

Synthesis of hydrogenated graphene

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The hydrogenation of graphene can dramatically change its properties. The fully hydrogenated graphene is termed as a graphane with ideal composition of $(C_1H_1)_n$. Several methods of graphene hydrogenation was reported recently.[1, 2, 3, 4, 5, 6] The methods based on high pressure hydrogenation typically produce only few atomic % of C-H bonds.[1] Interestingly the reduction reaction typically produce also certain degrees of hydrogenation, however the concentration of C-H bond is dependent on the concentration of oxygen functionalities in starting graphene oxide. Typical examples are reduction with complex hydrides ($LiAlH_4$ and $NaBH_4$) or hydrazine. These reductions led to the formation of $=CH_2$ and $-CH_2(OH)$ groups from ketone and carboxylic and based functionalities.[3, 4, 5] The other typical example is reduction with nascent hydrogen (Clemmensen reduction reaction) which form $=CH_2$ group from ketone functionalities.[5] For all of these methods is typical dependence of hydrogenation degree on the concentration and composition of oxygen functionalities in starting material.

Significantly higher degree of hydrogenation can be obtained using Birch reduction reaction. This procedure is based on reaction of carbonaceous nanomaterials (graphene and its derivatives, graphitic nanostructures and nanotubes) with solvated electron and proton source.[6] As a salvation medium is used liquid ammonia with dissolved alkali metals (Li or Cs) and as a proton source can be used various alcohols or water.[7] The most effective method for hydrogenation is use of potassium in liquid ammonia and water as a

proton source giving almost fully hydrogenated graphene.[7] This procedure can be applied also on graphite nanofibers and carbon nanotubes giving hydrogenated graphene nanostripes.[6] Compare to graphene or graphene oxide, hydrogenated graphene is significantly more reactive and can be used as a reactive precursor for halogenations or other reactions like coupling.

References

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