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THE PROPERTIES OF COMPOSITE PANEL MANUFACTURED FROM OIL PALM FIBRES AND PLASTICS

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ABSTRACT

The utilisation of agricultural fibres into useful plastics product has introduce new alternative materials to the plastics industry. The waste agricultural products obtain from jute, padi, palm and oil palm are some of the materials which can be used as fillers in polymer. Attempts have been made to incorporate oil palm fibre into thermoplastics and thermoset systems. In thermoplastic matrix, oil palm fibre (OPF) from frond parts was incorporated into Polypropylene/Nylon blend in different ratios and fibre length. Mechanical properties especially flexural and impact properties was found to improve slightly. Generally, higher composition and fibre length do affect its processsing characteristics during moulding. In thermoset system, OPF in a fixed composition was incorporated into unsaturated or vinyl ester resin. Variation in fibre length affected the density and water absorption of the composite. Although the OPF-plastics composite was inferior in terms of flexural properties compared to the unreinforced and reinforced glass system, the oil palm fibre-plastics composite can be regarded as a potential material for future application provided proper modifications are made.

Keywords: oil palm fibre, polypropylene, thermoplastic, thermoset, composite

INTRODUCTION

In recent years, interest has grown in composites made from wood flour or wood fibres in plastics matrices particularly for low cost/high volume applications. This development has occured because wood derived fillers have several advantages over inorganic fillers such as glass, magnesium or calcium carbonates, silicates and others. Such advantages include lower density, greater deformability, less abrasiveness to equipment and lower cost (Maiti and Subbarao, 1991). Moreover, wood based fillers are derived from a renewable resources.

Oil palm fibres are abundant in Malaysia and other tropical countries. It can be obtained from empty fruit bunches, fronds and trunk of the tree. It is a form of natural fibres which can be utilised to generate new added product from the oil palm wastes and hence assist in their disposal which is much needed from environmental perspective.

Plastics composite can be made by adding such oil palm fibers. Generally, composites are materials comprising of two or more components and consisting of two or more phases. Plastics composite may have various advantages in properties including strength to weight ratio, stiffness, toughness or impact strength, mechanical damping, resistance to fatique and many more (Lawrance, 1974).

Both thermoplastic and thermoset matrices can be exploited as the plastic phases. In our studies, polypropylene(PP)-Nylon 6 blend were used for the thermoplastic while unsaturated polyester act as the thermoset matrix. PP-Nylon blend (80 :20) were used because of much better toughness and stiffness, strength and good in high temperature engineering aspects. Unsaturated polyester with organic filler was also attempted to replace glass filled vinyl ester thermoset, more commonly named GRP.

In mixing plastics-fibre incompatible system, a compatibiliser is normally incorporated to increase the surface interaction between them. Maleated PP(MAPP) is used for the PP blend thermoplastic while a wax system was used for the thermoset system. It is hoped that the mechanical properties can be maintained with the use of such additives.

MATERIALS AND METHODS

Thermoplastics PP Blend OPF composite

The raw materials used in this study are as follows;
Polypropylene Homopolymer Injection Moulding Grade*(Profax 6331)* from *Titan Himont;* Nylon 6 Homopolymer *(Durethan B30S)* from *Bayer;* Oil palm fibres (OPF) from fronds and empty fruit bunches from *PORIM;* MAPP (Maleic Anhydride Polypropylene) compatibilizer, *Epolene E-43* from *Eastman* and Particleboard wax , *Immobilzer 739* from *FRIM.*

Oil Palm Fibre (OPF) from fronds were passed through a Thermokinetic Mechanical Pulp (TMP) machine at temperature 116°C using hot water to soft out the lignin structure. The fibres were subjected to blade holes with various range of sizes. The fibres were then dried in an oven for a few days to reduce moisture content to about 1 to 2 percent. The fibres were then meshed into desired sizes (0.5, 1.0 and 2.0 mm) with mesh number 60, 30 and 22 respectively using Endecott test sieve shaker.

Blended PP/Nylon of certain composition (80:20) was mixed homogenously in a twin screw compounder using Brabender DSK 42/7 available at SIRIM. About 5 % compatibiliser (MAPP) were used when mixing OPF with the blend. OPF were added after 10 minutes of mixing with a temperature range from 200° - 240° C. Total mixing time was about 30 minutes. Crusher machine was used to crush the mixed into smaller sizes. Test specimens were prepared by injection moulding using Battenfield CD Plus machine with temperature 200°-240° C.

