Crumpled Graphene Balls for Scalable Energy Applications

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A major problem in the scaled up production of sheet-like materials, such as graphene is their tendency to aggregate due to strong van der Waals attraction. Restacking of sheets not only reduces their solution processability, but also compromises their properties such as accessible surface area. Moreover, since materials typically experience some form of compressive stresses during manufacturing such as drying and pelletizing, their aggregation state tends to vary by processing history. Making layered materials aggregation-resistant will help to standardize the material and their performance for large scale applications. A number of strategies for preventing aggregation in solution have been developed, which typically include tailoring the solvent-graphene interactions, and employing dispersing agents. Crumpled graphene balls, which are made by compressing the sheets in evaporating aerosol droplets can help to solve this problem since the fractal-dimensional structure is highly resistant to aggregation in solution as well as in solid state, even after pelletizing at high pressure. Powders of crumpled graphene have robust high surface area that is much less dependent on processing history, which is beneficial for energy applications such as for scalable ultracapacitors, microbial fuel cell electrodes and support for hydrogen evolution catalysts. The crumpled graphene balls can also act as expandable shells to prevent Si nanoparticles from forming an excessive layer of solid-electrolyte interphase during their expansion/contraction cycles due to charging/discharging. This leads to drastically improved cycling stability and coulombic efficiency.