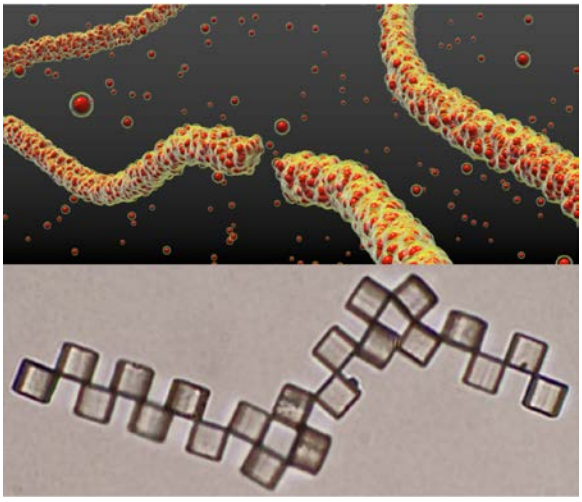
Dynamically Reconfigurable Soft Matter in External Fields: Smart Particle Gels, Engineered Clusters and Self-Propelling Microbots

Orlin D. Velev

Department of Chemical and Biomolecular Engineering
North Carolina State University, Raleigh, NC 27695, USA
odvelev@ncsu.edu; http://crystal.che.ncsu.edu/

This talk will present strategies for electric and magnetic field driven assembly and manipulation of a rich variety of dynamic structures from soft matter. We have shown earlier how metallo-dielectric Janus/patchy spheres and microcubes acquire complex polarization patterns in external fields, leading to multidirectional interactions and assembly. Now we will first describe how magnetically responsive Janus microcubes can be assembled hierarchically into dynamically reconfiguring microclusters and chains. The residual polarization of the metal-coated facets leads to magnetic interactions and reconfiguration, directed by the orientational sequence of the microcubes in the chains. The pre-assembled clusters can be reversibly actuated, oriented and spatially transported by magnetic fields. They are capable of grabbing and transporting target micro-objects and serve as prototypes of new microbot and colloidal origami structures. They can also be designed to be self-motile in media with non-Newtonian rheology. In the second part of the talk, we will describe a new smart gel system of ultraflexible chains from magnetically responsive nanoparticles inside multiphase water-oil systems (*Nature Mater.* 14:1104 2015). The nanoparticles are coated by condensed, surface-anchored lipid shells. The field collects the super-paramagnetic nanoparticles into filaments by magnetophoresis, while the lipid shells form on contact nanocapillary liquid bridges between them. After switching off the field the particles retain their structural arrangement by a soft attractive potential induced by the liquid bridges. The nanocapillary binding allows for easy particle rolling and sliding and the resulting ultrahigh flexibility was measured to be orders of magnitude higher than other linear structures reported to date. The soft, "snappable," capillary interactions enable the making of magnetically self-repairing gel networks and novel inks for 3D printing.



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Short bio and research interests

Dr. Orlin Velev received M.Sc. and Ph.D. degrees from the University of Sofia, Bulgaria, while also spending one year as a researcher in Nagayama Protein Array Project in Japan. After graduating in 1996, Velev accepted a postdoctoral position with the Department of Chemical Engineering, University of Delaware. He initiated an innovative program in colloidal assembly and nanomaterials and was promoted to research faculty in 1998. In 2001 formed his new research group in the Department of Chemical and Biomolecular Engineering, North Carolina State University, where he was promoted to an Associate Professor with tenure in 2006, to full professor in 2008 and to INVISTA chaired professor in 2009. He has contributed more than 180 publications, which have been cited more than 12,000 times, and has presented more than 210 invited presentations at major conferences and at universities and companies. Recent awards include NSF Career, Camille Dreyfus Teacher-Scholar, Sigma Xi, NC State Alcoa Distinguished Engineering Research, NC State Innovator of the Year, Springer Colloid and Polymer Science Lecture Award and election to an ACS Fellow. Velev has served as member of the Editorial Advisory Boards of *Langmuir*, *Chemistry of Materials*, *Biomicrofluidics and Particle.*

Velev has established a record of innovative research in the area of nanostructures with electrical and photonic functionality, biosensors, microfluidics and nanomanufacturing. He has been the first to synthesize "inverse opals", one of the most widely studied types of photonic materials today. Velev has also pioneered techniques for making novel nanoparticle materials, Janus particles, rod-like particles and responsive foams. Technologies based on his research have formed the basis of two Research Triangle Area startup companies, *Xanofi* and *Benanova*. He has been an advocate of incorporating the latest achievements in the areas of nanoscience and nanotechnology in the engineering curriculum.

Velev group web-page: http://www.che.ncsu.edu/velevgroup/

Velev faculty page: http://crystal.che.ncsu.edu/