Nano-Structures & Nano-Objects 12 (2017) 130–146

Contents lists available at ScienceDirect

Nano-Structures & Nano-Objects

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

Electromagnetic wave suppressors derived from crosslinked polymer composites containing functional particles: Potential and key challenges

Rani Rohini, Suryasarathi Bose *

Department of Materials Engineering, Indian institute of Science, Bangalore 560012, India

ARTICLE INFO

Article history:
Received 23 May 2017
Received in revised form 9 August 2017
Accepted 29 September 2017

Keywords:
Electromagnetic interference
Shielding effectiveness
Crosslinked polymer nanocomposites

ABSTRACT

In recent times researchers have been quite proactive towards the issue of electromagnetic interference (EMI). They have proposed solutions for reduction of this interference by shielding electronic devices. Currently, polymers or polymer composites are preferred materials for EMI shielding application in view of their lightweight and design flexibility. In the present article we have attempted to commemorate the remarkable efforts of various researchers that are reported to tackle EMI issue by developing crosslinked polymer based composites containing micro and nanofillers. Epoxy, polyurethane, elastomer based crosslinked polymer composites are most studied materials and have industrial significance as well. First section briefly explains the need of shielding electronic devices against electromagnetic radiation, followed by list of basic terminology used in this review article. Third section describes the mechanism involved in electromagnetic interference shielding. In the fourth section, we have reviewed various ways to design polymer composites based EMI shielding material, followed by conclusion and outlook.

Contents

1. Introduction

In this age of electronics, there has been huge demand of polymer based products in electrical and electronics industry. Due to its unique set of properties such as low density, ease of processing, flexibility, designing, moldability, tailored properties, etc.; polymers are preferred over other class of materials, like metals and ceramics. The application range for polymers extend from switches, enclosures, adhesives, housing, circuit board, cables, etc. Apart from various advantages, most of the polymers are electrical insulators. Hence polymers do not pose any resistance to electromagnetic radiation, in others words, they are transparent to EM waves. [1] Polymers, when used as enclosures, packaging, coatings, allow EM waves to penetrate and can cause interference with the waves coming from adjacent device (s). Electromagnetic interference (EMI) has been described as non-Gaussian random process, which causes severe damage to electronic systems. [2] EMI creates disturbance in proper functioning of a device and hence degrade its efficiency. In certain incidents, EMI based disturbances can be observed in television, radio transmission, computer, cellular phone, microphone, etc. [3] Few aircraft accidents in the past, for example air crash of Blackhawk helicopters and Harrier Jump Jet, occurred due to the coupling of EM waves from plane control system and radio transmitters. [4] Later the need for shielding of devices against EMI was realized. Researchers from both industry

* Corresponding author.
E-mail address: sbose@materials.iisc.ernet.in (S. Bose).

https://doi.org/10.1016/j.nanoso.2017.09.016
2352-507X/

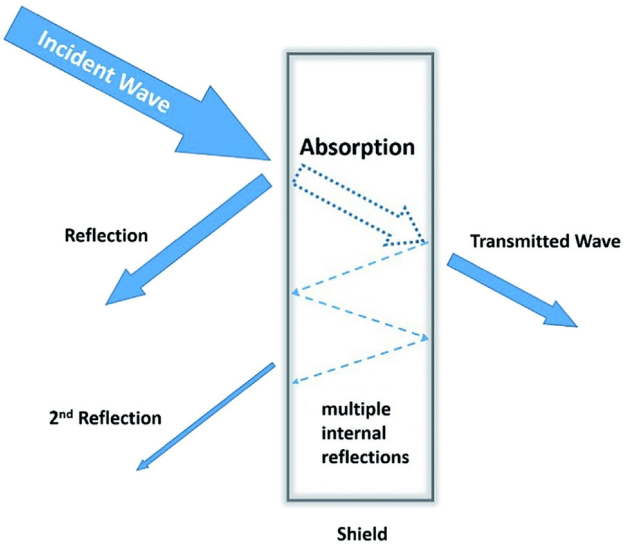

Fig. 1. Schematic of EMI shielding mechanism.
Source: Reproduced by permission from Ref. [30].
© 2015, Royal Society of Chemistry.

and academia have shown their keen interest in the development of shielding materials in couple of decades.

