CHAPTER III

LITERATURE REVIEW

3.1 Polymerization Technique of PMMA

Donovan *et al.* [1985] studied the PMMA polymerization technique at 4 conditions, i.e. normal pressure in the air, normal pressure in water, high pressure in the air, and high pressure in water. It was found that there was no difference between mechanical properties of each sample from above condition. However, the pores in the samples made in high pressure were less than those of samples made in low pressure.

Geerts and Jooste [1993] compared the bond strength of PMMA that was polymerized by heating with microwave oven and water bath. It presented that curing PMMA in microwave oven provided higher bond strength than that in water-bath.

3.2 PMMA reinforced with other materials

Kanie [2000] studied the reinforcing effect of woven glass fibers on deflection, flexural strength, flexural modulus and impact strength of acrylic denture base polymer. In this study, three silanized or unsilanized woven glass fibers were used. Heating the denture cure resin dough containing glass fibers, which were sheathed in the dough, made specimens, Specimens with four different thicknesses and of five different types were made incorporating the glass fiber. Three-point flexural test and flywheel type impact test were employed to determine the flexural properties and impact strength. When specimens contained unsilanized glass fiber, the flexural strength in specimens of 1 and 2 mm thickness and the impact strength in specimens of 2-mm thickness were higher than those of specimens without glass fiber. On the contrary, the flexural strength and deflection in specimens reinforced with silanized glass fiber of 1-mm thickness were significantly higher than those of unreinforced specimens were. Furthermore, the impact strength in specimens reinforced with silanized glass fiber of 2-mm thickness was significantly higher than that of unreinforced specimens. Statistically significant differences were found in the flexural strength and in the impact strength when specimens of 4-mm thickness were reinforced with two or three unsilanized glass fibers.

Shane *et al.* [1995] studied the effect of coupling agent (vinyltriacetoxysilane) on the physical properties of wood-polymer composites. Poly(methyl methacrylate) was used as the polymer in this study. The selected woods were the Radiata pine and Blackbutt. In general, it has been established that poly(methyl methacrylate) does not form bonds with the hydroxyl groups of the cellulose fibers, so the coupling agent was applied to enhance the adhesion. The result presented that the dimensional stability, compressive strength and hardness were improved. The morphology of the composites was examined by using Scanning Electron Microscopy, and improved adhesion was evident for composites treated with the coupling agent.

Larson *et al.* [1991] studied the effect of adding carbon graphite fiber in various kinds of acrylic resin on the elastic modulus. It was found that the addition of carbon graphite fiber provided higher elastic modulus than that of pure acrylic resin.

Chen [1990] studied the improvement of acrylic material used as denture base by using various kinds of reinforcement such as glass fiber, polyester fiber, and Kevlar fiber at various contents. It was presented that PMMA reinforced with 0.3 % wt of 6-mm polyester provided higher impact strength than that of pure PMMA. In the high content of fiber in the composite, the high impact strength was presented. Moreover, the impact strength of polyester fiber was close to that of Kevlar fiber. These two fibers both provided higher impact strength than that of glass fiber.

Berrong, Weed, and Young. [1990] studied the PMMA reinforced with Kevlar fiber. It was found that the composite with 2-wt % of Kevlar fiber was the optimal content for high fracture resistance.

3.3 Bamboo Characteristics

Li, Fu, and Zhou [1995] studied the microstructure of bamboo fibers. It has been observed that a bamboo fiber consists of several alternating broad and thin concentric layers, which were composed of microfibrils. The microfibril orientation angles in the broad layer are in the range of 3-10° with respect to the fiber axis, and those in the thin layers were in the range of 30-90°, but mostly 30-45°. The microstructure was complicated, so these researchers used glass fiber reinforced epoxy resin to imitate such a structural unit (a biomimetic double helical reinforcing element model) from microscale to macrofiber specimens. It was concluded that double helical fiber structure had the best comprehensive performance compared with other structure forms.

Manley, Bowman, and Cook. [1979] studied PMMA reinforced with carbon fiber. It was found that the composite provided higher physical properties than that of pure PMMA. However, the problem of the composite was its appearance.

3.4 The Use of Bamboo Fiber as reinforcing materials

Chen *et al.* [1998] studied the mechanical properties of a new type of bamboo fiber-reinforced polypropylene (PP) composite. To improve the interface between polypropylene matrix and bamboo fiber, maleic anhydride grafted on polypropylene (MAPP) was used as a compatabilizer. It was found that with 24-wt % of such MAPP being used in the composite formulation, the mechanical properties of the composite such as the tensile modulus, the tensile strength, and the impact strength all increased significantly. Moreover the effect of bamboo fiber size on the mechanical properties was studied. It was presented that the larger fiber size provided the lower tensile strength.

