Graphene: Impressive capabilities on the horizon

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The Air Force Office of Scientific Research (AFOSR), along with other funding agencies, helped a Rice University research team make graphene suitable for a variety of organic chemistry applications—especially the promise of advanced chemical sensors, nanoscale electronic circuits and metamaterials.

Ever since the University of Manchester's Andre Geim and Konstantin Novoselov received the 2010 Nobel Prize in Physics for their groundbreaking graphene experiments, there has been an explosion of graphene related discoveries; but graphene experimentation had been ongoing for decades and many ultimate graphene associated breakthroughs were already well under way in various labs when the Nobel committee acknowledged the significance of this new wonder material.

And one such laboratory was Dr. James Tour's at Rice, whose team found a way to attach various organic molecules to sheets of graphene, making it suitable for a range of new applications. Starting with graphene's two-dimensional atomic scale honeycomb lattice of carbon atoms, the Rice team built upon previous graphene community discoveries to transform graphene's one sheet structure into a superlattice.

While carbon is a key part in most organic chemical reactions, graphene poses a problem in that it plays an inert role—not responding to organic chemical reactions. The Rice team solved this dilemma by treating graphene with hydrogen. This classic hydrogenation process restructured the graphene honeycomb lattice into a two-dimensional, semiconducting superlattice called graphane.

The hydrogenation process can then be tailored to make particular patterns in the superlattice to be followed by the attachment of mission specific molecules to where those hydrogen molecules are located. These mission specific molecular catalysts allow for the possibility of a wide variety of functionality. They can not only be used as the basis for creating graphene-based organic chemistry, but tailored for electronics and optics applications, as well as novel types of metamaterials for nanoengineering highly efficient thermoelectric devices and sensors for various chemicals or pathogens. The beauty of this process is the promise it holds for future devices with the ability to efficiently accomplish a wide variety of highly sophisticated functions in one small affordable device.

Dr. Charles Lee, the AFOSR program manager who funded this research, notes that graphene chemistry in general can enable smart materials for many special applications and that this latest effort in particular can contribute to future electronics applications and may be a way to arrive at faster and less energy consuming electronics.

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