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Altering the gas/liquid interaction with surface molecules by inducing conformation change with temperature and electricity

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The functionality and properties of solid materials are strongly influenced by their surface properties. They control the behavior of gases and liquids with which the solid surfaces interact. Therefore, the ability to change the surface chemistry of materials in situ can open doors to many novel applications for functional materials. However, many methods for achieving this goal could be done only with complicated chemical reactions when the surface molecules are in contact with specific kinds of liquids that can induce the change. Therefore, this presentation proposes a simpler way of inducing the change in surface properties without having to induce chemical changes. First, the interaction between gas and surface molecules was controlled with temperature. A monolayer of ocatadecyltrichlorosilane (OTS) reversibly undergoes a melting-like transition. When the temperature of an OTS-coated particle and plate is moved through the range of OTS "melting" temperatures, there is a change in the lubrication force between the particle and plate in 1 atm of nitrogen gas. This change is interpreted in terms of a change in the flow of gas mediated by the slip length and tangential momentum accommodation coefficient (TMAC). The decrease in TMAC with increasing temperature to a decrease in the roughness of the monolayer on melting, which allows a higher fraction of specular gas reflections, thereby conserving tangential gas momentum. The flow of gas in a narrow channel can be controlled in situ by using an electric field to modify a thin organic surface film. The flow was determined indirectly by measurement of the lubrication forces between a glass sphere and a gold-coated plate. The plate was coated with a self-assembled monolayer of ω-COOH thiol. Application of the field to the ω-COOH plate caused a large decrease in lubrication force whereas application of the field to a ω-CH3 plate did not. The lubrication force reverts to the no-field value when the field is removed. This change can be used further to change the wettability of solids. It was hypothesized that the molecules would undergo conformation changes as their dipoles would align with the electromagnetic field induced by the applied current. Then, the hydrophobic backbone would be exposed to interact with the liquid above them compared to the molecular conformation with hydrophilic ω-COOH would be in contact with liquids. This was verified with four thiol molecules, and they controlled the contact angles of deionized water and hydrocarbon liquids. A quartz crystal microbalance and FT-IR were used to provide indirect evidence for the conformation change.

Dr. Dongjin Seo is an assistant professor of Chemical Engineering at Brigham Young University. After he completed his bachelor's degree in chemical engineering, he worked for an oil refinery in South Korea. This experience led to his interest in oil/gas-water systems. For his master's and Ph.D., he specialized in colloids and interfacial science within chemical engineering, focusing on responsive surface molecules. For his postdoctoral research, he studied oil-water systems and their interactions with solids for effective oil-water recovery. At Brigham Young University, he is exploring new avenues of responsive filters for oil-water separation by manipulating surface molecules and the interfacial properties of nuclear materials.