

# Keith Johnston Research Group

Nanomaterials Chemistry/Colloid and Interface Science/Polymer Science

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## Nanoparticle and Nanocapsule Interactions with Liq. and Solid Interfaces

Smart polymer nanocapsules for controlled release (subsurface reservoirs, drug delivery) (Guihua Yu)

Oil/water and gas/water interfaces (emulsions and foams) (Prodanovic, DiCarlo, Enick: Pitt)

Solid surfaces (adsorption and transport in porous media, electrocatalysts) (Pennell: Brown, Yu, UT)

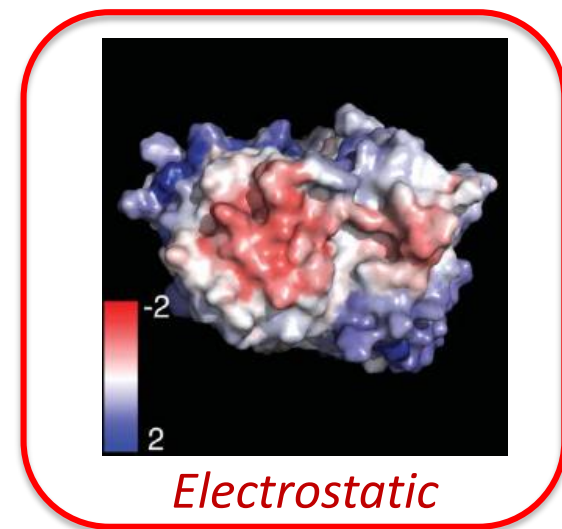
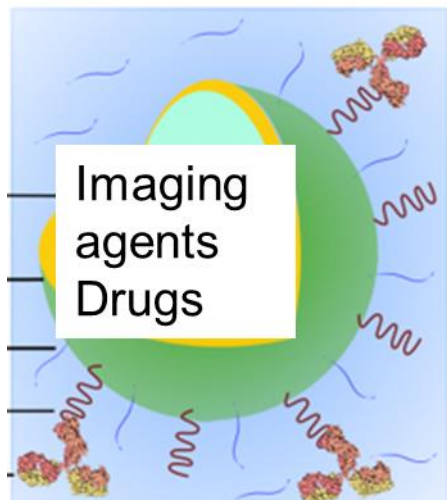
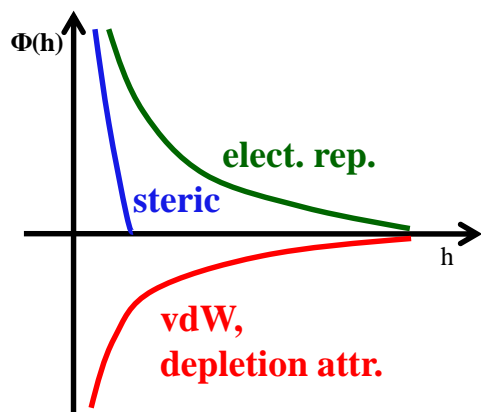
## Adv. Fxn'l Nanomaterials (metals, metal oxides, polymers)

Nanocapsules for cancer imaging (with Truskett and Sokolov: UT MDA Cancer Center)

Electrochemical energy storage (oxygen evolution, oxygen reduction reactions) (Guihua Yu, UT Mat. Sci.)

## Monoclonal antibody stability and drug delivery (colloid and polymer science)

Morphology, protein-protein interactions, statistical mechanics and rheology, SAXS (Truskett)



