CHAPTER III

LITERATURE SURVEY

3.1 Processing and mechanical properties of polymer composites

Tang et al. (2003) have investigated melt processing and mechanical property of multiwalled carbon nanotube/high density polyethylene (MWNT/HDPE) composite films. MWNT/HDPE composites (1,3 and 5 wt%) were melted in a beaker, heated in an oven at 200 °C for 10 min and then mixed and compressed. The resulting solid was broken up and added to a twin screw extruder at 170 °C and extruded through a slit die. The resulting film was then compression molded to form a thin film. After the composite films were tested by a small punch test, the results showed that the stiffness, the yield strength, and the fracture toughness of MWNT/HDPE composite films all increased with increasing MWNT contents.

Mahfuz et al. (2004) have investigated the polymer matrix composites by reinforcing carbon nanoparticles/whiskers through an extrusion process. Linear low density polyethylene (LLDPE) powder and carbon nanoparticles/whiskers were first dry mixed and continuous filaments were made by hot extrusion through a small orifice under a high shear force. After extrusion, the filament was partially cooled by chilled air, dried, and continuously wound in a spool. The filaments were then laid in rovings, stacked in a unidirectional fashion, and consolidated in a compression molding machine to construct laminated composite structures. Tensile coupons were then extracted both in longitudinal [0°] and transverse directions [90°] and tested in a Minimat Tester. It was found that with the addition of 2% by weight of carbon nanoparticles/whiskers in LLDPE, the tensile strength and modulus of the composite have increased by 16.9 and 16.37%, respectively.

Manchado et al. (2005) have investigated thermal and mechanical properties of single-walled carbon nanotubes (SWNT)-PP composites prepared by shear mixing. The effects of different SWNT concentrations on the thermal and physical properties of PP were analyzed with calorimetric analysis, tensile and dynamic mechanical tests. The results were then compared to those obtained for nanocomposites containing carbon black as filler. Low concentrations of SWNT generally resulted in an increase in Young's modulus and tensile strength, this effect being noticeably higher than that observed for CB/PP composites. At the highest content (i.e. 1 wt %), both stiffness and strength were significantly reduced. The results of the tensile tests suggest that nanotube incorporation of less than 1 wt% increases tensile strength due to strong interfacial bonding with respect to the un-reinforced polymer. The gain in terms of mechanical properties with respect to carbon black could be due to the favourable aspect ration of SWNT.

Yasmin et al. (2006) have investigated the different processing techniques and their effects on the mechanical behavior of expanded graphite reinforced polymer nanocomposites consisting of anhydride cured epoxy resin matrix and expanded graphite (EG) with the concentrations of 1–2 wt%. The nanocomposites were fabricated by direct, sonication, shear, and a combination of sonication and shear mixing method. The mechanical behavior of the nanocomposites was investigated as a function of particle concentration and processing technique. It was found that EG reinforced nanocomposites showed higher elastic modulus than neat epoxy. Moreover, it was found that the combination of sonication and shear mixing provided the best results in terms of elastic modulus and tensile strength with it can be attributed to the external shear forces generated in the shear mixing that separate and exfoliate the EG into graphite nanosheets followed by uniform dispersion in the resin. In contrast the direct mixing produced the lowest results among all processing techniques.

Yang et al. (2006) have investigated using PP as the matrix polymer and rice-husk flour and wood flour as the reinforcing filler, the tensile and Izod impact properties of lignocellulosic filler reinforced PP bio-composites made with different extruding systems. It was examined by assessing their mechanical properties and the morphology of the fracture surfaces. The test samples were injection molded, in order to determine the mechanical and morphological properties of the bio-composites made with two different extruding systems and at different filler loadings. The tensile strength and modulus of the bio-composites fabricated using the twin-screw extruding system were improved as compared with those fabricated using the single-screw extruding system, due to the improved dispersion of the fillers in the composite. There was no difference in the Izod impact strength of the composites fabricated using the twin-screw and single-screw extruding systems, the similar impact strength of both samples with different extruding processes might be due to the fact that impact test is not discriminating enough to reveal the difference in dispersion status of the present composites. The SEM micrographs revealed well-dispersed fillers on the fracture surfaces of the test samples fabricated using a twin-screw extruding system.

3.2 Effect of filler type and filler loading on mechanical properties of filler filled polymer composite

Ismail et al. (2002) have investigated the mechanical properties of bamboo fibre reinforced natural rubber composites as a function of fibre loading and bonding agent. Tensile modulus and hardness of composites increase with increasing filler loading and the presence of bonding agents. These results indicate the fact that the incorporation of bamboo fibre into the rubber matrix enhanced the stiffness of the composites. However, with the presence of bonding agent, these properties were further increased as a result of better interaction between fibre and rubber matrix. The adhesion between the bamboo fibre and natural rubber can be enhanced by use of a bonding agent. As the failure surface of without the presence of bonding agent exhibit the weak interfacial adhesion between the fibre and rubber matrix.

Premalal et al. (2002) have investigated the mechanical properties of rice husk powder (RHP) filled PP with talc filled PP composites. It was found that in terms of mechanical properties, Young's modulus and flexural modulus increased, whereas yield strength and elongation at break decreased with the increase in filler loading for both types of composite. Of these PP composites, the RHP composites exhibited lower yield strength, Young's modulus, flexural modulus, and higher elongation at break than talc composites. This may be due to the smaller particle size and higher surface area of talc particles. As the surface area is increased, filler-matrix adhesion is improves resulting in decrease in mobility of the macromolecules. SEM studies of tensile fracture surfaces of the composites indicate the poorer interfacial adhesion of RHP composites compared to talc composites.

Wu et al. (2005) have investigated the effect of particle surface treatment, matrix ductility and particle species on mechanical performance of silica nanoparticles filled PP. It was found that precipitated nano-silica is able to provide PP with stiffening, reinforcing and toughening effects at rather low filler concentration as fumed nano-silica. Having been grafted with different polymers onto the surfaces in terms of gaseous graft polymerization, the nanoparticles become more efficient to improve the strength and toughness of the composites. The nature of the grafting polymer chains plays an important role in the properties enhancement. Ductility of the matrix PP determines the toughening effect of the nanoparticles. Only in the case of moderate matrix ductility, the composites can receive the highest extent of toughness increase. Besides, the size and surface area of the nanoparticles are also important influencing factors. The smaller nanoparticles lead to higher Young's modulus and impact strength of the composites, and reduce the sensitivity of the static toughness to the status of filler distribution.

Ljungberg et al. (2006) have investigated nanocomposite films of isotactic polypropylene reinforced with cellulose whiskers highly dispersed with surfactant. Cellulose whiskers with three types of surface characteristics were prepared: aggregated whiskers without surface modification (AGWH), aggregated whiskers grafted with maleated polypropylene (GRWH), and novel surfactant-modified whiskers (SUWH). At large deformations the mechanical properties were found to depend strongly on the dispersion quality of the whiskers. The AGWH composite had mechanical properties inferior to the neat iPP as a result of the whisker aggregates rendering the material fragile. The polypropylene grafts in the GRWH composite enabled a better dispersion quality between the whiskers and the matrix as compared to the AGWH composite, but the most efficient filler dispersion was obtained in the SUWH nanocomposites as a result of the surface modification with surfactant. The high dispersion quality induced enhanced mechanical properties at large deformations at room temperature and the SUWH composite displayed an increased tensile strength and strain at break as compared to the neat matrix. There is also reason to believe that the tensile properties of the nanocomposite would be even more superior to those of the neat matrix at elevated temperature, making PP composite containing surfactant-modified cellulose whiskers an interesting candidate for high-temperature applications.