

## Poster Presentations

### **Approach-retract cycles with an oscillating nanotip: powerful methods to interrogate subsurface morphology and viscoelasticity on polymers**

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#### **Abstract**

Case studies on PDMS-based and other polymeric materials are presented to elucidate a rich variety of information obtainable in approach-retract measurements. Recently these measurements have been utilized in mechanistic studies of tip-sample interaction in “tapping” or “intermittent contact” modes, published primarily in physics journals. The procedures have been largely ignored, however, in most materials applications. Here our focus is on depth dependent and mechanical information derived from approach-retract measurements. Important connections to conventional height, amplitude and phase images are demonstrated. Indeed the utility of approach-retract measurements together with conventional images is greater than the sum of the parts. Our implementation further demonstrates the power of spatially resolved approach-retract measurements of amplitude or phase, acquired in so-called “force volume” and similar modes. The discussion includes weaknesses in most commercial AFM systems, and considers “third generation” systems exploiting advances in computing speed as well as data throughput, storage, reduction and analysis.

### **Atomic force microscopy of microbial cells: Influence of topography on several imaging modes**

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#### **Abstract**

Imaging whole microbial cells by AFM is usually quite difficult due to the large size of them. This is the case when imaging yeast cells, which are 4-5 micron in size. In this work the influence of topography on AFM images taken in several modes (topography, friction, phase imaging, error mode) is shown. From our results it is suggested that pushing the tip on a sloped region can cause it to twist a little, which can explain some artifacts encountered when collecting force curves over peripheral regions of spherical-shaped cells.

### **Bacillus subtilis spores and functional liposomes with peptide ligands: Interactions through exosporium-like shell**

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### **Abstract**

The liposomes, composed of phosphatidylethanolamine (PE) and 1,2-dioleoyl-sn-glycero-3-phosphoethanolamine-N-[3-(2-pyridyldithio)propionate] (N-PDP-PE), were functionalized by covalent attachment of peptides of the NHFLPKV-GGGC sequence. Interactions between the liposomes and spores of *Bacillus subtilis* were studied using Atomic Force Microscopy and Dynamic Light Scattering technique. An exosporium-like outer layer around *B. subtilis* spores was discovered. It was shown for the first time that in the course of interaction the spores attracted the functional liposomes into the outer layer. Herein the phospholipids penetrated and distributed inside this exosporium-like layer forming a smaller but a denser shell, probably, structured. The results obtained are potential for the detection of the spores of different types (including exosporium-containing *B. anthracis*).

### **Atomic force microscopy of gastric mucin solutions**

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### **Abstract**

We report on the first pH-dependent AFM study of porcine gastric mucin employing the tapping mode technique in aqueous solution. This glycoprotein is responsible for protecting the stomach epithelium from acid damage. We observed that at pH 6 mucin exists as individual fibers while at pH 5 it forms loose aggregations. At pH 4 and below individual fibers could no longer be detected within the aggregations instead homogeneous clusters were clearly seen. At pH 4 the clusters were more compact, and largely symmetrical while at pH 2 we observed larger elongated clusters aligned with each other in the direction of their long axes, suggestive of liquid crystalline ordering. We were also able to observe the pH dependent structural changes in situ. Individual clusters are of apparent size 50 nm long and 20 nm wide and 8 nm high, whereas at high pH the height was only 1.5 nm.

### **Atomic force microscopy studies of the conformation of cartilage aggrecan and related constituents**

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### **Abstract**

Charged proteoglycans (PGs) contribute >50% of the equilibrium modulus of cartilage. PGs composed of negatively charged, disaccharide polyelectrolytes, called glycosaminoglycans (GAGs) are covalently bound to a core protein forming the aggrecan

monomer. Visual characterization of aggrecan will give a nanoscale picture related to variations in bulk mechanical as well as intermolecular measurements. Atomic force microscopy (AFM) allows for imaging under physiological conditions, so that the macromolecular conformation more closely represents that found in native cartilage. Non-covalent binding of negatively charged GAGs to a positively charged amine-modified mica surface was achieved. The effects of incubation time and reaction conditions were studied in order to optimize sample preparation. The observed length and width of aggrecan monomers correlate well with published values. Preliminary results show GAG chains collapsing as ionic strength is increased as predicted by changes in the Debye length. Ongoing and future plans include studying the effect of ionic strength and pH as well as investigation of the proteoglycan self-assembling process.

### **Direct measurement of nanoscale interactions between pharmaceutical particles via high-resolution force spectroscopy**

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#### **Abstract**

Intersurface interactions between pharmaceutical particles are important in the processing of both solid dosage forms and inhaled drugs. In this project, we have attached micron-sized particles of excipients (such as microcrystalline cellulose and monohydrate lactose) and active pharmaceutical ingredients to silicon nitride probe tips on microfabricated cantilevers. The attached particle is brought into close proximity and contact with a second, stationary particle and the interparticle forces are monitored (at the pN-level) as a function of separation or indentation distance (at the nm-level). The intersurface interactions measured appear to include water capillary forces, mechanical interlocking, and electrostatic forces. The effects of humidity and particle chemistry on the jump-to-contact force, the jump-to-contact distance, and the pull-off adhesion force were determined. Environmental scanning electron microscopy (ESEM) and atomic force microscopy (AFM) were used to image the particle surfaces and obtain topography, roughness, and contact area between particles.

### **Measurement of the elastic modulus of polymer gels using the atomic force microscope**

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#### **Abstract**

To understand and control the mechanical behavior of polymer gels it is important to determine their physical properties at different length scales. Three difficulties of using

AFM for the measurement of the elastic modulus of thin polymer gel layers are discussed. The first concerns the use of sharp cantilever tips, which generally induce local strains that exceed the linear material regime. It is demonstrated that this problem can be solved by using microspheres as probes. A second difficulty is caused by the use of the Hertz contact mechanics model, which is not accurate for thin samples. Corrections are proposed for both bonded and non-bonded thin films. The third problem is to determine when does contact occur between the tip and the gel surface. Error estimates of the elastic modulus are discussed. Experimental results are shown for polyvinyl alcohol hydrogels. The AFM results are compared with macroscopic elastic modulus measurements.