CHARACTERISTICS OF GRANULAR ACTIVATED CARBON FROM UTM PILOT PLANT

NORMAH BT MULOP AND RAMLAN BIN ABD AZIZ
(UNIVERSITI TEKNOLOGI MALAYSIA, KUALA LUMPUR)

AND

KU HALIM BIN KU HAMID
(INSTITUT TEKNOLOGI MARA, KUALA LUMPUR)

ABSTRACT

The granular activated carbon is produced from coconut shell. The pilot plant initially carbonizes the raw coconut shell to produce charcoal. The crushed charcoal is then converted to activated carbon. Factors that are affecting the activation process such as time of activation and size of particles forming the bed are varied. The characteristics of the activated carbon produced are determined by using standard tests and a scanning electron microscope is used to determine the surface structures. The results show that the pilot plant is able to produce a good quality activated carbon from agricultural waste.

INTRODUCTION

The agricultural sector in Malaysia produces abundance of agricultural wastes such as coconut shell. This byproduct has not been put into beneficial use by the planters. The unused coconut shell can be turned into activated carbon. In this way the income of the planters can be increased as well as making use of a waste product.

Activated carbon is an amorphous form of carbon which is specially treated to produce a very large surface area ranging generally from 300 and 2,000 m^2/g. This large surface area means that the internal pore structure has been highly developed. It is this structure that provides activated carbon with the ability to absorb gases and vapors from gases, and dissolved or dispersed subtances from liquids. Present technology demands a very large production of activated carbon with appropriate characteristics for each application. From a general point of view an activated carbon to be used in any of the most common applications (adsorbents, catalyst support, etc) must have adequate adsorptive capacity, mechanical strength, chemical purity, etc. Furthermore, all these specifications should co-exist with a low production cost.

In addition to a knowledge of the adsorptive behaviour of an activated carbon, it is often desirable to have information as to other properties that can influence the utility and value of an activated carbon. This research studies the characteristics of the activated carbon produced from UTM pilot plant and also the influence of factors that are affecting the activation process on the characteristics.

EXPERIMENTAL PROCEDURE

The activation process was carried out at 800 °C by using the fluidised bed technique. Steam was used as the fluidizing as well as the oxidising medium. Sizes of the coconut charcoal forming the bed were varied as follows: 2.37 - 4.0 mm, 4.0 - 4.75 mm and 4.75 - 6.70 mm. For each particle size range of bed the time of activation was varied from 18 to 60 minutes. The activated carbon produced was then analysed.

The proximate analysis on the activated carbon was carried out following the procedures of British Standard BS 1016, part 4: 1973. The proximate analysis determined the amount of moisture, volatile matter and ash, fixed carbon was obtained by difference. The adsorption tests using solution of methylene blue were based on the Malaysian Standard MS 873: 1984 and iodine adsorption performance was based on JWWA K113-1985.

A sorption analyser was used to determine the surface area of the activated carbon. A mixture of an adsorbate (nitrogen) and an inert gas (helium) was passed through a glass cell containing the sample. At liquid nitrogen temperature helium would not adsorb while nitrogen would physically adsorb on all surfaces.The amount

of nitrogen adsorbed at various partial pressures can then be used to calculate the surface area.

The surface structures of the activated carbon were viewed through a scanning electron microscope.

RESULTS

The results obtained were displayed in the form of tables and graphs.

The proximate analysis of the activated carbon with initial size range of 4.0 - 4.75 mm and 60 minutes activation time is given in Table 1. Table 2 and Figure 1 show the variation of the fixed carbon content with time of activation when the activation process was carried out at a temperature of 800 °C.

Methylene blue adsorption ml/g versus time of activation is given in Table 3 and in Figure 2. An increase in activation time causes an increase in methylene blue adsorption. Adsorption by smaller size activated carbon (2.37-4.0 mm) is higher than by a bigger size activated carbon (4.75- 6.7 mm). Figure 3 shows the kinetics of methylene blue adsorption. The figure gives the relation between the percentage of methylene blue adsorbed with time. A comparison is made with a commercial activated carbon named Malbon R4 W10. Malbon R4 W10 is a powdered activated carbon made from wood charcoal.

