Chemical and Structural Characterization of Intercalated Graphene Oxide and Their Dispersibility in Organic Solvents

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Abstract

Graphene, a two-dimensional honeycomb lattice of sp^2 hybrid carbon, exhibit combination of unique characteristics such as high thermal and electrical conductivity, excellent mechanical strength and very high specific surface area, which promises their great potential for various applications including nanoelectronics, catalysis, sensors, energy storage devices, polymer composites, lubricants and gases adsorptions etc.[1-3] However, large scale production of high quality graphene still remains as a big challenge for these applications. Graphene oxide, an oxidized from of graphene produced by oxidation and then exfoliation of graphite being used largely for preparation of reduced graphene oxide and chemically functionalized graphene for diversified range of applications. Recently, the intercalation of graphene oxide and their dispersibility has become area of great interest for its potential applications in adsorption of various gases (CO_2, H_2), high performance supercapacitor electrodes, adsorbents of contaminants, lubricants and so on.[4-5]

Graphene oxide exhibits ample oxygen functionalities particularly hydroxyls and epoxides on their basal planes. In the present work, these functionalities were targeted for intercalation of graphene oxide using *n*-alkylamines ($C_nH_{2n+1}NH_2$, Where n = 4, 8, 12 and 18). The structural and chemical properties of intercalated products were evaluated by XRD, FTIR, and TG-DTA analyses. It was observed that with increasing chain length, orientation of intercalated graphene oxide became more ordered and crystalline. This could be due to increasing van der Waals interaction between intercalated alkyl chains, which usually increases with increasing number of methylene unit in alkyl chains. The chemical structure of alkylamines in the intercalated product was found to monitor their dispersibility in organic solvents. Owing to hydrophilic nature of graphene oxide, its dispersion in non-polar organic solvents is a big challenge. Herein, increasing chain length of alkylamines in the intercalated product facilitate their dispersion in non-polar organic solvents. However, still the presence of oxygen functionalities in such product hindered their dispersion stability. The reduction of intercalated product leads to removal of most of oxygen functionalities, resultant the presence of long alkyl chains in reduced intercalated product provides good dispersion in non-polar organic solvents.

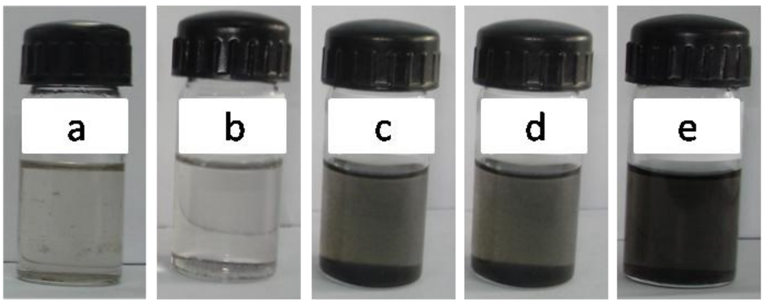

Figure 1: Dispersion of (a) graphene oxide, (b) octylamine, (c) dodecylamine and (d) octadecylamine-intercalated graphene oxide dispersion in hexadecane. Dispersion of (e) reduced octadecylamine-intercalated graphene oxide. Dispersion concentration: 0.1 mg mL^{-1}.

References

[1] K. Geim, Science, **324** (2009) 1530.
[2] C.N.R. Rao, A.K. Sood, K.S. Subrahmanyam and A. Govindaraj, Angew. Chem., Int. Ed., **48** (2009) 7752.
[3] M.J. Allen, V.C. Tung and R.B. Kaner, Chem. Rev., **110** (2010) 132.
[4] K. Zhang, L. Mao, L.L. Zhang, H.S.O. Chan, X.S. Zhao and J. Wu, J. Mater. Chem., **21** (2011) 7302.
[5] Q. Ji, I. Honma, S. Paek, M. Akada, J.P. Hill, A. Vinu, K. Ariga, Angew. Chem., **122** (2010) 9931.