KYUSHU UNIVERSITY

Public Relations Initiative, Kyushu University
744 Motooka Nishi-ku Fukuoka, 819-0395
TEL: +81-92-802-2443 FAX: +81-92-802-2139
E-MAIL: koho@jimu.kyushu-u.ac.jp
URL: https://www.kyushu-u.ac.jp

**PRESS RELEASE** (2026/08/18)

**Scientists 'see' nanoscale forces, providing evidence of electric fields at the air-water interface**

*Using 3D electron microscopy, researchers have captured direct evidence for a long-debated electric field at air-water interfaces, opening a path to rationally designed clean-energy materials.*

**Fukuoka, Japan**—Bubbles are round, and we know surface tension does that. But squeeze that gas-liquid boundary into a space only a few tens of nanometers wide—could other forces be at work?

Now, an international team from Kyushu University, Nankai University, Stanford University and the University of Alberta has taken a direct look. Publishing on July 14 in the *Journal of the American Chemical Society*, they combined three-dimensional transmission electron microscopy (3D TEM) with force analysis to provide evidence for a powerful electric field at nanoconfined air-water interfaces.

"Water looks simple, but it's actually incredibly complex," says Qin-Yi Li, Associate Professor at Kyushu University's Faculty of Engineering. "Its structure is especially rich at the water-air interface, and it shifts dramatically with scale."

A thin liquid film offers a good example—like the one forming the surface of a soap bubble. At everyday scales, it pops at the slightest touch. At the nanoscale, however, water molecules at the interface align like tiny compass needles, forming an ordered, layered structure. This alignment can generate an electric field, potentially strong enough to stabilize the ultrathin water film and at the same time drive chemical reactions, which may explain why reactions inside micrometer-sized droplets often proceed far faster than in bulk water.

Yet the field's strength and even its existence have remained debated. It is invisible, and earlier attempts to detect it, largely through chemical approaches, ran into the same obstacles. Either the measurement disturbed the field, or the droplet evaporated before it could be captured.

Li and collaborators set out to bridge physics and chemistry to overcome both. "If we could directly see the 3D shape of the interface, we could deduce the forces acting on it and provide evidence for the electric field," he explains.

His team did this by sealing air and water inside a carbon nanotube roughly 50 nanometers wide, about 1,000 times thinner than a human hair. This confinement stabilized the interface and suppressed evaporation. Then, using 3D TEM, they reconstructed the interface's full 3D shape.

What they saw was not a spherical cap meniscus but a continuously twisting, irregular surface, with water films ranging from a few to about 10 nanometers thick. Analyzing this geometry, the researchers deduced the repulsive force holding the thinnest films together, reaching roughly 10 megapascals in some spots—about 100 times atmospheric pressure. Classical theories fell far short of explaining it. The missing piece, they suggest, is the intense electric field from molecular alignment. When they calculated the force such a field would produce, it closely matched the interfacial shape they observed.

For more direct chemical evidence, the researchers introduced chloroauric acid, a solution containing gold ions, into the same confined system. Without adding a reducing agent, gold nanoparticles spontaneously formed within about two nanometers of the air-water interface. “We knew chemistry occurs at interfaces, but previous estimates of the active zone varied wildly,” Li notes. “Now we can see exactly where the reaction takes place.”

Li is careful not to overstate. Since the experiments were conducted under nanoconfinement, how this compares to free, unconfined systems remains an open question.

What the team emphasizes is the methodology: seal fluids in a nanotube, reconstruct an interface's 3D shape, deduce the forces, and confirm by tracking where reactions occur. This workflow can be applied across diverse materials, liquids, and reactions, building a reference for better design.

“That matters beyond the lab,” Li adds. “In fuel cells and water electrolysis—technologies central to a carbon-neutral energy future—key reactions happen inside nanoscale pores of porous materials, at countless invisible gas-liquid interfaces. A deeper understanding of fluid behaviors there could lay the groundwork for designing these nanoporous materials more rationally.”

###

For more information about this research, see “3D Electron Microscopy Reveals Evidence for Strong Electric Fields at Nanoconfined Air–Water Interfaces,” Ryota Saito, Haruka Tsuruda, Chenghui Zhu, Jianze Zhang, Xuehua Zhang, Koji Takahashi, Richard N. Zare, Xinxing Zhang, Qin-Yi Li, *Journal of the American Chemical Society*, https://doi.org/10.1021/jacs.6c08580

**About Kyushu University**

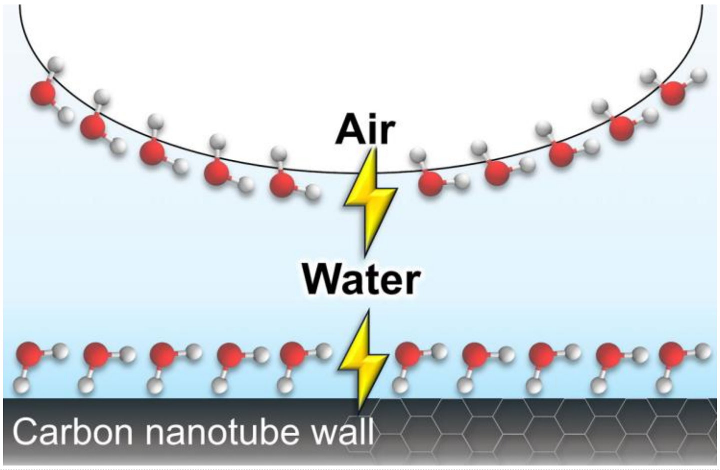


Fig. 1. Scientists 'see' nanoscale forces, providing evidence of electric fields at the air‐water interface
Using 3D electron microscopy, researchers have captured direct evidence for a long-debated electric field at air-water interfaces, opening a path to rationally designed clean energy materials.

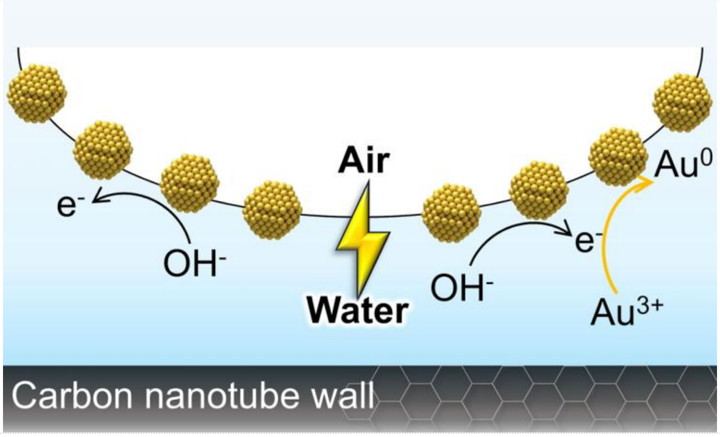


Fig. 2. Reduction of gold at the nanoconfined air-water interface provides chemical evidence for a strong interfacial electric field
For more direct chemical evidence, the researchers introduced chloroauric acid, a gold-containing solution, into the same confined system. Without adding a reducing agent, gold nanoparticles spontaneously formed within about two nanometers of the air-water interface.

[Contact]
Qin-Yi Li, Associate Professor
Faculty of Engineering
Tel: +81 92 802 3016
mailto:qinyi.li@aero.kyushu-u.ac.jp