Chemically Hydrogenated Graphene for Solid-State Hydrogen Storage Applications

Hydrogenated graphene, also known as graphane, is a 2-dimensional, sp^3 hybridized structure with the formula $(CH)_n$. This material is stable in air, but if heated to appropriate temperatures will thermally decompose, liberating H_2 gas. With a theoretical composition 7.74% hydrogen by mass, graphane has been proposed as a potential material for hydrogen storage applications. Perhaps an even more attractive metric of this material is its hydrogen storage density. Graphane's volumetric hydrogen density of 135 $g(H_2)\ L^{-1}$ is among the largest of possible H_2 storage technologies, and is well above current DOE targets of 50 $g(H_2)\ L^{-1}$. This high hydrogen density would be ideal for H_2 storage when volume, not mass, is the limiting parameter of the application, for example, in the powering of underwater vehicles.

Like graphene, the bulk synthesis of pristine graphane is not trivial, however, "graphane-like" materials can be generated through chemical hydrogenation of carbonaceous materials (such as graphite) using synthetic routes that follow the "Birch reduction". To date, the study of chemically hydrogenated graphene has been almost exclusively academic in nature, with most studies synthesizing only milligram quantities in chemically inert glove boxes. In order for this material to be realized as a medium for H_2 storage, practical and large scale synthetic protocols must be developed. Furthermore, standard operating procedures would need to be developed for the purification and storage of such a material, along with the design and execution of prototype demonstrations. This poster describes various experiments performed at the U.S. Naval Research Laboratory, which were designed to understand the practical application of hydrogenated graphene to power undersea systems. These studies provide large scale synthetic insights and protocols, post synthetic purification methods, measurements of critical material properties such as activation energy and enthalpy of reaction, as well as the first reported prototype demonstration of hydrogenated graphene used as a power source.