Toward a more efficient organic semiconductor

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"It's not that there aren't spin measurement techniques already," Christoph Boehme tells *PhysOrg.com*. "The problem is that many of those methods used to date have limited sensitivity."

Boehme, a scientist at the University of Utah in Salt Lake City, is part of a team that has found a way to measure spin states with greater sensitivity. And they found a way to do it for an organic semiconductor. At room temperature.

"This is really the first demonstration that we know of that shows coherent electrical spin measurements at room temperature, and in an organic semiconductor," says Boehme. "It's important to note that we see coherent spin states, which means we can not only observe spins, we also see their quantum state."

Boehme's colleagues on this project include an international team assembled from two different institutions in Berlin, Germany: Freie Universität and the Hahn-Meitner-Institut. Harneit, Schaefer, Huebner, Fostiropoulos and Lips, along with Boehme, published their findings in a piece titled "Room Temperature Electrical Detection of Spin Coherence in C_{60}" in *Physical Review Letters*. They offer a look into a process that could lead to further advances in a variety of technological applications.

"Semiconductors are quite important, and organic semiconductors offer uses in the future. Organic light emitting diodes and solar cells are examples for applications," Boehme explains. "These devices will contribute to energy conservation, so their energy efficiency is very important in both. If we can determine what the energy efficiency limiting processes are, and how they work, we can make new organic light emitting diodes and solar cells more efficient. This could be of great importance."

One key to making semiconductors more efficient is understanding how spins influence their performance. This means one needs methods to measure spins. "Traditionally, spin measurements were made with magnetic resonance," Boehme says. "This is difficult in thin film devices since you need a great number of spins to even see their presence with magnetic resonance. An organic semiconductor like a plastic solar cell consists of nanometer thin films. We say it is two-dimensional. Volume is lost, and therefore only very few spins are present. You can't measure them anymore with magnetic resonance."

And that is why this technique of detecting electronic transition was developed. "Instead of detecting a very weak electromagnetic signal," Boehme explains, "you detect an electric current that depends on the state of the spin. One electron influences how another moves. This is called spin-dependent transition, and this is what we detect."

Boehme goes on to say that the method used in this demonstration was used before on inorganic semiconductors: "I was part of the group in Berlin that did this first in 2002." He thought that the same basic process could be applied to an organic semiconductor, and they decided to try it at room temperature. "It was thought that at room temperature the spin states would be destroyed before they could be measured. This wasn't the case with the material we used, manufactured at the institutes in Berlin." Boehme and his colleagues used thin fullerene films of C_{60} for the demonstration. "This wouldn't work at room temperature with every material," he explains, "but it does work with these fullerene C_{60} films."

“The next step,” Boehme enthuses, “will be about application.” We want to take things like light emitting diodes and see if we can learn something about them using these measurement techniques. Dr. Fostiropoulos and Dr. Lips at the Hahn-Meitner-Institut will use it to improve organic solar cells.” He also says that such spin detection techniques might be used in moving toward the creation of quantum information devices. “That is the direction that Dr. Harneit is taking this in Berlin.”

“There’s a whole range of ideas how one can use spin for a whole range of applications.”