Diamagnetism of Pitch-based Carbon Fibers

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INTRODUCTION

One of the present authors (K.K.) with other research workers has measured diamagnetic susceptibility of benzene-drived and PAN-based carbon fibers between 77K and 300K, and has studied the relation between susceptibility and structure [1].

Benzene-drived fiber (hereafter BDF) is considered to be fibrous pyrolytic graphite and its structural change with H.T.T. is essentially the same as that of graphitizing carbon. On the other hand, PAN-based carbon fiber is a typical non-graphitizing carbon material, the three dimensional structural modification of which cannot be obtained easily by simple heat treatment.

In the present work, diamagnetic susceptibility of the pitch-based carbon fibers has been measured as a function of temperature, certain measurements being extended down to liquid helium temperature.

EXPERIMENTAL

Pitch-based carbon fibers are prepared by Nippon Steel Corporation and heat treated step wise at six temperatures between 1900 ℃ and 2900℃.

The specimen for susceptibility measurement is a bundle of fibers cut about 5mm in length tied with a thin cotton thread.

The magnetic susceptibility was measured by the Faraday method using Cahn RG and R2000 type electrobalances, The susceptibility was measured in two directions: the magnetic field applied perpendicular ($\chi_{\perp}$) and parallel ($\chi_{//}$) to the fiber axis. The method and specimen arrangement are essentially the same as those for BDF and PAN carbon fibers.

RESULTS AND DISCUSSION

Fig. 1 shows $\chi_{\perp}$ of the six specimens as a function of temperature between 77K and 300K. The $\chi_{\perp}$ value of the specimen heat treated at 1900℃ is considerably smaller than those of other specimens and it is almost independent of temperature. The magnitude of $\chi_{\perp}$ increases and its temperature dependence becomes more marked with H.T.T. between 2100℃ and 2500℃. However, the magnitude for specimens heat treated above 2500℃ becomes smaller than that heat treated at 2500℃.

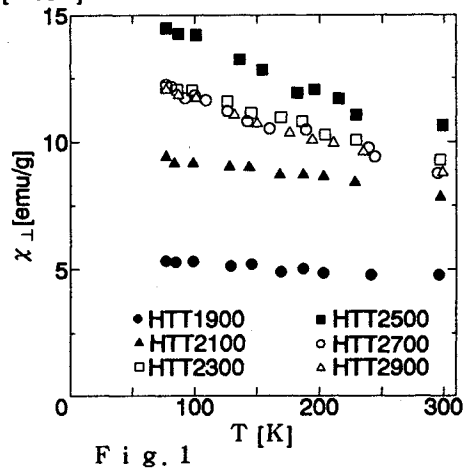

Fig. 1

$\chi_{//}$ is almost temperature independent for all the specimens and their magnitude is about 10% of $\chi_{\perp}$.

A conventional total susceptibility may be defined by $\chi_T=2\chi_{\perp}+\chi_{//}$, which gives structural information of carbon fibers.

Fig. 2 shows χ_T measured at 77K and 300K as a function of H.T.T.. The value of χ_T increases with H.T.T. up to 2500℃ and then decreases with H.T.T.. This indicates that heat treatment below 2500 results in the grow of hexagonal carbon network without significant ordering of the three dimensional stacking, while heat treatment above 2500℃ accelerates the three dimensional stacking. Therefore, the structure of pitch-based carbon fibers heat treated below 2500℃ is quite similar to that of quasi two dimensional turbostratic carbon.

Fig. 3 shows χ_T of certain representative specimens as a function of temperature between 4.2K and 300K. It is clearly shown that all the specimens have a peak at lower temperatures. This is characteristic of all carbon materials so far examined and also observed in the present work for carbon fibers. The increase of χ_T value with temperature at lower temperatures corresponds to the excitation of electrons to the N=0 Landau level, and its decrease with temperature at higher temperatures reflects the thermal broadening of the Fermi-Dirac distribution.

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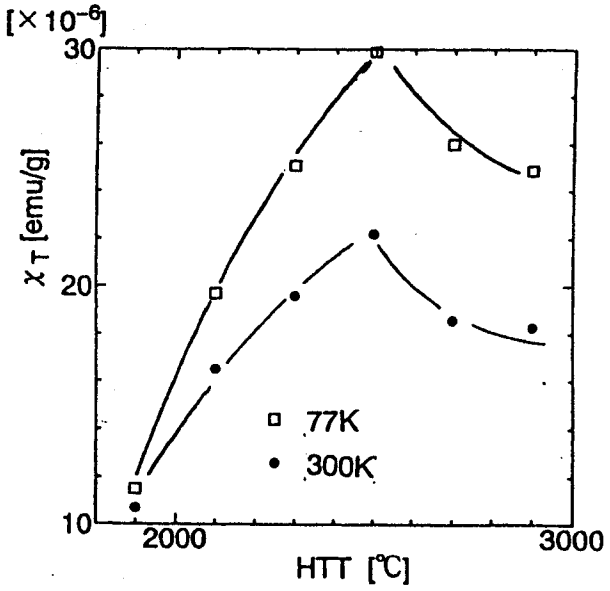

Fig.2

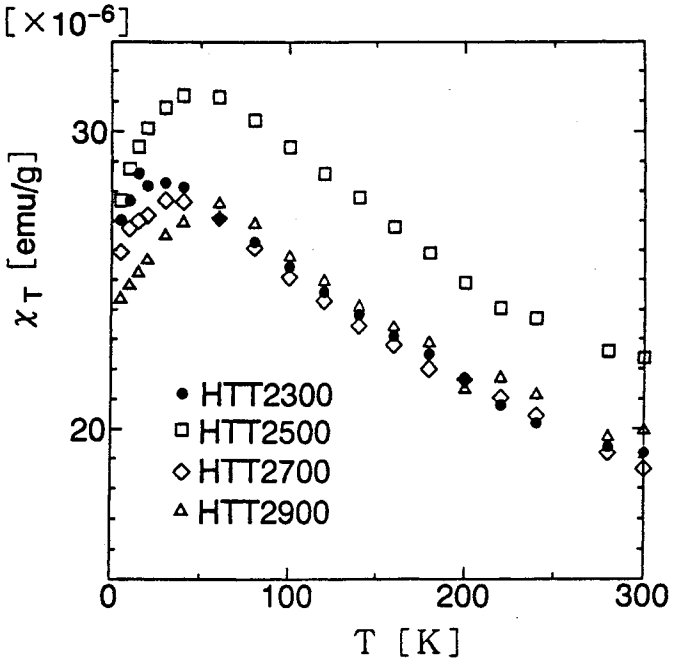

Fig.3

REFERENCES

1. K. Matsubara, K.Kawamura and T. Tsuzuku, Japan. J. Appl. Phys. 25, 1016 (1986)