Schedule for the 6th Mid-Atlantic Soft Matter workshop, June 18, 2010

Georgetown University, Institute for Soft Matter Synthesis and Metrology, Reiss 113

8:00 am

Registration and Breakfast

9:10 am

Opening Remarks

9:20 am

Edward Van Keuren (Georgetown)

Solution Self-Assembly of Nanoparticles

10:05 am

Sound-bite Session I

10:45 am

Coffee Break

11:10 am

Marcus Cicerone (NIST)

Protein stability in hydrophilic glass: Primary factors and correlations

11:55 am

Sound-bite Session II

12:30 pm

Lunch

2:00 pm

Arjun Yodh (U. Penn)

Swellable Particles are Swell

2:45 pm

Sound-bite Session III

3:20 pm

Break

3:55 pm

Daeyeon Lee (U. Penn)

Functional Nanoparticle Thin Films Based on Layer-by-Layer Assembly

4:40 pm

Christopher Jarzynski (UMD)

Guiding the motion of artificial molecular machines

End of Workshop

Marcus Cicerone, NIST

Protein stability in hydrophilic glass: Primary factors and correlations

For decades, proteins have been stabilized for biotechnology applications by drying them in the presence of sugars. An important example is found in biopharmaceuticals, an $80B industry. Approximately 1/2 of protein pharmaceutics are too labile to be shipped and stored in aqueous solution, and must be freeze-dried. Optimization of the dried sugar (glassy) formulations has been based on a combination of weakly predictive metrics and long-term stabilization studies; the metrics being particularly important as they are used to select a subset of formulations for long-term studies. I will present an evaluation of the traditional metrics - protein secondary structure, and relaxation of the glass, as well as a metric we recently introduced - β relaxation. I will show that secondary protein structure correlates coincidentally with stability over a limited parameter space only, present evidence that relaxation has a potentially causal, but indirect relationship with stability, and that β relaxation has a causal and direct relationship with protein stability in the glass. Time permitting, I will also discuss method development efforts in using fluorescence Stokes shifts to estimate mean squared displacements ($\langle u^2 \rangle$), and some questions that we can address in glass physics.

1. Cicerone, M.T. and C.L. Soles, Fast dynamics and stabilization of proteins: Binary glasses of trehalose and glycerol. Biophysical Journal, 2004. 86(6): p. 3836-3845.

2. Psurek, T., et al., Quantifying Changes in the High-Frequency Dynamics of Mixtures by Dielectric Spectroscopy. Journal of Physical Chemistry B, 2008. 112(50): p. 15980-15990.

3. Wang, B.Q., et al., Impact of Sucrose Level on Storage Stability of Proteins in Freeze-Dried Solids: II. Correlation of Aggregation Rate with Protein Structure and Molecular Mobility. Journal of Pharmaceutical Sciences, 2009. 98(9): p. 3145-3166.

Christopher Jarzinski , Dept. of Chemistry, U. Maryland

Guiding the motion of artificial molecular machines

Biology provides direct evidence of the astounding diversity of tasks that can be performed by molecular complexes a few nanometers in size, from the transport of microscopic cargo to the copying of genetic information. Inspired in part by these examples, researchers around the world are synthesizing artificial molecular machines. How can external stimuli can be used to control the mechanical motion of such synthetic molecular assemblies? I will consider this question within a theoretical framework in which the molecular machine makes transitions among a set of conformations, as the experimentalist guides the system by varying parameters "knobs" such as laser light, temperature and chemical conditions. I will discuss the conditions that are needed to induce directed currents, such as the unidirectional rotation reported in experiments on catenanes (mechanically linked ring-like molecules), and will derive a geometric, Berry phase-like formula for these currents.

Daeyeon Lee, Chemical and Biomolecular Eng., U. Penn.

Functional Nanoparticle Thin Films Based on Layer-by-Layer Assembly

Recent advances in materials chemistry have enabled the synthesis of nanoparticles with useful optical, catalytic, and magnetic properties. Assembly of these nanoparticles into functional structures, with precise control over their properties, would lead to great advances. However, it still remains a great challenge to achieve this goal through simple means. In this presentation, I will discuss a simple method known as layer-by-layer (LbL) assembly for the fabrication of functional thin films of nanomaterials. I will first discuss the layer-by-layer assembly of oppositely charged nanoparticles in aqueous solutions. It will be shown that multifunctional nanoparticle thin films can be generated by carefully tuning the assembly condition. In the second part of the talk, I will

describe the current trend in the field of LbL assembly and discuss why this method is typically limited to generating thin films in aqueous solutions. Considering that a large number of nanomaterials are synthesized and stable in non-polar solvents, layer-by-layer assembly in such media would undoubtedly expand the versatility of the technique. I will show our recent results on performing layer-by-layer assembly of charged species in non-polar media and describe how this approach can lead to the generation of functional thin films.

