



CHAPTER II

LITERATURE REVIEW

There are several studies of polyethylene or polypropylene blends, Tselios *et al.*, (1998) studied in situ compatibilization of polypropylene/polyethylene blend focus on thermomechanical and spectroscopic study. Blend of polypropylene (PP) with low density polyethylene (LDPE) in proportion of 75/25, 50/50 and 25/75 w/w PP/LDPE were prepared using two types of compatibilizer; poly(propylene-g-maleic anhydride; PP-g-MA) with 0.8 mol% MAH content and poly(ethylene-co-vinyl alcohol; EVAL) with 7.5 mol% vinyl alcohol content. The compatibilizers were added in concentration of 50/50 w/w by in situ reactive compatibilization. Total amount of those compatibilizer were varied from 2.5, 5, 10 and 20 wt%. The reaction of all components was studied using the changing of torque during internal melt mixing and also confirmed by FTIR spectroscopy. It was concluded that all mechanical properties were improved, particularly at 5 - 10 wt% compatibilizer show the attractive increasing of tensile strength, elongation and also impact strength.

2.1 Blending of PE /PA or PP/PA with Compatibilizers

Polyethylene (PE) or Polypropylene (PP) are always blended with Polyamide (PA) because PA exhibits good strength and can resist hydrocarbon solvent. Same as general polymer blend that it need to use compatibilizer to improve blend ability.

Using of grafting of maleic anhydride (MAH) onto PE or PP as compatibilizer was reported in several studies. Kudva *et al.*, (1999) studied morphology and mechanical properties of compatibilized nylon6/PE blend. In the work, PE was grafted with MAH and it can react with the amine group of nylon6 during melt processing. The effect of concentration, viscosity and functionality of maleated polyethylene (PE-g-MAH) were studied based on rheological, morphological and mechanical properties of nylon6/PE-g-MAH blend. The result show that low viscosity maleated polyethylene did not affect the toughening of nylon6 because during melt blending process PE became continuous phase even nylon6 was the

majority component. Whereas other two types of high viscosity maleated polyethylene were able to improve impact strength and low temperature toughness at all compositions of the blend ratio. Furthermore the molecular weight (Mw) of matrix phase affect the impact strength, increasing of impact strength when Mw of nylon6 increase. In ternary blend of nylon6/PE/PE-g-MAH, the effect of the ratio of maleated polyethylene to nonmaleated (PE-g-MAH/PP) was also studied. Increasing of maleated polyethylene content could reduce the disperse phase size of PE droplet result in increasing of impact strength of the blend.

Several kinds of maleic anhydride grafted material which used as compatibilizer precursors (CPs) for PE/PA blend. Filippi *et al.*, (2005) investigated the effect of different type of maleic anhydride grafted compatibilizer for blend of LDPE with PA6. Three types of compatibilizer, (Styrene-Ethylene-Propylene-g-MAH; SEPMA), SEPMA1 and L-HDPE-g-MAH were compared, the result of the work found that the efficiency of maleic anhydride grafted compatibilizer depended on blend ratio and also type of matrix phase. The strong efficiency of the handmade SEP functionalize with MAH (SEPMA with 1 wt% MA contents) can be comparable with SEPMA1 with 1.7 wt% MA content while L-HDPE-g-MAH with 1 wt% MA content was prepare from low molar mass HDPE exhibit lower activity, clearly observed when PA is the matrix phase (25/75 LDPE/PA) which could be explained by partial formed PA-g-CP copolymer into the bulk PA matrix phase.

Compatibilizer precursors (CPs) prepared from functionalized polyethylene with grafting with MAH were always used to improve compatibility of LDPE blend with PA6. Some studies reported that CPs efficiency depended on the microstructure and the molar mass or molecular weight of their PE backbones that mean initial molecular weight of maleated functionalized polyethylene were important criteria. Jiang *et al.*, (2003) basically studied of binary LDPE/CP; PA/CP and ternary LDPE/PA/CP blend to compare the effective of PE-g-MAH copolymer and the ethylene-acrylic acid copolymer (EAA). The result of the work, PE-g-MAH can react rapidly with PA than the EAA copolymer. Furthermore maleated functionalize LDPE were miscible with the blend component and did not locate at the interface between LDPE and PA component. It is interesting to note that better CP performance came from the maleated functionalized HDPE being immiscible with LDPE component.

