# EFFECT OF CARBONIZATION TEMPERATURE OF WOOD ON THE ADSORPTION PROPERTY

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## Introduction

Since charcoal carbonized from wood and bamboo has porous microstructure, chemical compounds can be adsorbed into the pore surface. The charcoal board as a building interior material has been newly developed by adhering charcoal powder with binder.[1][2][3][4] The charcoal board is able to adsorb volatile organic compounds (VOCs) such as formaldehyde, toluene and ammonia.

The specific surface area, the pore radius distribution and the chemical structure of the pore surface depend upon the carbonization temperature of wood, and consequently the adsorption capability of VOCs is influenced by the carbonization temperature.[5][6]

In this report, we studied the effect of carbonization temperature of wood on the absorption property of the charcoal. Formation of the micro pore is discussed from the results of the pore radius distribution and the specific surface area estimated by using different adsorbates.

## Experimental

Carbonization
Chips of sap wood of Hinoki (Chamaecyparis obutusa) several mm in size were used as a low material. Apparatus for carbonization of wood is shown in Figure 1. Wood chips of about 10 g were placed in the center of a quartz tube of 113 mm in inner diameter and 600 mm in length. The quarts tube was heated in a cylindrical electric furnace. Nitrogen gas was introduced in to the quartz tube at the rate of 200 $cm^3$/min during the carbonization process. The sample was heated to the carbonization temperature from 400$^oC$ to 1000$^oC$ with a heating rate of 20$^oC$/min and held at the carbonization temperature for 120 min. After the carbonization, the sample was cooled to room temperature with furnace cooling for about several hours.

Adsorption isotherms
The adsorption isotherms for the charcoals were measured with the BELSORP18. In order to eliminate gas component and $H_2O$ from the surface of the charcoal pore, the charcoal sample of 0.2 g in the sample tube was heated at 305$^oC$ for 5 hour in vacuo.

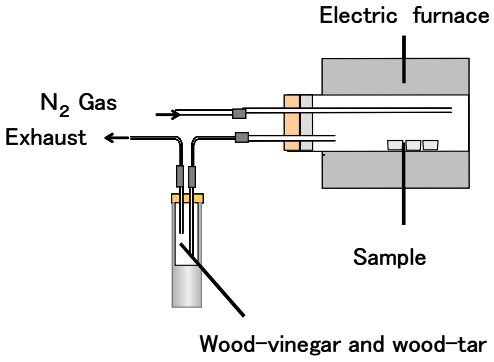


Figure 1. Apparatus for carbonization

$N_2$, $CO_2$ and $H_2O$ were used as adsorbates which were absorbed into the charcoal at 77 K, 195 K and 298 K, respectively. The specific surface area and the pore radius distribution of the charcoal were estimated with BET equation and HK plots, respectively, applied for the adsorption isotherms.

## Results and Discussion

The adsorption isotherms of $N_2$, $CO_2$ and $H_2O$ for the charcoal carbonized at 800$^oC$ are shown in Figure 2. In the $N_2$ adsorption at 77K and in the $CO_2$ adsorption at 195 K and 298 K, the I-typed adsorption isotherm is observed where abrupt increase in the low pressure region, which suggests the existence of micro pores in the charcoal. In the $H_2O$ adsorption at 298 K, the IV-typed adsorption isotherm is observed showing the existence of meso pores and macro pores in the charcoal.

Distributions of pore radius of the charcoals carbonized at temperatures from 400$^oC$ to 1000$^oC$, which are estimated in the $N_2$ adsorption isotherms, are shown in Figure 3.

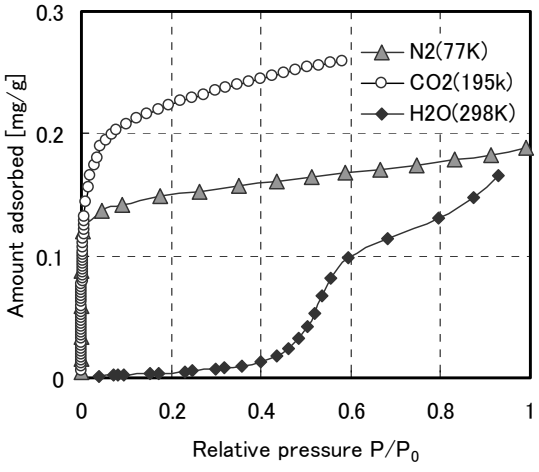


Figure 2. Adsorption Isotherms of $N_2$, $CO_2$ and $H_2O$ for the charcoal carbonized at 800$^oC$

