Freezing and Melting of Water in Mesoporous Carbon

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Freezing and melting of water confined in a restricted space is directly relevant to many phenomena such as freezing injury of plants, stone weathering, and cloud formation. In the graphitic pores of ordeed mesoporous carbons that are free of micopores and almost free of surface functional groups, water does not form an adsorbed film on the pore walls as the pressure approaches the saturation pressure of the bulk liquid (p^0) because water does not form hydrogen bonds with the carbon surfaces. Nevertheless, a large uptake of water vapor occurs very slowly close to p^0 due to capillary condensation of water. [1] To examine the effect of pore-wall properties on freezing/melting behavior of water in meopores, we measured the X-ray diffraction (XRD) pattern of water confined in the almost cylindrical pores of the mesoporous carbons during cooling and heating processes.

Three kinds of mesoporous carbons were prepared by a soft template method via self-assembly of resorcinol-formaldehyde and Pluronic F127 triblock copolymer according to the modified procedure of Wang, et al. [2] Graphitization was carried out in a high-temperature furnace under argon atmosphere at 2473 K for 1 h, in order to eliminate micropores inherent of porous carbon. Most of XRD measurements were carried out with Mo Kα radiation in a symmetrical transmission geometry.

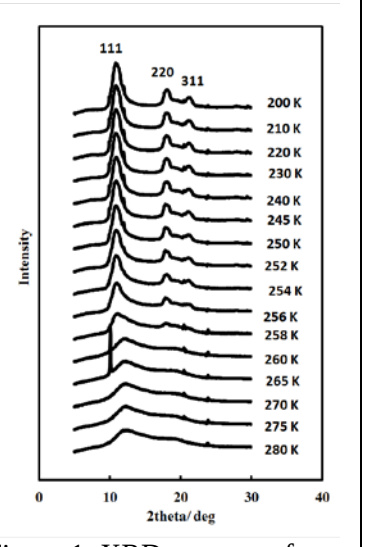

Figure 1: XRD patterns of water confined in mesoporous carbon of pore-radius 4.8 nm during a cooling process.

As Fig.1 shows, a confined water began to freeze at 258 K and formed cubic ice on cooling. The frozen water melted at 262 K on heating. These freezing/melting temperatures are almost identical to those observed for mesoporous silica with similar pore size, although the pore walls of the mesoporous carbon are crystalline and do not form hydrogen-bonding with water unlike mesoporous silica. This indicates that the freezing/melting behavior of a confined water does not depend appreciably on the properties of pore-wall confining it, in sharp contrast that capillary condensation of water is significantly affected by the poperties of pore-wall. The XRD patterns of ice formed in mesoporous carbons were almost the same as those in mesoporous silicas with similar pore sizes.

References

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[2] X, Wang, C. Liang, and S. Dai, Langmuir **24**, 7500 (2008).

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