Decolorisation Treatment of Wastewater Containing Reactive Yellow 15 Using Herbal absorbent of Wheat Husk

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Abstract**—** In the present work, Wheat husk was applied as a natural absorbent for the dye C.I. Reactive Yellow 15. Different effective parameters of the decolorization process such as contact time, stirring speed, temperature and pH of solutions were studied and the best condition for achieving the highest efficiency was introduced. It was found that the Wheat Husk activated with solution of $HClO_4$ has a higher adsorption capacity. The optimum reaction time, at a speed of 140 rpm, is 70 min. At very acidic and natural pH and at the temperature of 30 ^{o}C, C. I. Reactive Yellow 15 was removed more effectively. The Longmuir isotherm was found to be the most appropriate isotherm for describing the adsorption behavior of the reactive dye on wheat husk.

Keywords**—** Ractive dye, Waste water, Decolorisation, Adsorption, Wheat Husk.

I. Introduction

EFFLUENTS or wastewaters are the main pollutants of the environment. Over the past decades, increased attention has been directed to this issue, and many efforts have been made to clean up the environment. Different methods have also been developed for the refinement of effluents most of which are too expensive.

Great importance has been attached to textile industry in terms of its environmental impact because it consumes considerably high amounts of processed water and produces high quantities of polluted discharge colored wastewater including a great amount of dyes and chemical additions.

In textile industry wastewater may be produced from various sources causing the discharge of suspended particles (in different sizes, e.g., colloids), acidic or basic agents, heavy metals and soluble toxic compounds into the water [1-5]. For example, each of the washing (scouring), bleaching, mercerization, dyeing, printing and finishing processes can produce different types of wastewaters. The resulted effluent leading to the formation of the mentioned processes usually has a high temperature and pH and contains a large volume of organic non-biodegradable chemicals such as soaps, detergents, waxes, (in washing process), chlorine and peroxide compounds (in bleaching process), heavy metals caused by dyeing reactions, starches, and various toxic chemicals that are usually used in finishing processes. The presence of high magnitudes of salts in dye bathes (typically up to 100 g/l) makes the refinement and discharge of the wastewater more complicated. Hence, textile effluent treatment procedures usually encounter two main problems; Firstly the decolorisation and secondly the salt purification of the effluent. Furthermore, most of the dyestuffs are water soluble and not degradable under non-aerobic biologic refinement conditions [6-9].

Discharge of the pollutant waste water into the environment is undesirable; therefore, the effluent from textile processes has to be treated before it is released. Conventional refinement methods can mainly be subdivided into the physical, chemical and biological groups. In spite of a relatively good efficiency, these methods usually encounter difficulties when high amount of tint and color of the wastewater exists, which is actually one of the main problems in refinement processes. In this way, complementary methods should be applied to treat the effluent [10-12].

After the extraction of wheat grain, wheat husk is generated in large quantities. Wheat husk is considered to be a kind of waste material. In order to get rid of this huge amount of wheat husk, farmers use only a small volume of it in agricultural farms as a fertilizer and usually burn the rest of it in open air that can cause environmental problems. Therefore, it is necessary to properly manage and use the burnt residues in order to reduce its environmental impact including land and air pollution.

II. Experimental

III. Materials And Methods

IV. Preparation Of Wheat Husk

All chemicals and reagents used in this work were of analytical grade purity. The wheat husk was from Mazandran farm in the north of Iran and was extensively washed with water to remove soil and dust, and was air dried. The wheat husk was dried in an oven at 65°C for a period of 3 h. Finally, it was ground and sieved (meshes 2-35). The chemical modification of wheat husk was made according to the similar method previously described by Vaughan et al. (2001). The wheat husk absorbent was activated by stirring in 1 mol/lit solutions of HNO_3, HCl, H_2SO_4, $HClO_4$, H_3PO_4 and NaCl. Then the activated absorbent was washed by distilled water and filtered using a suction device. At the next step, the activated wheat husk absorbent was added to a 200cc solution of the reactive dye. The pH of the solution was adjusted by using buffered solution.

