Scientists Develop Graphene Aerogel Particles for Efficient Water Purification

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Writing in the Journal of Molecular Liquids, a team led by Professor Aravind Vijayaraghavan based in the National Graphene Institute (NGI) have produced 3-dimensional particles made of graphene, of many interesting shapes, using a variation of the vortex ring effect. The same effect is used to produce smoke rings and is responsible for keeping dandelion seeds flying. These particles have also been shown to be exceptionally efficient in adsorbing contaminants from water, thereby purifying it.

The researchers have shown that the formation of these graphene particles is governed by a complex interplay between different forces such as viscosity, surface tension, inertia and electrostatics. Prof Vijayaraghavan said: “We have undertaken a systematic study to understand and explain the influence of various parameters and forces involved in the particle formation. Then, by tailoring this process, we have developed very efficient particles for adsorptive purification of contaminants from water”.

Graphene aerogel particles.

Graphene oxide (GO), a functionalised form of graphene which forms a stable dispersion in water, has many unique properties, including being a liquid crystal. Individual GO sheets are one atom thin, and as wide as the thickness of human hair. However, to be useful, they need to be assembled into complex 3-dimensional shapes which preserves their high surface area and surface chemistry. Such porous 3-dimensional assemblies of GO are called aerogels, and when filled with water, they are called hydrogels.

The researchers used a second liquid crystal material called CTAB (cetyltrimethylammonium bromide), to aggregate GO flakes into small particles of graphene oxide hydrogels, without needing to reduce them to graphene. This was achieved by dropping the GO dispersion in water in the form of small droplets into a solution of CTAB in water. When the GO droplets hit the surface of the CTAB solution, they behave very similarly to when a jet of hot smoke hits cold air. The GO drop flows into the CTAB solution in the form of a ring, or toroid, because of differences in the density and surface tension of the two liquids.

By controlling various parameters of this process, the researchers have produced particles in the shape of spheres (balls), toroids (donuts) and intermediate shapes that resemble jellyfish. Dr Yizhen Shao, a recently graduated PhD student and lead author of this paper, said: "we have developed a universal phase diagram for the formation of these shapes, based on four dimensionless numbers – the weber, Reynolds, Onhesorge and Weber numbers, representing the inertial, viscous, surface tension and electrostatic forces respectively. This can be used to accurately control the particle morphology by varying the formation parameters." The researchers used high-speed photography to capture the formation and evolution of these particle shapes.

The authors highlight the significance of these particles in water purification. Kaiwen Nie, a PhD student and co-author of the paper, said: "We can tune the surface chemistry of the graphene flakes in these particles to extract positively or negatively charged contaminants from water. We can even extract uncharged contaminants or heavy metal ions by appropriately functionalising the graphene surface."

Read the original article on University of Manchester.