고정층에서 Trichloroacetic acid의 흡착특성

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Adsorption Characteristics of Trichloroacetic Acid in a Fixed Bed

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Introduction

Trichloroacetic acid (TCA) is a natural organohalogen in soil that may arise from chlorination of organic substances as reported previously. It belongs, however, also to the secondary atmospheric pollutants formed by photooxidation of chlorinated solvents in the atmosphere and was assumed to be one of the stress factors. affecting the health state of coniferous forests. The levels of TCA in conifer needles in Central Europe and Scandinavia were roughly between 1 and 150 ppb with decreasing tendency during recent years. The widespread and intensive use of chlorinated acid herbicides in agriculture and forestry may give rise to a number of toxicological and environmental problems, even though, when used at recommended application rates and procedures, the concentrations reached in the environment are well below the levels generally considered to be of concern. When misused or as the result of accidental spillage, these herbicides have potential to injure non-target cultivars and microorganisms, in particular herbicide degraders and others contributing to soil quality or used as biocontrol agents, and to cause adverse side-effects in mammals, including humans.

Various treatment techniques have been employed to treat the wastewater, including precipitation, adsorption, ion exchange, and reverse osmosis. Among them, adsorption onto solid adsorbents has great environmental significance, since it can effectively remove pollutants from both aqueous and gaseous streams. In wastewater treatment, activated carbon is a powerful adsorbent because it has a large surface area and pore volume, which remove liquid-phase contaminants, including organic compounds, heavy metal ions and coloring matters. The characteristics, pH, and temperature of wastewater are likely to vary with time, so design of a suitable adsorption system is not that simple. In order to design effective activated carbon adsorption units and to develop mathematical models which can accurately describe their operation characteristics, sufficient information on both the adsorption and the desorption of individual pollutants under different operating conditions is required. The main purpose of this work is to eliminate of TCA from its aqueous solution, and to study its adsorption characteristics experimentally as well as theoretically.

Experimental

The adsorbent used in this study was granular activated carbon (GAC), F400, manufactured by Calgon Co.. GAC was sieved into a narrow range of particle sizes (0.055~0.065 *cm*), and washed with distilled water several times to remove impurities. The GAC were then stored in a sealed bottles with silica gel to prevent the readsorption of moisture.

Column Test

The column tests were carried out in a water-jacketed pyrex column with inside diameter and length of 1.5 and 44 cm, respectively. The column was packed with beads to distribute the solution uniformly. The activated carbon with known weight dry was put into the column. Distilled water was pumped into the column from the bottom to remove air bubbles and to rinse the carbon. In adsorption cycle, TCA solution was continuously fed to the top of the column until the column was saturated with the feed TCA solution. The saturated column was then regenerated with distilled water. The column temperature for all the column tests was maintained at 25°C. The effluent samples were collected intermittently by a fraction collector and the concentration was measured by the UV spectrophotometer (Shimadzu 1601).

Result

Fig. 1 shows that the experimental equilibrium adsorption isotherms obtained at the different initial pHs for the adsorption of TCA onto GAC. As shown in this Figure, the equilibrium adsorption amounts of TCA onto GAC increased with decreasing solution pH. It is common observation that anions are favorably adsorbed on the surface of adsorbents at low pH because the presence of hydrogen ions renders the surface active for the adsorption of cations at high pH values. The experimental data are well represented by the Freundlich isotherm. The calculated parameters of isotherm equation are listed in Table 1.

In order to demonstrate the effect of pH on the breakthrough curves of TCA, breakthrough curves under different pH values are shown in Fig. 2. The breakthrough time was decreasing with increasing of pH values. Fig. 3 shows the effect of bed length on adsorption of TCA onto GAC. The experimental data of our study show shorter breakthrough time and sharper breakthrough curve for shallow bed compared to those for deeper bed. The choice of a certain regeneration method should depend upon the physical and chemical characteristics of both the adsorbate and the adsorbent. In this study, distilled water was used as desorbate for GAC. As shown in Fig. 4, desorption of TCA was about 95% only using distilled water of usually pH 7. The effluent pH decreased in the earlier adsorption stage, and then increased to influent pH as adsorption proceeded, as represented in Fig. 4. At pH 3.5 and TCA concentration of 0.45mol/m^3, the effluent pH sharply decreased up to about nearly 3.5 and then slowly increased.

