

Protein Adsorption on Solid Surfaces

Chemical Engineering and Materials

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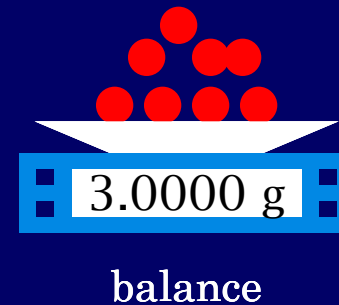
Research and Motivation

- **Fundamental: Understand the interactions of protein**
 - Protein-protein interactions
 - Surface-protein interactions
 - How much protein is on the surface?
 - What would happen if...?
- **Extend the life span of a biomedical implant**
 - Implant rejected by the body due to protein adsorption
 - Decrease the adsorption of protein
- **Funding: National Institute of Health**
 - Improve people's health
 - Prevent diseases/find causes and cures for diseases

Surface-Protein Interactions

How much protein is on the surface?

- **Proteins**
 - BSA (bovine serum albumin)
 - Tau
- **Surfaces**
 - Gold
 - Mica
 - Glue it on the crystal
 - Make sure it works
- **Need a “balance”**
 - Quartz Crystal Microbalance (QCM)
 - Super-sensitive balance
 - Detects the mass of adsorbed protein

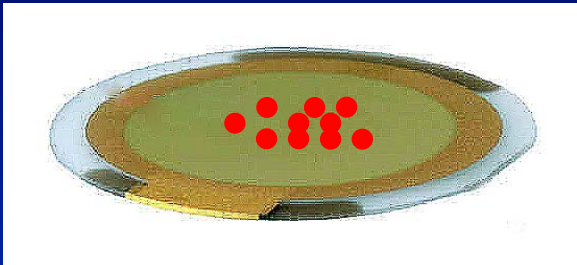




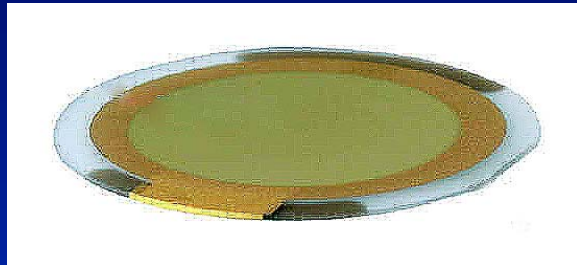
Q-Sense D300



q-sense.com/Q-Sense D300 User Manual

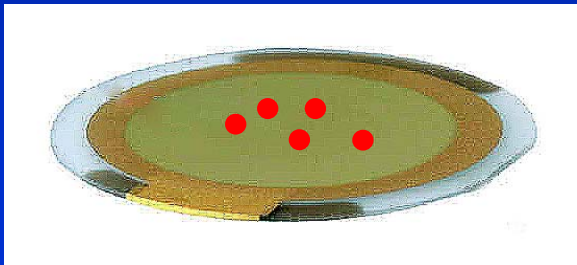


14,999,900.00 Hz

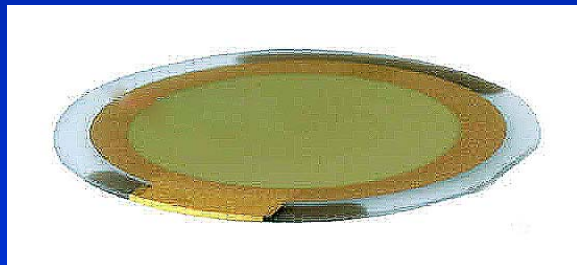


15,000,000.00 Hz
(15 MHz)

= -100 Hz



14,999,950.00 Hz



15,000,000.00 Hz
(15 MHz)

= -50 Hz

Sample Data

How much BSA protein is on the gold surface?

