Researchers develop innovative hybrid materials out of plastics and graphene

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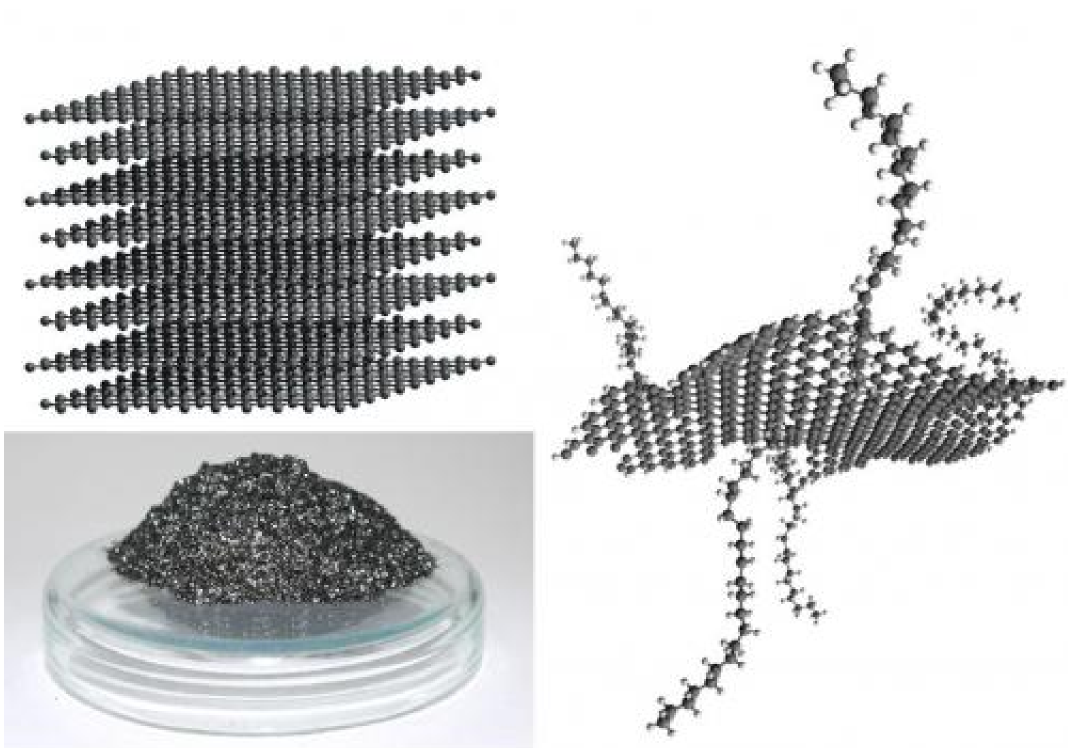

Graphite (lower left) consists of numerous layers of the carbon substance graphene (upper left). The graphene macromolecules developed in Freiburg are less than a millionth of a millimeter thick but cover a large surface area and achieve widths of over a hundredth of a millimeter (right)

German scientists in the joint research project "FUNgraphen" are pinning their hopes for new technologies on a particular form of carbon:

They have developed new carbon macromolecules and molecular carbon composite materials with special properties. The molecules are derived from graphene, a substance that consists of individual layers of carbon atoms arranged in a honeycomb-like pattern. The process previously necessary to make use of this substance was complex and expensive and thus of little value for most plastics applications.

A research group at the Freiburg Materials Research Center (FMF) of the University of Freiburg led by the chemist Prof. Dr. Rolf Mülhaupt, managing director of the FMF, has now succeeded in combining graphene with polymers, making them fit for plastics applications, and preparing them for material optimization on a kilogram scale. The project "FUNgraphen," funded by the Federal Ministry of Education and Research, is being coordinated at the FMF with support from an industrial advisory board. The other project partners besides the FMF are the University of Bayreuth, the Federal Institute for Materials Research and Testing (BAM) in Berlin, and the Fraunhofer Institute for Mechanics of Materials in Freiburg.

In the FMF processes individual layers of carbon atoms, derived from natural graphite and also renewable carbon sources, are physically and chemically attached to polymers. The result is giant molecules of carbon, so-called macromolecules, which are less than a millionth of a millimeter thick but can achieve widths of more than a hundredth of a millimeter. The resulting carbon macromolecules and carbon polymer hybrid materials are light, durable, environmentally friendly, and electrically conductive. Moreover, they are resistant to heat, chemicals, and radiation and are impermeable to gas and liquids. "They have the potential to vastly improve resource and energy efficiency of plastics," says Mülhaupt.

In addition, the researchers dispersed several of these large carbon molecules in water, nontoxic solutions, and plastics to produce concentrated stable dispersions without requiring either binders or dispersing aids. These mixtures can be used to coat surfaces and print conductive carbon films as well as electrically conducting micro patterns. In this way, carbon can replace expensive transition metals like palladium or indium. "The applications range from printed electronics to printed catalysts with a pore design for the production of fine chemicals with simple catalyst recovery," says Mülhaupt. The printed conductive carbon layers are much more mechanically robust than printed indium tin oxide layers. The scientists at the FMF also succeeded in mechanically reinforcing plastics and rubber with carbon macromolecules and simultaneously making them electrically conductive, resistant to radiation, and more gas-tight. These substances are interesting candidates for application in antistatic and impermeable fuel tanks and fuel lines, casings that are shielded against electromagnetic interferences, and gas-tight automobile tires for reducing fuel consumption in transportation.

Examples from the project partners' research also show that carbon macromolecules are far more versatile than the carbon nanoparticles typically used today, thus opening up new potential for the development of sustainable materials and technologies. Prof. Dr. Volker Altstädt from the "FUNgraphen" team at the University of Bayreuth was able to substantially reduce the cell sizes in foams by adding carbon macromolecules. This will allow the researchers to improve the thermal insulation properties of foams and develop new, highly efficient insulating material. The "FUNgraphen" group led by Dr. Bernhard Schartel at the BAM has succeeded in increasing the fire protection effect of halogen-free flame retardants by adding tiny admixtures of the new carbon macromolecules. A plastic equipped with this new material does not catch fire even after a flame has been applied to it several times - unlike unprotected plastics, which become deformed at high temperatures and start to burn immediately when they come into contact with fire.

More information: Toelle, F. et al. Emulsifier-Free Graphene Dispersions with High Graphene Content for Printed Electronics and Freestanding Graphene Films. *Advanced Functional Materials* (2012), 22(6), 1136-1144.

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