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Decoloration of Azophloxine by Adsorption and Photocatalytic Degradation

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A combination of adsorption and photocatalytic decoloration was explored in decoloration of azophloxine. The percentage of azophloxine adsorbed on activated carbon increases with increasing concentration of activated carbon in the solution. The maximum adsorption efficiency appears after the solution is stirred for 130 min. 85 min of photocatalytic degradation is needed to remove all the remaining dye molecules from the solution that is pretreated by 130 min of adsorption on activated carbon. Simultaneously application of adsorption and photocatalytic degradation can decolorize the dye in a much shorter time period. About 58.3 % of the initial azophloxine can be removed from the solution after 30 min when 5 mg activated carbon and 25 mg TiO_2 are used simultaneously.

Keywords: Azophloxine, Adsorption, Photocatalytic, Degradation, TiO_2.

INTRODUCTION

Industrial dyes are kinds of organic pollutants involved in discharged wastewater and are in varying concentrations in natural water systems[1,2]. The most applied wastewater treating method includes the degradation ability of microorganisms. However, the removal of organic materials through common water treatment processes is not always satisfactory[3-5]. Dyes can also be removed from wastewater through adsorption technique. A common used adsorbent is activated carbon. It can adsorb many kinds of organic pollutants from air and water because of its porous structure and large internal surface area[6].

Recently, oxidation of organic pollutants is regarded as a potential wastewater treatment method. Photocatalytic degradation is one of the most studied new technique in dealing with various environmental problems[7,8]. Titanium dioxide (TiO_2) is believed to be the most satisfactory photocatalytic material. Photocatalytic oxidation method can be combined with other traditional wastewater treating technique to obtain best result. These two methods can be used separately in different stage of water treating processes and can be used simultaneously for synergetic effect in wastewater treatment[9-12].

In the present work, a combination of adsorption and photocatalytic degradation was explored in decoloration of azophloxine. Activated carbon was applied as the adsorbent and TiO_2 was applied as the photocatalyst. These two materials were studied separately in decoloration of azophloxine and then the combination of these materials was investigated.

EXPERIMENTAL

Adsorption efficiency: Concentration of azophloxine aqueous solution (100 mL of 40 mg/L) was measured by spectrophotometer (Shanghai Spectrum Instruments 721E) at its maximum adsorption wavelength is found to be 510 nm. A certain amount of activated carbon was added into the solution and the suspension was stirred for some time. The concentration of the solution was measured again after the suspension reached its adsorption-desorption equilibrium. The concentration of azophloxine solution was calculated based on Lambert-Beer law.

Photocatalytic degradation: Photocatalytic activity of the photocatalyst was evaluated by measuring degradation rate of aqueous azophloxine under UV light irradiation. In each experiment, the photocatalyst TiO_2 was put into 50 mL of 40 mg/L aqueous solution of azophloxine in 200 mL beaker. A 20 W UV lamp was suspended 10 cm above the solution. The lamp can irradiate UV light at wavelength of 253.7 nm with the intensity of 1200 μW/cm^2. In prior to turn on the lamp, the solution was magnetically stirred for 0.5 h to ensure adsorption equilibrium. Azophloxine concentration was measured by a spectrophotometer (Shanghai Spectrum Instruments 721E) at its maximum adsorption wavelength of 510 nm. The suspensions were filtered through a Millipore filter (pore size 0.45 μm) before measuring.

RESULTS AND DISCUSSION

Azophloxine can be adsorbed on activated carbon that is one of the most applied adsorbents because of its large specific surface area and pore volume. 40 mg/L of azophloxine aqueous solution was used as initial solution. The amount of activated carbon is needed to be ascertained firstly in the work. Fig. 1 shows decoloration of azophloxine as the factor of the amount of activated carbon. The concentration of activated carbon adding into the solution is in the range between 100 and 600 mg/L. The results indicate that the percentage of azophloxine adsorbed on activated carbon increases with increasing concentration of activated carbon in the solution. It looks as if all the azophloxine molecules can be removed by adsorption on the surface of activated carbon if the concentration of activated carbon is high enough. In this work, the concentration of activated carbon is chosen as 300 mg/L in the following experiments.