1 monolayer of BSA \approx 15 ng

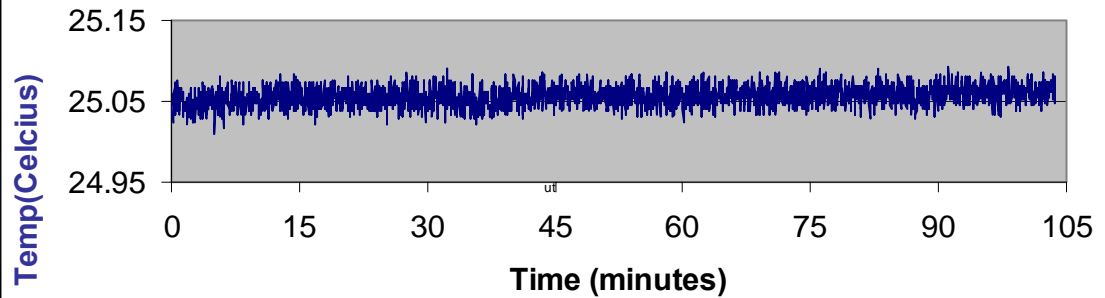
- 80 Hz \approx 22 ng

- 95 Hz \approx 26 ng

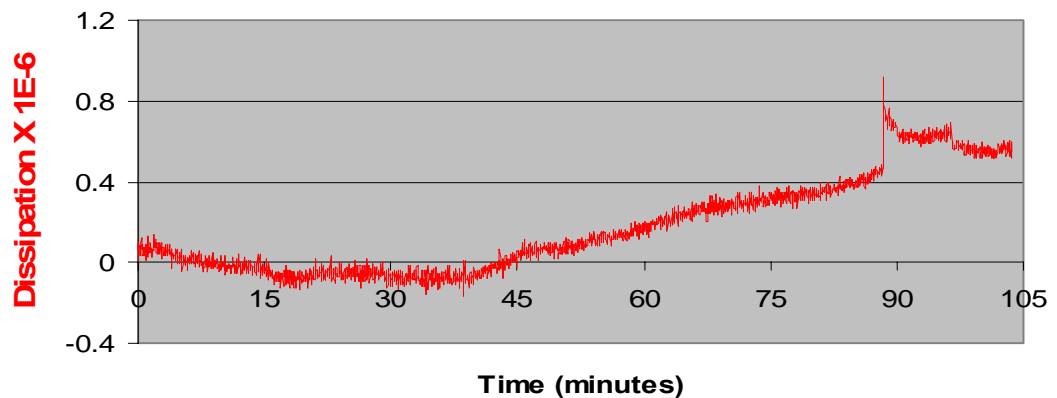
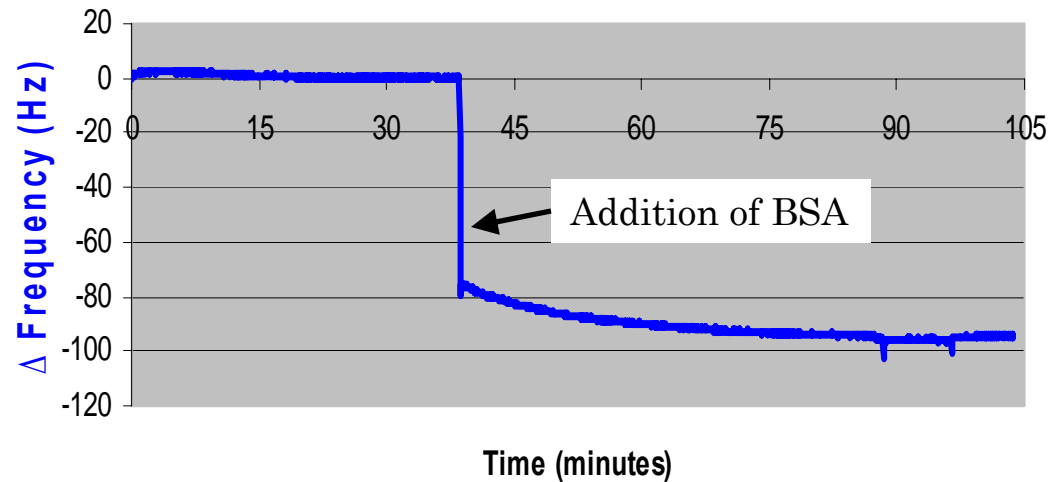
Dissipation

