The Potential of a Local White-rot Fungus for Effective Decolorization of Azo Dyes

Yanchun Li, Liwen Zheng, Deyi Zhu

Shandong Polytechnic University, Jinan, China
Daxue Road, Western University Science Park, 250353, lyc@spu.edu.cn

Abstract

Dyes contribute as one of the most important environment-polluting chemicals in the tannery effluent. Numerous articles had reported that some white-rot fungi could degrade aromatic compounds containing dyes non-specifically and effectively. In the study, a white-rot fungus had been extracted from the local environment, and the potential of the isolated fungus for effective decolorization of azo dyes had been evaluated. Nine kinds of commercial dyes as experimental materials, it was observed that this fungus was able to decolorize these dyes. To investigate whether the decolorization of the isolated fungus on these dyes attributed to the degradation or biosorption process, the decolorized dyes before and after the culture were monitored by UV-VIS spectrophotometer. The influence of nutritional and environmental factors such as temperature, pH and carbon source had been reported by this article. Specifically whether fatliquor could contribute as effective carbon source for the decolorization of the isolated fungus or not had been evaluated because of the particularity of the leather manufacture, there are little sugars but considerable organic pollutant in tannery wastewater. Moreover, the dose-response relationship and a kenotic equation describing the decolorization of the isolated fungus on the dyes had been established.

Keywords: white-rot fungus; azo dye; biological decolorization; tannery wastewater; nutritional and environmental factors.

Introduction

In recent years, due to need of seeking market development space, the treatment of leather wastewater and biodegradation of leather chemicals have received much attention. Dyes contribute as one of the most important environment-polluting agents in the leather manufacturing due to containing complex aromatic molecular structures. Numerous articles have reported new physicochemical techniques handling the dyeing wastewater of leather manufactory, such as adsorption, precipitation, chemical oxidation, photodegradation, or membrane filtration(Kanagaraj and Mandal 2012; Rosales et al. 2011). However, all of these

have serious restrictions as economically feasible methods for decolorizing the wastewater, such as high cost, formation of hazardous by-products or intensive energy requirements. That has resulted in considerable interest in the use of biological systems for the treatment of these wastewaters(Stolz 2001). However, in the leather processing industry, a wide range of structurally diverse dyes are used within short time periods in one and the same factory. Therefore the effluent from the dyeing process is extremely variable in component, with the consequence that the treatment of dyes in the wastewater is required a largely unspecific process. The current state of the art for the bio-treatment of wastewaters containing dyes is that various bacteria reduce the azo linkage under anaerobic conditions and result in the decolorization of dyes. Albeit this treatment is a largely unspecific process, some of these reduction productions show carcinogenic and mutagenic characters(dos Santos et al. 2007).

From the currently known biological systems, above mentioned unspecifity may still be obtained by using the peroxidases produced from the white-rot fungi. It has demonstrated that the fungi *P. ostreatus* and *P. chrysosporium* are able to decolorize and detoxify several toxic dyes efficiently(Faraco et al. 2009). And it is reported that mixed fungal cultures (containing the white-rot fungi) could degrade and detoxify three kinds of azo dyes(Nascimento et al. 2011). Furthermore, peroxidases are very unspecific for the oxidation of aromatic and xenobiotic compounds. Therefore, in the presence of organic tannin such as vegetable and synthetic tannin in wastewater of leather industry, also these will be oxidized by peroxidases simultaneously. By contrast with bacteria, greater efficiency of fungi to degrade the synthetic tannin had been proved experimentally(Song and Burns 2005). According to the above mentioned theory, the white-rot fungi have a considerable potential in industrial treatment of retanning and dyeing wastewater.

Generally the studies on the white-rot fungi used *P. chrysoprium*, however, which does not exist in the natural environment of china. Therefore, in the present study one kind of white-rot fungus had been isolated from the local environment. Nine kinds of commercial dyes as experimental materials, the potential of this fungus to decolorize dyes had been investigated. Aiming to certify the industrial potential of the white-rot fungus in leather wastewater treatment, whether fatliquor could contribute as effective carbon source for the decolorization had been examined. Moreover, the dose-response relationship and a kenotic equation describing the dye-decolorization of this fungus had been established in the present paper.

Materials and Methods

Materials

Table 1. Dyes used in the study: respective wavelength of optimum absorption (λ_{max}) and classes

Dye	Abbreviation	Optimum wavelength	Chemical structure class
Direct Brown 79	DB79	515 nm	Poly-azo
Direct Fast Bordeaux	DFB	465 nm	Dis-azo
Acid Red 74	AR74	510 nm	Dis-azo
Acid Black 10B	AB10B	620 nm	Dis-azo
Acid Violet 7	AV7	515 nm	Mono-azo
Direct Black 38	DB38	620 nm	Poly-azo
Acid Yellow 11	AY11	390 nm	Dis-azo
Acid Black 2	AB2	565 nm	Mono-azo
Acid Orange 7	AO7	485 nm	Mono-azo

Nine kinds of dyes were obtained from Tianjin Yadong Chemical Dyestuff Factory of China. These azo dyes form a representative group including a variety of mono-, dis- and poly- azo dyes. They are all commercially important dyes in the leather industry. The chemical structure classes and the optimum wavelengths of these dyes are shown in the Table 1.

