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Viscoelastic phase separation process and the development of micro and nanomorphologies in epoxy based blends for super toughness

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Phase separation in general could be either by diffusion or by diffusion and hydrodynamic flow. A new model has been suggested recently to follow the phase separation process in dynamically asymmetric mixtures composed of fast and slow components. This new model is often called the viscoelastic phase separation process due to the fact that viscoelastic effects play a dominant role in the phase separation process. The dynamic asymmetry can be induced by either the large size difference (mol. wt) or the difference in glass-transition temperature between the components of a mixture or blend. The mol. wt difference often exists in complex fluids, such as polymer solutions, polymer blends, micellar solutions, colloidal suspensions, emulsions, and protein solutions. The T_g differences, can exist in any mixtures. In dynamically asymmetric mixtures, phase separation generally leads to the formation of a long-lived 'interaction network' (a transient gel) of slow-component molecules (or particles), if the attractive interactions between them are strong enough. Because of its long relaxation time, it cannot catch up with the deformation rate of the phase separation itself and as a result the stress is asymmetrically divided between the components. This leads to the transient formation of network like or sponge like structures of a slow-component-rich phase and its volume shrinking. In the present talk we present our new results on the viscoelastic phase separation process in epoxy/SAN and epoxy/ABS blends. Epoxy resin is often blended with high molecular weight thermoplastics to generate micro structured morphologies for the better impact performance. These systems are very ideal to follow the viscoelastic phase separation process on account of their mol. wt and T_g differences. We have looked at the phase separation process in these blends by various techniques such as optical microscopy, scanning electron microscopy, transmission electron microscopy, atomic force microscopy, and small angle laser light scattering. The dynamics of phase separation has been carefully followed by optical microscopy and laser light scattering. In most cases, the system undergoes spinodal decomposition and the viscoelastic phase separation was prominent at higher concentration of the thermoplastic phase where phase inversion occurs. The particle in particle morphology (secondary, ternary and quaternary phases), IPN type of structures and unusual shrinkage have been examined as a result of the viscoelastic phase separation process. All these phenomena have been carefully quantified and correlated with the viscoelastic phase separation process.

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Anionic solution copolymerization of α -methylstyrene with conjugated dienes above the ceiling temperature of α -methylstyrene

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The successful copolymerization of α -methylstyrene with conjugated dienes such as 1,3-butadiene, isoprene and/or styrene was achieved by anionic solution polymerization in hexane using formulated catalyst systems at the ceiling temperature of α -methylstyrene. This polymerization is unique, since α -methylstyrene cannot homopolymerize above its equilibrium ceiling temperature of 60°C. Anionic copolymerization of 1,3-butadiene and α -methylstyrene was first performed in hexane at 65°C using 2/2/1 molar ratio of three different types of catalyst systems; cesium 2-ethylhexoxide (CsOR)/dibutylmagnesium (Mg(Bu)₂)/N,N,N',N'-tetramethylethylene diamine (TMEDA), CsOR/TMEDA/n-butyl lithium (n-BuLi), and potassium amylate (KOAm)/TMEDA/Mg(Bu)₂. Polymers produced from the CsOR-based system showed faster incorporation rates of α -methylstyrene than the KOAm-based system, resulting in the composition of α -methylstyrene as high as 50% compared to a maximum of approximately 25% for the KOAm. Copolymerizations have also been successfully carried out using CsOR/TMEDA/n-butyl lithium (n-BuLi), although other n-BuLi containing systems were not successful. Other monomers such as isoprene and styrene can be used with the CsOR/TMEDA/Mg(Bu)₂ catalyst system to produce randomly α -methylstyrene incorporated multiblock diene copolymers.

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