Table 1:Proximate analysis of activated carbon with initial size 4.0 - 4.75 mm and 60 minutes activation time

Komponen	%
Moisture	6.45
Ash	0.39
Volatile matter	5.69
Fixed carbon	87.47
Jumlah	100.00

Table 2: Fixed carbon content of activated carbon versus time of activation

Time of activation (minutes)	fixed carbon,% initial size (mm)	
	2.37 - 4.00	4.75 - 6.70
0	88.0	87.0
18	89.4	87.9
30	89.9	88.2
37	90.2	88.4
45	90.5	88.6
60	90.7	89.8

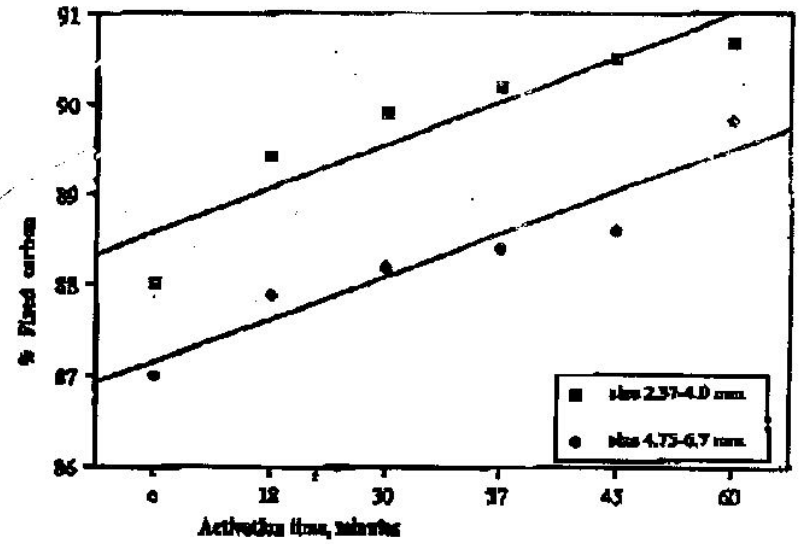

Figure1: The variation of fixed carbon with time of activation.

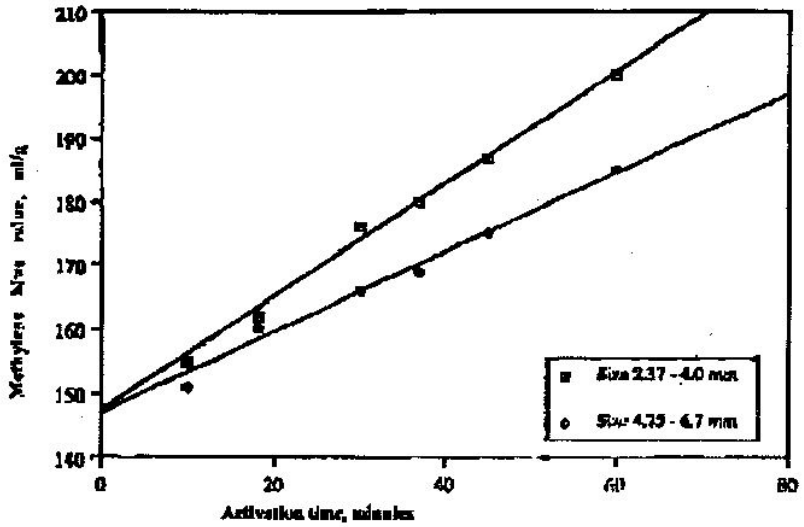

Figure 2: Methylene blue adsorption versus time of activation.

Table 3: Methylene blue adsorption performance versus time of activation.

