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Original Research Paper

Adsorption of Dye in Aqueous Solution by the Waste Polymer Activated Carbon

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ABSTRACT

The waste polymer activated carbon was prepared from tyre by NaOH activation, which was used for the adsorption of dye Direct Scarlet 4BS in aqueous solution. The influences of pH value, activated carbon dosage, adsorption time and reaction temperature on adsorption rate were discussed in details. It was shown that the activated carbon dosage, adsorption time and reaction temperature had an important effect on the removal of dye Direct Scarlet 4BS in aqueous solution. However, the removal of dye Direct Scarlet 4BS was little dependent on pH value in solution. At 0.6g of activated carbon, 60mg/L of initial dye concentration, 60min, 35°C and pH 4.0, the removal of dye Direct Scarlet 4BS reached 85.14%.

INTRODUCTION

The textile industry is the traditional and important industry for increasing of employment, boosting the construction of town, improving of the people livelihood and promoting the development of economy and society (Chan et al. 2012, Noorimotlagh et al. 2014). However, along with the development of the textile industry, the dye wastewater from the textile industry has an important effect on the environment. The dye wastewater has the following characteristic, such as high colour, high COD, high BOD and difficult degradation biology (Chan et al. 2012, Zahra & Azizian 2014, Michael et al. 2015). So, the dye wastewater is one of difficult wastewaters to be treated. Many researches have been carried out for treatment of the dye wastewater. At present, the methods of treatment were consisted of physical, chemical, physico-chemical and biological (Baêta et al. 2013, Li et al. 2013, Duan et al. 2014). The adsorption was given attention widely because of its simple adsorption craftwork, low cost, easy manipulation and so on. The macromolecule materials were applied widely into all kinds of produce industry for its excellent capability. They were one of an important materials in the development of economy. However, after the production of these macromolecule materials were used and casted off; they would pollute the environment for its difficult degradation. Some papers about the use of these waste polymers were reported. These waste polymers were treated by the propriety craftwork, and the activated carbon with big surface would be obtained (Al-Degs et al. 2009). These activated carbons from waste polymers will be applied into the adsorption of organic contamination and heavy metal (Kauspediene et al. 2010, Fernando et al. 2011).

In this paper, the waste polymer activated carbon was prepared from tyre by NaOH activation, which was used for the adsorption of dye Direct Scarlet 4BS in aqueous solution. The influences of pH value, activated carbon dosage, adsorption time and reaction temperature on adsorption rate were discussed in detail.

MATERIALS AND METHODS

The dye Direct Scarlet 4BS was used as dye wastewater. The waste tyres were obtained from the plant of rubber, and they were milled into 1.0 mm. The 30 g of the waste tyre was put into reactor, and carbonized for 1 h at 823 K with the protection of N_2. Then, it was cooled under the room temperature. The 60 g of NaOH was mixed with the waste tyre. It was carbonized for 2 h at 1073 K with the protection of N_2. Then the waste polymer activated carbon was obtained. It was dipped in the 500mL (1+1) HCl solution for 12 h, and washed into pH 6.0- pH 8.0 by distilled water. It was dried at 378 K for 24 h, and powdered into 200 mesh for adsorption experiment.

Adsorption experiment: Adsorption experiments were conducted in a set of 250 mL Erlenmeyer flasks containing waste polymer activated carbon and 100 mL of dye Direct Scarlet 4BS with initial concentrations in aqueous solution. The pH in solution was adjusted by (1+1) HCl and 10 % NaOH. The flasks were placed in a shaker at a constant temperature of 308 K and 120 rpm. The samples were then filtered and the residual concentration of dye Direct Scarlet 4BS was analysed using a UV-1600 spectrophotometer at a wavelength corresponding to the maximum absorbance for dye Direct Scarlet 4BS.

