Properties of Oil Palm Empty Fruit Bunch Fibers, Coconut Husk and Polypropylene Composite - Potential Furniture Material

Amran Shafie
Suhaimi Muhammed
Mohd Jafni Hashim

ABSTRACT

Composite panel was produced from agriculture waste fibers such as oil palm empty fruit bunch (EFB) fibers and coconut husk mixed with plastic material such as polypropylene (PP). The panels produced were then assessed for the mechanical strength properties (bending, tensile and impact) and physical properties (water absorption and thickness swelling) in accordance with the ASTM Standards. Results from the mechanical strength tests revealed that the panels made from coconut husk and PP gave bending strength values of 3278.27 MPa for MOE and 29.14 MPa for MOR. Tensile strength values were 3271.972 MPa for MOE and 18.29 MPa for MOR. Impact strength value for such panel was 11.452kJ. Meanwhile, panels made from the mixture of EFB fibers and PP gave bending strength values of 2832.80 MPa for MOE and 26.93 MPa for MOR. Tensile strength values were3108.557 MPa for MOE and 15.73 MPa for MOR. Impact strength value for such panel was 10.629 kJ. On the other hand, assessment on the physical properties indicated that panels made from the mixture of coconut husk and PP gave water absorption and thickness swelling values of 1.357% and 1.185% respectively, whereas, those panels made from the mixture of empty fruit bunch fibers and PP gave water absorption and thickness swelling values of 3.972% and 3.844% respectively. Thus, it can be concluded from the above findings that coconut husk has a much greater potential as an alternative raw material for the production of composite products when combined with polypropylene.

Keywords: *empty fruit bunch, coconut husk, polypropylene, mechanical and physical properties.*

Introduction

Composite in wood industry was defined as reconstituted product made from combination of two or more substances using some kind of mastic to hold the component together (Rowell, 1991). Wood plastic composites was a new product, which has fast replacing other products in many applications since they offer superior corrosion resistance, light weight, lower cost and flexibility in design. The term "wood plastics composites" refers to a new range of materials that resemble wood or agricultural fibers. It combines the advantages of wood or agricultural fibers with those of plastics. There are three great attractions of wood plastics composite. It can be extruded to make continuous profiles of any desired cross-section with great dimensional constancy and accuracy and very little waste, unlike real wood. WPC can also be injection moulded, and some development work has been done using rotational moulding.

Oil palm production is a major agricultural industry in Malaysia. It contributes about US$ 7.3 billion in export earnings each year, mostly from the export of palm oil. Currently, there are more than three million hectares of oil palm plantations. In total, about 90 million mt of renewable biomass (trunks, fronds, shells, palm press fiber and the empty fruit bunches) are produced each year. The empty fruit bunches (EFB) represent about 9% of this total. They are the residue left after the fruit bunches are pressed at oil mills, and the oil extracted. The oil mills are located near or in the plantation itself. EFB is a suitable raw material for recycling because it is produced in large quantities in localized areas. In the past, it was often used as fuel to generate steam at the mills. The ash, with a potassium content of about 30% was used as fertilizer (Lim, 2000). Burning is now prohibited by regulations to prevent air pollution. The EFB is now used mainly as a mulch (Hamdan, 1998). Placed around young palms, EFB helps to control weeds, prevent erosion and maintain soil moisture. However, due to the current labor shortage, the transportation and distribution of EFB in the field is getting more expensive. There is a growing interest in composting EFB, in order to add value, and also to reduce the volume to make application easier (Hashim et al., 1995; Damanhuri, 1998).

Coconut husk is the long fiber (15-35 cm) from the husk of the mature coconut and the average husk weighs 400 grams (Singh, 1979). Husk is a fiber source for many cottage industries and it is readily woven into mats and made into ropes and other articles for both domestic use and export. Husk has been used to produce a variety of composite products including particleboards and fiberboards. When used as a reinforcing fiber in inorganic-bonded composites, coir is very resistant to alkalinity and variations in moisture, when compared to other lignocellulosics.

