List of Publications

Journal Papers:


Conference Papers:

1. Studies on morphology, mechanical, thermal and rheological behavior of extrusion blended polypropylene and thermotropic liquid crystalline polymer in presence of compatibilizer, P. K. Mandal and D. Chakrabarty, Polymer 2006, 10-12 Feb, Indian Association for the Cultivation of Science, Kolkata.

Studies on Morphology, Mechanical, Thermal, and Rheological Behavior of Extrusion-Blended Polypropylene and Thermotropic Liquid Crystalline Polymer

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ABSTRACT: Polypropylene (PP) was melt-blended in a single-screw extruder with a thermotropic Vectra B-950 liquid crystalline polymer (LCP) in different proportions. The mechanical properties of such blends were compared in respect of their Young's moduli, ultimate tensile strength (UTS), percent elongation at break, and toughness to those of pure PP. The thermal properties of these blends were studied by differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA). The morphology was studied by using a polarizing light microscope (PLM) and a scanning electron microscope (SEM) while the rheological aspects of the blends and the pure PP were studied by a Haake Rheowin equipment. Mechanical analysis (tensile properties) of the blends showed pronounced improvement in the moduli and the UTS of the PP matrix in the presence of 2-10% of LCP incorporation. TGA of all the blends showed an increase in the thermal stability for all the blends with respect to the matrix polymer PP, even at a temperature of 410°C, while PP itself undergoes drastic degradation at this temperature. DSC studies indicated an increase in the softening range of the blends over that of PP. Morphological studies showed limited mixing and elongated fibril formation by the dispersed LCP phase within the base matrix (PP) at the lower ranges of LCP incorporation while exhibiting a tendency to undergo gross phase separation at higher concentrations of LCP, which forms mostly agglomerated fibrils and large droplets. © 2003 Wiley Periodicals, Inc.

Key words: liquid-crystalline polymers (LCP); mechanical properties; morphology; rheology

INTRODUCTION

Thermotropic main-chain liquid crystalline polymers (LCPs) consist of linear semirigid rodlike molecules that are capable of aligning to a very high degree during melt flow and thus form a highly ordered melt phase. When the polymer melt is cooled, the orientation is retained, which leads to a highly ordered fibrous structure and anisotropic properties. The properties of thermotropic LCPs are based on their oriented structure.1-3 The degree of orientation can be influenced by the processing conditions and its environment as well.

LCP moldings can exhibit a layer structure and a skin-core morphology. Near the surface there is a skin layer with extensive highly ordered fibers, while in the core there is less orientation and fiber formation.4-8 A similar skin-core structure can be found in the blends as in pure LCPs. In the skin layer, there are often more oriented fibrous LCP phases, while in the core the LCP phases are less oriented or in spherical form.11-42 The LCP content and processing conditions determine whether fibers are formed. The morphology and the resultant properties of the blends are also highly dependent on the composition of the two polymers. The mutual compatibility of the polymers and the interfacial adhesion between them play important roles here. The ratio of the melt viscosities of the polymers affects their miscibility and the fiber formation.13,14 In the solid state, blends of LCPs and thermoplastics can exhibit a composite fiber structure if sufficient orientation of the molten LCP phases during processing is achieved.15,16

In the present work, an ester-amide type of LCP was blended with an isotactic stereoregular polypropylene (PP) matrix by a single-screw extruder. The physical, mechanical, and thermal properties of the...
Studies on Morphology, Mechanical, Thermal, and Dynamic Mechanical Behavior of Extrusion Blended Polypropylene and Thermotropic Liquid Crystalline Polymer in Presence of Compatibilizer

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ABSTRACT: Polypropylene was melt blended in a single screw extruder with thermotropic Vectra B-950 liquid crystalline polymer (copolyester amide) in different proportions in presence of 2% of EAA, ethylene-acrylic acid copolymer (based on PP) as a compatibilizer. The mechanical properties of such compatibilized blends were evaluated and compared in respect of their Young’s Modulii, Ultimate tensile strength, percent elongation at break, and toughness to those of pure PP. The Morphology was studied by using a polarizing light microscope (PLM) and Scanning electron microscope (SEM). The Thermal characterization of these blends were carried out by differential scanning calorimeter (DSC). The mechanical properties under dynamic conditions of such compatibilized blends and pure PP were studied by dynamic mechanical analyzer (DMA). Mechanical analysis (Tensile properties) of the compatibilized blends displayed improvements in Modulii and ultimate tensile strength (UTS) of PP matrix with the incorporation of 2–10% of LCP incorporation. The development of fine fibrillar morphology in the compatibilized PP/LCP blends had large influence on the mechanical properties. Differential scanning calorimeter (DSC) studies indicated no remarkable changes in the crystalline melting temperature of the blends with respect to that of pure PP. However, an increase in the softening range of the blends over that of PP was observed. © 2008 Wiley Periodicals, Inc J Appl Polym Sci 111: 2345-2352, 2009

Key words: liquid crystalline polymer; compatibility; mechanical properties; thermal properties; morphology

INTRODUCTION

Main chain liquid crystalline polymers (MCLCPs) consist of linear semi rigid rod like molecules that are capable of aligning to a very high extent and thus form a highly ordered melt phase. When the polymer melt is cooled, the orientation is retained which leads to a highly ordered fibrous structures and anisotropic properties. The properties of thermotropic LCPs (TLCPs) are based on their oriented structure.1-5 The degree of orientation can be influenced by processing conditions and its environment as well.

