Researchers uncover factors that control ion motion in solid electrolytes

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University of Cincinnati researchers show for the first time that they can connect an increase in electrical (ionic) conductivity with flexibility of their networks. The same team of researchers discovered intermediate phases seven years ago in amorphous or disordered materials where networks are covalently bonded.

The team's results are presented in "Fast-ion conduction and flexibility of glassy networks," to be published this spring in *Physical Review Letters*.

"We find that when networks become flexible their electrical conductivity increases precipitously," says Deassy Novita. "Now we will be able to chemically tune these materials for specific applications. For example, the batteries implanted in patients who have heart pacemakers make use of a solid electrolyte."

Novita is a third-year doctoral student working in the lab of Punit Boolchand, professor of electrical engineering in the University of Cincinnati's College of Engineering. Originally from Indonesia and now a U.S. citizen, Novita began the ground-breaking research as part of her doctoral thesis.

"This system has been studied by about 35 groups all over the world over the past two decades. We are the first to make these samples in a 'dry' state," says Boolchand. "Most people who studied these materials produced them unwittingly in the laboratory ambient environment where the relative humidity is typically 50%, and that leads to samples that are — so to speak — in a 'wet' state. By special handling of the materials, we were able to produce them in a dry state, where we can see the intrinsic behavior of these materials."

The intrinsic behavior shows samples to exist in three elastic domains. In the first domain, at low AgI (silver iodide) content (less than 9.5%) they form networks that are rigid but stressed. In the second domain, called the "intermediate phase," at a slightly higher content of AgI (9.5 to 37.8%), they form networks that are rigid but unstressed. And finally in the third domain, at AgI content of 37.8% and higher, their networks become flexible.

The UC research team showed for the first time that such intermediate phases also exist in networks that are ionically conducting. In the flexible phase of these materials, "silver ions move like fish through water," says Boolchand.

We synthesized materials of the composition (AgI)x(AgPO3)1-x in a glassy or disordered state, and then examined their thermal, optical and electrical properties as a function of chemical composition. (Here "x" represents the amount of AgI electrolyte, and 1-x the fraction of the base AgPO3 glass or disordered solid.)

The next step in their research will be to understand why traces of water change the behavior of these electrolytes so drastically and to understand if the behavior observed here of three elastic domains is a general feature of all electrolyte glasses or is it peculiar to this very well studied material.

"We think the behavior will be observed in general in solid electrolytes," says Boolchand.

Source: University of Cincinnati