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Ultrasonic Assisted Flocculation of Azophloxine Using Polyaluminum Chloride

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A combination of flocculation with polyaluminum chloride and ultrasonic treatment was explored in decoloration of azophloxine. The solely using of ultrasonic treatment cannot decolorize the dye efficiently. The decoloration efficiency reaches the maximum value of 72.4 % at polyaluminum chloride amount of 12 mg/L when using polyaluminum chloride alone. Twenty minutes of flocculation is considered to be the optimal condition. Ultrasonic treating time shows very small influence on azophloxine flocculation by polyaluminum chloride. With the variation of ultrasonic power between 40 and 90 W, decoloration of the dye increases firstly and then decreases. The maximum decoloration rate is obtained using ultrasonic power of 50 W, at which 79.6 % of the initial azophloxine is decolorized after 0.5 h. It is interesting that decoloration rate increases with increasing initial azophloxine concentration.

Keywords: Ultrasonic, Flocculation, Azophloxine, Polyaluminum chloride.

INTRODUCTION

Dissolved organic materials are present in most water sources and wastewater at varying concentrations and are heterogeneous mixtures of complex organic materials[1-3]. Contaminated water from industrial sources contain a range of pollutants including organic substances. One general treatment adopted for such wastewater is coagulation which involves the addition of aluminium salts such as $AlCl_3$ or $Al_2(SO_4)_3$ that generate aluminum hydroxide flocs[4-6]. The coagulation process can also be initiated through the electrochemical generation of Al^{3+} or Fe^{3+} ions. These flocs absorb pollutants which are concentrated in the material which settles out and can thus be separated from the water.

In recent years, attention has been focused on the application of ultrasonic energy to solve the problems associated with water pollution, especially in removing toxic and hazardous organic compounds from contaminated water[7,9]. For many contaminants, the ultrasonic process has the advantage of completely destroying or converting these organics, not simply transferring them to another medium.

In the present work, a combination of flocculation with polyaluminum chloride and ultrasonic treatment was explored in decoloration of azophloxine. These two methods were studied solely to ascertain the individual decoloration ability. Furthermore, ultrasonic technique was explored to assist flocculation ability of polyaluminum chloride on decoloration of azophloxine.

EXPERIMENTAL

Flocculation process: 100 mL of 40 mg/L aqueous solution of azophloxine was put into a 250 mL beaker. 5 mL of the solution was taken out to determine the initial concentration of azophloxine. A suitable amount of polyaluminum chloride was added into the solution. Flocculation of the dye was conducted under magnetic stirring. Samples of the solution after different time were measured to determine decoloration rate of the flocculation process.

Ultrasonic assisted flocculation: 100 mL of 40 mg/L aqueous solution of azophloxine was put into a 250 mL beaker. 5 mL of the solution was taken out to determine the initial concentration of azophloxine. After a suitable amount of polyaluminum chloride was added into the solution, the beaker was placed in the bath of an ultrasonic cleaner. Ultrasonic power and time were indicated later. After that, samples were taken out of the beaker and measured by a spectrophotometer (Shanghai Spectrum Instruments 721E) at its maximum absorption wavelength. The suspensions were filtered through a Millipore filter (pore size 0.45 µm) before measuring.

RESULTS AND DISCUSSION

Decoloration efficiency of both ultrasonic treatment and flocculation with polyaluminum chloride were investigated individually. Fig. 1 shows ultrasonic treating of azophloxine as the factor of treating time. The ultrasonic frequency was

40 kHz with the power of 60 W. With the extending of treating time, the maximum decoloration rate is only 5.1 %. That means the solely using of ultrasonic treatment cannot decolorize the dye efficiently. The decoloration rate increases in the first 5 min, but maintains constantly up to 20 min and then decreases after 30 min. The power of ultrasonic may lead to destruction of the dye molecules and results in partly decoloration of the dye. However, ultrasonic power cannot be used to fully decolorize the dye. In this work, ultrasonic technique is used to assist decoloration of flocculating reagent such as polyaluminum chloride.

