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Adsorption of o-Cresol Using Activated Carbon

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Abstract. Commercial activated carbon was used for the adsorptive removal of o-cresol from dilute aqueous solutions. Batch mode adsorption studies were performed by varying parameters such as pH, adsorbent dosage and time. The experimental study show that adsorption with activated carbon can remove up to 95% of o-cresol from the wastewater within 10 minutes. The optimum process variables of this adsorption of o-cresol were found as pH 8 and adsorption dosage 5 g/L. The adsorption followed Langmuir Isotherm.

Keywords: o-Cresol, adsorption, activated carbon, Freundlich isotherm, Langmuir isotherm

1. Introduction

The worldwide production volume of o-cresol is approximately 37000 - 38000 tons/annum [1]. It is mostly used as an intermediate for the production of pesticides, epoxy resins, dyes and pharmaceuticals, but also as a component of disinfectants and cleaning agents. Approximately 60% of o-cresol is derived from coal tar and crude oil using classical techniques such as distillation, stripping, liquid-liquid extraction. Remaining amount is obtained synthetically by alkylation of phenol with methanol, either in the vapour or liquid phase. Most health exposures of o-cresol observed in people, include irritation and burning of skin, eyes, mouth, and throat, abdominal pain and vomiting, heart damage, anemia, liver and kidney damage facial paralysis, coma, and death [2].

2. Materials and Methods

2.1. Chemicals

All chemicals used in the present study were of analytical grade (A.R.), and purchased from Merck chemicals, Mumbai, India. Powdered activated carbon (having methylene blue rated adsorption capacity as greater than 180 mg/g) was also procured from Merck Chemicals and was used as an adsorbent in this study.

2.2. Analytical Methods

pH of the wastewater was measured by a digital pH meter (Polmon, LP-1395, India). COD was determined by the standard closed reflux method using a COD reactor (Hach, DRB200 COD reactor, USA) [**3**]. TOC was measured using a TOC analyzer (Shimadzu, TOC-VCSH, Japan).

2.3. Estimation of o-Cresol

o-Cresol was estimated using spectro-photometric method as proposed by APHA (2005) [3]. o-cresol was rapidly condensed with 4-Aminoantipyridine followed by its oxidation with potassium ferricyanide at pH 7.9 to yield red coloured compound. The absorbance was measured at 510 nm using UV-Visible spectrophotometer (Thermoelectron Corporation, GENESYS 20, USA).

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2.4. pH Study

The optimum pH for the process was determined from the data obtained from experiments carried out at varying initial pH (2, 4, 6, 8, 10 and 12) and all subsequent experiments were carried out at this pH.

2.5. Dosage Study

Adsorbent dosage was optimized by performing the experiments at varying adsorbent dosage (2, 3, 4, 5, 6 and 7 g/L) at optimum pH. Aliquots of the sample were collected at specified time intervals (10, 20, 30, 40 min) and analyzed by TOC and o-cresol by spectrophotometric method. The data obtained were used to plot isotherms which describe the adsorption process.

2.6. Batch Adsorption Study

As mentioned earlier o-cresol (500 mg/L, TOC 417 mg/L) was used as the model compound for adsorption studies. All the adsorption experiments were done in 100 mL glass-stoppered bottles containing pre-determined amount of activated carbon as adsorbent with 50 mL of synthetic wastewater. The flasks were labeled and kept in an orbital shaker (Trishul equipments, Thane) at a speed 120 rpm for 60 minutes. Batch experiments were carried out to evaluate the effect of the following parameters on the removal of o-cresol from the wastewater: pH, adsorbent dose and time. To evaluate the efficiency of adsorption, o-cresol and TOC of the wastewater before and after the treatment were determined. All the runs were carried out in duplicate to confirm the results.

3. Result and Discussion

3.1. Characteristics of o-Cresol

The characteristics of o-cresol are shown in Table 1. Initial pH is 6.8 and 417 mg/L of TOC.

Table 1: Characteristics of o-Cresol.