Physical Tests for Tensile Strength / Modulus (ASTM D 637) and Flexural Strength/Modulus (ASTM D790-86) , Izod Impact Strength (ASTM D256) were performed accordingly.

Thermoset Unsaturated Polyester OPF composite

Oil Palm Fibres (OPF) from fruit bunches were washed, refined into smaller sizes by TMP machine, sieved to various sizes with Endecott test sieve shaker, dried to less than 5 % water content in an oven for two days while maintaining temperature at 60°C.

Prior to incorporation, fibres were treated with 5 % wax particleboard agent and methanol in dispersion mixer. Mixing time was about 25 minutes at temperature 60°C. Hand laid-up thermoset samples were prepared into 290mm by 370mm plate.

25% weight of OPF fibres were used along with polyester resin and gelcoat in the ratio of 2 :1 by weight. Three layers of laminate were compressed under 5 tons pressure and cured at temperature 60°C for 25 minutes. Samples were cut into specimens for density, water absorption, impact and flexural tests according to ASTM Standard D792, D570, D256 and D790 respectively.

RESULTS AND DISCUSSION

Thermoplastics PP Blend OPF Composite

The density, tensile and flexural properties obtained for various composition of OPF and fibre length with PP blend are tabulated in Table 1.

Increase in composition of OPF content , was found to reduce the tensile strength (by more than 30 %) when fibre was increased from 20 to 40 %. Flexural stength shows a decrease in strength with increasing OPF content but to a lesser degree. The 70 : 30 compostion however showed greater reduction possibly due to defects found resulting from moulding process, as Nylon 6 may not be molten thoroughly. For **tehsile** and **flexural values**, the strength is a result from both component of fibres and polymer matrix. The strength of OPF fibre is about 3 orders of magnitude less than the matrix. The strength of the composites maintained. Greater than 30 % fibre pose not just structural variation in both matrix and fibre due to local weaknesses, stress concentrations, differences in plastic and elastic responses but also affected processing by its slow flow rate during injection moulding.

Flexural Modulus did not vary much but a reduction in Modulus was observed with increasing OPF content. Greater size of fibre contributed to increase in Tensile Modulus ; the increase is quite significant for 80 : 20 composition. However, this is not followed by 70: 30 composition whcih may be attributed to defect explained earlier. Flexural Modulus decresed with increasing OPF content and fibre length. Possibly due to short discontinous fibre and high shear injection during fabrication process, fibre breakdown occured resulting in the system not up to expectation. Because of this discontinuity nature of reinforcement , the tensile stresss experienced by fibres may be derived from shearing forces transmitted by the polymer (Darlington and Smith, 1977). The higher mean stress carried by fibres, the greater should be the modulus enhancement. From the result, it was found that there is some modulus enhancement with increase in fibre content and this enhancement may come from the fibre which can sustain more stress.

Reduction in percentage **Elongation** was found when fibre content increased but the affect to fibre length was less marked. Percentage Elongation reduction is consistent with increase in modulus as initially envisaged.

Fracture may occur due to various reasons: cohesive failure of the matrix, cohesive failure of the fibre, and adhesive failure at the interface (Sheldon, 1982). In this particular system, **Impact Strength** was found to improve remarkably when OPF was added. This was exemplified by all composition at different fibre length. Increase in impact force and energy were observed about 5 -10 %. It was thought that the OPF were more flexible and can enhance toughness. Longer fibre length gave better impact properties but processiblility was poor due to very low flow rate (Melt Flow Index was less than 2.0). Hence higher pressure and temperature were needed to inject the samples especially the longer fibre composition. Compared to just PP/OPF , incorporation of Nylon to PP increased the impact properties as Nylon add to its toughnes. When the fibre content is low(20%), toughness was mostly affected by longer fibre.

