

Development of activated carbons from waste biomass for CO₂ capture

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With its wide range of properties activated carbon has a wide range of applications, mostly as a purifying agent to remove trace quantities of undesirable species from gas or liquid phase, also as an economical media to recover materials[1-3]. Some of the common applications are listed as follows: food industry, pharmaceutical industry, water purification, gas or air treatment, chemicals, oil refinery processing . Special applications of activated carbon are found in agriculture, as catalyst and catalyst support in chemical industry, for precious metal recovery and making batteries and military clothing, and in nuclear power stations [4-6].

Because of worldwide increasing environmental problems and stricter regulations set by governments in both industrialized and developing countries, the demand for activated carbon will continue to increase[7,8]. Commercial production of activated carbon employs high temperatures of above 800°C [6], using steam or carbon dioxide as an activating agent from coal and limited amount of biomass by thermal activation process[9-11]. On the other hand, yield of activated carbon from biomass is low, e.g., 5 - 10 % from agricultural residue[12]. Consequently, activated carbon produced by conventional method is expensive. The retail price of activated carbon ranges from \$2 - \$6 per kg depending on the type. Accordingly, in this paper, a novel thermal process of producing high-yield activated carbons from waste biomass is presented. Rape seed oil cakes and walnut shells as agricultural by-products are employed as raw material in this process. It used a mixture consisting of 50% rape seed oil cakes and 50% walnut shells.

Rape seed oil cakes were in extrudates form and raw walnut shells were in hemispherical shape with about 25 mm diameter and 3 mm thickness that were grinding at a size of about 3-5 mm. Raw materials, both rape seed oil cakes and walnut shells undergo a series of pretreatments and posttreatments before forming the final products - activated carbons. Pretreatments included pyrolysis in a laboratory reactor, in which high yield carbons were obtained, and then followed by high temperature carbonization process at atmospheric pressure with nitrogen surroundings. The activated carbons were obtained by activation with oxidative vapour. Activated carbons were investigated to determine their adsorption properties (adsorption capacity, adsorption/desorption rate, and adsorption selectivity) and porosity(specific surface area, pore volume, and pore size distribution), as well as the effects of activation temperature and processing time. The increase in activation time resulted in a continuous steady rise of the mesopore area and volume, while the micropores and total pore area and volume reach a maximum at 3 h. The surface areas go through a maximum with increasing solid yields. The activated carbons were investigated regarding with CO₂ adsorption capacities. The CO₂ capture results did not show a linear relationship with the surface area. The sample with highest CO₂ adsorption capacity (64.5mg CO₂/g-adsorbent) was the carbon activated at 700°C for 2 h., whose surface area was only

620m²/g. Similarly, the carbon presenting the highest surface area (1080m²/g, 750°C for 3h) has a CO₂ capacity of only 42 mg CO₂/g-adsorbent. This is probably due to a relationship between microporosity and CO₂ physisorption processes, only certain size pores being effective for CO₂ adsorption.

Several surface treatment methods, including ammonium (NH₃) heat treatment and aqueous monoethanolamine (MEA) impregnation, were used to modify the surface properties of the activated carbons in an attempt to increase their CO₂ capture capacity at higher temperatures. The influence of temperature and type of chemical reagents on the porosity development was investigated and discussed. The surface treatment methods investigated change the porous structure and surface chemistry of carbon, and therefore affect their CO₂ capacities. NH₃ was found more effective than (MEA) as a chemical reagent under identical conditions in terms of both porosity development and yields of the activated carbons. The NH₃ treatment increases the surface area of the activated samples, especially at lower temperatures (600°C). The chemical impregnation with aqueous monoethanolamine (MEA) results in a decrease of the surface area of the activated carbon, probably due to pore blockage and surface coverage by (MEA). Both the NH₃ treatment and aqueous monoethanolamine impregnation can increase the CO₂ capture capacity of the activated carbons at higher adsorption temperature, due to the introduction of alkaline nitrogen groups on the surface of carbons, that are selectively to CO₂ adsorption.

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