Sum of all energy losses in the system per oscillation cycle

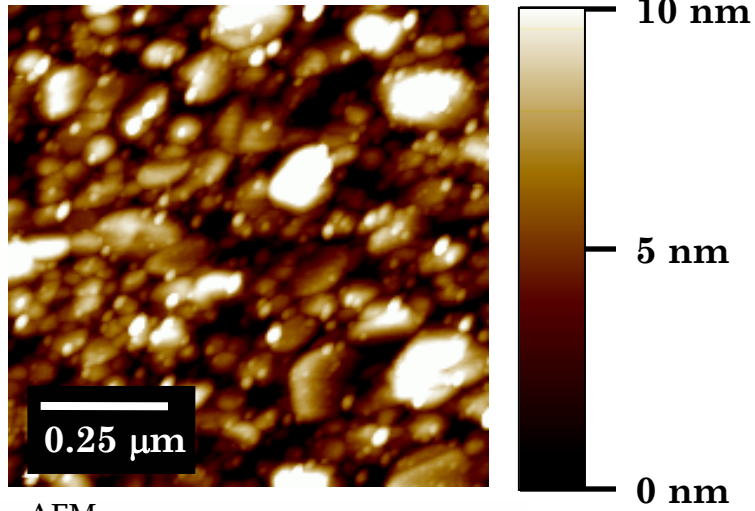
Soft/rigid film



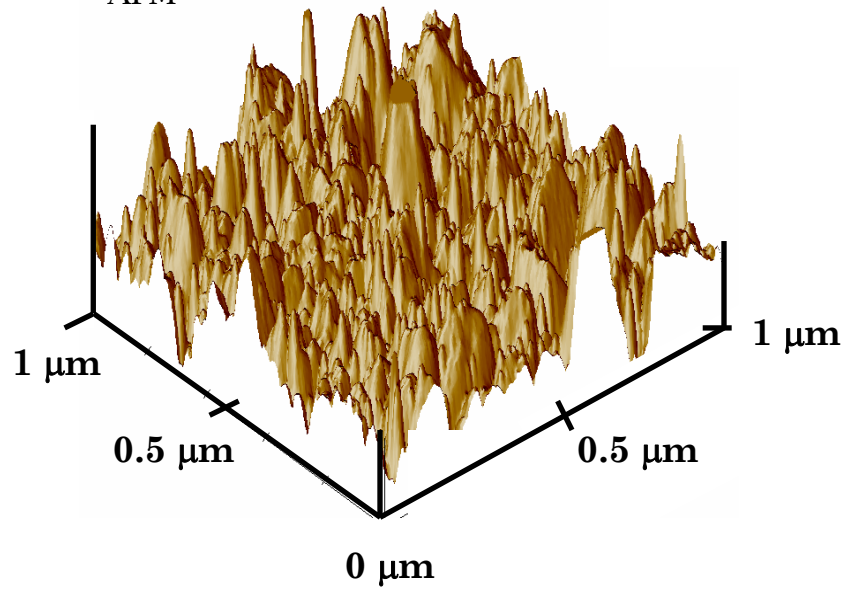
5 mg/ml BSA with 200 mM NaCl (15 Mhz)



