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Study on the Decolorization of Direct Dyestuffs Wastewater by White Rot Fungus

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Abstract: White rot fungi is a kind of effective filamentous fungi which has a good effect on the decolorization for dye wastewater. This experiment makes a comparation with the decolorization ratio of three kinds of dye wastewater, such as direct sunproof yellow, scarlet and light-green. The results showed that white rot fungi has a great effects on the color of light-green under standing conditions, its decolorization rate is 70.6%; the second is yellow which reaches 58.3%, however, the decolorizing effect of scarlet is the worst, only 36.2%. So, the direct sunproof scarlet are treated under the conditions of adding straw and vibration, respectively. The results showed that the color removal rates of direct fast scarlet dye is greatly improved by adding straw which increases from 36.2-69.6%, while violent vibration does not significantly improve its decolorization. Similarly, adding straw can also improve the removal efficiency of direct sunproof light green and yellow and their decolorization rate increases to 92.2 and 83.8%, respectively, which improves by 21.6 and 25.4% than that of under stable condition.

Key words: White-rot fungi, dye wastewater, decolorization rate

INTRODUCTION

In the social production activities, the dye wastewater treatment has the following difficulties: (1) The COD (chemical oxyen demand) is high, while the value of BOD/COD (chemical oxygen demand) is small and the biodegradability is poor; (2) It has a low chroma, complex composition and it is difficult to decolorization (Gao *et al*., 2010). Physical-chemical and biological methods are commonly used both at home and abroad. The wastewater chroma removal rate of physical-chemical methods is high but the COD is lower than the former with high processing cost, which may cause the problem of secondary pollution. The biological method, in contrast, is a kind of economical and effective method. At present, a lot of microbial species are found which can degrade dyes, mainly including three species of fungi, bacteria and algae. White rot fungi belongs to filamentous fungi which is saprophytic on wood or dead stumps and is a kind of wood rot fungi. It is the center of the carbon cycle and it is the only micro-organisms which can degrade lignin to CO_2 and H_2O in the pure culture (Zouari-Mechichi *et al*., 2006; Eichlerova *et al*., 2005).

In recent years, the technology of white rot fungi treating dye wastewater is an effective treatment method. It can degrade completely various synthetic dyes to CO_2 and H_2O by its special secretion of enzymes or other degradation mechanisms and it has a good effect on the decolorization. Therefore, it has been paid the attention by expert all over the world in recent years (Chander and Arora, 2007; Harazono *et al*., 2003). At present, many counties have done the thorough research which has been involved in e nzymology, degradation mechanism, molecular biology, biological repair and so on.

In this experiment, by preparing three kinds of dye solution of direct sunproof scarlet, yellow and light-green, the white-rot fungus are treated with different kinds of solutions and making a comparison of which kind of dye is the best for the decolorization effect. Then change the conditions for the same dye: under the conditions of adding straw and vibration, so as to find out the optimal conditions of treating dye wastewater by white-rot fundus.

MATERIALS AND METHODS

Test device: The reactor was manufactured by our laboratory, which is shown in Fig. 1.

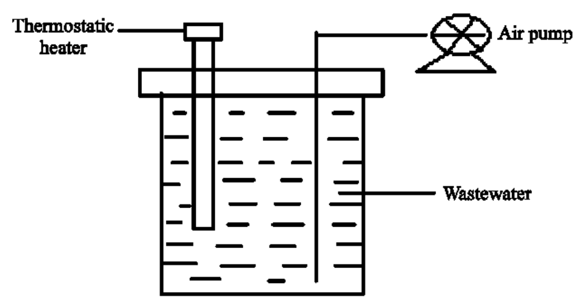

Fig. 1: Bioreactor of white rot fungi

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Test material

Strain: The bacteria used in this experiment was phanerochaete chrysosporium fungus, which is taken from the National Engineering Research Center of FGD, Hydropower College, Sichuan University.

Medium: Solid growth medium: Take peeled potatoes 200 g, cut into small pieces, add water 1000 mL to boil for 30 min and then filter the potato block; and the filtrate is added to 1000 mL with glucose 20 g, agar 15 g, KH_2PO_4 3 g and $MgSO_4$ 1.5 g, which are melted and then packaging and sterilization for 30 min.

Liquid nutrient limitated medium: the 1000 mL solution contains of 0.2 g KH_2PO_4, 0.05 g $MgSO_4$, 0.01 g $CaCl_2$ and 100 mL solution of 10 g glucose.

Cell culture: Strains is inoculated on the slant medium which cultures for 3-4 days at the temperature of 28°C, washed with sterile water into the conical flask and whisked by homogenizer, then it is divided into a flask containing culture which contained of potato juice, at the temperature of 28°C, with shaking and osillating cultivation with the speed of 150 rings min^{-1} for collecting the biomass.

