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Influence of NaCl on Azophloxine Decolouration by Adsorption and Photocatalytic Degradation

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A combination of adsorption and photocatalytic decolouration was explored in decolouration of azophloxine. When the activated carbon is used alone, the adsorption efficiency on the material is not as high as on the composite. Photocatalytic degradation of the dye on TiO_2 is apparently stronger than adsorption on the same amount of activated carbon. The concentration of azophloxine in NaCl solution does not change much with the variation of NaCl solution concentration. The photogenerated hydroxyl radicals can be removed by the Cl^- ion and therefore, photocatalytic degradation efficiency is not as high as that in the solution without NaCl. A composite of 400 mg/L TiO_2 and 200 mg/L activated carbon was also used to study the effect of NaCl on azophloxine decolouration. After the addition of NaCl, decolouration of the azophloxine is always higher than that without using NaCl in the solution.

Keywords: Azophloxine, Adsorption, Photocatalytic, Titanium dioxide.

INTRODUCTION

Wastewater from industrial and domestic sources contains various types of organic substances[1-3]. Traditional wastewater treatments are not capable of removing many kinds of toxic or hazardous organic pollutants from the water due to the limitation of microbial treatment[4-6]. Adsorption of such organic pollutants is a widely applied industrial technique. Activated carbon is one of the typical adsorbent which can be applied for various organic substances[7-9].

The oxidation of organic substances with the new developed techniques has aroused much attention. Titanium dioxide is believed to be the most satisfactory photocatalytic material in dealing with environmental pollutants[10-12]. An interesting trend is to use photocatalytic technique with some traditional water treating techniques such as adsorption, flocculation and filtration. This kind of combination can avoid the deactivation of microbial treatment.

The authors have tried to combine photocatalytic process in different stage of wastewater treatment. In the present work, a combination of adsorption and photocatalytic degradation was explored in removal of azophloxine. The influence of NaCl on the activities of adsorption ability and photocatalytic activity were studied.

EXPERIMENTAL

Adsorption efficiency: Azophloxine solution concentration was measured by a 721E spectrophotometer at the maximum adsorption wavelength of 510 nm. 40 mg/L azophloxine aqueous solution was used as the pollutant. In each experiment, 100 mL of azophloxine solution was put in a 250 mL beaker. Activated carbon was used as the adsorbent. The suspension containing activated carbon and azophloxine was stirred to reach adsorption-desorption equilibrium. The concentration of azophloxine solution was calculated based on Lambert-Beer law.

Photocatalytic degradation: Photocatalytic degradation of aqueous azophloxine was conducted under UV-light irradiation to evaluate the activity of the photocatalyst. In this work, Degussa P25 was used as the photocatalyst. The photocatalyst TiO_2 was mixed with 50 mL of 40 mg/L azophloxine aqueous solution in a 200 mL beaker. A 20 W UV-lamp was used as the light source. The lamp can irradiate UV-light at wavelength of 253.7 nm. The solution was magnetically stirred for 0.5 h to ensure adsorption-desorption equilibrium before photocatalytic degradation process. The suspensions were filtered through a millipore filter (pore size 0.45 μm) before measuring the absorbance.

RESULTS AND DISCUSSION

Adsorption of azophloxine on activated carbon and decolouration of azophloxine on the composite of TiO_2 and activated carbon were compared in Fig. 1. The activated carbon can only adsorb azophloxine on the surface of this material. The composite material has multifunction on decolouration

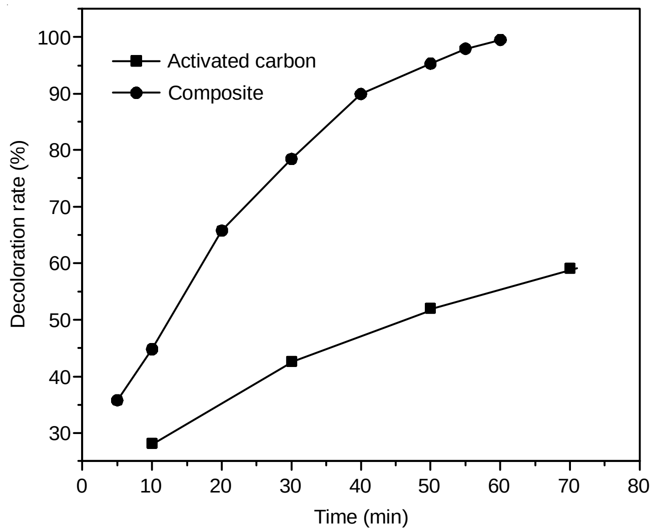

Fig. 1. Decolouration of azophloxine on activated carbon and the composite as the factor of time

of this dye. The activated carbon in the composite can also adsorb azophloxine on the surface of the composite material. Meanwhile, photocatalytic degradation of the dye can happen on the external surface of TiO_2 under UV-light irradiation. In this work, the addition amount of TiO_2 is 400 mg/L and the addition amount of activated carbon is 200 mg/L.

