Received: 12 January 2018 | Revised: 6 June 2018 | Accepted: 11 June 2018

DOI: 10.1002/adv.22113

RESEARCH ARTICLE

WILEY

Physical properties of polyvinylidene fluoride/multi-walled carbon nanotube nanocomposites with special reference to electromagnetic interference shielding effectiveness

Ranvijai Ram[1,2] | **Dipak Khastgir**[1] | **Mostafizur Rahaman**[3]

[1]Rubber Technology Centre, Indian Institute of Technology Kharagpur, Kharagpur, India

[2]Department of Chemistry, Maharaja Agrasen College, University of Delhi, New Delhi, India

[3]Department of Chemistry, College of Science, King Saud University, Riyadh, Saudi Arabia

Correspondence
Ranvijai Ram, Rubber Technology Centre, Indian Institute of Technology Kharagpur, Kharagpur, India.
Email: ranvijai.chemistry@gmail.com

Funding information
University Grant Commission (UGC), New Delhi; Indian Institute of Technology Kharagpur, West Bengal, India

Abstract

The polyvinylidene fluoride (PVDF)/multiwall carbon nanotube (MWCNT) composites, prepared by solution casting technique, can be used as electromagnetic interference (EMI) shielding material. The PVDF matrix shows MWCNT-dependent EMI shielding effectiveness, skin depth, morphology, mechanical, and dynamic mechanical properties. The transmission electron microscopy and field emission scanning electron microscopy images depict dispersion and distribution of MWCNT in PVDF matrix. The differential scanning calorimetry reveals MWCNT dependent crystalline melting temperature. The MWCNT is acting as reinforcing filler for PVDF matrix. The crystalline melting of PVDF and PVDF/MWCNT composites shows the occurrence of two endothermic peaks. Dynamic mechanical analysis of composites reveals MWCNT-dependent damping characteristics and storage modulus.

KEYWORDS

composites, electromagnetic interference shielding, mechanical property, morphology, skin depth

1 | INTRODUCTION

The prevention to propagate an electromagnetic wave (radiation) from one region to another by means of a magnetic or conducting material is called electromagnetic interference (EMI) shielding. The capacity of prevention of EMI of a material is called as its EMI shielding effectiveness (EMI SE).[1] Better EMI SE can be achieved by minimizing the radiation passing through the material by means of absorption and/or reflection of radiation inside the material. In case of metallic sheets, the EMI shielding is governed by reflection, whereas for extrinsically or intrinsically polymer composites, the EMI shielding is governed by both reflection and absorption of electromagnetic radiation.

The EMI shielding caused by the metallic sheet is called a Faraday cage effect. Metal sheet has poor mechanical flexibility because of high weight density, high stiffness, limited tuning of the SE, and propensity to corrosion.[2] Polymer-based EMI shielding materials has an advantage over metallic one because of their low cost, lightness, easy shaping, etc. The preparation of polymer-based composites for EMI shielding can be categorized in three ways. In one method, the dispersion of fibers, metallic fillers, and nanoparticles in the polymer matrix is carried out to increase their interaction with the EM radiation.[1,3–7] The composite foam based on polystyrene and carbon nanotube has been made by this method.[7] The second method is blending of conventional polymer with intrinsically conducting polymer or blending between two/more intrinsically conducting polymers. Polyaniline and polypyrrole are the examples of blending two intrinsically conducting polymers.[1,8–14] The third category in composite preparation method is the dispersion of conducting carbon fillers in the insulating polymer matrix. This type of conducting polymer composites is called extrinsically conducting polymer composites. Conducting carbon fillers, used to make such type of composite are carbon fiber, carbon nanotube, conducting carbon black, graphene, etc.[15–18] It has been