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V. Preparation Of Dye Solutions

A reactive Yellow dye (C.I. Reactive Yellow 15), was used in this study. All chemicals were supplied by Merck Chemical Corp. The sample of wheat husk was taken from a wheat flour making factory in Iran, grounded by 1mm open size. The spectrophotometric determinations were made by a UV-Visible CINTRA 10 spectrophotometer. A digital pH meter device was used for exact evaluation of pH of the samples. The stock solution had a concentration of 1 g/l of the dye.

The amount of decrease in dye concentration before and after the refinement process was calculated by Eq. (1):

$$\%R = (1 - \frac{c}{c_0}) \times 100 \quad (1)$$

Where C_0 is the concentration after decolorisation, C is the concentration of dye before decolorisation and R is the decolorisation efficiency.

VI. Results And Discussion

VII. Studying The Effect Of Activators

In order to investigate the effect of chemical modification on the C.I. Reactive Yellow 15 dye sorption of wheat husk, the removal capacities of modified Wheat Husk sorbing of C.I. Reactive Yellow 15 from aqueous solution were compared. The concentration of the activator and the experiment time were 1mol/l and 1 hour, respectively. The obtained results bearing to the fact that the treatment of Wheat Husk with $HClO_4$ as an activator is very interesting and can remove about 94.58 percent of C.I. Reactive Yellow 15 dye from aqueous solutions.

VIII. Effect Of Contact Time (Dye And Absorbent)

`The effect of contact time between absorbent and dye was evaluated in which the concentration of dye and the volume of the solution were 100 mg/l and 200cc, respectively. To evaluate the effect of contact time, the stirring time at constant rpm (130) was varied between 0 and 160 min. The results are illustrated in Fig. 1. As it is shown, the amount of absorbance increases up to the 70 minutes and then slightly decreases until it reaches to a saturated state. In further studies, the stirring time of 70 min was selected to guarantee the equilibration state.

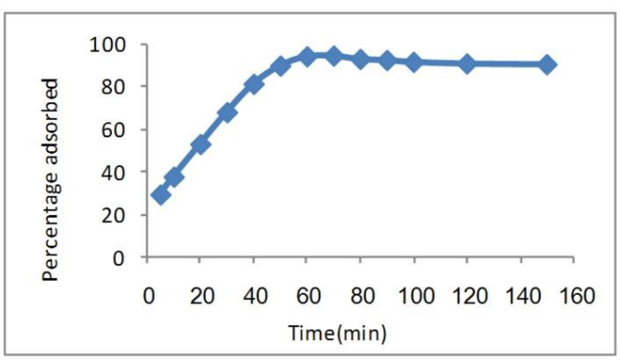

Fig. 1. The effect of contact time on the adsorption of C.I. Reactive Yellow 15 using activated Wheat Husk.

IX. Effect Of Stirring Speed

The effect of stirring speed was studied by changing the stirring speed of the instrument in the range of 50 to 300 rpm at constant concentration and stirring time 70 min. The maximum amount of absorption was observed at rpm of the 140, while at higher rpm, the dye molecules did not have enough time to contact with the active sites of the absorbent.

X. Effect OF pH

The effect of sample pH on the sorption process was investigated. Decolorisation process was investigated at room temperature and in the pH range of 2-12. The results obtained in Fig. 2 show that the absorption of dye is highly dependent on the pH of solution as well as the surface charge of the sorbent. As illustrated in this figure, in acidic (pH 3) and neutral state, the highest amount of absorption was achieved while toward basic conditions it decreased.

In acidic media (low pH), the active site on the sorbent is positively charged and can sorb the reagent dye, as the result of electrostatic attraction between negatively charged dye anions and positively charged adsorption sites and an increasing in dye adsorption. Maximum removal of C.I. Reactive Yellow 15 with Wheat Husk was at acidic pH of 3. In basic media the surfaces are probably negatively charged. It may be due to the abundance of -OH ions on sorbent which cause repulsion between the negatively charged surface and the anionic dye molecules. Besides, and also there are no exchangeable anions on the outer surface of the adsorbent at higher pH values and consequently the adsorption decreases.

