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Measurement of Diffusivities of Helium and Argon in Silicalite by Static Single Crystal Membrane Technique

Elie Chalhoub and D.B. Shah
Department of Chemical & Biomedical Engineering
Cleveland State University
2121 Euclid Avenue
Cleveland, Ohio 44115 USA

1. Introduction

Measurement of diffusivities of light and inert gases such as argon and helium with most macroscopic methods is difficult if not impossible because these gases are adsorbed only to a small extent. For helium, for example, the gravimetric method cannot be used because increase in the weight of the sample due to helium adsorption would be too small to measure accurately. Chromatographic method actually uses helium as an inert carrier to measure adsorption and diffusion of hydrocarbons. In this work, we have used Static Single Crystal Membrane (SSCM) [1,2] to measure diffusivities of helium and argon as a function of adsorbed phase concentration and temperature.

2. Experimental

An integral membrane containing a large single crystal of silicalite (100x100x300 μm) was placed in a diffusion cell and was subjected to different pressures of argon and helium on the inlet side. The linear increase in pressure of the adsorbate on the outlet side is related to both adsorption equilibrium constant and the adsorbed phase diffusivity. The phase equilibrium data for adsorption of helium and argon on silicalite were taken from recent measurements [3].

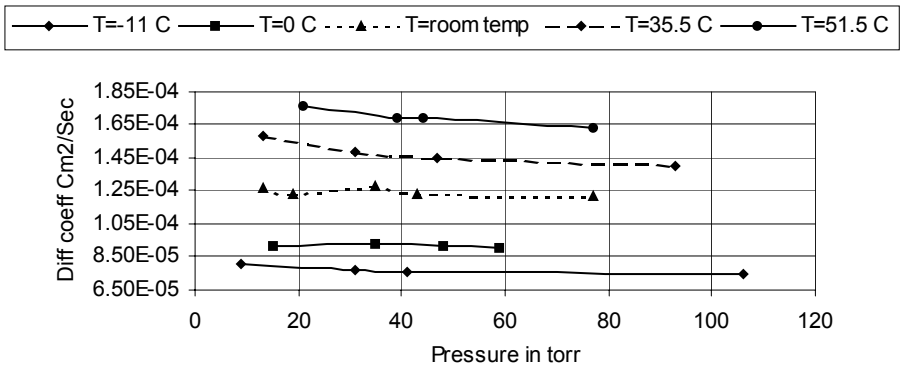

Figure 1. Argon diffusivities at different temperatures as a function of pressure

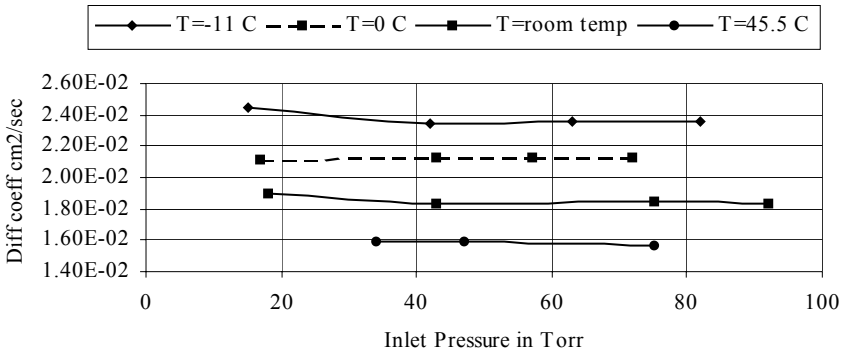

Figure 2. Helium diffusivities at different temperatures as a function of pressure

3. Results and Discussion

The calculated argon and helium diffusivities are shown in Figures 1 and 2 as a function of concentration and temperature. Argon and helium diffusivities were of the order of 10^{-4} and 10^{-2} cm^2/s (Figures 1 and 2). The energy of activation for argon diffusion was calculated to be 2.17 kcal/mol. However, the helium diffusivity data show abnormal results (adsorbed phase diffusivities increasing with decreasing temperatures).

4. Conclusion

The results indicate that either 1) there is a need to develop a different model for data analysis for helium or 2) more accurate helium adsorption isotherm measurements are needed.

5. References

[1] D.B. Shah and H.-Y. Liou, Zeolites, 14 (1994) 541-548.

[2] D.B. Shah, S. Chokchai-acha and D.T. Hayhurst, J. Chem. Soc. Faraday Trans., 89(16) (1993) 3161-3167.

[3] S. Gumma, D. Eng. Thesis, Department of Chemical and Biomedical Engineering, Cleveland State University, 2004.