TABLE 1 : Properties of polypropylene (PP) blend oil palm fibre (OPF) composite

Sample			Tensile properties			Flexural properties		Izod impact	
	ratio	Density (g/cm^3)	Tensile strength (MPa)	Tensile modulus (MPa)	Percent Elongation (%)	Flex Strength (MPa)	Flex modulus (MPa)	Impact force (kN)	Impact energy (kJ)
Size 0.5 mm									
PP : OPF	60 : 40	1.045	22.51	22.25	5.05	34.74	2213.02	565	6.510
PP/PA : OPF	80 : 20	0.991	21.35	20.74	4.99	32.55	2728.04	625	6.765
	70 : 30	0.967	18.63	21.55	3.77	25.88	2245.63	644	6.948
	60 : 40	1.065	13.92	19.98	1.89	30.72	1821.17	627	7.256
Size 1.0 mm									
PP/PA : OPF	80 : 20	0.996	22.89	22.69	3.47	35.95	2512.36	641	6.894
	70 : 30	0.954	15.78	21.13	2.08	26 85	2038.42	683	7.275
	60 : 40	1.071	14.14	20.35	1.98	32.85	1942.83	620	7.110
Size 2.0 mm									
PP/PA : OPF	80 : 20	1.012	23.77	23.68	3.12	36.52	2653.12	654	6.965
	70 : 30	1.059	18.83	21.86	2.65	33.84	2481.18	685	7.036
	60 : 40	1.075	14.56	20.65	2.24	32.98	1986.55	698	7.465

Generally, increase in **density** was observed on incorporation of OPF. This may be resulted from either enhanced dispersion and wetting or from enhanced nucleation of polymer crystallisation provided by OPF. The **dark colours** of the OPF composite could be due to degradation of the cellulose of OPF which may be accelerated by the acidic nature of the Epolene E 43 at melt processing temperature well above 200°C and this may lead to lower strength and impact properties compared to neat PP blend.

Thermoset Unsaturated (Vinyl) Polycster OPF composite

Density, flexural, impact and water absorption values for various fibre sizes or varying ratios for untreated and treated wax samples are tabulated in Table 2.

TABLE 2 : Properties of thermoset vinyl ester oil palm fibre (OPF) composite

Sample			Water	Flexural properties		Falling weight	
Type	Fibre ratio (L/D)	Density (g/cm^3)	Absorption (%)	Flex modulus (MPa x10^3)	Flex strength (MPa)	Impact force (kN)	Impact energy (kJ)
GRP	CSM (Random)	1.660	0.004	6.724	157.73	0.415	0.84
BLANK	-	1.234	0.230	3.467	49.92	0.075	0.03
UNWA-XED	43.60	1.239	1.367	2.700	19.25	0.069	0.30
	30.72	1.230	0.676	3.160	22.29	0.124	0.25
	21.27	1.238	0.476	3.280	17.79	0.313	0.32
WAXED	43.60	1.219	1.119	3.328	28.45	1.247	2.27
	30.72	1.228	0.550	4.589	28.72	0.063	0.04
	21.27	1.220	0.271	5.507	22.19	1.104	0.02

Water absorption was found to increase with incorporation of OPF fibre but treated wax fibre helps to reduce the water absorption . Low size / aspect ratio for the waxed fibre was found to increase its water absorption capablility . This could be due to higher surface area of the smaller fiber . **Density** of OPF composite did not show any appreciable variation. **Flexural Modulus** has quite signifcant increase when smaller size OPF was used, this is true for waxed sample. Slight reduction was seen with the unwaxed composite. Reduction in flexural strength was quiet significant (40 - 50 %) with OPF incorporation . Modulus enhanced could be brought about by better dispersion and wetting of fibre to thermoset matrix and some reinforcement was visible. Strength reduction could result from stress concentrators form OPF and presence of void , packing inperfection and crystallinity reduction (Rosen, 1965).

Impact force and enery was found to be very much less than GRP but waxed composite and the use of smaller aspect ratio of OPF can improve the impact properties compared to the blank. Hence introduction of these fibre do provide toughness to the composite though still quite inferior to glass fibre. Better coupling agent than the Immobilizer wax 739 could be sought to increase surface interaction between fibre and polyester matrix.

CONCLUSION

Promising mechanical properties was found if OPF were to be used as fillers . It could act as reinforcing fibres to replace mineral fillers in GRP which is quite abrasive to existing processing lines and pose handling problems. Though its flow and strength is still inferior, further work can be made to enhanced processing capability by adding other additives to improve its flow properties i.e MFI and thermal stabiliser to prevent degradation above 200°C. These value added product would be more environmental friendly as agricultural waste can be utilised efficiently.

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