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Influences of pH and NaCl on Metanil Yellow Decolouration by Adsorption and Photocatalytic Decolouration

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A combination of adsorption and photocatalytic decolouration was explored in decolouration of metanil yellow. The effects of pH and NaCl were studied for both processes. Adsorption of metanil yellow on the activated carbon decreases with increasing pH. Photocatalytic activity is also influenced by the variation of pH and the maximum photocatalytic decolouration efficiency appears at pH of 3. For the result of combination of adsorption and photocatalytic decolouration, a minimum decolouration rate is obtained at pH of 7. The decolouration rate increases obviously with decreasing pH of the solution. The addition of NaCl to the solution of metanil yellow can obviously enhance both adsorption efficiency of the dye on activated carbon and photocatalytic decolouration efficiency on TiO_2. The overall decolouration efficiency does not change much with the variation of NaCl concentration.

Keywords: Metanil yellow, Adsorption, Photocatalytic, TiO_2.

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]. The removal of organic materials through common water treatment processes is an emerging concern[4-6]. Activated carbon is widely used in water treatment for the removal of organic pollutants because of their porous structure and large internal surface area. However, it was not always effective in organic materials treatment[7].

Photocatalytic oxidation of organic pollutants becomes one of the most studied methods[8,9]. Titanium dioxide is believed to be the most satisfactory photocatalytic material in dealing with environmental pollutants. This technique has been combined with some other method to treat wastewater, since cost and efficiency are always of concern. The combination of adsorption and photocatalytic degradation methods is interesting because these two methods can be used separately in different stage of water treatment and they can be used simultaneously for synergetic effect in wastewater treatment[10-13].

In the present work, a combination of adsorption and photocatalytic degradation was explored in decolouration of metanil yellow. The effects of pH and NaCl on the functions of both adsorption and photocatalytic degradation processes, as well as the combined efficiency of the two methods in metanil yellow decolouration were studied.

EXPERIMENTAL

Adsorption efficiency: 100 mL of 30 mg/L metanil yellow aqueous solution was put in a 250 mL beaker. Metanil yellow concentration was measured by a spectrophotometer (Shanghai Spectrum Instruments 721E) at its maximum adsorption wavelength of 438 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 metanil yellow solution was calculated based on Scherrer formula.

Photocatalytic degradation: Photocatalytic activity of the photocatalyst was evaluated by measuring degradation rate of aqueous metanil yellow under UV irradiation. In each experiment, the photocatalyst TiO_2 was put into 50 mL of 30 mg/L metanil yellow aqueous solution in a 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. Metanil yellow concentration was measured by a spectrophotometer (Shanghai Spectrum Instruments 721E) at its maximum adsorption wavelength of 438 nm. The suspensions were filtered through a Millipore filter (pore size 0.45 μm) before measuring.

RESULTS AND DISCUSSION

Influence of pH: Fig. 1 shows adsorption of metanil yellow on 3 mg of activated carbon as the factor of pH. The initial pH of 30 mg/L metanil yellow aqueous solution is 5.35. At this pH, the adsorption rate on 3 mg of activated carbon is 45.3 %. The results indicate that adsorption of metanil yellow on the activated carbon decreases with increasing pH. It is the common trend that adsorption of acidic dye is not favorable at high pH.

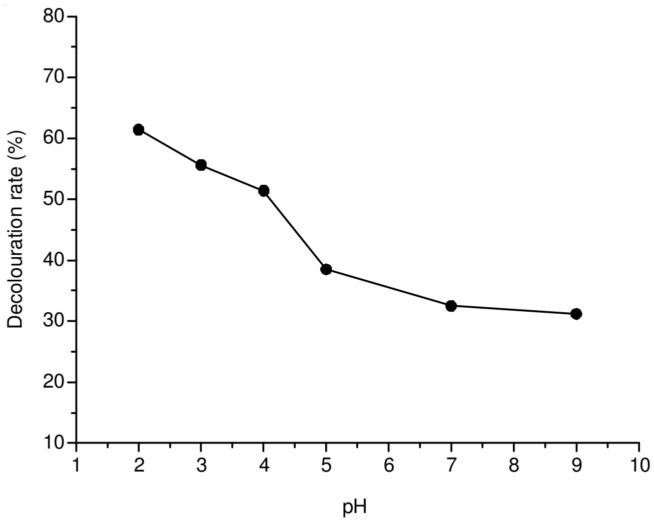

Fig. 1. Adsorption of metanil yellow on 3 mg of activated carbon at different pH

Photocatalytic decolouration of metanil yellow on 30 mg TiO_2 as factor of pH is shown in Fig. 2. The solution was irradiated under UV light for 45 min with the existence of 30 mg TiO_2. Photocatalytic decolouration rate is 63.8 % for the metanil yellow solution without changing of pH at 5.35. As shown in the figure, the maximum photocatalytic decolouration efficiency appears at pH of 3. The change of pH may have effect on adsorption of the dye on photocatalyst surface. Photocatalytic activity is also influenced by the variation of pH. Meanwhile, some organic substance may also have a certain pH to achieve the maximum decolouration efficiency.