Analytical methods: The surface physical morphology of waste polymer activated carbon was observed by a scanning electron microscope. The value of pH was measured with a pH probe according to APHA standard method. The concentration of dye Direct Scarlet 4BS was measured with a UV-1600 spectrophotometer at 500 nm.

The removal rate of dye Direct Scarlet 4BS was calculated as following:

$$Q = \frac{C_0 - C_t}{C_0} \times 100\% \qquad ...(1)$$

Where C_0 and C_t (mg/L) are the initial and equilibrium liquid-phase concentrations of dye Direct Scarlet 4BS respectively. Q is the removal rate of dye Direct Scarlet 4BS.

Statistical analyses of data: All experiments were repeated in duplicate and the data of results were the mean and the standard deviation (SD). The value of the SD was calculated by Excel Software. All error estimates given in the text and error bars in figures are standard deviation of means (mean±SD). All statistical significance was noted at α=0.05 unless otherwise noted.

RESULTS AND DISCUSSION

The surface physical morphology of waste polymer activated carbon: The surface physical morphology of waste polymer activated carbon was observed by a scanning electron microscope (Fig. 1.) The waste polymer activated carbon contains many abnormity figure pores. So, it can be concluded that the waste polymer activated carbon could be applied into the treatment of dye wastewater.

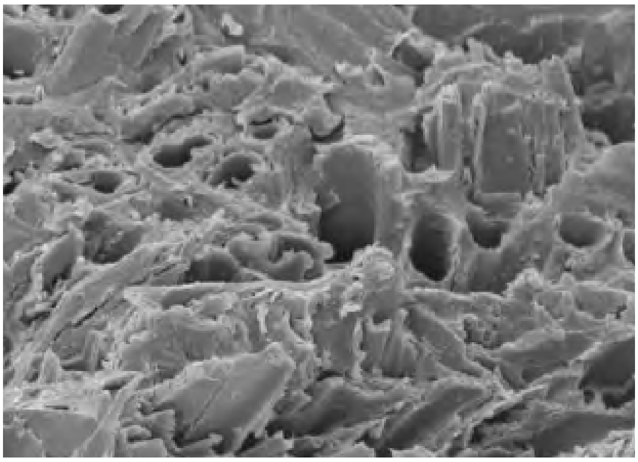

Fig.1: SEM image of the waste polymer activated carbon.

The effect of sorbent dosage: In order to study the effect of sorbent dosage, adsorption experiments were carried out. Adsorption experiments were conducted in a set of 250 mL Erlenmeyer flasks containing waste polymer activated carbon (0.2g, 0.4g, 0.6g, 0.8 g and 1.0 g) and 100 mL of dye Direct Scarlet 4BS with 60mg/L initial concentrations in aqueous solution. The pH in solution was adjusted by (1+1) HCl and 10 % NaOH. The flasks were placed in a shaker at a constant temperature of 308 K and 120 rpm. The effect of sorbent dosage is shown in Fig. 2.

As seen from Fig. 2, along with the increasing of sorbent dosage, the removal rate of the dye was increased. The removal rate of the dye reaches 85.14 % at the 0.6 g of waste polymer activated carbon. Above 0.6 g of waste polymer activated carbon, the increase in removal rate is little. So, the optimum sorbent dosage is 0.6 g.

The effect of reaction temperature: In order to study the effect of sorbent dosage, adsorption experiments were carried out. Adsorption experiments were conducted in a set of 250 mL Erlenmeyer flasks containing 0.6 g of waste polymer activated carbon and 100 mL of dye Direct Scarlet 4BS with initial concentrations 60 mg/L in aqueous solution. The pH in solution was adjusted by (1+1) HCl to 4.0. The flasks were placed in a shaker at a constant temperature ranged from 298 K to 318 K and 120 rpm. The reaction time is 60 min. The effect of reaction temperature is shown in Fig. 3.

It can be concluded that the reaction temperature had an important effect on the removal rate of dye Direct Scarlet 4BS. When the reaction temperature is increased, the removal rate of Direct Scarlet 4BS is also increased.

