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Formation of functionalized graphene by submerged liquid plasma process

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Recently, graphene has been emerged as a smart material specifically in the field of materials chemistry due to its remarkable mechanical flexibility, optical transparency, electrical and thermal conductivity. Functionalization of graphene is an important route to increase its dispersibility and stability in aqueous and/or organic solvents. Graphene oxide (GO) and reduced graphene oxides (r-GO) have been extensively studied by various research groups, but the major short come are (i) increase of oxygen in graphene domain increases the number of sp^3 carbon, (ii) high content of sp^3 carbon restricts electron mobility and leads to poor electrical properties, (iii) presence of sp^3 carbon reduces the conductivity and amplifying dis-orderness in graphene domain. Similarly, studies have been done on the formation of chemically modified graphene with organic moieties such as polyaniline, amino acids etc., by π–π stacking and/or van der Waals interactions. The strength of graphene hybrids or composite are highly vulnerable and their long-term association with graphene is thus highly questionable. In addition, large-scale synthesis of functionalized graphene should use a sustainable, economical, and eco-friendly process. In this study we have successfully demonstrated the formation of highly dispersive nitrogen functionalized graphene (N-FG) and nitrogen functionalized r-GO by submerged liquid plasma (SLP) process at ambient condition. Advantages of the SLP process include a simple setup, minimal surface damage due to fast moving electrons, no required further purification, possible large-scale synthesis, low operating cost and eco-friendliness. N-FG shows greater stability and electrical conductivity due to the presence of pyridinic and pyrrolic nitrogen. Raman spectrum confirms only marginal increase in dis-orderness when compared to the graphene and displayed remarkable dispersibility in both aqueous and organic solvents. Furthermore, fluorescence property of N-FG confirms the presence of -NH and -N=C- at the graphene sites, as supported by UV-Vis spectrometry and X-ray photoelectron spectroscopy studies.

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