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Decolouration of Metanil Yellow by Combination of Adsorption and Photocatalytic Degradation

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A combination of adsorption and photocatalytic degradation was explored in decolouration of metanil yellow. When using activated carbon alone, the suspension reaches adsorption-desorption equilibrium after nearly 110 min of stirring. Nearly 57 % of the initial metanil yellow is adsorbed on activated carbon after equilibrium. The addition of more activated carbon can lead to more decolouration of the initial dye. During photocatalytic degradation process, decolouration efficiency increases with extending reaction time. Nearly all the dye can be decolourized after 90 min of photocatalytic degradation. The combination of adsorption and photocatalytic degradation can be more effective on decolouration of metanil yellow. The maximum decolouration efficiency is obtained on the sample containing 1:3 of activated carbon and TiO_2.

Keywords: Metanil yellow, Adsorption, Photocatalytic, TiO_2.

INTRODUCTION

Activated carbon is a widely applied adsorbent in environmental pollutant treatment because it is possible to design its textural properties and subsequently modify the chemical properties of this material by impregnation treatments or gas phase oxidation. Due to the specific interactions between the substances dissolved in the solution and the surface functional groups, the chemical nature of this surface functional groups are essential in the adsorption process[1,2]. The surface characteristics of activated carbon and the number of active sites and functional groups favoring solute-adsorbent interactions affect the adsorption process, as well as the textural characteristics of the material[3,4].

Photocatalytic oxidation of organic pollutants becomes one of the most studied new methods[5,6]. 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[7-10].

In the present work, a combination of adsorption and photocatalytic degradation was explored in decolouration of an azo dye, metanil yellow. The functions of both adsorption and photocatalytic degradation processes, as well as the combined efficiency of these 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 adsorbent 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, 30 mg of the photocatalyst 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

Activated carbon has been used for adsorption of various environmental pollutant especially organic substances. Although such organic pollutants exist in water and air in very small concentration, the removal of these substances through adsorption by activated carbon is usually effective. In this work, adsorption efficiency of metanil yellow on activated carbon was investigated first. In each experiment, 3 mg activated carbon was added in 100 mL of 30 mg/L metanil yellow aqueous solution. The decolouration efficiency as the factor of adsorption time is shown in Fig. 1. Although adsorption efficiency shows almost linear relationship along with adsorption time in the first 60 min, the suspension reaches adsorption-desorption equilibrium after nearly 110 min of stirring. Nearly 57 % of the initial metanil yellow is adsorbed on activated carbon after equilibrium.

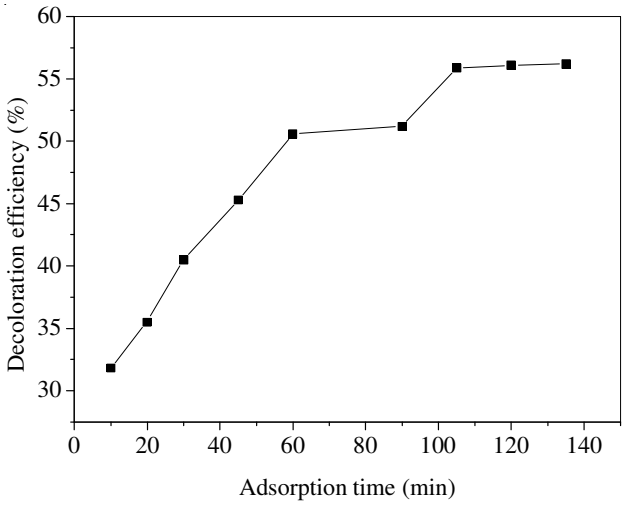

Fig. 1. Adsorption efficiency of metanil yellow on activated carbon as the factor of adsorption time. 3 mg activated carbon was used in 100 mL of 30 mg/L aqueous solution of metanil yellow

The effect of the amount of activated carbon applied in the solution was studied as well. In each experiment, adsorption time was set as 120 min since the period is enough for the suspension to reach adsorption-desorption equilibrium. The amount of activated carbon varied in 100 mL of 30 mg/L metanil yellow aqueous solution. As shown in Fig. 2, the effect of activated carbon adding amount has different relationship with decolouration efficiency. Normally, the addition of more activated carbon can lead to more decolouration of the initial dye. However, the increase of decolouration efficiency becomes slow after the amount of activated carbon reaches a certain amount.

