Advanced Functional Nanomaterials (metals and metal oxides/polymers)

Control morphology/crystallinity via nucleation and growth in sol’n
Colloidal stability (ligands and polymers on the surface)
Optical, magnetic and electrocatalytic properties = f (morphology)

Nanoparticle Interact. with Liq. and Solid Interfaces

Oil/water and gas/water interfaces (emulsions and foams)
Solid surfaces (adsorption and transport in porous media)

Nanocluster Self Assembly for Enhanced Properties

Protein delivery (control morphology/stability/rheology)
Metals: Au photonic NIR nanoclusters (biodegradable)
Metal oxides for subsurface imaging and electrocatalysis

Lilyestrom (13)
Scientific building blocks to create and advance applications in energy, materials and pharmaceutical/biomedical fields

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<td>Materials Chemistry: Nucleation, growth, passivation (aq., org.)</td>
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<td>Colloid interactions/stability (polymer science)</td>
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<td>Colloidal assembly nanocluster platform</td>
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<td>Nps/surfactants /polymers interfacial phen.</td>
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<td>Nps at solid interfaces/transport in porous media</td>
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<td>Target morphology for advanced functional properties</td>
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<td>Optical, magnetic, and catalytic properties</td>
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Design nps/surf. for low ift and high stability

Np adsorption at interface vs. surface structure

Foam stability: lamellae thickness, disjoining pressure, hole nucleation

Low adsorption on rock: DLVO theory

Oil jets dispersed w/ 1:100 clay

We propose self-healing holes
Nanotechnology to reduce water usage in hydraulic fracturing: viscoelastic foams

Development of nanoparticle-stabilized foams for reduced water usage in hydraulic fracturing

Water usage in hydraulic fracturing could be reduced by over 90% by using ultra-dry foams. The foams are stabilized using nanoparticles, surfactants and polymers.
High mag. susceptibility magnetic Nps with grafted polymers: transport and interfacial properties (contrast agents oil reservoirs, spills, fracturing, cancer)

Superparamag. IO nanoparticles

- Crystalline nps for high magnetic susceptibility
- Charged copolymers for electrosteric stab. in brine
- Low adsorption on sandstone: polymer coatings

Bagaria, KPJ et al. ACS Appl. Mat. Interfaces, 2013
Lowering viscosity by weakening mAb interactions with cosolutes

- Attractive mAb-mAb interactions incr. visc. at high conc.
  - Anisotropic electrostat. and charge-dipole attraction
  - Network formation
- At pH 5-6 guanidyl group of arginine is positively charged
  - Neutr. anionic sites and makes hydrophobic sites +
  - Weakens attraction

Connolly et al., *Biophysics J.* (2012),
Lilyestrom et al., *JPCB* (2013),
Shukla, et al., *JPCB* (2011),
Reversible Gold Nanoclusters for Imaging/Therapy

• Form “quenched equilibrium” nanoclusters with weakly adsorbed polymer
  – Colloidal assembly based on free energy model
  – Close spacing of primary gold particles produces intense NIR extinction

• Demonstrate reversibility of biodegradable nanoclusters
  – pH 5 HCl: degrades PLA groups on polymer
  – Primary particles clearable

Murthy, Johnston, Sokolov, Truskett, Stover
ACS Nano (13), JACS (13)
JPChem C (14)
Nanostructured Perovskite Oxides for Electrocatalysis
batteries, supercapacitors, water splitting

Oxygen Evolution Reaction (OER)

\[ 4\text{OH}^- \rightarrow 2\text{H}_2\text{O} + 4\text{e}^- + \text{O}_2 \]

LaNiO\(_3\) generates **3 times more current per mass** than the leading precious metal oxide catalyst IrO\(_2\) by utilizing **lattice oxygen**

Destination of PhD Students

- Gupta
- Balbuena
- Meredith
- Yates
- Da Rocha
- Lee
- Ziegler
- Lu
- Auburn
- Texas A + M
- U. Rochester
- Wayne State U.
- U. S. California
- U. Florida
- Nat. Univ. Singapore
- Shah
- Pham
- Chen
- Dickson
- Smith
- Overhoff
- Engstrom
- Matteucci
- Gupta
- Tam
- Patel
- Ma
- Miller
- Slanac
- Murthy
- Chen
- Pfizer
- Sematech
- Abbott
- Exxon-Mobil
- Exxon-Mobil
- Schering-Plough
- Bristol-Meyers-Squibb
- Dow
- Exxon-Mobil
- Bristol-Meyers-Squibb
- Lam Research
- Dupont
- Medimmune
- Dupont
- Roche
- Dow
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Will Hardin (Electrochem.)  CPE 5.426, willhardin@gmail.com
Bobby Stover (Biomedical imaging Au)  CPE 5.432, stover@che.utexas.edu
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Petr./Geosystems Engr. UT: David DiCarlo, Chun Huh, Kishore Mohanty, Quoc Nguyen, Masa Prodanavic, ChE Rice: Lisa Biswal and George Hirasaki.