Temperature Effect on Dielectric Property in Poly(vinylidene fluoride-*co*-hexafluoropropylene) / Poly(methyl methacrylate) Blend Films

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Introduction:

A significant number of papers were published related to ferroelectric materials as they have profound performance in energy storage properties and relatively low cost. Under high field strength a ferroelectric material usually was accompanied a high loss such as PVDF Poly(vinylidene fluoride) and PVDF copolymer ferroelectric polymer. Our work tried to give a possible solution to achieve high energy storage and low loss. Therefore, it is necessary for us to understand the fundamental aspects of competition between polarization and depolarization fields, dipole switching, crystal orientation, polymorphism, and phase transformations in ferroelectric materials. In this research, we studied the temperature effect on the dielectric property and the role of induced polarization in the amorphous domain of PVDF-HFP/PMMA blend system.

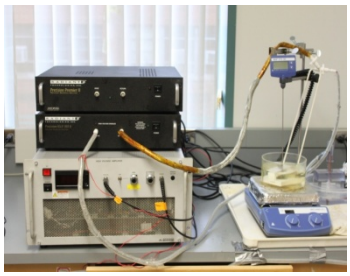
Sample Preparation:

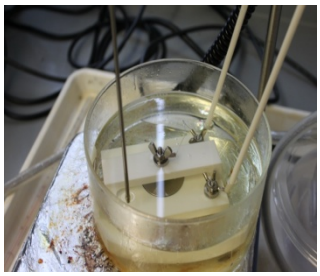
A film sample was obtained from hot-pressing at 235 °C and subsequently uniaxial stretched at 90 °C with a thickness of around 20 μm (extension ratio ca. 400%). Electric displacement/electric field (D-E) loops were performed in silicone

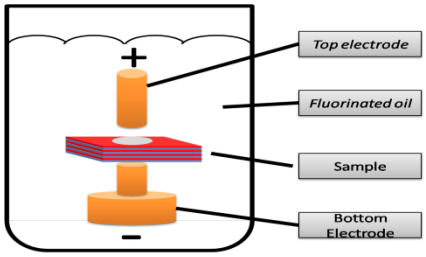
oil on samples with round aluminum electrodes (with radius of 1.2 mm) deposited on both sides by evaporation deposition.

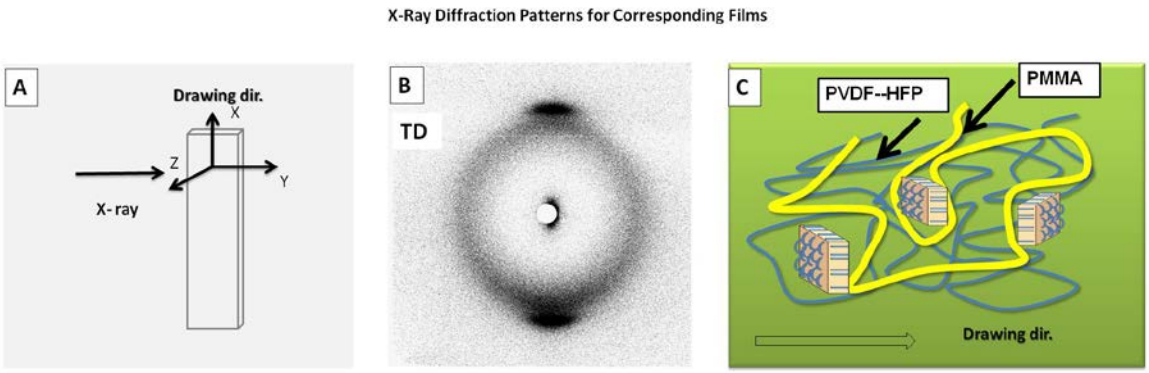
Displacement-Electric Field Loop Test:

Precision II high voltage system (Radiant Technology) was used at frequency of 10 Hz and the second loop was taken to reflect the real situation of usage. Aluminum electrodes of 0.045 cm^2 area were evaporated on the both side of film with desired thickness.



