Determination of Energy of Hydrophobic Interfaces through Contact Angle Measurements

[1]Jasmin Guerrero, [2] Saurabh Das and [2] Jacob Israelachvili
1 Department of Engineering, Santa Barbara City College;
2 Department of Chemical Engineering, University of California at Santa Barbara

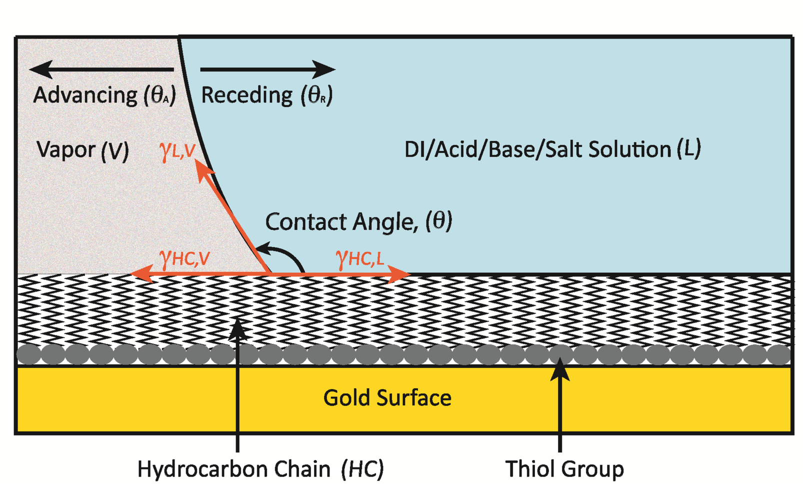
Introduction

Hydrophobic interactions have been under investigation for decades and questions regarding the energies between these molecules continue to be unanswered. These interactions cannot be explained through existing force or energy laws. We did surface force measurements using the Surface Force Apparatus (SFA) and developed a force law to explain the nature of hydrophobic interactions. The surface energy term, a parameter in the proposed hydrophobic force law was determined for the interface between 18-carbon chain length hydrocarbon-air-water interface.

Interfacial Energy from Young's Equation

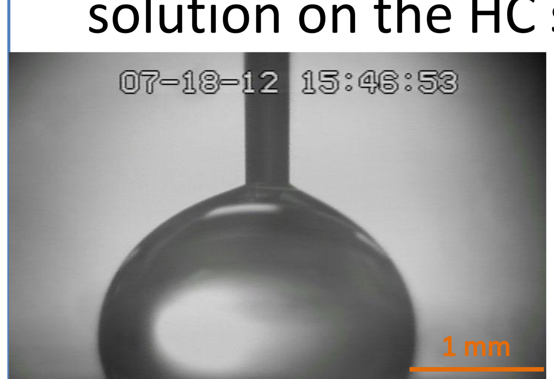
$$\gamma_{\text{HC to solution}} = \gamma_{\text{HC to vapor}} - \gamma_{\text{solution to vapor}} * \cos\theta$$

γ = Interfacial Energy
θ = Contact angle
HC = C-18 Hydrocarbon Chain
Units: mJ/m^2

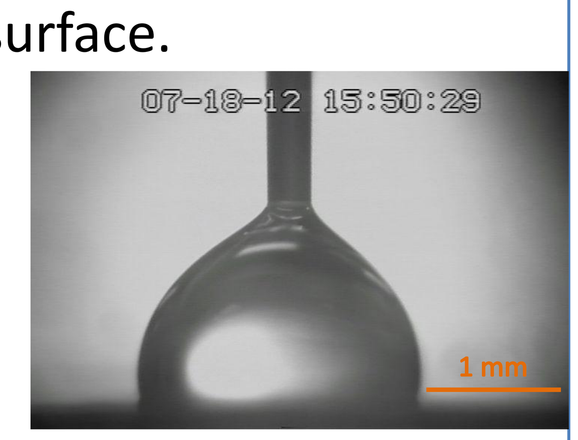


Methods

- Mimicking hydrophobic surface by attaching HC on gold surface.
- Dynamic contact angle experiments done by advancing and receding a drop of DI water and 5mM HNO_3/NaOH/KNO_3 solution on the HC surface.



