Bulk Nanostructured Solids Assembled from 2D Soft Carbon Sheets

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Two-dimensional (2D) sheets are uniquely well-suited for constructing dense, bulk nanostructured solids with scalable material performance or new emergent properties. A few examples will be given using graphene oxide (GO) as a model system. For example, a highly cohesive dough state of GO in water can be obtained without binder-like additives, which can be diluted to obtain gels or dispersions, and dried to yield hard solids. It can be kneaded without leaving stains, readily reshaped, connected, and further processed to make bulk GO and graphene materials of arbitrary form factors and tunable microstructures. The doughs can be transformed to dense “glassy solids” of GO or reduced GO without long-range stacking order of the sheets, which exhibit isotropic and much enhanced mechanical properties due to hindered sliding between the sheets. In another form factor, lamellar films made of GO sheets can be significantly stiffened if some of the sheets are drastically weakened by introducing in-plane porosity. This is attributed to the more compliant nature of the soft porous sheets, which act as a binder to improve interlayer packing and load transfer in the multilayer films. These examples illustrate how the assembly of the soft 2D sheets plays a critical in the final bulk material properties.