Parameter	Unit	Value
pH	--	6.8
COD	mg/L	1655
TOC	mg/L	417
Melting-point	^{o}C	31
Boiling-point	^{o}C	191
Density	kg/m^3	1046

3.2. Effect of pH on the Adsorption of o-Cresol

Results obtained from the adsorption of o-cresol at varying initial pH values are presented in Figure 1. Powdered activated carbon dose was kept 2 g/L in all the runs. It can be seen that TOC removal was maximum at pH 8 and showed a 65.32% reduction from the initial value.

Hence all subsequent experiments were carried out at this pH. Similar trend was obtained for the concentration of o-cresol at different pH values (Figure 1).

3.3. Effect of Adsorbent Dose

To observe the effect of adsorbent dose, the runs were conducted at different doses (2, 3, 4, 5, 6 and 7 g/L). From Figure 2, it can be seen that TOC decreased remarkably when the adsorbent dosage was increased from 2 to 3 g/L.

Beyond this adsorbent dose, TOC and substrate concentration continued to decrease. But it was found that any addition of adsorbent in the excess of 5 g/L did not exhibit applicable decrease (< 50% from the previous value). o-Cresol reduction always occurred in the same meaner as the TOC as TOC was due to o-cresol only. Hence all subsequent experiments were carried out using this dose.

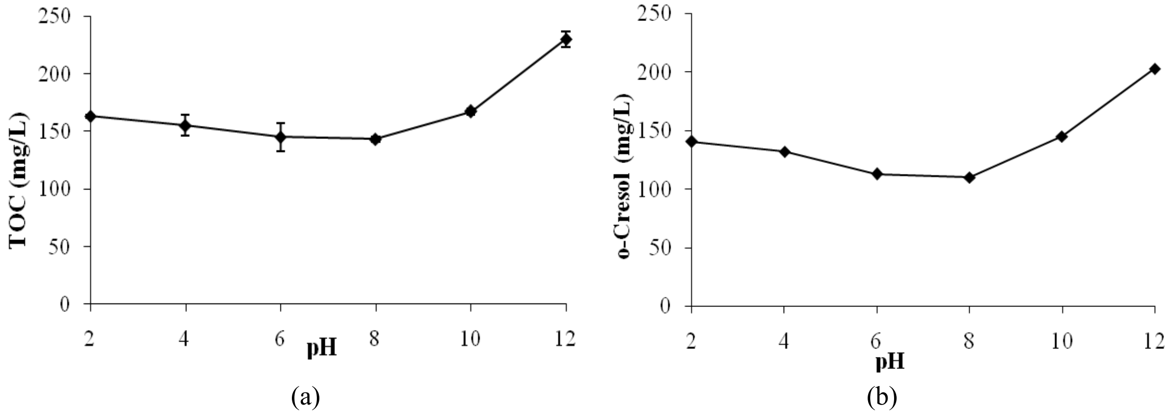


Fig. 1: Effect of pH on the adsorption of o-cresol. Experimental conditions: activated carbon used = 2 g/L; initial concentration of o-cresol = 500 mg/L, initial TOC = 417 mg/L.

