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Biodegradation and Adsorption Property of Charcoal Board with Superfine Natural Fibers as Building Interior Materials

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We newly developed charcoal board by adhering of carbonized material powders with superfine natural fibers as binder. The superfine cellulose and collagen fibers were prepared from defiberized milk cartons and leather scraps with a grinder, respectively. The board was degraded in soil after 6 months to decay collapsed into carbonized material powders. It should be mentioned that the cellulose and collagen in the natural fiber binder were biodegraded in the soil. The charcoal board adsorbed ammonia, formaldehyde and toluene gases from 20 ppm to almost 0 ppm within two hours. And it was confirmed that the charcoal board adsorbed and desorbed moisture depending on the relative humidity of the environment. When carbonized material powder was adhered with the superfine fibers, the function of carbonized material such as adsorption or humidity conditioning were maintained in the charcoal board.
Key words: Charcoal, Superfine natural fibers, Biodegradation, Adsorbtion.

1. INTRODUCTION

It is recognized that plants including wood are effective to reduce CO_2 concentration in atmosphere. Waste of wood materials re-evolves CO_2 by decaying and burning. Carbonization of wood waste enables CO_2 to be fixed as charcoal, which can be used as recycled resources.

We have proposed charcoal board, one of the new materials which are conscious of our environment[1]. This material composes of carbonized material powders and superfine natural fibers as binder. The superfine natural fibers consist of different kinds of fibers from waste milk cartons and leather scraps. Therefore, the basic materials are cellulose and collagen. One of the characteristics of the charcoal board is to use industrial waste as raw materials. And charcoal board does not contain harmful chemical compounds and does not generate them in the production process either. Furthermore, when the charcoal board is disposed, it returns to charcoal powder without polluting environment, because the binder is biodegraded by natural microbiological activities and the charcoal is never rotten and oxidized in the natural state.

In this paper, we study on the biodegradation property, the chemicals adsorption property and the humidity controllability by the charcoal board, and availability of the charcoal board as building materials is discussed.

2. EXPERIMENTAL

2.1 Sample preparation

The flowchart of sample preparation method is shown in Fig. 1. The charcoal board was made from cellulose and collagen as binder and charcoal powder. The charcoal bamboo was carbonized at 700 ℃. The superfine natural fibers were made by mixing the superfine cellulose and collagen fibers [2]- [4]. Then, charcoal powder was mixed with the superfine fibers, pressed and dried at 105 °C for 24 hr. The specific gravity of the board is 0.3～0.6 depending on the forming pressure. These preparation process is pollution free one; it dose not contain any chemical compounds.

The composition ratio of charcoal/superfine fiber in the charcoal board was adjusted to 8/2, and the composition ratio of cellulose fibers/ collagen fibers in the superfine fibers was 8/2.

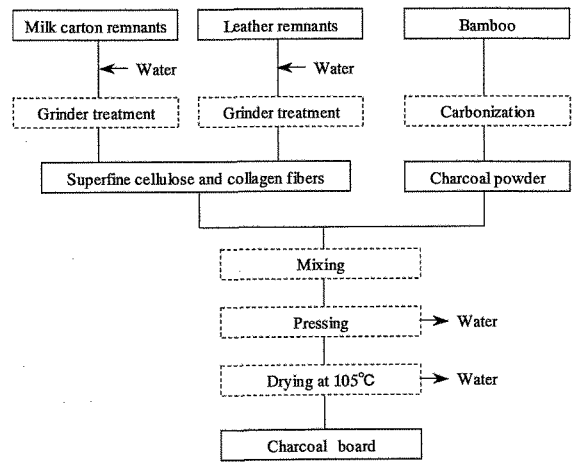

Fig. 1 Flowchart of sample preparation method.

2.2 Biodegradation test

2.2.1 Biodegradation test method

We buried the charcoal board in the soil, 100 mm in depth. The charcoal board was 100 mm × 100 mm, 20 mm in thickness and specific gravity of 0.5. Fig. 2 shows the sample layout set in the soil. Temperature of the soil was measured by a thermometer neighboring on the samples. Fig. 3 shows the temperature change of the soil. We grubbed the sample every one month during twelve months.