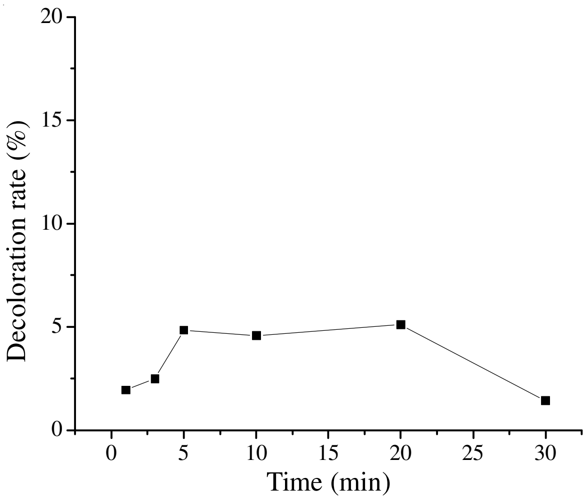

Fig. 1. Ultrasonic treatment of azophloxine

Polyaluminum chloride is widely used flocculating reagent in wastewater treatment due to its low cost and high efficiency in water cleaning power. Several factors may influence the performance of wastewater treating efficiency such as the amount of flocculating reagent and treating time. Fig. 2 shows the effect of amount of polyaluminum chloride in flocculation of azophloxine. 100 mL of 40 mg/L aqueous solution of azophloxine was used in the experiments. Decoloration rate increases drastically at the beginning. However, the decoloration efficiency reaches the maximum value of 72.4 % at polyaluminum chloride amount of 12 mg/L. The decoloration rate of the dye does not change much after increasing the amount of

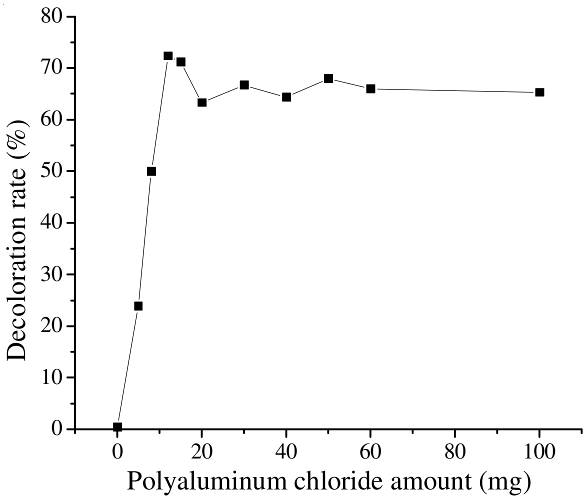

Fig. 2. Amount of polyaluminum chloride used in flocculation of azophloxine

polyaluminum chloride in the later experiments. Therefore, in this work, the amount of polyaluminum chloride is chosen as 12 mg/L in the following experiments.

Flocculation of azophloxine with polyaluminum chloride as the factor of time is shown in Fig. 3. After adding 12 mg/L of polyaluminum chloride in the solution, flocculation efficiency was evaluated at different time intervals. The overall decoloration rate shows the trend of continuing increasing with the extending of flocculation time. The maximum decoloration value appears at flocculation time of 20 min. Flocculation process is influenced by many factors such as chemical reagent, solvent and time. After the flocculation efficiency reaches its maximum value, the equilibrium may be disturbed at extending time with the result of release of deposited azophloxine dye. As a result, 20 min of flocculation is considered to be the optimal condition.

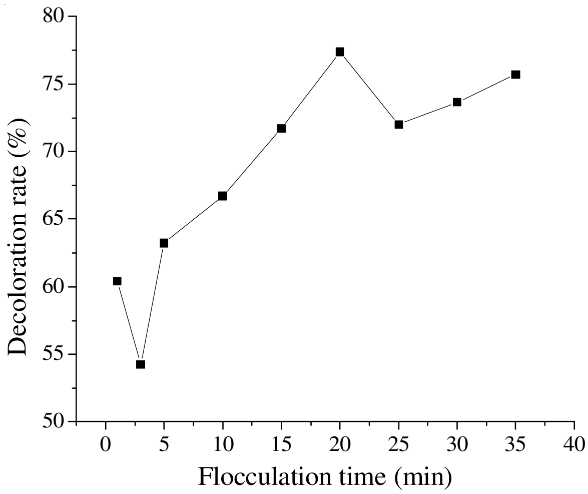

Fig. 3. Flocculation of azophloxine with polyaluminum chloride as the factor of time

The effect of ultrasonic assistance on polyaluminum chloride flocculation efficiency was also conducted in this work. Fig. 4 shows the effect of treating time on azophloxine decoloration. The amount of polyaluminum chloride used was 12 mg. Ultrasonic power was 90 W at frequency of 40 kHz. Although treating time does not oppose much influence on decoloration efficiency, decoloration rate of the dye has the maximum value after 1 min of ultrasonic assisted flocculation. As indicated in Fig. 1, ultrasonic treatment does not have much power on azophloxine decoloration. On the other hand, the power provided by ultrasonic wave may have positive effect on polyaluminum chloride flocculation process. However, too long time of ultrasonic treatment may cause release of the already flocculated azophloxine dye molecules. Normally, ultrasonic treating time shows very small influence on azophloxine flocculation by polyaluminum chloride.

