Synthesis of multilayer-graphene from direct decomposition of ethanol microwave plasma without using metal catalyst and substrate-free

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Abstract

Graphene is attracting the attention of the scientific community owing to its novel electrical and mechanical properties making it suitable for a wide range of applications in several fields as electronic, catalysis, energy storage and composite material. Traditionally, graphene has been synthesized by chemical vapor deposition (CVD), plasma-enhanced chemical vapor deposition (PECVD) and graphite exfoliation [1-2]; these techniques require the control of the substrate temperature and the addition of hydrogen during the process.

Microwave plasma is an exceptional reactive medium which allows us to enhance chemical reactions where the metal catalysts and additives are unneeded. Furthermore, the possibility of working at atmospheric pressure together with the use of cheap feedstock as carbon source makes plasma an attractive technology and economical technique for the implementation of the process on an industrial scale, reducing the productions costs. The synthesis of graphene from direct decomposition of ethanol by microwave plasma without using metal catalysts and substrate-free is presented. A microwave atmospheric-pressure plasma torch (2.45 GHz) working at 400 W was used for the synthesis of graphene powder. In order to reduce the impact of the surrounding atmosphere and its instabilities on the plasma operation, a cylindrical reactor was placed around the torch with an outflow opened to the atmosphere. An argon flow of 0.50 l/min was used as plasma gas and carrier gas to introduce 2 g/h of ethanol into the plasma. The ethanol was vaporized using a gas phase liquid delivery system (CEM) and the alcohol-argon mixture was passed through a steel tube heated at 110ºC to avoid ethanol condensation. Several minutes after plasma onset, the formation of graphene was observed into the reactor, obtaining a graphene production rate equals to 60 mg/h. The graphene was analyzed by Transmission Electron Microcopy (TEM) and Raman spectroscopy. Figure 1 shows the structure of the produced flakes as multi-layer graphene sheets. The Raman spectrum (Figure 2) shows the 2D characteristic peak of graphene placed at 2695 cm-1. The 2D peak FWHM was equal to 50 cm-1, corresponding to multi-layer graphene between 5 and 7 sheets. The low ratio between the intensities of D and G peaks was 0.26 which indicates the synthesized graphene contains a very low number of defects or disorder. The thermo-gravimetric analysis (TGA) (Figure 3), carried out under air atmosphere, shows a high purity and homogeneity of the graphene without the presence of amorphous carbon. All these results show the extraordinary quality of the graphene obtained from ethanol decomposition by using a microwave plasma torch in a single step and catalysts-free procedure.

References

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[2] M. Meyyappan, L. Delzeit, A. Cassell, D. Hash, Plasma Sources Sci. Technol. 12 (2003) 205

Figures

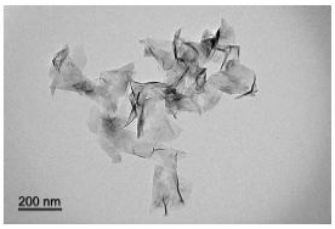

Figure 1. TEM image

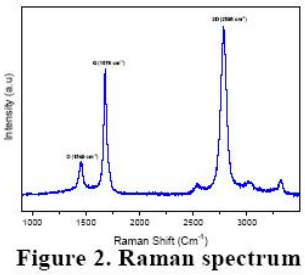

Figure 2. Raman spectrum

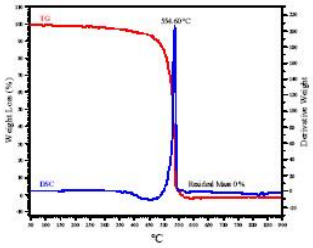

Figure 3. TGA analysis