In this study, three kinds of commercial fatliquors contributed as the extra carbon source and their availability had been tested by contrast with the glucose. In the leather manufacture, the fatliquor plays an important role, which adds oil into the leather fibers so that leather possesses an adequate compliance and softness(Liu and Popović 2002). According to various sources of raw materials, fatliquors could be classified as natural oil based fatliquors or mineral oil based fatliquors. Generally, the natural oil based fatliquors are easily biodegradable. It is worthy of notice that fatliquors with phosphate groups are able to inhibit the decolorization of azo dyes in the current wastewater-treatment system, albeit they are easily biodegradation(Zheng et al. 2012b). Three kinds of commercial fatliquors were used in the present paper as follows: Oxidized-sulfited fatliquor (Natural oil based fatliquor, Derminol OS-1 Liquid, Clariant Chemicals, China); Lecithin based fatliquor (Natural oil based fatliquor, Derminol NLM Liquid, Clariant Chemicals, China); Nonionic fatliquor (Mineral oil based fatliquor, Dermafinish LB Liquid, Clariant Chemicals, China).

All chemicals used for analysis are of analytical grade.

Inoculum and Mediums

A white-rot fungus was isolated from a deadwood of poplar which is placed for 15 days at 40℃ in the damp. And this fungus was named as *Y. Fungus* temporarily. The colony characteristics and the cellular morphology of this fungus are shown in the Fig. 1. According

to the cellular morphology of *Y. Fungus*, this fungus is classified as *Basidiomcycota* obviously. Biomass concentrations of cultures and inoculums were estimated by an absorbance at 600nm wavelength (OD_{600nm}) of the samples. The absorbance was measured using a diode array spectrophotometer (UV-2550 type, SHIMADZU, Japan). And the optical density is converted to the cell concentration of the fungus using an equation which was $X_{biomass}$ ($\times 10^8$ *cell/cm*^{3}*)=1.203* $\times OD_{600nm} - 0.009$ (R^2=0.998).This study employed two kinds of culture mediums which were PAD medium and fluid nutrient medium. The PAD medium is prepared by 1 L boiled water to add in 200 g the potato extract, 20 g glucose, 20 g agar, 3 g KH_2PO_4 and 1.5 g $MgSO_4$.The fluid nutrient medium contains 2 g/L KH_2PO_4, 0.25 g/L $MgSO_4$, 0.1 g/L $CaCl_2$, 15 mg/L $MnSO_4$, 15 mg/L VB_1, 0.2 g/L ammonium tartrate and 20 g/L glucose, and its pH value is at 4.5.

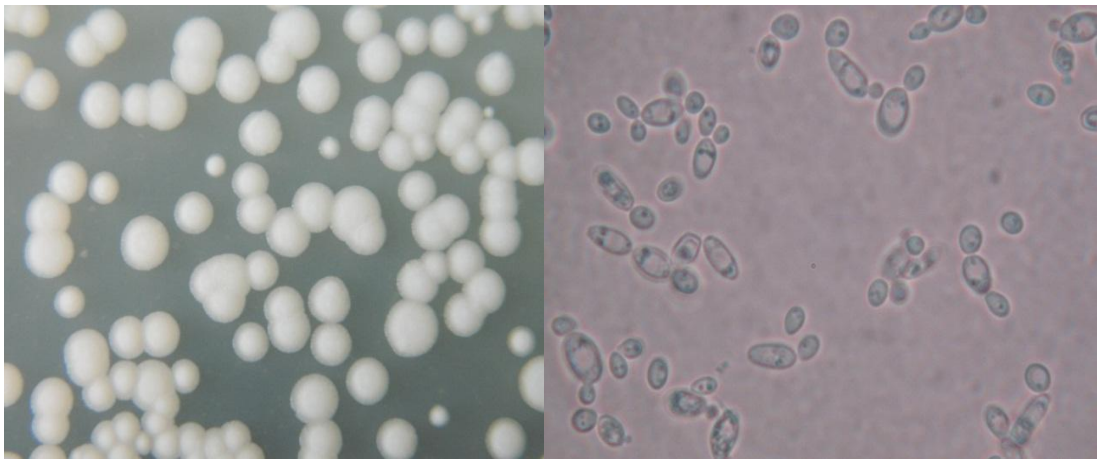

Fig. 1 The colony characteristics and the cellular morphology of *Y. Fungus*

Decolorization of dyes

The decolorization activities of dyes were detected spectrophotometrically by reading a supernatant of cultured sample at optimal wavelengths. The supernatant was prepared by a centrifugation at 10,000 rpm for 20 min (Centrifuger TGL-16G-type, Anke, China). Optic control was performed using the cultured medium in absence of dyes. According to the absorbance before and after the culture, the decolorization activities of dyes were calculated using the following equation.

$$\text{Decolorization activity}(\%) = \frac{\text{Initial absorbance} - \text{Observed absorbance}}{\text{Initial absorbance}} \times 100\%$$

Analysis of UV/Visible spectrophotometer

Under 100 rpm of shaking conditions and at 40℃, respectively the cultures with 20 mg/L various dyes were cultured to continue for 48 hours. UV/Visible spectra of cultured supernatants of 0 hour and 48 hours were compared and whether the decolorization of the isolated fungus on these dyes attributed to the degradation or bio-sorption process was

investigated.

