Electrospun PET Nanofibers and Their Application in Nanocomposites

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ABSTRACT

Nanofiber reinforced composites based on dispersion of electrospun PET nanofibers and LDPE were prepared by melt extrusion. The nanofibers were dispersed in 0.1, 0.5 and 1 wt%. Test specimens were prepared in a blown film extruder. Samples of each stage of nano fibers reinforced composites' manufacturing and processing were characterized by means of scanning electron microscopy (SEM), wide-angle X-ray diffraction (WAXD), differential scanning calorimetry (DSC), gas permeability, mechanical testing and heat seal strength.

Keywords: nanofibers, electrospinning, nanofibrer composites

INTRODUCTION

The present research deals with the effect of dispersion of PET nanofibers on LDPE films.

EXPERIMENTAL

Synthesis of Nanofibers.

The nanofibers were synthesized by the process of electrospinning. PET was dissolved in 20ml THF in 5% (w/w) concentration at room temperature. The solution was taken in a syringe and the syringe was fitted on a syringe pump. The solution was injected at a regulated speed of 5ml/h through a high voltage field of 10 kV using a high voltage power supply. The nanofibers were collected on a flat plate metal collector

Processing

The nanofibers were dispersed in the concentration of 0.1, 0.5 and 1 wt%. The dispersion of polymer and nanofibers was done in a counter rotating twin screw extruder. The strands were pelletized and predried at 90 °C. The pellets were fed to blown film extruder to form the films. The temperature profile was 120, 140, 160, 180 and 200 °C.

Characterization

Microscopic observations were performed on scanning electron microscope. Wide-angle X-ray scattering (WAXS) patterns LDPE and its composite with nanofibers were obtained using X-ray diffraction machine. DSC analysis was done in TA Q100 model. The gas transfer rate (O_2 and CO_2) through the films was determined according to ASTM D 1494. The mechanical properties were studied using a Universl Testing Machine. The tensile strength of the films in both MD and TD was determined according to ASTM D 882. Tear strength of the films in both directions was determined according to ASTM D 1004. The heat sealing of the films was done according to ASTM F88.

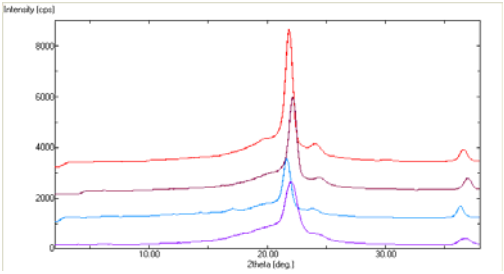
RESULTS AND DISCUSSIONS

Crystallinity of Films

X-ray diffraction is a versatile, non-destructive analytical method for identification and quantitative determination of various crystalline forms, known as 'phases' of compound present in powder and solid samples. Diffraction occurs as waves interact with a regular matrix structure whose repeat distance is about the same as the wavelength.

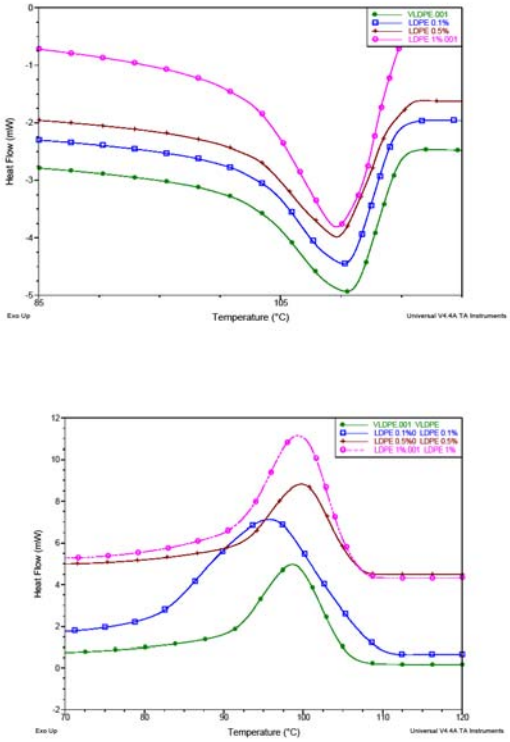
DSC analysis was done at a by giving both heating and cooling cycles at a ramp of 10 °C/min at a temperature range of 20-150 °C.

