

I INTRODUCTION

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I.1 Background

Activated carbons are sponge-like substances having highly and complex porous structure that can collect and retain certain chemical compounds on its surface in which the process is called adsorption. Therefore it has extremely high surface area for adsorption [1].

Activated carbons are widely used for adsorption of pollutants from gaseous and liquid phases. They have many functions in many economic and industrial sectors, such as food and beverage processing, chemical, pharmaceutical, petroleum, mining, nuclear, automobile, and vacuum manufacturing. Some of these applications are very demanding with regard to the surface chemistry and characteristics of these carbon adsorbents [2].

Activated carbons with high surface area and pore volumes can be produced from a variety of carbonaceous source materials such as coal [3] and wood [4-5]. Coal is including non-renewable resources and wood is also not suitable alternative because of its high value and applications in other areas. So, nowadays people make activated carbon from agricultural and industrial waste such as cassava peel [1], coconut shell [6-10], oil palm trunks [6], palm shell, palm stone [8], coconut coirpith [11], ears of palm tree, natural compost, molasses [12], hazelnut shell, plum stone, pistachio-nut shells [13], almond shell [14], macadamia nutshell [15], walnut shell [16], peanut hull [17], corn cob [18-20], apricot stone [21], softwood bark residues, olive stone [22], peach stone [23],

cherry stone, date pits [24], grape seeds [25], grain sorghum [26], apple pulp [27], teak sawdust [28], rubber wood sawdust [29], coffee bean husks [30], cotton stalks [31], rice husks [32], sugar cane bagasse [33], *Arundo donax* cane [34], cork waste [35], waste newspaper [36], petroleum wastes [37], used tire [38], eucalyptus leaves [39], heavy-oil fly ashes [40], bamboo scaffolding waste [41], surplus sewage sludge [42], pecan shells, rice straw and hulls [43], and flax shive [44]. Among the precursor mentioned above, in industrial practice, coal and coconut shell are two main sources for the production of activated carbon [1, 6].

The pore structure and control of pore size distribution in activated carbon depends upon the nature of the raw materials and the method of activation. The process for manufacturing activated carbons generally carried out in two main steps: the carbonization of the carbonaceous raw materials below 1073 K in an inert atmosphere and the activation of the resulting char in the presence of suitable oxidizing agents. In carbonization, most of the non-carbon elements like hydrogen and oxygen are first removed in gaseous form by pyrolytic decomposition producing a fixed carbon mass with a rudimentary pore structure. And the purpose of activation is to enlarge the diameters of the fine pores and create new pores so that it enhances the adsorptive power of the product obtained from the carbonization stage [10].

Activation can be carried out by chemical or physical means. In the chemical activation process, these two steps are carried out simultaneously using chemical activating agents as dehydrating agents and oxidants. On the other hand, physical activation involves carbonization of a carbonaceous precursor followed

by the activation of the resulting char at elevated temperature in the presence of suitable activating agents such as carbon dioxide or steam. It has been found that the chemical activation process normally takes place at a temperature lower than those used in the physical activation process [15]. In chemical activation, the precursor materials are impregnated with chemical agents such as $ZnCl_2$, H_3PO_4 , and KOH to inhibit the formation of tar [45] and reduce the evolution of volatile matter [21] resulting in high conversion of the precursor to carbon. Therefore, the development of a porous structure is better for the chemical activation process [15]. Among the chemical activating agents, zinc chloride ($ZnCl_2$) in particular is the most widely used chemical in the preparation of activated carbon [15]. But, nowadays, the use of zinc chloride process is declined related to problems of environmental contamination by zinc compounds. The activated carbons prepared by zinc chloride cannot be used in pharmaceutical and food industries because it can contaminate the product [16]. And the KOH is found to be the most effective alkali salt in the production of activated carbons [15].

One of the agricultural wastes in Indonesia is the shell of durians. Production of durians in Indonesia is 562,710 tones per year at 1998 and it is estimated that production of durians will increase in the next few years because nowadays Indonesian people can harvest durian many times in a year [46]. Besides that, the increasing number of durian consumption is also because generally people like durian very much and it is called the king of fruit. So, it can be concluded that large quantities of shells can be available as they are disposed of after the consumptions of the fruits.