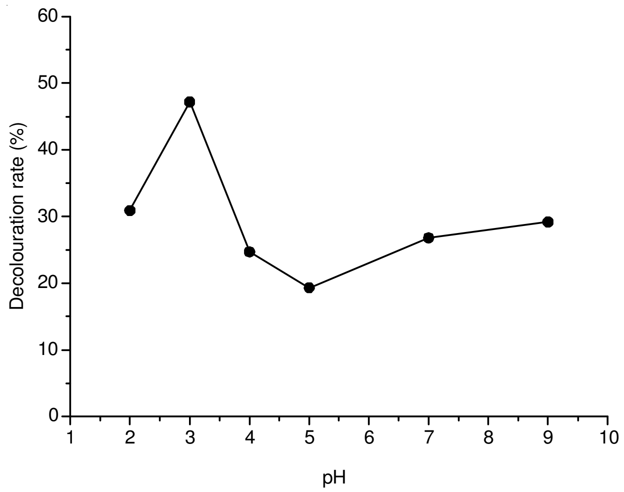

Fig. 2. Photocatalytic decolouration of metanil yellow on 30 mg TiO_2 at different pH

A combination of adsorption and photocatalytic decolouration was also investigated to study the influence of pH, as shown in Fig. 3. After mixing 3 mg activated carbon and 9 mg TiO_2 in the solution, the solution was irradiated under UV light for 45 min. The combined decolouration rate without changing pH of the solution is 68.2 %. A minimum decolouration rate is obtained at pH of 7. The decolouration rate increases obviously with decreasing pH of the solution. Meanwhile, an increase of pH may also lead to enhanced decolouration rate. Low pH is favored by adsorption of metanil yellow on activated carbon. Photocatalytic decolouration also has good result at lower pH.

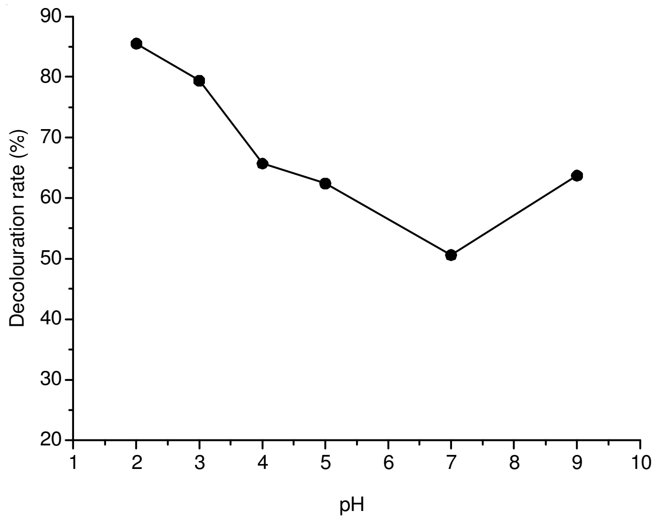

Fig. 3. Decolouration of metanil yellow under combined condition of adsorption and photocatalytic decolouration at different pH. 3 mg activated carbon and 9 mg TiO_2 were used in the solution

Influence of NaCl: Influence of the addition of NaCl was also studied. Fig. 4 shows adsorption of metanil yellow on 3 mg of activated carbon with the variation of NaCl concentration. The adsorption time was set as 45 min to achieve adsorption-desorption equilibrium. The addition of NaCl into the solution of metanil yellow can obviously enhance adsorption efficiency of the dye on activated carbon. Adsorption rate increases with increasing concentration of NaCl in the solution. The existence

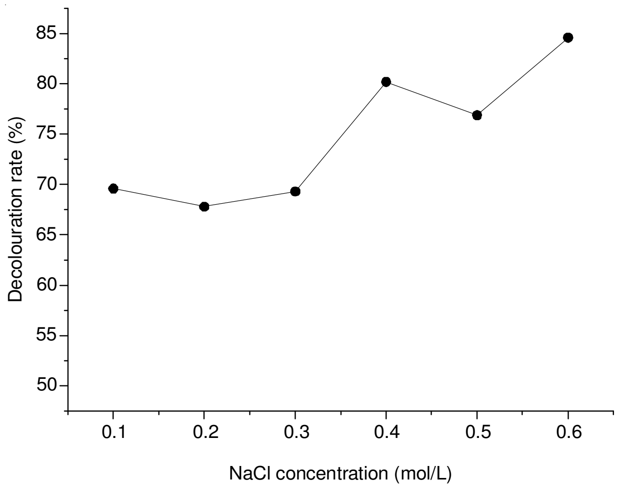

Fig. 4. Adsorption of metanil yellow on 3 mg of activated carbon with the variation of NaCl concentration

of NaCl may affect charge balance on the surface of the activated carbon and may affect charge character of the dye.