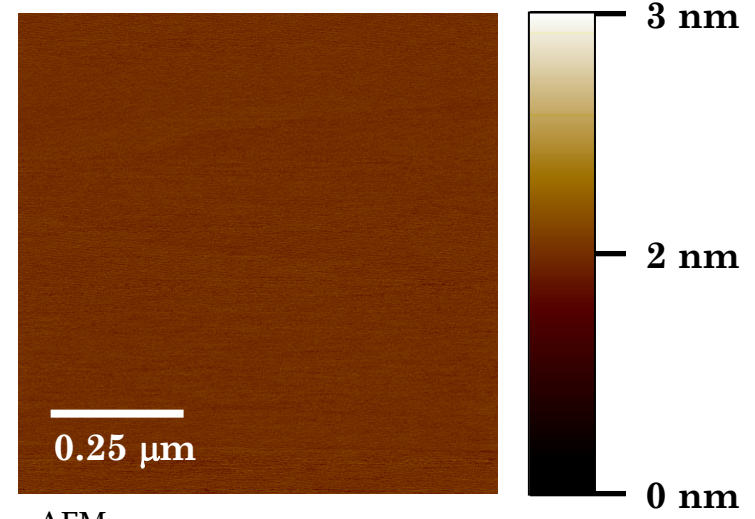
GOLD



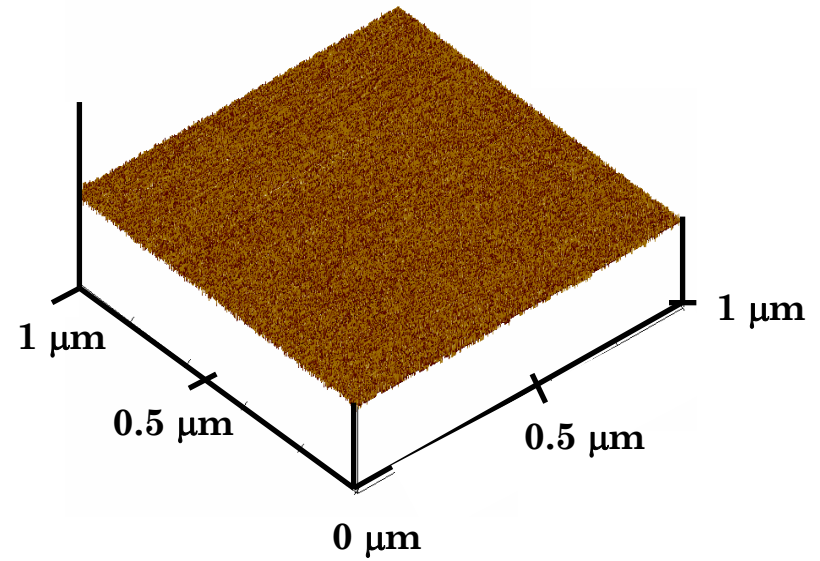
AFM



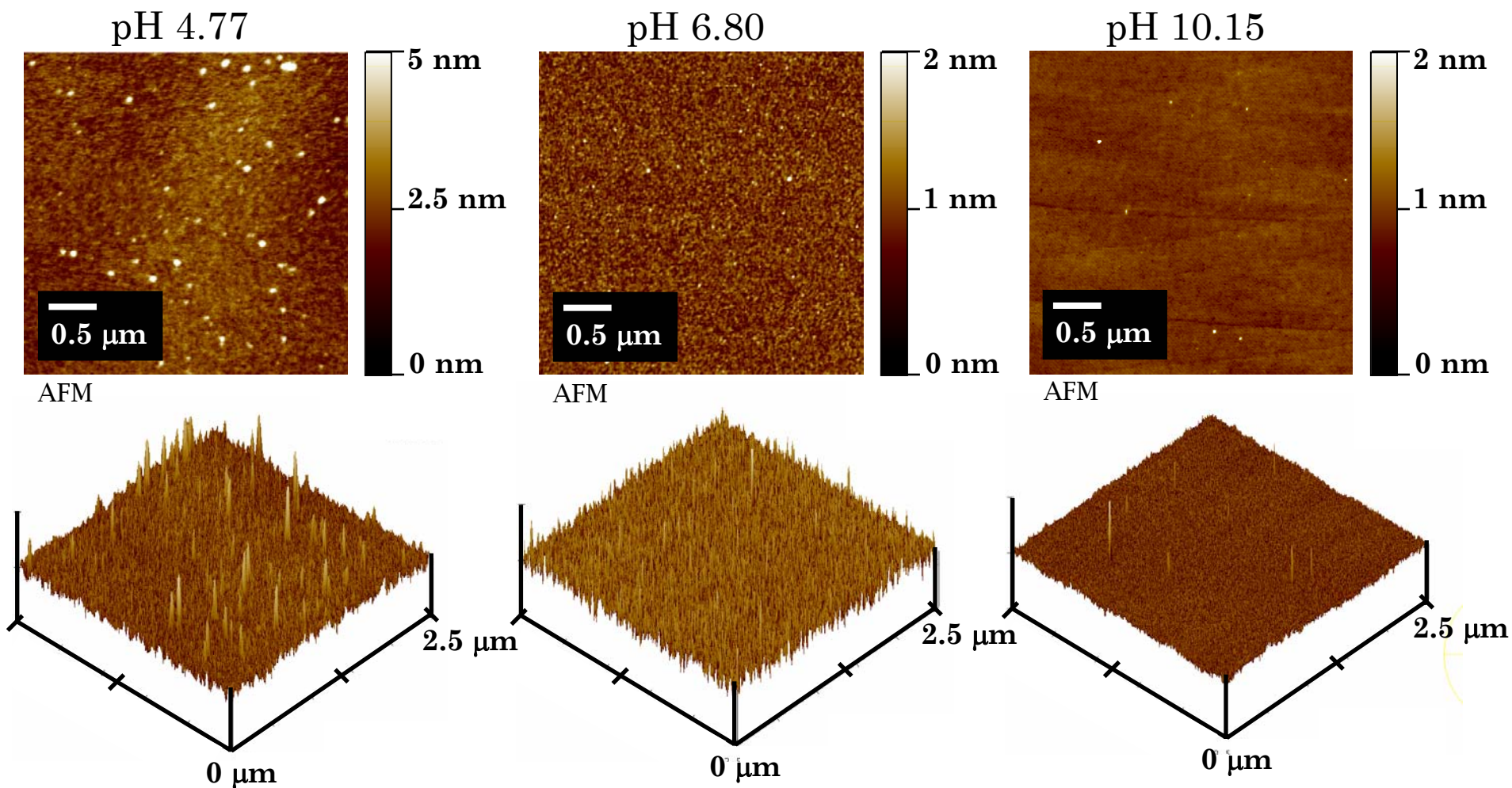
MICA



AFM

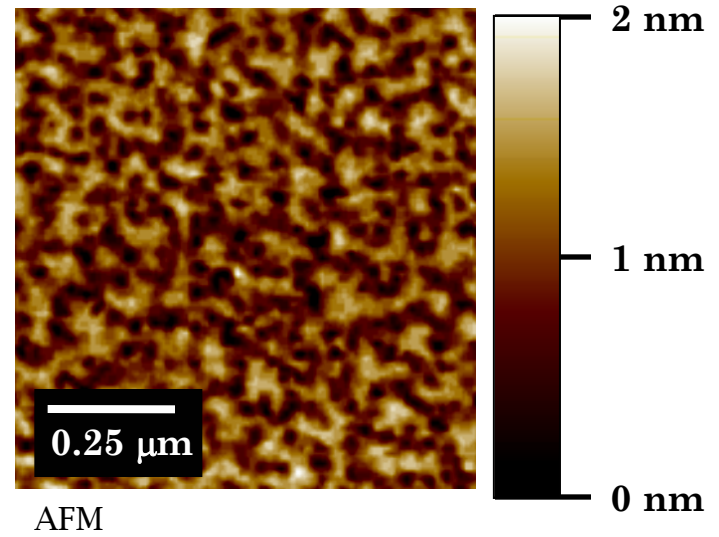
