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New Faces of Graphene Oxide: 2D Soft Material and Nanofluidic Channels

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Graphite oxide sheets, now called graphene oxide (GO), can be made from chemical exfoliation of graphite by reactions that have been known for 150 years. Because GO is a promising solution-processable precursor for the bulk production of graphene, interest in this old material has resurged. Apart from making graphene, GO itself has many intriguing properties. Like graphene, GO is a two-dimensional (2D) sheet with feature sizes at two abruptly different length scales. The apparent thickness of the functionalized carbon sheet is approximately 1 nm, but the lateral dimensions can range from a few nanometers to hundreds of micrometers. Therefore, researchers can think of GO as either a single molecule or a particle, depending on which length scale is of greater interest. At the same time, GO can be viewed as an unconventional soft material, such as a 2D polymer, highly anisotropic colloid, membrane, liquid crystal, or amphiphile.

In this talk, I will highlight the soft material characteristics of GO. GO consists of nanographitic patches surrounded by largely disordered, oxygenated domains. Such structural characteristics effectively make GO a 2D amphiphile with a hydrophilic periphery and largely hydrophobic center. This insight has led to better understanding of the solution properties of GO for making thin films and new applications of GO as a surfactant. Changes in pH and sheet size can tune the amphiphilicity of GO, leading to intriguing interfacial activities. In addition, new all-carbon composites made of only graphitic nanostructures using GO as a dispersing agent have potential applications in photovoltaics and energy storage. On the other hand, GO can function as a 2D random diblock copolymer, one block graphitic and the other heavily hydroxylated. Therefore, GO can guide material assembly through π–π stacking and hydrogen bonding. Additionally, the selective etching of the more reactive sp3 blocks produces a porous GO network, which greatly enhances interactions with gas molecules in chemical sensors. GO sheets can also be used to construct massive arrays of nanofluidic channels, showing surface charged governed ionic transport and higher than normal ionic currents through the space between neighboring sheets.