Experimental equipment: Electric-heating standing-temperature cultivator (DRP-9082), reciprocating oscillator (SHZ-82), inoculating loop, pressure cooker, colorimeter (XS-1), portable steam pressure sterilizer (GMSX-280), single operation sterilization (SW-CJ-ID) etc.

Dye wastewater: Take three kinds of dyes of direct sunproof scarlet 4 BS, direct sunproof yellow 5 GL and direct sunproof light green compounded to the solution of 50 mg L^{-1} and then take 10 mL installed in a 150 mL conical flask containing liquid culture medium. Take the direct fast scarlet 4 BS as the research object, the above solution of 10 mL is taken into the two bottles of liquid edium which one added straw and the other with vibratory condition for 2000 ring min^{-1}.

Test methods: There are many factors that affect the decolorization of white rot fungi. In this experiment, the oxygen of specific growth environment is fluent for white rot ungus and the culture temperature is 37°C. The stable nutrients are added to the liquid medium to guarantee white rot fungic growing well and the PH value is constant at 4~5, which is the best conditions for the growth of white rot fungi. On the basis, the other factors that affect the growth of white rot fungi are tested, by changing different types of conditions to test the color variation, such as, dyes, concentrations, oscilation, adding straw and so on, so as to find out the optimal decolorization conditions.

Analysis method: Determination and calculation of decolorization rate: the change of decolorization rate is determined through the reduction of chroma of dye wastewater by colorimeter.

After dye samples are added in liquid culture medium, place it in an incubator to make mycelium and jelly precipitate and take a certain amount of culture of outer bacterial cells from the sample every 24 h, with 2000 ring min^{-1} to centrifugal 10 min. Next, use colorimeter to measure the chroma of supernatant and calculate the decolorization rate with the following equation (Selvam *et al*., 2003):

$$\eta = (A_0 - A)/A_0 \bullet 100\%$$

In the equation: η is the decolorization rate; A_0 and A respectively are the chromaticity before and after wastewater treatment.

RESULTS AND DISCUSSION

Comparison of the decolorization of three kinds of dyes: Under stable condition, three kinds of dye solutions of direct sunproof yellow, light-green and scarlet are added in 150 mL liquid medium, then inhale accurately 10ml different dye wastewater in corresponding conical flask with pipet. The changes of color is measured every day under the same conditions (such as, temperature, humidity, pH, etc.) and the test results are shown in Fig. 2.

Figure 2 showed that decolorization rate of three kinds of dye wastewater by white-rot fungus increases gradually with the time but the rate is different. At the beginning, the decolorization rate increases relatively fast,

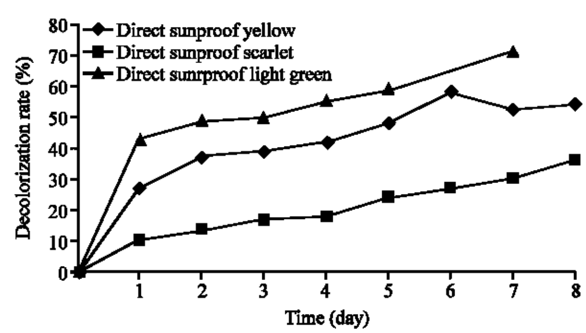

Fig. 2: Changes of decolorization ratio under stable condition

then gradually slow down. This may be due to the reduction of nutrient content of medium leading to the slow growth of white rot fungus, which impacts the degradation effect (Nilsson *et al*., 2006). Among them, the removal effect of direct fast fruit-green is the best, which attained the maximum of 70.6% after 7 days. The second is yellow after 6 days, the bleaching rate reachs 58.3%. This proves that its bleaching effect is worse than the light-green. Because of the different molecular structures of varies dyes, a very small structural difference will cause great different decolorization effects, which may be related to the electronic distribution, the charge density and the spatial configuration of the dyes (Blanquez *et al*., 2008). The worst is direct fast scarlet and its decolorization rate is only 36.2%. The decolorization rate of red dye by white rot fungi is very low, probably due to direct sunproof scarlet 4 BS what is a double azo planar molecule. It is difficult to degrade for this kind of dye and containing a sulfonic acid group (-SO_3) which can inhibit the biodegradability (Trovaslet *et al*., 2007).

Different conditions for treatment of direct sunproof scarlet: Since in a stable condition, the decolorization effect of direct sunproof scarlet is not very ideal, further study the changes of its decolorization rate under the conditions of adding straws and oscillation. Take 150 mL liquid culture medium and 10 mL of dye wastewater of direct sunproof scarlet into two different conical flask and add about 5 g of straws into one of them; put the oscillation bottle in the other conical flask in the thermostatic incubator for oscillation at a constant speed. Measure its color changes every other day and the test results are shown in Fig. 3.