The decolouration of azophloxine on activated carbon and the composite as the factor of time has different efficiency. When the activated carbon is used alone, the adsorption efficiency on the material is not as high as the composite. The reason is that the composite has multifunction on decolouration of the dye. Adsorption of the dye on the activated carbon may reach the maximum value after adsorption-desorption equilibrium. On the other hand, photocatalytic degradation of azophloxine can continue until all of the dye is removed after a certain time.

The amount of material is a key factor influencing decolouration efficiency. Fig. 2 shows azophloxine decolouration with respect to the amount of activated carbon and the composite. The results obviously reveal the increment on azophloxine

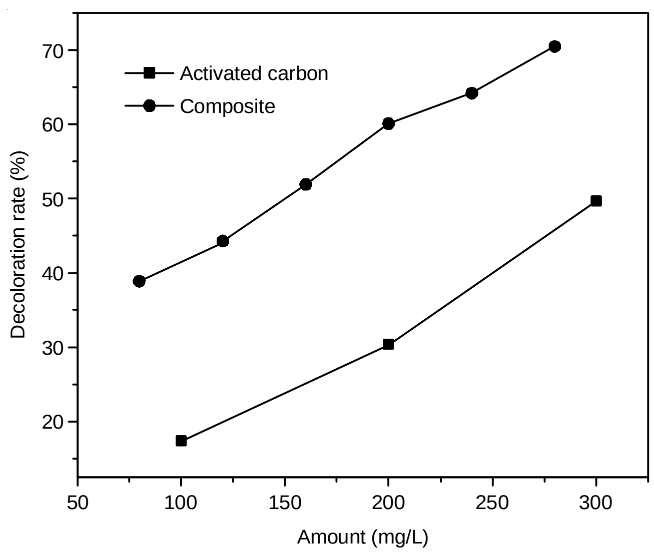

Fig. 2. Decolouration of azophloxine with respect to the amount of activated carbon and the composite

decolouration using composite material as compared to the use of activated carbon alone. Photocatalytic degradation of the dye is the main reason of the enhanced efficiency after using the composite of activated carbon and TiO_2, although the same amount of material is used in both treatments. Adsorption of azophloxine on activated carbon can increase with the increasing amount of adsorbent. Meanwhile, photocatalytic degradation of the dye on TiO_2 is apparently stronger than adsorption on the same amount of activated carbon. Furthermore, the adsorption of azophloxine may reach its maximum value after adsorption-desorption equilibrium. However, photocatalytic degradation of the dye on TiO_2 continues with extending reaction time, because the azophloxine is degraded into small molecules and can be converted into the final products as CO_2 and H_2O.

The influence of NaCl on decolouration of azophloxine was also studied (Fig. 3). The concentration of azophloxine in NaCl solution does not change much with the variation of NaCl solution concentration. The existence of some kinds of electrolytes may influence the absorbance of dyes in aqueous solution. Therefore, it is not clear whether the electrolyte affect concentration of the dyes. As can be seen from the results, NaCl in low concentration does not cause large difference in concentration of azophloxine. Decoloration of azophloxine does not happen by addition of NaCl alone.

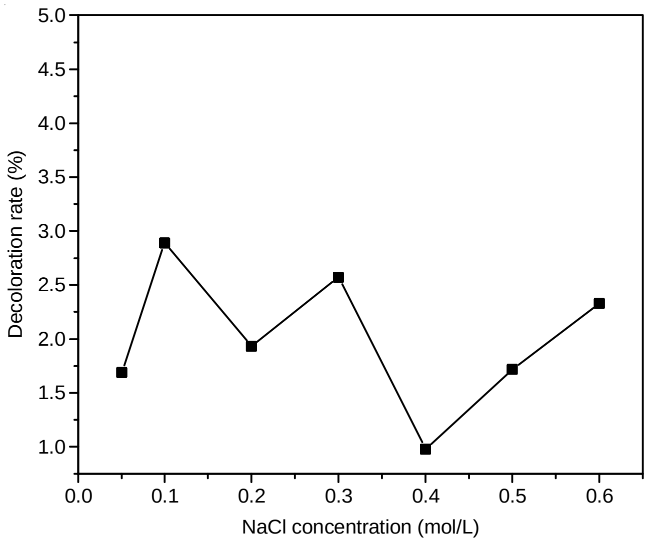

Fig. 3. Decolouration of azophloxine in NaCl solution

Fig. 4 shows the influence of NaCl concentration on azophloxine decolouration with the existence of 400 mg/L TiO_2. The addition of NaCl can affect photocatalytic degradation of azophloxine on TiO_2. Although photocatalytic degradation efficiency and the total decolouration rate of azophloxine vary with different NaCl concentration, the maximum decolouration rate is 21.4 %, which is lower than decolouration rate of 28 % by using 400 mg/L of TiO_2 alone. That means the addition of NaCl has detrimental effect on azophloxine decolouration. It is believed that Cl^- ion is a kind of cleaner for free radicals. The photogenerated hydroxyl radicals can be removed by the Cl^- ion and therefore, photocatalytic degradation efficiency is not as high as that in the solution without NaCl.