Edward Van Keuren, Dept. of Physics and I(SM)^2, Georgetown U.
Solution Self-Assembly of Nanoparticles
Room temperature solution-based synthetic methods are an important option for the production of a wide range of nanomaterials. As new synthetic methods have been developed, there has been a shift from creation of single component materials to strategies for engineering a wide range of multifunctional nanomaterials. Directed growth of nanoparticles to achieve multiple specific properties requires a detailed understanding of the structure property relations between the molecular components and bulk material as well as the ability to change the synthesis conditions in order to tailor the material properties. My group has been working on the development of single and multi-component nanoparticles using a reprecipitation technique in which nanoparticle nucleation and growth is induced by the rapid injection of a molecular solution into a miscible non-solvent. In addition to having a long history of basic research, related methods are used in industry for the manufacture of single component nanoparticles. I will show that a wide variety of particle morphologies can be achieved using this method, and that these shed light on the mechanisms of the formation. We have also recently demonstrated that it can be extended to multiple components by inducing two or more different components to co-aggregate or co-crystallize into nanoparticles. I will present some of these results as well as our work in creating a simple model, using Hansen solubility parameters, for predicting the conditions under which composite nanoparticles composed of two or more constituents can form.

Arjun Yodh, Dept. of Physics, U. Penn.
Swellable Particles are Swell
Temperature-sensitive microgel particles present experimenters with a fantastic new variable for creation of novel phases and control of phase transformations. I will describe experiments from my laboratory which exploit this phenomenon to learn new condensed matter physics. Recent experiments, for example, permit us to explore first steps of bulk melting in three-dimensional crystals [1], to elucidate melting mechanisms in liquid crystalline phases of matter [2], to characterize melting and phase-transformations in two-dimensions [3], thin films [4] and narrow cylinders [5], to create geometrically frustrated colloidal anti-ferromagnets [6], and to study aging [7] and jamming [8] in glassy media.

[1] A.M. Alsayed, M.F. Islam, J. Zhang, P.J. Collings, A.G. Yodh, Science 309, 1207-1210 (2005).
[2] A.M. Alsayed, Z. Dogic, A. G. Yodh, Physical Review Letters 93, 057801 (2004).
[3] Y. Han, N.Y. Ha, A.M. Alsayed, A.G. Yodh, Phys. Rev. E 77, #041406 (2008).
[4] Y. Peng, Z. Wang, A.M. Alsayed, A.G. Yodh, Y. Han, Phys. Rev. Lett. 104, #205703 (2010).
[5] M.A. Lohr, A.M. Alsayed, B.G. Chen, Z. Zhang, R.D. Kamien and A.G. Yodh, Phys. Rev. E81, #040401 (2010).
[6] Y. Han, Y. Shokef, A. M. Alsayed, P. Yunker, T. C. Lubensky, A. G. Yodh, Nature 456, 898-903 (2008).
[7] P. Yunker, Z. Zhang, K.B. Aptowicz, A. G. Yodh, Physical Review Letters 103, #115701 (2009).
[8] Z. Zhang, N. Xu, D.T.N. Chen, P. Yunker, A. Alsayed, K.B. Aptowicz, P. Habdas, A.J. Liu, S. Nagel, and A.G. Yodh, Nature 459, 230-233 (2009).

1. Lora Angelova (Georgetown University)
   Partially Hydrolyzed Poly(vinyl acetate) and Borax Cross-Linked Gels

2. Richard Arevalo (Georgetown University)
   Investigating the strain-stiffening behavior of sheared collagen networks using a confocal-rheometer

3. Anindita Basu (University of Pennsylvania)
   Shear deformation in polymer networks

4. Daniel J. Beltran-Villegas (Johns Hopkins University)
   Dynamical Navigation of Energy Landscapes in Colloidal Assembly

5. Ramon Castaneda-Priego (University of Guanajuato (Mexico) and University of Delaware (sabbatical visitor))
   Colloids as model systems in soft matter physics

6. Sudeep Dutta (Georgetown University)
   Rheological and Microscopic Properties of Compressed Emulsions

7. Jeffrey Guasto (Haverford College)
   Oscillating flows induced by swimming microorganisms

8. Jaime Juarez (Johns Hopkins University)
   Electric field mediated colloidal assembly and control

9. Elizabeth Knowlton (Georgetown University)
   Temperature induced size changes of NIPA under different osmotic pressures

10. Daniel Koch (Georgetown University)
    Mechanics in Neuronal Navigation

11. Pramukta Kumar (Georgetown University)
    Measuring Deformations in Collagen Networks

12. Myung Han Lee (University of Pennsylvania)
    Polymer- and nanoparticle-shelled bubbles based on microfluidics

13. Sarah Mastroianni (University of Delaware)
    Nanostructured photovoltaic materials using conjugated block copolymer assemblies

14. Armstrong Mbi (Georgetown University)
    Confocal Rheology of bidispersed glassy silica

15. Ryan McAllister (Georgetown University)
    Early Images of Confocal Rheometry on Cancer Cells

16. Michel de Messieres (University of Maryland)
    A new method of measuring the energy landscape of an unfolding transition

17. Maki Nishida (Georgetown University)
    nanoscale crystal formations and progression in the self-organization of TCNQ

18. Subramanian Ramakrishnan (Florida State University)
Dynamics and Rheology of Colloidal Gels

19. Kelly Schultz (University of Delaware)
High-throughput microrheological characterization of biocompatible hydrogelators

20. Colleen Treado (Georgetown)
3D Traction Forces in Cancer Cell Migration

21. Maeva Tureau (University of Delaware)
Phase Behavior of Neat Triblock Copolymers and Copolymer/Homopolymer Blends Near Network Phase Windows

22. Xinli Wang (Johns Hopkins University)
Transport of Brownian particles confined to a weakly corrugated channel

23. JeongJae Wie (University of Delaware)
Polymer nanoparticle composites: Unusual reinforcement and non-Einstein behavior