Availability of various carbon sources and physical parameters

In the paper, availability of fatliquors and optimum physical parameters were measured using *Acid Red 74* as the experimental object, and the initial concentrations of this dye were all 20 mg/L. Availability of carbon sources were studied using various fatliquors (*Oxidized-sulfited fatliquor, Lecithin based fatliquor* and *Nonionic fatliquor*) by contrast with the medium added into the glucose. And in this study, the initial concentrations of the fatliquors and glucose were 10 g/L. In order to study the optimum pH value of this fungus to decolorize, 0.02 M potassium phosphate buffer was a substitute for 2 g/L KH_2PO_4 within the fluid nutrient medium, and testing pH values were set on between 4.5 and 9.0. Moreover, the decolorization activities of *Acid Red 74* and the final biomass of these cultures were measured under different frequency of shaking conditions (60, 80 and 100 rpm) and at various temperature (20, 30 and 40℃).

The dose-response relationship and kenotic characteristics

Aiming to verify the decolorization ability of *Y. Fungus* for higher concentrations of dyes during short times, *Direct Fast Bordeaux* and *Acid Red 74* were chosen to contribute as the experimental objects. The concentration width of these dyes were set on 10-100 mg/L, and under 100 rpm of the shaking conditions and at 40℃, the cultures were continued for 24 hours. The concentrations of these decolorized dyes were detected spectrophotometrically by reading a supernatant of cultured sample at the optimal wavelengths, and that of *Direct Fast Bordeaux* and *Acid Red 74* were at 465 and 510 nm respectively. The supernatant was prepared by a centrifugation at 10,000 rpm for 20 min. And then the absorbance were converted to the concentration of *Direct Fast Bordeaux* and *Acid Red 74* using equations which were C_{DFB} *(mg/L)=142.857* $\times A_{465nm}$ (R^2=0.99304) and C_{AR74} *(mg/L)=142.857* $\times$ A_{510nm}(R^2=0.99783) respectively. In the study on kenotic characteristics of dye decolorized by *Y. Fungus*, *Acid Red 74* and *Direct Black 38* were chosen to contribute as the experimental objects. The initial concentrations of these dyes were set on 20 mg/L, and under 100 rpm of the shaking conditions and at 40℃. The absorbances of these cultures at optimum wavelengths were detected spectrophotometrically per 1 hour, and the cultures were continued for 12 hours. And the optimum wavelengths of *Acid Red 74* and *Direct Black 38* are 510 and 620 nm respectively. The decolorization rates of the dyes were characterized in term of $\eta = \ln\left(\frac{\text{Observed absorbance}}{\text{Initial absorbance}}\right)$.

Results and Discussion

The decolorization activities of various dyes

Nine kinds of commercial dyes shown in Table 1 were used in decolorization assays of 48 hours. The initial concentrations of all dyes were 20 mg/L and the cultured temperatures

were 40℃. 9.387E+5cell/cm^3 *Y. Fungus* were inoculated initially. Under the shaking (the shaking frequency was 100 rpm) and static conditions respectively, the decolorization activities of these dyes by *Y. Fungus* and the obvious biomass of these cultures after 48 hours were evaluated and the experimental results were shown in Table 2.

Table 2. The decolorization activities of these dyes and the obvious biomass of the cultures

Dyes	**The decolorization activities of the dyes (Unit: %)**		**The obvious biomass of the cultures (Unit: cell/cm^3)**	
	Shaking culture	Static culture	Shaking culture	Static culture
Direct Brown 79	36.025	13.458	2.007E+08	2.985E+07
Direct Fast Bordeaux	29.714	10.857	1.905E+08	1.881E+07
Acid Red 74	92.613	0.369	1.869E+08	1.545E+07
Acid Black 10B	92.745	8.824	1.834E+08	1.425E+07
Acid Violet 7	65.164	-	1.812E+08	1.155E+07
Direct Black 38	89.691	82.131	1.777E+08	1.504E+08
Acid Yellow 11	16.814	-	1.804E+08	1.438E+08
Acid Black 2	42.286	21.505	2.143E+08	1.665E+08
Acid Orange 7	11.030	-	1.831E+08	1.450E+08

- "-" expresses that the decolorization activity calculated was a negative value, that means the dye did not degraded.

It has been proved that under the shaking conditions all of these dyes were decolorized by *Y. Fungus* in obvious degrees. And specially, the decolorization activities of AR74, AB10B and DB38 after 48 hours cultures accomplished above 80%. Moreover, *Y. Fungus* under the shaking conditions shown a higher decolorization efficiency and growth activity than that under static conditions. And under the shaking conditions, there was no difference order of magnitude in the obvious biomass of *Y. Fungus* between the mediums containing various the dyes, which have evinced the toxin immunity of this fungus against dyes. The color disappearances of all azo dyes depended on the growth of *Y. Fungus* evidently. In order to investigate whether the decolorization of these dyes could be attributed to the degradation by *Y. Fungus*, UV/Visible spectra of cultured supernatants of 0 hours and 48 hours had been compared. UV/Visible spectra of these dyes before and after the shaking cultures are shown in Fig.2. These spectra contain the absorbance analyzed from 280 nm to 800nm. By contrast with the spectra of the dyes before the cultures, the cultured dyes showed disappearance or decline of original absorbance-peaks and appearance of new absorbance-peaks, and which indicates that this local white-rot fungus isolated from our laboratory is able to degrade azo dyes efficiently under aerobic conditions.

