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# Development of High-Quality Woodceramics from Waste Papers

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A new manufacturing process of high quality woodceramics from waste papers such as copy paper, advertisement paper, magazine, bamboo pulp and newspaper was developed. The woodceramics prepared by new process showed the uniform electrical resistivity in the whole area of the woodceramics board and showed the nearly same mechanical properties as those made from MDF (medium-density fiberboard).

Key words: woodceramics, waste paper, electrical resistivity, bending property

## 1. INTRODUCTION

The increasing pressures of the public pollution by industrial wastes and the greenhouse effect on the earth due to the increasing $CO_2$ content in the air make it highly necessary to develop the novel environmental-friendly Eco-material. For this purpose, we developed a new porous carbon material known as woodceramics, which was obtained by carbonizing MDF (medium-density fiberboard) impregnated with phenolic resin a few years ago [1]. As the woodceramics has superior mechanical property [2], wear property[3], electrical property[4] and electromagnetic shielding property *etc.*[5], they are being used in more and more wide industrial fields. In the present work, we tried to prepare high quality woodceramics from five kinds of waste papers. Moreover, the new electric furnace with a rotating table was developed to obtain the high-quality woodceramics board with the uniform electrical resistivity characteristics in the whole area.

## 2. EXPERIMENTAL PROCEDURE

### 2. 1 Raw materials (waste papers and phenolic resin)

Five kinds of papers, *i.e.*, copy paper, advertisement paper, magazine, bamboo pulp and newspaper, were used for the raw materials. The moisture content of each row material was about 10%.

The BRP-5933 type phenolic resin powder made by Showa Highpolymer Co., Ltd. was used as the binder.

2.2 Processing

The refining of the waste papers, mixing of refined paper fibers and phenolic resin powder and the hot-pressing of the mixtures were performed using TCP-30 WS type combined system machine made by Toyou Co., Ltd., in which the waste papers was refined with a rotating shredder. The size of the refined paper was controlled and classified to six groups shown in Table 1(A-F) by controlling the rotating speed of shredder and changing the mesh size of the exit screen through which the refined paper was exhausted, where the large mesh has 342 pieces of 9.93mm diameter hole in the 490 $cm^2$ area, the middle mesh has 540 pieces of 6.75mm diameter hole in the 490$cm^2$ area, and the small mesh has 961 pieces of 4.86 diameter hole in the 490 $cm^2$ area.

Table 1 Refining condition.

| | Large size | Middle size | Small size |
|---|---|---|---|
| 1125 r.p.m. | A | C | E |
| 2250 r.p.m. | B | D | F |

The fiber length was measured by using Nikon optiphoto 150 microscope with computer image system where the mean fiber length was obtained by averaging 25 fibers. The weight ratio of the unrefined paper to the total paper (named unrefined ratio hereafter) was calculated through measuring the dry weight of the paper which could not untied with tweezers in the water.

The refined fibers and phenolic resin powder were mixed with jet mixer, where the weight ratio of paper fiber and phenolic resin powder was 10: 1, and the mixture were compacted under the pressure of 5 MPa for 15 minutes at 250 ℃.

The preform compacted mixture was carbonized at 650 ℃ in vacuum furnace after it was impregnated with phenolic resin solution (PX-1600 produced by Honen Co., Ltd.,) and dried 8h at 60℃ and then heated to 135℃. In order to make sure the woodceramics quality, the rotated furnace shown in figure 1 was employed.

Fig.1 Carbonizing furnace with the rotating specimen table.

2.3 Characterization

The bending tests of the preforms (compacted mixtures) and the carbonized woodceramics were carried out using the Shimadzu EHF-EA5 type machine with three point bending system, where the beam span was 200 mm, the cross head speed was 5mm/min, and the deflection was measured with a dial gauge.

The volume electrical resistivity of woodceramics board was measured using MCP-T600 system at 20℃. In order to avoid the effect of the water content upon the electrical resistivity of the woodceramics board, the specimens were dried at 60 ℃ for 1 hour and at 105 ℃ for 1 hour.

