Materials Chemistry and Physics 206 (2018) 251–258

Contents lists available at ScienceDirect

Materials Chemistry and Physics

journal homepage: www.elsevier.com/locate/matchemphys

Electromagnetic interference shielding of polycarbonate/GNP nanocomposites in X-band

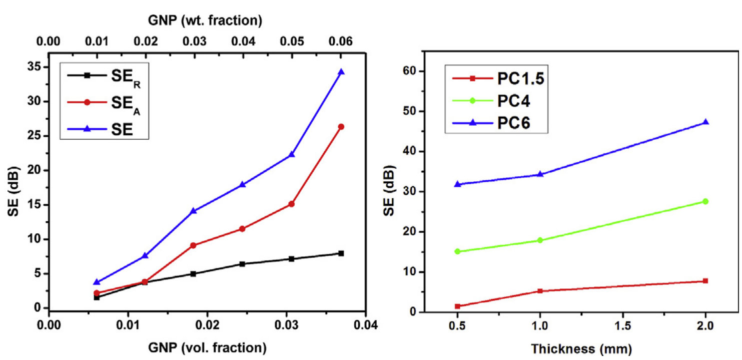
Pratik Nimbalkar, Amit Korde, R.K. Goyal*

Department of Metallurgy and Materials Science, College of Engineering Pune, Shivaji Nagar, Pune 411005, India

HIGHLIGHTS

- Facile preparation of Polycarbonate/GNP nanocomposites.
- Low percolation threshold of 0.005 vol fraction GNP.
- Electrical conductivity of 0.413 S/m at 0.037 vol fraction GNP.
- X-Band EMI SE of 35.0 dB and 47.2 dB for 1 mm and 2 mm thick sample, respectively.
- Exponential increase in EMI SE with respect to logarithm of conductivity.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:

Keywords:
Graphene
Electromagnetic interference
Nanocomposites
Electrical properties
Polycarbonate

ABSTRACT

Polycarbonate (PC)/graphite nanoplatelet (GNP) nanocomposites were prepared using a facile solution-method followed by hot-compaction. The effects of GNP content on electrical properties and electromagnetic interference shielding effectiveness (EMI SE) of the nanocomposites in X-band were studied. A very low percolation threshold of 0.005 vol fraction GNP was achieved. Scanning electron microscopy (SEM) revealed uniform dispersion and three-dimensional network of the GNPs in the matrix. The electrical conductivity of the nanocomposites containing 0.037 vol fraction GNP was about 0.413 S/m. Its EMI SE for 1 mm thick sample was 35 dB, which was further increased to about 47 dB for 2 mm thick sample. An exponential increase in EMI SE was observed with increasing logarithm of electrical conductivity.

1. Introduction

Electromagnetic Interference (EMI) has become a serious concern for electronic devices because of continuous increase in wireless communication. EMI tends to deter normal functioning of electronic devices and could lead to failure of electronic systems in extreme cases. In order to counter EMI, shielding of electronic devices against Electromagnetic (EM) waves has become paramount. Composite systems have been gaining importance for EMI shielding because of their superiority over conventionally used metals. Light weight, insusceptibility to corrosion, easier manipulation of properties and better processability make polymer composites attractive for EMI shielding applications [1–6].

Polymer composites with conductive fillers are under research for a long time. The advent of carbon allotropes such as carbon nanofibers, graphene and carbon nanotubes (CNTs) [7,8] has enthused the

* Corresponding author.
E-mail address: rkg.meta@coep.ac.in (R.K. Goyal).

https://doi.org/10.1016/j.matchemphys.2017.12.027

researchers worldwide because of their superiority over micro-sized particles. In addition to nano-scale dimensions, graphene and CNTs have superior electrical properties [9–13] and high aspect ratio which make them attractive for EMI shielding applications. The strength of electrical component of EM waves drops to 1/e of the original strength at a certain depth. This effect is known as 'skin effect' and the depth at which EM waves attenuate to 1/e of the original strength is known as 'skin depth'. Because of skin effect, nano-sized conductive fillers are more effective than micro-sized. Graphene and CNTs have a cross-section smaller than their skin depth [14], which results in effective use of the entire cross-section leading to higher EMI SE at lower volume fraction [15]. Reflection, absorption and multiple-reflections are three mechanisms which contribute to total EMI SE. The large specific surface area and excellent electrical properties of graphene and CNTs lead to numerous sites in the nanocomposites for reflections and multiple-reflections of EM waves. For commercial applications, an EMI SE of 20 dB corresponding to 99.99% attenuation of the signal is desirable [10,16].