Fig. 3 shows photocatalytic degradation of metanil yellow after adsorption on activated carbon. Photocatalytic degradation process was conducted after adsorption of the dye on activated carbon. The suspension was filtrated after adsorption to remove activated carbon and then TiO_2 was added into the solution further for subsequent photocatalytic degradation process. 3 mg activated carbon was applied into 100 mL of 30 mg/L aqueous solution of metanil yellow. Photocatalytic degradation was conducted after adsorption of the dye on activated carbon. 30 mg TiO_2 was used as the photocatalyst in each experiment. 55 % of the initial metanil yellow was adsorbed on activated carbon before photocatalytic process began. During photocatalytic degradation process, decolouration efficiency increases with extending reaction time. Nearly all the dye can be decolourized after 90 min of photocatalytic degradation. Total treating time including adsorption and photocatalytic degradation is 210 min.

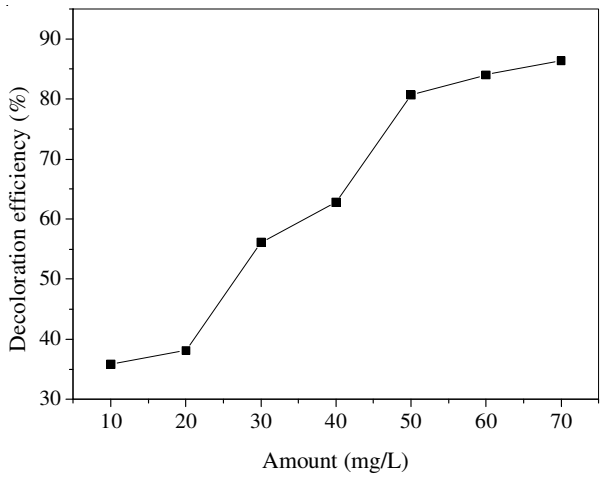

Fig. 2. Adsorption efficiency with respect to the amount of activated carbon in 100 mL of 30 mg/L metanil yellow aqueous solution. Adsorption time was 120 min

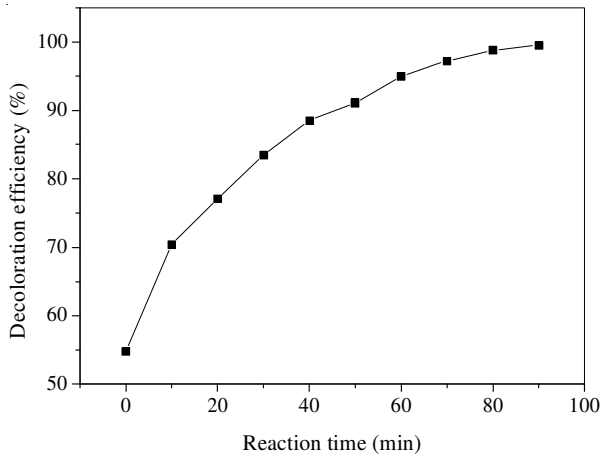

Fig. 3. Photocatalytic degradation of metanil yellow after adsorption on activated carbon. 3 mg activated carbon was applied into 100 mL of 30 mg/L metanil yellow aqueous solution. Photocatalytic degradation was conducted after adsorption of the dye on activated carbon. 30 mg TiO_2 was used as the photocatalyst

Combination of adsorption and photocatalytic degradation: Decolouration of metanil yellow by a combination of adsorption and photocatalytic degradation was presented in Fig. 4. 30 mg TiO_2 and 3 mg were added into 100 mL of 30 mg/L metanil yellow aqueous solution. Since adsorption and photocatalytic degradation are conducted at the same time, less time is needed to remove the dye. About 150 min is needed to decolourize all the initial dye, which is 0.5 h less than using photocatalytic degradation process alone. Therefore, the combination of adsorption and photocatalytic degradation can be more effective on decolouration of metanil yellow.

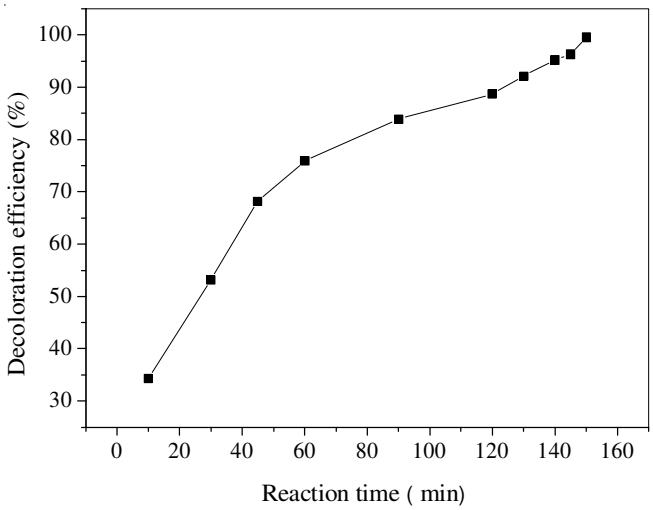

Fig. 4. Decolouration of metanil yellow by a combination of adsorption and photocatalytic degradation. 30 mg TiO_2 and 3 mg were added into 100 mL of 30 mg/L aqueous solution of metanil yellow

