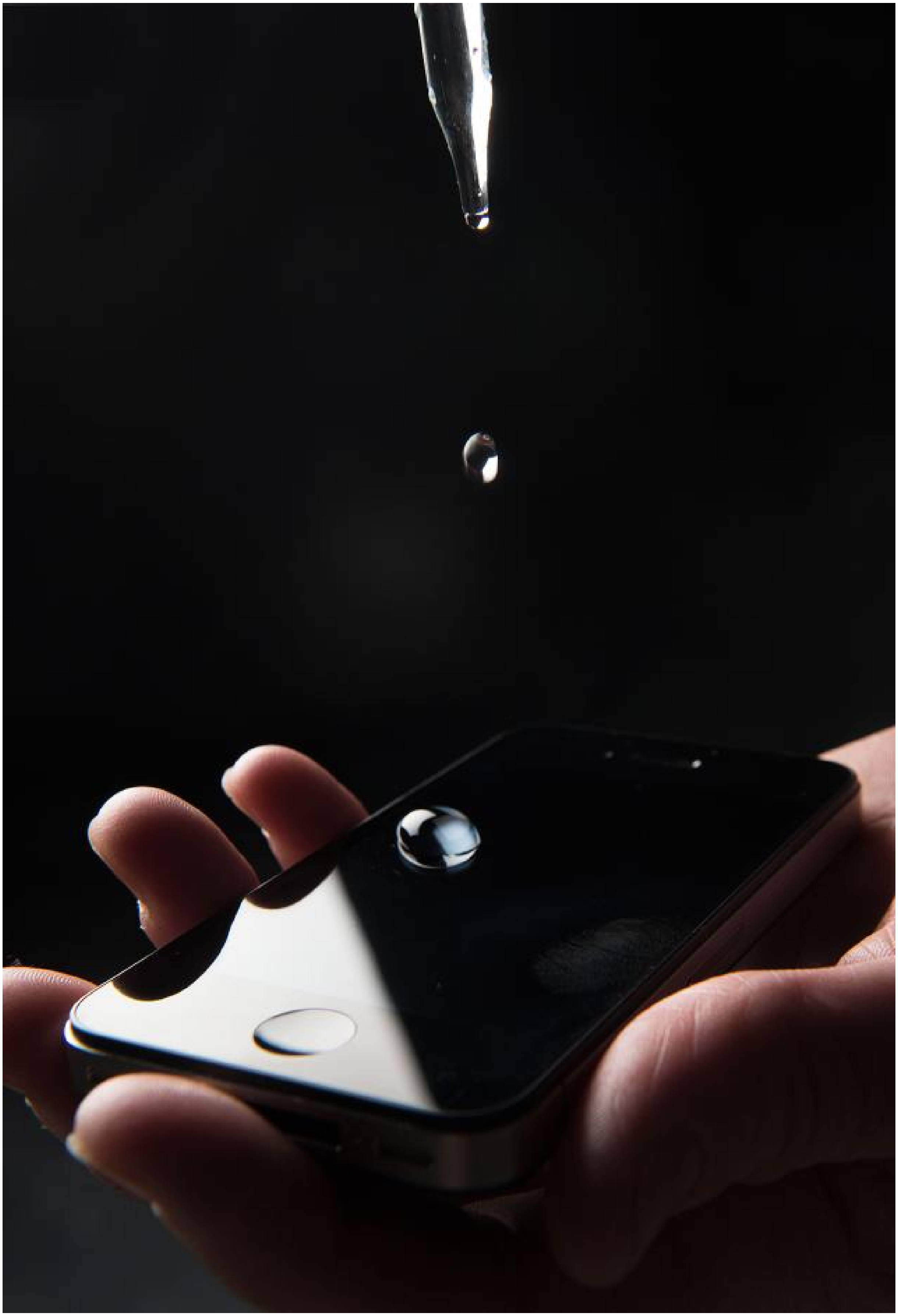
At attention, molecules! Chemists report molecules in ionic liquids arrange themselves, but it takes time

May 17 2016, by Richard C. Lewis



University of Iowa chemists have learned about a molecular assembly that may help create quicker, more responsive touch screens, among other applications. The researchers report the interfacial layer -- when molecules interact with a surface -- of electrically charged fluids called ionic liquids is thicker than previously realized. Credit: Tim Schoon, University of Iowa

When you touch your phone's screen, you might not realize that you've set off a molecular chain reaction.

