Orlin D. Velev

S. Frank and Doris Culberson Distinguished Professor

Department of Chemical and Biomolecular Engineering

North Carolina State University

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Professional Preparation

Chemical Engineering, University of Delaware, Post-doctoral Fellow	1996-1998
University of Sofia and Bulgarian Academy of Sciences, Ph.D. in Physical Chemistry	1996
University of Sofia, BS and M.Sc. in Chemical Physics and Theoretical Chemistry	1989

Appointments

2009-	S. Frank and Doris Culberson Distinguished Professor, NC State University
2009-2018	INVISTA Professor, Chemical and Biomolecular Engineering, NC State University
2008-2009	Professor, Chemical and Biomolecular Engineering, North Carolina State University
2006- 2008	Associate Professor, Chemical and Biomol. Eng., North Carolina State University
2001- 2006	Assistant Professor, Dept. of Chemical Engineering, NC State University
1998- 2001	Research Assistant Professor, Dept. of Chemical Engineering, Univ. of Delaware
1994-1995	Researcher, Japanese Exploratory Research for Advanced Technology, Tsukuba

Professional Awards and Honors

Langmuir Lecture Award (ACS)	2018
S. Frank and Doris Culberson Distinguished Professor	2018
Andreas Acrivos Award for Professional Progress in Chemical Engineering (AIChE)	2017
R.J. Reynolds Award for Excellence in Teaching, Research and Extension (NCSU)	2017
Fellow of the Materials Research Society (MRS)	2017
Dinesh O. Shah Annual Lecture in Surface Science (UFL)	2017
Chancellors' Innovation Fund Award (NCSU)	2016
Springer 1st Colloid and Polymer Science Lecture Award	2014
NC ACS 2013 Distinguished Speaker Award (NC ACS Section)	2013
Alumni Distinguished Undergraduate Professor (NCSU)	2013
Fellow of the American Chemical Society (ACS)	2011
Alumni Association Outstanding Research Award (NCSU)	2011
Innovator of the Year Award (NC State University)	2011
Mercator Visiting Professor Fellowship (DFG – Germany & TU-Berlin)	2010
Alcoa Foundation Distinguished Engineering Research Award (NCSU)	2010
INVISTA named professorship (NC State University)	2009
NC State University Academy of Outstanding Teachers	2006
3M Nontenured Faculty Award (3M Company)	2006
Camille Dreyfus Teacher-Scholar Award (Camille and Henry Dreyfus Foundation)	2006
CAREER award (The National Science Foundation)	2003

Sigma Xi Faculty Research Award (Sigma Xi NCSU Chapter)	2004
Ralph E. Powe Junior Faculty Award (Oak Ridge Associated Universities)	2002
Camille and Henry Dreyfus New Faculty Award (Camille and Henry Dreyfus Found.)	2001

Synergistic Activities and Scholarly Achievements Metrics

- **203** peer-reviewed publications, including ones in *Nature, Science, Nature Mater., Nature Nanotech., Adv. Mater, JACS,* etc. (*See the separate list of 25 selected publications*)
- **H-index = 70** and more than **21,500 citations** reported by Google Scholar
- **236** invited, keynote and plenary presentations at scientific meetings, companies, universities and government labs. **26** regular presentations at scientific conferences and meetings. More than **215** presentations and posters by Velev's students, postdocs and collaborators.
- Velev's work has been highlighted in more than **210** press releases and articles in the mass media.
- PhD students advised = **36** (of which **15** female, **8** co-advised). Post-doctoral researchers and visiting scientists = **21**. Undergraduate researchers = **82** (including **13** minority, **33** female).
- Developed and taught new graduate and undergraduate level courses: *Colloid Science and Nanoscale Engineering* and *Special Topics in Nanoscience*, both at NC State University and TU-Berlin.

Selected outreach and entrepreneurial activities

- Participating faculty in the NCSU Initiative for Maximizing Student Diversity, 2008 - 2018.
- Member of the team launching an NC State spinout startup company, Xanofi, based on Velev's technology, October 2010 - present (www.xanofi.com).
- Co-founder and President, Benanova, NC State spinout startup company, based on Velev group's technology, March 2013 - present (www.benanova.com).

