Phase Diagram of ^{4}He Adsorbed in 1D 2.4 nm Nanopores of FSM

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Superfluidity of ^{4}He adsorbed in one-dimensional (1D) nano-channels of FSM has been observed by the torsional oscillator experiment[1]. The superfluid properties depend on the pore diameter as well as the coverage (the amount adsorbed). Here, we studied the state of ^{4}He adsorbed in 2.4 nm diameter 1D pores as a function of the coverage by measuring the pressure for adsorption and heat capacity. In the 2.4 nm pores, uniform ^{4}He layers are formed up to about 1.7 atomic layers. At the lower coverages than about 1.1 layers, the ^{4}He atoms are localized below a temperature T_{L} which lowers with increasing the coverage. The heat capacity isotherms have maxima n_{B} about 1.4 layers. The decrease of heat capacities above n_{B} indicates Bose quantum fluid layers on inert layers, where qualitatively different low-temperature heat capacities between ^{4}He and ^{3}He isotopes were adsorbed in other pore diameter FSM. The ^{4}He superfluid is observed above about 1.5 layers. Since the inert-layer thickness is estimated to be about 0.55 nm, the tubes (or column) of the ^{4}He fluid about 1.3 nm in diameter shows the superfluidity. The fluid tubes are likely to be in a 1D state at low temperatures where the thermal phonon wavelength is longer than the tube diameter.

[1]N. Wada, Y. Minato, T. Matsushita, M. Hieda, J. Low Temp. Phys. **162**, 549 (2011). H. Ikegami, et.al., Phys. Rev B. **76**(14), 144503 (2007).