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# Flocculation of Azophloxine Using $FeCl_3$ by Ultrasonic Treatment

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A combination of flocculation with $FeCl_3$ and ultrasonic treatment was explored in decoloration of azophloxine. The results reveal that decoloration rate of the dye increases with increasing amount of $FeCl_3$ used in the solution when $FeCl_3$ amount is less than 15 mg. The decoloration of the dye reaches its maximum value when 15 mg of $FeCl_3$ is added into the solution. The optimal flocculation time is 40 min. The optimum ultrasonic treating time in assisting flocculating of azophloxine is 15 min and the most suitable ultrasonic power to assist flocculating efficiency of $FeCl_3$ is 80 W. Decoloration rate is smaller at higher initial azophloxine concentration.

**Keywords: Ultrasonic, Flocculation, Azophloxine, $FeCl_3$.**

## INTRODUCTION

It is not desirable to discharge wastewater without treatment into a natural water system. The purification of polluted water such as industrial wastewater becomes a task of increasing importance in environmental protection[1-3]. Wastewater from industrial and domestic sources can contain a range of pollutants including organic substances. One general treatment adopted for such wastewater is coagulation which involves the addition of aluminum salts such as $AlCl_3$ or $Al_2(SO_4)_3$ that generate aluminum hydroxide flocs[4-6]. These flocs absorb pollutants which are concentrated in the material which settles out and can thus be separated from the water.

There is an increasing approach on the application of ultrasonic energy in removing toxic and hazardous organic compounds from wastewater[7,9]. The ultrasonic power to some extent destroy or convert organic 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 with $FeCl_3$ and ultrasonic treatment was explored in decoloration of azophloxine. Ultrasonic technique was explored to assist flocculation ability of $FeCl_3$ on decoloration of azophloxine.

## EXPERIMENTAL

**Flocculation process:** 100 mL of aqueous solution 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 $FeCl_3$ 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 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 $FeCl_3$ 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 flocculation with $FeCl_3$ was investigated firstly. Fig. 1 shows the influence of the amount of $FeCl_3$ in flocculation of azophloxine. Decoloration rate of the dye increases with increasing amount of $FeCl_3$ used in the solution when $FeCl_3$ amount is less than 15 mg. The decoloration of the dye reaches it maximum value when 15 mg of $FeCl_3$ is added into the solution. At this condition, 23.2 % of the initial azophloxine is removed. The continuing increase of $FeCl_3$ in the solution cannot further lead to more decoloration of the dye. As a result, decoloration rate reaches to a comparable stable value even when the added $FeCl_3$ is as more as

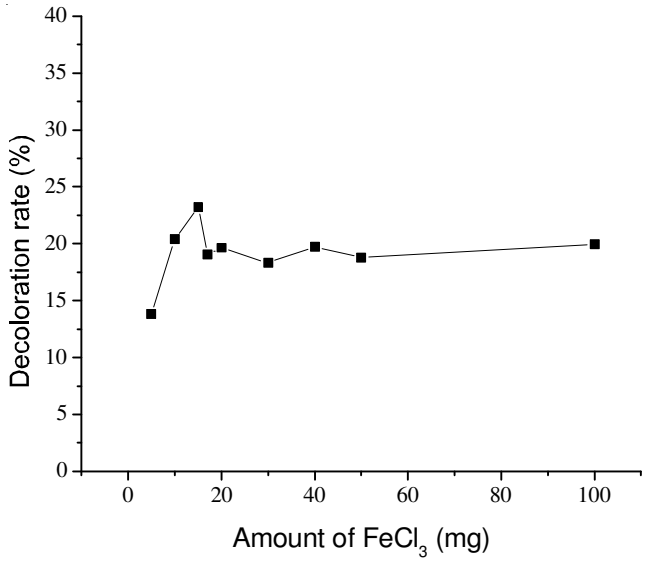


Fig. 1. Amount of $FeCl_3$ in flocculation of azophloxine

100 mg. It is suggested the optimal amount of $FeCl_3$ added in the solution is 15 mg.

Flocculation of azophloxine with $FeCl_3$ as the factor of time is shown in Fig. 2. 15 mg of $FeCl_3$ was added in the solution, while flocculation time varied from 1 to 50 min. The decoloration of the dye increases drastically at the beginning, when flocculation time is less than 7 min. The increase of decoloration rate becomes slowly after flocculation time is more than 10 min and up to 40 min. While decoloration rate continually increases with extending flocculation time up to 40 min, the maximum decoloration rate of 32.4 % appears when flocculation time is 40 min. After that time, a decreasing trend appears with increasing flocculation time. Thus, the optimal flocculation time is 40 min when using 15 mg of $FeCl_3$ added in the solution.