Advancing drop of KNO_3 on HC surface



Receding drop of KNO_3 on HC surface

- Equilibrium Angle (θ_E) measured by allowing drop to sit on the HC surface for several hours.
- Control experiments on mica-templated gold surface were also performed.

Droplet Interactions on Surface

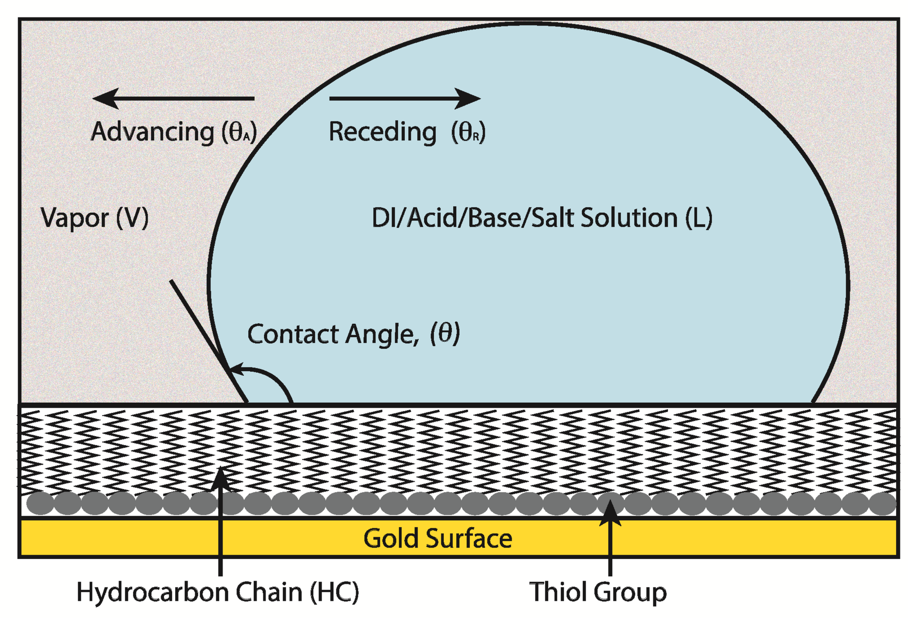


Figure 1. Diagram of θ of various solutions on HC-air-water interface.

