IESL and TETY seminar

Thursday February 16, 12 noon

FORTH seminar room 1

Peptide nanotubes formed by Lanreotide, an analog of the natural peptide hormone Somatostatine-14: supramolecular structure, mechanism of formation, size control and role of the counterions.

Dr. Maité Paternostre
CEA iBiTec-S / SB²SM & UMR CNRS 8221,
CEA-Saclay, F-91191 Gif-sur-Yvette,
France

Host: Anna Mitraki ext. 4095

Supramolecular self-assembly is an attractive pathway for bottom-up synthesis of novel nanomaterials. In particular, this approach allows the spontaneous formation of structures of well defined shapes and monodisperse characteristic sizes. Since nanotechnology is mainly relying on size-dependent physical phenomena, the control of the monodispersity is required, but the possibility of tuning the size is also essential. For self-assembling systems, shape, size and monodispersity are mainly settled by the chemical structure of the building block. Tentative of changing noticeably the size by chemical modification usually end up with the loss of self-assembly. In this context, Lanreotide is a dicationic octapeptide spontaneously forming long nanotubes (few hundreds of μm) but monodispersed in diameter (24.4nm)[1,2]. Their molecular and supramolecular structure and their mechanism of formation have been recently solved[3]. The most noteworthy feature of these nanotubes is that their walls are curved bi-dimentional crystals and the mechanism of formation of these nanotubes shows that the curvature radius of the nanotube is fixed at a very early stage of the assembly, upholding the idea that molecular determinants are controlling the curvature radius. For diameter tuning, we based our strategy on a structural approach[6]. We modified the size of a precise aromatic amino acid involved in close contacts between peptide within the nanotube walls. We demonstrate that this approach indeed enable the accurate tuning of the diameter of the nanotubes from 9 to 35 nm while keeping a strict monodispersity. We finally build a geometrical model taking into account the close-contact that explains how a modification of a few Å of a single aromatic residue induces a 4-fold increase of nanotube diameter. We further demonstrate the application of such strategy by the formation of composite (silica-peptide) nanotubes of various diameters. We also explored the role of the counterions and repulsive forces in the self-assembly mechanism and by this study we evidence that counterions are tightly bound to the nanotubes and that specific interactions occur[7].

1. Biomimetic organization: Octapeptide self-assembly into nanotubes of viral capsid like dimension. Valery, C. et al. Proceedings of the National Academy of Sciences of the United States of America 100, 10258-10262 (2003).

2. Self-association process of a peptide in solution: from beta-sheet filaments to large embedded nanotubes. Valery, C. et al. Biophys J 86, 2484-501 (2004).
3. Elucidation of the Self-Assembly Pathway of Lanreotide Octapeptide into beta-Sheet Nanotubes: Role of Two Stable Intermediates. Pouget, E. et al. Journal of the American Chemical Society 132, 4230-4241 (2010).
4. Self-assembly of the octapeptide lanreotide and lanreotide-based derivatives: the role of the aromatic residues. Pandit, A. et al. J Pept Sci 14, 66-75 (2008).
5. Molecular origin of the self-assembly of lanreotide into nanotubes: a mutational approach. Valery, C. et al. Biophys J 94, 1782-95 (2008).
6. Control of peptide nanotube diameter by chemical modifications of an aromatic residue involved in a single close contact. Tarabout C, et al. Proc Natl Acad Sci U S A. on line (2011)
7. Structural Role of Counterions Adsorbed on Self-Assembled Peptide Nanotubes Gobeaux F. et al., Journal of the American Chemical Society 2011, in press.