Superconducting Characteristics of 4-Å Carbon Nanotube–Zeolite Composite*

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Following the discovery of superconductivity in doped buckyballs [1] and proximity-induced superconductivity in carbon nanotubes [2], a natural question arises whether pure carbon can superconduct in any of its natural forms. While superconductivity has been widely observed in many material systems, its existence in pure, undoped carbon structures is still an intriguing problem. Single and very thin carbon nanotubes are essentially one-dimensional (1D) systems and it is well known that 1D systems do not exhibit phase transitions and superconductivity, owing to fluctuation effects and the Peierls structural instability [3-6], which will always make a 1D system insulating. But what happens when the carbon nanotubes are bundled or when they are in the form of multiwalled nanotubes? Then the possibility of superconductivity becomes real.

We have fabricated nanocomposites consisting of 4-Å carbon nanotubes embedded in the 0.7-nm pores of aluminophosphatefive zeolite that display a bulk superconducting specific-heat transition at 15 K [7]. The transition is suppressed at >2 T, with a temperature dependence characteristic of finite-size effects. Four-probe resistance measurements also indicate a superconducting transition initiating at 15 K. Two types of resistive transitions are found in different samples: One is characteristic of thin nanotube bundles with strong fluctuation effects for which the resistance decreases continuously from 15 K towards zero at T=0. A magnetic field has a negligible effect in this case. The other type is characteristic of coupled Josephson arrays, with a slow resistance decrease starting at 15 K switching to a sharp, order of magnitude drop at ~7.5 K. In the latter case the transition exhibits strong field dependence with a clear anisotropy. These experiments clearly confirm superconductivity in carbon nanotubes. At the same time, many intriguing phenomena not yet completely understood have been revealed. These open questions represent theoretical and experimental challenges to be further pursued.

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[1] A.F. Hebard *et al.*, Nature 350 (1991) 600, K. Tanigaki *et al.*, Nature 352 (1991) 222.
[2] A. Yu. Kasumov *et al.*, Science 284 (1999) 1508.
[3] Y. Huang *et al.*, Sol. Stat. Comm. 97 (1996) 303.
[4] K.-P. Bohnen *et al.*, Phys. Rev. Lett. 93 (2004) 245501.
[5] J. Gonzalez *et al.*, Phys. Rev. B 72 (2005) 205406.
[6] D. Connetable *et al.*, Phys. Rev. Lett. 94 (2005) 015503.
[7] Z.K. Tang *et al.*, Science 292 (2001) 2462, R. Lortz *et al.*, PNAS 106 (2009) 7299.