Enhancement of Piezoelectric Properties in PVDF-HFP/PZT Nanocomposites

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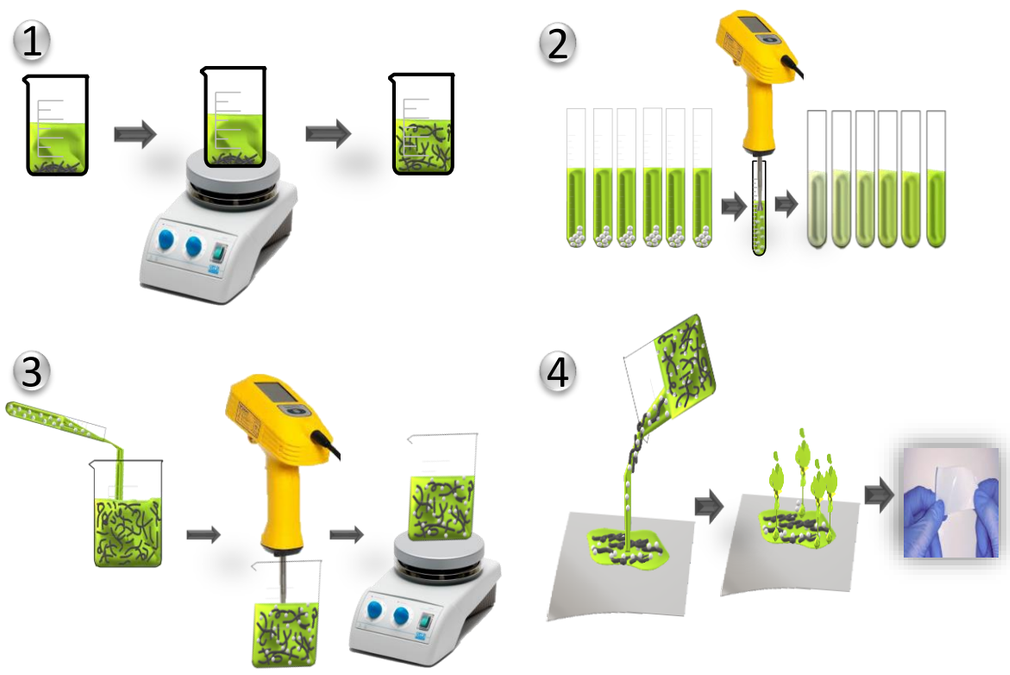
Abstract

In recent years, piezoelectric nanocomposites have gained considerable popularity in the field of microelectromechanical systems, particularly in sensing and actuation applications [1]. In this study, we present a novel type of flexible nanocomposite piezoelectric sheets, comprised of lead zirconate titanate (PZT) nanoparticles embedded within a poly(vinylidene fluoride hexafluoropropylene) (PVdF-HFP) matrix. The enhancement of piezoelectric and ferroelectric properties in these sheets is directly linked to the advancement of the crystalline β phase [2]. To assess the interaction between PZT and PVdF-HFP, Fourier transform infrared spectroscopy (FTIR), and scanning electron microscope (SEM) was employed [1]. The outcomes revealed a substantial improvement in these properties compared to pure PVdF-HFP, ascribed to the enhanced crystallinity and more uniform distribution of nanoparticles within the PVdF-HFP matrix. These thin film nanocomposites were fabricated via a solvent casting process using varying concentrations of PZT. The results of these experiments demonstrate the suitability of the investigated thin-film nanocomposites for a wide range of applications in energy storage and energy harvesting.

Method of preparation

Solvent casting method



1. Dissolution of the polymer in the solvent
2. Dispersion of the nanofiller in the solvent
3. Sonication and stirring of the polymer-solvent mix
4. Drying of the nanocomposite

Results & discussion

1- Infrared spectroscopy (FTIR)

