Like Bees to Honey:
Drawing in Hydrogen by Charging Fullerenes

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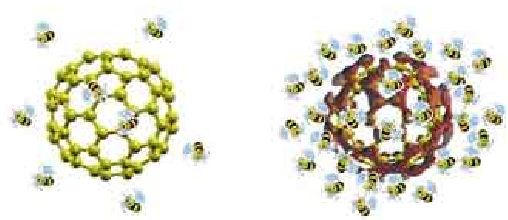
At first glance, hydrogen seems the perfect candidate for alternative fuel research. It's clean, abundant, and reusable. But in practice it plays by its own rules when introduced to other materials, and so capturing hydrogen has been a challenge for the scientists who have tried.

In their September *Nano Lett* article, "Charged Fullerenes as High-Capacity Hydrogen Storage Media," Mina Yoon, Shenyuan Yang, Enge Wang, and Zhenyu Zhang report on their work to entice hydrogen to "stick" to carbon fullerenes in an effort to store hydrogen, a crucial step in making it useful for fuel cells and other applications. Yoon is a research scientist at Oak Ridge National Laboratory and also a research assistant professor in the UT physics department. Zhang is a physics professor and chair of excellence at UT and holds a distinguished research scientist position at ORNL. Wang is a professor with the Chinese Academy of Sciences Institute of Physics (CAS). Yang is a visiting student at UT from the CAS, working on her doctorate with Wang and Zhang.

Fullerenes are molecular cages composed entirely of carbon. One of the most abundant types of fullerenes is buckyballs, or Buckminsterfullerenes, which consist of 60 carbon atoms and resemble soccer balls. Cylindrical fullerenes, or carbon nanotubes (CNTs), are strong, stiff cylinders only a few nanometers (one billionth of a meter) in diameter. CNTs have been studied as a storage option for hydrogen for more than a decade, in part because they offer the possibility of absorbing and releasing hydrogen rather than simply containing it as a free-floating gas. But using traditional approaches to bind hydrogen with CNTs and other types of carbon-based nanomaterials hasn't been very successful.

As Yoon explains, binding hydrogen in atomic form (*chemisorption*), yields high storage capacity, but the temperature needed to release the hydrogen is so high that it won't work for practical applications. On the other hand, in *physisorption*, where the hydrogen binds nondissociatively, the binding strength is too weak and the operating temperature is too low. And while doping fullerenes or carbon nanotubes with metal atoms could result in higher binding strengths, the binding is highly localized, limiting storage efficiency and capacity. To overcome these problems, the UT/ORNL/CAS collaboration tried a different method. They generated a high electric field near the surface of the fullerenes to polarize hydrogen molecules. Like honey to a bee, the field attracted hydrogen molecules with enhanced binding strength that proved to be non-localized (covering the entire fullerene surface) and tunable.



Hydrogen molecules (represented by bees) are drawn to the charged fullerene on the right.

The work was chosen as a highlight for the "Nanoseconds" section of *Nano Lett* and is also listed on *nanotechweb*. It could be a good starting point for applying the charging method to work with other nanoscale materials for hydrogen storage. Zhang is no stranger to this research area, as he and Physics Professor Hanno Weitering won a $1.2 million grant from the Department of Energy earlier this year to study quantum tuning of chemical reactivity for storage and generation of hydrogen fuel.