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Research Article

Dye Degradation Studies on *Schizophyllum commune* and *Trametes hirsuta*

M Raghunath[1,2], P Ruban[1]* and P Sagadevan[2]

[1]Departments of Biotechnology and Research, Shri Nehru Maha Vidyalaya College of Arts and Science Coimbatore, Tamilnadu, India
[2]Department of Biotechnology, KSG College of Arts and Science, Coimbatore, Tamilnadu, India

***Corresponding Author:** P Ruban, Departments of Biotechnology and Research, Shri Nehru Maha Vidyalaya College of Arts and Science Coimbatore, Tamilnadu, India.

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Abstract

White rot fungi are the only microorganisms capable of degrading the entire wood component (e.g. lignin, cellulose and hemicellulose). This ability is due to the secretion of extracellular, nonspecific ligninolytic enzymes during secondary metabolism, usually caused by nutrient deficiency. Because these enzymes are nonspecific, they can transform a wide variety of persistent and dangerous pollutants, including polycyclic aromatic hydrocarbons (PAHs), pesticides, fuels, alkanes, polychlorinated biphenyls (PCBs), explosives, and synthetic dyes. Furthermore, their extracellular nature allows white rot fungi to access nonpolar, insoluble compounds. This makes white rot fungi highly attractive for application in various industrial and biotechnological processes. Further more fungal processing of lignocellulosic materials can lead to new commercial products and processes. The implementation of such applications contributes to the creation of more sustainable industries and the development of a circular economy. Fungi such as *Schizophyllum* commune and *Trametes hirsuta* decolorize methylene blue and methyl orange these fungal strains decolorize above 93% and adsorb above 90%.

Keywords: *Schizophyllum commune; Trametes hirsuta; Degradation; Vogels Medium*

Introduction

One of the main environmental problems facing the world nowadays is the pollution of soil, water and air by toxic chemicals. Most of these chemicals are known to be carcinogenic and mutagenic posing a serious hazard to the ecosystem and human beings. Therefore, such compounds have to be removed before entering into the environment. However, the in-use techniques for the treatment of these type of compounds are rather costly, time-consuming, mostly ineffective and sometimes generate hazardous sub-products [1]. Industrialization and rapid development in the developing countries along with population explosion has resulted in accelerated environ-mental degradation on a large-scale [2,3]. Environmental pollution resulting from numerous types of industries is one of the major challenges faced by the modern world. Textile industry is one of the oldest and diverse among all industries and has a significant impact on global economy [4,5]. Despite the significance of this industry, it is also considered as one of the major contributors for the current environ-mental pollution in many textile producing countries [6]. Rapid industrialization has caused the modern world to utilize textiles for a vast array of applications leading to increased demand for textile products. As a result, textile industry and their wastewater have been rising proportionally, causing a major problem of pollution in the world.

White rot fungi are filamentous wood-decaying fungi that are widespread in nature. The majority of white-rot fungi belong to the Basidiomycota phylum, which includes several important genera, such as *Pleurotus, Phanerochaete, Trametes, Ganoderma,* and *Lentinus.* Among them, the fungus *Phanerochaete chrysosporium* is considered to be the first white-rot fungus to be studied. It has emerged and established itself as a model organism for lignin biodegradation studies. The term "white rot" comes from the pale, bleached appearance of wood exposed to these fungal attacks, resulting from the removal of dark lignin [7]. There are two types of white-rot fungi: simultaneous or nonselective white-rot decomposers and selective white-rot decomposers. Nonselective white-rot removers can degrade all components of wood, including cellulose, hemicellulose, and lignin, while selective white-rot removers selectively degrade lignin, leaving cellulose intact [8]. Fungi play an important role in the degradation of lignocellulose. This ability of fungi can be attributed to their ability to grow on a variety of synthetic and natural substrates. Among them, white rot fungi (WRF) have attracted the most attention due to their intrinsic potential to degrade lignin, a complex and heterogeneous aromatic plant polymer with a variety of chemical bonds. The lignin degradation ability of WRF has been exploited in various ways, especially in mushroom production and to improve feed digestibility in biopulping and bioleaching. To perform these functions, WRF possess a number of enzymes, namely lignin peroxidase, manganese peroxidase, and laccase, which help these microorganisms to cleave various bonds in the lignin polymer. Many studies have been conducted on lignolysis. Current research is investigating the potential of WRF in new application areas, such as bioremediation of xenobiotics and various recalcitrant compounds, focusing on their mineralization and complete biodegradability. Triphenyl methane dyes are used in many industrial dyeing processes, such as paper, leather, plastics, paints, fats, and waxes, and are also widely used in the textile industry, such as nylon, wool, silk, and cotton [9].

