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Manufacture of Active Carbons from Woody Waste Materials

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Active carbons were manufactured from various woody waste materials such as wastepaper, plywood, fiberboard and particleboard with activation gas mixed carbon dioxide and water vapour. Wastepapers were defibrated and converted into paper pellets and waste panel products were cut into cubic pieces before carbonization and activation. Carbonation and activation were carried out in one step in one reactor. Activation temperature was at 850℃, and the activation time was determined at this temperature. Some kind of wastepaper contained a lot of ash and carbon yield was very low. Wastepapers mainly made of cellulose were easily burned to ash in the case of long time activation. Although starting materials such as plywood, fiberboard and particleboard contained urea resin, active carbon from plywood had no nitrogen. On the other hand, active carbons from fiberboard and particleboard contained a few percent nitrogen.

Key words: active carbon, woody waste material, wastepaper, urea resin, adsorption test

1. INTRODUCTION

Lignocellulosic materials such as wood have been promised as renewal resources produced by sustainable forest management. However wastepapers from city trash and woody wastes from demolished houses have been increased and the cost to treat these wasted materials has become high remarkably. It is important to establish the recyclable utilization of woody waste materials for environmental problems caused by waste products. A lot of active carbon will be required in the future to remove various kinds of pollutants and clarify water and air. So it is quite useful to manufacture active carbon from abundant woody waste materials. In the process of manufacturing active carbon, the heat from the incineration of waste materials can be used for carbonization and the resultant combustion gas, carbon dioxide and water vapour can be used in activation step. The present study was conducted to manufacture active carbons from woody waste materials such as wastepaper, fiberboard, plywood and particleboard with activation gas mixed carbon dioxide and water vapour. Normally woody waste products are not pure lignocellulosic materials. Wastepapers usually contain inorganic additives and woody boards or panel products contain adhesives. Although there are some reports on the active carbons from newsprint[1,2], plastics such as urea resin and melamine resin[3,4], active carbons from other kind of wastepapers or complex materials such as wood and adhesives are not fully elucidated yet. Therefore, it is necessary to elucidate the effect of these components other than lignocellulose in manufacturing active carbons from waste materials.

2. EXPERIMENTAL

Wastepapers were defibrated in water with a mixer then converted into paper pellets. The average size of paper pellets was 20mm x 20mm x 80mm. Fiberboard, plywood and particleboard were cut into pieces approximately size of 20mm x 12mm x 50mm. The carbonization and activation were carried out in one step in one reactor (Fig.1).

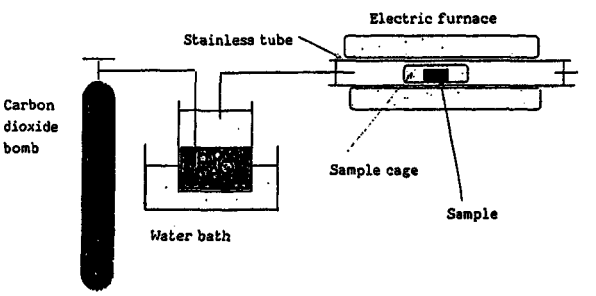


Fig. 1. Reactor used for manufacturing active carbon.

Each sample was set into a net cage and inserted into a

reactor made of stainless steel tube which was set in an electric furnace. The electric furnace used in this study was in the size of 35cm long, inner diameter 8cm with 4kw heater,200V,20A. The stainless tube was heated under the flow of mixed gas of carbon dioxide and water vapour. Mixed gas was obtained by bubbling carbon dioxide with flow rate 2 *l*/min. into hot water at 75℃. In this condition, 1 ml water was introduced into reactor in 10 minutes as water vapour with carbon dioxide. Activation temperature was set at in reference to the report of Shimada[1,2]. Activation time was estimated when the temperature of reactor reached 850℃. It took about 40 minutes from room temperature to 850℃. After the activation, the reactor was cooled down to the room temperature and the sample was taken out to crush, grind, sieve with the screen of aperture 150 μ m. After that the samples were subjected to the adsorption test using methylene blue and iodine. These adsorption tests were carried out according to JIS K 1470 and JWWA K 113. Ash content of the samples were determined after heating the samples in a muffle furnace at 600 ℃ overnight. Specific surface determined by the BET method and pore distribution were obtained from the nitrogen isotherm using Belsorp 18 Plus-T. Elementary analysis was carried out with SiberHegner CHNO-rapid.

3. RESULTS AND DISCUSSION

Table 1 shows the ash content of wastepaper samples.

Table 1 Ash content of various wastepapers.

