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Activated Carbon Adsorption Isotherms: The Effect of Volatile Organic Contaminant Size and Shape

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Introduction:

The adsorption capacity of activated carbon for volatile organic contaminants is known to be dictated by the physical and chemical properties of the adsorbent and the contaminant. Previous studies have revealed the strong relationships between an activated carbon's capacity at a specified contaminant concentration and: 1) its surface area;[1,2] 2) the chemistry of both the activated carbon surface and the contaminant.[3-5] Herein we evaluate two organic contaminants that differ slightly in their size, shape, and chemistry; the primary objective being to study how these factors influence the adsorption capacity of a typical activated carbon. Two prototypical organic contaminants, toluene and 2,2,4-trimethylpentane (TMP), were chosen since they are typically used to model chemical filter performance, such as those used to protect microelectronic devices, hard disk drives, fuel cells, and many manufacturing processes and environments.

Experimental:

Single component adsorption isotherms of toluene and TMP were determined at ambient in nitrogen over the concentration range of 5-100 ppmv using gravimetric methods. The test setup is described in references 4 and 5. Carbon C (see our previous reports)[4,5] is used and has a total BET surface area of 1530 m^2/gr, a micropore area of 984 m^2/gr., and a total pore volume of 0.704 ml/gr.

Table 1 gives some of the physical and chemical properties for toluene and TMP.

Table 1: Contaminant Properties.

	MW [a]	BPt. [b]	MSA [c]	μ [d]
Toluene	92.1	113.3	83.8	0.36
TMP	114.2	105.8	106.0	0.00

a) molecular weight (gr/mole); b) boiling point (°C); c) molecular surface area ($Å^2$); d) dipole moment (Debye).

Results and Discussion:

The adsorption isotherm results in Figure 2 are given on a weight percent basis. We note that on a mole basis the observed difference in adsorption capacity is slightly amplified. We also note that the data at 5 ppm TMP is estimated.

Based on the properties given in Table 1, toluene is smaller and less volatile than TMP. Toluene also has a dipole moment, which allows it to interact with polar sites on the activated carbon surface. Since TMP is essentially nonpolar, it cannot directly interact with these sites to any significant extent. These contaminant property differences all contribute to the increased capacity of toluene on Carbon C relative to TMP.

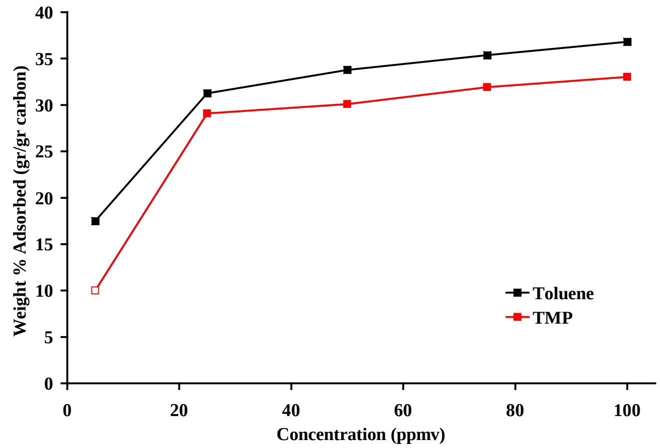

Figure 2: Adsorption isotherms of toluene and TMP at ambient.

Although, toluene and TMP have similar cross sectional areas in the plane of toluene's aromatic ring, TMP has a significantly larger cross sectional area when considering the area perpendicular to toluene's aromatic ring. This area becomes important when considering the ability of an organic molecule to enter pores of different shapes and sizes.[6]

Summary:

Through the use of adsorption isotherms measured at low concentrations it has been shown that the activated carbon evaluated here, adsorbs more toluene than 2,2,4-trimethylpentane and has been interpreted based on the size, shape and chemistry of the two organic contaminants. These results suggest that both toluene and 2,2,4-trimethylpentane are adequate models for evaluating the adsorption capacity of activated carbons; however, they cannot be directly substituted for one another since they probe slightly different properties of the activated carbon's physical and chemical structure.

References:

1. K. L. Foster, et al.; Chem. of Materials, 1992, 4, 1068-1073.
2. C. L. Mangun, et al.; Carbon, 1997, 36, 123-131.
3. T. J. Bandosz, et al.; Langmuir, 1996, 12, 6480-6486 .
4. A. J. Dallas, et al.; Donaldson Company, Inc., Chemical Filtration Technical Note: CFTN-1-DD, 2003.
5. A. J. Dallas, et al., Donaldson Company, Inc., Chemical Filtration Technical Paper: CFTP-1, 2004.
6. F. Rouquerol, J. Rouquerol, and K. Sing, *Adsorption by Powders and Porous Solids*, Academic Press, 1999.

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