Polymer-graphene nanocarpets to electrify smart fabrics

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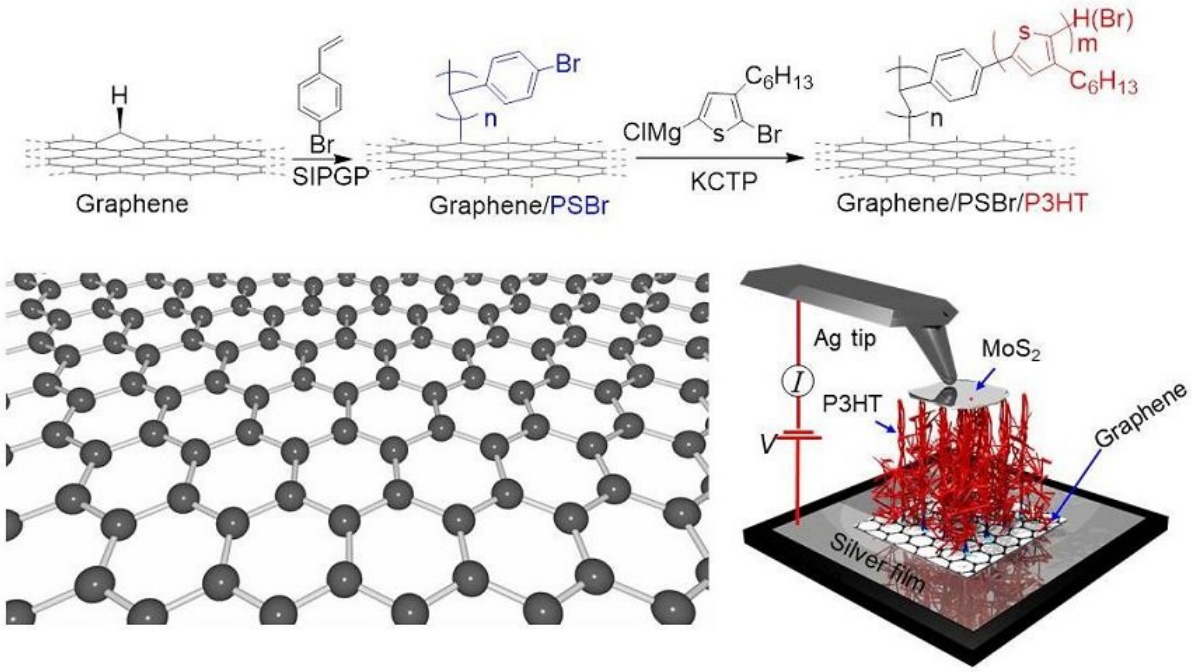

The scheme for obtaining a hybrid structure of 'graphene-polymer'. Credit: Tomsk Polytechnic University

Researchers from Tomsk Polytechnic University, together with their international colleagues, have discovered a method to modify and use graphene, a one-atom thin conductor of current and heat, without destroying it. Thanks to the method, the researchers were able to synthesize a well-structured polymer with a strong covalent bond on

single-layer graphene. They call the result "polymer carpets." The structure is highly stable and less prone to degradation over time, holding promise for the development of flexible organic electronics. If a layer of molybdenum disulfide is added over this "nanocarpet," the resulting structure generates current under exposure to light. The study was published in the *Journal of Materials Chemistry C*.

Graphene is simultaneously the most durable, light and an electrically conductive carbon material. It can be used for manufacturing solar batteries, smartphone screens, thin and flexible electronics, and even in water filters, since graphene films pass water molecules and stop all other compounds. Graphene must be integrated into complex structures to be used successfully. However, this comprises a challenge. According to scientists, graphene itself is stable enough and reacts poorly with other compounds. In order to make it react with other elements, i.e. to modify it, graphene is usually at least partially destroyed. This modification degrades the properties of the materials obtained.

Professor Raul D. Rodriguez, from the Research School for Chemistry & Applied Biomedical Sciences, says, "When functionalizing graphene, you should be very careful. If you overdo it, the unique properties of graphene are lost. Therefore, we decided to follow a different path. In graphene, there are inevitable nano-defects, for example, at the edges of graphene and wrinkles in the plane. Hydrogen atoms are often attached to such defects. It is this hydrogen that can interact with other chemicals."

To modify graphene, the authors use a thin metal substrate on which a single graphene layer is placed. Then graphene is covered with a solution of bromine-polystyrene molecules. The molecules interact with hydrogen and are attached to the existing defects, resulting in polyhexylthiophene (P3HT). Further exposed to light during the photocatalysis leads to the development of a polymer.

"In the result, we obtained the samples with a structure resembling 'polymer carpets,' as we call them in the paper. Above such a 'polymer carpet,' we place molybdenum disulfide. Due to a unique combination of materials, we obtain a sandwich structure that functions like a solar battery. That is, it generates current when exposed to light. In our experiments a strong covalent bond is established between the molecules of the polymer and graphene, which is critical for the stability of the material obtained," notes Rodriguez.

According to the researcher, this method for graphene modification produces a very sturdy compound; it is also simple and cheap, as affordable materials are used. The method is versatile because it makes growing very different polymers directly on graphene possible.

"The strength of the obtained hybrid material is achieved because we do not destroy graphene itself, but use pre-existing defects and a strong covalent bond to polymer molecules. The study is promising for the development of thin and flexible electronics in which solar batteries can be attached to clothes, and when deformed, will not break," the professor says.

More information: Tao Zhang et al, Bottom-up Fabrication of Graphene-based Conductive Polymer Carpets for Optoelectronics, *Journal of Materials Chemistry C* (2018). DOI: 10.1039/C8TC00554K

Provided by Tomsk Polytechnic University