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ACTIVATED CARBON FROM INDIGENOUS INFERIOR WOODS
Part II. Activation Temperature, Time and Particle Size Influence

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The influence of temperature, time and particle size at the same impregnation ratio of activating agent viz. $ZnCl_2$ on different physical and chemical properties of activated carbon samples from an inferior wood i.e. Babul (*Acacia arabica*) has been studied. Their effect on adsorptive properties of the different products shows no change in mesoporosity, a little in micro and a considerable change in macroporosity of the final products.

Key words: Activated carbon, Babul *(Acacia arabica)*, Influence of variables.

Introduction

Activated carbons are unique and versatile adsorbents because of their extended surface area, microporous structure and high adsorption capacity. These may be grouped into four classes depending upon their physical structure, properties and appplications [1,2] viz. gas or vapour adsorbent, decolorizing, metal adsorbent and medicinal carbon used in different chemical and petrochemical industries [3]. The use of activated carbon in the form of carbonized wood dates back many centuries. The Egyptians used it around 1500 B.C. as an adsorbent for medicinal purposes. Wood charcoal was first used in Europe in the eighteenth century for the refining of raw sugars [4]. Any cheap material with a high carbon content and low in inorganics like wood, coal, lignite, coconut shell and peat can be used as a raw material for the production of activated carbon [5]. Among these raw materials, wood is the major one in the order of importance and in terms of production capacity as its annual consumption for the production of activated carbon is 1,30,000 tons [6].

Among the activating agents commonly used for the production of activated carbon, zinc chloride is the most effective one as it strips off hydrogen and oxygen from the wood undergoing carbonization and form water [7]. In effect, this leaves hydrocarbon compounds in the charcoal produced, and a more active carbon surface is formed which is free to attract and adsorb coloring matter and other impurities from certain solutions [8].

In an earlier work [9], the influence of impregnation ratio of zinc chloride on the properties of activated carbon from different indigenous woods has been described. There it was concluded that for the removal of low molecular weight compounds, lower impregnation ratio works satisfactorily whereas in the case of high molecular weight compounds, a higher percentage of impregnating agent is desirable.

The present investigations describe the influence of activation temperature, time and particle size on different physical and chemical properties of activated carbon from a native inferior wood i.e. Babul *(Acacia arabica)*, abundantly available and presently used as a fuel and packing material. The data thus generated may give some useful information about the influence of different parameters on various properties of activated carbons so produced.

Experimental

The wood sample was first debarked and dried in an oven at 105°. The dried sample was then ground in a ball mill and sieved to different particle sizes of 0.25-0.50 mm, 0.125-0.250 mm and 0.088-0.125 mm. The powdered raw material, 100 gms (W_1) in each set of experiments was treated with 200 gms (W_2) of impregnating agent i.e. $ZnCl_2$ dissolved in 100 ml of 10% HCl and dried. The dried mass in each case was carbonized in a muffle furnace out of contact with air at temperatures of 500 and 700° for 2,3 and 4 hr respectively. The carbonized materials were weight (W_3), washed with 10% HCl and distilled water, then dried and weighed again (W_4). These products were then powdered to -200 mesh and stored in airtight bottles for their characterization. The percentage yield and activating agent recovery in each case was also calculated [10]. The loss in weight (L.W) and hence yield i.e. (100-L.W) of the various products obtained under different conditions were calculated by the formula:

$$\text{L.W.} = \frac{W_1 - W_4}{W_1} \times 100$$

The percentage recovery of the activating agent (R.R.) was then calculated by the formula:

$$\text{R.R.} = \frac{W_3 - W_4}{W_2} \times 100$$

The pore space [11] and ash content of these samples were also determined. The surface area of pores greater than 10A and 28A has also been calculated [12].

The iodine, methylene blue and molasses number of these activated carbon samples were determined [12] to measure their adsorptive capacity.

Results and Discussion

The Babul *(Acacia arabica)* wood with impregnation ratio of 1:2 as established in an earlier work [9] has been employed during all these investigations. The present study describes the influence of particle size, temperature and time on different physical and chemical characteristics of activated carbon samples.

