Self-Assembly of Nanoscale Colloids

Prof. Nicholas A. Kotov

Departments of Chemical Engineering, Materials Science and Engineering, Biomedical Engineering, University of Michigan, Ann Arbor, MI;   kotov@umich.edu

Self-organization of nanoparticles (NPs) and nanoscale objects in general represents one of the most dynamic areas of modern science. Better understanding of these phenomena is important from both fundamental and practical perspectives because nanoparticle self-organization processes

(1) identify similarities between biological and non-biological nanoscale species;
(2) lead to unusual optical properties from different combinations of nano- and microscale features;
(3) can potentially simplify manufacturing of electronic, photonic, and sensing devices.

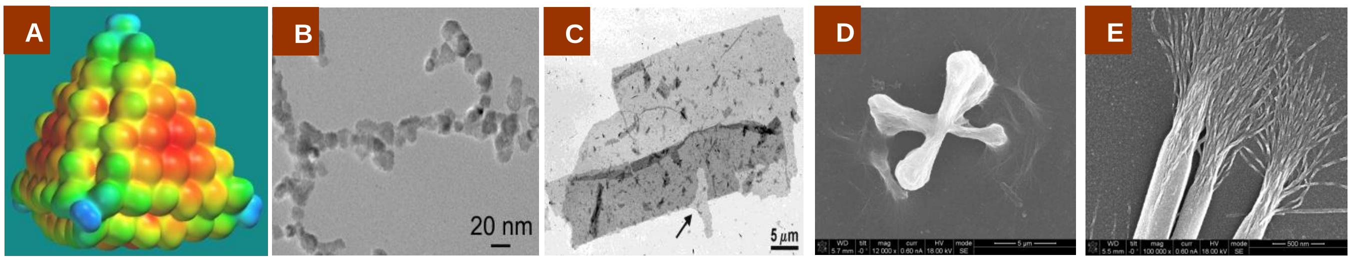

Figure 1: (A) Atomic model of CdTe NPs used in quantum mechanical calculations. (B) Self-assembled chains of ZnO NPs. (C) Self-assembled NP sheets from CdTe NPs. (D) Transient "dog-bone" 3D assemblies of CdTe NPs. (E) Twisted nanoribbons.

Over a period of last decade we demonstrated that intricate 1D, 2D, and 3D systems from CdTe, CdS, Au, ZnO NPs could be formed. It was achieved by exercising fine degree of control over attractive and repulsive interactions between the NPs. Pivotal roles in expanding the variety of self-assembled structures were attributed to factors determining anisotropy of the force fields around NPs: geometry of the NP facets, crystal lattice, dipole moments, distribution of a stabilizer, and intrinsic chirality of the NP cores. Rationalization of the topology of the self-assembled structures (Figure 1) in the framework of different contributions to the force fields, such as electrostatic, dipolar, hydrophobic forces, and hydrogen bonding will be presented. Fine tuning of the interactions also resulted in dynamic NP assemblies capable of restructuring in response to different media parameters.

The analysis of the self-assembly processes for NPs also revealed surprising analogies with self-organization behavior of biological macromolecules. The idea of NP-protein analogy can also extended not only to geometry but to biological functions of proteins. Latest data on the design of inorganic biomimetic inhibitors, enzymes, and cellular signaling agents based on inorganic NPs will be presented. Advantages and limitations of protein replications by nanocrystals will be discussed. The latest results will also include the finding of NP assemblies into structures reminiscent of viruses. Such systems open a new pathway to the manufacturing of complex self-assembled systems in large quantities.

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