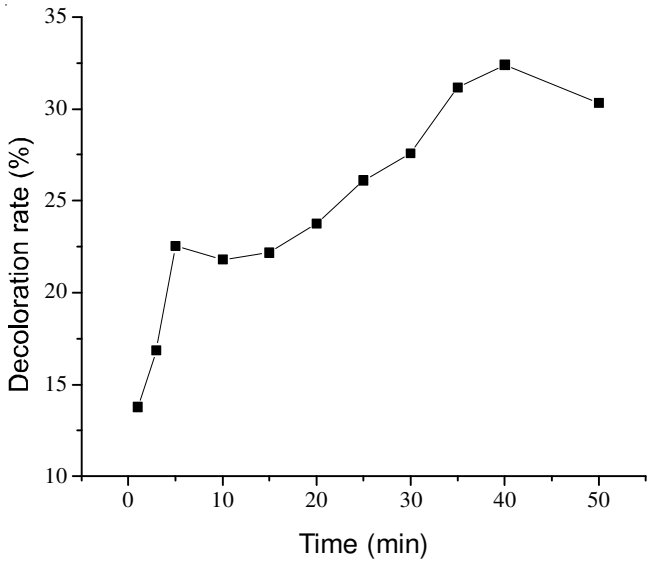


Fig. 2. Flocculation of azophloxine with $FeCl_3$ as the factor of time

Fig. 3 shows the effect of ultrasonic treating time on azophloxine decoloration. 15 mg of $FeCl_3$ was added in the solution and the flocculation time was 40 min. At this experiment, ultrasonic power was used to assist the flocculation

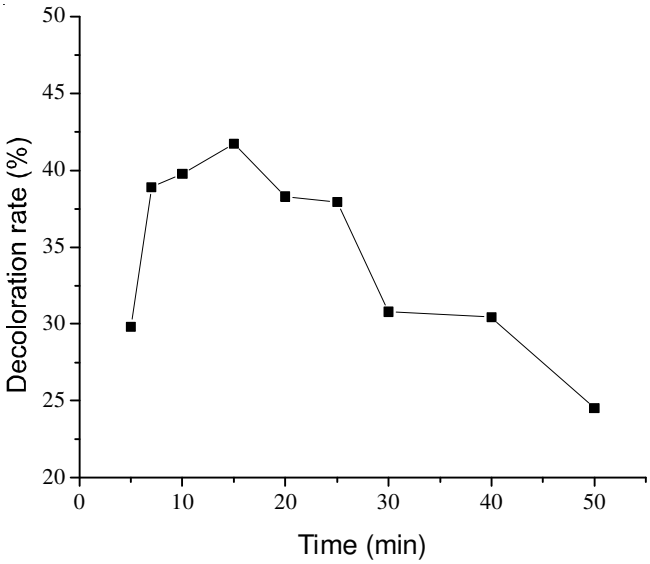


Fig. 3. Effect of ultrasonic treating time on azophloxine decoloration. The amount of $FeCl_3$ used was 15 mg

process using $FeCl_3$ as the flocculating reagent. Ultrasonic frequency was 40 kHz and the power was 90 W. Ultrasonic treating time was between 5 and 50 min. In this time range, decoloration rate of azophloxine in the solution increases firstly until it reaches the maximum value and then it begins to drop with extending treating time. The maximum decoloration rate is achieved after 15 min of treating. At this time, decoloration rate of the dye is as high as 41.8 %. Therefore, the optimum ultrasonic treating time in assisting flocculating of azophloxine is 15 min using $FeCl_3$ as the flocculating reagent.

The effect of ultrasonic power on decoloration of azophloxine is presented in Fig. 4. 15 mg of $FeCl_3$ was added in the solution and the flocculation time was 40 min. Ultrasonic frequency was 40 kHz and the power varied from 40 W to 90 W. The decoloration rate changes with the variation of ultrasonic power. The results indicate the maximum decoloration of azophloxine at ultrasonic power of 80 W, at which decoloration rate is as high as 35.1 %. Decoloration rate declines slowly in the ultrasonic power range between 40 W

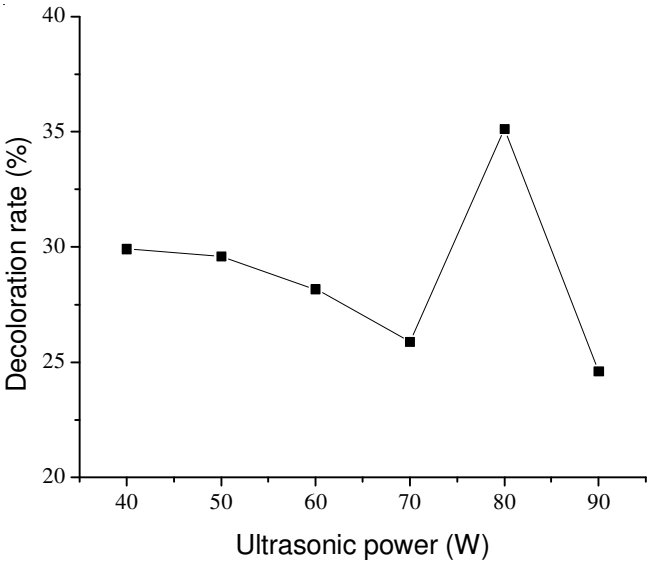


Fig. 4. Effect of ultrasonic power on decoloration of azophloxine

and 70 W. Meanwhile, decoloration rate at ultrasonic power of 90 W is even lower than that at ultrasonic power of 70 W. Therefore, it can be concluded that the most suitable ultrasonic power to assist flocculating efficiency of $FeCl_3$ is 80 W.

