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To cite this article: T Miao et al 2017 IOP Conf. Ser.: Earth Environ. Sci. 81 012007

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Kinetics of Benzene-Ethylene Dichloride Mixture System on Activated Carbon

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Abstract. In this paper, studies are focused on a kinetic model for granular activated carbon (GAC), that describes the adsorption of trace organic components of benzene-ethylene dichloride mixture system. This work deals with kinetic experimental study of adsorption of gaseous single onto (GAC) and the kinetic model was modified to investigate binary assault systems. The breakthrough curves were obtained at 25 °C. These curves obtained at varying assault concentrations, every component fixed at same concentration. The values of theoretical parameters were determined.

1. Introduction
Volatile organic compounds (VOCs) is a major source of air pollution and it is danger for human health[1,2]. In order to meet the environmental pollution, carbon is applied to remove hazardous VOCs. When activated carbons are used in air or water treatments, they faced not a single component but mixture of VOCs. Competitive adsorptions between VOCs are most likely to occur. Kinetics of VOCs adopted in activated carbons are different in mixture system. Studies of adsorption mixed components are somewhat limited. The study collected experimental data for binary mixtures with respect to the concentration total constant. Yoon YH and Nelson JH have investigated a theoretical model to describes the adsorption of individual organic compounds and binary assault systems of benzene-ethylene dichloride[3-6].

2. Experimental

2.1. Materials and Methods
The adsorbents used in the work were produced by Beijing Chemical Reagent Co., China. For the experiments of each system, the temperature was 25±1 °C and the flow rate was controlled 24L/min. The experiment system consisted of the following units which were shown in Figure 1. The system consisted of following units:

1. The solvent-generation system was made with airflow.
2. The thermostat system kept the temperature.
3. The detection system consisted of HP 6890 gas chromatograph with a flame ionization detector (FID).

Concentrations in the approximate rang of 0.1 to 1.0 mg/L were selected to facilitate a comparison of single system to binary system.
2.2. Breakthrough

Typical experimental breakthrough curves for benzene or ethylene dichloride single system were depicted in Figure 2. Each experimental breakthrough curves were sigmoidal.

Figure 2. (a) Breakthrough curves of benzene vapour of different concentrations on CAC carbon in canister. (b) Breakthrough curves of ethylene dichloride vapour of different concentrations on CAC carbon in canister ($T = 298$ K, $L = 1$ cm, $v = 0.75$ L·cm$^{-2}$·min$^{-1}$).

Typical experimental breakthrough curve for benzene ethylene dichloride binary system is depicted in Figure 3. In general there was little difference between the breakthrough curves for benzene in single system and the binary system. In contrast to benzene, breakthrough curves for ethylene dichloride were considerably different from the single-component ethylene dichloride in Figure 3.

Figure 3. Typical breakthrough curves of a binary assault system.

The experimental breakthrough curve of benzene was sigmoidal, but the experimental breakthrough data for ethylene dichloride was different from those observed for the single system. The
breakthrough increased until ethylene dichloride reached a maximum breakthrough concentration. Therefore, Equation (1) be employed to determine to calculate breakthrough curves of benzene, Equation (2) be employed to determine to calculate breakthrough curves of benzene, ethylene dichloride.

2.3. Adsorbed phase calculations
A discussion of a model that be applied to the breakthrough curves for singe-component systems and for binary systems is presented in this study. The single system goes first. The following equation (1) was pertaining to a single-component system, and also strong component of binary system.

\[
\frac{c_t}{c_0} = \frac{1 - e^{-k_1 t}}{1 + e^{-k_1 t(t - \tau)}}
\]  

(1)