# Controlled release of chemicals with stimuli responsive nanocapsules (energy applications and drug delivery)



phase  
change

T goes above  $T_g$  or  $T_m$  of shell



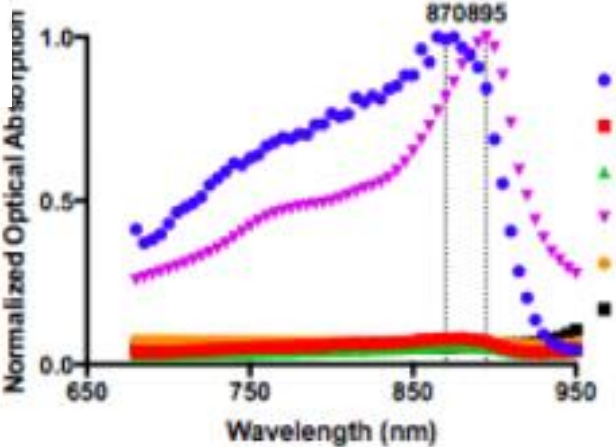
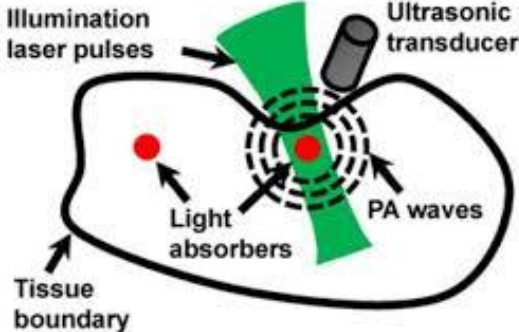
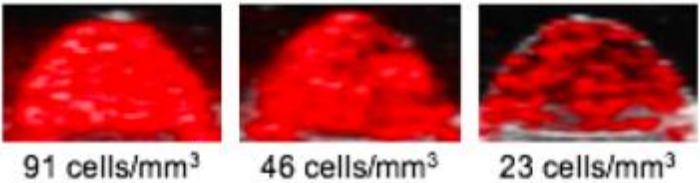
pore  
opening

Mixture of polymers  
One shrinks with heat leading to pores

Esser Kahn, Moore 2011

- T, pH, salinity, mechanical forces
- Use chemicals more efficiently, raise oil production and in greener manner (crosslinkers for conformance control, enhanced oil recovery chemicals)
- Coat capsules with polymers for colloidal stabilization and migration in reservoirs
- Cancer imaging project with polymersomes: use acid pH in endosomes for release

# Design of platform polymersomes with colloid and polymer science: advance imaging and therapy goals



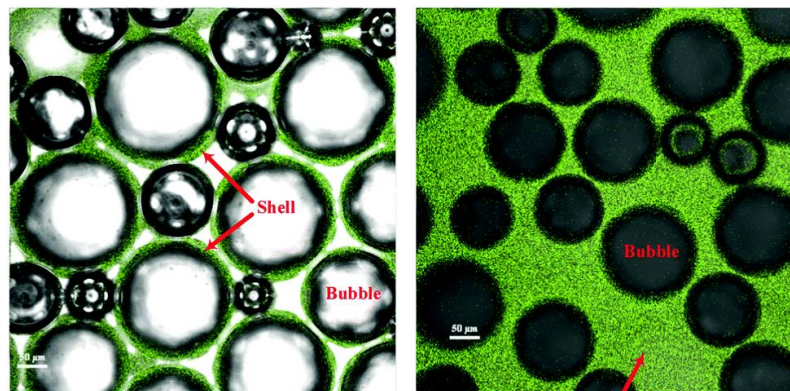
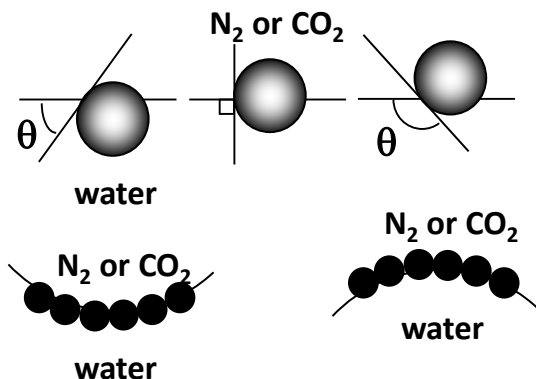
Austin: Johnston and Truskett

Houston: UT MD Anderson Cancer Center Sokolov  
Photoacoustic imaging: cells ovarian cancer cells