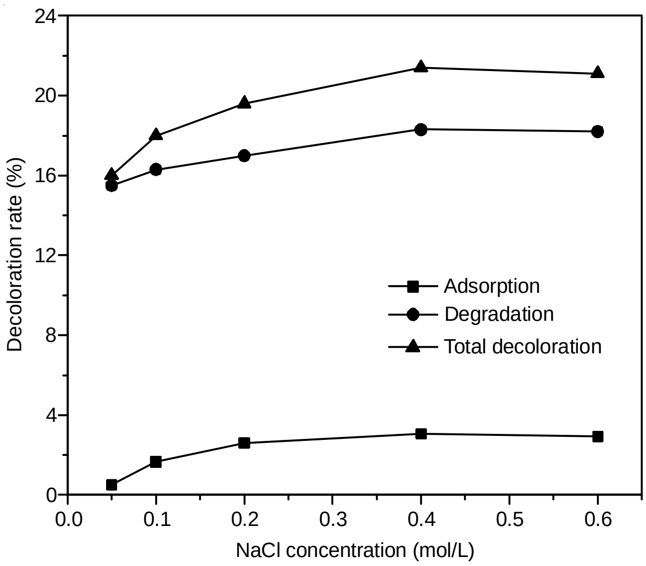

Fig. 4. Influence of NaCl concentration on decolouration of azophloxine with the existence of 400 mg/L TiO_2

A composite of 400 mg/L TiO_2 and 200 mg/L activated carbon was also used to study the effect of NaCl on azophloxine decolouration (Fig. 5). After the addition of NaCl, decolouration of the azophloxine is always higher than that without using NaCl in the solution. The maximum decolouration efficiency is found in the solution containing 0.4 mol/L NaCl. It is interesting to note that the existence of NaCl has positive effect on decolouration of azophloxine. The reason is difficult to explain, it can be attributed to the influence of NaCl on the surface properties of the composite. The existence of NaCl in the solution of azophloxine may improve adsorption on the surface of TiO_2 and activated carbon. The adsorption of the dye on the surface of TiO_2 is quite essential for the subsequent photocatalytic degradation process. Since the azophloxine molecules adsorbed on the surface of TiO_2 is continually degraded into small parts, the remaining azophloxine molecules in the solution will be further adsorbed on the surface and therefore, photocatalytic degradation of the dye can maintain in a high speed.

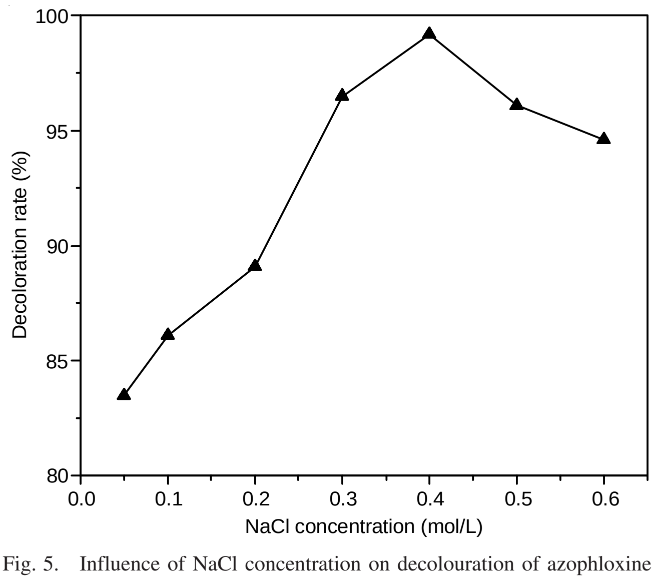

Fig. 5. Influence of NaCl concentration on decolouration of azophloxine with the existence of 400 mg/L TiO_2 and 200 mg/L activated carbon

Conclusion

Both adsorption and photocatalytic degradation processes were used for decolouration of azophloxine. Adsorption of the dye on the activated carbon may reach the maximum value after adsorption-desorption equilibrium. Photocatalytic degradation of azophloxine can continue until all of the dye is removed after a certain time. Decoloration of azophloxine does not happen by addition of NaCl alone. The addition of NaCl can affect photocatalytic degradation of azophloxine on TiO_2. The existence of NaCl has positive effect on decolouration of azophloxine by using composite material.

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