Synthesis and characterization of stimuli-responsive block copolymers for the reversible compatibilization of polymer blends

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Abstract

It is often necessary to blend polymers in order to introduce or improve certain useful properties. However, not all polymers are miscible. Several polymers phase separate when blended with other ones[1]. This set back is often overcome by adding block copolymers as compatibilizers to the blends[2]. Although the addition of block copolymer stabilizes the blends, it also makes it impossible to recover the different homopolymers by recycling the material. We envisioned that a stimuli responsive compatibilizer would perform the dual function of stabilizing the blend in the first instance and subsequently cleave when stimulated to allow the material to be recycled. Therefore, temperature-responsive block copolymers bearing a stimuli-responsive molecular switch between their blocks were synthesized and their response to thermal stimuli was studied. Several polystyrene-block-poly(lactic acid) block copolymers were synthesized via sequential Atom Transfer Radical Polymerization (ATRP) and Ring Opening Polymerization (ROP) from a bifunctional but asymmetrical initiator based on an anthracence-maleimide diels-alder adduct. Such adducts can be cleaved by temperature[3] and by mechanical forces[4]. In order to show that the block copolymer can be cleaved by heat, the block copolymer was refluxed in THF and the products were analyzed by gel permeation chromatography (GPC). A reduction in molecular mass and an increase in dispersity were observed. This is consistent with the idea that the "thermophore" cleaves in responds to heat. The thermal response of the polymer follows a retro [4+2] cycloaddition mechanism.

The block copolymers were used as a compatibilizer in blends of the homopolymers of polystyrene and poly(lactic acid). 10%wt of the block copolymer led to smaller domain sizes in the blend, as observed on atomic force microscopy (AFM) images. Above 110°C the block copolymer cleaves and the two homopolymers phase separate into large domain sizes. This allows for the recycling (recovery) of the different homopolymers from the blend.

References

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