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Formation of graphene nanosheets/epoxy resin composite and study its structural, morphological and nonlinear optical properties

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ABSTRACT

The attention towered the fabrication of graphene nanosheets/polymer composites have gradually boosted in the scientific research since these systems have exhibited improved thermal and mechanical stabilities and nonlinear optical properties compared to the pristine polymer. Herein, graphene nanosheets (GNS) were firstly synthesized through liquid phase exfoliation (LPE) of graphite in isopropanol then mixed with epoxy resin (ER) creating a composite of GNS/ER. The properties of the as-obtained structure were evaluated by transmission electron and ultraviolet–visible spectroscopies. The nonlinear optical properties (NLO) of GNS/ER were investigated through single beam *Z*-scan technique using a continuous-wave (CW) laser beam obtained from a solid-state laser (SDL). The results reveal that GNS/ER composite shows a negative nonlinear refractive index of (-0.26×10^{-8} cm^2/W). Optical limiting (OL) measurements were performed on the GNS/ER and the mechanism of the OL is ascribed to the nonlinear refraction (thermal effects). These outcomes specify the potential use of cost-effective produced GNS/ER composite to boost the NLO and OL for future photonic applications.

1. Introduction

Low dimensional (LD) materials have continued to shift extensively the scientific interest due to their capability for exhibiting fabulous physical properties which enable them to be the base of several applications [1–7]. Among numerous LD materials, graphene-family nanomaterials have been broadly investigated and usually shown outstanding performances for several applications including batteries and supercapacitors, sensors, solar cells and catalytic supports [8] owing to their large specific surface area [9], high mobility of electrons [10], excellent mechanical stiffness [11], flexibility [12] as well as exceptional properties such as electrical [13] and thermal conductivities [14].

Recently, many researchers have focused their special treatments on finding suitable materials that possess high nonlinear optical properties [15–19] along with a fast response time for several photonic applications using high density optical data storage [20–23], optical limiting [24–32], optical bi-stability [33–35], all optical switches [36,37] as well as optical phase conjugation [38]. Recently, prodigious deal of attention has prearranged to study nonlinear optical properties of graphene-family nanomaterials such as graphene oxide nanosheets [39], graphene nanoribbons [40], graphene oxide colloids [41], graphene fluoride in aqueous dispersions [42] and graphene oxide [43]. Additionally, several composites based on graphene-family nanomaterials have been extensively explored to improve the NLO of the pristine graphene-family materials including conjugated polymer–graphene oxide composite [44], graphene oxide/Fe_3O_4 hybrid [45], graphene oxide/organic solvents [46,47], graphene oxide/silver nanocomposite [48], reduced graphene oxide/zinc oxide [49], TiO_2/reduced graphene oxide nanocomposites [50], graphene oxide/bimetallic nanoparticles [51], graphene oxide/zinc (II) phthalocyanine [52,53] and graphene and carbon nanotube polymer composites [54]. Among these composites, the state-of-art has revealed that graphene nanosheets-epoxy resin composite is appropriate for many photonic related applications [55,56].

Many methods have been successfully used to form the sheets of graphene such as mechanical exfoliation, liquid phase exfoliation and chemical vapor deposition. Among these methods, liquid phase exfoliation (LPE) is introduced as one of the most promising cost-effective technique to produce single and/or multi-sheets of graphene in solution based. In this article, the fabrication of graphene nanosheets using LPE technique by exhalation the graphite powder in isopropanol is

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