Graphene Complex Cellular Networks

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Abstract

The advance of a wide range of key and emergent technologies demands the creation of complex three-dimensional architectures that scale in structure and function, can reversibly respond to external environments or store and transport energy. Graphene is an ideal nano-scale building block that if properly integrated into these complex structures has the potential to form novel platforms for a wide range of functional systems. However, to achieve this goal we need to develop ways for the controlled assembly of three-dimensional materials using a two-dimensional building block.
In this work, we have developed a mesoscale self-assembly strategy for the manufacturing of ultra-light ($\rho \geq 1$ mg cm^{-3}) chemically modified graphene CMG cellular networks. The approach is based on the use of soft templates and the controlled segregation of CMG to liquid interfaces allowing for manipulation of the structure at multiple levels. We can control the densities of the materials over two orders of magnitude, from 1 to 200 mg cm^{-3}, cell shape (from lamellar, polyhedral to spherical) and sizes (~7 to over 60 μm) at the micro-level to the cell walls topography, porosity and chemistry at the micro to nano-level. Further, due to the intrinsic flexibility of emulsions, it is possible to extrude CMG wires with cellular architectures showing promise for the fabrication of complex structures at the macroscale. As a result we show it is possible to tune properties like surface area (up to 3280 ± 287 m^2 g^{-1}), elasticity, specific strength, energy loss coefficient, electrical conductivity, and organic absorption capabilities (above 600 grams per gram of material).
This opens up new opportunities to explore applications in numerous fields of key technological areas including energy damping, compression tolerant supercapacitors, catalyzers or any application where separation, absorption, or filtration is required.