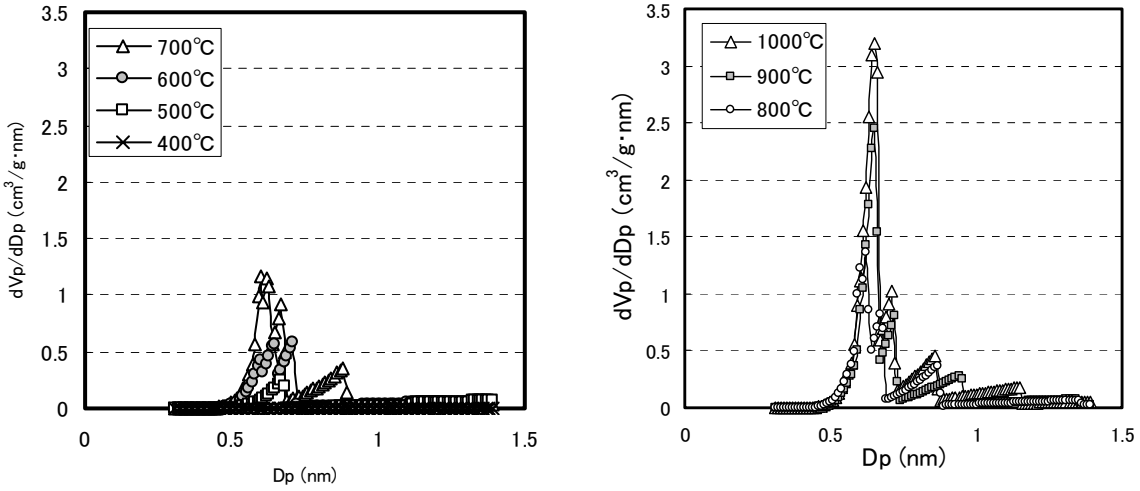


Figure 3. Distribution of pore radius of the charcoal estimated by $N_2$ adsorption at 77K

In the distribution of the charcoal carbonized at 400°C, no pores of diameter under 1.5 nm are observed. Peaks at ca. 0.7 nm are observed in the charcoals prepared at 500°C and 600°C. In the charcoals carbonized at 700°C and 800°C, the peak at 0.6 nm increases and new peak at 0.9 nm appears.

Figure 4 shows change of the specific surface area of the charcoals vs. the carbonization temperature from 400°C to 1000°C. In $N_2$ adsorption experiment the specific surface area increases with increasing the carbonization temperature, which corresponds to the results of the pore radius distribution in Figure 3. In the charcoal carbonized at 400°C, the specific surface area is small value, 10 $m^2$/g. However, the specific surface volume estimated by $CO_2$ adsorption for the charcoal carbonized at

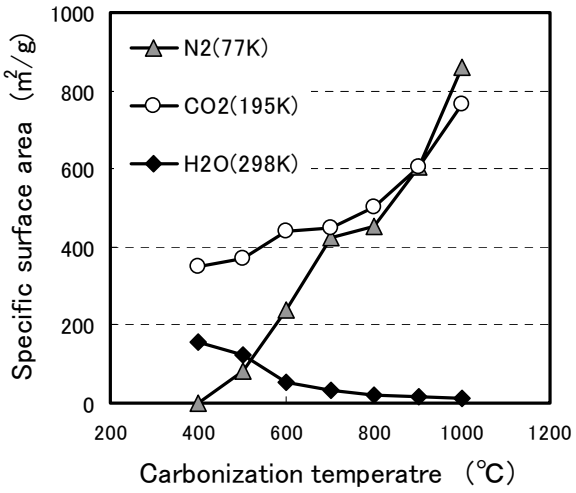


Figure 4. Temperature dependence of specific surface area of the charcoals estimated by $N_2$, $CO_2$ and $H_2O$.

400°C is 380 $m^2$/g, and the value increases gradually with the increase of the temperature. These results suggest that in the lower carbonization temperature the number of sub-nm pores increases.

The specific surface area estimated by $H_2O$ adsorption decreased from 150 $m^2$/g to 20 $m^2$/g with increase of the carbonization temperature from 400°C to 1000°C. This suggests that functional groups on the inner surface of the charcoal degrade and diminish as the carbonization of wood proceeds.

## Conclusions

It was found that carbonization temperature affects the adsorption of chemical compounds; $N_2$, $CO_2$ and $H_2O$ were selected as adsorbate gas. The specific surface area of the charcoals was estimated with the BET equation. The charcoal carbonized at 400°C had the specific surface area of 10 $m^2$/g by $N_2$ adsorption at 77 K and of 380 $m^2$/g by $CO_2$ absorption at 195 K. The specific surface area by $N_2$ and $CO_2$ increased with increasing the carbonization temperature. These results show that in the lower carbonization temperature the number of sub-nm pore increases. The specific surface area by $H_2O$ decreased. This suggests that functional groups on the inner surface of the charcoal degrade and diminish as the carbonization of wood proceeds.

## References

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