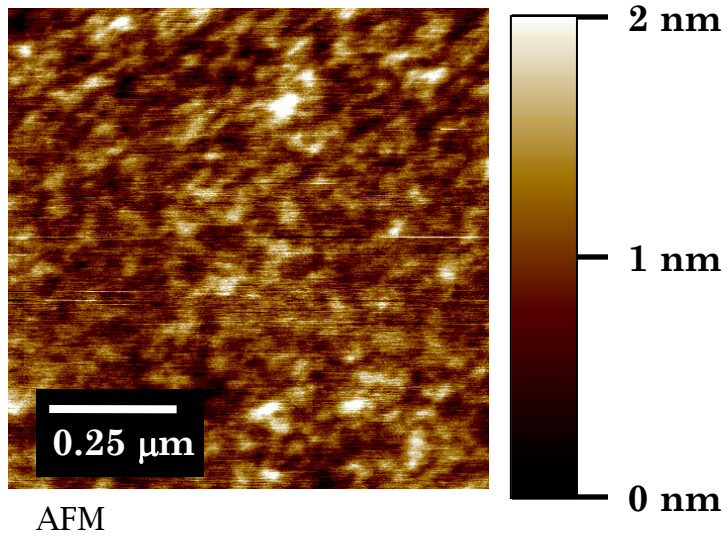


Gold vs. Mica



Preliminaries: 1mg/ml BSA on Mica

Does the pH of the solution matter?



Preliminaries: Tau on Mica

Does Tau concentration matter?

