



Velev Research Group

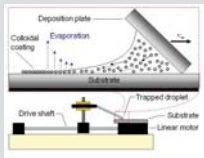
Department of Chemical & Biomolecular Engineering, North Carolina State University

<http://www.che.ncsu.edu/velevgroup/>



New nanocolloidal materials

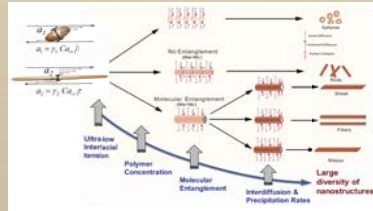
Novel particle deposition method: Continuous Convective Assembly



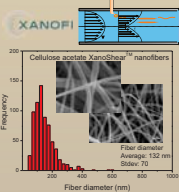
Convective assembly allows rapid deposition of controlled number of layers

Schematic of continuous convective assembly apparatus

Nanospinning for functional nanofibers



Continuous flow process

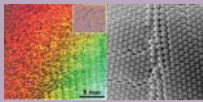


Droplets spontaneously break-up and are stretched in parallel by the shear stress in the medium

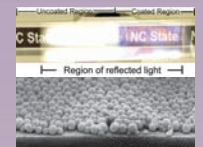
Velev et al. US Patent 7323540, Smukov et al., US Patent pending

Process allows large scale inexpensive fabrication of nanofibers

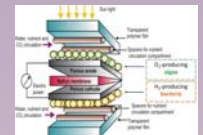
Engineered deposition of functional nanoparticle coatings



Latex colloidal crystals behave as diffraction gratings when illuminated
Prevo et al., *Langmuir* (2004)

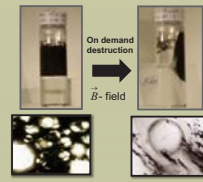
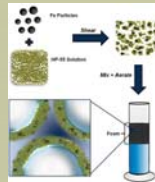


Antireflective (AR) coatings of colloidal silica.
Prevo et al., *J. Mater. Chem.* (2007)
Prevo et al., *Chem. Mater.* (2005)



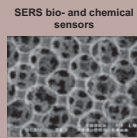
Concept of a soft, flexible photobiological fuel cell constructed from biocoatings hydrogen-producing photosynthetic bacteria and oxygen-producing algae (Velev and Fikinger)
Jenkins et al., *J. Col. Inter. Sci.* (2012)

Magneto-Pickering foam

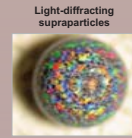


Lam, S. et al., *J. Am. Chem. Soc.* 2011, 133, 13856

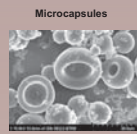
Microparticles with various morphology



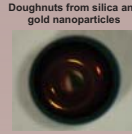
Kundicky et al., *J. Mater. Chem.* (2008)



Rastogi et al., *Adv. Mater.* (2008)



Koo et al., *Chem. Mater.* (2006)



Rastogi et al., *Macromol. Rapid Commun.* (2010)



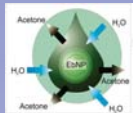
Alargova et al., *Adv. Mater.* (2004)



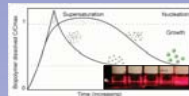
Alargova et al., *Langmuir* (2004), *Langmuir* (2006)

Environmentally-benign nanoparticles (EbNP)

High Purity Lignin (HPL) EbNP synthesis



HPL biopolymer EbNP synthesis via solvent-antisolvent precipitation process.
- Final EbNPs bear negative surface charge and are electrostatically stabilized



EbNP follows general nucleation and growth theory.

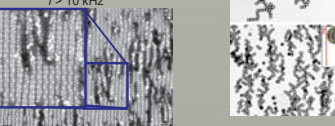
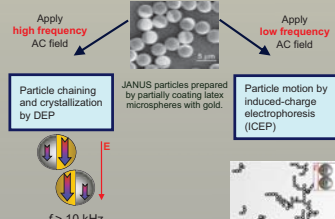
- EbNP size control: 50-250 nm
- pH stability range: pH 3 to 10
- Time stability: > 3 month.