Activation time (minutes)	Methylene blue adsorption (ml/g)	
	Initial size range (mm)	
	2.37-4.00	4.75-6.70
0	148	148
18	162	160
30	176	166
37	180	169
45	187	175
60	200	185

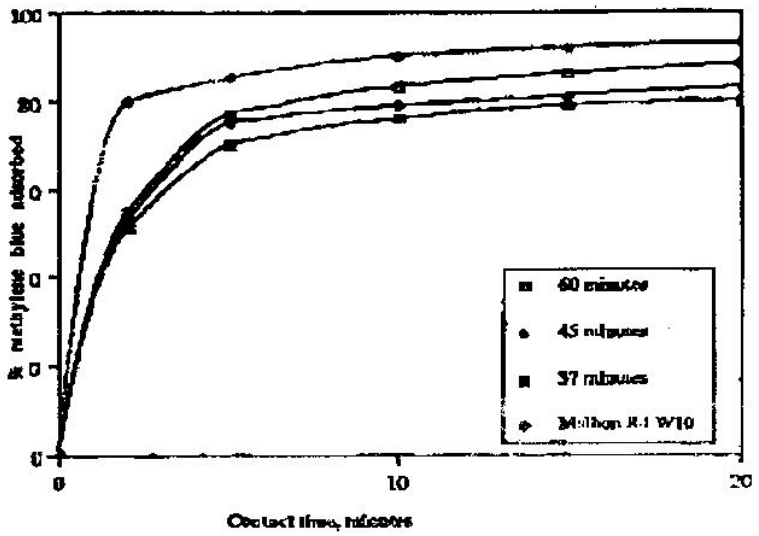

Figure 3: Adsorption kinetics of methylene blue.

Table 4 and Figure 4 show the performance of iodine adsorption versus time of activation. Activated carbon with the smallest initial particle size gives the highest

adsorption compared with a bigger size activated carbon. The pH value of a activated carbon produced is alkaline and is in the range of 7.5 - 9.5. The pH valu is not affected by time of activation or the initial size of activated carbon particles

Table 4: Iodin adsorption performance Vs time of activation

Time of activation	Iodine adsorption (mg/g)		
	Initial size range (mm)		
(minutes)	2.37-4.00	4.00-4.75	4.75-6.70
0	110	110	110
18	200	193	185
25	222	214	207
30	233	225	219
37	248	240	234
45	262	253	245
60	282	268	262

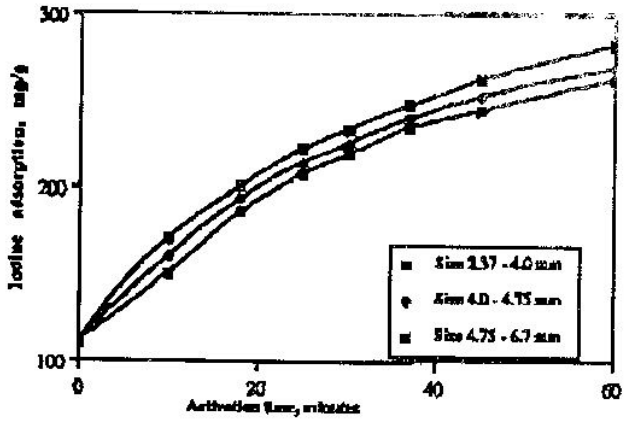

Figure 4: Iodine adsorption performance versus time of activation.

Figure 5 gives the variation of specific surface area with time of activation and initial size of activated carbon particles. Figures 6 - 9 shows the surface structures of coconut charcoal and activated carbon produced as viewed under a scanning electron microscope. Micropores can be seen clearly at the surface of the activated carbon as compared with the surface of the charcoal.

