *C. elegans* biomass was highly effective from pH 3 to pH 11 (for amounts of adsorbed dye up to 1054 and 667 mg of dye g^{-1} biomass dry weight, respectively); thus, this biomass can be considered an excellent and exceptionally versatile biosorbent material.

An enormous number of articles published in the last two decades cover the 'fungal dye decolourization'[44]. This proves that great attention has been paid by researchers to use the lignin degrading enzymatic system of white-rot fungi for solving this serious pollution problem. A considerable amount of work in the fungal decolourization studies has been conducted on a laboratory scale to find fungal strains with effective enzymes. The main fungal enzymes have been indicated and various mechanisms have been explained, however, several studies show that unknown enzymes or mechanisms, respectively, are still present. The studies mainly cover chemically defined dyes, while the research with wastewater from dyestuff industry is are. White-rot fungi as a group can decolourize a wide range of dyes. Nevertheless, the chemical and physical decolourization and/or degradation processes are usually faster than the processes using fungal cultures. In addition, a fungal cultivation takes place under sterile conditions, which increases the cost of bioremediation technology and additionally lowers the economics of the process. Unfortunately, there are not many results of dye degradation during the cultivation under non-sterile operation conditions available yet. Therefore, the research of screening or genetic manipulation of fungi to be more resistant, to be capable of faster dye degradation, to reach higher mineralization degree or to use dyes as sole substrates would also be of great interest.

Dyes and pigments are widely used, mostly in the textile, paper, plastics, leathers, food and cosmetics industry to color products. Textile industry consumes large volume of water and produce large amount of wastewater during all phases of textile production and finishing. The release of colored effluents represents a serious green pollution and a human health concern particularly in developing countries like Ethiopia (East Africa). Color removal, especially from textile effluents, has gargantuan challenge over the last decades, and up to now there is no single and cost-effectively attractive treatment that can effectively decolourise as well as treat the dyes effluents.[45]

A fungal isolate Aspergillus terreus SA3 previously isolated from the waste water of a local textile industry was efficiently utilized for the removal of dye (Sulfur black) from textile effluent. The treatment was performed in a self designed lab scale stirred tank bioreactor. The reactor with 5 L capacity (working volume 2 L) were operated at room temperature and pH 5.0 in continuous flow mode with different dye concentrations (50, 100, 150, 200, 300 and 500 ppm) in simulated textile effluent (STE). The reactors were run on fill, react, settle and draw mode with hydraulic retention time (HRT) of 24-72 h, depending upon the concentration of dye. Overall color, BOD and COD in the Stirred tank reactor system (STR) were removed by 84.53, 66.50 and 75.24%, respectively with 50 ppm dye concentration and HRT of 24 h. The removal efficiency of the reactor decreased as the concentration of the dye was increased. This STR system was found very effective for efficient treatment of textile waste water (up to 200 ppm Sulfur black dye) by the fungal strain A.[46]

A number of biotechnological approaches have been suggested by recent research as of potential interest towards combating this pollution source in an eco-efficient manner, including the use of bacteria or fungi, often in combination with physicochemical processes[47]. Biotreatment depicts a cheaper and environmentally friendlier alternative for colour removal in textile effluents. The ecofriendly microbial decolorization and detoxification is a alternative to the physical and chemical methods. The kinetics of decolorization and the environmental factors affecting the decolorization rates is relatively scarce[61]. A wide variety of microorganisms arecapable of decolorization of a wide range of dyes some of them are as bacteria *Escherichia coli* NO_3, *Pseudomonas luteola*, *Aeromonashydrophila*; Fungi: *aspergillus niger*, *Phanerochaete chrysosporium*, *Aspergillusterricola*, *P. chrysosporium*; yeasts: Saccharomyces cerevisiae, Candida tropicalis, C. lipolytica; algae: Spirogyra species Chlorella vulgaris *C. sorokiniana*, Lemna minuscula, Scenedesmus obliquus, C. pyrenoidosa and Closterium lunula[48].

