

CHAPTER III

LITERATURE REVIEW

Activated carbons have been produced world-wide for a long time as mentioned in Chapter I. Originally, they were prepared in the laboratory scale using fixed-bed technique. The properties of the activated carbons are characterized by the adsorption of various molecules in liquid; such as iodine adsorption, molasses adsorption, methylene-blue adsorption, and carbontetrachloride adsorption. Then the production was developed to the large scale.

In Thailand, researches of activated carbons have just begun in 1974 by Department of Science Service and Thailand Institute of Scientific and Technological Research. Some of researches are reviewed henceforth.

Girgis, Khalil, and Tawfik (1984) prepared the activated carbon from dried ground sugarcane bagasse impregnated with 50% inorganic acids and carbonized at 500°C, showed the sequence of $\text{H}_3\text{PO}_4 > \text{H}_2\text{SO}_4 > \text{HCl} > \text{HNO}_3$, with respect to the efficiency of activation. Sugarcane bagasse was treated with phosphoric acid of various concentrations (30–50%) and was carbonized at 300–500°C for 3 hours. Pore structure parameters were determined from the low-temperature adsorption of nitrogen, by applying the BET and α_s methods. Activated carbons obtained at low

temperatures are essentially microporous with a low degree of mesoporosity. At higher temperatures, products of higher surface area and total pore volume with developed mesoporosity and low microporosity are formed. An increase in the period of carbonization leads to a small decrease in both surface area and pore volumes. Activated carbons with surface areas higher than 1,000 m²/g and mean pore dimension around 2.0 nm, suitable for various purposes, are thus obtained.

Production of activated carbon was achieved by leaching silica in rice husk char using caustic soda solution (NaOH) of different concentrations. It has been observed that 90% reduction in ash content was obtained by using 10%–15% caustic solutions. The process yielded low ash, soft, and activated carbon. The activity of the carbon has been determined against iodine, acetic acid, and methylene blue. It has been found that the product activity against low molecular weight substances is considerably upgraded as compared with the char. It has been suggested that this property can be utilized for gas and vapour adsorption from air and in upgrading the quality of water containing low molecular-weight organic impurities [Ali Beg and Usmani, 1985].

Nguyen, Ahmadpour, and Do (1995) prepared activated carbon from nut shells using a conventional two-stage method: carbonization followed by activation. Activation with steam or carbon dioxide as activating agent produced a range of chars of different burn off. These were characterized for their total and micropore surface areas, and benzene adsorption capacity. Benzene adsorption measurement provided an insight into the effect of porosity development on the adsorptive properties of the adsorbent. It was found that activated carbon products from nut shells were

comparable, in terms of adsorption characteristics, with activated carbons from other lignocellulosic precursors. The evolution of porosity of resulting carbons shows that carbon dioxide is the preferable agent for the production of activated carbon with a narrow micropore size distribution.

Four binders (coal tar, sugarcane molasse, sugar beet molasse, and corn syrup) were mixed with three agricultural by-products (rice hulls, rice straw, and sugarcane bagasse) in different combinations and these mixtures transformed into granular activated carbons (GACs). GACs were evaluated for the physical properties of burn-off/yield, surface area, bulk density, and hardness together with the chemical properties of pH and ash. These properties, except for burn-off/yield, were compared to the same properties of two commercial reference carbons made from bituminous coal with coaltar binder. The results showed that GACs made with corn syrup as binder exhibited surface areas, bulk densities, hardness, pH, and ash values closed to the reference carbons [Pendyal, et. al., 1999].

Bernado, Egashira, and Kawasaki (1997) studied the removal of the brown color of the sugar industry's wastewater using activated carbon from sugarcane bagasse. Sugarcane bagasse obtained from countries such as Japan, the Philippines, Thailand, and Brazil were used in this work. Activated carbons were prepared by carbonizing with nitrogen gas at 300°C for an hour and activating with steam at 800°C for 1 and 1.5 hours. Adsorption equilibrium experiments were done to obtain the adsorptive capacities of the activated carbons using melanoidin solution. Comparison of surface areas obtained by the BET Single Point Method and the Cranston-Inkley (CI) method was done. Regeneration of activated carbons from Japanese and Philippine bagasse

was also performed. The results of this study showed that activated carbon from Japanese bagasse has the highest adsorptive capacity. The surface areas obtained showed values comparable to those of commercial activated carbons.

