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Insight into friction in carbon nanotubes: guest-host interactions and thermal-driven pinning and unpinning in nanopeapods

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We report a complete neutron scattering investigation of the structure and dynamics of monomer and polymer phases of C_{60} carbon peapods. When the temperature is lowered below 300 K, the temperature evolution of the monomer data reflects a continuous increase of the orientational correlations between adjacent molecules, a signature of the strong rotation-translation coupling in this system. This transition is not observed in the polymer data, the orientation between the confined fullerenes being locked by covalent bridges. Above 200 K, the physics of the confined chain can fully be described without accounting for the nanotube, the latter merely playing the role of a container for a 1D system. As the temperature is lowered below some 200 K, the signature of the chain-tube interaction is observed by the progressive damping of the 1D acoustic phonon measured in both monomer and polymer data. We suggest that this damping originates from the friction between the confined chain and the nanotube host, friction that appears at low temperature due to the pinning of the C_{60} chain onto an incommensurable lattice – the nanotube. These results are supported by molecular dynamics simulations and are discussed within the framework of Aubry's transition by breaking of analycity.

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