Triphenylmethane dyes are also used as medical and biological dyes. In wastewater, these colored chemicals absorb light and disrupt aquatic biological processes in the environment, causing aesthetic and environmental problems. In addition, most of them are toxic molecules and are difficult to biodegrade in conventional wastewater treatment plants. When treated with activated sludge, the dyes are adsorbed onto the biomass without being effectively decomposed, and inhibition of microbial growth by certain toxic dyes has been reported. Therefore, industrial wastewater containing dyes is generally treated with physicochemical methods [10] but biological methods have many advantages, such as the ability to decompose dye molecules and produce less sludge. White-rot fungi can decompose a variety of pollutants, including textile dyes. Reported the involvement of the lignin degradation system of *Phanerochaete chrysosporium* in the decolorization of triphenylmethane dyes using a purified culture broth containing fungi and extracellular enzymes. Later, decolorization of crystal violet by various fungi including *Trametes hirsuta* was reported. More recently, degradation of triphenylmethane dyes by various white-rot fungi has been reported. Several factors can affect fungal biodegradation, including the growth conditions of the fungus and the chemical structure of the compound. Dyes with ortho- and para-substituted mono- and polyphenolic groups or aromatic amines in their chemical structure are decolorized more easily and rapidly than dyes with un substituted aromatic structures.

Materials and Methods

Dye

Dyes are purchased from the college laboratory. The dyes are methylene blue and methyl orange.

Collection and identification of fungi

Wood rot fungi are collected from the Western Ghats Region of Tamil Nadu. The fungal strains are identified by the Department of Microbiology, Agriculture University Coimbatore. The fungal strains are *Schizophyllum commune* and *Trametes hirsuta.*

Pure fungal strains *Schizophyllum commune* and *Trametes hirsuta* were inoculated in plates containing Vogels medium with 0.1 mg/mL of different dyes. Plates were incubated at 30°C. After incubation, decolorization was observed. Fungal strains such as *Schizophyllum commune* and *Trametes hirsuta* were inoculated in a conical flask containing Vogels medium with 0.1 mg/mL for fifteen days. For every 24 hours the OD reading at 510 nm, 670 nm, and 470 nm, a total of seven days of reading was noted. Fungal strains such as *Schizophyllum* *commune* and *Trametes hirsuta was were* inoculated in a conical flask containing fungal biomass with 0.1 mg/ml of Methylene blue and methyl orange dye. The fungal were degrading at 30°C with constant shaking at 250 rpm. Organic compounds, or CO_2 some were even capable of utilizing a few azo dyes as their sole source of carbon and nitrogen [11].