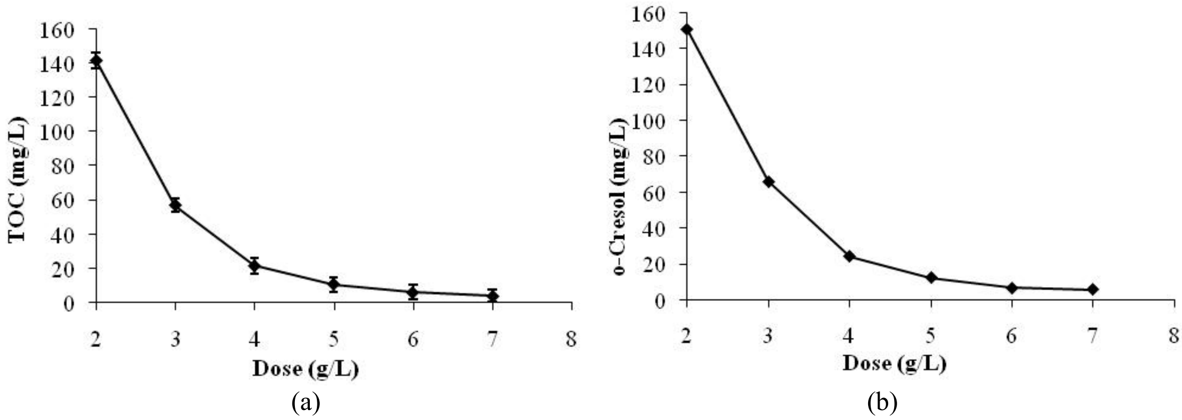


Fig. 2: Effect of adsorbent dose on the adsorption of o-cresol. Experimental conditions: experimental pH = 8; initial concentration of o-cresol = 500 mg/L; initial TOC = 417 mg/L.

3.4. Effect of Reaction Time

The effect of reaction time on the overall o-cresol removed was studied by withdrawal of samples at an interval of 10 minutes. The total duration of the runs was 40 minutes. The adsorbent was taken 5 g/L and the solution pH was kept at 8.0. The results are plotted in Figure 3. It can be seen that 95% removal of TOC occurred in 40 minutes. However, most of the removal was achieved within 10 minutes.

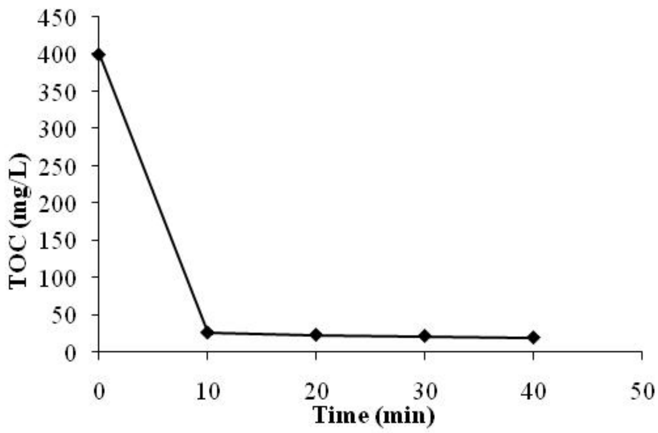


Fig. 3: Effect of time on the adsorption of o-cresol. Experimental conditions: activated carbon used = 5 g/L; pH maintained = 8; initial concentration of o-cresol = 500 mg/L.

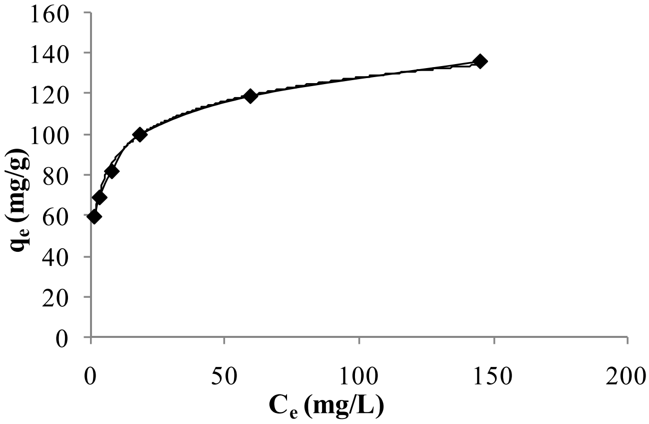


Fig. 4: Adsorption isotherm plot for o-cresol on activated carbon.

