Graphene large scale production by direct exfoliation in presence of water

D. Rubira1, E. Navarro1,2 and P. Marín1,2

1Instituto de Magnetismo Aplicado, UCM-CSIC-ADIF, P.O. Box 155, 28230 Las Rozas, Madrid, Spain 2Departamento de Física de los Materiales, Facultad de Físicas, UCM, CEI Moncloa, 28040 Madrid, Spain

Due to its extraordinary physical, chemical and mechanical properties and widening applications such as solar cells, energy storage and environmental remediation among others, the need of high quality, low cost and large scalable production of graphene sheets has become essential. This necessity can be satisfied by ball milling direct exfoliation using a solvent that matches the barrier of the bounding energy between graphene layers.

One of the problems with solvent exfoliation of graphene is that the best conventional solvents -like N-methyl 2 pyrrolidone (NMP) and N,N-dimethylformamide (DMF)- tend to be toxic, and their high boiling point involves the deterioration of further applications [1]. To overcome this issue we propose water as an alternative low cost, environmental friendly, non toxic and most plentiful solvent. Furthermore, water represents a great potential in graphene exfoliation due to its unique property which involves the surface energy as an ideal exfoliation assistant. The use of water has been reported by the previous literature [2] at room temperature, when surface energy of water is higher than bounding energy between graphene sheets. To optimize the exfoliation potential of water, we realize that at high temperature surface energy of water exactly matches the energy between graphene layers, giving place to a suitable direct exfoliation.

The present study combines the potential exfoliation power of surface energy of water at high temperatures with the shear forces which can separate graphene layers by using a planetary ball milling equipment. To overcome the principal disadvantage in the use of water, which resides in the hydrophobic properties of graphene, we have used a combination of water and surfactant as well as a novel method that consist on the addition of a small amount of ammonia solution. Then, diverse characterization methods such as Raman, XRD and SEM have been employed to investigate the morphology and quality of as-prepared graphene sheets.

References

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