BSA on Gold

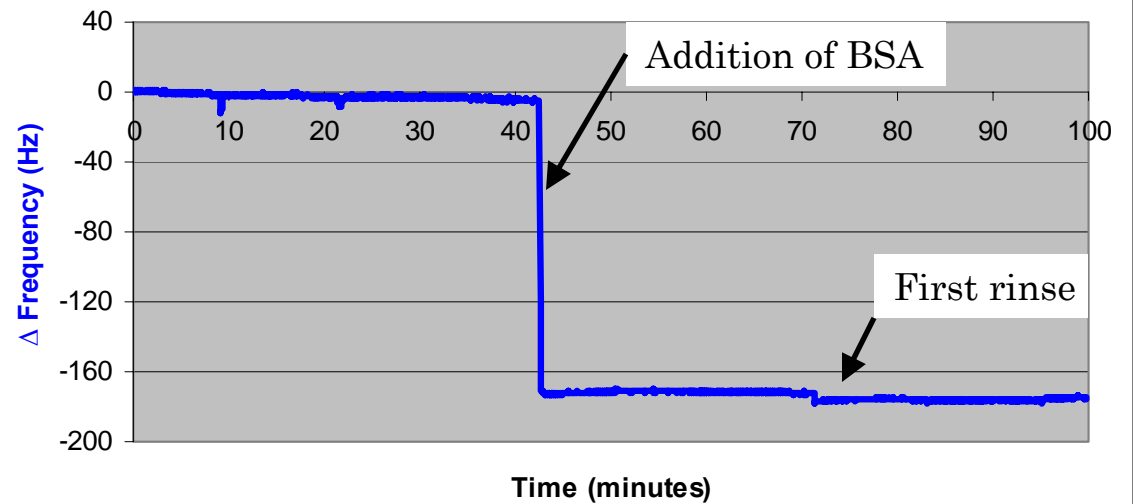
Does the pH of the solution matter?

1 monolayer of BSA \approx 15 ng

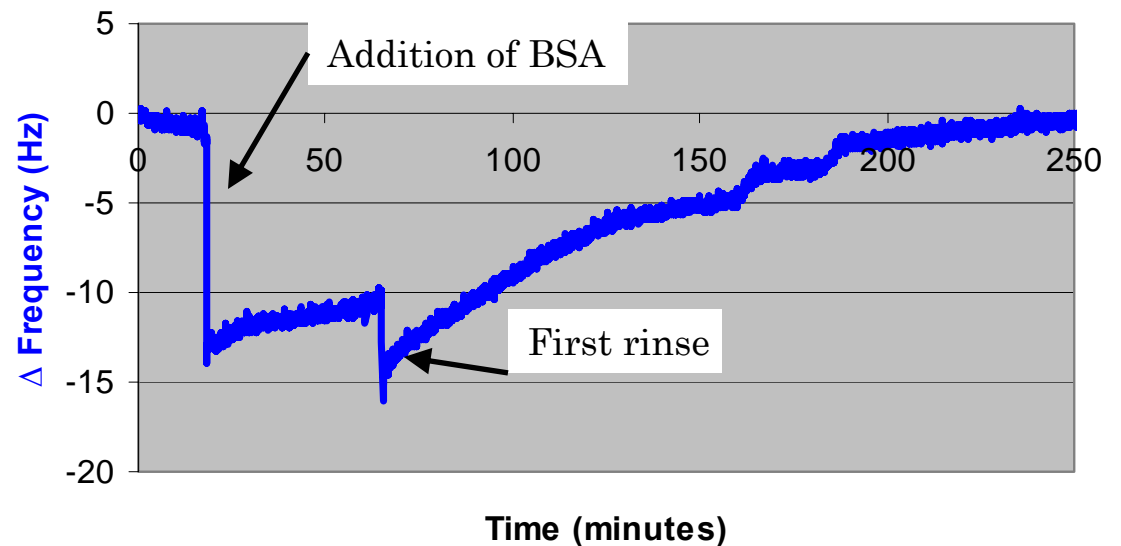
- 170 Hz \approx 48 ng (3 layers)