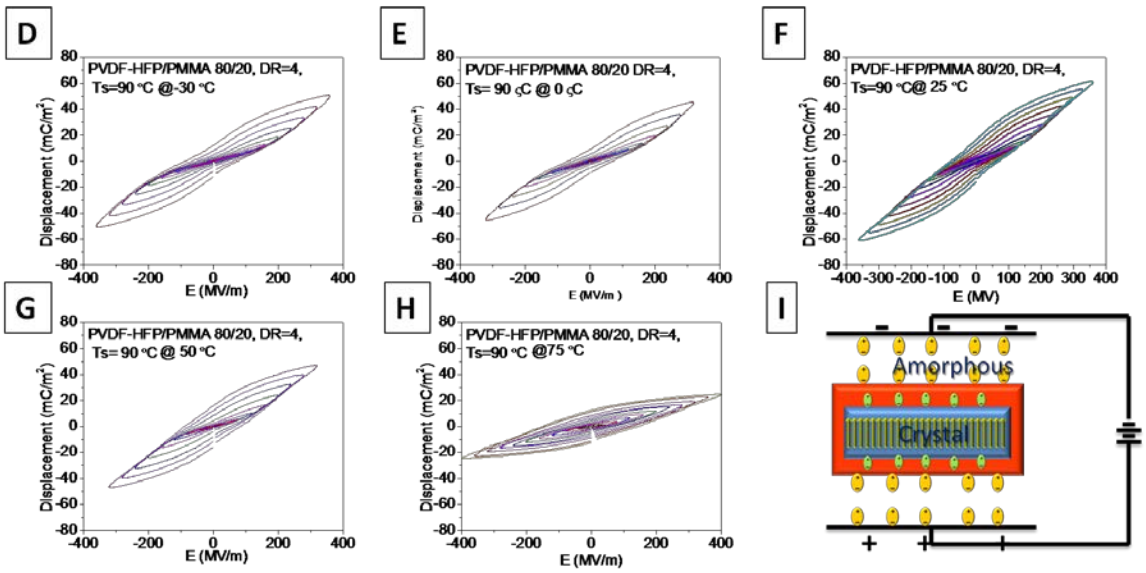






Figures A-C, Fig. A shows the setting for the WAXD experiment setting; Fig. B shows X-Ray Diffraction Patterns for PVDF-HFP/PMMA stretched films; Fig. C is the schematic for the lamellar crystal orientation in the sample.

Results:



Figures D- I, Fig. D – H shows the DE loop result at different temperature for PVDF-HFP/PMMA 80/20 stretched films; Fig. I is the schematic for electrically poled ferroelectric PVDF crystal sandwiched among amorphous layers.

First, at the temperature of -30 °C to 25 °C, the DE loop showed the antiferroelctric like loop at different field as the PMMA /PVDF-HFP amorphous domain was frozen. The DE loop became more ferroelectric-like as the temperature went to 25 °C and 50 °C , it was because the induced polarization in the amorphous became closed to polarization in the crystal domain. And eventually, the at 75 °C, the polarization PVDF-HFP/PMMA amorphous domain relaxed very fast, leading the ellipsoidal like DE loop.

Conclusion:

In summary, It was found at temperature from -30 to 25 °C PVDF-HFP/PMMA amorphous domain provided the low dielectric loss environment for PVDF dipole domain, benefiting the energy discharge as the PMMA concentration in the blend ca 20% also showed the antiferroelectric-like shaped DE loop. However, the higher temperature

as 50 °C increased the induced polarization in amorphous domain giving ferroelectric like loop because the amorphous domain stabilized the orientation polarization in the crystal domain. Then at the temperature as 75 °C, the polarization in the amorphous domain relaxed much faster, leading to the elipsoid like DE loop.

Future Directions:

In the future we will study the amorphous polar polymer dielectric property of and PVDC [Poly(vinylidene chloride)] to understand the dielectric behavior above and below the glass transition temperature. We need to develop high crystallinity system PVDF/ PMMA blend sample to do the comparison with the sample with lower crystallity.

Personal Experience:

Conducting real scientific research is something I have never done before. I really enjoyed working in a lab and using high tech equipment. Learning new material and finding results made this experience memorable.

Acknowledgements:

I had assistance from [redacted]. I would also like to thank the ACS SEED Program for funding this experience.