



ABSTRACT

Aromatic compounds are harmful pollutants in the environment, that are carcinogenic, hence the removal of this compound from air or from the gas to be utilized by humans, such as in the LPG is of high environmental interest. To reduce the aromatic from gas, adsorption is an alternative method particularly when low gaseous phase pollutant concentrations are involved. Due to high surface area and broad pore distribution, activated carbon is suitable to adsorb aromatic vapor. Adsorption is generally on either a fixed bed or a fluidized bed of activated carbon. Fixed bed adsorption is common in industry. Both equilibrium and kinetic data are crucial for further adsorption process design. Designing fixed bed adsorption, equilibrium parameters and both external and internal mass transfer parameters are needed. Therefore both external and internal particle mass transfers are studied in this research to explain quantitatively aromatic vapor adsorption both pure and binary mixture vapor by activated carbon.

This research consists of three stages, the first stage is the study of equilibrium, the second stage is the study of simultaneously external and internal mass transfer, and the third stage is the study of the internal particle scale mass transfer. Three types of activated carbon (Ajax, GAC and the local activated carbon) were characterized by using Quantachrome Nova BET surface area. Further study conducted was equilibrium with Batch and fixed bed systems. Then the experiment using fixed bed system was carried out to study the simultaneous external and internal mass transfers, to find out the influence of internal mass transfer in adsorption process of aromatic vapor on activated carbon. Finally, the internal mass transfer is studied in-depth with the Differential Permeation Technique system.

Characterization of materials showed the BET surface area for Ajax, GAC and the local activated carbon are 1118, 757 and 226 m² /g respectively. Equilibrium data for the three activated carbons either in batch or fixed bed system, showing the same trend. Adsorption capacity data of fixed beds showed values 20 % larger than the capacity of batch data. With increasing temperature the activated carbon capacity is decreasing. The amount of heat adsorption is 2440 J / mole or 0.58 kcal / mole so that the adsorption is physical adsorption which generally has a heat of adsorption value of 0.5 to 5 kcal / mole. The simultaneous external and internal mass transfers in Benzene vapor adsorption by activated carbon bed shows the Biot numbers ranging from 3-15, so that the internal mass transfer controls the process. Therefore, further studies focused on the particle scale internal mass transfer.

Because the kinetics of adsorption is affected by many factors and mechanisms, this research tried to perform specific studies on the factors and mechanisms, and then describe the overall adsorption kinetics. Modeling of particle kinetics adsorption showed the isothermal model fits the adsorption process with a small different pressure, and for large different pressure, non-



isothermal model is more suitable. At low pressure, heterogeneous model is better than the homogeneous model, but at high pressures both models can simulate the benzene adsorption on activated carbon surfaces equally well.

Solid adsorbent porosity decreases with increasing concentration in adsorbate solid pores. Theoretical porosity based on calculations assuming that the benzene adsorbed in the pores as a liquid, has the same tendency to porosity value of curve fitting results.

Surface diffusivity is a function of surface concentration for benzene vapor adsorption on the surface of activated carbon, surface diffusivity at different concentrations on the surface of solids does not follow the model of Darken. Darken model can be applied at sub mono layer, at low coverage, when high interaction between the adsorbed phase and the solid surface. This experiment had very high range coverage, up to 8300 mole/m³, at high coverage, the adsorbate occupied the lower energy level, therefore the interaction between the adsorbed phase and the solid surface was not strong. Based on the hydrodynamic model of Gilliland which regards the adsorbed gas phase as a laminar flowing film of viscous liquid, at higher loading, the adsorbed gas phase follows Gilliland model. The model is consistent with the porosity model indicates that the adsorbate is adsorbed in liquid form. Surface diffusivity is increasing with temperature with activation energy of $E = 44.7 \text{ kJ / mole}$.

Binary mixture of propane-benzene adsorption at low pressure, all the three model developed fit the experimental data quite well, at low pressure, each molecule can move freely without being influenced by other molecules, so that using all three models did not differ significantly. Whereas at high pressure, there is influence of other molecules, so that the diffusion model of Maxwell - Stefan which takes into account the influence of other molecules and IAST equilibrium model fit the experimental data better than other models. Binary adsorption can be modeled by using single component adsorption data with some corrections, especially at the surface diffusivity parameters and equilibrium parameters.

This research develop a number of mathematical models and evaluate the value of parameters which are expected to quantitatively describe the process of particle scale internal mass transfer and useful for designing industrial-scale adsorber.

Keywords : Adsorption, Aromatic vapor, Activated Carbon, Kinetic, Internal mass transfer, Fixed bed, Differential Permeation Technique