Objectives: Controlled size of polymersomes

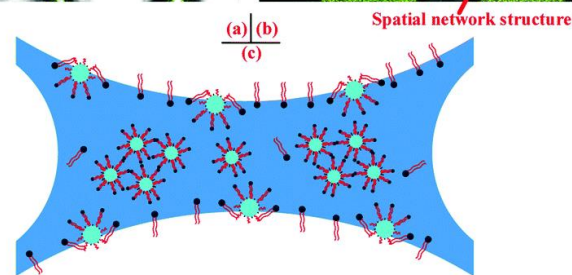
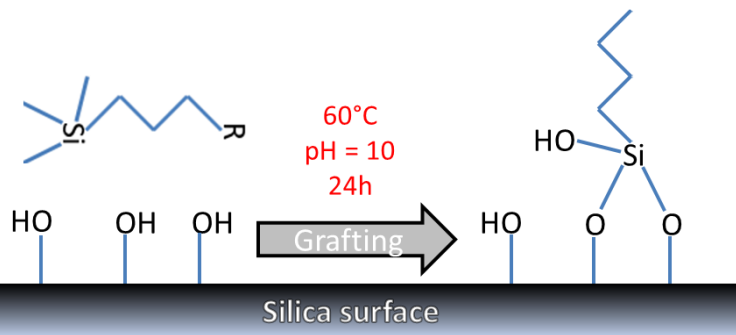
- Platform particles, nontoxic, stable for 24 hours, clearable, FDA approved materials
- mAbs targeting of particular cancers: click chemistry azides with alkynes
- Cocktails of imaging agents and drugs: easy to load in capsules
- Changes define biological processes in endosomes (example of future goal)

# Designing Interfacial Properties of Nanoparticles/Polymers/Surfactants: Foams, Wettability Alteration and Advanced Materials

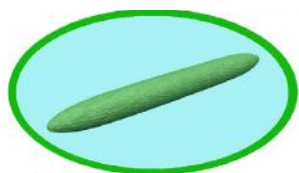


$$E = \pi r^2 \gamma_{ow} (1 \pm \cos \theta)^2$$

R

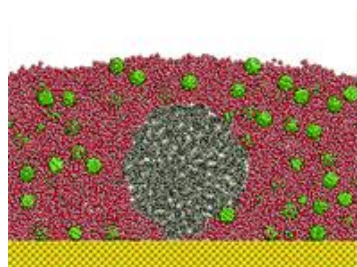


Nanoparticle synthesis/surface modification:  
NMR, TEM,  $\theta$ , static and dynamic  $\gamma$   
Nanoparticle colloidal stability: DLS, SAXS  
Nanoparticle adsorption and assembly  
Interfacial and bulk rheology  
Foam morphology and rheology



Cellulose Nanocrystal

Applications:

