



# 复旦大学物理系物质科学报告

## Physics Department Colloquium

**From Biological Self-Assembly to Novel Peptide Nanostructures of Unique Mechanical, Optical, Piezoelectric and Semiconductive Properties**  
(从生物自组装到具备独特力,光,压电,半导体性能的多肽纳米结构)

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### **Abstract**

Bio-inspired nanotechnology is a key front in the field of molecular self-assembly of new structures and composite families at the nano-scale. Concept and notions from biological self-assembly could allow the design and fabrication of nanomaterials, while molecular self-assembly paradigm could be applied to biological systems. Our works on the mechanism of aromatic peptide self-assembly, lead to the discovery that the diphenylalanine recognition motif self-assembles into peptide nanotubes with a remarkable persistence length. Other aromatic homodipeptides (including those with non-coded amino acids as DOPA) could self-assemble in nano-spheres, nano-plates, nano-fibrils and hydrogels with nano-scale order. The modification of peptide building blocks with the Fmoc protecting group allows the formation of hydrogels with nano-scale order. We demonstrated that the peptide nanostructures have unique chemical, physical and mechanical properties including ultra-rigidity as aramides, semi-conductive, piezoelectric and non-linear optic properties. We also demonstrated the ability to use these peptide nanostructures as casting mould for the fabrication of metallic nano-wires and coaxial nano-cables. The application of the nanostructures was demonstrated in various fields including electrochemical biosensors, tissue engineering, and molecular

imaging. We had developed ways for depositing of the peptide nanostructures and their organization. We had use inkjet technology as well as vapour deposition methods to coat surface and from the peptide “nano-forests”. We recently demonstrated that even a single phenylalanine amino-acid can form well-ordered fibrillar assemblies of distinct electron diffraction pattern and toxic properties. The combination of DNA properties and peptide backbone in the form of Peptide Nucleic Acid (PNA) resulted in light emitting assemblies that exhibit both stacking and Watson-Crick base-pairing. We recently extended our studied to single amino acids and metabolites. We established the concept that even these entities can form well-ordered assemblies with amyloid like properties including ultrastructural morphology, toxicity leading to apoptosis, ThT-binding, and Congo-red birefringence.

1. Reches, M. and Gazit, E. (2003) Casting Metal Nanowires within Discrete Self-Assembled Peptide Nanotubes. **Science** 300, 625-627.
2. Reches, M. and Gazit, E. (2006) Controlled Patterning of Aligned Self-Assembled Peptide Nanotubes. **Nature Nanotechnology** 1, 195-200.
3. Adler-Abramovich L., Aronov D., Beker P., Yevnin M., Stempler S., Buzhansky L., Rosenman G. and Gazit E. (2009) Self-Assembled Arrays of Peptide Nanotubes by Vapour Deposition. **Nature Nanotechnology** 4, 849-854.
4. Adler-Abramovich, L., Vaks, L., Carny, O., Trudler, D., Frenkel, D., & Gazit, E. (2012) Phenylalanine Assembly into Toxic Fibrils Suggests Amyloid Etiology in Phenylketonuria. **Nature Chem. Biol.** 8, 701-706.
5. Levin, A. Mason, T. O., Adler-Abramovich, L., Buell, A. K., Meisl, G., Galvagnion, C., Bram, Y., Dobson, C. M., Knowles, T. P. J., & Gazit, E. (2014) Ostwald’s Rule of Stages Governs Structural Transitions and Morphological Control of a Dipeptide Supramolecular Polymer. **Nature Commun.** 5:5219.
6. Berger, O., Adler-Abramovich, L., Levy-Sakin, M., Grunwald, A., Liebes-Peer, Y., Bachar, M., Buzhansky, L., Mossou, E., Forsyth, V. T., Schwartz, T., Ebenstein, Y., Frolow, F., Shimon, L. J.W., Patolsky, F. and Gazit E. (2015) Light Emitting Self-Assembled Peptide Nucleic Acids Exhibit Both Stacking and Watson-Crick Base-Pairing. **Nature Nanotechnology** 10, 353-360.
7. Shaham-Niv, S., Adler-Abramovich, L., and Gazit E. (2015) Extension of the Generic Amyloid Hypothesis to Non-Proteinaceous Metabolite Assemblies. **Science Adv.** 1:e1500137
8. Mondal, S., Adler-Abramovich, L., Lipman, S., and Gazit E. (2015) Formation of Functional Super-Helical Assemblies by Constrained Single Heptad Repeat. **Nature Commun.** 6:8615.

**Time: 2:00pm, Tuesday, 2015.11.24**

**Location: Physics Building, Room 221B**

**(Cookies and coffee are served from 1:30 pm)**