Chapter 1

Introduction

Volatile organic compounds (VOCs) are widely used in many industrial processes,such as surface coating, spray painting and textile finishing [1]. Those solvent vapors especially, toluene, xylene, alcohol, ketone, are highly poisonous, flammable and bad-smelling.

One of the most effective method of controlling emission of VOCs is the adsorption on an appropiate adsorbent and processing conditions [2]. General adsorbents, such as silica gel, activated alumina, zeolites and activated carbons, are always used in separation processes. They are extremely porous solids providing large internal surface areas which is are perferable to large adsorption capacity.

Several types of adsorbents have been used to adsorb VOCs from gas phase. Activated alumina and silica gel are common adsorbents for dehydration of gas or liquid steams. However, they can be used to adsorb hydrocarbon compounds, such as benzene and cyclohexane [3].

Other well-known inorganic adsorbents are zeolite molecular sieve, which are micropores crystalline aluminosilicates of alkali metals, such as sodium, or alkaline earth metals, such as calcuim. The surface characteristics depend upon the Si/Al ratio, i.e. the degree of polarity decreases with an increase in the Si/Al ratio, Therefore, the molecular sieves with high Si/Al ratio, namely silicalites, are used for separation of non-polar hydrocarbons, such as benzene and toluene, with adsorption [4].

Activated carbon are another types of adsorbents for adsorption of non-polar hydrocarbon compounds, especially, for removals of coloured compounds, or ordorous compounds. Some types of activated carbons are also used commonly for dechlorination of process water or drinking water. This demonstrates that activated carbons can be used to removal some polar compounds. For environmental pollution aspects, activated carbons are widely used for removals of hazadous organic compounds, such as benzene, toluene and xylenes, phenotic and hylogenated organic compounds [5].

For adsorption of volatile orgainic compounds (VOCs), the activated carbons have been used widely for both liquid and gas phases. The first industrial application of adsorptive carbons made use of its behavior in liquid systems rather than its gas adsorption [6]. The application of activated carbon for adsorption volatile organic compounds from aqueous solution has been used for diverse process water treatment applications, such as dechlorination of disinfected water supplied prior to uses, removals of trace organic contaminants for protection of resin beds, treatment of steam condensate for recycle and recovery the volatile organic compounds from industrial processes, such as coating, painting and polymer processing.

Dimitrios [7] determined the both equilibrium and batch rate adsorption and desorption. Edward J. Simpson [8] developed isotherm mearsurement technique of benzene, toluene, chlorobenzene, p-xylene, carbon tetrachloride, chloroform and compared the sorption capacity of polymer sorbents with activated carbon for various aromatics. Jame J. Spivey [1] studied the recovery of volatile organic from small industrial sources by using three generic technologies ; adsorption, absorption and condensation. The systems were usually practical for small flow rate of volatile organic compound containing gas and low volatile orgainic compound concentration. Since indoor air environment is a multicomponent system consisting of many volatile organic compounds (VOCs) and water vapor, Mark P.Cal [9] examined the effect of humid air on the adsorption capacity of soluble(acetone) and insoluble (benzene) for a activated carbon cloth. The results was reported that the presence of water vapor along with acetone had little effect on the adsorption capacity but water vapor was more inhibitory for benzene adsorption as decreasing benzene concentration in the gas stream. Mario Okazaki [10] also studeid the influence of humidity on adsorption equilibria of organic solvent vapors. When humidity was high, capillary condensation of water take place, the adsorption of solvents was hindered. The predicted results were compared with experimental results for two kinds of activated carbons for water-soluble solvents (methanol and acetone) and water-insoluble solvents (benzene and toluene).

For vapor or gas phase applications, the activated carbons were also the most universal adsorbents for purifying breathing air by adsorbing organic vapors. The very low concentrations in exhuast air have been expensive to treat but it is of interest becuase of the carcinogenic of serveral vapors and the long exposure times that humans have to be in the indoor air environment [11]. Purification of the air instead of ventilation it will also decrease the emission to the environment. The adsorption by activated carbon increases the concentration to a level at which it is feasible to clean up. Gerry Ordell Wood [12] estimated the adsorption capacities of organic vapors on the activated carbons which are often the major determinants of service life.

To design an adsorber, one needs to know the adsorption equilibrium behavior and dynamic of adsorption. Although many studied have been conducted on gas adsorption on activated carbons, few have been performed in the very low concentrations region. Ji-Wei Yu [13] investigated adsorption equilibria of organic components, toluene, ketone, and methylcyclohexane, in the air by an activated carbon at concentration around a few parts per million (ppm) and predict multicomponent adsorption equilibria from single component isotherms by a number of methods.

Mark P.Cal [14] characterized experimentally and numerically the equilibrium adsorption capacities of an activated carbon fiber for gas steams containing acetone and benzene. The adsorption isotherms described how adsorbate would interact with the activated carbon fiber and were critical in optimizing the use of the activated carbon fiber as an adsorbent for removal of volatile organic compounds commonly found in indoor air. The observation indicated that the mean pore size, BET surface area and pore volume of the activated carbon fiber were important when characterizing the adsorption capacities.

Massimo Sacchetti [15] proposed a process for removing and recovering volatile organic substances from industrial waste gases by adsorption onto activated carbons and desorption by hot inert gas circulating in a closed cycle, carried out continuously or intermittenly. For this process, the volatile organic substances were recovered from the inert desorption gas partially by condensation by mean of cooling and partially by readsorption onto solid adsorbents.

Chin-Hsiung Chang [16] studied the removal of organic compounds such as acetone, chlorobenzene, toluene, para-xylene and nitrobenzene from gas streams by contacting with a bed of adsorbents comprising carbon molecular sieves. The carbon molecular sieves characterized by their method of manufactures could be used to remove a wide variety of organic chemicals from vapor streams. The adsorbed chemicals might be acetone, chlorobenzene, toluene, para-xylene and nitrobenzene.

Timothy C.Golden [17] studied adsorption equilibrium and kinetics for trace impurities such as acetone, toluene, propylene, Freon-12, Freon-22, n-butane, methylene chloride and n-hexane from various carrier gases. Activated carbons at serveral temperatures and pressure were used as the adsorbents. Two emperical characteristic curves were generated. The first one was the relationship between equilibrium isotherms of trace impurities and their physical properites and the other was the relationship between the mass transfer coefficients and equilibrium properties. These could be used to predict equilibrium capacites and mass transfer zone lengths from multiple trace impurities and design a thermal swing adsorption system.

Many reasearcher such as Schneider and Smith [18] [19], Carleton [20], Kunitoro Kawazoe [21] and Hufton and Danner [22] investigated adsorption equilibrium constant and rate of adsorption with chromatographic technique by method of moment.

The propose of this work is to determined adsorption equilibrium constant, heats of adsorption and the mass transfer coefficient for adsorption of some dilute volatile organic compounds in helium on various commercial activated carbon by gas chromatographic technique.