Self-Assembly of Nanoscale Colloids

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Self-organization of nanoparticles 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.

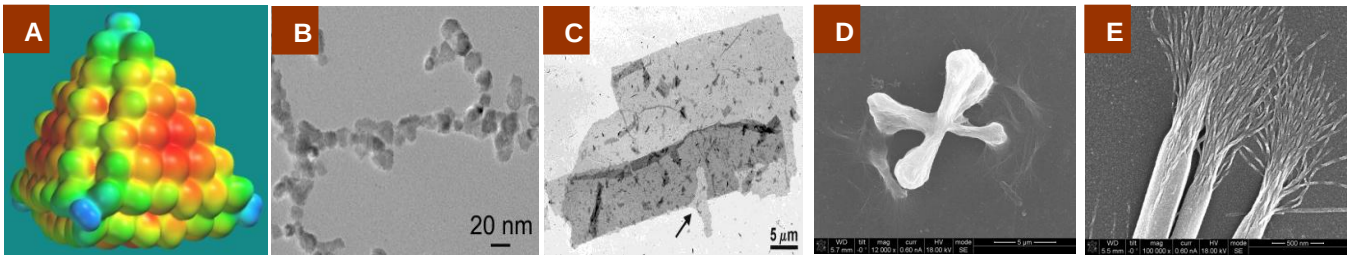

Figure 1: (A) Atomic model of CdTe NPs used in quantum mechanical calculations. (B) Self-assembled chains of ZnO NPs. (C) Self-assembled NP sheets from CdTe NPs. (D) Transient "dog-bone" 3D assemblies of CdTe NPs. (E) Twisted nanoribbons.

Over a period of last decade we demonstrated that intricate 1D, 2D, and 3D systems from CdTe, CdS, Au, ZnO nanoparticles could be formed. It was achieved by exercising fine degree of control over attractive and repulsive interactions between nanoparticles. Pivotal roles in expanding the variety of self-assembled structures were attributed to factors determining anisotropy of the force fields around nanoparticles: geometry of the nanoparticle facets, crystal lattice, dipole moments, distribution of a stabilizer, and intrinsic chirality of the nanoparticle 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 finding dynamic nanoparticle assemblies capable of restructuring in response to different media parameters.

The analysis of the self-assembly processes for nanoparticles also revealed surprising analogies with self-organization behavior of biological macromolecules. Besides examples mentioned above, a case of self-assembly of inorganic analogs of viral capsids was also demonstrated. The idea of nanoparticle-protein analogy was also extended to other protein functions. Latest data on the design of inorganic biomimetic inhibitors, enzymes, and cellular signaling agents based on inorganic particles will be presented. Advantages and limitations of protein replications by nanocrystals will be discussed.

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