2.2.2 pH and Electric conductivity measurement

pH and Electric conductivity were measured in the soil neighboring on the board sample. The measurement of pH is in conformity to JSF T 221[Test method for the pH of the soil] [5]

2.3 Humidity control test

2.3.1 Equilibrium moisture adsorption

The test sample was 200 mm x 200 mm, 12 or 20 mm in thickness. The sample surface except the front surface (200 mm × 200 mm) was covered by aluminum tape etc. in order to prevent adsorption and desorption of moisture via the back surface and the side surface. The humidity control test method is shown in Fig. 4. The test sample was placed in RH=53% until adsorption equilibrium was reached.

In the first test step from 0 hour to 168 hours, relative humidity of the test chamber was adjusted to 75 % at 23°C.

2.3.2 Moisture adsorption and desorption

In the first test step from 0 hour to 24 hours, relative humidity of the test chamber was adjusted to be 75 %, and in the second period after 24 hours to 48 hours relative humidity was 53 %. Moisture content of the sample measured automatically every 5min.

2.4 Chemical compounds adsoption test

The test sample was 100 mm x 100 mm, 10 mm in thickness. The test sample was dryed at 105 °C for 12 hour. Formaldehyde and ammonia were selected as adsorbed gas. The initial gas concentration was 100 ppm in a chamber at 23 °C. Detector tube was used for measurement of chemical compounds in the chamber.

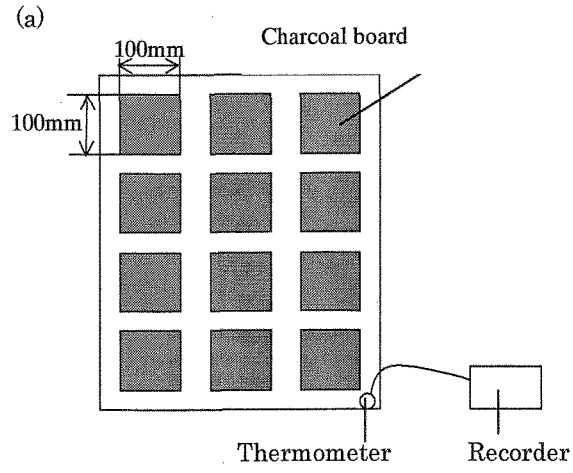

Fig.2 Layout of charcoal board set in soil.
(a) plane and (b) cross section.

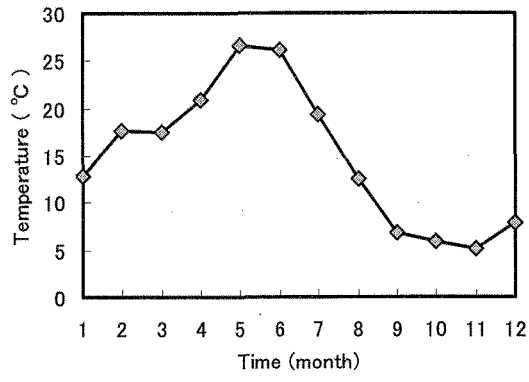

Fig.3 Temperature change of soil at 100mm in depth.

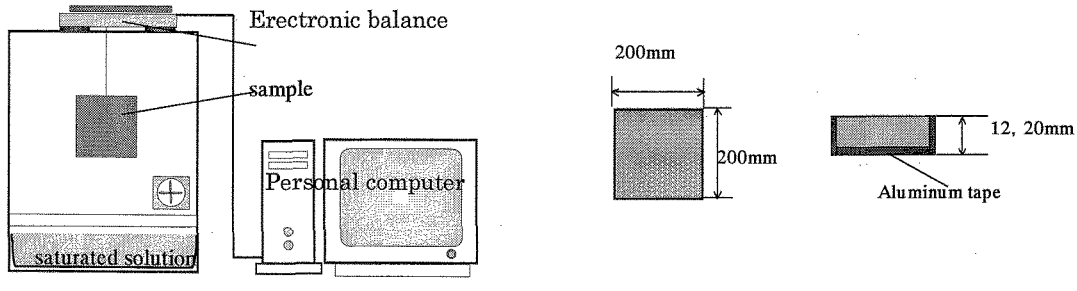

Fig.4 Method for measurement of humidity control test.

