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Boosting the structure, thermal, optical and dielectric properties of a thermoplastic polymer by some nanoperovskites

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Abstract. Given their technological applications, nanoperovskites are an intriguing class of multifunctional materials. To exploit their unique features while avoiding some of their shortcomings, developing low-cost and flexible perovskite/polymer nanocomposites with enhanced physicochemical properties attracts various research groups. In this report, two different perovskites, lanthanum ferrite nanoparticles (LF NPs) and lead titanate (LT) NPs were obtained by a solid-state route and mixed with a polyvinyl acetate/polyvinyl chloride (PVAc/PVC) thermoplastic blend. LF and LT nanostructuration have been investigated by the transmission electron microscope (TEM) and X-ray diffraction (XRD). The NPs' good dispersion, uniform distribution on the homogeneous film surface and their complexation with the blend chains were clarified by XRD and field emission (FE)-scan electron microscopy (SEM). The Fourier transform infrared (FT-IR) technique identified the influence of these nanoperovskites on the vibrations of the blend's characteristic (chemical) groups. The thermogravimetric analysis (TGA) also examined the impact of LF and LT NPs on the films' thermal stability. LT NPs are more effective at manipulating the transmission spectra in the UV–vis and IR regions and shrinking the blend's optical band gap than LF. The study of the dielectric properties showed that the LT/blend had a higher dielectric permittivity, better conductivity (2.72×10^{-6} S/cm) and higher energy density (0.48 J/cm^3). The absorption index, dual-band gap nature, dielectric loss and dielectric relaxation in the nanoperovskite/polymer were reported. The findings of this study declare that these nanocomposites are the best candidates for photonic devices and supercapacitor fabrication.

Keywords. $PbTiO_3$ nanoperovskites; thermoplastic nanocomposites; optical parameters; dielectric relaxation; energy density.

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1. Introduction

The preparation and characterisation of nanoperovskite/polymeric blend hybrid films (HFs) are garnering increased interest. These nanocomposites are free of low processability, high density and other shortcomings of the perovskites and combine their advantages into cost-effective, flexible and transparent films. These HFs can exhibit efficacious electronic, dielectric, optical, biological, magnetic, etc., features suitable for optoelectronic and energy storage devices, biomedical and engineering applications [1–8].

Blending technology has become a well-known approach for realising new polymeric materials without the need for sophisticated chemical techniques. Polyvinyl acetate (PVAc) is a non-toxic, inexpensive, amorphous and hydrophobic polymer that can form beneficial films. It has a moderate T_g ~ 30°C and melts at 70–210°C temperature range [9,10]. The side chains in PVAc provide a large dipole moment and relaxation time [11]. Therefore, the adhesive industry extensively uses PVAc as a reinforcing agent for glass, wood and plastics, as well as in microelectronic devices. However, PVAc's rubbery nature (poor mechanical properties), low performance at high temperatures (low thermal stability)

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