It can be drawn from Fig. 3 that decolorization rate of direct sunproof scarlet by white rot fungi with added straw is significantly increased, the maximum value attains 69.6%, which improves by 33.4% than in the stable condition. Decolorization effect is obvious in the environment with straw, which may be due to straw that plays an important role of biofilm in the simulated wastewater, so that white rot fungi can grow very well. And the number of white rot fungi existing in the sample increases, therefore, the single cell could form zoogloea that make it easy to decolorize for dye wastewater with contact area increasing, so the bleaching effect is better (Zhao *et al*., 2008).

Under oscillation condition, however, the dye removal effect of direct sunproof red is not obvious, which is only up to 38.7% in the tenth day. Consequently, compared with stable condition, oscillation does not significantly improve its decolorization effect. May be because of the violent vibration in the culture medium that will cause the formation of pellet cells and strongly inhibit the enzymatic activity of lignin degradation, so there is not much change in the test results (Boer *et al*., 2004).

Effect on decolorization of direct light green and direct yellow by adding straw: In summary, due to the decolorization efficiency of two kinds of dye wastewater of direct light-green and yellow were not very high by white-rot fungus under stable condition. Similarly, according to direct soonproof scarlet, the straw can also improve their bleaching effect. The other operating conditions are the same as the third group test, the color changes are measured every other day and the test results are shown in Fig. 4.

It can be seen from Fig. 4, the chroma removal effect of white-rot fungi treating dye wastewater of direct fast light green significantly improved after adding straw, which reaches 43.4% only 1 day later. Visible, the degradation efficiency of dye wastewater by white rot fungi is higher than no straw's environment in the condition of a fixed carrier. After 7 days for culture, the decoloration rate reaches a maximum value of 92.2%, which improves by 21.6% than that under stable condition. Thus, added straw can improve its

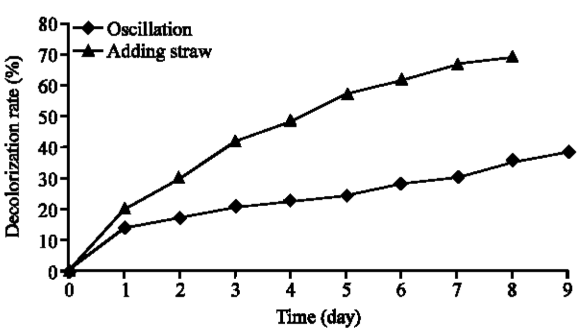

Fig. 3: Effect of straws and oscillation on decolorization rate of direct sunproof scarlet

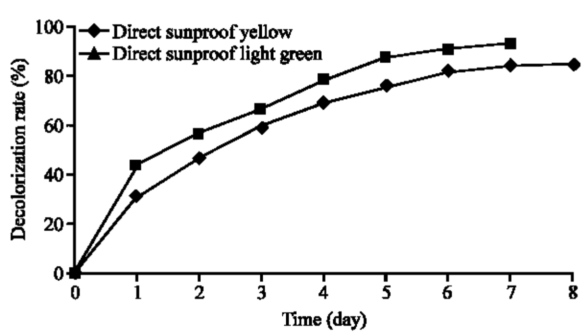

Fig. 4: Effect of straw on decolorization rate

decolorization effects, mainly because the white-rot fungi can grow on the end of straw which is the fixed carrier as well as the nutrients' source of bacteria (Radha *et al*., 2005).

Similarly, the decolorization rate of direct yellow had greatly improved in the environment with straw and its maximum value reaches by 83.8% after 8 days, which is higher 25.4% than that under stable condition. Therefore, the wastewater biochemical treatment bioreactors combines with white-rot fungi technique, namely white-rot fungi fixed on a particular packing and forming a biofilm reactor, which can significantly improve the dye wastewater decolorization ability of white-rot fungus.

CONCLUSION

Under the stable condition, the treatment on direct sunproof light green by white rot fungus is better and the maximum of decolorization rate reaches by 70.6%; the second is direct sunproof yellow and its decolorization rate is 58.3%; while the direct sunproof scarlet, its decolorization effect is the worst, only 36.2%.

Adding straw means to join the carrier of biofilm, which can provide the greatest amount of hanging membrane, in favor of the diffusion of oxygen and the transfer for a variety of substances. So, the treatment effect of direct sunproof scarlet by white rot fungus is greatly improved and the maximum of decolorization rate achieves 69.6%, which increases by 33.4% compared to under stable condition. At the same time, adding straw can also improve the color removal efficiency of direct sunproof light green and yellow by white rot fungus and their decolorization rate increases to 92.2 and 83.8%, respectively, which improves by 21.6 and 25.4% than that of under stable condition. In contrast, the vibratory condition cannot improve the effectiveness very well for treating dye wastewater of direct sunproof scarlet by white rot fungi. This may be the existing forms of white rot fungus are changed and the production and activity of enzymes of lignin are inhibited because of vibration, which affect their treatment effect.

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