EMI shielding refers to the approach in order to limit the technical malfunctioning of the devices or components, due to the interference of EM waves. Shielding can be carried out in two ways either by altering the circuit design or encapsulating the delicate device against undesired EM radiation. But altering circuit design becomes more tedious and compromising from performance aspect. Hence it is preferable to develop material for EMI shielding. EMI shielding in a material occurs via three mechanism i.e., reflection, absorption, multiple reflection. It has been discussed elaborately later in Section 3.

With the advancement and innovation in the electronic and telecommunication field, modern systems need higher bandwidth/frequency for efficient functioning. In recent times, the rules and regulations to control the emission of EM waves from devices have become quite stringent. Hence the importance of EMI shielding has become more relevant in the present scenario. There is huge demand for EMI shielding material in various industries such as aircraft, automobile, electronic gadgets, microprocessor, satellite communication, etc. EMI shielding materials are available in different construct like gaskets, coatings, adhesives, foam, sheets, packaging and meshes. Since past few decades various classes of materials has been used as EMI shield, which include metals, ceramics and polymers [5–16].

Polymer composites filled with various fillers such as carbon based materials, metal and magnetic particles, etc. have been studied extensively in order to obtain excellent material for EMI shielding application. Usually polymers are electrically insulating in nature and hence do not contribute to the shielding mechanism of composite. But they provide matrix for proper dispersion and processing of fillers, and enhanced connectivity between the particles which can further improves EMI shielding behavior of composites. Conducting polymers such polyaniline, polypyrrole, polythiophene, etc can act as host to many conducting fillers to form conducting blend. Such kind of conducting system can assist in attenuation of EM waves and enhance the shielding efficiency. The incorporated fillers such as graphene, CNTs, graphite in conducting polymers can assist in inducing polarization and dielectric losses which contributes towards higher overall SE. Wide range of fillers (conductive, magnetic, dielectric materials) such as graphite, carbon black, carbon fibers, metal particles, carbon nanotubes, graphene, barium titanate, Ni, Co, Fe, Fe_3O_4, etc. have been used to prepare polymer composite for EMI shielding application. Overall shielding effectiveness of polymer composite is influenced by kind of fillers [17–24].

2. Basic terminology

In this section, we have enlisted important terminologies that will be used in this article [25–27] .

S-parameter: Scattering parameter is defined in terms of wave variables which are more easily measured at microwave frequencies than voltage and current.

Vector network analyzer (VNA): It is the system to analyze the performance of microwave radiation in terms of S-parameter. It provides both amplitude and phase of the signal.

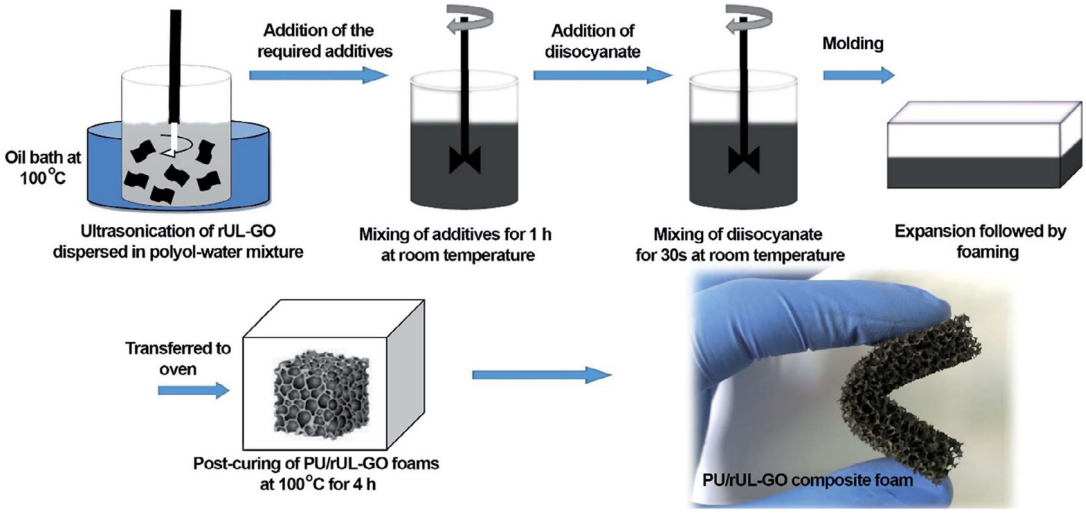

Fig. 2. Preparation steps of PU/rUL-GO composite foam.
Source: Reproduced by permission from Ref. [37].
© 2016, Royal Society of Chemistry.