Polymer 267 (2023) 125650

Contents lists available at ScienceDirect

Polymer

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

Improving the optical, dielectric properties and antimicrobial activity of Chitosan–PEO by GO/MWCNTs: Nanocomposites for energy storage and food packaging applications

Asmaa M.M. Ibrahim [a], A. Abou Elfadl [a], Adel M. El Sayed [a,*], Ibrahim M. Ibrahim [b,**]

[a] Physics Department, Faculty of Science, Fayoum University, El Fayoum, 63514, Egypt
[b] Department of Agricultural Microbiology, Faculty of Agriculture, Fayoum University, El Fayoum, 63514, Egypt

ARTICLE INFO

Keywords:
Chitosan–PEO blend
GO/MWCNTs nanocomposites
Optical constants
Energy storage
Antimicrobial activity
Thermal stability

ABSTRACT

This work is an attempt to improve the multifunctionality of chitosan–polyethylene oxide (Ch.–PEO) blend for different industrial applications including energy storage and food packaging applications. Graphene oxide (GO)/blend and multi-walled carbon nanotubes (MWCNTs)/GO/blend films were prepared by the solution casting method. FTIR analysis indicated the existence of Ch. and PEO functional groups and the positive interaction between the added nanofillers and the blend chains. XRD data confirmed interfacial compatibility between PEO and Ch. and showed that the semicrystalline nature of the blend was decreased after the incorporation of the filler. SEM analysis displayed that the blend surface is homogenous and crack-free, and the MWCNTs/GO were well-dispersed and uniformly distributed on the surface. The blend showed transmittance in the visible and NIR regions in the range of 76–91%. Loading MWCNTs/GO reduced this range and significantly increased the extinction coefficient of the blend. The indirect/direct band gap decreased from 4.3/5.2 eV to 3.0/3.8 eV with increasing fillers content. Moreover, the optical constants of the blend and nanocomposite films were determined. The dielectric measurements revealed that MWCNTs/GO doping increases the defects and results in a larger number of dipoles inside the blend and hence increases the dielectric constant of the blend. In addition, tan (δ) for all films is very small (< 0.05) and MWCNTs/GO/blend exhibits conductivity four times greater compared with the pure blend. The conduction mechanism, dielectric modulus, and Cole-Cole plots in the temperature range of 30–110 °C and frequencies in the range of 10^{-2} Hz–10 MHz were reported. The thermal analyses (TGA and DSC) for the blend and nanocomposite films were performed in the temperature range of 25–550 °C. TGA and DTG revealed three distinct weight-loss events for the samples; 25–122 °C, 229–360 °C, and 365–440 °C. The doped samples were more thermally stable where the blend lost 20% of its weight at 180.9 °C, while after doping with GO and codoping with MWCNTs, this temperature increased to 190.5 and 210.2 °C, respectively. The blend and nanocomposite solutions showed a wide antimicrobial activity against gram-positive and gram-negative bacteria, yeast, and fungi. Specifically, both GO/Ch.–PEO and 0.004%MWCNTs/GO/Ch.–PEO represented the highest antimicrobial against all tested microbes. *Staphylococcus aureus* ATCC 8095 was founded to be the most sensitive among the examined microbes. Additionally, the least sensitivity to studied solutions was recorded by *Penicillium roqueforti*. The improvements in the optical and dielectric properties make the prepared nanocomposites suitable for energy storage devices, while the antimicrobial activity suggests the use of GO/Ch.–PEO and MWCNTs/GO/Ch.–PEO nanocomposites for food packaging applications.

1. Introduction

To produce novel polymeric materials with superior property profiles relative to those of the individual polymers, blending technology is convenient, far less costly, and less time-consuming. It is one of the most possible and promising ways to improve the ionic conductivity of polymeric membranes as solid polymer electrolytes for batteries as well as other technological applications [1,2]. In addition, polymer-based

* Corresponding author.
** Corresponding author.
E-mail addresses: ams06@fayoum.edu.eg (A.M. El Sayed), imb00@fayoum.edu.eg (I.M. Ibrahim).

https://doi.org/10.1016/j.polymer.2022.125650
Received 16 December 2022; Accepted 26 December 2022
Available online 30 December 2022
0032-3861/