Table 1 shows the effect of the above variables on the yield, activating agent recovery and ash contents of different carbon samples so produced. It can be noticed that as particle size (D) increases, the loss in weight (L.W) decreases or yield increases as may be seen in the samples A,B, and C. It is further observed that with increase of temperature (T) and activation time (t), the yield of the products gradually decreases and ranges between 29.8 to 32.1%. It may be due to the fact that low heating rate during pyrolysis results in lower volatization and higher char yield [11]. As far as activating agent recovery (R.R) is concerned, it shows a marked decrease with increase in temperature. With increase of activation time at 500°, R.R. shows a remarkable decrease with rather a regular pattern whereas at 700°, this decrease is somewhat less pronounced. This decrease in R.R. with increase of temperature and time is due to the evaporation effect of $ZnCl_2$ [10]. The above pattern may be due to the fact that rapid loss of activating agent occurs at higher temperature and its optimum level is reached at 700° in 2 hours time. The ash content (Table I) of the activated carbon samples does not seem to depend on these variables and generally ranges between 3.22 to 5.75%.

TABLE 1. EFFECT OF DIFFERENT PARAMETERS ON YIELD, ACTIVATING AGENT RECOVERY AND ASH CONTENT.

Sample	Raw material particle size D, m.m.	Tempe-reture T°C	Time (T)hrs	Yield %	Reagent recovery R.R.,%	Ash content %
A_1	0.25-0.50	500	2	32.10	69.52	4.37
A_2	-do-	-do-	3	31.91	41.71	3.87
A_3	-do-	-do-	4	31.85	29.61	3.77
A_4	-do-	700	2	31.20	19.46	5.55
A_5	-do-	-do-	3	30.97	15.29	5.08
A_6	-do-	-do-	4	30.50	13.57	3.20
B_1	0.125-0.250	500	2	31.61	69.82	5.71
B_2	-do-	-do-	3	31.42	43.52	4.83
B_3	-do-	-do-	4	31.11	30.21	5.49
B_4	-do-	700	2	31.09	20.24	5.57
B_5	-do-	-do-	3	30.97	17.19	5.60
B_6	-do-	-do-	4	30.81	14.97	5.47
C_1	0.088-0.125	500	2	30.51	70.02	5.17
C_2	-do-	-do-	3	30.34	45.57	5.00
C_3	-do-	-do-	4	30.21	31.12	4.22
C_4	-do-	700	2	31.12	21.14	5.71
C_5	-do-	-do-	3	29.89	18.95	5.75
C_6	-do-	-do-	4	29.81	17.21	5.50

Table 2 depicts the different physical characteristics such as bulk and true density, pore space and surface area of pores 10 and 28A of these samples. It is evident from Table 2 that increase in pore space is directly related to the decrease in bulk density and increase in activity of the relevant samples. The low bulking value also helps in improving the plant economy by reducing the length of filtration cycle [12].

TABLE 2. PHYSICAL CHARACTERISTICS OF ACTIVATED CARBON SAMPLES.

Sample	Bulk den-sity (Db) gm/cc.	True den-sity (Dt) gm/cc	Pore space c.c/100 gm	Surface area of pores> 10A	Surfce area of pores> 28A
A_1	0.3924	1.5385	189.82	1140	314
A_2	0.3972	1.4965	184.92	1132	437
A_3	0.3959	1.6582	192.32	1274	552
A_4	0.4246	1.7107	176.99	1242	451
A_5	0.4157	1.8103	185.42	1270	491
A_6	0.3994	1.6865	190.54	1278	669
B_1	0.3601	1.4778	209.81	1193	149
B_2	0.3490	1.5374	221.46	1215	1974
B_3	0.3440	1.4626	222.30	1283	2120
B_4	0.4309	1.5541	167.73	1248	664
B_5	0.4278	1.6043	171.42	1288	826
B_6	0.4244	1.4867	168.36	1306	975
C_1	0.4085	1.6014	182.35	1206	734
C_2	0.4150	1.6843	181.59	1225	768
C_3	0.3904	1.6590	195.87	1311	809
C_4	0.4288	1.6930	174.14	1255	761
C_5	0.4158	1.7253	182.54	1292	732
C_6	0.4046	1.7014	188.38	1322	848

TABLE 3. ADSORPTION CHARACTERISTICS OF DIFFERENT ACTIVATED CARBONS.

Sample	Iodine No. mg/gm	Methylene blue No. mg/gm	MolassesNo. mg/gm
A_1	1237	291	651
A_2	1228	294	906
A_3	1380	293	1146
A_4	1346	295	937
A_5	1376	294	1018
A_6	1385	293	1389
B_1	1294	295	3111
B_2	1317	292	4097
B_3	1390	293	4400
B_4	1352	295	1377
B_5	1395	293	1714
B_6	1415	294	2024
C_1	1308	292	1524
C_2	1328	293	1594
C_3	1420	294	1680
C_4	1360	293	1580
C_5	1400	290	1520
C_6	1432	291	1760

The adsorptive characteristics of these carbon samples have been determined against iodine, methylene blue and molasses (Table 3) which generally correspond to their micro, meso and macroporous structure and correlate with surface area of pores greater than 10,15 and 28A in diameter respectively [14].