3. RESULTS AND DISCUSSION

3.1 Biodegradation property

The charcoal board was grubbed every one month and the shape was observed. Result of biodegradation test is shown in Photo. 1. From one to three months the shape of the board is observed to be almost constant. The samples after 4 and 5 months are softened. After 6 months the sample separated to the small fragments and reverted partially to the charcoal powder. This is because cellulose and collagen fibers as a binder were biodegraded by micro natural microbiological activities [6].

3.2 pH and electric conductivity of soil

Change of pH and electric conductivity of soil neighboring on the samples are shown in fig. 5. The pH of 8 is observed throughout the year. The electric conductivity of soil is constant of ca. 200 μ S/cm as same as the pH change. These results mean that chemical ions making soil basic and acidic property are not evolved during the biodegradation of the board.

3.3 Humidity control

Moisture adsorption curves of the charcoal board under relative humidity of 75% are shows in fig. 6. Compared with the adsorbability of the different thickness boards, the adsorbing rate in the initial state is same, because adsorbing area of 200 x 200 mm^2 is the same between them. Adsorbed moisture amount is dependent on the amount of the charcoal. Equilibrium moisture content of about 130 g/m^2 and 75 g/m^2 is for the sample 20 mm and 12 mm in thickness, respectively. This shows that the moisture diffuses into the charcoal of the inner region of the board.

Charcoal adsorbs and desorbs moisture depending on the relative humidity of the environment. The humidity control test is shown in Fig. 7. In the first test step from 0 hour to 24 hours, relative humidity of the test chamber was adjusted to be 75 %. Under relative humidity of 75 %, the charcoal board adsorbs moisture up to 100 g/m^2, and then under 53 % moisture amount in the charcoal board decreases until 30 g/m^2. That is, the charcoal board releases moisture of 70 g/m^2 in the second step.

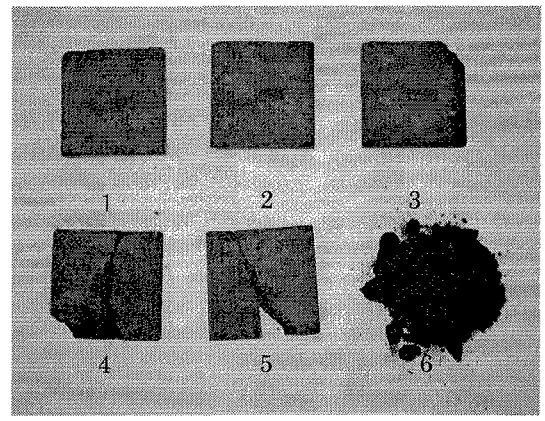

Photo.1 Photographs of grubbed samples.
(1)-(6): after biodegradation test for 1~6 month.

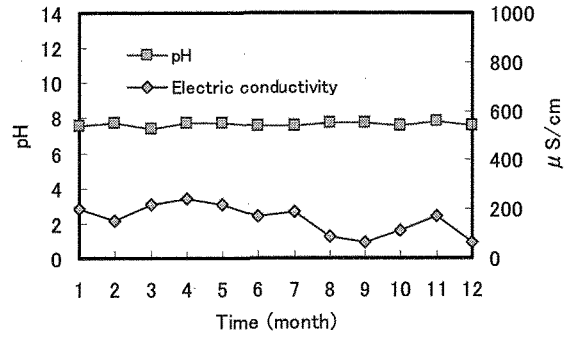

Fig.5 pH and electric conductivity change of soil at neighboring on the sample.