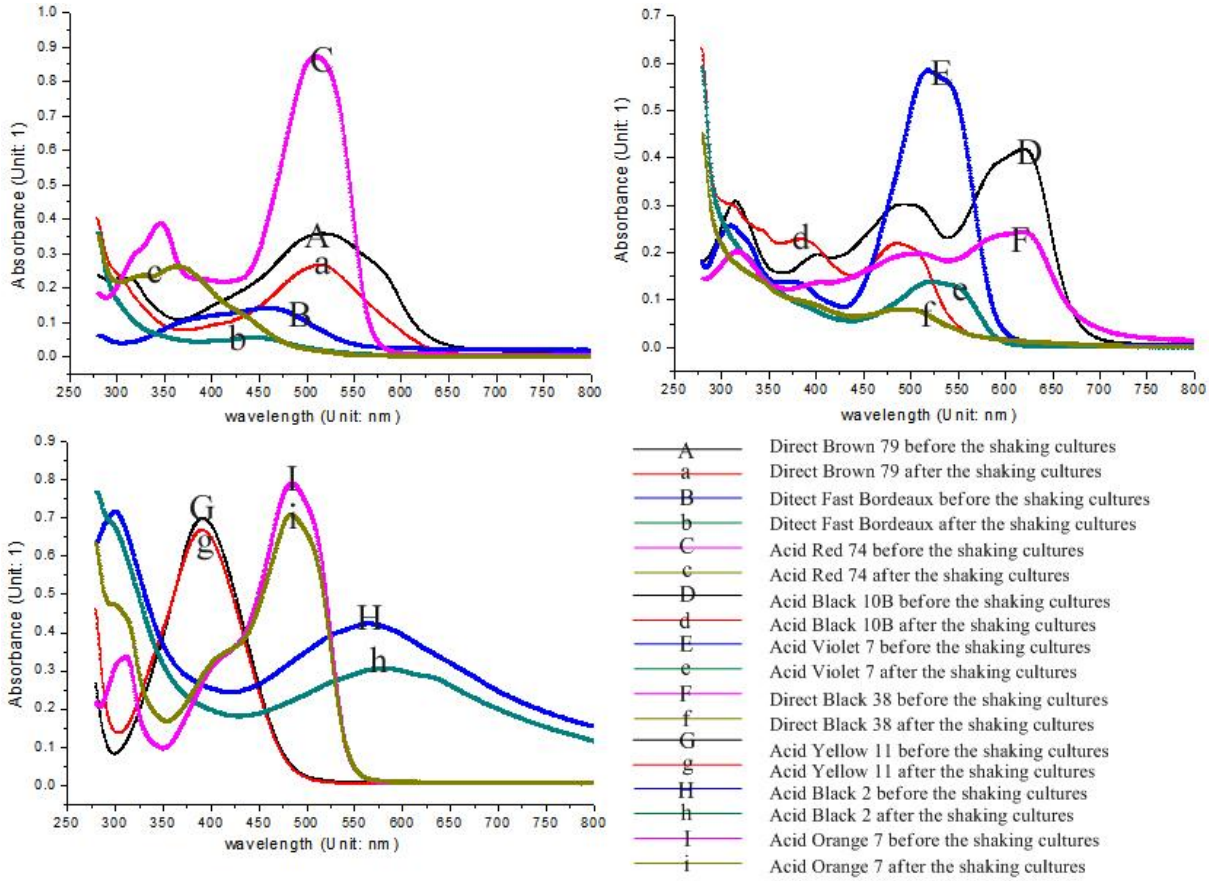

Fig. 2 The spectra of various dyes before and after the shaking cultures

Availability of fatliquors to supply carbon sources

The decolorization activities of AR74 using various carbon sources were determined by conducting four parallel tests. And 1.15E+6 cell/cm^3 *Y. Fungus* were inoculated into the cultures and the cultures were continued for 2 days under 100 rpm of the shaking conditions at 40℃. The mean values of the decolorization activities of AR74 using the various carbon sources, which were the glucose, *Oxidized-sulfited fatliquor, Lecithin based fatliquor* and *Nonionic fatliquor,* were 95.452, 36.242, 45.383 and 33.195% respectively. It is obvious that the efficiency of the glucose to supply the carbon source of the dye decolorization is higher than that of the fatliquors. However, the dye in the cultures with these fatliquors was decolorized in certain degrees. And on condition that *Lecithin based fatliquor*, which is a kind of fatliquor with phosphate groups, contributed as the carbon sources of the growth of *Y. Fungus*, the decolorization activity of AR74 cannot be inhibited by contrast with the activated sludge of tannery as an inoculum(Zheng et al. 2012a). Moreover, there is not a significant difference in the decolorization activities among using the various fatliquors.