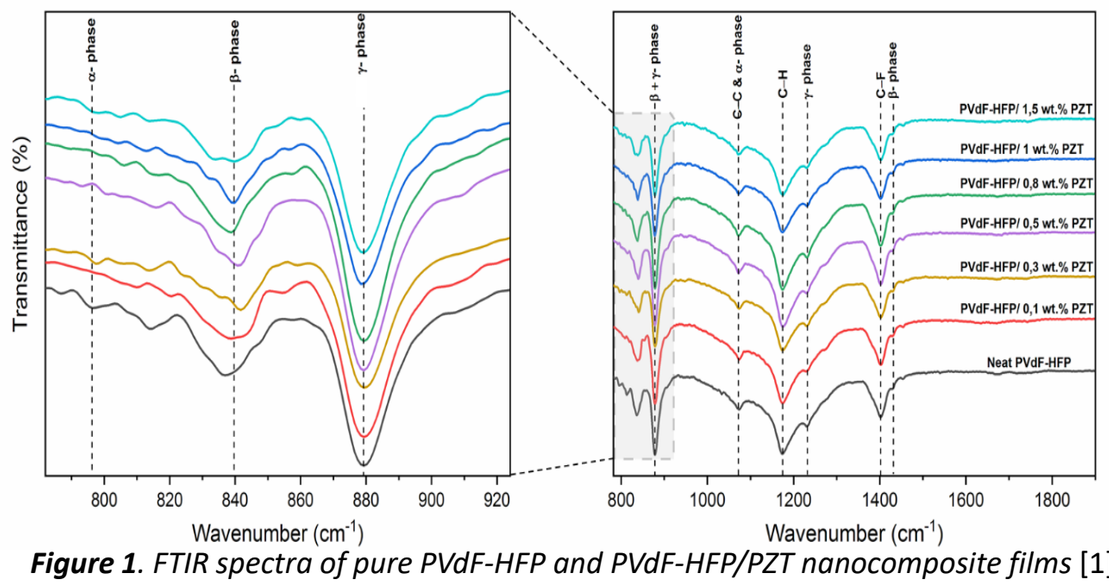


***Figure 1**. FTIR spectra of pure PVdF-HFP and PVdF-HFP/PZT nanocomposite films* [1].

***Table 1.** Relative fraction of the β-phase in P(VDF-HFP)/PZT nanocomposite films*

Cristalline phase	α-phase	β-phase	γ-phase
Infrared bands (cm^{-1})	796;1071	840; 1232	1176
Evolution	decreased	increased	increased

2- Scanning electron microscope (SEM)

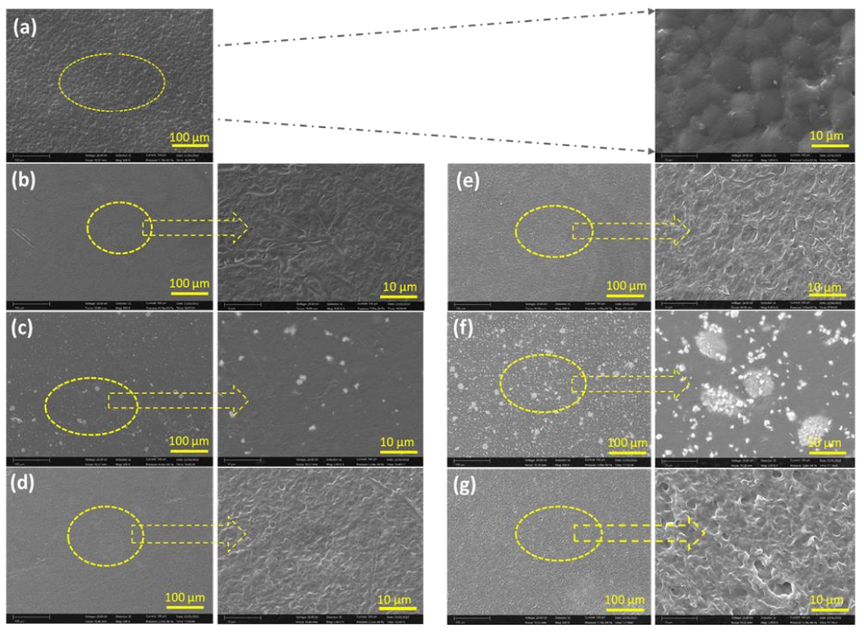


***Figure 2**. SEM images of pure PVdF-HFP and PVdF-HFP/PZT nanocomposite films* [1].

- A weak interaction between the PVdF-HFP and PZT nanofillers
- A homogeneous distribution of PZT nanoparticles within the polymer matrix
- Obtaining autonomous, flexible and non-porous films just with the incorporation of a small amount of nanofillers of PZT

Conclusion

The incorporation of PZT nanofillers into the polymer matrix emerges as a highly effective strategy for enhancing the piezo and pyroelectric properties, surpassing the dominance of the β-phase. The remarkable formation of the β-phase within these nanocomposites further substantiates the successful functionalization of PZT nanofillers on the PVdF-HFP matrix. These findings underscore the inherent high piezoelectric properties of PZT, establishing it as a vital piezoceramic widely employed for reinforcing the nucleation of the polymer matrix. Consequently, the integration of PZT nanofillers opens up new avenues for advancing the appearance and performance of piezo and pyroelectric materials.

References

[1] Oumghar, K., Chakhchaoui, N., Assal, M., Eddiai, A., El Achaby, M., Meddad, M., & Cherkaoui, O. (2022). PVDF–HFP/PZT nanocomposite thin films: preparation, structure and piezoelectric properties. European Physical Journal-Applied Physics, 97.
[2] Oumghar, K., Chakhchaoui, N., Eddiai, A., Cherkaoui, O., & Mazroui, M. (2023). Flexible piezoelectric nanocomposites based on PVDF-HFP/PLA blend doped PZT. In *IOP Conference Series: Materials Science and Engineering* (Vol. 1266, No. 1, p. 012004). IOP Publishing.