COMPATIBILIZATION OF HDPE/PS BLENDS BY TAPERED DIBLOCK PE-PS COPOLYMERS

Michel F. Champagne and Michel M. Dumoulin

Industrial Materials Institute
National Research Council Canada
75, Boul. de Mortagne
Boucherville
Canada
J4B 6Y4

ABSTRACT

Addition of diblock copolymers is a well-known technique for production of polymer blends with enhanced mechanical performance. This paper investigates some of the relationships between the molecular structure of PE-co-PS tapered diblock copolymers and the compatibilization produced by their addition in HDPE/PS blends. The emulsification generated by the addition of a given amount of copolymer molecules was found to be directly related to the block copolymer molecular weight; the higher the copolymer molecular weight, the finer the HDPE dispersion. On the other hand, an optimum molecular weight seemed to exist when the fracture resistance of compatibilized blends is considered. Improvement of blends fracture resistance was only observed upon addition of the intermediate molecular weight copolymer (PS_{520}-PE_{2320}). Both the low (PS_{480}-PE_{80}) and high (PS_{375}-PE_{6950}) molecular weight copolymers did not improve the fracture resistance of 15 wt% HDPE/PS blends. The lack of homopolymer-copolymer molecular entanglement could explain the poor performance of the low molecular weight copolymer while the formation of a dry brush was postulated in blends compatibilized by the high molecular weight material.
INTRODUCTION

An increasing number of new materials is made from polymer blends. Materials with accurately tailored properties can be efficiently produced by polymer blending and alloying. Unfortunately, most polymers blends show strong immiscibility and as such, often display coarse morphology and poor interfacial adhesion. This situation generally leads to materials with inferior properties. In these conditions, the compatibilization seems to be the key for production of polymer blends with interesting characteristics.\textsuperscript{1,2}

An efficient way of improving the performance of immiscible polymer blends is by addition of a copolymer. The copolymer must be made from polymeric segments miscible with the two homopolymers constituting the blend. Most often, small amounts of a block copolymer A-B are added to a blend of homopolymers A and B.\textsuperscript{3-10} The literature also reports some examples of the addition of block copolymer A-D, C-B or even C-D, where blocks C and D are respectively miscible with homopolymer A and B.\textsuperscript{11-13} This compatibilization technique relies on an enthalpically-driven migration (caused by unfavorable interactions) of the added block copolymer to the blend's interfaces. These very same unfavorable interactions can also lead the added block copolymer to create micelle-type structures in one (or both) of the blend components. Results reported in the literature indicate that diblock copolymers are better compatibilizers than graft, triblock or star-shaped copolymers.\textsuperscript{8} The higher efficiency of tapered diblock over pure diblock copolymers is also reported in the literature.\textsuperscript{6,14}

The copolymer migration toward interfaces creates many positive effects on the blends. It reduces the blend's interfacial tension and particle-particle coalescence rate, both accounting for the finer dispersion usually observed after copolymer addition. Presence of the copolymer at the interface also enhances the chain entanglements between the two homopolymers of the blend. This latter phenomenon explains the improved phase adhesion observed in well compatibilized systems.\textsuperscript{9,10,15-17}

It is noteworthy that block copolymer molecules involved in micelle formation are not available for interface modification. These molecules can then be considered as lost to the compatibilization process. The compatibilizing effectiveness of a given copolymer is then intimately related to its capacity of efficiently migrating toward blend's interfaces. The structure and composition of the added copolymer must be carefully tailored to minimize micelle formation and maximize interfacial activity.

The objective of this work is to find some of the relationships between polyethylene-polystyrene (PE-co-PS) tapered diblock copolymer structure and compatibilizing efficiency. Three PE/PS block copolymers with different compositions and molecular weights were investigated in this work. Blends of 15 wt% high density PE in PS containing increasing amounts of these block copolymers were produced in a lab-scale batch mixer. The morphological and mechanical behavior of the blends were characterized using scanning electron microscopy and three-point bending tests, respectively.