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## Review on Biosorption of Dyes by Fungi

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**ABSTRACT:** Microorganisms dead or alive are successfully exploited for bioremediation of xenobiotics by biosorption. Textile effluents are among the most difficult-to-treat wastewaters, due to their considerable amount of recalcitrant and toxic substances. Fungal biosorption is viewed as a valuable additional treatment for removing pollutants from textile wastewaters. The overall economics of the biosorption is influenced mainly by the cost of procuring/growing the biomass. Application of fungal biomass to remove textile dyes from industrial waste water is attractive for industry as it may decrease the overall effluent treatment cost. Food and industrial fermentation processes can provide a cheap and constant supply of fungal biomass or the biomass can be cultured using inexpensive growth media and unsophisticated fermentation techniques.

**KEYWORDS:** Biosorption, Biosrbent, Biomass, Fungi, Textile dyes.

### I. INTRODUCTION

Wastewaters from textile, cosmetics, printing, dyeing, food colouring, paper-making industries are polluted by dyes. The dye pollution caused by the industrial wastewater is an important and hazardous problem faced by many countries. Dye pollution from industrial effluents has a direct impact on human's health and ecological equilibrium. Dyes even in low concentrations affect aquatic and terrestrial life.

Azo dyes have been found to be mostly used in the textile industries. They contain  $-N=N-$  group as chromophore group [1]. They are resistant to microbial and chemical attack and are most recalcitrant compound which are carcinogenic, mutagenic, triggers allergic reactions in human [2].

Some dyes show carcinogenic and mutagenic effect when inhaled and when in contact with the skin. Therefore, the removal of the dyes from wastewater is required [3].

For this purpose, many methods such as activated carbon adsorption, chemical oxidation, coagulation, ultra-filtration, electrochemical etc. have been developed for treating dye-containing wastewaters [4]. Of those methods, activated carbon adsorption is highly effective for the removal of different pollution from wastewater and industrial effluents. However, the use of activated carbon is not suitable for developing countries because of its high cost. Therefore, many efforts have been made to find cheaper control methods and materials recently. For example, low-cost sorbents such as peat [5], fly ash [6], perlite [7,8], sawdust [9], etc. have been utilized for dye removal. Among all the wastewater treatments, the adsorption process has been recognized to be an effective and economical procedure for the removal of dyes from industrial effluent [10]. Biodegradation, Bioaccumulation and biosorption were the three main technologies used in biological dye removal process. On the other hand, biosorption process has also been commonly used for the removal of dyes as well as heavy metal and organic pollution.

**Biosorption** is a process in which solids of natural origin are employed for sequestration and isolation of heavy metals from an aqueous environment [11]. The removal of organic colour using biosorption process stems from the work on the removal of metals in biological wastewater treatment systems [12].

Biosorption is a physico-chemical process and includes such mechanisms as absorption, adsorption, ion exchange, surface complexation and precipitation. Biosorption is a property of both living and dead organisms (and their components) and has been heralded as a promising biotechnology for pollutant removal from solution, and/or pollutant recovery, for a number of years, because of its efficiency, simplicity, analogous operation to conventional ion exchange technology, and availability of biomass. Most biosorption studies have been carried out on microbial systems, chiefly bacteria, microalgae and fungi [13].

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These include natural materials derived from waste materials from industry and agriculture, as well as biosorbents that are produced from microbial biomass like *Corynebacterium glutamicum*, *Escherichia coli*, *Pseudomonas luteola*, and *Rhizopus arrhizus* [14]. Traditionally, the fungal biomass byproduct is incinerated for disposal or used as a fertilizer of a low economic value for agricultural use. This potential biosorbent can usually be obtained relatively free of charge in rather substantial quantities, from the respective producers since they already present disposal problems to them. The only costs incurred should be those of drying, if required and transport. Thus, the use of fungal biomass as an adsorbent for dye pollution control can generate revenue for industries presently wasting the biomass and at the same time ease the burden of disposal costs associated with the waste biomass produced.

The efficiency of the biosorption process of reactive azo dyes, under equilibrium conditions by some fungi has been shown to be more efficient than activated carbon. Generally, biosorptive processes can reduce capital costs by 20%, operational costs by 36% and total treatment costs by 28% when compared with conventional systems [10]. A major advantage of biosorption is that it can be used in situ, and with proper design may not need any industrial process operations and can be integrated with many systems in the most eco-friendly manner.

## II. BIOSORPTION USING DEAD BIOMASS

Compared to the live biomass, the use of dead fungal biomass offers various advantages such as reusability of biomaterial, easy storage, more efficiency, easy operation and hence cost effectiveness for the treatment of large volumes of wastewaters containing low dye concentrations, short operation time, and no production of secondary compounds which might be toxic.

Biosorption capacity of the dead biosorbent is due to high surface to volume ratio. Being metabolic independent process, there are no restrictions of enzymatic activities of adsorption [15]. It is harmless, cheap, eco-friendly, highly efficient. Recover and reuse of bioadsorbent is possible. Biomass generated at fermentation industries can be used as biosorbent after killing it thereby making it a best practice for GLP of fermentation industries. Thus better alternative for conventional methods of adsorption is biosorption and it is necessary to make use of biosorption at large scale for treatment of wastewater[2].

