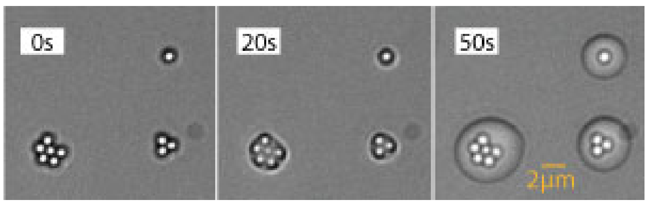
Theoretical model reveals how droplets grow around tiny particles on a surface

January 11 2017



Water droplets grow around clusters of silica particles on a surface. Credit: Ref. 1 via CC-BY-4.0 © T. S. B. Quang et al.

A mathematical model that predicts how water condenses around tiny particles could help to improve chemical industrial processes, including the production of drug tablets, fertilizers and catalysts.

Previous condensation models differ in their rate predictions, depending on factors such as the shape and composition of the surface that the droplet grows on. Fong Yew Leong of the A*STAR Institute of High Performance Computing wanted to develop a more realistic theoretical model to help his collaborators understand their experimental condensation results. "This is where modeling and computation gets really useful, in providing physical insights that can't be obtained from experiments," says Leong.

He and his colleagues modeled a water droplet growing in the crevice between a micrometer-sized particle and a flat surface. Their model considers factors such as particle size, the surface tension of the droplet, and how much the underlying surface attracts or repels water.

The model shows, for example, that a growing droplet covers a water-attracting (hydrophilic) surface more quickly than a water-repelling (hydrophobic) surface. The volume of a droplet initially increases more slowly on a hydrophobic surface, but then speeds up as the droplet becomes more convex. "The droplet doesn't shrink during condensation; it instead wets the particle completely," says Leong.

The team carried out experiments to test their model, filming how water condensed around micron-sized silicon dioxide particles on a glass slide (see image). They saw that water always condensed in the crevice between a particle and the slide, rather than forming standalone droplets on the surface, and found that the droplets' growth was almost the same as that predicted by their model. The researchers also adapted the model to predict the growth of droplets around clusters of particles.

These results demonstrate that it is not possible to accurately simulate condensation based on a single factor, the team says. Indeed, it appears that there is a competition between the particle and the substrate that determines how fast each one is covered in water as the droplet condenses. "It points to significant implications for wetting at small scales," says Leong. The team now hopes to model condensation and liquid interactions at even smaller length scales.

More information: Tran Si Bui Quang et al. Growth and wetting of water droplet condensed between micron-sized particles and substrate, *Scientific Reports* (2016). DOI: 10.1038/srep30989

Provided by Agency for Science, Technology and Research (A*STAR),

Singapore