Droplet response to electric voltage in solids exposed

EurekAlert!

DURHAM, N.C. – For the first time, scientists have observed how droplets within solids deform and burst under high electric voltages.

This is important, the Duke University engineers who made the observations said, because it explains a major reason why such materials as insulation for electrical power lines eventually fail and cause blackouts. This observation not only helps scientists develop better insulation materials, but could also lead to such positive developments as "tunable" lenses for eyes.

As the voltage increases, water droplets, or air bubbles, within polymers slowly change from their spherical shape to a more tubular shape, causing extremely large deformation within the material. Over time, this can lead to cracking and failure of the polymer, the researchers said. Polymers are a class of "soft" materials that can be found almost everywhere, most commonly as an insulator for electrical wires, cables and capacitors. Droplets or bubbles can be trapped in these polymers as defects during fabrication.

"The effects of electric voltage on droplets in air or in liquid have been studied over decades,' said Xuanhe Zhao, assistant professor of mechanical engineering and materials science at Duke's Pratt School of Engineering. "We take advantage of the understanding of these electrified drops in air or liquid every day, such as in the use of ink-jet printers.

"Conversely, no one has actually observed the effects of electric voltages on droplets in solids," Zhao said.

The results of Zhao's experiments were published online Oct. 23, 2012, in the journal *Nature Communications*. His work is supported by and the National Science Foundation's Research Triangle Materials Research Science and Engineering Center, National Science Foundation's Materials and Surface Engineering program and National Institutes of Health.

In air or liquid, droplets subjected to increased voltage tend to transform into a cone shape that eventually emits tiny droplets from the pointed end of the cone. This is the basic phenomenon that is taken advantage of in inkjet printers and similar technologies.

"Changes in electrified drops in solids have not been well studied, because it has been very difficult to observe the process as the solid would usually break down before droplet transformation could be captured," Zhao said. "This limitation has not only hampered our understanding of electrified droplets, but has hindered the

development of high-energy-density polymer capacitors and other devices."

This knowledge becomes especially important, Zhao said, as scientists are developing new polymers designed to carry higher and higher loads of electricity.

Zhao's experiments involved droplets, or bubbles, encapsulated within different types of polymers. Using a special technique developed by Zhao group, the team observed and explained how increased voltage caused the droplet to form a sharp "tip" before evolving into the tubular shape.

"Our study suggests a new mechanism of failure of high-energy-density dielectric polymers," Zhao said. "This should help in the development of such applications as new capacitors for power grids or electric vehicles and muscle-like transducers for soft robots and energy harvesting."

The experiments also showed how polymers "deformed," or changed shapes, at different voltages before they failed.

"It appears that it could be possible, just by varying voltages, to change the shape of a particular polymer," Zhao said. "One of the new areas we are now looking into is creating lenses that can be custom-shaped and used in ophthalmic settings."

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