J. Indian Chem. Soc.,
Vol. 96, January 2019, pp. 198-199

Low-cost activated carbon derived from *Cassia alata* seeds for the removal of xylenol orange from aqueous solution: Kinetic, equilibrium, thermodynamic studies

G. Ushanandhini[a], K. Arivalagan[a]* and R. Tamilarasan[b]

[a]Department of Chemistry, Govt. Arts College for Men, Nandanam, Chennai-600 035, India

E-mail: arivualagan16@gmail.com

[b]Department of Chemistry, University College of Engineering Pattukottai, Rajamadam-614 701, Tamilnadu, India

Manuscript received online 30 August 2018, accepted 10 October 2018

An inexpensive and porous activated carbon (AC) was prepared from *Cassia alata* (CA) matured seeds using sulphuric acid as an activating agent. The prepared activated carbon was employed for the adsorption of Xylenol Orange (XO) in an aqueous solution. The experiments were conducted in a batch method to optimize various experimental parameters. The resulting materials were characterized by two different techniques such as SEM and FT-IR analyses.

Keywords: Activated carbon, dye removal, isotherm, thermodynamic parameters.

Introduction

Dyes are known to be widespread in the environment from industrial waste[1a]. Dyes are coloured substances that give colour when applied to a substrate. Chromophores and auxochromes are responsible for the colour of dyes[1b]. Dyes are most dangerous contaminants in water sources. These contaminants create some permanent health issues for all the living things and changes the properties of water. Adsorption is one of the traditional methods to remove dyes from waste water. Compare to other techniques it is cheap, efficient and feasible technique and it will not produce any harmful by products[1c]. Xylenol Orange highly soluble in water causes irritation to eye and skin, also causes gastrointestinal irritation with nausea, vomiting and diarrhea. So, it is necessary to remove this dye. Therefore, in the present work, activated carbon was prepared from *Cassia alata* plant seeds and H_2SO_4 used as an activating agent. The adsorption capacity of this prepared activated carbon was analyzed using synthetic dye Xylenol Orange.

Experimental

Preparation of activated carbon:

The Xylenol Orange stock solution was prepared by dissolving desired amount of dye in distilled water to the concentration of 1 g/L.

The crushed *Cassia alata* seed sample carbonized in a furnace at 450°C for 5 h. The carbonized sample was transferred into 500 ml of 1:1 sulphuric acid solution for 12 h. The suspension was filtered and the modified samples were washed several times with distilled water until the pH of the washings become neutral. Finally, the modified activated carbon was dried in an electrical oven at 105°C for 12 h.

Results and discussion

The FTIR spectrum of XO:CA-AC shown in Fig. 1(a). The peak at 3833 cm^{-1} corresponds to N-H stretching vibrations. The vibration at 3737 cm^{-1} and the broad vibration at 2354 cm^{-1} revealed the O-H stretching vibration. The absorption at 1687 cm^{-1} reveals C=O stretching vibrations. The vibration band at 1530 cm^{-1} indicates the N-O stretching vibra-

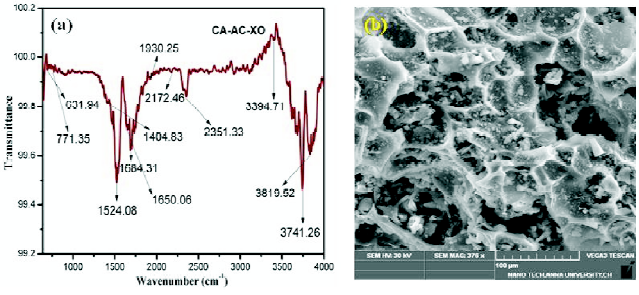

Fig. 1. (a) FTIR spectrum of XO loaded CA-AC and (b) SEM image of CA-AC before adsorption.

tion[2]. SEM image shown in Fig. 1(b) reveals that activated carbon has a smooth surface and regular morphology. Activated carbon prepared in this study has a homogeneous and uniform structure with macropores.

From the Fig. 2(a) correlation coefficient (R^2) value of Langmuir and Freundlich model, the system is more pronounced Langmuir adsorption isotherm rather than Freundlich adsorption isotherm. The R^2 value for second order kinetic model is more than the R^2 value of first order kinetic model shown in Fig. 2(b). This adsorption kinetics follows the second order kinetic model. The negative values of Gibbs free energy change ($\Delta G°$) acquired for the adsorption, confirm the spontaneous nature of the adsorption process. The positive values of enthalpy change ($\Delta H°$) and entropy change ($\Delta S°$) calculated from the plot shown in Fig. 2(c) and Table 1, at various temperatures indicates that the adsorption reactions were endothermic and slight increase of randomness at solid liquid interphase.

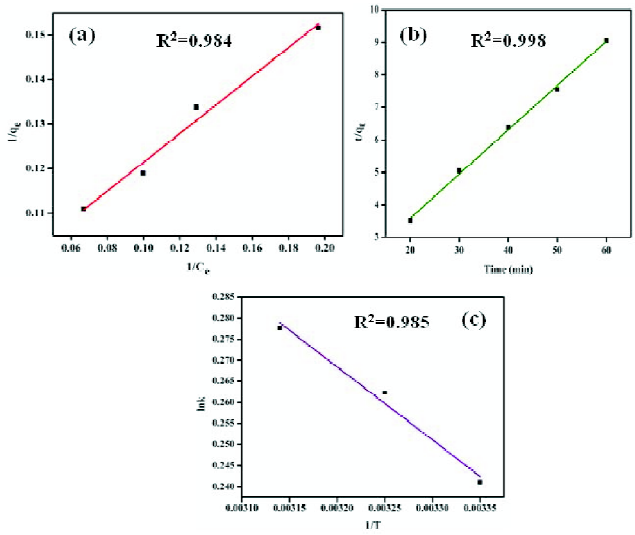

Fig. 2. (a) Langmuir plot, (b) pseudo-second order kinetic plot and (c) thermodynamic plot.

Table 1. Thermodynamic parameter for the adsorption of XO dye

	Thermodynamic parameters		
T (K)	$\Delta G°$ (kJ/mol)	$\Delta H°$ (kJ/mol)	$\Delta S°$ (J/mol K)
298	–0.5973	3.316	15.73
308	–0.6716		
318	–0.7339		

Conclusions

In the present study it has been clearly shown that *Cassia alata* seed activated carbon could be effectively used as a low cost adsorbent for the removal of Xylenol Orange from aqueous solution with over 92% dye removal.

References

1. (a) V. K. Gupta, D. Mohan and S. Sharma, *Sep. Sci. Technol.*, 2000, **35**, 2097; (b) H. Qunluo, S. P. Liu and Z. F. Liu, *Analytica Chimica Acta*, 2001, **449**, 261; (c) K. Kadirvelu, C. Karthika and N. Vennilamani, *Chemosphere*, 2005, **60**, 1009.
2. C. Chen, M. Zhang, Q. Guan and W. Li, *ChemEngJ.*, 2012, **183**, 60.