CHAPTER 1

INTRODUCTION

Adsorption processes are chemical unit operations used to separate liquids from liquids , solids from liquids , as well as to separate gases from gas mixtures.

Adsorption has received widespread attention in the past several years for bulk separation of gases especially with the use of pressure swing adsorption (PSA). One advantage cited generally is the low energy requirement of such operations , one disadvantage cited is that absolute gas purity is difficult to obtain with a PSA system. However for some separations high purity can be obtained , for example PSA can be used to purify hydrogen to 99.999 percent [1].

In a pressure swing adsorption system two or more columns are normally utilized. In one column adsorption may be taking place at one pressure , and in parallel in another column desorption may be taking place at a lower pressure.

Thermal swing adsorption is an adsorption unit operation that uses heat to regenerate the adsorbent. Thus thermal swing adsorption separates gases by a change of temperature in the column instead of a change in pressure. The guiding phenomena is that at low temperatures adsorbents can adsorb more gas than at higher temperatures.

Adsorption techniques use properties of porous solids that preferentially adsorb gases onto their internal surface. Thus , a gas molecule (A) will be selectively adsorbed at the internal surface of an adsorbent over a gas molecule (B) which is less adsorbed and which will pass through the adsorption column with more release as shown in fig. 1.1.

The widespread applications of gas separation by adsorption has created a need for predicting performances of adsorption equipment. The design of fixed-bed adsorbers involves the prediction of the concentration-time relationships , or breakthrough curves of the effluent stream. Quantitative treatment of adsorption equipment requires values of the diffusion and adsorption rate constants that describe the adsorption mechanism.

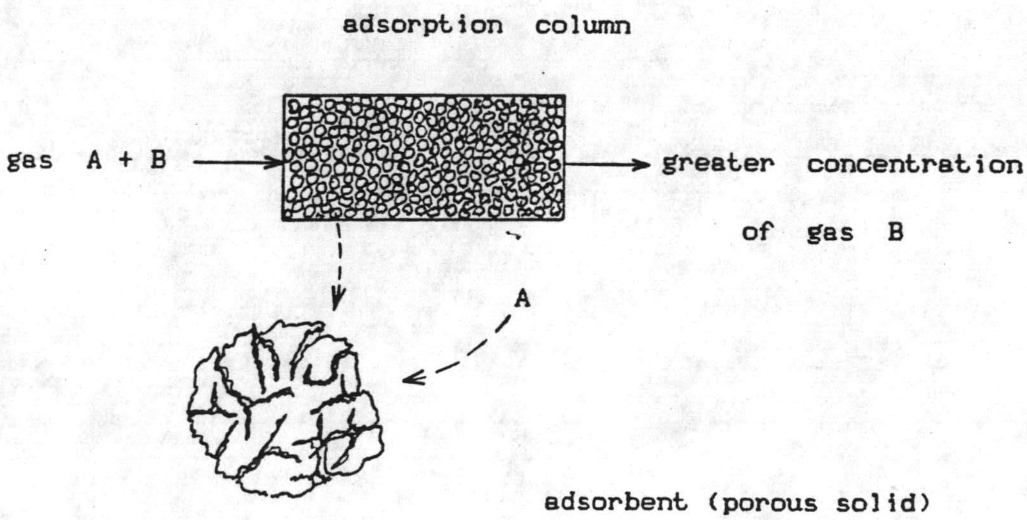


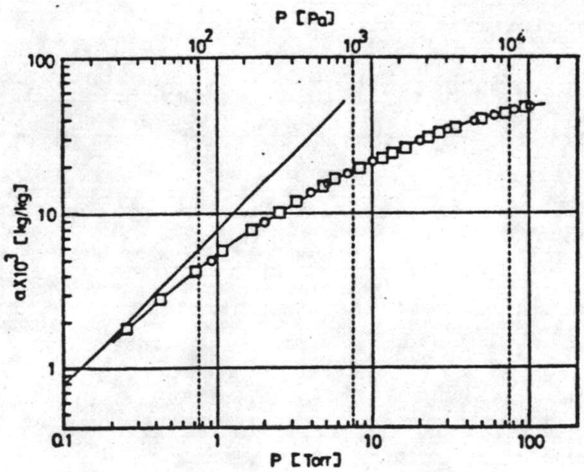
Fig. 1.1 Adsorption column where gas A is preferentially adsorbed on internal surface of adsorbent.

1.1 Previous studies of carbondioxide , methane , and propane adsorption onto MSC-5A.

- The adsorption isotherms for single gas components.

Single component adsorption isotherms for carbondioxide , methane , and propane on MSC-5A were measured by Kawazoe and Kawai [2] using a gravimetric method (static method) for pressure up to 10 kg/cm^2.