This study is aimed to achieve the objective such as to determine the physical and mechanical properties of composite panel made from oil palm empty fruit bunch (EFB) fibers, coconut husk and polypropylene and to find out the most appropriate combination of oil palm empty fruit bunch (EFB) fibers and coconut husk for the production of superior composite panel.

Materials and methods

Material Preparation

EFB fibers and coconut husk have to be screened to remove oversized fibers and to get the required size. The size of screener used was 40 meshes as the top layers and 60 mesh as the bottom layers. Gilson Screener Machine was used to screen the fibers.

The PP was also prepared using the percentage of filler loadings that were used to produce WPC. The percentage of filler loading and shown in the following table: -

Table 1: Formulation of Filler Loadings

Filler Loadings	Fibers	Polypropylene (PP)
50%	1000gram (EFB)	1000gram
50%	1000gram (coconut husk)	1000gram
50%	500gram (EFB) and 500gram (coconut husk)	1000gram
30%	300gram (EFB) and 300gram (coconut husk)	1400gram

Melting and blending process

Sawdust and Polypropylene were mixed together using the Dispersion Mixer machine. Here sawdust of oil palm empty fruit bunch and coconut husk was used as filler and polypropylene as the plastic compound.

This process was done by putting sawdust and polypropylene stage by stage, where the polypropylene was put first until it melted, followed by the sawdust. The temperature of Dispersion Mixer set was at 190°C, to accelerate the increase of temperature. When the temperature has reached 180 °C, the polypropylene was put into heating chamber and after several minutes it was melted down. The period of melting process depended on the percentage of polypropylene

It took a few minutes for the fibers and PP to melt completely. The wood plastic pallet can be removed out using the scrapple if the temperature has decreased into 135^0C.

Making polypropylene composite pallet

After granulating process, the granules were converted into thermoplastic pallet using the crusher. The thermoplastic pallet is easy to be moulded because it is almost uniform in sizes. These WPC pallets are then ready for making tensile and bending test boards.

Moulding process

The moulding process is the final process before wood plastic composites can be produced for testing method purpose. The WPC pallets were the calculated the weight was based on the type mould used. Table shows the amount of WPC pallets required for every board samples. Before pouring the pallets into mould the silicon were sprayed for both moulds to avoid WPC from sticking on the mould. Then the pallets were poured slowly into the different moulds for both tensile and bending board.

Table 2 : Formulation for WPC manufacturing

Samples	Mould size (mm)	WPC Pallet (g)	Hot Press Setting	Cold Press Setting
Bending	240 x 150 x 6	216	Temperature: 180°C Pressure: 1000 psi Time: 300 seconds	Temperature: 20°C Pressure:500 psi Time:120 seconds
Tensile	300 x 240 x 2	144	Temperature: 180°C Pressure: 1000 psi Time: 350 seconds	Temperature: 20°C Pressure: 500 psi Time: 120 seconds

Pressing Process

The pallets were poured into moulds, and then the pallet were placed into hot press and sent to cold press process. The WPC pallets were pressed under heat and pressure in the press to melt the pallets. Then they were sent to cold press to cool down the temperature before the WPC board is produced. Both tensile and bending are used in same process to manufacture the board.

Composite trimming

The standard used in this testing is America Society of Testing and Material (ASTM). The WPC board for both testing was cut into the size requirement according to ASTM like shown in the table. The cutting process was done using the table saw, which specify for cutting WPC in Wood Workshop 3. There are various sizes of board to prepare for different types of testing like shown in the table.

Table 3: The sample size for the specific type of testing.

Testing Types	Sizes
Bending	150 mm x 25 mm
Tensile	150 mm x 10 mm
Impact	80 mm x 10 mm
Water Absorption and Thickness swelling	50 mm x 50 mm

Results and discussions

Mechanical and physical properties

The results of composite panel manufacture from a combination of WPC with oil palm fruit fibers and coconut husk is first discussed based on the central tendency of the performance using different ratio of filler loading such as 50% and 30% and also in different types of fiber. Then the mean of mechanical and physical properties are discussed.

