Asian Journal of Chemistry; Vol. 27, No. 5 (2015), 1581-1583

ASIAN JOURNAL OF CHEMISTRY

http://dx.doi.org/10.14233/ajchem.2015.17369

Flocculation of Azophloxine Using Polyaluminum Chloride-$FeCl_3$ Under Ultrasonic Treatment

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Received: 12 February 2014; *Accepted*: 7 July 2014; *Published online*: 20 February 2015; AJC-16847

A combination of flocculation and ultrasonic treatment was explored in decolouration of azophloxine. $FeCl_3$ and polyaluminum chloride (PAC) were used as a combined flocculating material. Polyaluminum chloride (9 mg) and $FeCl_3$ (3 mg) are selected as the optimized mixture of flocculating reagents in the experiments. Flocculation of azophloxine is fast when using a composite flocculating reagent. The maximum decolouration rate is found after 10 min of treatment with the total decolouration rate of 67.2 %. The solution treated at 40 W of ultrasonic power shows the maximum decolouration rate of 62 %. After 10 min of treatment, the solution containing 30 mg/L of azophloxine shows the highest decolouration rate. The solution containing 20 mg/L of azophloxine shows the lowest decolouration rate.

Keywords: Ultrasonic, Flocculation, Azophloxine, Polyaluminum chloride, $FeCl_3$.

INTRODUCTION

There is an increasing discharge of industrial and domestic wastewater. These wastewater must not be discharged into natural water system without treatment because the various pollutants inside the water[1]. Water treatment is desirable and must be taken since the natural aquatic system cannot convert many organic or inorganic substances into unharmful substances[2,3]. There has some kinds of traditional wastewater treating techniques such as coagulation which involves the addition of aluminum salts that generate aluminum hydroxide flocs[4,5]. The so-called flocculation process can therefore absorb pollutants inside wastewater so that the flocs can settle out and can thus be separated from the water[6,7].

Ultrasonic energy has also been used to remove toxic and hazardous organic compounds from wastewater[8,9]. The ultrasonic power can in some extent destroy or convert organic pollutants and furthermore, ultrasonic power can also help many other wastewater treating methods on removal of pollutants. However, there is a relative lack of information in the literature about the removal of organic pollutants from wastewater by flocculation combined with the ultrasonic power. In the present work, a combination of flocculation and ultrasonic treatment was explored in decolouration of azophloxine. Ultrasonic technique was explored to assist flocculation ability on decolouration of azophloxine. Two flocculating reagents, $FeCl_3$ and polyaluminum chloride (PAC) were used as a combined flocculating material.

EXPERIMENTAL

Flocculation process: 100 mL of aqueous solution of azophloxine (40 mg/L) 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 $FeCl_3$ and 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 decolouration rate of the flocculation process.

Ultrasonic assisted flocculation: 100 mL of aqueous solution of azophloxine (40 mg/L) 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 $FeCl_3$ and 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

Decolouration of azophloxine through flocculation with respect to the ratio of $FeCl_3$ and polyaluminum chloride was studied first (Fig. 1). In this experiment, the total amount of flocculating reagent was set as 12 mg. The ratio of $FeCl_3$ and polyaluminum chloride was changed in order to obtain the

optimized adding amount of the two substances. As can be seen from the figure, the ratios of $FeCl_3$ and polyaluminum chloride were set as 3:9, 6:6, 8:4, 9:3, 10;2 and 11:1, respectively. The ratios of 3:9 and 11:1 are obviously not suitable for removing azophloxine. The maximum decolouration rate appears at the ratio of 9:3, at which the total decolouration rate is 63 %. Therefore, 9 mg of polyaluminum chloride and 3 mg of $FeCl_3$ are selected as the optimized mixture of flocculating reagents in the following experiments.

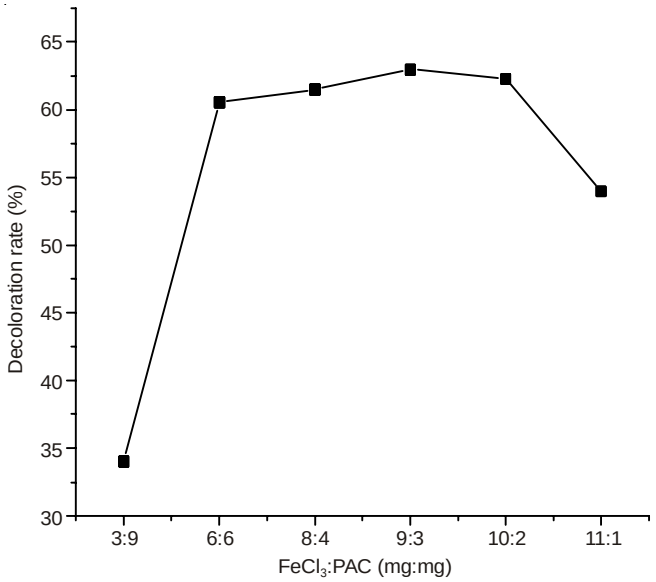

Fig. 1. Decolouration of azophloxine through flocculation with respect to the ratio of $FeCl_3$ and polyaluminum chloride