The effect of initial concentration of azophloxine on decoloration efficiency is also indicated in Fig. 5. The initial concentrations of azophloxine are 20, 30 and 40 mg/L. While the amount of $FeCl_3$ is not changed for treating of different concentration of azophloxine, decoloration rate is smaller at higher initial azophloxine concentration. That means the added $FeCl_3$ has a maximum power in flocculating a certain amount of azophloxine. If applied in large scale wastewater treatment, the initial concentration of pollutant must be controlled to obtain a suitable quality of the discharged water.

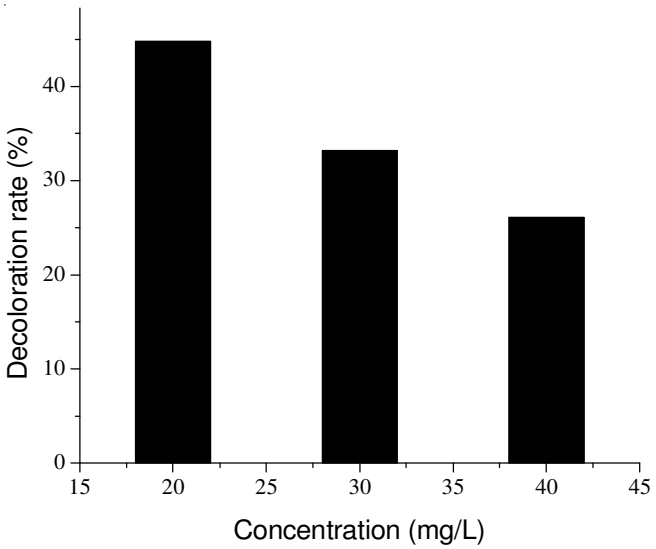


Fig. 5. Effect of initial concentration of azophloxine on decoloration efficiency

Fig. 6 compares decoloration efficiencies using $FeCl_3$ and combination of $FeCl_3$ and ultrasonic. When $FeCl_3$ was used solely, the amount of $FeCl_3$ was 15 mg. For the combination of $FeCl_3$ and ultrasonic, the amount of $FeCl_3$ was 15 mg and ultrasonic power was 60 W. Treating time was used as the factor to compare these two methods.

Decoloration of azophloxine by $FeCl_3$ alone increases with increasing treating time. The maximum decoloration rate, 32.4 % removal of the initial dye is obtained after 40 min of treatment. Decoloration of azophloxine by combination of $FeCl_3$ and ultrasonic power shows the maximum activity after 15 min of treatment with decoloration rate of 41.8 %. It appears that the use of combination of $FeCl_3$ and ultrasonic power is superior to using $FeCl_3$ alone especially when the treating time is less than 0.5 h.

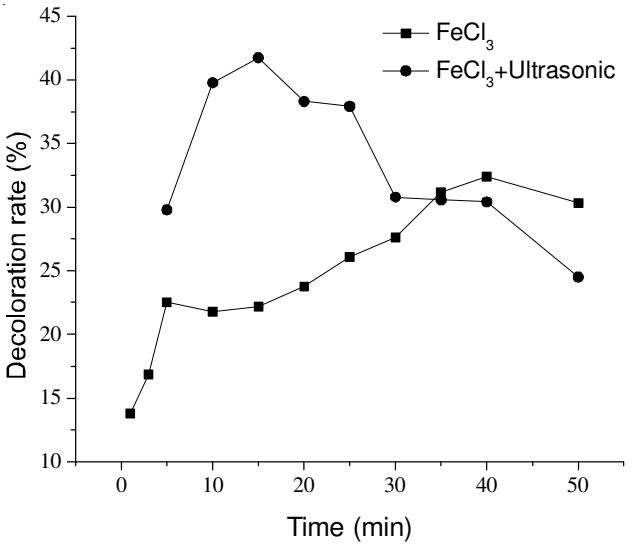


Fig. 6. Comparison of decoloration efficiencies using $FeCl_3$ and combination of $FeCl_3$ and ultrasonic

## Conclusion

Ultrasonic technique is used to assist flocculating decoloration of azophloxine with $FeCl_3$. The optimal flocculation time is 40 min when using 15 mg of $FeCl_3$ added in the solution. Decoloration rate of the dye is as high as 41.8 % after 15 min of treating. Decoloration of azophloxine by combination of $FeCl_3$ and ultrasonic power shows the maximum activity after 15 min of treatment with decoloration rate of 41.8 %. The maximum decoloration of azophloxine appears at ultrasonic power of 80 W.

## ACKNOWLEDGEMENTS

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