Frangville et al., *ChemPhysChem* (2012)

Richter et al., US Patent pending

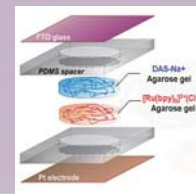
Electrically functional & responsive nanosystems

'Janus' particles in AC electric fields



Unusual crystal symmetry, conductive lines self-assemble
Gangwal et al., *Langmuir* (2008)

Photovoltaic devices based on hydrogel



Hydro-Gel Photo-Voltaics (HGPV)

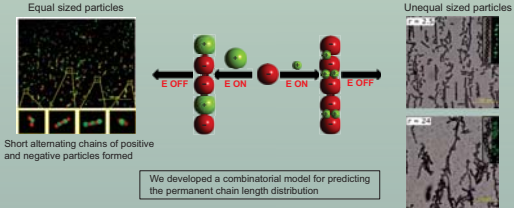


Flexible version of HGPVs

The photocurrent of HGPV cells is higher than that of other biomimetic or ionic photoactive systems recently reported.

Koo et al., *Adv. Funct. Mater.* (2012)
Koo et al., *J. Mater. Chem.* (2011)
Koo et al., *Small* (2010)

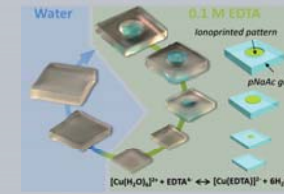
Permanent chains of oppositely charged particles



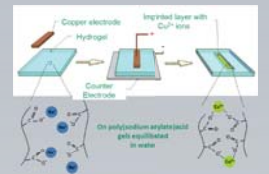
Assembly rules
• Long chains obtained for unequal sized particles
• Chain length increases with particle number ratio r

$r = \frac{\text{no. of small particles}}{\text{no. of large particles}}$
Longer chains formed with increasing r .
Bhari et al., *Sci. Rep. (Nature)*, (2012)

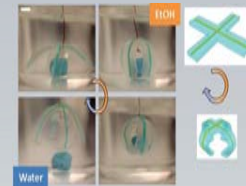
Copper ionoprinting on hydrogel



Localized ion binding changes the elastic and diffusive properties of the imprinted layer



The depth of the imprint and amount of bound copper is controlled by the current

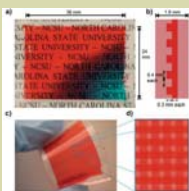


Tuning the local hydrogel properties enables shape memory and actuation in when immersed in solvents

μ-fluidics & self-propelling particles

Microfluidic materials

Color-changing Shape-memory

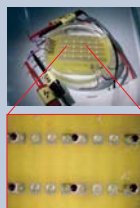


Simple and versatile soft microfluidic materials that can be turned transparent or colored on demand
Ucar et al., *Soft Matter*, (2012)

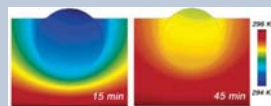


Solidified photoresist inside microchannels acts as "endoskeleton" enabling shape-memory
Chang et al., *Adv. Mater.*, (2009)

Manipulation of microdroplets using DEP

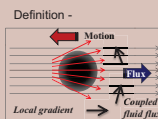


Simultaneous production of "eyeballs" using a DEP chip.
Velev et al., *Nature* (2003)
Millman et al., *Nat. Mater.* (2005)



Temperature profile in a drying droplet freely suspended on DEP chip to understand particle microseparations inside droplets.
Chang & Velev, *Langmuir* (2006)

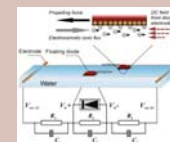
Background: Self-propelling particles



Potential applications -

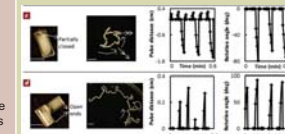
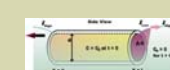
- Pumping/mixing fluids in lab-on-chip devices
- Drug delivery
- Sensors for toxicity detection
- Cargo pick-ups/transportation
- Microbotics

Remote steering of self-propelling diode by electric field

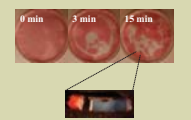
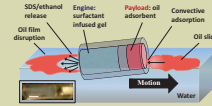


Change in symmetry of the AC field causes diode rotation
Chang et al., *Nat. Mater.* (2007)

Oil clean-up by gel-based self-propelling particles



Unique pulsating motion due to Marangoni effect
Sharma et al., *Langmuir* (2012)



Simultaneous and efficient oil collection and dispersion