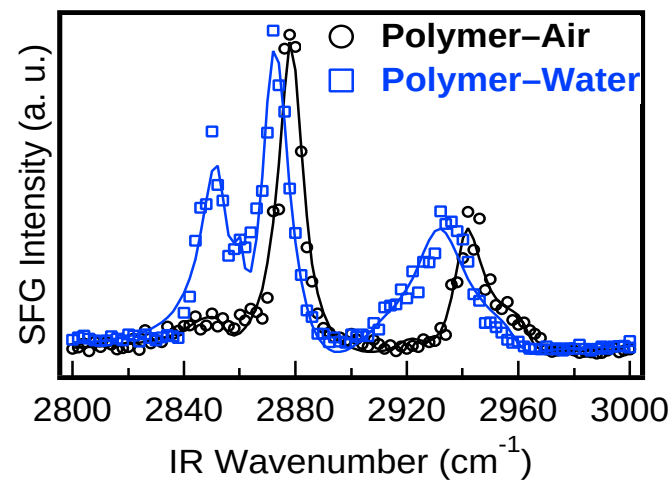
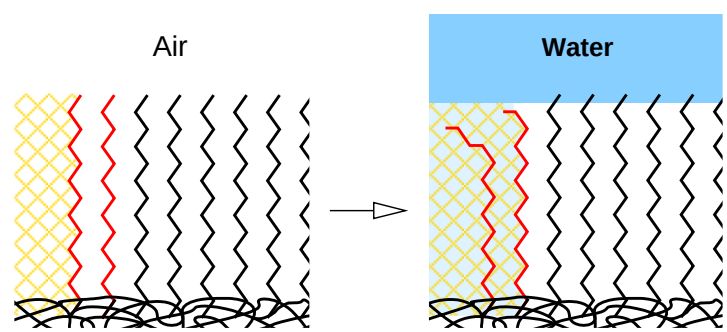
Molecular Structure of an Alkyl-Side-Chain Polymer-Water Interface: Origins of Contact Angle Hysteresis

Ali Dhinojwala, University of Akron, DMR-9984886

Measurement of contact angles, of a liquid at the surface of a solid, is a popular and economical method that is used to characterize surfaces in several areas of science and technology---for example, adhesion, biomedical engineering, biological surfaces, and coatings. These measurements are complicated by the fact that the surface of any real solid is nonideal. Young's equation relates the equilibrium contact-angle with the interfacial tensions between the solid, liquid, and vapor phases. However, the equation assumes that the solid surface is ideal---smooth, homogeneous, and having time-invariant interfacial energies with the other phases. However, in spite of the widespread use of these measurements, the conclusions are, at best, based on indirect evidence. Here, we measured the first, direct evidence of heterogeneity that explains the observed contact-angle hysteresis of water on a polymer surface. The main points of this work are summarized in Figure 1. SFG spectra of the PVNODC surface under the following conditions: freshly prepared film in air (circles); while the film is exposed to water (squares). Figure 2 is the cartoon showing a cross-section of the PVNODC–air interface (left part) and its transition to a PVNODC–water interface (right part). The cross-sectional plane is perpendicular to the polymer surface, and it cuts through a typical grain-boundary. In both parts, the ordered side-chains to the right are in a crystalline domain, and the yellow, crosshatched section to the left is the grain boundary. Over time, some amount of water will diffuse into the grain-boundary regions, as shown by a light blue shading of the crosshatched region (right part). The water contact angle measurements support the conclusions summarized in Figure 1.





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Education:

Under this grant, three students have completed their Ph.D. degrees: Dr. Alexander Schwab (post-doc at Haverford), Dr. Keshav Gautam (GE Plastics), and Mr. Ashwin Rao (joining NIST as a post-doc student in October 2004). Four REU undergraduate students have also been supported: Mr. Paul Crider, Ms. Laurie Hanne, Mr. Brian Tefft, and Mr. Casey Shaffer. Currently, five Ph.D. graduate students: Mr. Gary Harp (5th year), Mr. Hasnain Rangwalla (4th year), Ms. Betul Buehler (5th year), Mr. Shishir Prasad (2nd year), and Mr. Kumar Nanjundiah (1st year) are involved in this project.

Outreach:

As a Director of District 5 Science Day I have been involved in organizing District Science Day from last five years. We receive around 250 projects every year. Students from grade K5 to K12 participate in this competition. Top 90 projects are then selected to participate in the State Science Day held in Columbus. This activity takes significant planning and we have the first and second year graduate students in the Department of Polymer Science helping us with the organization of the District Science Day. Additionally, they perform simple polymer-related experiments for the school kids on District Science Day.

(http://www2.uakron.edu/cpspe/wrsd/wrsd.htm)