One main concern about using of the functionalized polypropylene as compatibilizer is its grafting efficiency. Generally, higher grafting efficiency will result in higher grafting degree. However, this depends on chemical substance used to functionalized polypropylene. Steven *et al.*, (1999) compared the compatibilizing efficiency of carboxylated polypropylene and maleated polypropylene, for PP blend with PA6,6, the result show that carboxylated PP demonstrated better compatibilization because of higher grafting efficiency 40%, while anhydride functionalized got only 20% grafting efficiency, so the blend need high grafting degree of compatibilizer.

Recently, Shashidhara *et al.*, (2009) studied the blend of PA and polyolefin that increase compatibility by chemical modification of polyolefin. The effect of PP-g-MAH compatibilizer content in polypropylene and nylon6 blends was investigated. Blending of nylon6 and polypropylene copolymer (PPCP) were prepared using a twin screw extruder. In case of Nylon6 is matrix phase, adding of PP-g-MAH can increase 25% in tensile strength and also flexural modulus of the blend increase significantly. This result can be explained by the improved of interfacial adhesion between two components due to addition of PP-g-MAH. However the improvement depends on amount of added compatibilizer and amount of PP also.

One way to observe the miscibility of the blends is by observing the decreasing of droplet size of the disperse phase or domain. Chongprakobkit *et al.*, (2007) compared the effect of compatibilizer at 70/30 w/w PP/PA6 blend ratio, 0.87 % grafting of PP-g-MAH from solution process used as a compatibilizer. Morphology of the blend investigated by SEM technique exhibited decreasing in size of the dispersed domain and cooperated consider with tensile strength was substantially higher than uncompatibilized blend.

An interesting work which developed several years ago which provides good understanding in the blending of PP and Nylon 6 using maleic grafted polypropylene (PP) as compatibilizer. Sathe *et al.*, (1996) investigated the properties of these blend. They varied blend ratio and also varied PP-g-MAH copolymer from 2.4 wt%, 4.8 wt% and 9.1 wt%. At fixed ratio the SEM picture showed that smallest particle size of disperse phase were around 1-2 μm at optimum content of PP-g-MAH of 4.8 wt% that mean to the reaction between PP, Nylon6 and PP-g-MAH

occurred during melt mixing, so the PMAH compatibilizer act as the bridge between incompatible phase by locating at the interface of polymer component. The result from SEM agreed with mechanical properties and flow ability (MFI) observation that tensile modulus, tensile strength and flexural strength increase and MFI went down refer to formation of PP-g-Nylon6 copolymer, so it was easily flow.

Properties of the raw material for polymer blend pay a role in the miscibility and final properties of these blends. Agrawal *et al.*, (2007) studied effect of different PP and different compatibilizers on the rheological mechanical and morphological properties of nylon6/PP blend. From the work, blend ratios were fixed at 80/10/10 (wt) for nylon6/compatibilizer/PP. Two different type of PP were used as minor phase. PP H103 represented high MFI (40 g/10min) and PP H503 represented low MFI (3.5 g/10 min). Same as in compatibilizer which used for two types were maleic anhydride functionalized polypropylene (PP-g-MA) and acrylic acid functionalized propylene (PP-g-AA). It was interestingly that unlike PP/PE blends, that MFI of PP did not affect the mechanical properties of PP/PA in both of uncompatibilized and compatibilized blends. However in the compatibilized blend the impact strength of the blend of neat polymer was increased, especially compatibilized with PP-g-MA better than PP-g-AA due to PP-g-MA have higher interaction with PA phase. Eventually improve the compatibility of PP/PA blend, PP-g-AA were not stable because of the acid group in acrylic acid can induce degradation to nylon6.