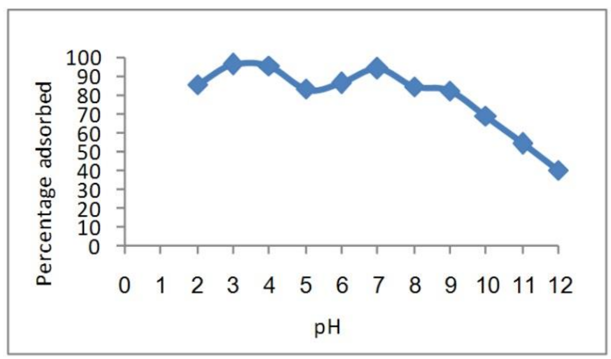

Fig. 2. The effect of pH on the absorption of C.I. Reactive Yellow 15 using activated Wheat Husk.

XI. Effect Of Temperature

The decolorisation process was investigated at 10 different temperatures (20, 25, 30, 35, 40, 45, 50, 55, 60, and 65°C) when the solution was neutral (pH 7) and the concentration of dye was 0.1 g/l. As it is shown in Fig. 3, the absorbance reaches to a maximum amount at 30°C and then decreases, i.e. the absorbance for 65°C is the lowest.

It is due to desorption of C.I. Reactive Yellow 15 from sorbent to the solution at high temperature. Nevertheless as the uptake of C.I. Reactive Yellow 15 by Wheat Husk was fast and at room temperature, another experiment was conducted at ambient temperature.

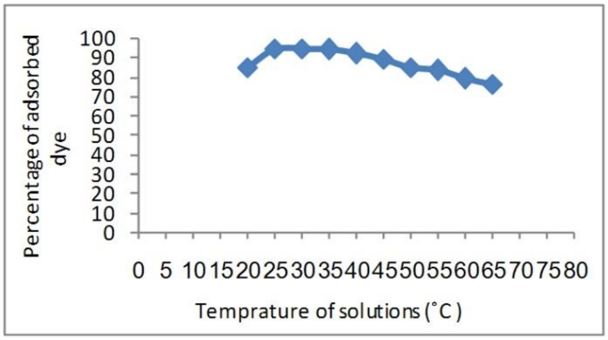

Fig. 3. The effect of temperature on absorption of C.I. Reactive ig. Yellow 15 (pH 7 and contact time 60 min.)

XII. ADSORPTION ISOTHERM

In order to determine the type of adsorption isotherm of the Reactive Yellow dye on the Wheat Husk, the temperature of 25^{o}C (room temperature) was selected, and the absorbance behavior at different dye concentrations was evaluated. The results are illustrated in Fig 4. The obtained absorbance data were fitted on two conventional adsorption isotherms, namely: Langmuir (Fig. 5) and Froehlich (Fig. 6).

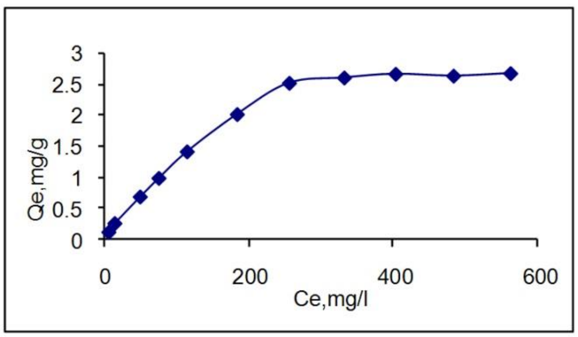

Fig. 4. Adsorption isotherm for the dye C.I. Reactive Yellow 15 using activated Wheat Husk at 25^{o}C.

