



Developing PbTiO₃-PMMA-PVDF dielectric composites for optoelectronics and capacitive energy storage applications

Turki Alotaibi^{1,*} and Adel M. El Sayed^{2,*}

¹ Department of Physics, College of Science, Jouf University, P.O. Box 2014, Sakaka, Saudi Arabia

² Department of Physics, Faculty of Science, Fayoum University, El Fayoum 63514, Egypt

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ABSTRACT

The present study investigates the impact of lead titanate nanoparticles (PTO NPs) on the physical properties of the blended polyvinylidene fluoride (PVDF). XRD and ATR/FTIR, FE-SEM&EDX techniques were employed to investigate the structural, morphological, and chemical properties of the produced films. The results show that the films have a semicrystalline nature, a multiphase structure with a dominant β -phase, a crystallinity index in the range of 18–38%, a porous surface, grain-like morphology, high fluorine content, and uniform Pb and Ti elemental distribution. The PVDF's transmittance (40–70%) increased upon blending with polymethyl methacrylate (PMMA), then decreased to 10–31% after PTO NPs doping. The optical band gap of PVDF can be engineered between 4.1 and 5.6 eV by PMMA and PTO contents. TGA analyses revealed the thermal stability, and DSC was employed to explore the transition temperatures of the films. Various dielectric parameters were evaluated in the frequency range of 10^{-1} – 10^7 Hz. PTO NPs improved the dielectric constant, maintaining the dielectric loss so small. The films exhibited DC conductivity in the range of $(0.95\text{--}2.9) \times 10^{-11}$ S/m, and AC conductivity in the order of 10^{-3} S/m at $f > 0.45$ MHz, depending on the films' composition. Loading PTO NPs significantly improved the energy density of the PMMA/PVDF blend from 4.5 J/cm³ up to 6.8 J/cm³. The findings of this study reveal that the PTO/PMMA/PVDF films are the best candidates for energy storage devices with improved thermal stability and capacitive performance for microelectronics and optoelectronic devices.

1 Introduction

The advancement of microelectronic technology based on energy storage devices, utilizing lightweight and cost-effective polymer dielectric composites (PDCs),

has emerged as a significant area of research [1–4]. The relatively low dielectric constant (ϵ') and low energy storage density of the polymeric materials represent a restriction for direct use in modern electronic devices. This problem can be solved by dispersing dielectric

Address correspondence to E-mail: tботаibi@ju.edu.sa; ams06@fayoum.edu.eg