Your fingertip sends a jolt of electricity (albeit tiny) that disturbs rows of molecules meticulously assembled at the screen's surface and dictates the action, whether it's opening a new window or typing the next word on your text message.

But what if those molecules could be jostled more easily and rapidly snap back in formation, enabling quicker touches and swipes—and on smaller screens to boot?

University of Iowa chemistry researchers are taking such an approach by examining how molecules in an electrically charged fluid (called an ionic liquid) are disrupted at the liquid's surface and how quickly they reassemble themselves. In a paper published online this month in the American Chemical Society journal *Langmuir*, the UI team reports that the molecules reassemble without having to be prodded into position. But their complete reorientation takes time, and the layer of molecules affected by surface disturbances is thicker than previously known—in some instances at least 100 times thicker. The results help better define the potential uses of ionic liquids, from touch screens to energy use and storage.

"One aspect that makes our finding intriguing is the molecules show the ability to self-assemble," says Scott Shaw, assistant professor in the UI Department of Chemistry and corresponding author on the paper. "That would make the process of making a capacitive touch screen simpler. Right now, the molecules (in touch screens) are forcibly arranged in hundreds of layers. Rather than doing that layer upon layer, we could put (an ionic liquid) drop on the surface, and the molecules would self-organize. And that could make the process faster and cheaper."

What makes ionic liquids attractive for potential commercial use is they carry charges and have a natural urge to be orderly. Think of them like soldiers who yearn to be in a precise formation at all times. Because of their negative and positive charges, molecules in ionic liquids could respond to external forces more quickly than other materials—whether it's the tap of a finger or an electrical impulse from a battery pack—and order themselves over longer distances from the surface point.

But how these molecules arrange themselves at the interfacial region—the area where molecules are affected by contact with the surface—and how deeply the ripple from that contact penetrates the molecular assembly has been something of a mystery.

Shaw's team found highly ordered layers of ionic liquids extending to 1,000 nanometers, or 1 micron, from solid or vapor surfaces. Previous studies had shown molecules in ionic liquids order to an upper limit of 50 nanometers.

"The chemical models that guide the community's understanding and definition of the interfacial region of (ionic liquids) are evolving even as the reported thicknesses and magnitude of the interfacial region is diverging," the authors write. "Our most recent results add a new and intriguing layer of intricacy to this field."

The researchers discovered the expanded interfacial layer through "dumb luck," Shaw says. Radhika Anaredy, a graduate student in Shaw's lab, had been using a slowly rotating disc to examine how gravity and shearing could be employed to produce thinner interfacial regions. Frustrated one evening, Anaredy turned off the disc and left the lab. When she returned the next morning and measured the ionic liquid film, she was surprised to see the interfacial layer was 700 nanometers, far thicker than she, or anyone else, expected.

That's when the researchers figured out the molecules simply needed more time to complete their assembly. In fact, when testing other ionic liquids, Shaw's group observed that the self-ordering begins nearly instantaneously, but the molecules in the entire interfacial region aren't completely organized for 25 minutes to two hours, depending on the liquid.

"Typically, these measurements are done over 30 seconds or two minutes," Shaw explains. "No one's ever sat around and waited for these things to hang out and arrange themselves."

Of course, a touch screen that takes any appreciable time to react wouldn't be very useful.

"The trick is to make the reordering much faster," Shaw says. "Right now, it takes at least 20 minutes. We'll need to make it much, much faster."

More information: Radhika S. Anaredy et al, Long-Range Ordering of Ionic Liquid Fluid Films, *Langmuir* (2016). DOI: 10.1021/acs.langmuir.6b00304

Provided by University of Iowa