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Intermolecular Interactions in Colloidal Graphene Dispersions

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ABSTRACT

One of the most exciting challenges in chemical engineering is the development of industrially scalable production and processing techniques for nanomaterials. Our research group has studied intermolecular interactions in the process of dispersing graphene from graphite without covalently functionalizing the graphene basal plane; this “pristine,” unfunctionalized graphene holds promise for applications ranging from nanofilled structural materials to electrochemical adsorption and sensing.

In particular, our group has shown that both polyvinylpyrrolidone (PVP) as well as pyrene derivatives can naturally absorb to the graphene surface, create repulsive (steric and electrostatic) forces, and prevent aggregation. This allows for graphene dispersion in a range of solvents and polymer without disrupting the graphene basal plane. Such dispersions are stable against aggregation even when subjected to freeze drying or pH changes. The interactions between graphene and pyrene derivatives can be tuned by the type and number of functional groups and counterions on the dispersant. We have recently shown that PVP and pyrene can serve as a graphene anchor in novel “designer dispersants” that precisely tailor graphene-matrix interactions in polymer nanocomposites. We have demonstrated that pristine graphene can be used a filler for epoxy composites, polyvinyl alcohol films and nanofibers, as well as a variety of hydrogels and aerogels. These composites consistently show enhanced modulus, strength, and electrical conductivity. Many of these processing steps have attracted interest from industry and may potentially be generalized to the broader family of two-dimensional nanomaterials.