RHEOPTICAL STUDIES OF BLENDS OF POLY(STYRENE-B-BUTADIENE-B-STYRENE) AND POLYSTYRENE.

S. D. Hong* and M. Shen

Department of Chemical Engineering
University of California
Berkeley, California 94720

and

T. Russell and R. S. Stein
Department of Polymer Science of Engineering
and Polymer Research Institute
University of Massachusetts
Amherst, Massachusetts 01003

ABSTRACT

Polyblends of poly(styrene-b-butadiene-b-styrene) and polystyrene were cast from a tetrahydrofuran/methyl ethyl ketone mixture using a spin caster. These samples were found to undergo a "strain-induced plastic-rubber transition" upon deformation. Infrared dichroism and birefringence studies both indicate the high orientation of the polybutadiene chains, but not of the polystyrene chains. Thus most of the deformation after the "transition" has taken place is due to the rubbery domains. Scanning electron micrographs show some surface fracture upon stretching for those samples containing high polystyrene content. Small angle x-ray scattering results reveal that the morphology in the three coordinate directions was different. Upon stretching, the polystyrene domains may have broken up into smaller sub-domains, which could be responsible for the observed plastic-rubber transition. Furthermore, there was a decrease in the total scattering intensity for the stretched samples, indicating a change in the mean square fluctuation of electron density of the stretched sample. The small angle light scattering patterns appear to be consistent with the above proposed interpretations.

* Jet Propulsion Laboratory, 4800 Oak Grove Drive
Pasadena, California 91103
INTRODUCTION

Polymer blends in general have synergetic properties which the individual homopolymers do not have. High impact polystyrene and ABS block copolymers are excellent examples. Because polymers are generally found to be incompatible as a consequence of positive free energy of mixing, most polymer blends exhibit phase separation (1-3). Blends of incompatible homopolymer do not have good mechanical properties because of the lack of sufficient adhesion between the different phases (4-6). An alternate process to improve adhesion between different phases in a blend is to add a graft copolymer or block copolymer. It was found that the use of these copolymers as additives in homopolymer blends greatly improves the mechanical properties of the blends (4-9). The morphology and mechanical properties of these blends have been studied by a number of workers (10-17).

Upon deformation block copolymers and blends of copolymer and homopolymer often exhibit stress softening (18-20). Furthermore the deformed samples demonstrate a healing effect in that, upon removal of stress, properties of the original undeformed sample are restored (18,20). For example, when a sample of the blend of poly(styrene-b-butadiene-b-styrene) and polystyrene is strained beyond the yield point, it becomes rubbery and exhibits high elasticity rather than irreversible drawing (20). The stress-softening effect in pure block copolymer has previously been attributed to the breaking up of some sort of rigid structures (18,21, 22) and the healing effect to the reformation of the original domain structures (18). Inoue et al., (15), on the other hand, found that in the blends of poly(styrene-b-isoprene) with polystyrene, the sample underwent yielding upon stretching. In this work, a rheo-optical investigation of the strain-induced plastic-rubber transition is presented in an effort to further elucidate the mechanism of this interesting phenomenon.

EXPERIMENTAL

Poly(styrene-b-butadiene-b-styrene) block copolymer (SBS), designated as Kraton 1101, was received from Shell Chemical Company. The copolymer contains 28% polystyrene and 72% polybutadiene. The weight average molecular weight of the copolymer is 84,000 and the polydispersity index is 1.21. The styrene blocks of the copolymer have a number average molecular weight of 13,300. The polybutadiene (PB) blocks have 46% trans-1,4, 46% cis-1,4 and 8% vinyl structures. Polystyrene (PS) was supplied by Polysciences, Inc., and has a number average molecular weight of 41,000 and polydispersity index of 2.32.

Samples of the block copolymer and its blends with PS were cast in the form of sheets from a 10% solution of tetrahydrofuran