Graphene and CNTs cannot be used as bulk for EMI shielding applications because their bulk samples are fragile. Therefore, their electrical properties are exploited by adding them into an appropriate polymer matrix. However, good EMI shielding is obtained only when there is a good dispersion of fillers in the polymer matrix otherwise their mechanical properties are deteriorated. Though, polymer matrix is not electrically conductive, the type of polymer matrix can affect connectivity of fillers, thereby overall EMI SE is affected [2]. In order to manipulate the properties of composites easily, the polymer matrix needs to have good processability. Therefore, polycarbonate (PC) a thermoplastic amorphous polymer well known for its excellent processability and toughness was used as matrix. However, it is electrically highly insulating (electrical conductivity: 10^{-12} -10^{-14} S/m). There are few reports on electrical properties of PC based nanocomposites filled with CNTs, graphene (monoatomic thick carbon layer), few layer graphene (FLG) and multilayer graphene [13,14,17,18]. However, multilayer graphene, known as graphite nanoplatelet (GNP), is highly preferred because

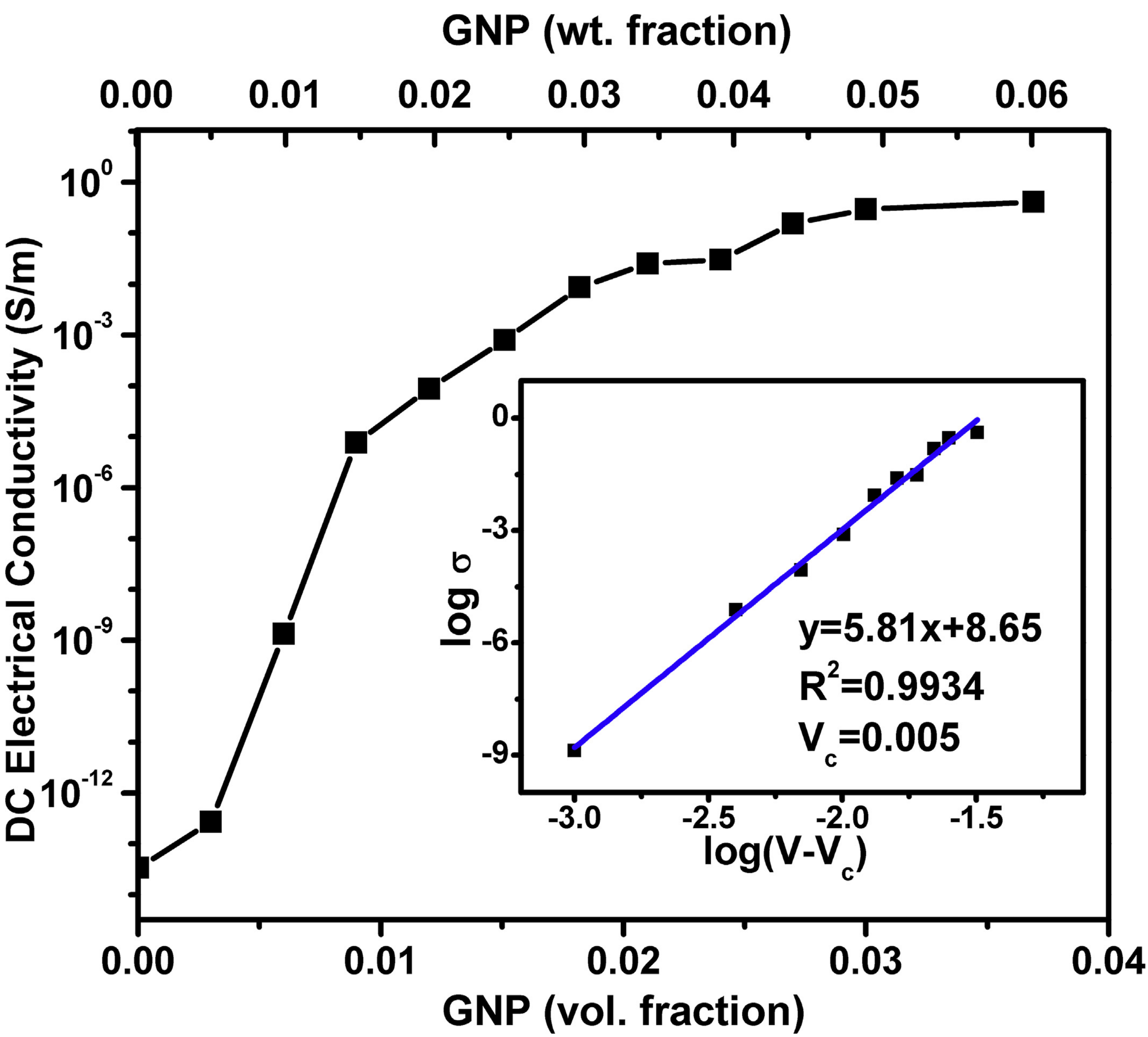


Fig. 1. Electrical conductivity vs GNP content for the PC/GNP nanocomposites.