

CHAPTER II

LITERATURE REVIEW

Due to the requirement of high quality polymer, there are many research work have been studied about polymer blending and try to find the way to have a good compatibilizer by using maleic anhydride as a part of compatibilizer.

Gaylord *et al.* (1987) studied the effect of maleic anhydride and peroxides on degradation and crosslinking of ethylene propylene diene rubber. There are three types of peroxides, dicumyl peroxide (DCP), benzoyl peroxide and t-butyl perbenzoate. The reactions occurred at temperature 180°C, 160°C, and 140°C respectively by melt mixing in Brabender Plasticoder. Then the reaction products were extracted by using cyclohexane at 22°C for 60 hr and xylene at reflux temperature for 5 hr and measuring the viscosity and MA content. They found that the moderate amount of peroxide resulted in the chain extension of the product (crosslinking) and at higher amount of peroxide, the chain scission would occur. If MA was at constant concentration, gel content decreased with amount of peroxide and MA. At constant DCP concentration, amount of cyclohexane insoluble polymer (gel content) decreased when MA content increased.

Hudec *et al.* (1993) studied the role of maleic anhydride-grafted polypropylene that was used as compatibilizer in the ethylene-propylene (PRP) triblock copolymer and ethylene-vinyl acetate copolymer (EVA) blends. The maleic anhydride, which was grafted onto propylene, could react with EVA and made EVA disperse more in the PRP phase. Moreover, at small amount of MA-g-PP, the blends were improved in mechanical properties, impact resistance, low temperature brittleness and interfacial

interaction. By increasing amount of MA-g-PP, the mechanical properties were deteriorated.

Samay *et al.* (1995) studied the grafting of maleic anhydride onto high density polyethylene (HDPE) in the presence of various comonomers by using an intermeshing corotating twin screw extruders at temperature 180°C and rotor speed 50 rpm. The peroxide initiator were 2,5-dimethyl peroxide 2,5-di(t-butyl peroxy)hexane peroxide. The comonomers were styrene, acrylic acid, fumaric acid etc. Then the samples were characterized by FTIR and Instron capillary rheometer. They found that the vinyl monomers were the most effective in increasing the molecular mass of the grafted HDPE. Ester of maleic and fumaric acid showed nearly the same possibility as did maleic anhydride but they could prevent crosslinking. Cyclic dicarboxylic anhydride showed less tendency than maleic anhydride in grafting onto PE.

Axtell *et al.* (1996) studied the effect of modified natural rubber compatibilizers on polyamide 6 (PA6) and natural rubber blends. Natural rubber was first reacted with maleic anhydride by using a water cooled two-roll mill. The blends were prepared in an internal mixer and then were put in the single screw extruder. Amount of maleic anhydride was characterized by potentiographic titration. The grafted level of 0.75 and 1.2 % MA were found for 5 and 10 % by weight of MA respectively. The blends were investigated for mechanical properties; i.e. impact strength, tensile properties, morphologies, shrinkage testing, melt rheology, molau test, and FTIR characterization. They found that the blends of PA6 and NR were compatibilized by NR-g-MA copolymers. The higher amount of compatibilizer gave higher degree of dispersion and the smaller rubber particles such as impact strength, tensile strength, etc.

Nachtigall *et al.* (1999) studied grafting of maleic anhydride onto polypropylene by using dicumyl peroxide as an initiator. The effect of MA

concentration, DCP concentration, temperature, and time were determined to correlate with degree of functionalization and molecular weight of PP. The reactions were carried in a mixing chamber at 50 rpm. Two temperatures were used, 170°C and 180°C. Then the sample were characterized by FTIR, GPC, titration, and torque measurement. The reaction time were not showed the significant effect while the concentration of MA, DCP, and temperature played more important roles on degree of functionalization and molecular weight. Moreover, if concentration of MA and temperature were considered together, they found that these parameters played important role in the reaction product.

In order to understand the blend properties, several works have tried to relate morphology and mechanical properties.

Namita and Anil (1989) studied the blends of natural rubber and polyolefins in ratio of 70/30 by weight. Both phases were modified in order to make them compatible. The modified rubbers that they used were ethylene propylene diene rubber (EPDM), epoxidized natural rubber (ENR), and sulfonated EPDM. Maleic anhydride was used to modify polyolefins by using benzoyl peroxide as an initiator. The blends were investigated for adhesion, mechanical properties and morphology by electron microscope. They found that both modification of the plastic phase and the rubber phase improved mechanical properties in NR/PE system but not in the NR/PP system. The morphologies showed the continuity of both phases that correlated with the mechanical properties.

Monica and Huston (1991) studied the process for the functionalization, preferably maleation of polypropylene by the use of selected class of peroxides. They were t-butyl peroxidypivalate and isononanoyl peroxide, which did not cause the molecular weight of the polyolefins to be significantly degraded. The maleated polypropylene resulted from the invention having more than 0.3 weight percent grafted

maleic anhydride on the polymer chain. Its Melt Flow Rate (MFR) was less than 100.

Braun *et al.* (1996) studied efficiency of compatibilizers, block-graft copolymers, in PS/PVC blend. Normally, the block copolymers are better than the graft ones but they are produced from the non-versatile technique and expensive. Then grafting of polymer onto readily available block copolymer, such as styrene-*b*-butadiene (*SbB*) can be suitable. In this study, polystyrene (PS) and poly(vinyl chloride) (PVC) were blended by using styrene-*b*-butadiene-*g*-cyclohexylmethacrylate (*SbBgCHMA*) and styrene-*b*-butadiene-*g*-methylmethacrylate (*SbBgMMA*) as compatibilizers. Transmission electron microscope showed that the block-graft copolymers acted as good compatibilizers by reducing the size of dispersed phase and covering the interfaces between PS and PVC with monolayer. Moreover, the resulting structures were finer than the predicted model due to shearing on phase domains during mixing in the kneader.

Heinen *et al.* (1996) determined grafting of maleic anhydride onto polyethylene, polypropylene and ethane-propane copolymers by using ^{13}C NMR. The reaction was carried out in solution and melt state by using *tert*-butyl cumyl peroxide as an initiator. They found that maleic anhydride attacks methine and methylene carbon in the backbone for random EPM and attached solely to polymer methines. For alternating EPM and iPP, Maleic anhydride attached to the polyethylene in form of single succinic anhydrides ring and also short oligomers.

Rosales *et al.* (1998) studied grafting of polyethylene by reactive extrusion. The grafting of various HDPEs and LLDPEs with diethyl maleate (DEM) was carried out in two corotating twin screw extruders with different screw configurations and extrusion conditions. Two initiators at different concentrations were used. It was found that when the initiator level was risen in the LLDPEs, the grafting degree increased. Besides, the terminal vinyl

groups concentrations decreased at the expense of increasing the trans unsaturation concentrations. This was consistent with the formation of long-chain branching. Additionally, the weight average molecular weight of grafted high-density polyethylene decreased. The grafting efficiencies were consistent with the attained residence time and also with the kinetics of the decomposition of the peroxides

Potschke and Wallheinke (1999) studied the morphology and mechanical properties of the blends of thermoplastic polyurethane and maleic anhydride grafted polyethylene. The polyethylene was first grafted with maleic anhydride and then blended with thermoplastic polyurethane in a corotating twin-screw extruder. Quantitative IR was used to determine the MA content. The morphology and mechanical properties were investigated. They found that addition of PE-g-MA reduced the particle size of the blend. Moreover, the mechanical properties of the blend were improved.