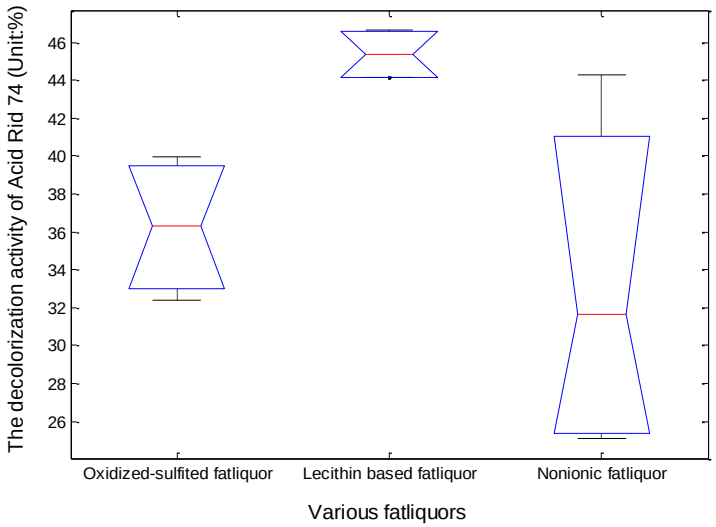

Fig. 3 The results of a one-factor experiment on the availability of various fatliquors

For investigating whether type of fatliquor affects the decolorization of azo dyes by *Y. Fungus*, a one-factor experiment of the dye decolorization was tested using Matlab7.1.0.246, which method is [P, tab, stats] = anova1(X), in where, "X" is the sample matrix. The testing result was shown in Fig. 3, and respectively the F-value and P-value of this testing were 4.57 and 0.0426. According to these statistics results, type of fatliquor has not an obvious effect on the decolorization of AR74. It means that *Nonionic fatliquor* is able to supply carbon sources for the decolorization of dyes by *Y. Fungus,* albeit it is hardly biodegraded by the activated sludge of tannery(Zheng et al. 2011).

Effect of pH on dye decolorization

Generally the dye decolorization of the white-rot fungi exhibit an optimum at pH 4.5~5, however a pH width of the wastewater of the retanning and dyeing processes changes with various processes of leather making. Aiming to measure a survivability of *Y. Fungus* at a higher pH value, the decolorization activities of AR74 and the obvious biomass of these cultures were determined by conducting four parallel tests. And 3.75E+5 cell/cm^3 *Y. Fungus* were inoculated into the cultures and the cultures were continued for 24 hours under 100 rpm of the shaking conditions at 40℃. Utilizing the above experimental results, the one-factor experiments of the dye decolorization and the *Y. Fungus* growth were tested using Matlab 7.1.0.246, which method is [P, tab, stats] = anova1(X). The testing results were shown in Fig. 4 and Fig.5. The testing F-value and P-value of the dye decolorization were 8.86 and 0.0007 respectively, and the testing F-value and P-value of the *Y. Fungus* growth were 11.53 and 0.0002 respectively. According to these statistics results, the pH values of the wastewater have an obvious effect on the decolorization of AR74 and the growth of *Y. Fungus*, and the effect of pH values on the *Y. Fungus* growth is more obvious than that on the decolorization of AR74. According to the experimental results, a rather acid pH of the wastewater treatment system is able to accomplish the dye decolorization *of Y. Fungus*.

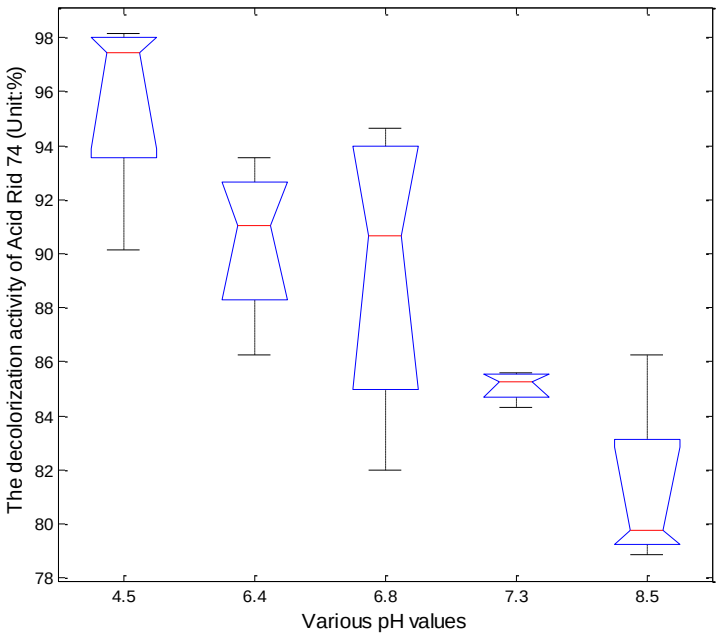

Fig. 4 The results of a one-factor experiment on the pH value affecting the decolorization