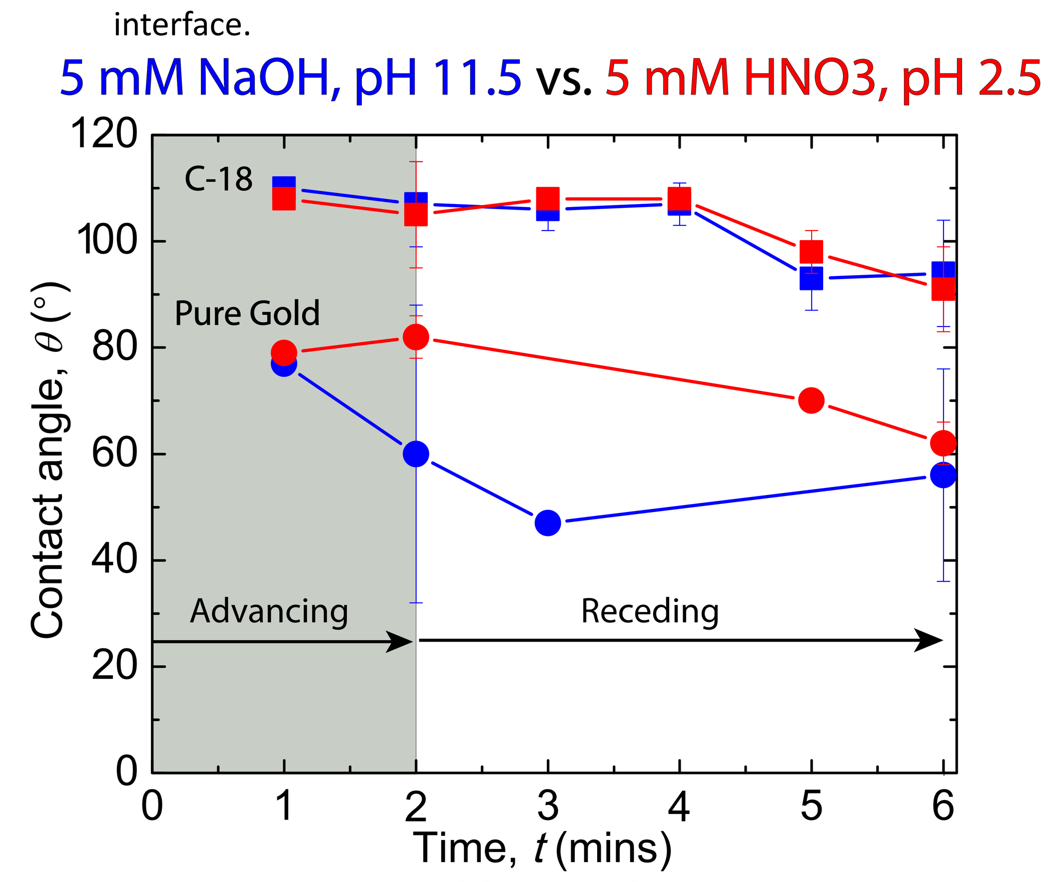


Figure 2. Comparison of θ values of basic and acidic solution on HC and pure gold surface. Closed squares represent HC surface and the filled circles denote the pure gold surface.

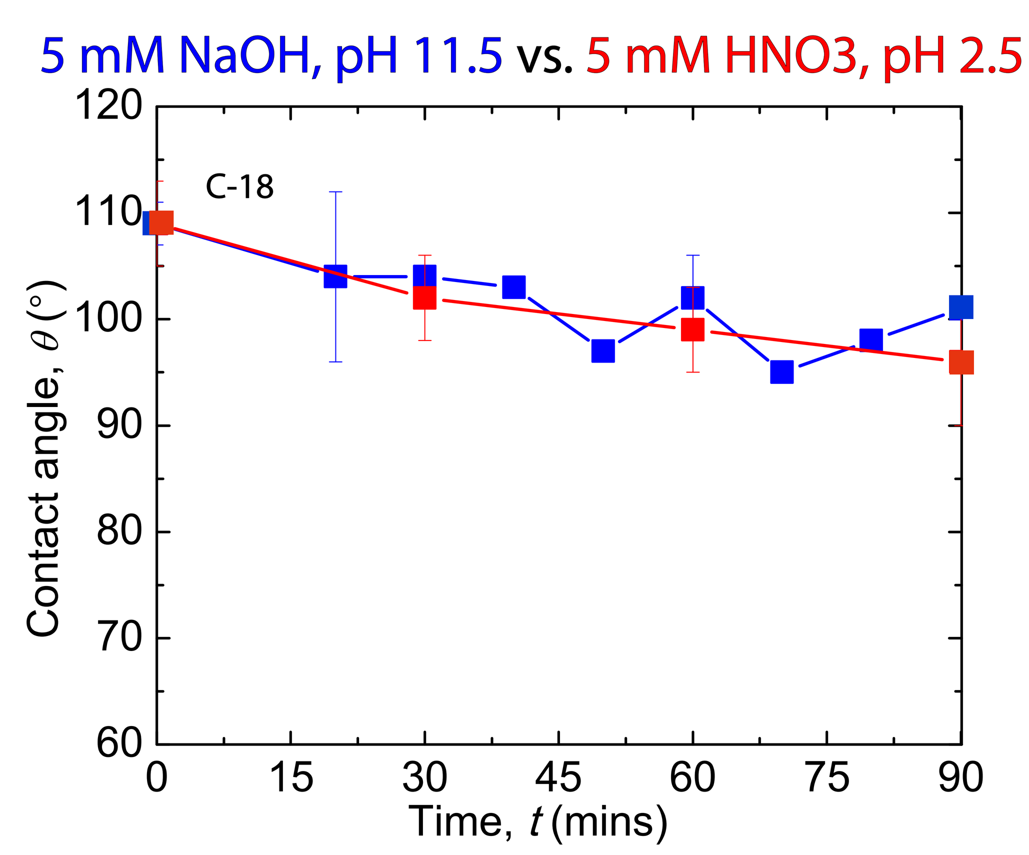


Figure 3. Comparison of θ values of basic and acidic solution on HC. Closed squares represent HC surface and the filled circles denotes the pure gold surface.