The following definitions apply.
- \(c_t\) = contaminant breakthrough concentration (mg/l)
- \(c_0\) = contaminant assault concentration (mg/l)
- \(t\) = breakthrough time (min)
- \(k_1\) = rate constant \((\text{min}^{-1})\)
- \(k_3\) = rate constant \((\text{min}^{-1})\)
- \(\tau\) = time required for 50% contaminant breakthrough (min)

\[
\frac{c_t}{c_0} = \frac{1 - e^{-k_3 t}}{1 + e^{-k_3 t(t - \tau)}} \times \left(1 + \frac{A}{1 + e^{-k_3 t(t - \tau)}}\right)
\]  

(2)

The following definitions apply.
- \(k_2\) = rate constant \((\text{min}^{-1})\)
- \(\tau_1\) = time required for 50% contaminant breakthrough (min)
- \(A\) is defined as \(\frac{c_{\text{max}}}{{c_0}}\)

3. Results and Discussion
The calculation on breakthrough curves for benzene or ethylene dichloride in single system using equation (1) requires knowledge of values in Table 1. These values were used to calculate theoretical single component breakthrough curves at various assault concentrations. The values of parameter \(k_1, \tau, k_3\) all depended on the relative concentration.

| \(c_0\) | \(k_1\) | \(\tau\) | \(k_3\) | \(c_0\) | \(k_1\) | \(\tau\) | \(k_3\) |
|---------|---------|---------|---------|---------|---------|---------|---------|
| (mg/L)  | (min\(^{-1}\)) | (min) | (min\(^{-1}\)) | (mg/L) | (min\(^{-1}\)) | (min) | (min\(^{-1}\)) |
| 0.11    | 0.023   | 501.1  | 0.011   | 0.18    | 0.031   | 241.4  | 0.011   |
| 0.22    | 0.040   | 292.4  | 0.018   | 0.32    | 0.039   | 157.5  | 0.021   |
| 0.25    | 0.043   | 262.3  | 0.017   | 1.33    | 0.112   | 72.0   | 0.066   |
| 0.53    | 0.078   | 167.0  | 0.021   | 2.16    | 0.177   | 52.8   | 0.122   |
| 0.92    | 0.090   | 124.3  | 0.029   | 4.99    | 0.278   | 32.5   | 0.199   |

There was same assault concentration of benzene and ethylene dichloride (Table 2), it is easy to ascertain the value of \(A\) from experimental results. Note that the parameter \(A\) was roughly invariant. The values of \(\tau, \tau_1, \tau_2\) (Table 2) depend on the concentration of both benzene and ethylene dichloride. The values of \(k, k_1, k_2, k_3\) increase with increasing assault concentration.
4. Conclusions

A theoretical model was developed for the single component contaminant assault of fix carbon bad. The model was extended to address the breakthrough characteristics of binary mixture. The calculated theoretical breakthrough curves for both benzene ethylene dichloride binary systems were in agreement with experimental data.

The major advantage of this model is that it may be applied to not single but mixture system. The single model was extended to investigate a binary system of benzene and ethylene dichloride. The breakthrough curves of each compound in the binary system were compared with those of pertinent single-component.

The breakthrough curves of benzene were sigmoidal in either single system or binary system in presence of ethylene dichloride. The ethylene dichloride breakthrough concentration eventually reached a maximum level. The value of $A$ can describe the compete of binary system. Values of the theoretical parameters $k_1, \tau_1, k_2, \tau_2, k_3$ were determined for various binary systems.

References

[1] Atkinson R, Arey J 2003 Chem. Rev. 1034605.
[2] Chuang CL, Chiang PC 2003 Chemosphere 53 17.
[3] Yoon YH, Nelson JH 1984 Am Ind Hyg Assoc J 45 509.
[4] Yoon YH, Nelson JH, Lara J 1991 Am. Ind. Hyg. Assoc. 52 65.
[5] Yoon YH, Nelson JH, Lara J 1992 Am. Ind. Hyg. Assoc. J 53 493.
[6] Yoon YH, Nelson JH, Lara J 1996 Am. Ind. Hyg. Assoc. J 57 809.