LCP molding can exhibit a layered structure with skin and core morphology. Near the surface there is a skin layer with extensively high ordered fibers, while in the core there is less orientation and consequently less fiber formation.4-6

LCPs are blended with thermoplastics mainly to reinforce the matrix thermoplastics or to improve its dimensional stability. A small amount of LCP can also make viscous thermoplastics (conventional) easier to process due to its relatively low melt viscosity, although a thermotropic LCP and thermoplastics blend consists of two separate phases and are mainly immiscible.9,10

The blend possesses higher mechanical properties over the thermoplastics and can be processed far more easily than the thermoplastic one. A similar skin core structure can be found in the blends as in pure LCPs. In skin layer, there are often more oriented fibrous LCP phases while in the core the LCP phases are less oriented or in spherical form.11,12

The LCP content, type and processing conditions as well as the presence of compatibilizers determine the ultimate morphology.13-15 The morphology and resultant properties of the blends are also highly dependent on the composition of the blend.

The mutual compatibility and interfacial adhesion is expected to be improved by using EAA as a compatibilizer and that was reflected in the modulus and other mechanical properties of the blends.

The ratio of melt viscosity of the polymers affects their miscibility and the mode of fiber formations.16,17 In the solid state, blends of LCPs and
Mechanical, Thermal and Morphological Characteristics of incompatible 
bLENDS of Lldpe and Thermotropic Liquid Crystalline Polymer in its low 
range of incorporation

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ABSTRACT

Thermotropic liquid crystalline polymer (TLCP), VECTRA-B950 has been melt blended with thermoplastic 
(commodity) linear low-density poly-ethylene (LLDPE) in a single screw extruder in different blend 
ratios. These blends were characterized in respect of their mechanical, thermal and physical properties. 
The morphologies of different blends developed as such have been investigated in relation to various 
properties. The rheological behaviour of such blends has been studied as function of blend composition. 
Both the ultimate tensile strength (UTS) and Young's Modulus of the LLDPE matrix undergo a steady 
increase with increasing proportions of TLCP. The percent elongation at break and toughness of the 
bLends, however, exhibit a decreasing trend. The thermal resistances of the blends increase with 
increasing proportion of TLCP incorporation within the range temperature under study, as envisaged 
from the TGA analysis. The DSC tracings of the various blends apparently resemble those of 
heterogeneous phase blends. The initial softening temperatures of the mixture of LLDPE and TLCP 
decrease in all the blends while the melting temperature of the modifying TLCP almost remains 
unaltered. The thermo mechanical analysis of the various samples under compression mode exhibits 
an increase in thermal resistance as was envisaged from TGA analysis. An extended fibrillar structure 
of the LCP phase is present in an incompatible LLDPE matrix and is assumed to improve the mechanical 
by a mechanism in which the in-situ generated LCP fibrils are expected to function as reinforcing 
component in such incompatible fibre reinforce composites.

*Key words: Thermotropic, composites, LCP, fibrillar, morphology.

INTRODUCTION

A new class of materials having an excellent combination of superior processibility and physico-
mechanical properties has recently been synthesized by blending commodity thermoplastics with liquid crystalline polymers
Studies on the Engineering Properties of LCP-Vectra B 950/PP Composites

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Polypropylene was melt blended in a single screw extruder with thermotropic vectra B-950 liquid crystalline polymer (co polyester amide) i) in different proportions ii) at a fixed compatibilizer with variations in LCP concentration & iii) with variations of compatibilizer (EAA) at fixed 5 % LCP content; ethylene acrylic acid copolymer being used as a compatibilizer in all the cases. The mechanical properties of such compatibilized blends & blends without any compatibilizer were evaluated and compared in respect of their Young's Moduli, Ultimate Tensile Strength, Percent Elongation at Break and Toughness to those of Pure PP. The Morphology was studied by using a Optical Microscope and Scanning Electron Microscope (SEM). The Thermal characterization of these blends were carried out by Differential Scanning Calorimetry (DSC) and Thermo-gravimetric analysis (TGA). The rheological properties of such compatibilized blends and pure PP were studied by Rheotron. Mechanical Analysis (Tensile Properties) of the compatibilized blends displayed improvements in Modulii and Ultimate Tensile Strength (UTS) of PP matrix with the incorporation of LCP. The development of fine fibrillar morphology in the PP/LCP blends had large influence on the mechanical properties.

Differential Scanning Calorimetry (DSC) studies indicated no remarkable changes in the crystalline melting temperature of the blends with respect to that of pure PP. However an increase in the softening range of the blends over that of PP was observed. Thermogravimetric Analysis (TGA) of such compatibilized blends indicates the thermal stability for all the blends with respect to pure PP. The rheological properties indicate the decrease in melt viscosity of various blends under the shear rate studied. The PP/LCP composites are used in various field such as adhesives, in making multi layer films, engine parts, aerospace, helicopter blades, solar panels, electronics & optical fibre jackets, barrier film for packaging etc.

Keywords: Liquid crystalline polymer, Compatibility, Mechanical properties, Thermal properties, Morphology.

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