Samples	Newsprint	Printing paper	Corrugated paper	Coated paper	Magazines
Ash content (%)	1.6	3.2	7.9	28.7	7.8

Papers usually contain inorganic substances such as kaolin, calcium magnesium salts to increase the whiteness of paper. Coated paper which is used for catalogues contained a lot of ash. Corrugated board and magazines also showed high ash content. High inorganic substances content reduce the resultant carbon yield from waste materials. Moreover inorganic substances often cause unfavorable effect on active carbon manufacture. They accelerate the activation reaction too much and the surface area of resultant active carbon become small[5,6,7]. Therefore coated paper, corrugated board, magazines are not good raw materials for making charcoal or active carbon.

Fig. 2 shows the active carbon yield from various samples.

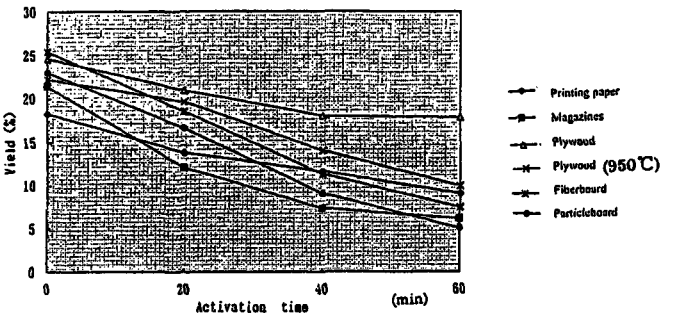


Fig. 2. Yield and activation time of samples.

Printing paper used for copy machines or printers of computer systems is abundantly exhausted from office. This kind of paper is almost lignin free cellulose and some inorganic additives to increase whiteness. In manufacturing active carbon, printing paper was easily burned to ash. After 20 minutes activation, the surface of active carbon from printing paper gradually changed to white with ash covering. This may because of lacking lignin and additives such as kaolin and magnesium carbonate accelerate the oxidation reaction. Normally in manufacturing active carbon from woody materials, adsorption ability increase with the decrease of its yield. But in the case of printing paper or magazines, even if the yield of active carbon became low, the adsorption ability did not become high.

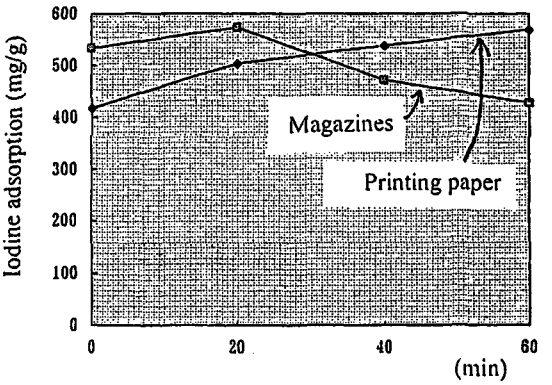
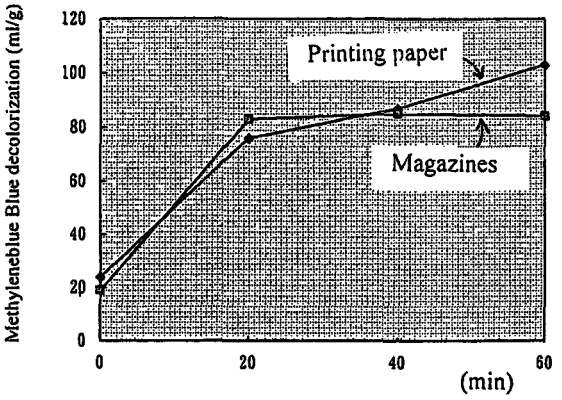


Fig. 3. Iodine adsorption and activation time.



Methyleneblue Blue: 1.2 g/*l* (JWWA K 113)

Fig. 4 Methyleneblue Blue decolorization and activation time.

The cause of yield decrease in this case was mainly the formation of ash. On the other hand, Shimada reported newsprint which has basically the same components as wood was an excellent raw materials both in yield and adsorption properties[1,2].

Wood waste materials often contain other substances such as plastics. The most probable plastics are adhesives, especially urea resin. Plywood, fiberboard and particleboard containing urea resin were used in this experiment. Table 2 shows the nitrogen content in active carbon and charcoal.

Table 2. Nitrogen content of carbonized samples.

Carbonized materials	Carbonized temperature(℃)	Nitrogen content (%)
Particleboard bonded with urea-melamine resin.	850	1.57
	500	2.72
Particleboard bonded with urea resin.	850	1.34
	500	1.76
Medium density fiberboard bonded with urea resin	850	2.81
	500	2.91
Plywood bonded with urea resin	850	less than 0.1
	500	0.75

All charcoals from these panel product made at 500℃ contained a few percent of nitrogen. Active carbons made at 850℃ with 20 minutes activation still contained a few percent of nitrogen except active carbon from plywood. Plywood contains less adhesive than fiberboard or particleboard, so at the higher temperature urea resin was burn out, on the other hand in the case of fiberboard or particleboard, carbonized urea resin was incorporated into resultant active carbons.