The effect of reaction time: Adsorption experiments were conducted in a set of 250 mL Erlenmeyer flasks containing 0.6 g of waste polymer activated carbon and 100 mL of dye Direct Scarlet 4BS with the initial concentration of 60 mg/L in aqueous solution. The pH in solution was adjusted by (1+1) HCl to 4.0. The flasks were placed in a shaker at a constant temperature of 298 K and 120 rpm. The reaction time ranged from 15 min to 120 min. The effect of reaction time is shown in Fig. 4.

From Fig. 4, it can be seen that the removal rate of Direct Scarlet 4BS was increased along with the increasing of reaction time. The reaction time of 60 min is equilibrium time.

The effect of pH in solution: Adsorption experiments were conducted with 0.6 g of waste polymer activated carbon and 100 mL of dye Direct Scarlet 4BS with the initial con-

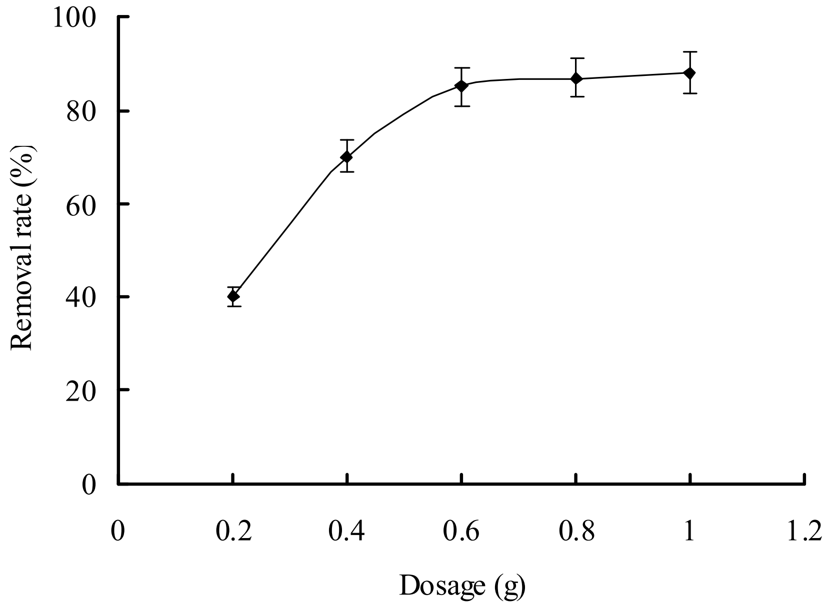

Fig.2: Effect of activated carbon dosage on removal rate of dye Direct Scarlet 4BS.