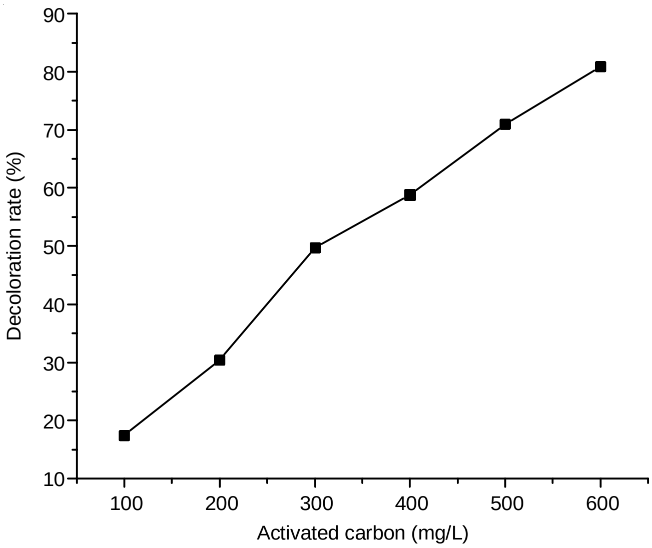

Fig. 1. Decoloration of azophloxine as the factor of amount of activated carbon

When the concentration of activated carbon is fixed, another factor influencing adsorption efficiency is adsorption time. Adsorption of azophloxine on activated carbon with respect to time is shown in Fig. 2. The concentration of activated carbon is 300 mg/L in this experiment. Decoloration rate during adsorption increases in a certain time period until the solution reaches its adsorption-desorption equilibrium. As can be seen from the figure, the maximum adsorption efficiency appears after the solution is stirred for 130 min. That means adsorption-desorption equilibrium is reached after 130 min of adsorption. Therefore, adsorption time is chosen as 130 min in the following experiments. Decoloration rate does not change after the solution reaches its adsorption-desorption equilibrium. A certain amount of activated carbon has its maximum adsorption capacity.

Photocatalytic degradation of azophloxine after adsorption on activated carbon was also conducted in the work. The result is shown in Fig. 3. 15 mg of activated carbon was mixed with 100 mL of 40 mg/L azophloxine aqueous solution. After 130 min of stirring, the solution was filtrated to remove the

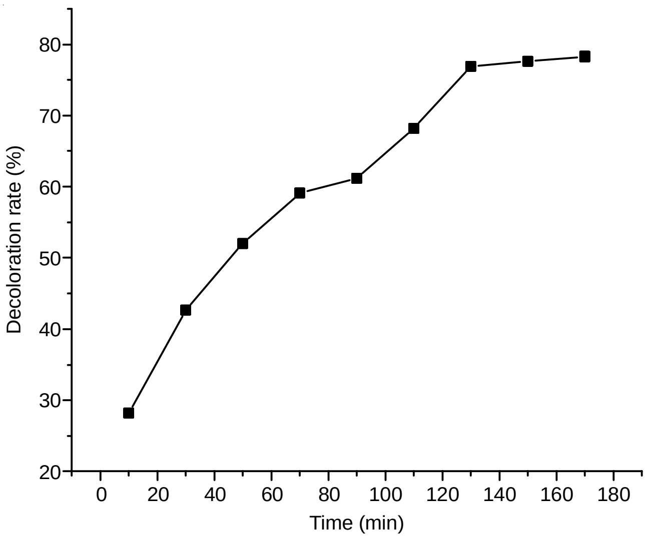

Fig. 2. Adsorption of azophloxine on activated carbon with respect to time

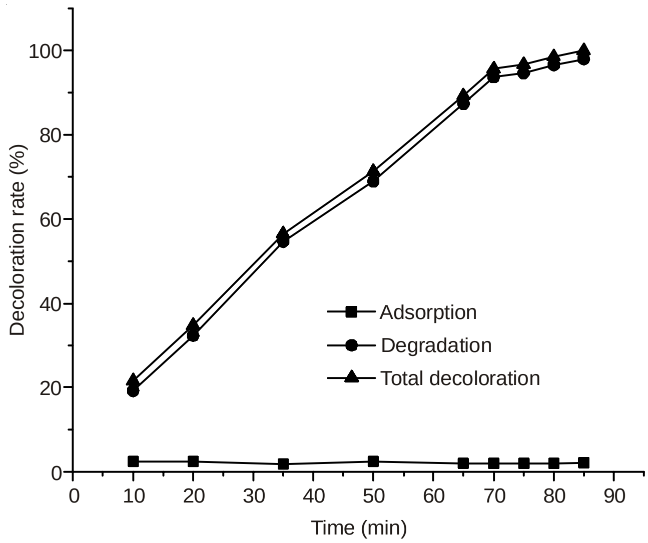

Fig. 3. Photocatalytic degradation of azophloxine after adsorption on activated carbon

adsorbent. 50 mL of the filtrated solution was mixed with 20 mg TiO_2 in a beaker. After 20 min of stirring in the dark, the suspension was irradiated under the UV light for photocatalytic degradation. After 130 min of adsorption on activated carbon, 78 % of the initial dye remains in the solution before photocatalytic degradation.

Photocatalytic decoloration rate of the solution containing TiO_2 increases with irradiation time. The adsorption of the dye on TiO_2 is not noticeable. After 85 min of irradiation, all of the dye molecules in the solution are decolorized. The means 85 min of photocatalytic degradation is needed to remove all the remaining dye molecules from the solution that is pretreated by 130 min of adsorption on activated carbon. From the above discussion, a conclusion can be made that photocatalytic degradation technique can be combined with adsorption on activated carbon. Since all of the organic pollutants cannot be removed by simple treatment with activated carbon, photocatalytic degradation process is capable of removing the remaining organic pollutants in industrial application.