The effect of ultrasonic power on decoloration of azophloxine is shown in Fig. 5. The amount of polyaluminum chloride used was 12 mg. Ultrasonic frequency was 40 kHz. With the variation of ultrasonic power between 40 and 90 W, decoloration of the dye increases firstly and then decreases. The maximum decoloration rate is obtained using ultrasonic power of 50 W, at which 79.6 % of the initial azophloxine is

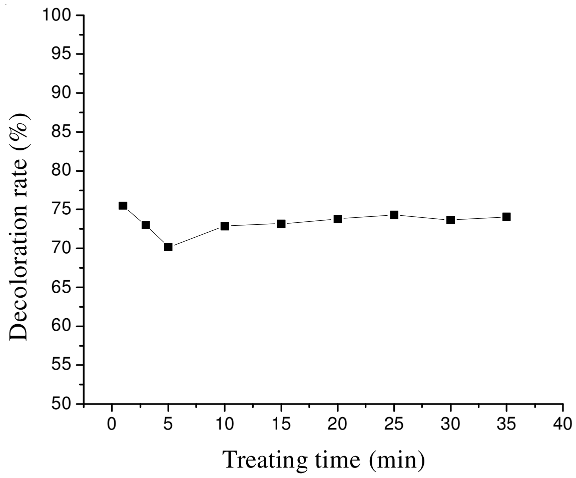

Fig. 4. Effect of treating time on decoloration of azophloxine. The amount of polyaluminum chloride used was 12 mg

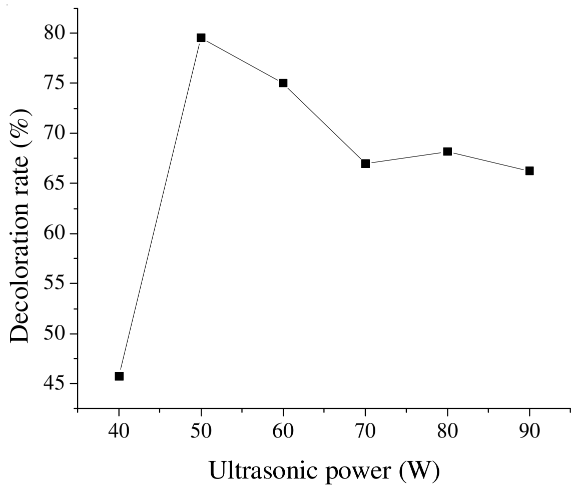

Fig. 5. Effect of ultrasonic power on decoloration of azophloxine

decolorized after 30 min. This decoloration rate is 19.2 % higher than using polyaluminum chloride alone. It is reported that the existence of ultrasonic power can help on production of hydroxyl radical in the solution and therefore leads to promoted decoloration efficiency. However, after ultrasonic power reaches its peaks value, the actual power being used decreases with the increase of ultrasonic power. Consequently, there is an optimal ultrasonic power in assistance of polyaluminum chloride flocculation of azophloxine. In fact, low ultrasonic power is favorable since energy is saved at low power. On the other hand, wastewater treating facilities are easily set up with low output power.

The effect of initial concentration of azophloxine on decoloration efficiency was also studied (Fig. 6). 15 mg of poly-aluminum chloride was added into 100 mL aqueous solution of azophloxine. The initial azophloxine concentrations were 20, 30 and 40 mg/L. It is interesting that decoloration rate increases with increasing initial azophloxine concentration. That means high concentration of the dye can be used in the wastewater without prior dilution of the wastewater. Since the actual wastewater may have high concentration of organic pollutants, the combination of ultrasonic treating

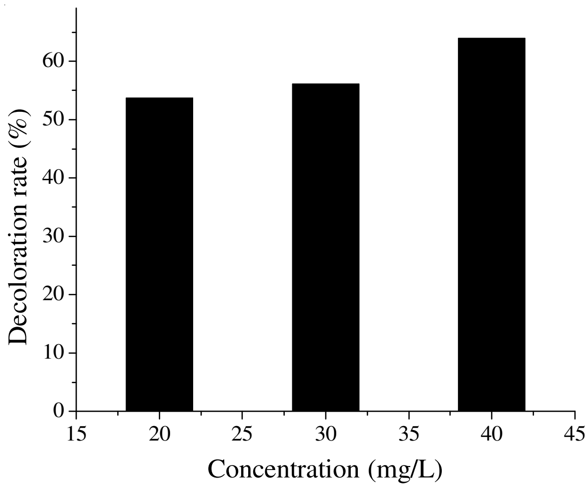

Fig. 6. Effect of initial concentration of azophloxine on decoloration efficiency

and flocculating technique can have interesting application potential in industrial wastewater treatment. The cost can be saved at treating with high concentration of pollutants present in wastewater.

Conclusion

Ultrasonic technique is used to assist flocculating decoloration of azophloxine with polyaluminum chloride. The amount of polyaluminum chloride is chosen as 12 mg/L. The overall decoloration rate shows the trend of continuing increasing with the extending of flocculation time. Although treating time does not oppose much influence on decoloration efficiency, decoloration rate of the dye has the maximum value after 1 min of ultrasonic assisted flocculation. There is an optimal ultrasonic power in assistance of polyaluminum chloride flocculation of azophloxine. High concentration of the dye can be used in the wastewater without prior dilution of the wastewater.

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