## III. MECHANISM OF BIOSORPTION

Fungal cell walls are complex macromolecular structures predominantly consisting of chitins, glucans, mannans and proteins, but also containing other polysaccharides, lipids and pigments, e.g. melanin. This variety of structural components ensures many different functional groups are able to bind metal ions to varying degrees [13]. Chitin is a very important structural component of fungal cell walls and is an effective biosorbent for metals and radionuclides, as are chitosan and other chitin derivatives. In *Rhizopus arrhizus*, biosorption involves coordination to the amine N of chitin, adsorption in the cell wall chitin structure and further precipitation of hydroxylated derivatives. Chitosan is of low cost compared with commercial activated carbon (chitosan is derived by deacetylation of chitin, the most abundant aminopolysaccharide in nature) and strongly complexes pollutants, especially metals. However, industrial production of chitosan generates large quantities of concentrated effluent containing polluting bases and degradation products while conversion to chitosan at high temperature with strong alkali can cause variability of product properties and increase the processing costs which appears to limit industrial acceptance. Since chitin is a dominant component of fungal cell walls, a fermentation approach to cultivate fungi for subsequent chitosan preparation has been proposed although the economics of this do not appear favourable and extraction procedures would still result in noxious wastes. Chitosan and its grafted and cross-linked derivatives have also been assessed for dye removal from aqueous solutions[16]. Fungal phenolic polymers and melanins possess many potential metal-binding sites with oxygen-containing groups including carboxyl, phenolic and alcoholic hydroxyl, carbonyl and methoxyl groups being particularly important. Fungal biomass has also received attention as biosorbent materials for metal-contaminated aqueous solutions, because of the ease with which they are grown and the availability of fungal biomass as an industrial waste product, e.g. *A. niger* (citric acid production) and *S. cerevisiae* (brewing).

The biosorption process exhibits two phases. One phase is a solid phase (biomass/ sorbent/ biosorbent/ biological material) and another is liquid phase (solvent, usually water) containing a dissolved species to be sorbed (sorbate/

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metal ion). Because of biosorbent affinity for the sorbate, the sorbate is bound with biosorbent with various mechanisms and this process continues till equilibrium is established between the amount of solid-bound sorbate species and its fraction remaining in the solution. The degree of biosorbent affinity for the sorbate determines its distribution between the solid and liquid phases [17].

The biosorption processes are more practically applicable compared to the bioaccumulation processes since living system (i.e. active uptake of heavy metals) commonly needs the nutrients supply to carry out the metabolic activities and consequently, raise biological oxygen demand (BOD) or chemical oxygen demand (COD) of the effluent/ solution [18]. Typically, uptake of the pollutants takes place at the cell wall and many biotic and abiotic factors affect it[19].

## IV. RECENT STUDIES ON BIOSORPTION

Fu & Viraraghavan (2001) [20] reported in their review that the white rot fungi namely *Phanerochaete chrysosporium* was used in early 1980's to decolorize the lignin containing pulp and paper waste water. Thereafter *P. chrysosporium* had been examined for decolorization of pulp mill waste water and various dyes by many researchers. other than white rot fungi, namely *Rhizopus oryzae* investigated by Polman & Breckenridge (1996) [21] showed an adsorption. Fu & Viraraghavan (2001) distinguish obviously about living cells and dead cells of biomass. Lignin modifying enzymes, laccase, manganase peroxidase (MnP) and lignin peroxidase (LiP) were produced in living cells to mineralize the dyes. Also, the relative contribution of laccase, MnP and LiP for the decolorization of dyes were different for different fungus. The mechanism for dead cells is biosorption, which involves physico-chemical interactions, such as adsorption, deposition and ion-exchange. An obvious comparison was reached by Fu & Viraraghavan (2001) for living and dead fungal biomass. In screening a number of bacteria, fungi and yeast for the binding capacity of reactive dyes, [22]. Mahmooda takey *et al* 2014 [2] showed bioremediation of xenobiotics of textile industry effluent by biosorption using dead fungus biomass of *Aspergillus flavus*. The dead biomass of fungus *Aspergillus flavus* showed maximum biosorption for three toxic components (Methyl orange, chromium, lead) of textile industry effluent under different parameters. Sukhada and Varsha 2015 [10] evaluated three fungal biosorbents namely, dead biomasses of *A. niger*, *A. oryzae* and *R. arrhizus* for their potential to remove 13 different dyes belonging to various classes. The dyes included Reactive dyes (Reactive orange 13, Reactive blue 256, Reactive blue 222, Reactive Black 5, Reactive Red 120, Reactive Green 8), Remazol dyes (Reactive orange 16, Reactive violet 5), Acid azo dyes (Acid Red 151, Acid orange 7), direct azo (Direct Blue 9, Direct Blue 199) and Basic azo dye (Basic blue 9). Effect of pH on the specific uptake capacities of the biomasses was studied which indicated significant contribution of pH on biosorption capacities. All the three fungal biosorbents tested, proved to be efficient in dye biosorption.

## V. CONCLUSION

The three main technologies used in biological dye removal process - Biodegradation, Bioaccumulation and biosorption, possess good potential to replace conventional methods for the treatment of dye bearing industry effluents. Biological processes can be carried out in situ at the contaminated site, these are usually environmentally benign i.e., no secondary pollution and they were cost effective. These are the principle advantages of biological technologies for the treatment of dye industry effluents. Hence in recent years, research attention has been focused greatly on biological methods for the treatment of effluents. The disadvantage of the degradation process is that it suffers from low degradation efficiency or even no degradation for some dyes and practical difficulty in continuous process. The important disadvantage bioaccumulation process is using living organism, which is not advisable for the continuous treatment of highly toxic effluents. This problem can be overcome in biosorption by the use of dead biomass, which is flexible to environmental conditions and toxicant concentrations.

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