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Synthesis of Graphene Sheets and Characterization of Poly(3-hexylthiophene):Graphene Blends

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Graphite is a bulk-layered material that can be separated into sheets which exhibit folds and pleat-like structures. Graphene sheets are easily obtained via an exfoliation process using graphite in organic solvent. Spin-coated graphene:poly(3-hexylthiophene) (P3HT) blend films are characterized by absorption and photoluminescence spectroscopy measurements. Doping of 2.5% graphene into P3HT induces better light absorption and photoluminescence quenching in the blend film. This finding indicates that graphene is a potential alternative material in various applications such as an acceptor material in organic solar cells.

Key words: Carbon materials, conducting polymer, graphene, poly(3-hexylthiophene)

INTRODUCTION

Graphene was discovered for the first time in 2004. It is a one-atom-thick two-dimensional molecule made up of sp^2-hybridized carbon atoms.[1] Graphene is a gapless semiconductor[2] exhibiting very high charge mobility of 100,000 $cm^2\ V^{-1}\ s^{-1}$ at room temperature.[3] As a result of these unique electronic properties, graphene and graphene oxide have both drawn considerable attention in technological applications such as the following: as a transparent electrode to replace high-cost indium tin oxide (ITO),[4] as a mixture or dopant in polymeric poly(3-hexylthiophene):phenyl-C_{61}-butyric acid methyl ester (P3HT:PCBM) solar cells,[5] and as an electron acceptor material in organic photovoltaic devices.[6] Most graphite oxides have been produced using Hummer's method, after which soluble graphene was obtained via a functionalization treatment.[5,6] However, we report here an easy and mild way to produce soluble graphene without any chemical modification through direct exfoliation of graphite in organic solvents.

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EXPERIMENTAL PROCEDURES

Graphite Exfoliation Process

In this study, graphene sheets were obtained using a graphite exfoliation process. Graphite flake (200 mg, 3061; Asbury Graphite Mill Inc.) was placed in a vial. Then, 10 mL chloroform was added and the solution was sonicated for 6 h. To obtain thin sheets of graphene, the solution was later centrifuged at 4000 rpm for 20 min. The supernatant of the solution was then separated from the precipitate to obtain the graphene sheets.

Film Fabrication and Characterization

For film fabrication, 20 mg poly(3-hexylthiophene) (P3HT; Sigma Aldrich) was added to approximately 0.5 mg graphene in 1 mL chloroform. Then, the blend solution of P3HT:graphene was spin-coated at 800 rpm for 30 s and dried for 30 min in a covered glass Petri dish. The films were annealed at 130°C for 10 min on a hot plate in a glovebox filled with high-purity nitrogen to remove the residual solvent from the film. Both photoluminescence and Raman spectra were measured using a Renishaw Raman microscope, while the absorption spectra were measured using a UV 3600 Shimadzu UV–Vis–NIR spectrophotometer on the P3HT:graphene film. A FEI