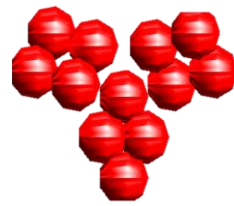


Subsurface CO<sub>2</sub> sequestration, oil recovery, green fracking

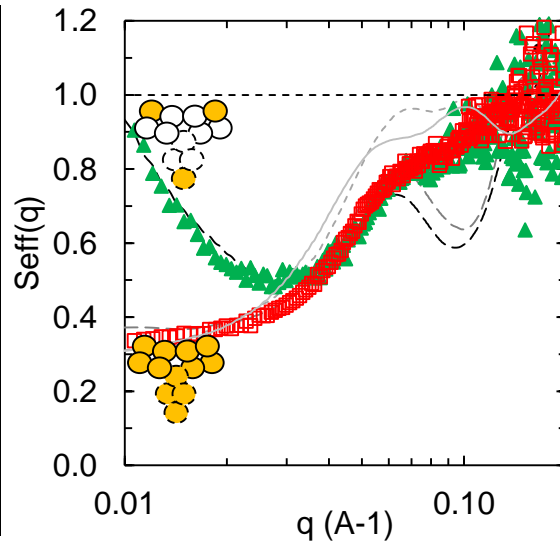
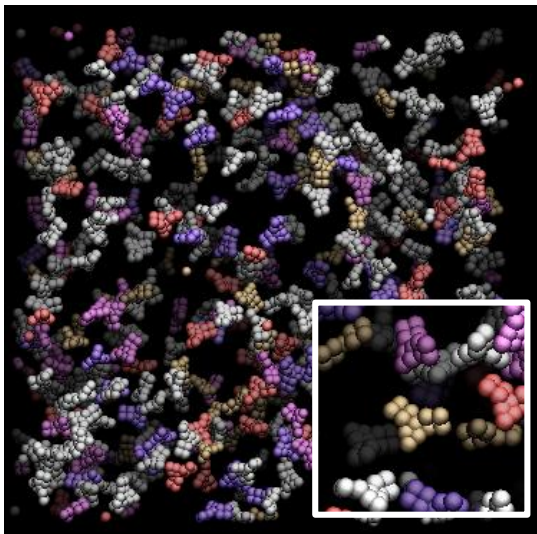
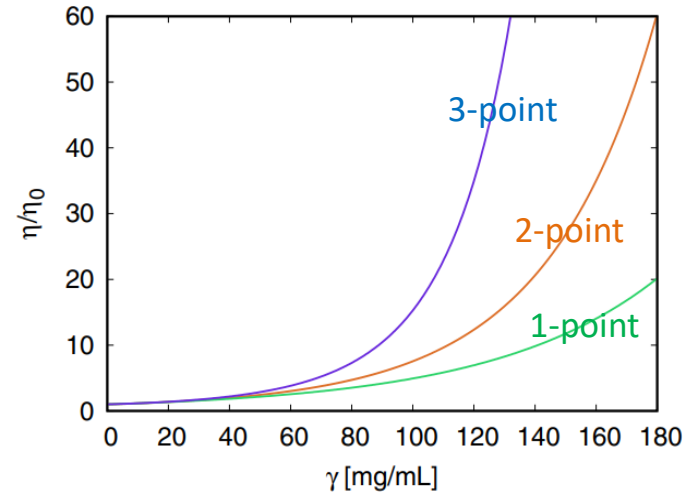
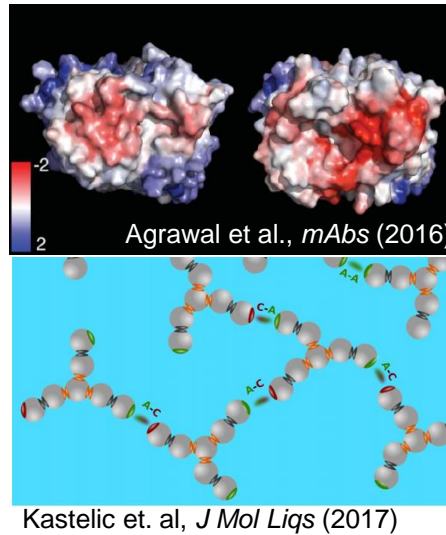
Relevant in many fields: materials, energy, electrocatalysts, environment



# Understanding Protein-Protein Interactions/Rheology at High Conc.



- Provide fund. and mechanistic understanding of protein stability and viscosity at high concentrations
  - measurements/MD simulations of interactions and “clustering”
  - Effect of mAb structure, pH, ionic strength, cosolutes



**Characterize protein clusters in terms of protein-protein interactions for 125 to 250+ mg/mL mAb (reversible oligomers)**

- 12 bead model and Yukawa model (screened elect. attr.)
- Static structure: small angle X-ray scattering, static light scattering
- Dynamic structure: dynamic light scat., shear rheology

Potential application for discovery/developability, protein processing, storage, and drug delivery



## **Nanoparticles at interfaces**

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## **Cancer imaging polymersomes**

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## **Protein colloids**

Amjad Chowdhury

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NSF Inspire Program  
DOE CFSES, DOE NETL  
Advanced Energy  
Consortium, AbbVie,  
Pfizer, Merck

Welch Foundation  
Abu Dhabi Nat. Oil. Co.  
Total  
GOMRI, NSF CBET,  
NIH

# Destination of PhD Students

• Gupta	Virginia Tech.	• Shah	Pfizer
• Balbuena	Texas A + M	• Pham	Sematech
• Meredith	Ga. Tech.	• Chen	Abbott
• Yates	U. Rochester	• Dickson	Exxon-Mobil
• Da Rocha	Virginia Tech.	• Smith	Exxon-Mobil
• Lee	U. S. California	• Overhoff	Schering-Plough
• Ziegler	U. Florida	• Engstrom	Bristol-Meyers-Squibb
• Lu	Nat. Univ. Singapore	• Matteucci	Dow
• Elhag	Petroleum Inst. (Abu Dhabi)	• Gupta	Exxon-Mobil
		• Tam	Bristol-Meyers-Squibb
		• Patel	Lam Research
		• Ma	Dupont
		• Miller	Medimmune
		• Slanac	Dupont
		• Murthy	Roche
		• Chen	Dow
		• Xue	Ecolab
		• Borwankar	Bristol-Meyers-Squibb
		• Worthen	Exponent
		• Hardin	Exponent
		• Hung	Bristol-Meyers-Squibb
		• Dear	Bristol-Meyers-Squibb