Synthetic textile dye under static and shaking conditions with respect to various parameters. Direct red dye belong to an important group of synthetic dye used in textile industries. They are considered as recalcitrant compound for degradation. In the present study batch experiment was conducted for the decolorization of direct red dye using Aspergillus niger and Aspergillus flavus under static and shaking conditions. At 50 mg/L 97% and 87 % decolorization was achieved with *Aspergillus niger* in 48 hrs at static and shaking condition but in case of A. flavus percentage of decolourization was found to be 78 % and 83 %

in 48 hrs in static and shaking condition, respectively. During the adsorption isotherm studies decolorization followed Freundlich model for both the organisms with regression coefficient value of 0.833 and this study brings out the ability of *Aspergillus sp.* to degrade reactive dyes and reinforces the potential of this group of fungi for the decolorisation of textile effluents[49].

A dye decolorizing fungal strain, *Phanerochaete chrysosporium* MTC 787 was used in batch experiments for decolorization of the dye, Acid orange 10. Effects of initial substrate (dye) and fungal concentrations on the rate and extent of dye decolorization were investigated. The initial pH and oxidation–reduction potential (ORP) was kept at 4.5 and −250 mV, respectively. The rate and extent of dye decolorization increased with increasing dye concentration up to100 g L^{-1} and then decreased for larger dye concentrations. The rate of enzyme utilization and dye decolorization alsoincreased linearly with increasing initial biomass concentration. A kinetic model describing the rate of enzyme utilization and substrate inhibition as function of the initial substrate and flow rate was developed. The kinetic constants were determined using the experimental data. The initial biomass should be above 3.2 x 105 cell/mL to obtain high rates and decolorization percentage and to avoid substrate inhibition[50].

The discharge of highly coloured effluents containing dyes can be damaging to the receiving marine water bodies and can result in serious environmental pollution problems[51]. Hence, considerable attention has been given in determining the ability of marine microorganism in decolorization and degradation of textile dyes. Decolorization and degradation of reactive blue 171 was carried out using the acclimatized Marinobacter sp. NB-6 (AccessionNo. HF56873) isolated from soil. The decolorization of dye reactive blue 171 in 24 hours was up to 95.00% in nutrient broth having 8.0% NaCl and also it showed 93.11% decolorization in half strength nutrient broth having the same NaCl concentration. The percent decolorization of the dye was also studied by cell-free extract and was observed that the isolate can decolorize the dye 90.00% in 24 hours. The percent decolorization of the dye was determined spectrophotometrically at 590 nm. The percent COD reduction of the dye by the isolate was 86.00%. The degradation products formed after degradation were analyzed by GC-MS technique and it was found that this culture degraded reactive blue 171 to the products having molecular weights 98, 99, 149, 150, 223, 70, 86, 125, 154, 155, 149, 150, 223, 149, 150, 223, 57, 113, 149, 167 and 279. The microbial toxicity study revealed the degradation of reactive blue 171 into non-toxic products by Marinobacter sp. NB-6. From the study performed, we conclude that, this acclimatized species can prove better option for bioremediation of textile dye in wastes containing high salts and in marine environment.

Water pollution through industrial discharges, which is mainly in the form of effluent or wastewater, is one of the biggest problems. These effluents have strong concentrations of chemical oxygen demand (COD), phenol and its derivatives and often contain metals, inorganic nutrients, organic compounds, proteins, cyanides, chlorinated lignin and dyes. Bioremediation of toxic industrial effluents by microorganisms serves as an effective method to substitute the conventional recovery and removal processes. Fungal biomasses have huge capability of treating effluents discharged from various industries. White rot fungi are ubiquitous in nature and their adaptability to extreme conditions makes them good biode-graders. Their enzyme producing activity makes them effective decolorizers; they remove toxic metals by biosorbtion ultimately rendering the effluents more ecofriendly[52-57].

CONCLUSION

Fungal decolorization of dye effluent is receiving much consideration due to cost effective and less regeneration by microorganisms such as bacteria, fungi, yeast, algae, and plants. Recent fundamental research works have revealed the existence of wide variety of microorganisms capable of decolorizing wide range of dyes. The use of microorganisms for the removal of synthetic dyes from industrial effluents offers considerable advantages this process was relatively inexpensive, running costs were low and the end products were completely mineralized with no toxicity. Degradation of dye is a complex process works to detoxify, decolorize, and degrade the dyes are done in lab scale only. Hence the need of effective complete conversion of textile effluent into useful liquid waste by using microbes is required.

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