Pattamasuda, Chanika, and Wanwisa (1997) prepared activated carbon from palm shell in a continuous mode. Before introducing palm shell into the carbonization process, it was treated by grinding and impregnating in a saturated ammonium chloride solution at 25°C overnight to reduce tar by-products. There were two studied variables such as temperature and duration of pyrolysis. The results showed that temperature increased with the percentage of carbon-content product. The period of time during pyrolysis increased with the capacity of adsorption. Moreover, pyrolysis temperature dominantly influenced with the quantity of surface area.

A comparative study was conducted on the adsorption/desorption of organic vapors (toluene and para-xylene) on a synthetic resin (XAD4) and activated carbon using a gravimetric method involving the use of a quartz spring expansion. It was observed that activated carbon adsorbed more organic vapor than the synthetic resin did at low concentrations; but at higher industrial level concentrations, the resin adsorbed more organic vapor. The rate of adsorption was higher than that of desorption for the two organic vapors regardless of the sorbent [Noll, et. al., 1985].

Khalil and Girgis (1995) studied the effects of temperature on the adsorption of p-nitrophenol (PNP) from aqueous solution which has been determined at various initial phenol concentrations. Eight activated carbons were tested, being laboratory-prepared from apricot stone shells impregnated with H_3PO_4 and carbonized at 300–500°C. The adsorption capacity increased as a function of the percentage of activating

acid added as well as the temperature of carbonization. The PNP surface area evaluated were generally lower than the nitrogen BET surface areas due to restricted adsorption inside certain pores.

The adsorption isotherms of benzene and methylbenzene vapors on activated carbon were obtained by a static volumetric apparatus. The measurement were done at 30, 40, 50, 60, and 70°C and pressure up to 7 kPa for benzene and 2 kPa for methylbenzene, respectively. The experimental data obtained were correlated by the UNILAN equation, which is generally used for heterogeneous adsorbents such as activated carbon [Yun and Choi, 1997].

The pore size distribution of activated carbon prepared from coconut shell employing different activation methods was investigated. “Physical” activation with pure CO₂ at 800°C resulted in a bimodal pore size distribution featuring both the widest macropores and the narrowest micropores among the sample studied. The introduction of potassium phosphate as a catalyst for the gasification with CO₂ led to a decrease in macropore volume and diameter, and to a slight increase in micropore diameter. Wider micropore and significant mesoporosity resulted when employing “chemical” activation with phosphoric acid at lower temperature (500°C). Surface area was found to increase with increasing median micropore diameter between about 7–15 Å [Laine and Yunes, 1992].

Paolo davini (1990) studied the adsorption and desorption of SO₂ on active carbon in relation to the surface characteristics of the carbons. Surface basic groups (with pyronic or pyronic-like structure) greatly increase the adsorption of SO₂, that can be divided into two forms, one weakly and the other strongly bonded to the carbon.

The surface area of the carbon and the temperature of the process were the fundamental parameters of the desorption process of SO₂.

Chromatographic techniques were used for measuring the adsorption of toluene and naphthalene on silica gel packed beds under the super critical and subcritical conditions at 301–308 K, 54–150 atm, and $0.3 < Re < 7$. The moment method was used to determine the equilibrium constants and rate parameters. The results showed a significant reduction of adsorption equilibrium constant as the pressure changed from subcritical to supercritical; the axial dispersion coefficients at supercritical conditions were intermediate to those of what would be obtained in gases and liquids [Lee, Byeon, and Holder, 1996].

Gas adsorption on solid zeolitic adsorbents is the basis of many gas separation processes. The accurate design of these units requires gas-solid diffusion and equilibrium data over a wide range of temperature and pressure. Perturbation chromatography has been proven to be a very convenient experimental technique that can be used for the determination of these parameters. Although various types of perturbations could be used, the laboratory has found that the tracer pulse technique, in which a pulse of radioactive adsorbate was injected into the chromatographic system, resulted in a simpler and more straight forward analysis procedure [Hufton and Danner, 1991].