It may be seen in Fig. 1 and 2 that in case of iodine and molasses numbers, activity generally increases with decrease in particle size of the raw material from A to C. This increase in activity is rather nominal in iodine and more pronounced in case of molasses where an optimum stage is attained at a particle size of 0.125-0.25° mm at 500°. This particular behaviour also corresponds with the surface area of the pores greater than 10 and 28A in these samples. As far the influence of temperature and time on adsorptive behaviour of these

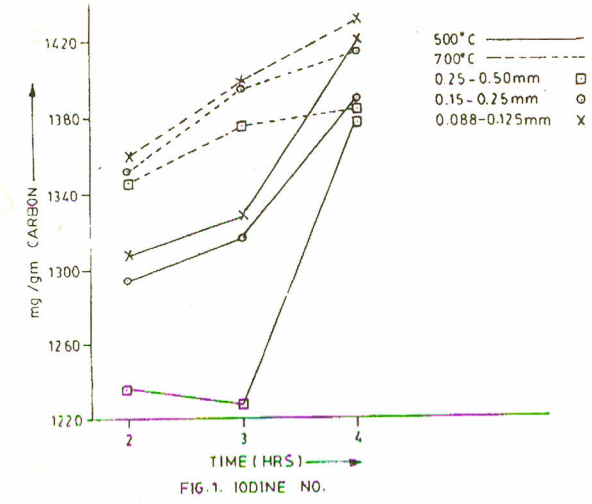

Fig. 1. Iodine No.

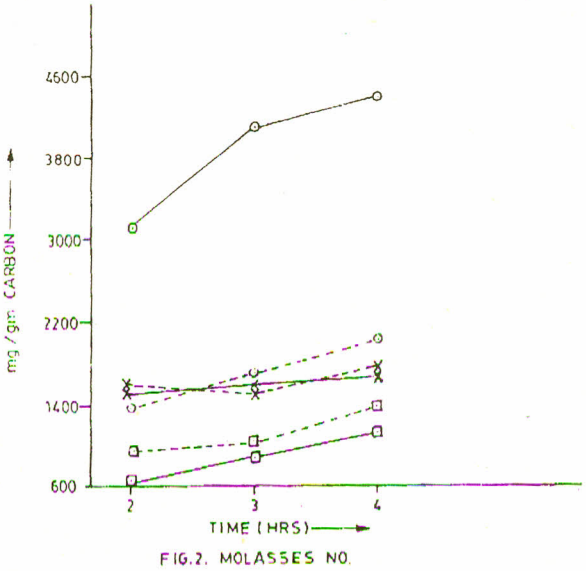

Fig. 2. Molasses No.

samples is concerned. Their effect is rather negligible in the case of iodine. It may be due to the fact that char microporosity is independent of the heating rate and the basic microporosity is formed at 500° and some pores which remain blocked at lower temperature could be available at higher temperature and results in slightly higher iodine number [6]. In molasses, the activity pattern is some-what different and generally increases with the increase of these variables. It may be due to the widening of micropores and complete burnout of the walls between the adjacent pores [6] at higher temperature. There is an exception with sample B to this behaviour where activity increases with increase of time but at low temperature. Table 3 also presents the methylene blue number which is a test now used for evaluating carbons in water purification requirements. It shows that this decolorizing property in these samples is independent of the variables studied.

This study reveals that adsorptive capacity in case of iodine in these samples vary slightly whereas in methylene blue this difference is rather negligible which may be due to the fact that the adsorption capacity determined largely by the degree of impregnation [9] at a particular temperature is the same in all the cases. In the case of molasses, this behaviour is different and activity increases with increase of temperature and time indicating an increase in the macroporosity.

Conclusions

1. Babul wood is an appropriate raw material to obtain activated carbon of low bulking value and high adsorption capacity by the activation method.

2. The variables of particle size, temperature and time studied at the same impregnation ratio of activating agent viz. $ZnCl_2$ show a little effect on microporosity (iodine No.), no change in mesoporosity (methylene blue no.) and a considerable increase in macroporosity (molasses no.) of the final products.

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