Table 4: - Mechanical and physical properties of oil palm empty fruit bunch and coconut husk panel

Types of fibers	Filler loading	Bending strength (MPa)		Tensile strength (MPa)		Impact strength (kJ)	Water absorption (%)	Thickness swelling (%)
		MOR	MOE	MOE	MOR			
EFB	50%	26.93	2832.80	3108.557	15.73	10.629	3.972	3.844
Coconut husk	50%	29.14	3278.27	3271.972	18.29	11.452	1.357	1.185
EFB and Coconut	50%	26.49	2746.85	2855.676	16.70	9.334	2.490	1.763
EFB and Coconut	30%	32.81	3175.62	3185.186	18.87	10.275	1.697	1.235

Table 5: - Statistical significant

Source of Variance	Df	Bending strength MOR	Bending strength MOE	Tensile strength MOE	Tensile strength MOR	Impact strength	WA	TS
WPC (Effect on fibers type)	1	9.304*	23.082*	2.292	7.327*	28.264*	252.327*	108.046*
WPC (Effect on filler loadings)	1	14.109*	41.415*	28.502*	17.985*	24.740*	56.942*	123.545*

The table above shows, the composite panels using different types of fibers with different properties. Composite panels that were made from coconut husk have better properties compared to the oil palm empty fruit bunch. It can conclude that the coconut husk produce the greater results in term of properties compared to oil palm empty fruit bunch. Furthermore, fillers loading of 30% are greater than 50%, the lesser filler loading the higher the strength of the board.

Bar chart presentation for the above results can be seen from Figure 1 to Figure 12.

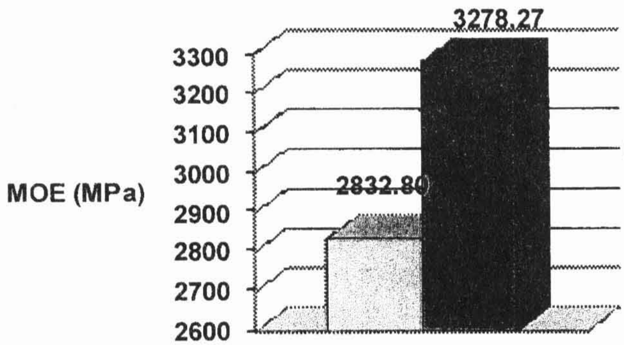

Figure 1: Bending strength (MOE)

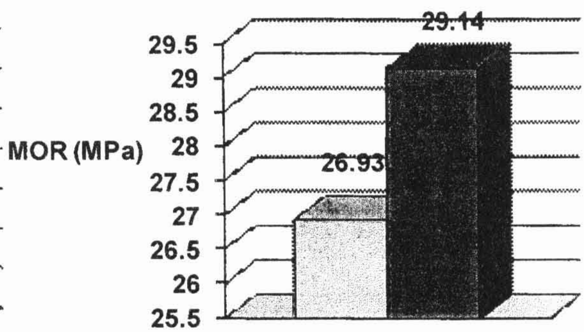

Figure 2: Bending strength (MOR)

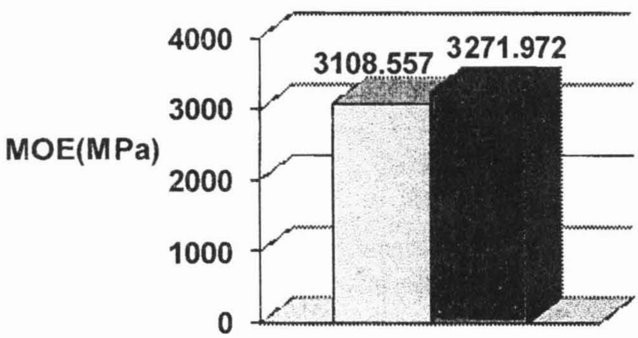

Figure 3: Tensile strength (MOE)

