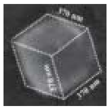

Nano rice

[June 1, 2010]

Heat rice flour to 600 Celsius under a nitrogen atmosphere and then dousing it in concentrated nitric acid is not the usual way to cook it, but researchers in India have done just that. The product, rather than a bowl of light and fluffy grains is a plethora of nanoscopic carbon cubes and bricks, the team says. They have used a platter of techniques, including Fourier transform infrared (FTIR) and Raman spectroscopy, and energy-dispersive X-ray analysis (EDAX) to study the process and products.

Rice, a surprising source for carbon nanotechnology

Sumit Kumar Sonkar, Manav Saxena, Mitali Saha, and Sabyasachi Sarkar of the Department of Chemistry, at the Indian Institute of Technology in Kanpur, India, have turned to a somewhat surprising, but readily available starting material for their work in nanotechnology, rice.

"Our method utilizes the natural ability of the amylose and amylopectin polymer chains within the starch granules to assemble into an organized micro-nanoscale structure, without the use of any external agent or catalyst," the team explains. As such, rice is the perfect ingredient for a nanotech recipe.

The potential technological innovation of carbon nano materials, such as the fullerenes, carbon nanotubes and graphene, and graphane, have become the focus much attention over the last couple of decades because of their potential for novel optical and electronics applications. Sarkar and colleagues point out that chemists have a major role to play in exploring easier ways to synthesise these materials and to investigate their structure-based properties.

Commonly, a sophisticated technique, such as laser ablation of a carbon substrate like graphite, is used to pyrolyse the material and produce deposits of new forms of nano carbon, carbon dots, for instance, on to a surface. Most recently, this approach has been used to synthesise carbon nanocubes in a liquid by Yang and colleagues at Zhongshan University, in China (**Nano Lett, 2008, 8, 2570-2575**); their carbon nanocubes have photoluminescent properties.

Other researchers have built on this earlier work in order to enhance the photoluminescent properties of nano carbon materials by adding impurities, such as organic polymeric materials, to impose quantum confinement on the behaviour of the cubes. Strictly speaking, this work all builds on the 1980 work of Sumio Iijima, now at Meijo University, who reported the existence of several distorted forms of graphitic carbon deviating from its planar form towards a bent tetrahedral form. Iijima, of course, went on to discover carbon nanotubes a decade later, while working at NEC.

With these earlier advances and developments in mind, Sarkar and colleagues reasoned that "burning" carbonaceous materials under insufficient oxygen not only produces common soot, but might lead to imperfect surface oxidation that could also generate materials with fluorescence in the visible region. "We have selected rice as a prototypical carbonaceous source material for pyrolysis," the team explains, "and report the synthesis of nanocube and nanobricks shaped carbon by pyrolysing rice flour."

The team subjected 1 gram of powdered rice to heat treatment under a nitrogen atmosphere, heating it by 5 degrees per minute up to 600 Celsius in a muffle furnace. At 600, the black solid residue was left to stand for 30 minutes, cooled to room temperature and then treated with concentrated nitric acid for 12 hours. The acid was then removed and the black solid washed with water and dried before analysis.

They used scanning electron microscopy (SEM) equipped with energy-dispersive X-ray analysis and transmission electron microscopy (TEM) together with Raman and IR spectroscopy, and X-ray diffraction to characterise the carbon nanocubes and nanobricks, of several hundred nanometre dimensions, present in their black residue. EDAX showed that both carbon and oxygen were present, while FTIR revealed the presence of carboxylic acid groups, explaining the oxygen identified by EDAX. The Raman data confirmed that sp^2 and sp^3 carbon atoms are present.

The team concedes that while the technique produces nice examples of carbon nanobricks, albeit with truncated corners, the next step will be to control the range of sizes and shapes produced using this technique. "Further research will focus on understanding their shape and size selective synthesis and their separation are underway to understand the fluorescence and other properties based on a specific size and shape," the team concludes.

To control the size and shape we are now fixing the size of the rice powder and trying to understand if a fixed mesh size has some role in the shape of the product," Sankar told SpectroscopyNOW.com. "There is another vaiable, the space available to disperse the starting material before pyrolysis. We hope to get preferential size and shape of these carbon units. Also the quality of rice or carbonaceous matter may influence the product," he adds.

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