Scientific service – editorial and organizational activities

- Section Editor, "Active Colloids" (2014 – present) and "Colloidal Dispersions" (2009 – 2014) of *Current Opinion in Colloid and Interface Science*.
- Member of the Editorial Boards, *Langmuir*, 2008 – 2016, *Biomicrofluidics*, 2006 – present, *Particle* 2012 – present, *Chemistry of Materials*, 2008 – 2015, *Adv. Colloid Interface Science* 2012 – 2015.
- Member of American Chem. Soc. (ACS), American Inst. of Chemical Engineers (AIChE), Materials Research Soc. (MRS), Royal Soc. Chem. (RSC), European Colloid and Interface Soc. (ECIS).
- Leader of Interdisciplinary Research Group 1 (IRG 1) and member of the Steering Committee of the Triangle MRSEC on Programmable Soft Matter 2011 – 2017.
- Chair and Host (together with P.K. Kilpatrick) of the 82nd ACS International Colloid and Surface Science Symposium at North Carolina State University, June 2008; Symposium organizer at the 2010, 2007, 2005 and 2003 Spring MRS meetings; Session organizer at the 2012, 2009, 2006 and 2004 ACS Colloids meeting; Organizer and chair of 7 sessions at AIChE meetings 2005-2015, co-chair of ECI smart particles conference (2016), many others.

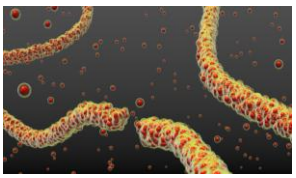
Selected publications (out of 202)

1. K. Han, C. W. Shields, O. D. Velev, *Adv. Funct. Mater*. **1705953**, 1- (2018). The Evolution of Active Particles: Towards Externally Powered Self-Propelling and Self-Reconfiguring Particle Systems.
2. U. Ohiri, C. W. Shields, K. Han, T. Tyler, O. D. Velev, N. M. Jokerst, *Nature Comm.*, **9**, 1791, 1- 9 (2018). Reconfigurable engineered motile semiconductor microparticles.