Suzuki and Sakoda [3] used a chromatographic method to measure the adsorption isotherms of ethane and compared their results to those measured by gravimetric methods as shown in figure 1.2. The results obtained by chromatographic methods show very good consistency with the data obtained by gravimetric methods.



□: this work
O: gravimetric method by using electrobalance
–: Henry's relation based on equilibrium constant from estimated chromatographic method[1)]

Figure 1.2 Comparison between isotherms for ethane on MSC -5A at 19 ° C. (Suzuki and Sakoda [3])

- The adsorption isotherms for mixtures.

Konno , Shibata and Saito [4] measured adsorption isotherms for mixtures of methane and ethane by a volumetric method (static method). The adsorption isotherm thereby obtained is shown in figure 1.3

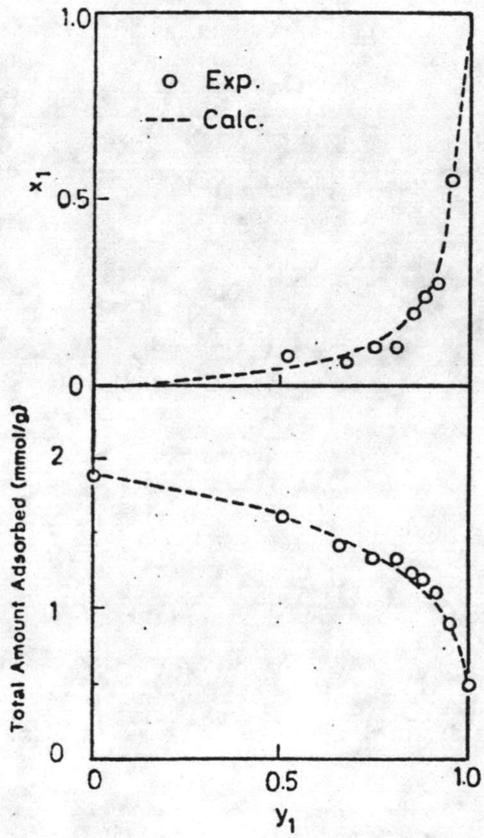


Figure 1.3 Adsorption isotherm of mixture of CH_4 and C_2H_6 [4].

The adsorption isotherm for mixtures of carbondioxide and methane was measured by Carrubba et al.[1] Figure 1.4

shows the uptake rates of CO_2 and CH_4 in MSC -5A.

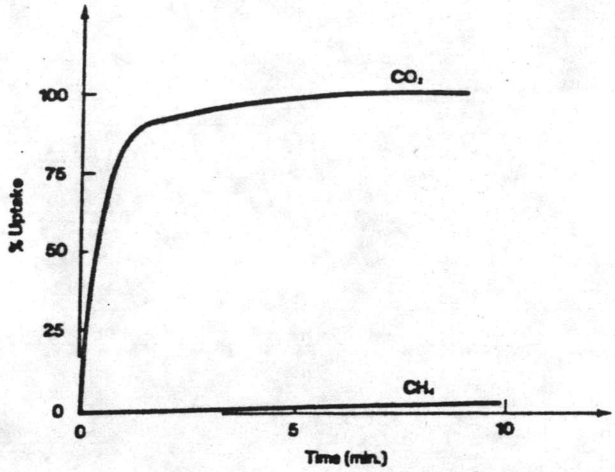


Figure 1.4 The uptake rates of CO_2 and CH_4 in MSC-5A [1].

- The adsorption rate constants.

No information about adsorption rate constants of carbondioxide , methane , and propane onto MSC -5A have been found in the literature. However the adsorption rate constant for propane onto silica gel was measured by Schneider and Smith.[5] They used a moments analysis to find adsorption rate constants from chromatographic curves of square functions of propane passing through an adsorption column. The measured adsorption rate constant for propane on silica gel was found to be about 255 ml/g.sec.

1.2 The objectives of this work

1. To measure adsorption isotherms of methane , propane , carbondioxide and their mixtures on molecular sieve carbon-5A

at low concentrations of hydrocarbons.

2. Determination of adsorption rate constants of methane,propane, and carbondioxide on molecular sieve carbon-5A.

1.3 The scope of this work

1. To measure single gas adsorption isotherms for methane , propane , and carbondioxide on molecular sieve carbon-5A at low concentrations of hydrocarbons.

2. To measure adsorption isotherms of gas mixture of methane and carbondioxide and mixture of propane carbondioxide on molecular sieve carbon -5A at low concentrations of methane and propane.

3. To determine adsorption rate constants for methane , propane , and carbondioxide on molecular sieve carbon - 5A.