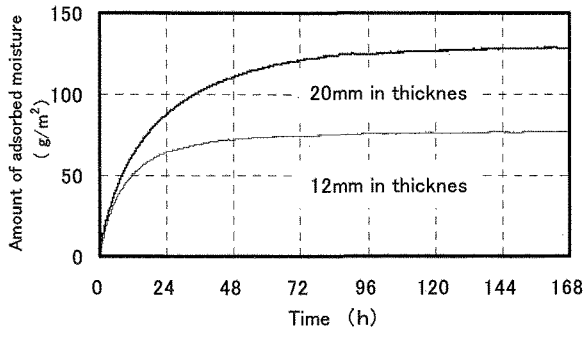

Fig.6 Moisture adsorption curves of the different thickness boards.

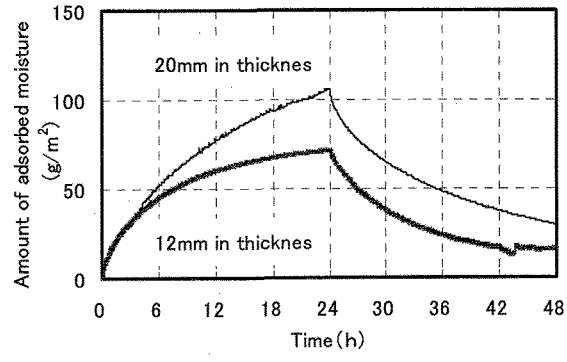

Fig.7 Moisture adsorption and desorption

3.4 Chemical compound adsorption

As the charcoal has porous structure, chemical compounds can be adsorbed into the pore surface. Fig. 8 shows result of adsorption test of formaldehyde by charcoal board. Formaldehyde was selected as adsorbed gas. The initial gas concentration is 100 ppm in a chamber. The gas concentration decreases with increasing adsorption time. After 300 minutes the charcoal board adsorbs almost gas.

In the same manner, ammonia concentration decreases with increasing adsorption time, as shown in Fig. 9. Ammonia gas of 100 ppm in the tedla bag is almost adsorbed after 400 min.

This means that using superfine natural fibers as a binder, adsorbabilits of the charcoal is maintained, because superfine natural fibers dose not cover micropore on the charcoal surface. In the case of using polymer resin as a binder the adsorbability of the charcoal should decrease, because polymer covers the micropores of the charcoal. The charcoal board can be expected to be applied for building materials of Healthy Housing [7].

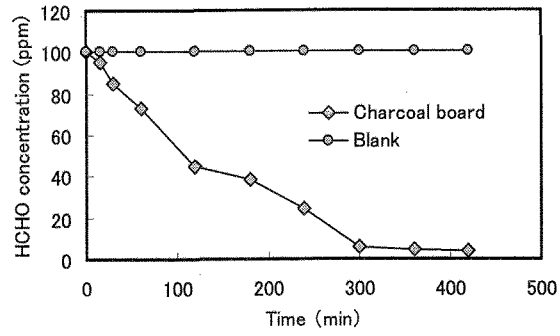

Fig.8 Formaldehyde adsorption by the board

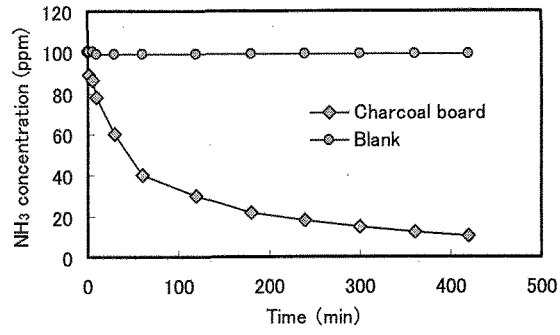

Fig.9 Ammonia adsorption by the board

5. SUMMARY

The charcoal board was prepared from carbonized material powders with superfine natural fibers. This is because cellulose and collagen fibers as a binder were biodegraded by micro natural microbiological activities, and the sample separated to the small fragments and reverted partially to the charcoal powder. Chemical ions making soil basic and acidic property were not evolved during the biodegradation of the board.

It was confirmed that the charcoal board adsorbed formaldehyde and ammonia, and adsorbed and desorbed moisture. When charcoal powder was adhered with the superfine fibers, the ability of the performance of charcoal was maintained in the charcoal board.

6. ACKNOWLEDGMENT

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