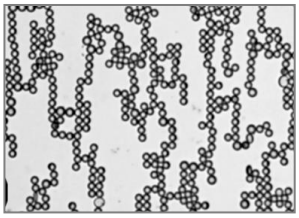
3. K. Han, C. Wyatt Shields, N. M. Diwakar, B. Bharti, G. P. López and O. D. Velev, *Science Adv.* **3**, e1701108, 1-6 (2017). Sequence-Encoded Colloidal Origami and Microbot Assemblies from Patchy Magnetic Cubes.
4. S. Roh, D. P. Parekh, B. Bharti, S. D. Stoyanov and O. D. Velev, *Adv. Mater.* **29,** 1701554, 1-7 (2017). Three-dimensional printing by multiphase silicone/water capillary inks.
5. B. Bharti, A-L. Fameau, M. Rubinstein and O. D. Velev, *Nature Mater.*, **14**, 1104–1109 (2015). Nanocapillarity-mediated magnetic assembly of nanoparticles into ultraflexible filaments and reconfigurable networks.
6. A. P. Richter, J. S. Brown, B. Bharti, A. Wang, S. Gangwal, K. Houck, E. A. C. Hubal, V. N. Paunov, S. D. Stoyanov and O. D. Velev, *Nature Nanotech*., **10,** 817-823 (2015). Nanoengineered antimicrobial nanoparticles with environmentally benign cores infused by silver ions.
7. B. Bharti and O. D. Velev, *Langmuir,* **31**, 7897−7908 (2015). Assembly of Reconfigurable Colloidal Structures by Multi-directional Field-induced Interactions. *Invited feature article.*
8. S. Lam, K. P. Velikov, O. D. Velev, *Curr. Opinion Colloid Interface Sci.* **19**, 490–500 (2014). Pickering Stabilization of Foams and Emulsions with Particles of Biological Origin.
9. E. Palleau, D. Morales, M. D. Dickey and O. D. Velev, *Nature Comm.*, **4**, 2257, 1-7 (2013). Reversible patterning and actuation of hydrogels by electrically assisted ionoprinting.
10. H.-J. Koo and O. D. Velev, *Biomicrofluidics*, **7**, 031501, 1-10 (2013). Ionic Current Devices – Recent Progress in the Merging of Electronic, Microfluidic and Biomimetic Structures.
11. A.-L. Fameau, S. Lam and O. D. Velev, *Chem. Sci.*, **4**, 3874–3881 (2013). Multi-stimuli responsive foams combining particles and self-assembling fatty acids.
12. S. Lam, E. Blanco, S. Smoukov, K. P. Velikov, O. D. Velev, *J. Am. Chem. Soc.*, **133**, 13856–13859 (2011). Magnetically responsive Pickering foams.
13. O. D. Velev and S. Gupta, *Adv. Mater.* **21**, 1897–1905 (2009). Materials fabricated by micro and nanoparticle assembly - The challenging path from science to engineering.
14. S. Gangwal, O. J. Cayre and O. D. Velev, *Langmuir*, **24**, 13312-13320 (2008). Dielectrophoretic assembly of metallodielectric Janus particles in AC electric fields.
15. S. Gangwal, O. J. Cayre, M. Z. Bazant, O. D. Velev, *Phys. Rev. Lett.*, **100**, 058302, 1-4 (2008). Induced-charge electrophoresis of metallo-dielectric particles.
16. S.-T. Chang, V. N. Paunov, D. N. Petsev and O. D. Velev, *Nature Mater.*, **6**, 235-240 (2007). Remotely powered self-propelling particles and micropumps based on miniature diodes.
17. J. R. Millman, K. H. Bhatt, B. G. Prevo and O. D. Velev, *Nature Mater.*, **4**, 98-102 (2005). Anisotropic particle synthesis in dielectrophoretically controlled microdroplet reactors.
18. O. D. Velev, B. G. Prevo and K. H. Bhatt, *Nature*, **426**, 515-516 (2003). On-chip manipulation of freely suspended droplets.
19. K. D. Hermanson, S. O. Lumsdon, J. P. Williams, E. W. Kaler and O. D. Velev, *Science*, **294,** 1082-1086 (2001). Dielectrophoretic assembly of electrically functional microwires from nanoparticle suspensions.
20. O. D. Velev, A. M. Lenhoff and E. W. Kaler, *Science*, **287**, 2240-2243 (2000). A class of microstructured particles through colloidal crystallization.
21. O. D. Velev and E. W. Kaler, *Langmuir* **15**, 3693-3696 (1999). In situ assembly of colloidal particles into miniaturized biosensors.
22. O. D. Velev, P. M. Tessier, A. M. Lenhoff and E. W. Kaler, *Nature*, **401**, 548-548 (1999). A class of porous metallic nanostructures.
23. O. D. Velev, T. A. Jede, R. F. Lobo and A. M. Lenhoff, *Nature*, **389**, 447-448 (1997). Microstructured porous silica via colloidal crystallization.
24. N. D. Denkov, O. D. Velev, P. A. Kralchevsky, I. B. Ivanov, H. Yoshimura and K. Nagayama, *Nature*, **361**, 26-26 (1993). Dynamics of two-dimensional crystallization.

Velev – Summary of High-Impact Pioneering Research

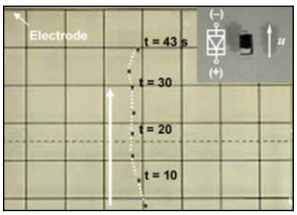
Professor Orlin Velev has established a record of innovative interdisciplinary studies, creativity and intellectual leadership in colloid science, nanoscience, and microfluidics. His key contributions are in the area of colloidal assembly. His group advanced the field of directed and programmed colloidal assembly by using electric fields to make structures out of nanoparticles, microspheres, Janus and patchy particles. Velev's group has also recently discovered and developed new types of self-propelling microdevices, gel-based photovoltaic cells, soft robotic hydrogel actuators and microbot prototypes. His earlier research achievements include the first report of convective assembly of 2D colloidal crystals, the first templated fabrication of “colloidosome” and supraparticle clusters and the synthesis of "inverse opal” structures.