- 13 Hz \approx 3.5 ng

1mg/ml BSA with Acetic Buffer, pH 4.77



1 mg/ml BSA with Carbonate Buffer pH 10.15



BSA on Gold

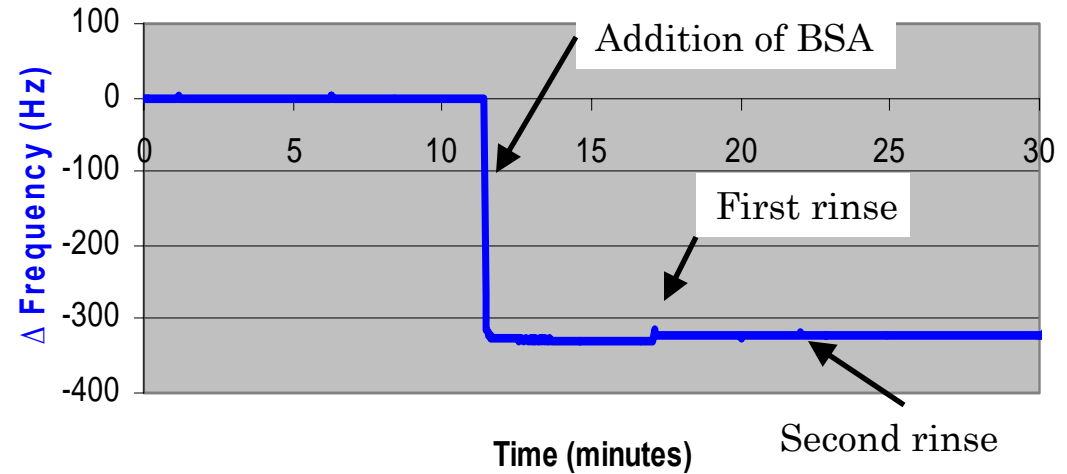
Does salt concentration matter?

1 monolayer of BSA \approx 15 ng

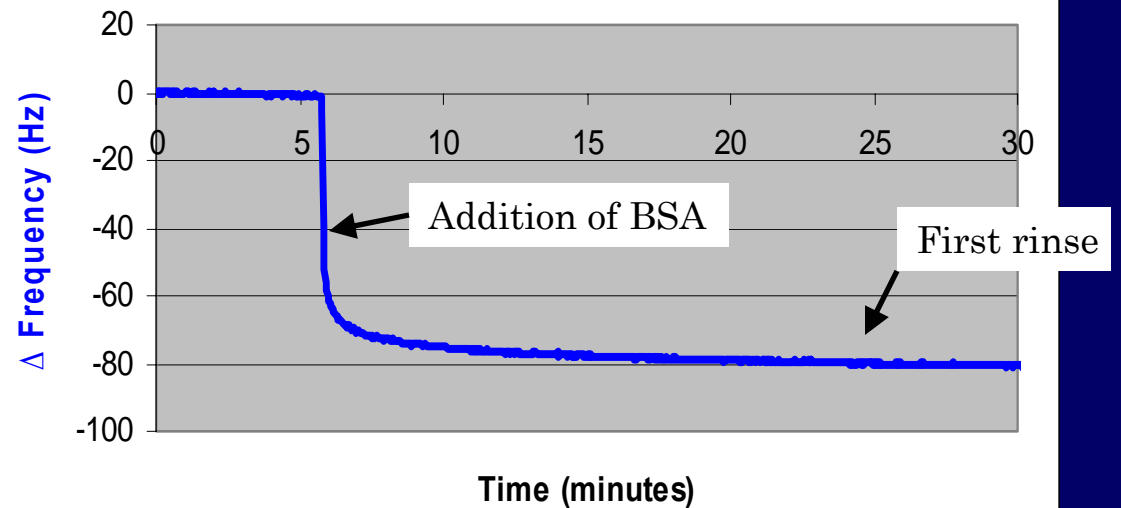
-80 Hz \approx 22 ng

-300 Hz \approx 83 ng (5.5 layers)

