POLYMER BASED ELECTRO-ACTIVE MICRO- AND NANO-COMPOSITES

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Abstract

Polymeric materials filled with micro and nanoparticles have been widely investigated in the last few years. Till recently, mainly the mechanical reinforcement effect of these nanofillers was highlighted. Nowadays, several composites and nano-composites of electroactive polymers have been investigated due to their potential applications. In this way, carbon nanotubes/ polymer nanocomposites with high dielectric constant; electroactive polymers with metallic nanoparticles in order to tune electro-optic properties, magnetostrictive nanoparticles inducing magntoelectric response, and the introduction of ceramic microparticles to tune dielectric and piezoelectric properties have been investigated. [1]

In this work several nanocomposites of carbon nanofibers, magnetic nanoparticles and ceramic micro-particle with electroactive PVDF have been prepared by a solution method with *N*, *N*-dimethylformamide for different wt% concentration of the fillers. The crystalline phase of the matrix was the non-polar α-PVDF. Further, the nanocomposites are uniaxially stretched in order to achieve the phase transformation to polar β-phase within the polymeric matrix.

The general issues related to the processing of the electroactive composites such as dispersion, stretching and poling will be presented and discussed. The influence of the amount of crystalline part of the polymer, morphological properties, macroscopic mechanical and electrical properties and thermal stability of the composites were studied.

SEM micrographs of the samples show that the composites crystallise in a spherulitic structure, similar to the one of pure α-PVDF [1]. AFM micrographs also show the crystalline spherulitic structure with randomly distributed nanoparticles. (Figure 1)

The insertions of nanofillers also have a significant effect on the elastic modulus, electrical properties and electro-optical properties of the composites with respect to the polymer matrix. As an example, the elastic modulus of the PVDF-CNF composites nearly doubles for a small incorporation of CNF (lower than 1%) and remains almost constant for higher concentrations.

The α to β phase transformation in order to get the electroactive β-phase of the polymer was studied for the nanocomposites and it was concluded that the maximum amount of β-phase is obtained by stretching ratios of 5 or more at a temperature of 80 ºC [1-3] (Fig. 2).

In order to achieve the desired electromechanical, magnetoelectric and electro-optical properties, the composites have to poled (Figure 3 and 4). The poling behaviour of the polymer matrix nanocomposites, and the selection of the poling method, is also evaluated taking into account the poling behaviour of the ferroelectric PVDF-matrix.

The general issues related to the processing of the electroactive composites such as dispersion, stretching and poling will be presented and discussed. The influence of these parameters on some key macroscopic properties such as the electrical and mechanical properties will be also presented.

Particular attention will be drawn on the stretching and poling process necessary to achieve

polar β-phase within the polymeric matrix, as this critical step shows specific issues within the different nanocomposites.

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Figures:

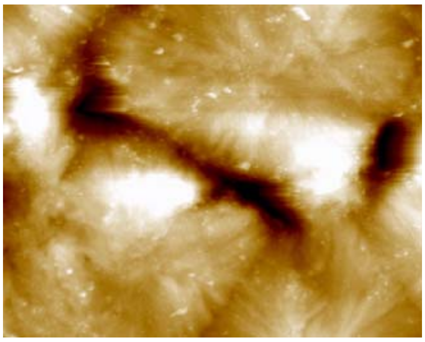

Figure 1. AFM images of the spherulitic structure with with randomly distributed nanoparticles

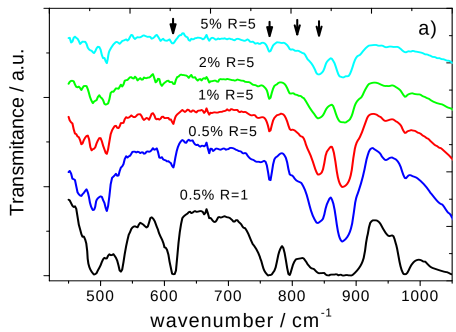

Figure 2. FTIR spectra of PVDF-CNF nanocomposites with different CNF concentrations.

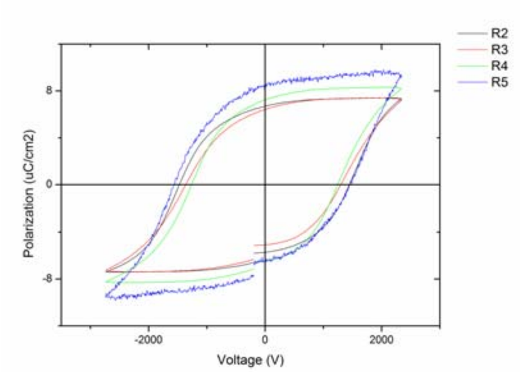

Figure 3. Hysteresis loops for different stretching ratios R2-R5.

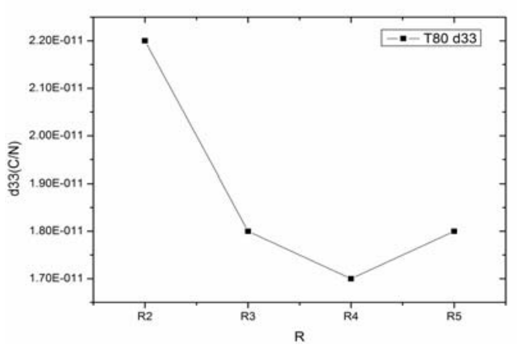

Figure 4. d_{33} coefficient for different stretching ratios R2-R5 in a sample stretched at a temperature of 80 ºC.