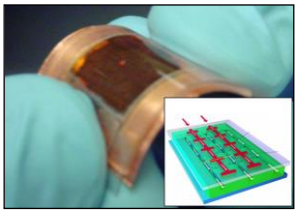
Nanocapillary Liquid Bridging: Making Ultraflexible Nanoparticle Filaments and Reconfigurable Gel Networks (2014-). Velev’s group discovered a new class of materials where ultraflexible filaments are assembled from magnetic nanoparticles wetted by liquid and bound by capillarity. The superparamagnetic nanoparticles used as structural units are covered by condensed lipid films, which form nanocapillary liquid bridges between them. These new soft and magnetically responsive structures can be dynamically reconfigured and used in magnetically self-repairing gels and new types of inks for 3D printing. ***Representative publications:*** *Adv. Mater. Technol*., 1800528 (2019); *Adv. Mater.* ***29,*** 1701554 (2017)*; JACS*, **138**, 14948 (2016); *Nature Mater.*, **14**, 1104 (2015); *Faraday Discuss.*, **181**, 437 (2015).



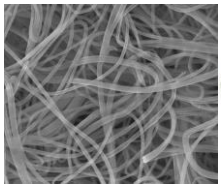
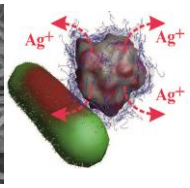
Directed and programmed electric and magnetic field assembly (2006-). The group has performed extensive work in using electric and magnetic fields as a tool for on-chip assembly and manipulation of nanoparticles, microparticles, and live cells. Their research has been among the first to focus on Janus, patchy and cubic metallodielectric particles. A new AC-electrokinetic mobility mode of Janus metallodielectric particles was discovered. Means to form percolated networks by induced multipolar interactions hold promise for numerous new materials. ***Representative publ.:*** *Small*, **12**, 2283 (2016); *Langmuir*, **31**, 7897 (2015); *Langmuir*, **30**, 6577 (2014); *Sci. Rep.*, **2**:1004 (2012); *Soft Mater*, **6**, 1413 (2010); *Soft Matter*, **5**, 1285 (2009); *Langmuir*, **24**, 13312 (2008); *Soft Mater*, **2**, 738 (2006); *Science*, **294,** 1082 (2001).



Active particles: Self-propelling microcircuits, novel functional motile particles and microbots (2007-). Velev’s group has demonstrated how miniature semiconductor diode "particles" suspended in water propel themselves electroosmotically. The diodes suggest rudimentary solutions to problems facing self-propelling microdevices, including harvesting power from external sources, internally controlled movement, and can be steered remotely. ***Representative publ:*** *Nature Comm., 9, 1791 (2018); Science Adv.* **3**, e1701108 *Adv. Funct. Mater.*, **25**, 5512 (2015); *Langmuir*, **28**, 10128 (2012); *Annu. Rep. Prog. Chem., Sect. C,* **105**, 213 (2009); *Phys. Rev. Lett.*, **100**, 058302 (2008); *Nature Mater.*, **6**, 235 (2007).

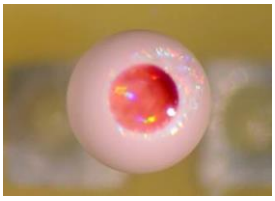


New types of electronic, photovoltaic and soft robotic devices based on aqueous soft matter (2007-). Velev is a leader in the emerging research area of constructing biomimetic circuits, solar cell and "soft robots" from hydrogels. The latest research revealed new hydrogel actuators, "walkers" and soft robotic prototypes. ***Representative publ.:*** *Soft Matter*, **10**, 1337 (2014); *Nature Comm.*, **4**, 2257 (2013); *Sci. Rep.*, **3**, 2357 (2013); *Biomicrofluidics*, **7**, 031501 (2013); *Adv. Mater*, **23**, 3559 (2011); *Small*, **6**, 1393 (2010); *JACS* **129**, 10801 (2007).

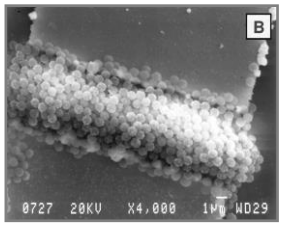



Scalable liquid nanofabrication of nanofibers and environmentally benign nanoparticles (2006-). Velev and collaborators have developed a number of scalable, rapid and cost-effective processes for the synthesis of functional nanomaterials by biphasic precipitation under shear. Their "shear nanospinning" liquid-based technique for scalable fabrication may revolutionize the scale and scope of nanofiber application. Velev *at al.* also introduced a new class of environmentally-benign microbicidal nanoparticles with biodegradable cores made of lignin. ***Representative publ.:*** *Nature Nanotech*., **10,** 817 (2015); *Adv. Mater.*, **27**, 2642 (2015); *Curr. Opin. Colloid Interface Sci.* **19**, 490 (2014).