Fig. 5 shows decolouration of metanil yellow as the factor of the ratio of activated carbon and TiO_2. 3 mg of activated carbon was added in the solution. Irradiation time was 45 min. The maximum decolouration efficiency is obtained on the sample containing 1:3 of activated carbon and TiO_2. The individual amounts of activated carbon and TiO_2 are 30 mg/L and 90 mg/L, respectively.

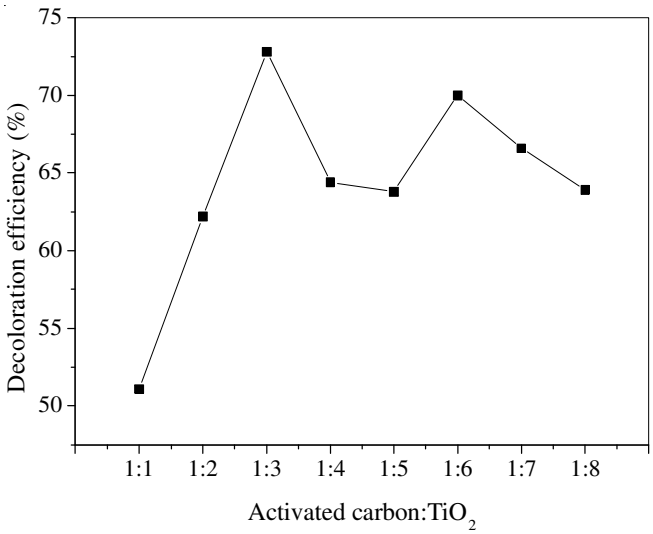

Fig. 5. Decolouration of metanil yellow as the factor of the ratio of activated carbon and TiO_2. 3 mg of activated carbon was added in the solution. Irradiation time was 45 min

Conclusion

Both adsorption and photocatalytic degradation processes were used for decolouration of metanil yellow. About 55 % of the initial metanil yellow was adsorbed on activated carbon before photocatalytic process began. During photocatalytic degradation process, decolouration efficiency increases with extending reaction time. Nearly all the dye can be decolourized after 90 min of photocatalytic degradation. Total treating time including adsorption and photocatalytic degradation is 210 min. A combination of these two methods was also studied. About 150 min is needed to decolourize all the initial dye, which is 30 min less than using photocatalytic degradation process alone. The maximum decolouration efficiency is obtained on the sample containing 1:3 of activated carbon and TiO_2. The individual amounts of activated carbon and TiO_2 are 30 mg/L and 90 mg/L, respectively.

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REFERENCES

1. R.C. Bansal, J.B. Donnet and H.F. Stoeckli, Active Carbon, Marcel Dekker, New York, pp. 27-118 (1988).
2. C. Faur-Brasquet, K. Kadirvelu and P. Le Cloirec, *Carbon*, **40**, 2387 (2002).
3. N. Spahis, A. Addoun, H. Mahmoudi and N. Ghaffour, *Desalination*, **222**, 519 (2008).
4. C. Moreno-Castilla, M.A. Álvarez-Merino, L.M. Pastrana-Martínez and M.V. López-Ramón, *J. Colloid Interf. Sci*., **345**, 461 (2010).
5. M.R. Hoffmann, S.T. Martin, W. Choi and W. Bahnemann, *Chem. Rev*., **95**, 69 (1995).
6. A. Fujishima, T.N. Rao and D.A. Tryk, *J. Photochem. Photobiol. Chem*., **1**, 1 (2000).
7. D.H. Quiñones, A. Rey, P.M. Álvarez, F.J. Beltrán and P.K. Plucinski, *Appl. Catal. B*, **144**, 96 (2014).
8. B.F. Gao, P.S. Yap, T.M. Lim and T.T. Lim, *Chem. Eng. J*., **171**, 1098 (2011).
9. H. Slimen, A. Houas and J.P. Nogier, *J. Photochem. Photobiol. A*, **221**, 13 (2011).
10. X.J. Wang, Y.F. Liu, Z.H. Hu, Y.J. Chen, W. Liu and G.H. Zhao, *J. Hazard. Mater*., **169**, 1061 (2009).