Nanotubular Structures of Microtubule Complexes with Spermine and Lipid Membrane

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The self-assembled structures of microtubules (MT) in the presence of spermine and charged membranes were investigated. Small angle X-ray diffraction and electron microscopy revealed several distinct morphologies of assembly. Complexation with spermine induced MT's to transform into a columnar phase of inverted tubules, in which the orientation of the tubulin units was switched from inside out. This rearrangement between two arrays of hierarchically structured nanotubules occurs through a novel phase transition driven by a discrete conformational change in the constituent tubulin subunit. In MT-membrane complexes, two new structures were observed. Depending on conditions, lipid vesicles either adsorb onto the microtubule, forming a 'beads on a rod' structure, or coat the microtubule to form a sheath. Tubulin rings can then coat the external lipid bilayer to form a multi-shell tubular structure with a tubulin-lipid-tubulin radial profile. Kinetic experiments were conducted to shed light on the mechanism of hierarchical complex formation.

Keywords: microtubule, protein nanotube, small-angle x-ray scattering