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CARBON ORIGAMI: A NOVEL APPROACH TO FABRICATE LIGHTWEIGHT CARBON CELLULAR MATERIALS

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Cellular carbon materials possess interesting properties including low density, high surface area, high chemical inertness, high oxidation resistance, adjustable electrical conductivity, and high mechanical properties. Due to such properties, they find their use in different applications such as high temperature filters, catalytic support, thermal insulators and structural materials. The current state-of-the-art to manufacture cellular carbon materials includes direct foaming method and template method. However, 3D complex shapes, especially with thin cross-sections, are challenging to fabricate in these current techniques. Here we present origami technique for the fabrication of lightweight, 3D complex structures of cellular glassy carbon materials. The 3D complex shapes of glassy carbon were fabricated by carbonizing an origami structure fabricated by automatic pre-creasing and manual folding of a flat piece of pure cellulose paper. The carbon origami structures featured density (ρ) as low as 0.014 ± 0.005 g/cm^3, 0.93% the density of bulk glassy carbon. The carbon origami structures exhibited bending-dominant failure mechanism under compressive load. The stiffness (E) of the carbon structures scales to $E \sim \rho^{1.72}$. This scaling suggests better load transfer capability and compares advantageously to other cellular materials such as silica aerogel, carbon nanotube foam, graphene elastomer, metallic microlattices and carbon aerogel. Glassy carbon is widely used in energy and sensing applications. Furthermore, it features excellent chemical inertness and a high temperature tolerance up to 500 °C in oxidative environment and 3000 °C in inert atmosphere. Hence, we postulate carbon origami as a candidate to fabricate lightweight, multifunctional materials.

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EIB 132