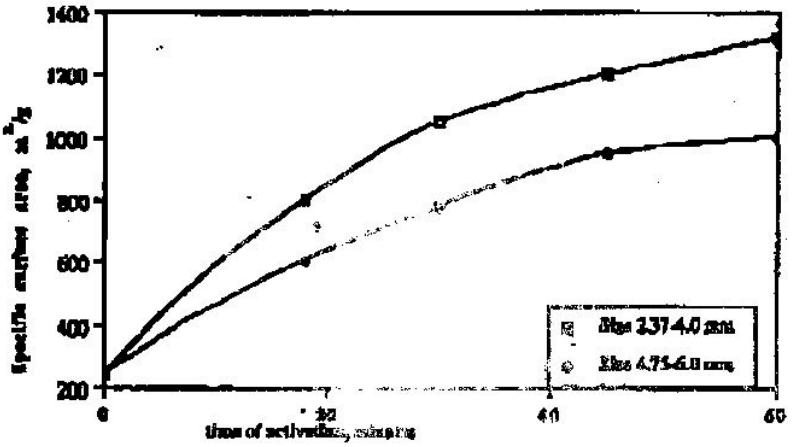

Figure 5: Specific surface area m^2/g versus time of activation.

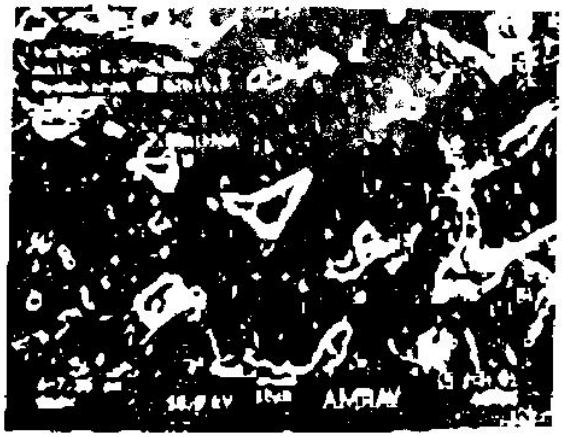

Figure 6: Result after carbonization process. No significant pores existed.

Figure 7: Result after 15 minutes activation. Significant number of pores begin to exist.

Figure 8:Result after 1 hour activation. Large number of pores with bigger sizes existed.

DISCUSSION

As deduced from the result of Table 2, the fixed carbon content increases as the time of activation is increased. The small increment in fixed carbon content shows that the carbonization carried out was able to remove most of the volatile matter present in the raw material. The removal of the volatile matter was then continued in the activation process. The low ash content is an interesting feature of these activated carbons.

The adsorption of methylene blue and iodine increases with time of activation. This phenomenon is related to the increase in surface area when time of activation is increased. A longer activation time causes the walls between pores being oxidised and the pores already existed increased in size as well as opening pores that are blocked by volatile matter in the raw material. A smaller size charcoal particles give a higher surface area. This may be due to the steam being able to penetrate better and produce pores on the smaller carbon as compared to a bigger size carbon.

At the initial stage of the adsorption process there are many empty pores on the outside surface of the activated carbon. When these pores have been filled the late coming molecules have to find new location inside the carbon. The findings requires the movements of molecules through small and turtuous channels. The phenomenon explains the rapid initial adsorption followed by a slower adsorption rate as shown by Figure 2. For contact time less than 5 minutes, rate of adsorption for the 3 samples of activated carbon are very rapid. after 10 minutes, a 60 minutes activation time carbon has adsorbed 83 % 0.005 g/l methylene blue solution as compared to 75 % adsorbed by a 37 minutes activation time activated carbon. HEnce activated carbon produced by a longer period of activation have a better adsorption performance.

The internal structure of activated carbon appears to include a connecting network of irregularly shaped gaps and crevices in the carbon. The smaller size apertures are called micropores and they provide most of the surface area on which adsorption occurs. The larger apertures are called macropores. Macropores provide passageways through which adsorbable molecules can more readily reach interior micropores.

CONCLUSION

The research finds that the fixed carbon content, specific surface area and adsorption performance of the activated carbon produced by UTM pilot plant varies directly with time of activation and varies inversely with bed particle size. As a whole the pilot plant is able to produce a good quality granular activated carbon from agricultural waste.

FURTHER RESEARCH WORKS

Studies are now being planned to use other agricultural wastes that lay abundance as raw materials to produce activated carbon. These materials are palm kernel shell, rice husk, wood chips, cocoa shell etc.

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