Results and Discussion

The ability of the fungi to degrade the azo dyes, methyl blue and methyl orange, was studied in Vogel's medium inoculated with fungal spore suspensions and incubated at 30°C for 6 days in an orbital shaker. After six days, the dyes were added. The samples were withdrawn at regular intervals, filtered, and the optical density of the clear filtrate was measured in a spectrophotometer at 503 nm and 497 nm, respectively, for methylene blue and methyl orange. Samples were withdrawn at regular time intervals and analyzed for total color removal. In the present study, three fungi were studied for the removal of Methylene blue from inoculated broth. The results were tabulated in table 1. The control value was observed to be 0.225 at 503 nm. The fungus *Trametes hirsuta* (96.7%) and *Schizophyllum commun*e (90.2%) removed dye from the dye-inoculated broth within the fourth day of the incubation period. In the present study, three fungi were studied for the removal of methyl orange from inoculated broth. The results were tabulated in table 2. The control value was observed to be 0.214 at 497 nm. The fungi *Trametes hirsuta* (95.5%) and *Schizophyllum commune* (94.8%) removed dye from the dye-inoculated broth within the fourth day of the incubation period. Compared to the fungal strains, *Trametes hirsuta* has a high level of decolorization.

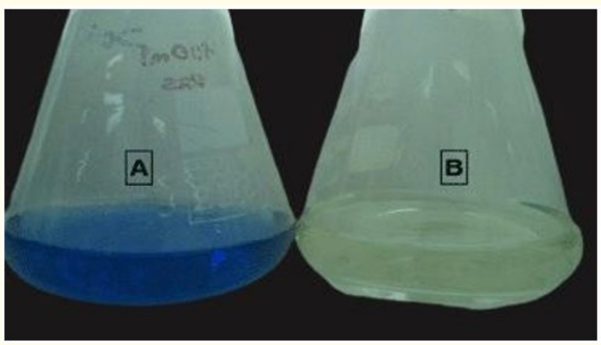

Figure 1: *Adsorption and degradation of methylene blue by white rot fungi Trametes hirsuta (In broth).*

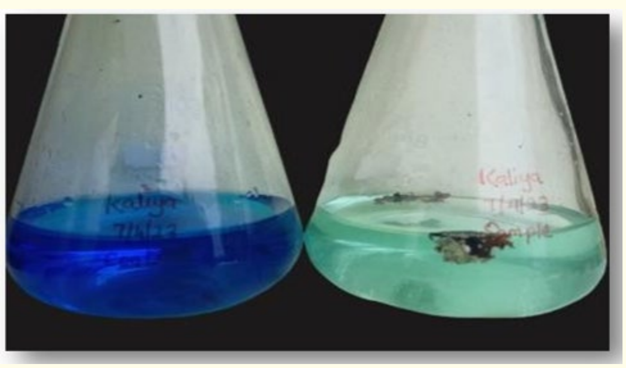

Figure 2: *Adsorption and degradation of methylene blue by white rot fungi Schizophyllum commune (In broth).*

S. No	Hours	OD at 503 nm		% of degradation	
		Trametes hirsuta	***Schizophyllum commune***	***Trametes hirsuta***	***Schizophyllum commune***
1	24	0.086	0.089	60	60.4
2	48	0.015	0.036	93.9	84
3	72	0.008	0.03	95.3	86.6
4	96	0.006	0.026	96.7	90.2

Table 1: *Degradation of methylene blue by white rot fungi Trametes hirsuta and Schizophyllum commune.*

Control value = OD0.225 at 503 nm.

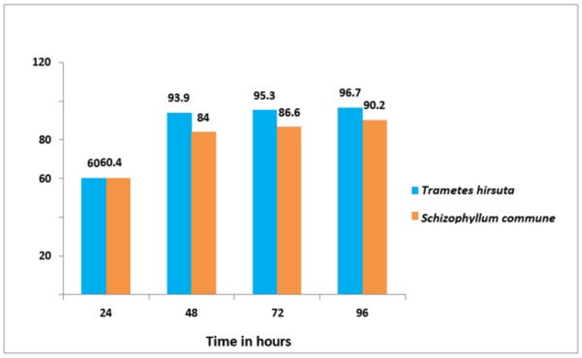

Figure 3: *Degradation of methylene blue by white rot fungi Trametes hirsuta and Schizophyllum commune.*

Figure 4: *Adsorption and degradation of methyl orange by white rot fungi Schizophyllum commune (In broth).*

