

SYNTHESIS AND CHARACTERIZATION OF PROCESSABLE GRAPHENE NANOSHEETS

¹Tapas Kuila, ¹Partha Khanra, ²Nam Hoon Kim, ¹Bae Seon-Hyeong, ^{1,2,3}Joong Hee Lee

¹BIN Fusion Research Team, Department of Polymer & Nano Engineering

²Department of Hydrogen and Fuel Cell Engineering

³Department of BIN Fusion Technology, Chonbuk National University, Jeonju, Jeonbuk, 561-756, Republic of Korea

Introduction

Graphene, which has been considered as the “thinnest materials” in the world, has attracted considerable attention from both the academic and industrial point of view. The pure graphene materials show exceptional mechanical and thermal properties, high electrical conductivity and satisfied co-efficient of thermal expansion (CTE) behaviour [1,2]. But it is well known that pure graphene sheet always have a tendency to form aggregates or even restack to form graphite through strong π - π stacking and van der Waals interaction [1]. Therefore, the prevention of agglomerates is of particular importance for graphene sheets to get the unique properties of individual graphene sheets. In order to prevent agglomeration, surface of graphene oxide (GO) should be modified before reduction [1]. Till now, various successful attempts have been taken to modify the surface of graphene [3]. Attempts have also been paid on the preparation of stable dispersion of graphene in water or in organic solvents [1,3]. But in most of the cases, the modified graphene is either soluble in water or in organo solvents. In the present work, we have successfully prepared 6-amino-4-hydroxy-2-naphthalene sulfonic acid doped graphene (ANS-G), which is soluble both in water and organic solvents.

Experimental

Graphite oxide was prepared from natural flake graphite by modified Hummers method [4]. The resulting GO was dried under vacuum for 7 days at 40°C. For, surface modification, 500 mg of GO was dispersed in 250 ml water by 1 hour ultrasonication. 2 g of 6-amino-4-hydroxy-2-naphthalene sulfonic acid and 0.75 g of KOH was dissolved in 10 ml water which gave brownish-red solution. Then this

solution was added carefully to the GO dispersion and stirred for 24 hours at 70°C. Finally, 5 ml of hydrazine monohydrate was added to the reaction mixture and stirred for another 24 hour at 80°C. A characteristic smell of ammonia was coming out confirming the reductions modified GO. The homogenous black solution was filtered through cellulose acetate filter paper and washed several times with distilled water until the filtrate became colourless and pH became ~ 7 . The resulting product (ANS-G) was dried under vacuum for 72 hours.

Results and Discussion

Fig. 1 shows the Fourier transform infrared (FTIR) spectra of pure graphene oxide and chemically functionalized graphene nanosheets (ANS-G). It shows that the characteristic peaks of GO are either vanished or peak intensity is reduced in ANS-G. Moreover, appearance of new peaks at 1568 cm^{-1} corresponds to the combined C-C and C-N stretching vibration is observed in ANS-G. Characteristic S=O stretching vibration peak at 1082 cm^{-1} and C-H out plane bending vibration peak at 805 cm^{-1} are also noted in ANS-G. The in-plane C-H stretching vibration peak appears at 1032 cm^{-1} in the modified graphene. These observations clearly suggest that the ANS molecules have been successfully doped on to the graphene surfaces.

The chemically modified graphene (ANS-G) sheets are hydrophilic as well as organophilic. The digital camera photograph of ANS-G dispersion is shown in Fig. 2. It has been found that the functionalized graphene (ANS-G) forms dispersions very easily in water, dimethyl formamide (DMF) and dimethyl acetamide (DMAc). We have noted that the resulting dispersion is stable for more than a month.

However, the degree of dispersion in water is higher than the organic solvents.

Fig. 3 show atomic force microscopy (AFM) image of ANS-G. It is seen that the average thickness of ANS-G layers are 2.4 nm. The observed higher thickness of ANS-G compared to pure graphene (0.34 nm) may be attributed to the attachment of large ANS molecules. However, the formation of multilayer graphene also can not be ruled out.

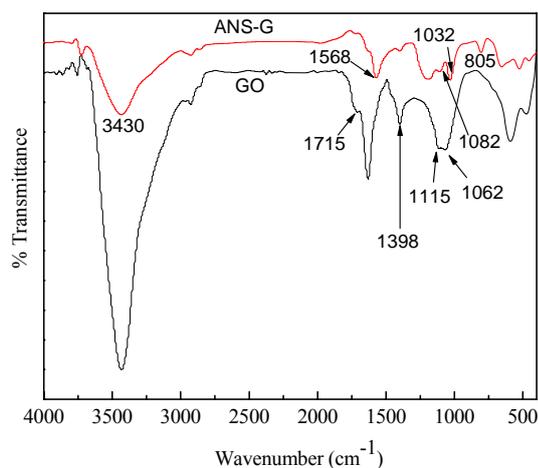


Fig. 1 Fourier transform infrared (FTIR) spectra of graphene oxide and chemically functionalized graphene (ANS-G).

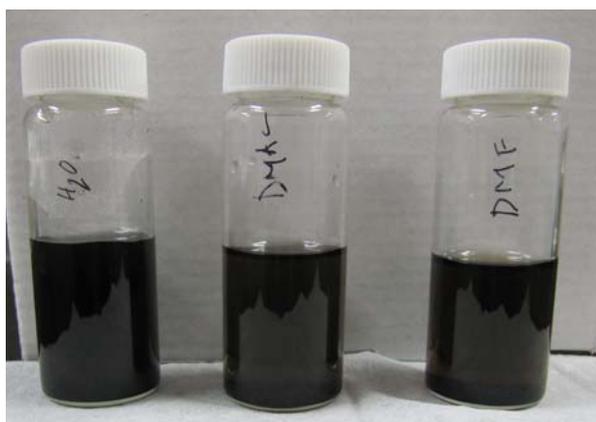


Fig. 2 Digital pictures of chemically functionalized graphene (ANS-G) dispersion in water, DMAc, and DMF.

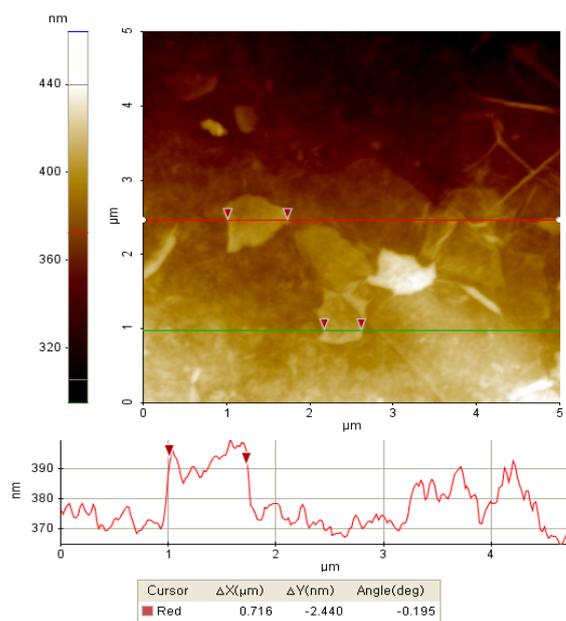


Fig. 3 AFM image of functionalized graphene (ANS-G)

Conclusion

Water and organic solvent soluble graphene has been prepared successfully by the nucleophilic addition of ANS molecules to the graphene surfaces. The average thickness of modified graphene is 2.4 nm which is much higher than pristine single layer graphene. This is due to the attachment of large organic molecules or the formation of multilayer graphene.

References

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