3. RESULTS AND DISCUSSION

3.1 Fiber length and unrefined ratio

Figure 2 shows the fiber length of five kinds of refined papers under six conditions shown in table 1. The fiber length of each paper was classified into two groups. The copy paper and advertisement paper belonged to the first group with about 2.5mm length of fiber. The magazine, bamboo pulp and newspaper belonged to the second group with about 4mm length of fiber. The main reason why the fibers of the first group were short lied in that the papers with the first group

were coated with paint, namely the fibers in the papers were difficult to be separated (untied) each other and cut shortly.

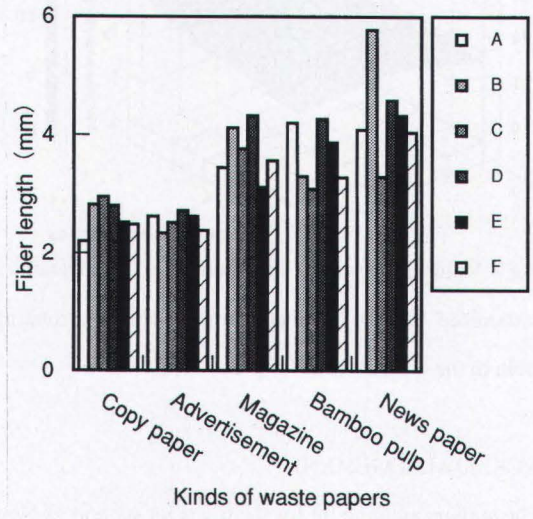


Fig.2 Fiber length of five kind papers refined under six conditions shown in table 1.

Figure 3 shows the unrefined ratio of five kinds of waste papers refined under six conditions shown in table 1. The unrefined ratio decreased with decreasing mesh size of the exit screen and with increasing rotation of the rotating shredder. The condition known as F, under which the unrefined ratio was below 20%, was most suitable condition among six conditions.

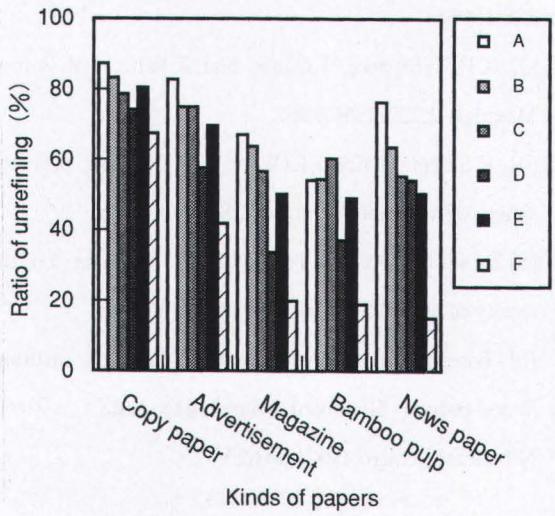


Fig.3 Unrefined fiber ration of five kinds of waste papers refined under six conditions shown in table 1.

3.2 Bending strength

Figure 4 shows the bending strength of the compacted preform board. The compacted boards made of the fibers of the first group in Fig.2 showed the lower strength than those of the second group. The reason may be due to the shortness of the first group fibers. The strength of the compacted boards made of the second group fibers was lower than that of MDF. Figure 5 shows the bending strength of the woodceramics made from the waste paper. The results showed that the woodceramics from the waste paper, except from the advertisement paper, have the nearly same bending strength as the woodceramics made of MDF[6].

