Seeing all the angles: Scientists measure how water and oils interact with surfaces

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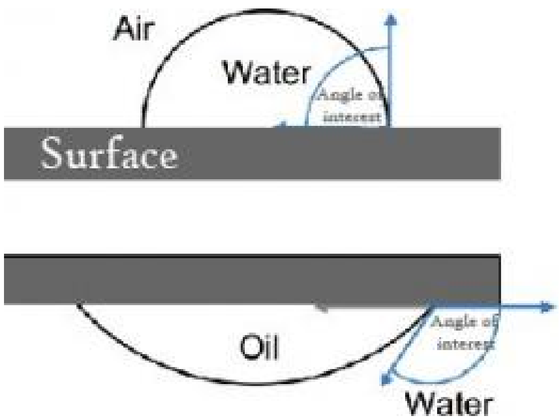

Water droplets can spread to a thin layer like a lens or bead up to a round fraction of sphere, depending on the interaction with the surface. The interaction with the surface, which influences a host of phenomena, is measured using the contact angle. Scientists at Pacific Northwest National Laboratory measured the contact angles for water in air on numerous surfaces and, in the process, discovered a linear relationship between the contact angles of water drops surrounded by air and oil drops surrounded by water.

(Phys.org) -- Scientists at Pacific Northwest National Laboratory determined the wettability—the preference of a rock or other surface to attract or repel water—of different surfaces by experimentally measuring contact angles. Contact angles are observed on the periphery of a drop in contact with the solid surface. Contact angles can be determined for both water droplets on surfaces in the air and for oil droplets in water on the same surfaces. A simple direct relationship was found between contact angles determined for these two different cases.

"This outcome is of practical importance because air-water contact angles are more commonly available and easier to obtain than oil-water contact angles," said Dr. Jay Grate, a Fellow at PNNL and a key researcher on this study, which appeared on the cover of *Langmuir*.

Producing power with fossil fuels accounts for just over half of the planet's human-made carbon dioxide emissions, and that number is rising. These emissions are altering the climate, changing weather patterns, and affecting cities and crops. Reducing emissions by storing them in underground geologic reservoirs could ease these changes. The outcomes of injecting a fluid such as supercritical carbon dioxide depends critically on the wettability of the porous medium. Understanding wettabilities in terms of the oil-water contact angle provides vital information about how such processes are expected to proceed.

"Being able to predict these contact angles from more commonly available air-water contact angles might considerably reduce the required experimental efforts," said Grate.

The researchers began with clean silica surfaces, and coated them with different silanes, materials composed primarily of silicon and hydrogen. Changing the coating changed the wettability. On each surface, repeated measurements of the air-water and oil-water contact angles were carried out, using the Ramé-Hart Model 500 advanced goniometer in the Environmental Molecular Sciences Laboratory. The instrument was purchased especially for this study. In addition, the team demonstrated a method to change the wettability of surfaces inside a microfluidic structure that mimics the pores in geological structures such as sandstone.

Wettability is a basic property of soil and other porous structures that affects a host of phenomena in multiphase flow, such as saturation by the displacing fluid. The contact angle is the conventional way to measure a change in the wettability. Surface chemists almost always measure the air-water contact angle. However, when studying how two immiscible liquids behave, such as oil and water, scientists need the oil-water contact angle. The present work provides a clear relationship between these two measurements.

"Given their value, it is remarkable that the relationships between water-air and water-oil contact angles have not been tested experimentally on so many diverse surfaces," said Karl Dehoff, a post-masters associate at PNNL who worked on the project.

"Eventually, we made enough surfaces with enough silanes yielding enough different wettabilities that we had a data set we could correlate," said Grate. "This gave us enough information to figure out the relationship between the oil-water and the air-water angles."

"The results are in nearly perfect agreement with the theory," said Dr. Mart Oostrom, the physicist at PNNL who led the study.

The next challenge for the team is modifying the interior surfaces of microfluidic models using silanes to do flow displacement experiments with water, oils, and supercritical carbon dioxide.

More information: JW Grate, et al. 2012. "Correlation of Oil-Water and Air-Water Contact Angles of Diverse Silanized Surfaces and Relationship to Fluid Interfacial Tensions." *Langmuir* 28(18):7182-7188. DOI: 10.1021/la204322k

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