Graphite oxide at high pressure opens a road to new amazing nano-materials

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(PhysOrg.com) -- New results by scientists at Umeľ University, Sweden, show that not only water but also alcohol solvents can be inserted to expand the structure of graphite oxide under high pressure conditions. The information is helpful in the search for new methods to develop amazing materials that could be used for instance in nanoelectronics and for energy storage.

Graphite oxide has a layered structure like common graphite, used in pencils, but with increased distance between the layers. It also has a unique ability to incorporate various solvents between the layers. Even after 150 years of studies the structure of graphite oxide remains to be somewhat of a mystery.

The interest in graphite oxide has recently been heated up due to the possibility to convert it to graphene - a sheet of carbon only one atom thick. Graphene has the potential to serve as the basis of an entirely new class of materials, which are ultra-strong yet lightweight. The extraordinary materials could for instance be used for nanoelectronics, in solar cells, for preparation of exceptionally strong paper, and to improve fuel efficiency in cars and airplanes. Graphite oxide can be converted into graphene by moderate heating and even by a flash from a usual camera. An alternative method is chemical treatment of graphite oxide dispersed in solution. To make conversion of graphite oxide to graphene more efficient researchers need to know detailed information about the structure of graphite oxide, including its structure in solution at various conditions.

"We have found a range of new phenomena for graphite oxide at high pressure conditions. This gives additional possibilities to develop new composite graphene-related materials using high pressure treatment and to modify graphite oxide chemically. Clearly, we can insert larger molecules between graphite oxide layers due to the expansion of the lattice at high pressure conditions. Also, when layers of graphite oxide are separated by several layers of solvent it is more likely that they will stay separated after reduction thus preventing formation of graphite and assisting the synthesis of graphene", says Dr Alexandr Talyzin.

Last year an international team of scientists from Sweden, Hungary, Germany and France reported an unusual property of graphite oxide: the structure expanded under high pressure conditions due to insertion of liquid water. The new study lead by scientists from Umeľ University and performed at the Swiss-Norwegian beamline (ESRF, Grenoble) reports that not only water but also alcohol solvents (methanol and ethanol) can be inserted between oxidized graphene layers under high pressure conditions.

"However, it happens in a very different way compared to when water is inserted under high pressure. Alcohol is inserted in a single step as a complete layer in the structure at a certain pressure while water insertion occurs gradually, without clear steps", says dr Alexandr Talyzin. Experiments with methanol and water mixtures proved that water between the layers of graphite oxide is in the liquid state and remains to be liquid even when bulk water solidifies around grains of the material.

"The extra amount of water and methanol is also released from the structure when the pressure decreases, which results in a unique structural "breathing" effect. It is also remarkable that for ethanol the high pressure expanded structure was observed even after full release of pressure", says Dr Alexandr Talyzin.

The experiments were performed using diamond anvil cells, which allow to squeeze tiny samples up to very high pressures and to study phase transformations using X-ray diffraction through diamonds. The new results are published in J. Am. Chem. Soc by Alexandr V. Talyzin, Bertil Sundqvist, (Sweden), Tamás Szabó, Imre Dekany (Hungary) and Vladimir Dmitriev (France).

More information: pubs.acs.org/doi/full/10.1021/ja907492s

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