In the activation process carbon yield from plywood decreased more slowly than those of fiberboard and particleboard. Plywood contains urea resin as thin films among the veneers. After the resin film is burned out, remained veneers are carbonized. Fiberboard and particleboard are consisted of small element such as fiber or particle. These elements are bonded with resin is distributed as spots on each element. So after resin is burned out, they are easily broken into pieces. These elements are far smaller than vneers from ploywood and are rapidly carbonized and activated. Although plywood was required higher temperature than other boards, resultant active carbons are not so different in iodine adsorption test(Fig.5).

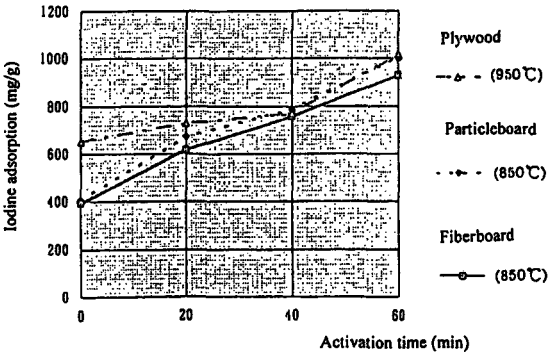


Fig.5 Iodine adsorption of active carbon from panel products.

Pore distribution of these active carbons in meso pore area showed the peak around 2 nm but the curve of each sample was slightly different (Fig.6-Fig.8).

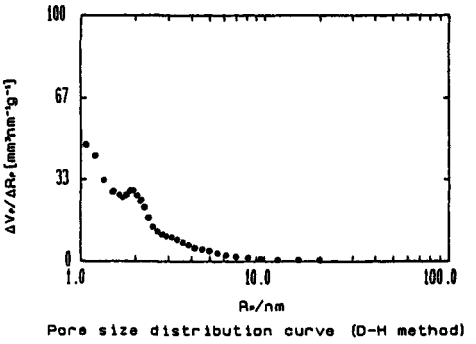


Fig.6 Meso pore distribution of active carbon from plywood.

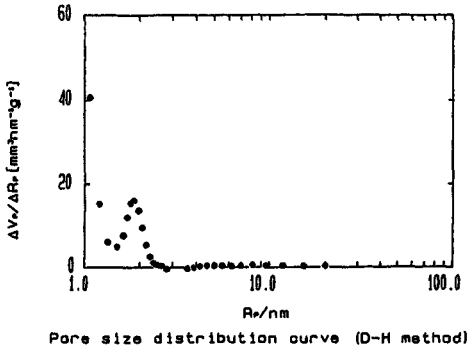


Fig.7 Meso pore distribution of active carbon from particleboard.

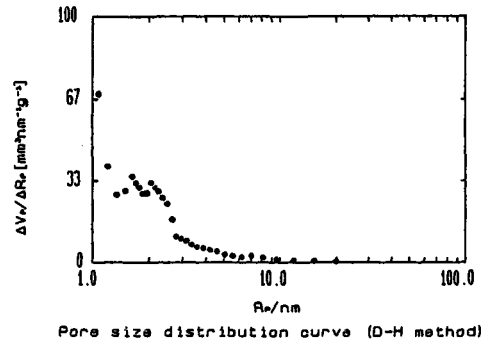


Fig.8 Meso pore distribution of active carbon from fiberboard.

Surface area of the samples were almost the same as commercially available active carbon (Table 3).

Table 3. Methylene Blue test ,BET surface area and activation conditions.

Samples	Time (min)	Temperature (℃)	Methylene Blue test (ml/g)	BET Surface area (m^2/g)
Plywood	60	950	145	886
Particleboard	60	850	130	857
Fiberboard	60	850	118	823

Methylene Blue: 1.2 g/l (JWWA K 113)

Although active carbons from woody waste materials have enough adsorption ability for actual use, there are some problems in utilizing waste materials. Some woody waste materials from demolished houses often contain toxic wood preservatives. These materials cannot be used. Moreover, the pyroligneous fume and liquor formed during the carbonization of urea resin containing wood waste materials smell quite uncomfortable. They include many kind of nitrogen containing materials such as amides, pyridines, and pyrimidines that are not good to health. Wood vinegar is useful but this fume and liquor should be collected and burned into nitrogen oxides then should be treated with a scrubber to prevent environmental pollution.

Acknowledgement

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