Acknowledgment

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Reference

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Table 1. Adsorption equilibrium constants of TCA onto activated carbon at 298K

Isotherm type		pH 3.5	pH 7.0	pH 10
Langmuir	q_m	0.79	0.26	0.23
	b	124.09	8.21	12.62
	error (%)	8.06	6.29	5.76
Freundlich	k	0.94	0.28	0.26
	n	6.45	2.73	3.306
	error (%)	3.09	5.90	3.47
Sips	q_m	1113.5	1113.5	1113.5
	b	0.001	0.0003	0.0002
	n	6.45	2.73	3.305
	error (%)	3.09	5.91	3.47

Table 2. Experimental conditions for a fixed bed adsorption

Variables	Range	Unit
Bed length	0.075～0.125	m
Flow rate	3.56×10^{-3}～1.02×10^{-2}	m/s
Bed porosity	0.271	-
Packing density	741.3	kg/m^3
Bath temperature	298	K

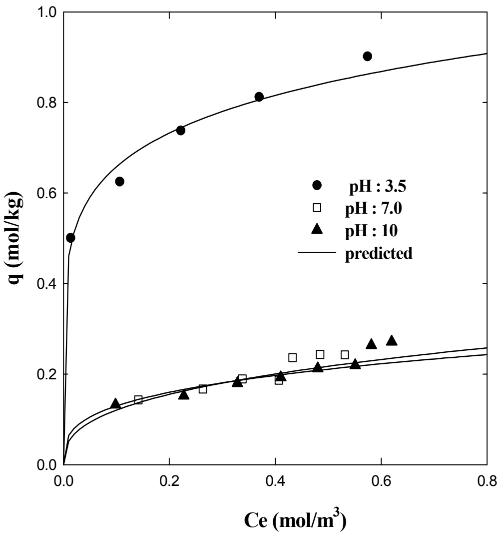

Fig. 1. Adsorption isotherm of TCA onto activated carbon in terms of pH (25°C)

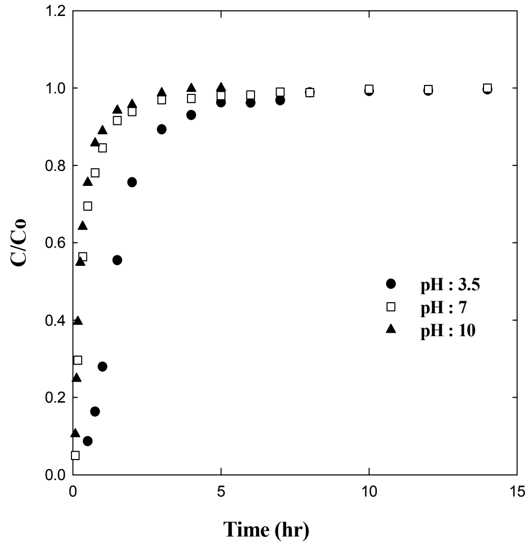

Fig. 2. Effects of pH on the experimental results and model predictiopn of adsorption breakthrough curves (298K, Vs ; 6.95 x 10^{-3}m/s, Co ; 0.45mol/m^3)

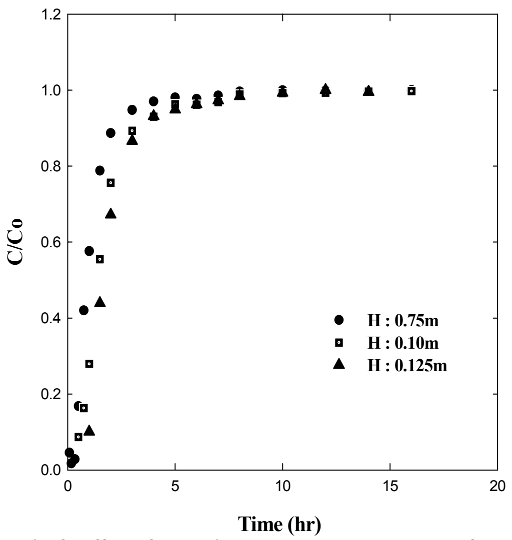

Fig. 3. Effect of bed height on breakthrough curves for TCA onto GAC. (298K, 0.54 mol/m^3, pH_i 3.5)

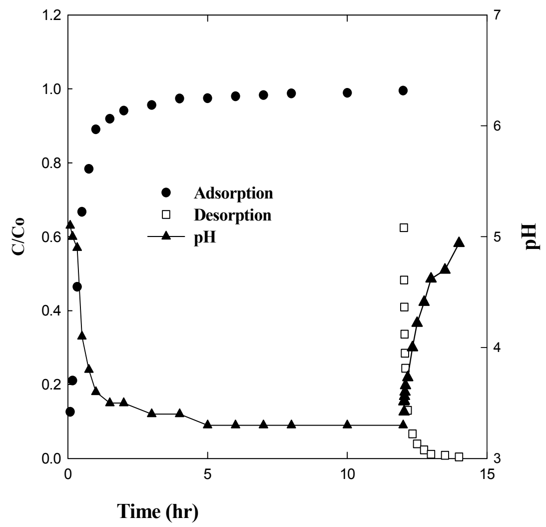

Fig. 4. pH variarion during adsorption and desorption process for TCA (25°C, Co ; 0.45mol, V ; 1.02x10^{-2}m/s, pH_i ; 3.5, L ; 0.1m)