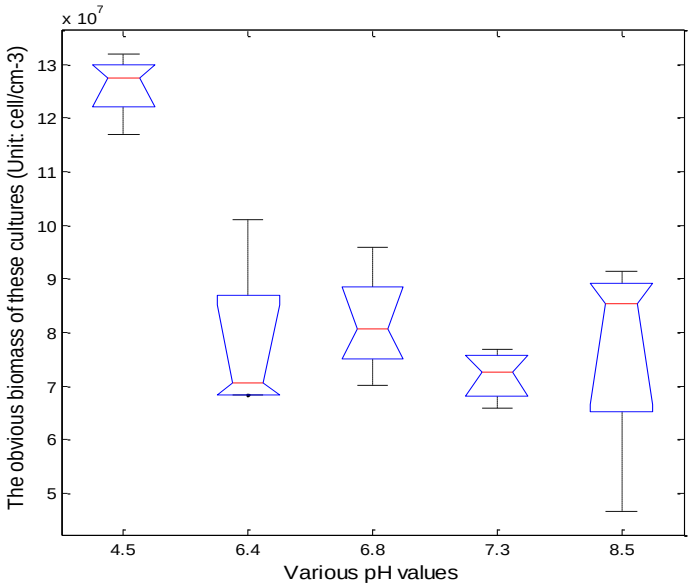

Fig. 5 The results of a one-factor experiment on the pH value affecting the growth

Effect of temperature and shaking frequency on dye decolorization

Under various cultured conditions, the decolorization activities of AR74 and the obvious biomass of these cultures had been determined by conducting four parallel tests. And 5.48E+5 cell/cm^3 *Y. Fungus* were inoculated into the cultures and the cultures were continued for 12 hours. The determined results were shown in Table 3.

A two-factor experiments of the dye decolorization and the *Y. Fungus* growth were tested using Matlab 7.1.0.246, which method is [P, tab, stats] = anova2(X, Rep), in where, "X" is the corresponding sample matrix and "Rep" is the number of the parallel experiment preformed. On condition that the effect of the shaking frequency of the cultures was tested, the testing F-value and P-value of the dye decolorization were 167.09 and 0 respectively, and the testing F-value and P-value of the *Y. Fungus* growth were 4.23 and 0.0253 respectively. On condition that the effect of the cultured temperature was tested, the testing F-value and P-value of the dye decolorization were 132.94 and 0 respectively, and the testing F-value and P-value of the *Y. Fungus* growth were 11.89 and 0.0002 respectively. According to the above mentioned results, the effects of the cultured temperature and the shaking frequency on the dye decolorization are more obvious than that on the *Y. Fungus* growth, and the shaking frequency has not an obvious effect on the *Y. Fungus* growth. Moreover, the optimum conditions of the dye decolorization and the *Y. Fungus* growth are under 100 rpm of the shaking cultures and at 40℃.

Table 3. Effect of temperature and shaking frequency on the dye decolorization and the *Y. Fungus* growth

	60 rpm		**80 rpm**		**100 rpm**	
	Decolorization	Biomass	Decolorization	Biomass	Decolorization	Biomass
20℃	21.183%	3.77E+07	12.098%	5.69E+07	64.334%	4.93E+07
	23.299%	3.70E+07	13.042%	5.31E+07	48.785%	4.80E+07
	21.459%	4.23E+07	16.399%	5.91E+07	63.071%	4.89E+07
	23.942%	4.06E+07	13.776%	5.77E+07	70.845%	4.68E+07
30℃	61.258%	4.81E+07	45.187%	5.49E+07	93.683%	4.67E+07
	55.781%	5.10E+07	50.429%	7.24E+07	95.724%	5.53E+07
	57.809%	5.95E+07	41.416%	5.88E+07	93.100%	4.06E+07
	58.824%	5.81E+07	47.302%	6.93E+07	96.501%	6.22E+07
40℃	57.051%	5.80E+07	78.296%	9.17E+07	96.696%	6.37E+07
	65.696%	6.43E+07	65.788%	8.46E+07	93.586%	5.55E+07
	41.232%	5.82E+07	64.040%	4.47E+07	96.890%	1.17E+08
	34.795%	5.85E+07	66.616%	9.82E+07	95.335%	9.44E+07

The dose-response relationship and kenotic characteristics of dye decolorization

According to the results of the above mentioned experiment, at a low dye-concentration *Direct Fast Bordeaux* and *Acid Red 74* respond a low and high decolorization activity respectively. 9.15E+5 cell/cm^3 *Y. Fungus* were inoculated and the mediums were cultured for 24 hours. The degraded concentrations of two dyes were shown in Fig. 6. From the experimental data, it is obvious that the two dyes were decolorized by *Y. Fungus* at higher concentrations of the dyes. Moreover, the decolorization of the dyes by *Y. Fungus* cannot be limited within 10~100 mg/L of the dye-concentration width, and evidently the degraded concentrations of the dyes rose linearly with the increase of the initial concentrations of the

dyes. The dose-response relationship of the decolorization of these dyes by *Y. Fungus* is fitted linearly as shown in Table 4.