1 mg/ml BSA with K-PIPES, 1000mM NaNO₃, pH 6.80



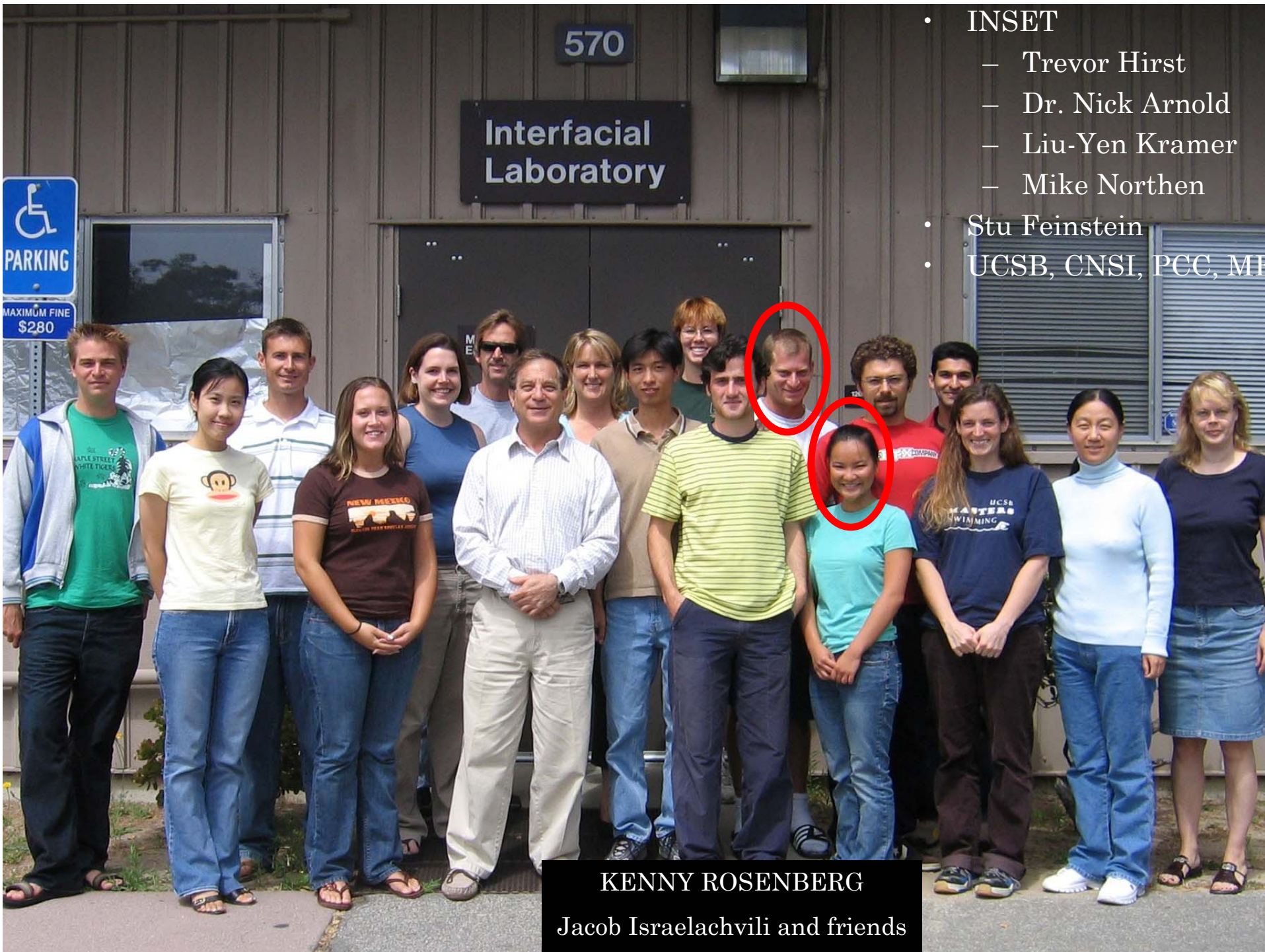
1 mg/ml BSA with K-PIPES, 1mM NaNO₃, pH 6.8



Summary and Future Research

- It takes less than 5 seconds for the majority of the protein to adsorb onto the surface
- pH of the solution matters
- Salt concentration matters too

- Produce a mica-modified crystal that works
- Study Tau



- INSET
 - Trevor Hirst
 - Dr. Nick Arnold
 - Liu-Yen Kramer
 - Mike Northen
- Stu Feinstein
- UCSB, CNSI, PCC, ME

KENNY ROSENBERG
Jacob Israelachvili and friends