The XRD pattern showed increase in the percent crystallinity with the increase in the concentration of nanofibers. The same trend is shown by DSC analysis.



No.		File name	Sample name	Comment	Date
1	☑	VLDPE.raw	VLDPE	VLDPE	11-07-09
2	☑	LDPE 0.1%.raw	VLDPE	LDPE 0.1%	11-07-09
3	☑	LDPE 0.5%.raw	LDPE 0.5%	LDPE 0.5%	11-07-09
4	☑	LDPE 1%.raw	LDPE 1%	LDPE 1%	11-07-09

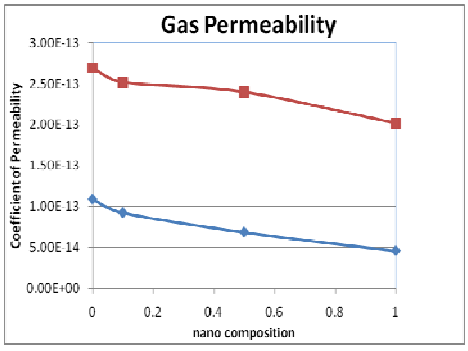
XRD patterns of virgin LDPE and its composite with nanofibers



Melting and Crystallinity graphs

Gas Permeability

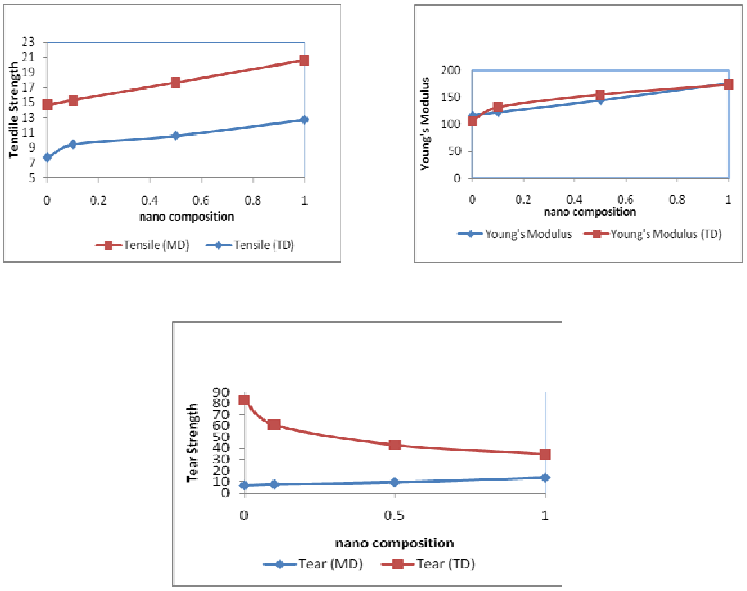
The films were tested for their oxygen and carbon dioxide permeability. It was observed that as the fiber concentration increased, the coefficient of permeability decreased. It is due to the fact that as the fiber concentration increased, the resistance to the flow of gas increased, thereby decreasing the gas permeability. Figure below shows the graph of coefficient of permeability vs % composition.



Gas Permeation of the films

Mechanical Properties

The tensile strength and Young's Modulus of the films increased in both the directions. This is commemorative to the fact that as the percent crystallinity increases, the tensile strength also increases. The tear strength also increased in the machine direction. This is due to the fact that the nanofibers get highly aligned in the machine direction. Figures below show the graphs of tensile strength, Young's Modulus and tear strength respectively.



Graphs of tensile strength, Young's Modulus and tear strength of films

Heat Seal Strength

The films were sealed at 200 °C, keeping a residence time of 2 sec at 30 psi pressure. The specimens were then tested for their peel strength. It was observed that the peel strength of the films increased with increase in nanofiber concentration. Thus it could be inferred that the films have good bonding.

CONCLUSION

Using the experience gained during the development of microfiber composites, another type of polymer–polymer composites, the nanofiber composites were created. The nanofiber composites show an improvement of Young's modulus and tensile strength. The reduction in the gas permeability values suggest that the nanofiber dispersed films have got an excellent resistance to transfer of O_2 and CO_2 . The increase in tear properties of the films shows that this composite gives good tear resistant strength in machine direction. The increase in peel strength shows that the films have excellent bonding nature. Thus it can be concluded that the nanofiber dispersed films have got excellent prospects as packaging material.