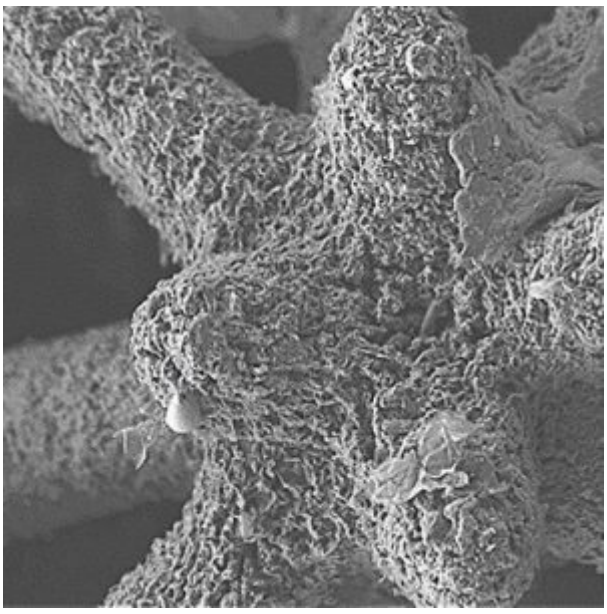
3-D Printing Graphene Aerogels

A U.S. research team from Virginia Tech and the Lawrence Livermore National Lab (LLNL) has demonstrated a light-based approach for 3-D printing strong, lightweight, porous graphene aerogels—at a resolution an order of magnitude finer than other techniques. 3-D printing is well advanced for polymer foams, with some notable success, but is still an active area of research for graphene foams. Researchers have published schemes for printing 3-D graphene using a number of approaches, such as extrusion. As a result, according to the researchers, these techniques have generally printed out 3-D graphene structures with relatively weak, bending-dominated configurations, such as stacked "woodpile" structures, and relatively large achievable feature sizes (greater than 100 microns). That's a far cry, they say, from the high-resolution, complex structures that could open up applications in areas such as energy storage and conversion.



In particular, they opted for a form of 3-D printing called projection micro-stereolithography (PμSL)—a light-based technique that allows the resin feeding the 3-D printing

process to be shaped into fine-scale, intricate forms via patterned light. Using this technique, an entire layer of 3-D-printing resin can be cured, at very fine scales, via a single UV flash. That advantage, the team reasoned, could potentially overcome some of the toolpath and sequence issues experienced by other approaches to 3-D printing of graphene. The big trick was to figure out a way to make a photocurable graphene resin—one that would quickly firm up under a light beam, but that also was sufficiently runny to be slathered layer by layer on the workpiece. To get there, Hensleigh spent some time in the chemistry lab, developing a porous graphene-oxide hydrogel with cross-linked sheets, and then using ultrasound to disperse the cross-linked graphene oxide into a dilute, 1-weight-percent suspension.

The result is exquisite, intricate, airy structures, such a lattices of octet trusses, with feature sizes on the order of 10 microns—an order of magnitude finer, according to the team, than other 3-D-printed graphene structures. They're lightweight enough to balance on a single filament of a strawberry blossom (see image at top of story). And they're also strong; as measured by their Young's modulus, the strength of the PμSL-printed structures seems to hold up better than that of most other 3-D graphenes and other carbon aerogels as the density of the structure decreases.

For more information: doi: 10.1039/C8MH00668G