3.5. Langmuir Isotherm

The results obtained for the experimental studies, shown in Figure 4, were fitted in the equation prescribed for Langmuir isotherm [2, 4]:

$$q_e = K_L C_e /(1 + bC_e) = q_m bC_e /(1 + bC_e) \quad (1)$$

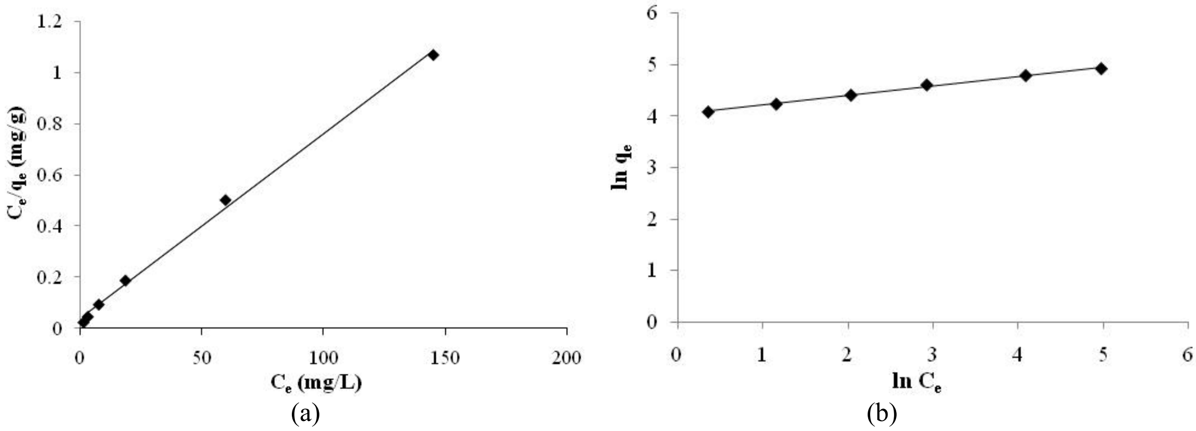
where q_e is the adsorption capacity (mg/g), C_e is equilibrium concentration of adsorbate (mg/L), K_L and b are Langmuir constants, and q_m is the Langmuir monolayer adsorption capacity.

3.6. Freundlich Isotherm

The results obtained for the experimental studies were fitted in the equation prescribed for Freundlich isotherm [1, 5]:

$$q_e = K_F C_e^{(1/n)} \quad (2)$$

where q_e is adsorption capacity (mg/g), C_e is equilibrium concentration of adsorbate (mg/L), and K_F and n are Freundlich constants.



(a) (b)

Fig. 5: Langmuir (a) and Freundlich (b) isotherms for adsorption of o-cresol on activated carbon.

The equilibrium adsorption data obtained were then fitted to Langmuir and Freundlich isotherms. Figure 5 shows the langmuir and Freundlich Isotherm plots and Table 2 shows the parameter for both the models.

Table 2: Isotherm parameters for the adsorption of o-cresol on activated carbon

Model	K_L	Q_{max}	b	R^2
Langmuir	142	27.78	5.142	0.997

Model	K_f	1/n	n	R^2
Freundlich	56.24	0.1819	5.497	0.995

4. Conclusion

The present study proved that the commercial activated carbon can remove up to 95% of o-cresol from the wastewater within 10 minutes by adsorption technique. The results were fitted with Langmuir Isotherm.

The optimum process variables of this adsorption of o-cresol were found as pH of 8 at an adsorbent dosage of 5 g/L.

5. References

[1] A. D. Vasu. Removal of phenol and o-cresol by adsorption onto activated carbon. *E-Journal of Chemistry* 2008, **5** (2): 224–232.

[2] H. I. Maarof, B. H. Hameed, and A. L. Ahmad. Adsorption Isotherm of o-cresol from Aqueous Solution by Granular Activated Carbon. *Proc. International Conference on Chemical and Bioprocess Engineering.* Universiti Malaysia Sabah, 2003, pp. 111-114.

[3] American Public Health Association (APHA). *Standard Methods for the Examination of Water and Wastewater*, 21st ed., APHA, Washington, DC, 2005.

[4] S. Juang, F. C. Wu, and R. L. Tseng, Adsorption isotherms of phenolic compounds from aqueous solutions onto activated carbon fibers. *Journal of Chemical & Engineering Data* 1996, **41** (3): 487–492.

[5] Y. Foo, and B. H. Hameed. Insights into the modeling of adsorption isotherm systems. *Chemical Engineering Journal* 2010, **156** (1): 2–10.