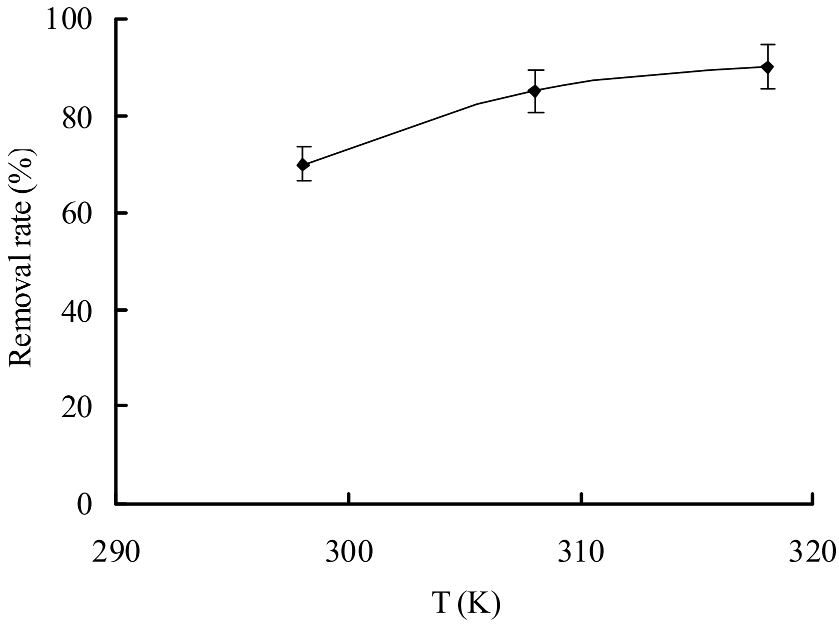

Fig. 3: Effect of reaction temperature on removal rate of dye Direct Scarlet 4BS.

centration of 60 mg/L in aqueous solution. The pH in solution was adjusted by (1+1) HCl or 10 % NaOH from 2.0 to 10.0. The flasks were placed in a shaker at a constant temperature of 298 K and 120 rpm. The reaction time is 120 min. The effect of pH in solution is shown in Fig. 5. The pH value in solution had little effect on the removal rate of dye Direct Scarlet 4BS.

CONCLUSIONS

In this paper, it is shown that the activated carbon dosage, adsorption time and reaction temperature have an important effect on the removal of dye Direct Scarlet 4BS in aque-

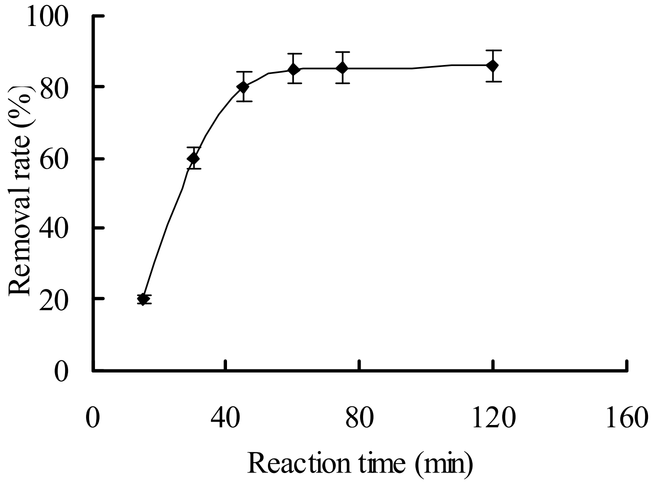

Fig.4: Effect of reaction time on removal rate of dye Direct Scarlet 4BS.

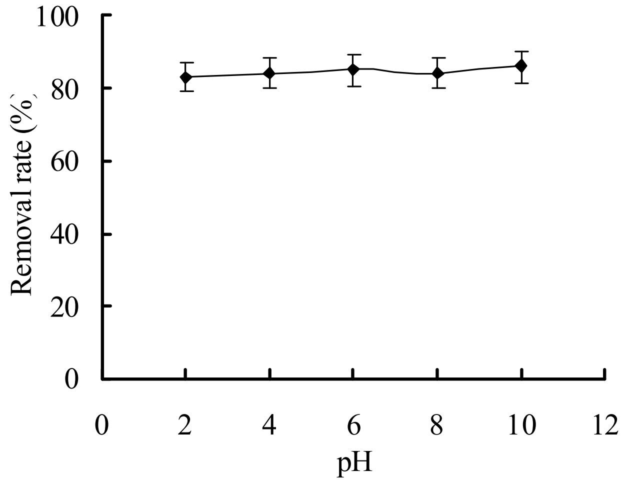

Fig. 5: Effect of initial pH value on removal rate of dye Direct Scarlet 4BS.

ous solution. However, the removal of dye Direct Scarlet 4BS was little dependent on pH value in solution. At 0.6g of activated carbon, 60mg/L of initial dye Direct Scarlet 4BS concentration, 60min, 35°C and pH 4.0, the removal of dye Direct Scarlet 4BS reached 85.14 %.

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