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MONTMORILLONITE INDUCED γ-PHASE IN PVDF WITH SUPERIOR DIELECTRIC PROPERTY

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ABSTRACT

The dielectric performance of montmorillonite (MMT) nano-clay doped PVDF has been investigated systematically in the broad range of frequency (20 Hz to 2 MHz). The superior performance as a perfect insulating behaviour of the nanocomposite films was understood in the frame work of perfect intercalation of the polymer matrix into layered silicates of MMT nano-clay. The intercalation features are consistently revealed through the FT-IR and XRD techniques. These investigations propose a suitable route to achieve a super flexible dielectric material in a single step process. However, the electroactive γ-phase formation is systematically investigated using several wt% of montmorillonite (MMT) nano-clay doped PVDF composite films via a single step process. The FT-IR spectrum shows that preferential formation of ordered electroactive γ-phase formation is systematically enhanced upon increasing concentration of MMT nano-clay. It has been found that fully flexible (as it can be fully rolled) composite film shows max. 95% of ferroelectric ordered γ-phase. The presence of layer structure in MMT intercalated into PVDF structure with increasing concentration of MMT in the composite film was consistently investigated using Scanning Electron Microscopy (SEM) and X-ray diffraction (XRD) spectra. The degrees of crystallinity of the PVDF-MMT nanocomposites are sequentially decreased with increasing concentration of MMT nano-clay. As a consequence the dielectric constants of the composite films are increased with increasing amount of nano-clay. In addition, these composites films can sustain a very high electric filed. Thus, PVDF-MMT nanocomposites serve as superb potential stuff for isolated ordered γ-phase and might be one of ideal solution for next generation high energy density storage applications.

Keywords: PVDF, MMT nano-clay, γ-phase, nanocomposite, dielectric study, high energy density storage.

INTRODUCTION

Poly (vinylidene fluoride) [PVDF, $(CH_2\text{-}CF_2)_n$] is considered as good dielectric, ferro-, piezo- and pyro-electric material that promises wide range of applications such as in biomedicine, energy generation and storage, sensors and actuators, separator in power cell, proton exchange membranes, smart scaffolds, and many others. Most of these applications are based on the electroactive phases of PVDF. It is a semi crystalline polymer consisting of at least four different crystalline polymorphs (α, β, γ, and δ phases). The most common polymorph α designated as an electrically inactive non-polar phase, whereas others are electrically active polar phases. Due to non-early saturation of polarization in γ-phase (TTTG), it can be utilized in high energy density storage applications [1, 2].

In this work, we have achieved maximum 95 % of electrocactive γ-phases in PVDF due to the perfect intercalation of the MMT nano-clay into the polymer matrix which is confirmed through XRD and FT-IR. As a consequence, the crystallinity (χ_c) of the clay doped polymer films decreases which eventually increases the dielectric constant with insignificant increment of the dielectric loss.

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