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DIRECT FABRICATION AND CHARACTERIZATION OF FUNCTIONALIZED GRAPHENES AND THEIR HYBRIDS VIA SUBMERGED LIQUID PLASMA AND ELECTROCHEMICAL EXFOLIATION UNDER AMBIENT CONDITIONS

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Nano-carbons like graphenes have greatly been interested in various fields of researches, where the large scale synthesis of nano-carbon should be free from using excess energies for firing, sintering, and melting, vaporizing and/or expensive equipment. We, propose here soft processing (green processing) of functionalized graphenes at ambient conditions. The soft processing provides number of advantages which includes: simple reaction set up; at ambient conditions; simple procedure and; less operating costs and wastes. In the present study, we have utilized Submerged Liquid Plasma (SLP) and Electrochemical Exfoliation (ECE) methods. SLP methods resulted in the direct synthesis of nitrogen functionalized graphene nano-sheets from graphene suspension and/or graphite electrode in acetonitrile liquids. Products contains few layers (<5) graphene nano-sheets. Unsaturated or high energy functional group (e.g. C=C, C=N and C=N) have formed in the products. We could confirm those functionalized graphenes are electrochemically active. Using pencil rods instead of graphite rods we have also succeeded to prepare the nano-clay/graphene hybrids by this SLP method. Reduction and functionalization of graphene oxides and synthesis of graphene/Au hybrids was realized by SLP. In the ECE, graphite anode is exfoliated electrochemically by H_2O_2-NaOH or glycine-H_2SO_4 aqueous solutions under ambient temperature and pressure, for 5-30 min with +1-+5 volt, into 3-6 layers graphene nano-sheets [GNs]. Those conditions are much milder than those reported before using other chemicals like ionic liquids and/or H_2SO_4-KMnO4, etc., because O22- ions or ionic complex like glycine-HSO_4- would assist the exfoliation of graphite layers. Our products: GNs suspended in solutions can be transformed in the 2_{nd} step in the same container using $BrCH_2CN$/dioxane into N-FG, further into Au-hybridized N-FG by the sonification with Au nanoparticles. We have confirmed the excellent catalytic performance of those hybrids. It should be noted that soft processing can directly produce graphene ink; graphenes dispersed in various liquids, under mild conditions. Other 2D materials like MoS_2 can also be dispersed in a solution via sonochemical and/or electrochemical ways.

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