Preliminary

Research and Development of Carbon Composites from Wood Charcoal for Environmental Clean-up and their Applications*[1]

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Introduction

Recently, attempts to purify the waste water systems which are heavily polluted with various detrimental and toxic substances have been attracting interests in the field of environmental protection.

Activated carbons, charcoal activated with steam or carbon dioxide at higher temperatures[1)], have been widely used as adsorbents for the water treatment of industrial waste water and drinking water[2,3)] or for removal of metal ions from liquid solutions[4)].

Although wood has been essentially excluded as a starting material for the production of activated carbon because of its poor strength and friability[5)], powder-wood based activated carbons are still being used in water treatment and other applications of liquid purification. However, the capability of powder-wood based charcoal to use as adsorbent is not yet known in detail and few studies have been conducted in harnessing its potential as adsorption materials especially in water treatment.

This study was conducted to investigate the possibility of using carbonized wood materials from sugi (*Cryptomeria japonica* D. Don) as adsorbent materials in single and mixture aqueous solutions of some of the toxic materials such as heavy metals.

Materials and Methods

Small diameter logs were cut into flakes and ground to powder and they were carbonized at varying temperatures at 200, 400, 600, 800, 1000, 1200, 1400, 1600, 2000 and

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2400°C using a furnace. Single and mixture solutions of heavy metals of mercury (Hg), lead (Pb), zinc (Zn), arsenic (As) and cadmium (Cd) were prepared at 1, 5, 10, 50 and 100 ppm concentrations, and carbonized wood powder, raw wood powder and activated charcoal were mixed in these solutions as the adsorbents. The mixed solutions were stirred continuously in a constant temperature bath at 30°C for different periods. The concentration of heavy metal in the filtrates were analyzed using atomic absorption spectrometer or Inductively Coupled Plasma to determine the adsorptive capacity of the samples. The physical, chemical and anatomical characteristics of wood carbonized at different temperatures were also evaluated.

Results and Discussion

In low concentrations of mercuric chloride solutions, carbonization was not necessary when using wood powder as adsorbents. The tested materials have sufficient capacities to adsorb the mercury in the solutions although the adsorption rate varies depending on the type of adsorbents. Only small amounts of lead and zinc were adsorbed in raw wood powder and wood powder carbonized at low temperatures. Wood powder carbonized at 1000°C showed the limited capacity for adsorbing lead and zinc although the adsorption rate was very fast. All types of adsorbent attained the saturation point within only one hour for any kinds of heavy metals.

When different metallic compounds were present in a solution, the adsorption followed a certain order depending on the metal-base. The presence of different metal ions in a solution in equal quantities decreased the adsorption of each of them. Apart from the fact that the metal ion was selectively adsorbed, the one was preferentially adsorbed preventing the adsorption of other ions. In this study, mercury was found to be more readily adsorbable and followed by lead. Arsenic and cadmium were not adsorbed in wood charcoal at all except in activated charcoal[6].

Wood powder carbonized at higher temperature have higher adsorption capacity than activated charcoal, raw wood powder, and wood powder carbonized at lower temperature. However, further increase in the carbonization temperature reduced the adsorptive effectivity of wood charcoal and it was assumed that the optimum range of carbonization temperature existed from 1000 to 1400°C.

In highly concentrated aqueous solutions of mercuric chloride, carbonized wood powder could still be used as adsorbent with a greater adsorptive power than activated charcoal (Fig. 1). The maximum capacity of adsorption was found to be higher in wood powder carbonized at 1000°C than raw wood powder and wood powder carbonized at 200°C or 600°C as well as activated charcoal. The optimum soaking time was also shorter, that was, 1 hour for 1000°C carbonized charcoal compared to 8 hours for activated charcoal.

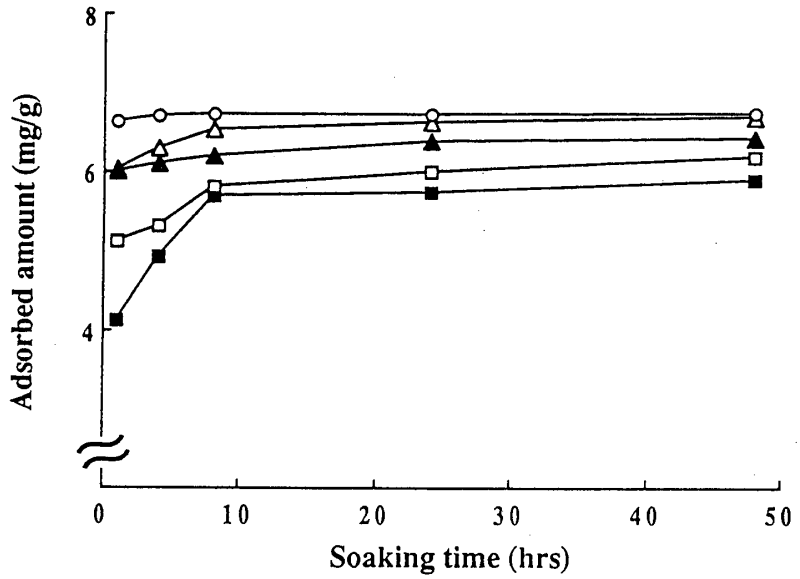

Fig. 1. Relationship between soaking time and adsorbed amount of mercury in different adsorbent materials.
Note: One gram of each adsorbent material was mixed into 50 ml of 50 ppm $HgCl_2$ aqueous solutions.
Legend: ■ Wood powder ovedried at 105°C
□ Wood powder carbonized at 200°C
△ Wood powder carbonized at 600°C
○ Wood powder carbonized at 1000°C
▲ Activated charcoal from coconut shell powder

Although raw wood powder and wood powder carbonized at 200 and 600°C showed the relatively larger pores with non-uniform distribution, the wood powder carbonized at 1000°C created micropores of specific dimensions which was similar to that of the activated charcoal. The large value of the cumulative pore volume was also observed for the wood powder carbonized at the higher temperature. The large difference of the specific surface area was detected between wood powder carbonized at 600 and 1000°C, and the value increased rapidly as the carbonization temperature was raised up.

SEM observations visualized the cellular structure of carbonized wood with the peculiar features of the cell walls even the high carbonization temperature at 2400°C was applied.

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