2.2 Blending of PE/PP

As above mention that several reported papers studied on the melt blending between polypropylene (PP) and polyethylene (PE). A lot of these works reported on the morphology, compatibility, mechanical properties and rheology of PP/PE blends. First thing that we have to concern for making polymer blend was the matching of the different polymer in order to easily process and also be explain for compatible behavior of polymer. Rheology is a part of flow ability of material in melt state depending on the physical properties of raw material and including to processing condition (Agrawal *et al.*, 2008).

In earlier work of PP/PE blend field, flow properties of the blends were reported. Liang *et al.*, (1997) studied uncompatibilized blend of PP with PE. The effect of two types of PP which is different in melt flow index (MFI) were used to study the flow and mechanical properties of PP/LDPE blend. Remarkable that PPH represent PP with higher MFI and PPL represented PP with lower MFI, Both of them were blend with LDPE. From the result, it was suggested that compatibilizer of PPL/LDPE was better than PPH/LDPE. Former blend is smaller different in MFI or easily said that MFI of PPL was close to LDPE. Whereas PPH/LDPE is higher different in MFI result in low adhesive strength at the interface then the relative slip between neighboring melt layer occurred that can observe the reducing of MFI of PPH when the LDPE content increase. This result can be confirmed by previous the research work of Liang *et al.*, (1996) who did comparative study of PP/HDPE and PP/LDPE blend focusing on the melt flow properties of those blends. From this study, it was found that PP/HDPE blend which the viscosity different is quite high leading to the interlayer slip of polymer melt then the melt viscosity went down mean to increasing in MFI. At the same time, PP and LDPE, their viscosity is close to each other, so the producing of interlock structure at the interface of PP and LDPE in melt state was appeared, and the viscosity of the melt blend also increased. However both of works agreed that PP blend with PE gave incompatibility blend.

Polypropylene (PP) blend with polyethylene (PE) can be called polyolefins blend because both of them are the polyolefin material. There are many compound developed for compatibilization such as ethylene-propylene copolymer, styrene-butadiene-block copolymer. These compatibilizers were sometime used in relative high concentration and also can obstruct processibility of polymer blend. These are the reasons for developing other new types of compatibilizer. Krulis *et al.*, (1998) tried to investigate the reactive compatibilization of polyolefins using low molecular weight polybutadiene (L-PB) by making the blend of LDPE/PP in the ratio of 50/50 w/w and found that just L-PB alone was not sufficient to act as a compatibilizer. While adding of organic peroxide could promote higher efficiency of compatibilizer, observing from impact strength increased and the smaller particle size of PP disperse particle size are smaller. This observation was observed due to the radical reaction

of peroxide. Krulis also investigated in effect of EPDM could also increase the impact strength, however the different compatibilizer have the different mechanism.

Although many developed compatibilizer can solve the compatibility problem, cost of the compatibilizer is the one criteria that have to pay attention to. Ubonnut *et al.*, (2007) studied on the interfacial adhesion enhancement of polyethylene-polypropylene mixtures by adding synthesized diisocyanate compatibilizer. They synthesized Ziegler-Natta PE/PE – block copolymer by diisocyanate became PP-b-PE which containing diisocyanate linkage in their structure added into PP/PE commercial grade. They found that the mechanical properties such as tensile strength was improved. This improvement could be explained by phase binding due to PE and PE segment from PP-b-PE bond with PE /PP matrix and minor phase. However the best content of added PP-b-PE that showed the reinforce effect was at 6 wt % PP-b-PE, at more than 6 wt% (e.g. 12-20 wt%) lead to reduce the mechanical properties of the blend due to PP-b-PE itself has higher molecular weight than PE/PP commercial grade. Having the high molecular weight which different from the molecular weight of PE or PP component resulted in less compatible of the PE/PP

OBJECTIVES

- To evaluate the efficiency of using of two set of MAH grafted material as compatibilizer for HDPE/PP blend to improve miscibility of the blend.
- To apply the blending principle of HDPE/PP with the compatibilizer into the recycle technology with no need waste separation.