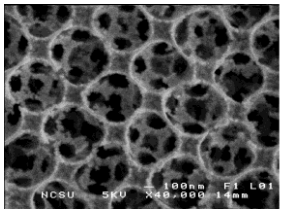
Synthesis of responsive capsules, rod-like particles and foam superstabilization (2005-). Velev and his group have engineered new classes of magnetically, thermally and light-responsive foams. Earlier, the group discovered a novel shear-based method for the efficient scalable preparation of polymeric microrods that make ultrastable foams and emulsions. Historically, Velev is the first to report formation of the (later-named) "colloidosome" assemblies during his independent research in Japan. ***Representative publ.:*** *Chem. Sci.*, **4**, 3874 (2013); *Langmuir*, **29**, 10019 (2013); *J. Am. Chem. Soc.*, **133**, 13856 (2011); *Langmuir*, **24**, 11959 (2008); *Adv. Mater.*, **16**, 1653 (2004); *Chem. Mater*, **18**, 3308 (2006); *Langmuir* **12**, 2374 (1996).



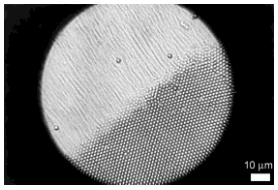
Development of free droplet microfluidic techniques (2003-). Velev *et al.* developed a new microfluidic chip for dielectrophoretic manipulation of microdroplets suspended on the surface of fluorinated liquid. They reported a new method for templated assembly of supraparticles inside droplets suspended on superhydrophobic surfaces. These assemblies can be anisotropic, layered, patchy, magnetic or biologically active. ***Representative publ.:*** *Angew. Chem. Int. Ed.*, **53**, 586 (2014); *Adv. Mater.*, **20**, 4263 (2008); *Langmuir*, **24**, 1371 (2008); *Biomicrofluidics*, **1**, 014107 (2007); *Nature Mater.*, **4**, 98 (2005); *Nature*, **426**, 515 (2003); *Science*, **287**, 2240 (2000).



Microbiosensors and bionanomaterials via on-chip assembly (1999-). Velev is among the first to explore and demonstrate the formation of electrically-functional microdevices by interfacing colloidal assemblies with on-chip electronic circuits. Microscopic electronically readable biosensors have been assembled *in situ* by dielectrophoresis. ***Repr. publ.:*** *Biomicrofluidics*, **8**, 054108 (2014); *Lab Chip*, **12**, 4279 (2012); *Langmuir*, **26**, 3441 (2010); *Soft Matter*, **4**, 726 (2008); *Anal. Chem.*, **23**, 5498 (2007); *Langmuir* **15**, 3693 (1999).



First to synthesize "inverse opals" (1997) and Au nanoparticle inverse opals (1999-2005). Velev was the first to report the use of colloidal crystals as templates for the preparation of "inverse opals," which are now one of the most widely studied classes of photonic materials. The original report was on "inverse opal" silica. Velev and collaborators later synthesized a unique new type of material, hierarchically porous structured gold, via assembly of metallic nanoparticles. ***Representative publ.:*** *Adv. Mater.* **21**, 1897 (2009)-;*J. Mater. Chem.*, **16**, 1207 (2006); *Adv. Mater.*, **13**, 396 (2001); *Nature*, **401**, 548 (1999); *Nature*, **389**, 447 (1997).



Discovery and engineering of the convective assembly process (1993-). As a graduate student Velev was a key experimental investigator in the team that discovered the method of "convective assembly" of microparticles in the meniscus of drying water films. The Velev group at NCSU has engineered a convenient and controllable convective assembly apparatus, and used it in the deposition of antireflective and conductive nanocoatings, biofilms from live

cells, biomacromolecules, aligned Tobacco Mosaic Viruses and other functional nanocoatings.
Representative publ.: *Langmuir*, **25**, 5692 (2009); *J. Mater. Chem*., **17**, 791 (2007); *Chem. Mater.*, **19**, 141 (2007); *Small*, **2**, 1462 (2006); *Chem. Mater.*, **17**, 28 (2005); *Langmuir*, **20**, 2099 (2004); *Nature*, **361**, 26 (1993).

Recent Velev group journal covers