Photocatalytic decolouration of metanil yellow on 30 mg TiO_2 with the variation of NaCl concentration is shown in Fig. 5. The addition of NaCl at low concentration may retard the photocatalytic decolouration efficiency, mostly because the existence of Cl^- can occupy photogenerated holes on the material and in turn be harmful to photocatalytic decolouration activity. With the increase of NaCl to a suitable concentration, photocatalytic decolouration efficiency also increases due to promoted redox activity of photogenerated electrons and holes. Photocatalytic activity is enhanced with the subsequently produced oxidative species.

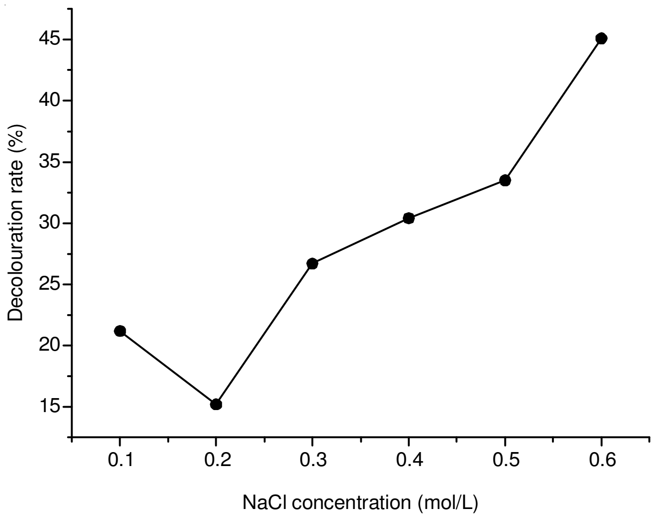

Fig. 5. Photocatalytic decolouration of metanil yellow on 30 mg TiO_2 with the variation of NaCl concentration

Decolouration of metanil yellow under combined condition of adsorption and photocatalytic decolouration with the variation of NaCl concentration was also studied. As shown in Fig. 6, the existence of NaCl can promote adsorption and photocatalytic processes. The overall decolouration efficiency does not change much with the variation of NaCl concentration. Adsorption repetition and reaction repetition occur in the solution with the addition of NaCl. Total decolouration rate varies with increasing NaCl concentration while reaches the maximum value at pH of 4.

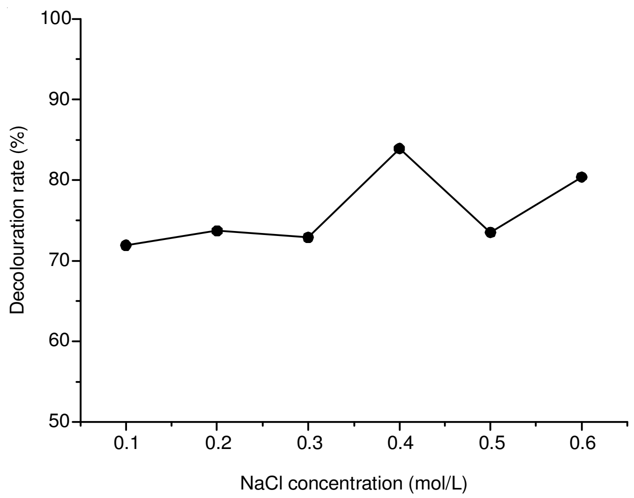

Fig. 6. Decolouration of metanil yellow under combined condition of adsorption and photocatalytic decolouration with the variation of NaCl concentration. 3 mg activated carbon and 9 mg TiO_2 were used in the solution

Conclusion

Both adsorption and photocatalytic degradation processes were used for metanil yellow decolouration with the variation of pH and addition of NaCl. Low pH is favored by adsorption of metanil yellow on activated carbon. Photocatalytic decolouration also has good result at lower pH. The existence of NaCl can promote adsorption and photocatalytic processes. Adsorption repetition and reaction repetition occur in the solution with the addition of NaCl. Total decolouration rate varies with increasing NaCl concentration while reaches the maximum value at pH of 4.

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