Figure 5: *Adsorption and degradation of methyl orange by white rot fungi Schizophyllum commune (In broth).*

S. No	Hours	OD at 497 nm		% of degradation	
		Trametes hirsuta	*Schizophyllum commune*	*Trametes hirsuta*	*Schizophyllum commune*
1	24	0.085	0.095	60	55.1
2	48	0.019	0.018	90.1	90.6
3	72	0.01	0.012	92.5	93.9
4	96	0.009	0.01	95.5	94.8

Table 2: *Degradation of methyl orange by white rot fungi Trametes hirsuta and Schizophyllum commune.*

**Control value = OD 0.214 at 497 nm.*

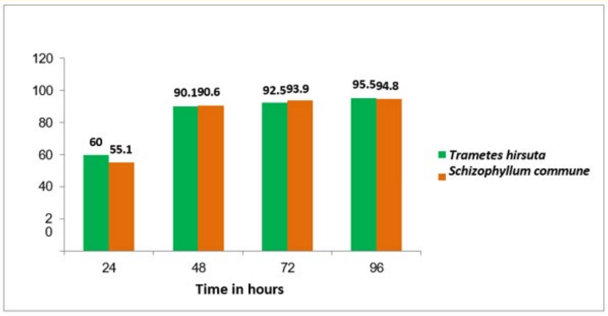

Figure 6: *Degradation of methyl orange by white rot fungi Trametes hirsuta and Schizophyllum commune.*

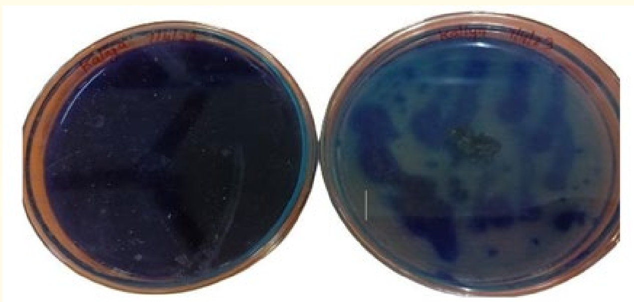

Figure 7: *Degradation of methylene blue by white rot fungi in solid vogels medium Trametes hirsuta and Schizophyllum commune.*

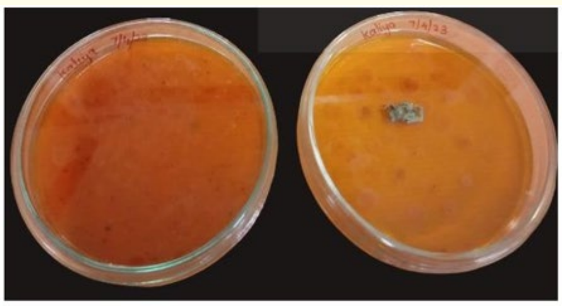

Figure 8: *Degradation of methyl orange by white rot fungi in solid vogels medium Trametes hirsuta and Schizophyllum commune.*

Conclusion

White rot fungi are ubiquitous in nature, particularly in hard wood forests as hardwood, and can degrade all wood components or, preferentially, lignin. The former are named simultaneous or non-selective WRF, and the latter selective WRF. The selective WRF are of special bio-industrial interest since they remove lignin, leaving the valuable cellulose intact. Had variable decolorizing capability for different effluents as a result of dye mixtures being used in different industrial units. White rot fungi are the only known organisms that effectively degrade lignin. The lignolytic enzymes are mono specific and take part in various oxidative reactions. There are three methods involved in the dye degradation: physical, chemical, and biological techniques. Each technique has technical and economic limitations. Physic chemical dye methods have drawbacks because they are too expensive biological treatments in an expensive way to remove dyes in the experiments. Fungi stains such as *Schizophyllum commune* and *Trametes hirsuta* to decolorize methylene blue and methyl orange these fungal strains decolorize above 93% and adsorb above 90%.

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