Flocculating time was studied secondly: The ratio of $FeCl_3$ and polyaluminum chloride was 9:3 in this experiment, as shown in Fig. 2. After adding 9 mg of polyaluminum chloride and 3 mg of $FeCl_3$ into the solution containing azophloxine, the solution was stirred with magnetic stirring for different time. Interestingly, although the total decolouration rate varies with extending flocculating time, there is no obvious difference in the whole time period. If comparing the data, 25 min can be regarded as the optimal stirring time with decolouration rate of 68.8 %. However, the decolouration rate difference after 10 and 25 min of stirring is only 0.5 %. Therefore, 10 min is more suitable for the decolouration process for the purpose of time efficiency. It can be concluded from the result that, flocculating of azophloxine is fast when using a composite flocculating reagent of $FeCl_3$ and polyaluminum chloride with the ratio of 9:3. Fast removal of pollutant is desirable for industrial application.

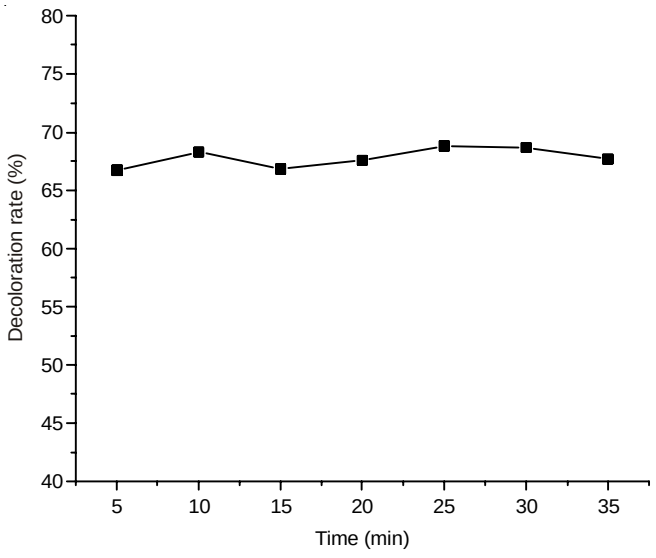

Fig. 2. Decolouration of azophloxine through flocculation as the factor of time. The ratio of $FeCl_3$ and polyaluminum chloride was 9:3

The application of ultrasonic power in the experiment is to investigate the function of ultrasonic treatment in flocculating process. The energy provided by ultrasonic power may promote the flocculating mechanism. Fig. 3 shows decolouration of azophloxine through flocculation as the factor of ultrasonic treating time. The ultrasonic power in the experiment was 90 W and the frequency was 40 kHz. 9 mg polyaluminum chloride and 3 mg $FeCl_3$ were added into the solution. Ultrasonic treating time is between 5 and 35 min. The result reveals that decolouration of the dye is fast at shorter treating time. The maximum decolouration rate is found after 10 min of treatment with the total decolouration rate of 67.2 %. After 10 min, decolouration of the dye decreases with increasing treating time. As a result, treating time is set as 10 min in the following experiments. The composite polyaluminum chloride and $FeCl_3$ can flocculate azophloxine in a short time with the help of ultrasonic power. However, continuing treating with ultrasonic power may lead to release of the dye into the solution.

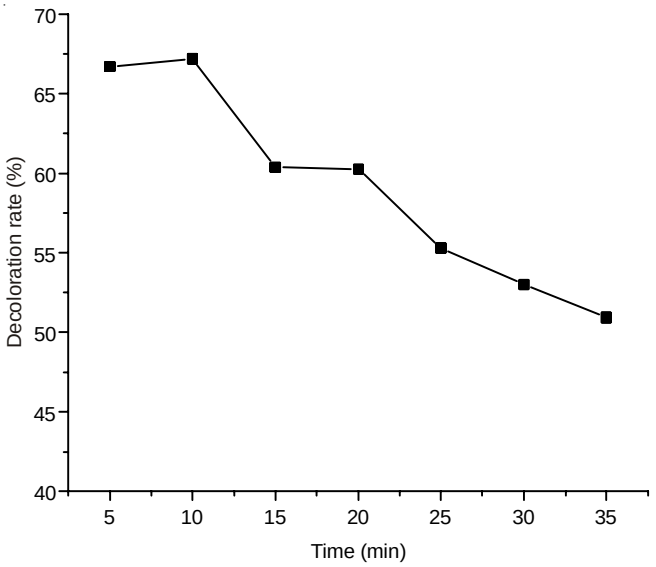

Fig. 3. Decolouration of azophloxine through flocculation as the factor of ultrasonic treating time. Ratio of $FeCl_3$ and polyaluminum chloride was 9:3

The influence of ultrasonic power on flocculation of azophloxine was also investigated, as shown in Fig. 4. The ultrasonic frequency was 40 kHz. Polyaluminum chloride (9 mg) and $FeCl_3$ (3 mg) were added into the solution. All the solutions were treated with ultrasonic power for 10 min. Ultrasonic power varies from 40 to 90 W. The solution treated at 40 W of ultrasonic power shows the maximum decolouration

rate of 62 %. With increasing ultrasonic power, decolouration rate decreases to a minimum point at ultrasonic power of 60 W. High ultrasonic power does not seem to have positive effect on flocculating of the dye. High ultrasonic energy may lead to partly release of the dye into the solution.