T he Langmuir adsorption isotherm is presented by Eq. (2).

$$Q_e = \frac{K_1 * Q_m * C_e}{1 + K_1 * C_e} \quad (2)$$

Where Q_e and C_e are dye concentration at equilibrium condition on the absorbent (mg.g^{-1}) and in the solution (mg.dm^{-3}), respectively. Q_m is the absorption capacity of the absorbent (mg.g^{-1}) and K_1 (dm^3.mg^{-1}) is called the Langmuir absorption constant.
The Freandlich absorption equation is presented by Eq. (3).

$$Q_e = K_f C_e^{\frac{1}{n}} \quad (3)$$

Where K_f and n are the Freandlich isotherm constants.
According to the obtained correlation values in table I, the best adsorption isotherm model for single layer adsorption of the Reactive Yellow 15 dye on the wheat husk is Longmuir isotherm.

Hence, it can be concluded that there are sites on the wheat husk that either chemically or physically absorb the dye. By complete occupying of the sites, saturation state in adsorption is achieved, which is actually the adsorption capacity of the Longmuir isotherm.

TABLE I.
ISOTHERM PARAMETER FOR THE ADSORPTION OF REACTIVE YELLOW 15 ONTO ACTIVATED WHEAT HUSK AT 25˚C

Model	Parameter Value		R^2
Langmuir	K_l (L/mg)	Q_m (mg/g)	0.9985
	0.002978	5.3561	
Freandlich	K_f (mg/g)(L/g)^n	n	0.9658
	0.03356	1.3469	

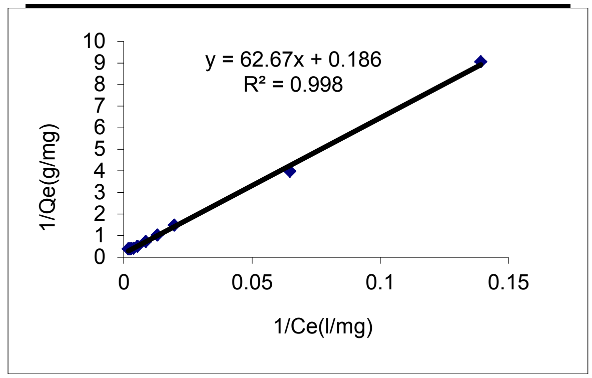

Fig. 5. Langmuir isotherm for the dye C.I. Reactive Yellow 15 on activated Wheat Husk at 25˚C

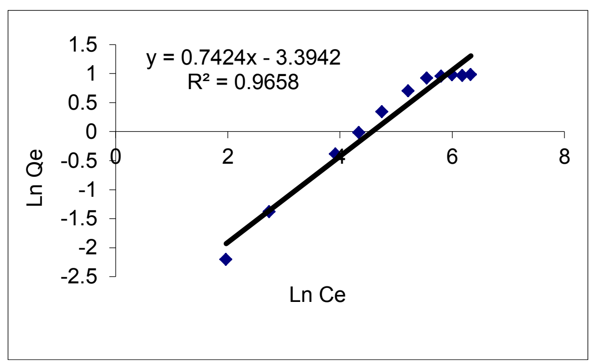

Fig. 6. Freandlich isotherm for the dye C.I. Reactive Yellow 15 with activated Wheat Husk at 25^{o}C

XIII. CONCLUSIONS

The present study showed that the wheat husk can be used as an adsorbent for the removal of C.I. Reactive Yellow 15 from aqueous solutions. Wheat Husk was easily available in large quantity and the treatment method of biosorbent seemed to be economical. Different effective parameters in the decolorisation process of dye solution were studied. The amount of dye sorbed was found to vary with initial solution pH, contact time, stirring speed and treatment of the wheat husk.

The decolorisation efficiency for the used reactive dye in very acidic and neutral conditions was higher. In addition, the temperature of 30^{o}C, contact time of 70 minutes and stirring speed of 140 rpm were found to be conditions for achieving the best results. Longmuir isotherm was also found to be the best model for the adsorption behavior of the reactive dye on the wheat husk.

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