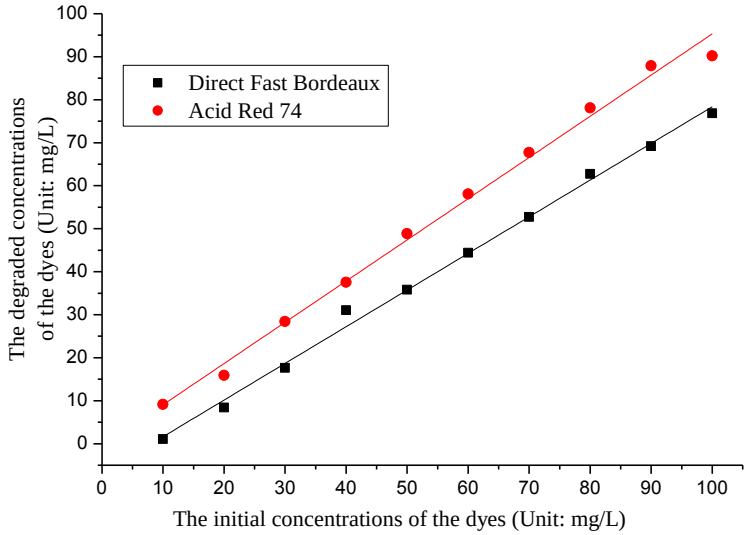

Fig. 6 The degraded concentrations of *Direct Fast Bordeaux* and *Acid Red 74*

Table 4. The linearly fitting results of the degraded concentrations of the two dyes

Dyes	**The model *y=a+bx***				
	The fitting values of the parameters		The results of the statistic testing		
	a	b	R^2 value	F value	P value
DFB	-6.895	0.852	0.995	2017	6.670E-11
AR74	-0.518	0.958	0.993	1285	4.014E-10

According to the results of the statistic testing, the linear equation is able to describe the dose-response relationship of the decolorization of these dyes within 10~100 mg/L of the dye-concentration width. From the fitting values of the parameters, *Direct Fast Bordeaux*is degraded hardly by *Y. Fungus* at low concentration of the dye and its decolorization activity depends on the dye concentration evidently.

The degradation of the dyes by the white-rot fungi attribute to the special peroxidases, which are thought to be expressed in most cases only during secondary metabolism following growth when carbon and/or nitrogen sources become limited. According to the characteristic of the retanning and dyeing wastewater, this paper chose nitrogen sources as the limited nutrient, and the fluid nutrient medium contains 0.2 g/L ammonium tartrate. In the beginning of the cultures, the product of these peroxidases is limited because of the ammonium tartrate, and the degradation rates of dyes are limited extremely by the low concentration of these peroxidases in the mediums. In this stage, the dyes can not be degraded by *Y. Fungus* and the degradation rates of dyes are 0. With the continuation of the cultures, the ammonium tartrate is exhausted, and then *Y. Fungus* is transformed into the secondary metabolism and produces the peroxidases which are able to catalyze the degradation of the dyes. The degradation rates

of dyes only depend on the concentration of the dyes in the period. Therefore there is a retaining time in the degradation of dyes, and the degradation of dyes with times should be in accord with the following equation.

$$\begin{cases} if\ t < t_0, \quad \eta = \ln\left(\dfrac{Obvious\ Absorbance}{Initial\ Absorbance}\right) = 0; \\ if\ t > t_0, \quad \eta = \ln\left(\dfrac{Obvious\ Absorbance}{Initial\ Absorbance}\right) = -k(t - t_0); \end{cases}$$

Where, t_0 is the retaining time during the dye degradation and k is the degradation rate of the dye after the retaining time. *Acid Red 74* and *Direct Black 38* as the experimental objects, 1.19E+6 cell/cm^3 *Y. Fungus* were inoculated and the absorbance of the cultures were detected per 1 hour. The degradation rates of the dyes with times were shown in Fig. 7. From the Fig. 7, it is obvious that the decolorization of the dyes is limited before 6 hours of the cultures. The data were fitted utilizing the above mentioned equation, and the fitting results were shown in Table 5.

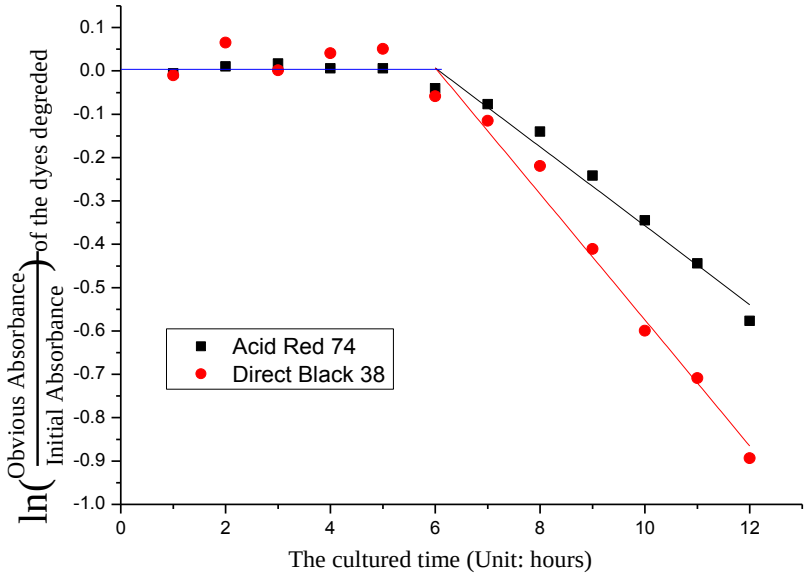

Fig. 7 The degraded rates of *Acid Red 74* and *Direct Black 38*

Table 5. The fitting results of the degraded rates of the two dyes

Dyes	**The model** $\begin{cases} if\ t < t_0, \quad \eta = 0; \\ if\ t > t_0, \quad \eta = -k(t - t_0); \end{cases}$				
	The fitting values of the parameters		The results of the statistic testing (Number of the data points is 7)		
	k	t_0 (Unit: hours)	R^2 value	F value	P value
AR74	0.091	6.074	0.971	202	3.074E-5
DB38	0.145	6.047	0.978	272	1.493E-5

According to the results of the statistic testing, the above mentioned equation is able to describe the time-variation to the decolorization rates of *Acid Red 74* and *Direct Black 38.* According to the fitting values of the parameters, the stimulation of *Acid Red 74* to the peroxidases is greater than that of *Direct Black 38,* but the ability of these peroxidases to degrade *Acid Red 74* is lower.

