



## CHAPTER II LITERATURE SURVEY

Wu (1987) suggested a relation between interfacial tension and interfacial thickness. Statistical mechanical theories of polymer interfaces lead to the relations

$$\gamma_{12} \propto \chi^{1/2}$$

and

$$L \propto \chi^{-1/2}$$

where  $L$  is the interfacial thickness and  $\chi$  is the Flory-Huggins interaction parameter. Therefore, we have

$$\gamma_{12} \propto L^{-1}$$

thus,  $\gamma_{12}$  should be inversely proportional to  $L$ . However, a least-square regression of the experimental data gives

$$\gamma_{12} = 7.6L^{-0.86}$$

where  $\gamma_{12}$  is in mN/m and  $L$  is in nm.

### 2.1 Core-shell morphology development in ternary blends

The polymeric ternary blend system refers as a polymer blend that consists of three polymer components in which one component with limited amount may act as a compatibilizer. The following works review the observation of the interface and morphology development in term of shape, size, interface reaction, molecular structure, and correlation between surface tension, free energy, and spherical size. More importantly, the core-shell morphology with and without subinclusion were observed and discussed for the relation to mechanical properties.

Oshinski *et al.* (1992) reported that in Nylon6/[SEBS/SEBS-g-MA] using nylon6 80%wt and varying the weight ratio between SEBS/SEBS-g-MA, the particle size of dispersed phase were varied from 0.05 to 5  $\mu\text{m}$ . The particle size decreased with increasing SEBS-g-MA composition. Only, the particle sizes in the range of 0.1-1  $\mu\text{m}$  showed higher Izod impact strength than those having upper or lower size. And, the SEBS-g-MA blends showed the higher impact strength than SEBS blend.

In 1994, Tang and Huang showed that, when the compatibilizer used was either a block or graft copolymer, each was present at the interface and as micelles in matrix or dispersed phases. A greater quantity added only led to less effective participation as a compatibilizer. Moreover, at low concentration of the compatibilizer, each molecule occupies more interfacial area than at the higher concentration where the molecules arrange themselves more compactly in the interfacial area.

Park and Jo (1996) studied the reactive compatibilization of immiscible PS/PA6 blends using PS modified with Maleic Anhydride (MPS). The study showed that, although the content of MA in the MPS is low, the MPS acts effectively as a reactive compatibilizer. The compatibilizing ability of the MPS was very dependent on the molecular weight of the MPS. The high molecular weight MPSs were more effective in reducing and stabilizing the domain size of dispersed phase than the relatively low molecular weight MPS.

Guo *et al.* (1997) showed that the calculations based on the model suggest that interfacial tensions play the major role in establishing the phase structure, whereas a less significant (but still important) role is played by the surface areas of the dispersed phases. Their model is based on the concept that the phase morphology of a multicomponent polymer system will be that which has the lowest free energy. Moreover, the phase structures of multiphase polymer blends can be changed by the addition of suitable interfacially-active agents such as block or graft copolymer. Finally, they found that the driving force to minimize the free energy was apparently so strong that the phase structure having the lowest free energy level is formed even under the non-equilibrium mixing condition.

In the blends of PA6 and PC where PA6 is the continuous matrix, the added maleinated polymer (SEBS-g-MA and PS-g-MA) reacted with the amide end groups of PA6, and this interfacial reaction induced the change of the formation of the two dispersed phase from the stack formation to the capsule formation. (Horiuchi *et al.*,1997)

Asthana and Jayaraman (1999) showed that a polymer reaction at the interfacial in reactively compatibilized polymer blends led to a reduction in particle size of the dispersed phase as well as a reduction in interfacial tension.

Moreover, rheological observations show that besides a reduction in interfacial tension, there is an additional relaxation mechanism leading to enhancement in the storage modulus of the reactive blends as compared to the case of the nonreactive blends.

Jeon and Kim (1998) studied the 75/25 %wt poly (butylterphthalate) and polystyrene (PBT/PS) blends. The study showed that the dispersed phase diameter increased with annealing time and the irregular shape domain became spherical within 30 s in order to reduce the interfacial tension. When the PS-g-MA was added, the drop size decreased within a short time. Carone *et al.* (2000) showed that for Polyamide6 and NR blends, addition of MA to NR at room temperature prior to blending with Polyamide6 led to an in situ graft copolymer formation. Maleic Anhydride molecules reacted with both Natural Rubber and Polyamide6 matrix during processing. This grafting reaction reduced particle size dramatically.

In 1997, Schneider *et al.* studied the toughening of polystyrene by natural rubber-based composite particles. This work was focused on the influence of the morphology of composite natural rubber (NR)-based particles on the toughness of polystyrene (PS). The results suggested that core-shell particle containing PS subinclusions in the rubber core are well suited for the toughening of PS. The hard shell assures adequate stress transfer at fast deformation speed and the rigid subinclusions render the rubber particles capable of stabilizing a generated craze since the incorporated rubber particles do not debond from the matrix.

Ohlsson *et al.* (1998) showed that the 50/50, PP/PA melt mixing blends were made using up to 25% of thermoplastic elastomer as a compatibilizer, either SEBS or SEBS-g-MA. Even at high concentration, unmodified SEBS was found to be a poor compatibilizer. On the other hand, SEBS-g-MA showed a strong tendency to develop a separated PP/PA interface. The total surface area of PA phase seemed to increase with increasing SEBS-g-MA content. The thickness of the interphase layer (shell thickness) almost stays constant and is independent of the compatibilizer concentration. The interphase layer thickness was estimated to be about 15 nm. At high concentrations of SEBS-g-MA (15% and 20%), the PA domain from the large interphase, held together by a thermoplastic elastomer interphase network.

Wilkinson *et al.* (1999) studied the PP/[PA6/SEBS] blends having various ratio of PA6 : SEBS. The 70/30 PP/PA6 blend showed very coarse morphology and poor mechanical properties. In 70/[15/15] PP/[PA6/SEBS] isolated dispersed phase of PA6 and SEBS were exhibited. Using the reactive compatibilizer, SEBS-g-MA, PA6 was encapsulated by SEBS-g-MA and the impact strength was increased.

In 1999, Luzinov *et al.* showed that for the ternary PS/SBR/PE blends, the average number of PE cores per SBR phase decreases when the PE content in SBR is increase, and finally only one PE subphase is observed in SBR, that actually forms a shell around a PE core and provides the dispersed phase with a core-shell morphology.

HDPE/PS/PMMA ternary blends was studied by Reignier and Favis (2000). It showed that the encapsulation process occurred very early in the compounding operation and remained stable in time. The morphology observed was composed of a HDPE matrix, a PS dispersed phase, and PMMA subinclusion within the PS dispersed phase.

Xing *et al.* (2000) showed that retraction of deformed drop method (DDRM) was based on the balance between the interfacial forces and viscous forces.

The morphology and mechanical properties of ternary blends consisting of PS matrix and PO/SBR core-shell dispersed phases have been studied by Luzinov *et al.* (2000). The study showed that polyolefin (PO) formed cores in SBR domains. Upon increasing the viscosity of PO, the size of the cores and the SBR domains including them increase. Moreover, the extend of the stress transfer from the matrix to the core through the shell depends on the modulus of the SBR layer.

Luzinov *et al.* (2000) showed that the ultimate mechanical properties of the ternary blends containing SBR/PE and SBR/PS core-shell dispersed phase are closed to the properties of the PS/SBR and PE/SBR binary blends, respectively. However, at constant content of the matrix (PS; 75%wt), the SBR/PE composition of the core-shell dispersed phase had strong influence on the mechanical properties.