In many places, the pilings up of durian shells waste can be seen, even in the drains or ditches [47]. These bring no use for the communities. The pungent smell is very disturbing. Besides that, during the wet season the shells will be spoilt and these will hamper the flow of water and the smell is pungent as well. If we keep ignoring this, it will cause many kinds of diseases, especially respiratory diseases. To overcome this, we have to make use of this waste in order to increase the economic value of this waste.

A challenge in production of carbon adsorbents is to produce very specific materials with a given pore size distribution from low cost precursors at low temperature [4]. For this reason, we would like to investigate whether it is possible to produce activated carbon from a new precursor, durians shell, by chemical activation with KOH and the effects of different operating parameters during the process of making the activated carbon on its surface chemistry.

Then, the activated carbons produced were used for the removal of methylene blue from aqueous solutions. Several industries, such as textile, ceramic, paper, printing, and plastic use dyes in order to color their product. In the coloring process, these industries also consume substantial volumes of water, and as a result, large amount of colored wastewater are generated. The present of dyes in water is undesirable since even a very small amount of these coloring agents is highly visible and may toxic to aquatic environment [48-52]. Several methods are available for color removal from wastewater such as membrane separation, aerobic and anaerobic degradation using various microorganisms, chemical oxidation, coagulation and flocculation, adsorption using different kind of

adsorbents, and reverse osmosis [48, 50, 52]. Among them, adsorption is a promising removal technique that produces effluents containing very low levels of dissolved organic compounds.

Considerable research has been conducted into the removal of dyes from water effluent using adsorption technique using different adsorbent such as activated carbon [48-52], fly ash [53], sawdust [54-56], corncob [57], barley husk [57], orange peel [58], dead or living biomass [59-64], and other low-cost adsorbents [48]. The most widely used adsorbent for this purpose is activated carbon, but commercially available activated carbons are expensive and so they may not be economical for wastewater treatment. Other untreated low-cost adsorbents often have low adsorption capacities; therefore their removal efficiencies are poor. If an activated carbon with high adsorption capacity for wastewater treatment purpose can be produced from low-cost or waste materials, then its use as an adsorbent should be economical.

Activated carbon is the most popular adsorbent for the adsorption process since it has high adsorption capacity. The adsorption capacity of activated carbon depends not only on its surface area, but also on its internal pore structure, surface characteristic, and the presence of functional group on pore surface. Internal pore structure and surface characteristic play an important role in adsorption processes and depend both on the precursor used and method of preparation [28]. Different methods are available for characterizing the pore structure (surface area, pore volume, pore size distribution, etc) of activated carbon such as small angle X-ray, mercury porosimetry, scanning electron microscopy, and gas as well as liquid

phase adsorption [65]. The characteristics of adsorption behavior of activated carbon are generally inferred in terms of both adsorption kinetics and equilibrium isotherm [66]. Therefore, to study both of adsorption kinetics and equilibrium, it is important to understand the adsorption mechanism for the theoretical evaluation and interpretation of thermodynamic parameters [66-68].

Although there are many studies in the literature concerning to the preparation activated carbon and its application for liquid phase adsorption, there is no information for the production and utilization of activated carbon from durian shell for color removal. In this article, we report our study of the preparation of activated carbon from durian shell and the adsorption equilibrium and kinetics of methylene blue on this carbon. We also compared the applicability several well known adsorption isotherm and kinetics models to describe the equilibria and dynamic.

I.2 The Objectives

1. To study the preparation of activated carbon from durian shell and the effect of the activation condition to its adsorption capacity,
2. To determine the surface area and pore size distribution of the resulting product,
3. To study the adsorption equilibrium and kinetics of methylene blue on the one of the resulting activated carbon which has the best adsorption ability of methylene blue.

I.3 The Limitations

1. The raw material used is the shell of durian variety *Monthong* or golden pillow,
2. The activation method used is chemical activation with KOH as activating agent,
3. The optimum condition is based on the highest methylene blue adsorption capacity of the product.