Decoloration of azophloxine was also conducted under simultaneously adsorption and photocatalytic degradation. 20 mg TiO_2 and 15 mg activated carbon were added into the solution which contained 40 mg/L azophloxine solution. The solution was put under UV light irradiation throughout the treatment. As shown in Fig. 4, decoloration of azophloxine increases with increasing reaction time. The dye is nearly fully decolorized after 60 min of treatment. In this experiment, adsorption of the dye on activated carbon and photocatalytic degradation of the dye on TiO_2 both contribute to the overall decoloration of azophloxine. As compared to the former treatments, simultaneously application of adsorption and photocatalytic degradation can decolorize the dye in a much shorter time period. This method has obviously the application potential in industrial wastewater treatment.

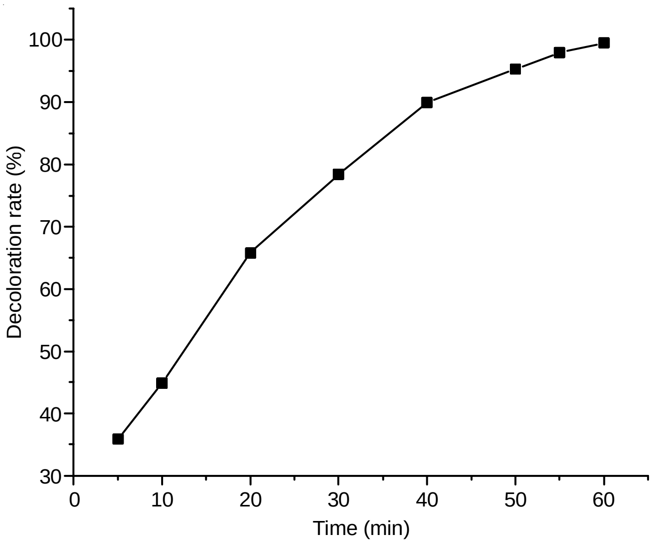

Fig. 4. Decoloration of azophloxine under simultaneously adsorption and photocatalytic degradation

Fig. 5 shows the effect of TiO_2:activated carbon ratio on decoloration of azophloxine. The amount of activated carbon was fixed as 5 mg. The amount of TiO_2 varied as 5, 10, 15, 20, 24, 30, 35 and 40 mg. In other words, the ratio of TiO_2:activated carbon was 1:1, 1:2, 1:3 1:4, 1:5, 1:6, 1:7 and 1:8, respectively. In this experiment, the amount of activated carbon does not change in different samples. Normally, the increase of TiO_2 can definitely improve the total decoloration of azophloxine. This is true when the amount of TiO_2 is not very high. The maximum decoloration rate is achieved at TiO_2:activated carbon ratio of 1:5. About 58.3 % of initial azophloxine can be removed from the solution after 0.5 h, when 5 mg activated carbon and 25 mg TiO_2 are used simultaneously. Excessive doping of TiO_2 leads to decrease of total decoloration rate. TiO_2 in the lower layer of the solution cannot take part in photocatalytic degradation of azophloxine because UV light irradiation can only penetrate a thin layer of the solution. Furthermore, TiO_2 can also be adsorbed on the surface of activated carbon and occupy active adsorption site on the surface of activated carbon.

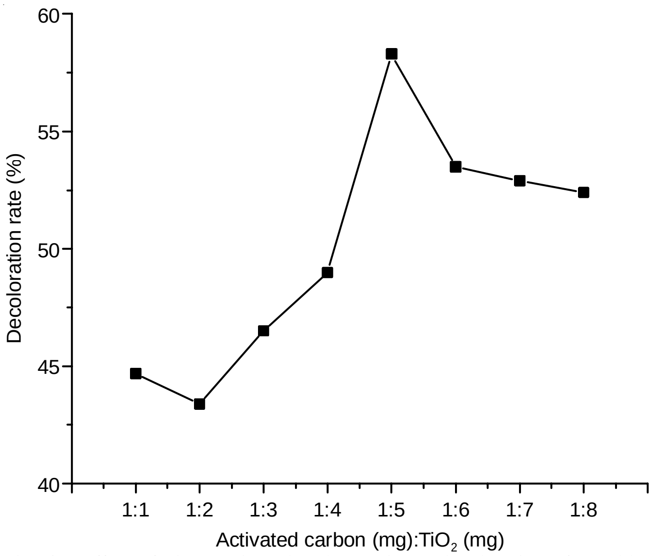

Fig. 5. Effect of TiO_2: activated carbon ratio on decoloration of azophloxine. The amount of activated carbon was fixed as 5 mg

Conclusion

Both adsorption and photocatalytic degradation processes were used for azophloxine decoloration. The concentration of activated carbon is chosen as 300 mg/L in the experiments. The maximum adsorption efficiency appears after the solution is stirred for 130 min. Photocatalytic degradation technique can be combined with adsorption on activated carbon. Adsorption of the dye on activated carbon and photocatalytic degradation of the dye on TiO_2 both contribute to the overall decoloration of azophloxine.

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