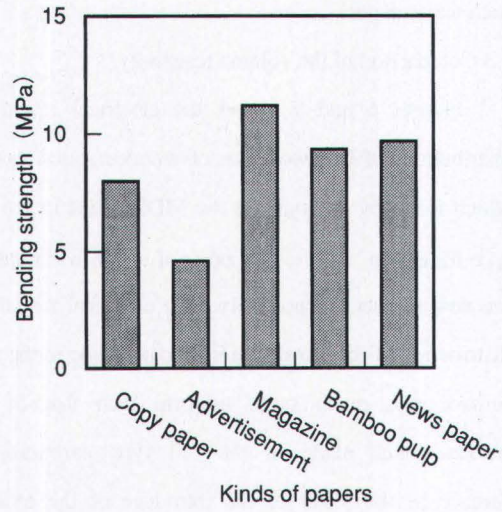


Fig.4 Bending strength of the compacted board made of each waste paper.

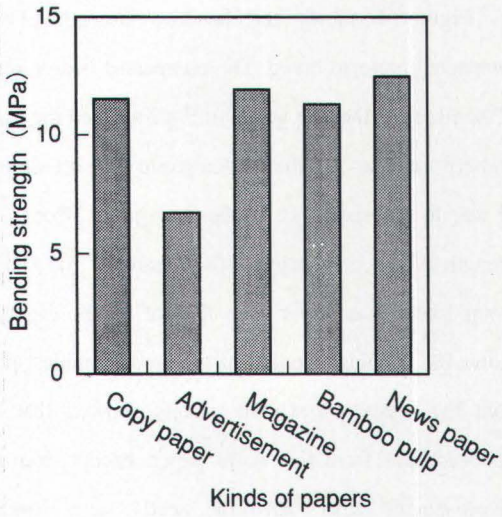


Fig.5 Bending strength of woodceramics made from each waste paper.

3.3 Comparison of the volume resistivity

Figures 6 and 7 shows the electrical resistivity distributions of the two types of woodceramics, one of which made by carbonizing the MDF board in the old type furnace at 650℃, the other of which was made in the new furnace, respectively. The electrical resistivity distribution of the woodceramics board made in the new furnace was much more uniform than that of the woodceramics made in the old type carbonization furnace as the result of the introduce of the rotation specimen table in the new type of the carbonization furnace.

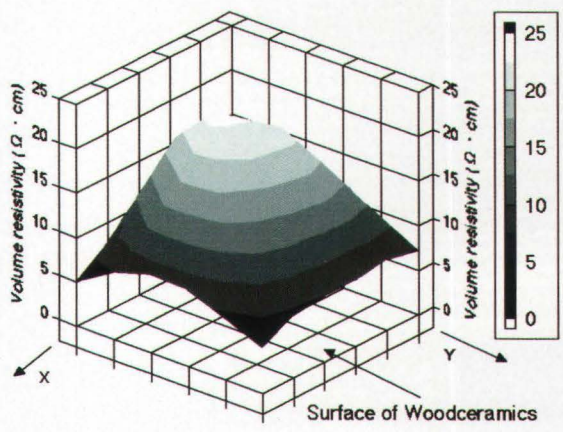


Fig.6 Volume resistivity distribution of woodceramics carbonized by old-fashioned furnace.

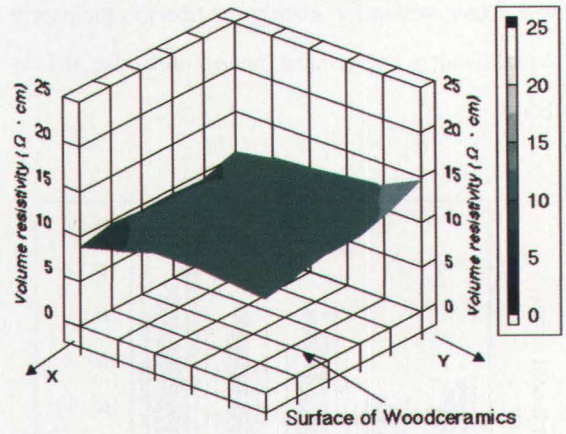


Fig.7 Volume resistivity distribution of woodceramics carbonized by new-fashioned furnace with the rotating table in the present study.

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