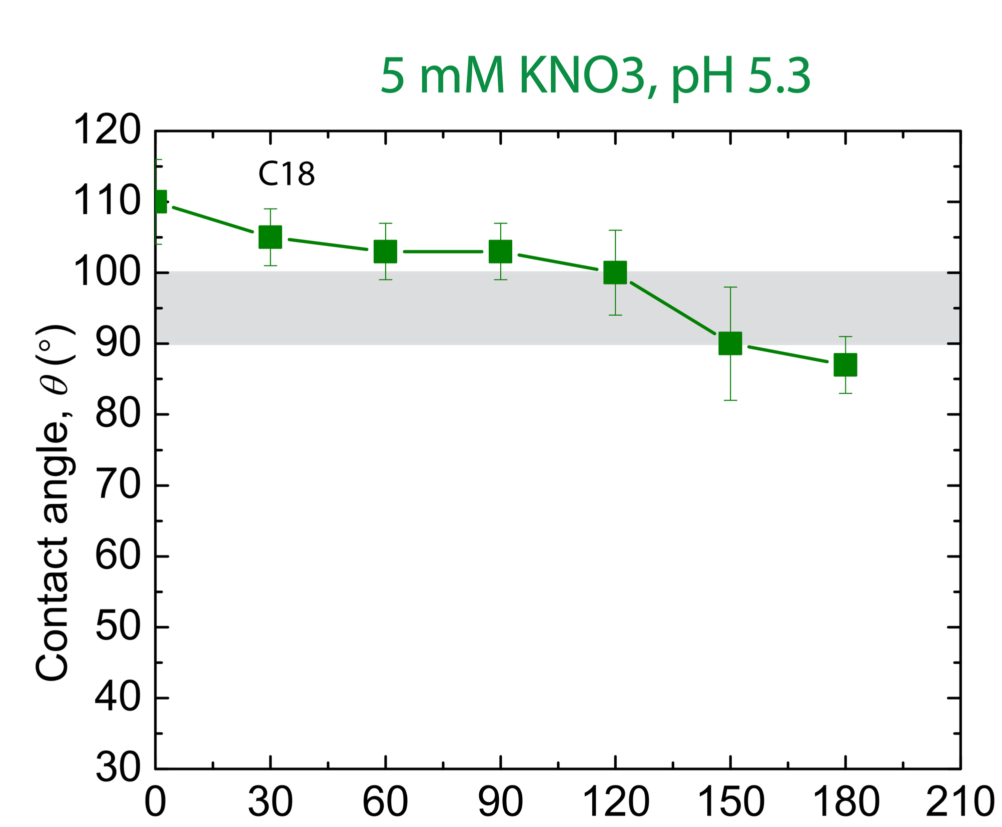


Figure 4. θ values of salt solution on HC. Shaded area represents the possible existence of θ_E in 95 ± 5°.

Results

- Equilibrium Angle (θ_E) between 18-carbon chain and air-water interface relaxed from 110° to 95° for a variety of solutions.
- The interfacial energy is 31 mJ/m^2 at θ_E = 95°, independent of the surface history.

Summary and Future Work

- Measured and analyzed contact angle results for 5 mM HNO_3, KNO_3, NaOH solutions and DI water conditions on C-18 hydrocarbon chains.
- Expect θ_E for each solution will result in interfacial energy for the proposed hydrophobic equation.
- When system is allowed to relax over time after any change, an equilibrium contact angle exists, regardless of the disturbance of the drop on surface.
- Discuss and experiment with larger variety of solutions on C-18 surface to confirm that an equilibrium contact angle exists at 95°± 5 for all solutions.
- Experiment with different hydrocarbon chains (C-11) and compare contact angles to confirm contact angle is independent of hydrocarbon chain used.

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Contact Info

guerreroj45@yahoo.com