Piyawan Tangkawanwanit [1998] studies natural fiber-reinforced plastic composites prepared from bamboo fibers and acrylonitrile-butadiene-styrene (ABS) as polymer matrix. In order to improve interfacial adhesion between the fibers and the matrix, the bamboo fibers were grafted with Poly (methyl methacrylate) (PMMA) by using simultaneous γ-ray irradiation method at various total doses from 0 to 20 kGy. The optimum grafting content was studied corresponding to optimum mechanical properties of the composites, such as, tensile strength, impact strength, hardness, etc. Comparative study of the untreated and treated bamboo fiber /ABS composites was also carried out in the study. It was found that mechanical properties were improved with increasing the fiber loading in the composites. Contaminates, impurities, and weak layers were removed when treating bamboo fiber with acetone. The extracted & ungrafted bamboo fiber / ABS composites showed improved mechanical properties compared to the unextracted & ungrafted ones. % Grafting yield was highest at total dose of 15 kGy. The extracted bamboo fibers had higher % grafting yield than the unextracted bamboo fibers.

3.5 Fiber Treatment

Solnit [1991] studied the effect of silane solution used in the composite between PMMA and glass fiber. It was presented that there was better adhesion in the interface when using silane solution. That leaded to the higher physical properties.

Ramos, Runyan, and Christensen [1996] studied the fracture strength of PMMA reinforced with polyethylene fiber. It was compared with the composite that applied silane-coupling agent. Three-point compression loading was used to detect the flexural strength. The result showed that the composite with coupling agent gave higher strength than that without coupling agent.

Vallittu [1997] studied the condition of curing coupling agent (γ– MPS) onto the surface of glass fiber, which was used to reinforce PMMA by Autopolymerization method. It was found that the suitable curing temperature was 100 °C for 120 minutes. This condition provided high strength and good adhesion between the matrix and fiber.

3.6 The Use of Silane Coupling Agents

Matias *et al.* [2000] studied of the reactions of two cellulosic materials (an industrial by-product from Kraft pulp and almost pure cellulose) and three coupling agents, which were used to improve compatibilizer between cellulosic reinforcements and thermoplastic matrices. The three coupling agents were maleated polypropylene wax, N-2-aminoethyl-3-aminopropyltrimethoxysilane, and methyltrimethoxysilane. The result presented that the two cellulosic materials reacted in a similar way and the three coupling agents were covalently bonded to the cellulose. The appropiate reaction conditions converted most of the cellulose reactive groups.

Niranchana Kasemsook [1999] studied the physical properties when using two coupling agents, γ-methacryloxypropyltrimethoxysilane (γ-MPS), and Vinyltriethoxysilanethe (VTS) in kenaf/unsaturated polyester composite. The results showed that there was a slight improvement in both tensile and flexural properties of the composites, made from fibers treated in 1 wt % of the two silane-solutions. At 5-wt%silane concentration, the two silane solutions showed distinctive difference in their effects on the mechanical properties of the composites. γ-MPS treated fiber composite provided higher physical properties than VTS-treated fiber composite. When increasing silane concentration to over 5-wt %, the γ-MPS treated fiber composite showed slight improvement in mechanical properties. When comparing treating temperature, the composite made from fiber treated in 5-wt% of γ-MPS at 50°C was found to have the highest tensile properties.

Kongsak Dokbua [1993] studies the effect of lignin content in the coir fiber on tensile strength of fiber and unsaturated polyester composites. The effect of coupling agent (2-diallylamino-4, 6-dichloro-s-triazine) to enhance the interfacial adhesion between fiber and matrix was also studied. The results indicated that the highest tensile strength of the coir fiber was obtained at Klason lignin content on the coir fiber of about 6.09. The presence of the coupling agent in polyester composites gave better mechanical properties than that with less coupling agent. Additionally, the length of the coir fiber (about 1 to 15 cm) did not affect the mechanical properties; and fiber loading of 20 to 30 % gave the highest mechanical properties (higher than the neat ones of about 50 % in strength and 15 % in modulus) except that the impact resistance which changed accordingly with the amount of fiber loading.

3.7 Effect of lignin on the cellulose composite

Rozman *et al.* [2000] studied the effect of lignin as a compatabilizer on the physical properties of coconut fiber-polypropylene composites. The study demonstrates that composites with lignin as a compatililizer possessed higher flexural properties as compared to the control composites. The results also showed that tensile properties did not improve as lignin was incorporated. Furthermore, lignin was shown to reduce the water absorption. Overall, composites with meleic anhydride-modified polypropylene as a compatabilizer displayed greater mechanical properties than those with lignin.

3.8 Silane absorption and PMMA attachment

Liu *et at* [2001] studied the interaction of the silane coupling agent methacryloxypropyltrimethoxysilane (MPS) with PMMA resin matrix by using thermogravimetric analysis and Fourier transform infrared spectroscopy. The study presented that the amount of PMMA attachment increases with an increase of firmly adsorbed MPS.

3.9 Effect of Aspect Ratio of Short Fiber

Ryu S. R. and Lee D. J. [2001] studied about the effects of fiber aspect ratio on the tensile and tear properties of short-fiber reinforced rubber. It was reported that when increase the aspect ratio of short fiber of rayon, the stored energy at the rapture and tensile strength also increased.