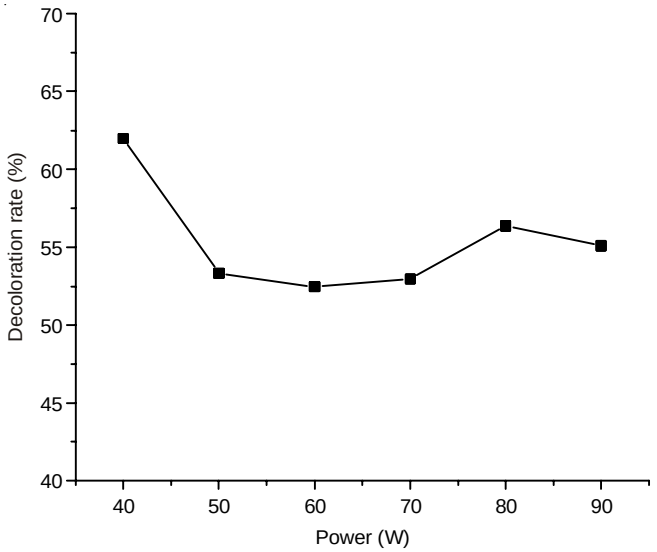

Fig. 4. Decolouration of azophloxine through flocculation as the factor of ultrasonic treating power. The ratio of $FeCl_3$ and polyaluminum chloride was 9:3

Fig. 5 shows decolouration of azophloxine through flocculation as the factor of initial azophloxine concentration. The ultrasonic power in the experiment was 90 W and the frequency was 40 kHz. 9 mg of polyaluminum chloride and 3 mg of $FeCl_3$ were added into the solution. After 10 min of treatment,

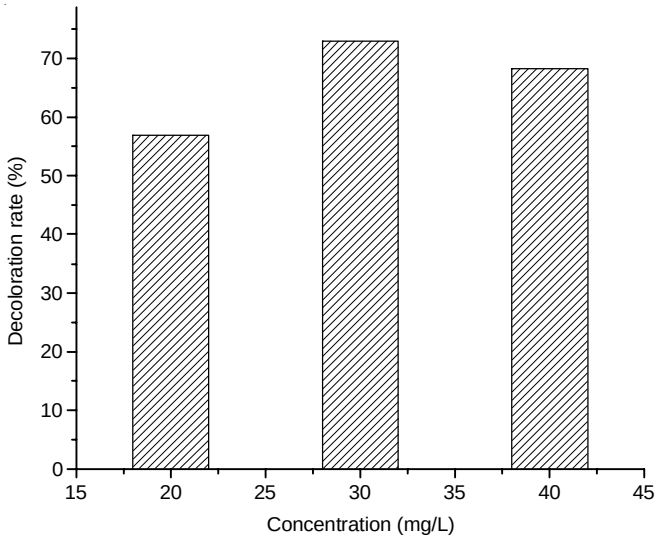

Fig. 5. Decolouration of azophloxine through flocculation as the factor of initial azophloxine concentration. The ratio of $FeCl_3$ and polyaluminum chloride was 9:3

the solution containing 30 mg/L of azophloxine shows the highest decolouration rate. The solution containing 20 mg/L of azophloxine shows the lowest decolouration rate. It can be seen that flocculating of the dye is efficient at higher initial dye concentration although too high concentration is not suitable. Industrial application of this technique will be benefit to the property because high initial concentration of pollutant can be treated directly in the plant without the need of dilution.

Conclusion

Ultrasonic technique was explored to assist flocculation ability on decolouration of azophloxine. Two flocculating reagents, $FeCl_3$ and polyaluminum chloride (PAC) were used as a combined flocculating material. The maximum decolouration rate appears at the ratio of 9:3, at which the total decolouration rate is 63 %. 10 minutes is more suitable for the decolouration process for the purpose of time efficiency. The composite polyaluminum chloride and $FeCl_3$ can flocculate azophloxine in a short time with the help of ultrasonic power. The solution treated at 40 W of ultrasonic power shows the maximum decolouration rate of 62 %. Flocculating of the dye is efficient at higher initial dye concentration although too high concentration is not suitable.

ACKNOWLEDGEMENTS

This work was supported by the National Natural Science Foundation of China (No. 41271251).

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