Conclusions

In the leather processing industry, a wide range of structurally diverse dyes are used within short time periods in one and the same factory, and therefore the treatment of the dyeing wastewater needs a largely unspecific process of dyes degraded. From the currently known biological systems, the above mentioned unspecifity may be obtained by using either the peroxidases from the white-rot fungi or the unspecific reduction processes catalyzed by various bacteria under anaerobic conditions. However, these anaerobic bacteria cannot degrade the aromatic structure of dyes, and some of intermediate produced from the reduction of dyes show carcinogenic and mutagenic characters. By contrast, the white-rot fungi could degrade dyes into non-toxic products, and also they are able to degrade organic tannin such as vegetable and synthetic tannin. The present study has isolated one kind of white-rot fungus from the local environment and measured the potential of this fungus for the dye degradation. The experimental results have proved that this isolated fungus has a prodigious ability to degrade azo dyes. Moreover, availability of fatliquors as carbon sources of the decolorization had been evaluated. It is proved that the fatliquor in the wastewater is able to supply carbon sources for the dye decolorization of this isolated fungus.

However, some limitations are worth notice. In addition to the fatliquors and dyes, the wastewater of retanning and dyeing process contains some other chemicals, such as organic tannin and Cr (III). It is evidenced that the white-rot fungus produce the peroxidases depending on the aromatic structures of pollutions in the mediums, and the same aromatic compound at different concentrations may function as either an inducer or a repressor to the peroxidases(Elisashvili et al. 2010). Moreover, metal ions, such as Cr (III), may inhibit the activity of the peroxidases. Future work should therefore include follow-up work designed to evaluate whether organic tannin and Cr (III) would affect the decolorization of dyes by this isolated fungus.

Acknowledgments The authors would like to gratefully thank the support from the National Natural Science Foundation (N0.21276150), China.

Reference

Dos Santos, AB; Cervantes, FJ; van Lier, JB (2007) Review paper on current technologies for decolourisation of textile wastewaters: Perspectives for anaerobic biotechnology. Bioresource Technology 98 (12):2369-2385.

Elisashvili, V; Kachlishvili, E; Khardziani, T; Agathos S (2010) Effect of aromatic compounds on the production of laccase and manganese peroxidase by white-rot basidiomycetes. Journal of Industrial Microbiology & Biotechnology 37 (10):1091-1096.

Faraco, V; Pezzella, C; Giardina, P; Piscitelli, A; Vanhulle, S; Sannia, G (2009) Decolourization of textile dyes by the white-rot fungi Phanerochaete chrysosporium and Pleurotus ostreatus. Journal of Chemical Technology & Biotechnology 84 (3):414-419.

Kanagaraj, J; Mandal, A (2012) Combined biodegradation and ozonation for removal of tannins and dyes for the reduction of pollution loads. Environ Sci Pollut Res 19 (1):42-52.

Liu, CK; Popović, Z (2002) Synthesis of complex dynamic character motion from simple animations. ACM Trans Graph 21 (3):408-416.

Nascimento, C; Magalhães, DdP; Brandão, M; Santos, AB; Chame, M; Baptista, D; Nishikawa, M; Silva, MD (2011) Degradation and detoxification of three textile Azo dyes by mixed fungal cultures from semi-arid region of Brazilian Northeast. Brazilian Archives of Biology and Technology 54:621-628

Rosales, E; Pazos, M; Sanromán, MA (2011) Comparative efficiencies of the decolourisation of leather dyes by enzymatic and electrochemical treatments. Desalination 278 (1–3):312-317.

Song, Z; Burns, R (2005) Depolymerisation and biodegradation of a synthetic tanning agent by activated sludges; the bacteria Arthrobacter globiformis and Comamonas testosteroni; and the fungus Cunninghamella polymorpha. Biodegradation 16 (4):305-318.

Stolz, A (2001) Basic and applied aspects in the microbial degradation of azo dyes. Appl Microbiol Biotechnol 56 (1-2):69-80.

Zheng, LW; Li, YC; Liu, J; Chen, YF (2012a) Study on influence of leather fatliquor on the biodegradation of dye. Journal of AQEIC 63 (4):77-84

Zheng, LW; Li, YC; Liu, J; Cheng, YF (2011) Study on the Biodegradability of Fatliquors. China Leather 3:32-36

Zheng, LW; Li, YC; Zhou, JH (2012b) Doso-effect Relationship Influence of fatliquor on Biodegradation of Acid Fuchsin Dye. Paper presented at the The 9th National Conference on Leather Chemicals; Beijing; China: 247-252.