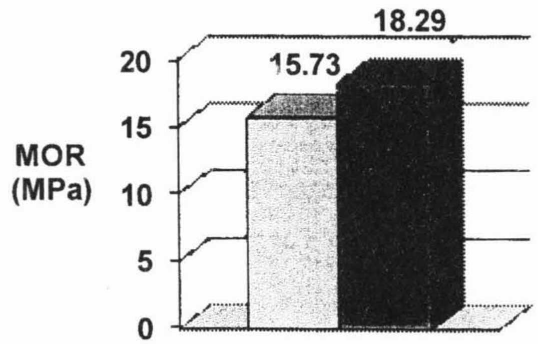

Figure 4: Tensile strength (MOR)

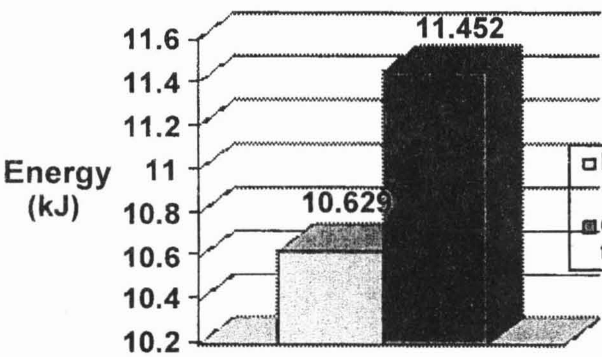

Figure 5: Impact strength

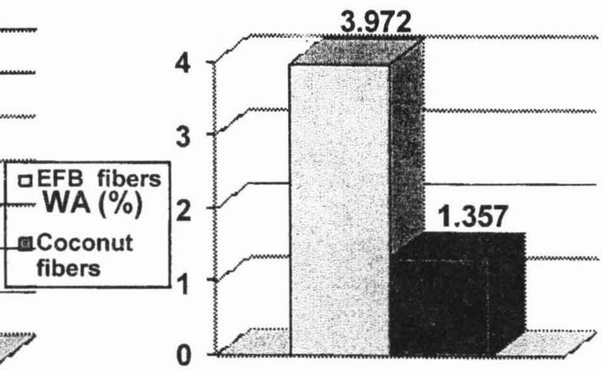

Figure 6: Water Absorption

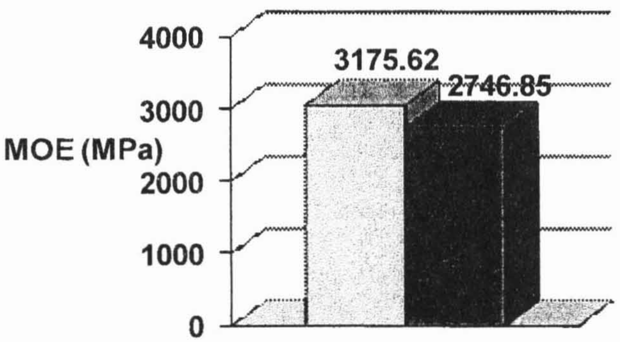

Figure 7: Bending strength (MOE)

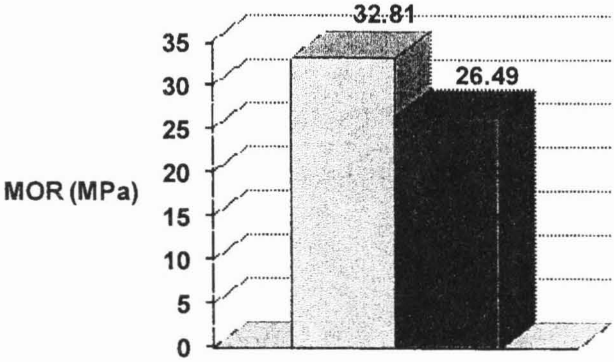

Figure 8: Bending strength (MOR)

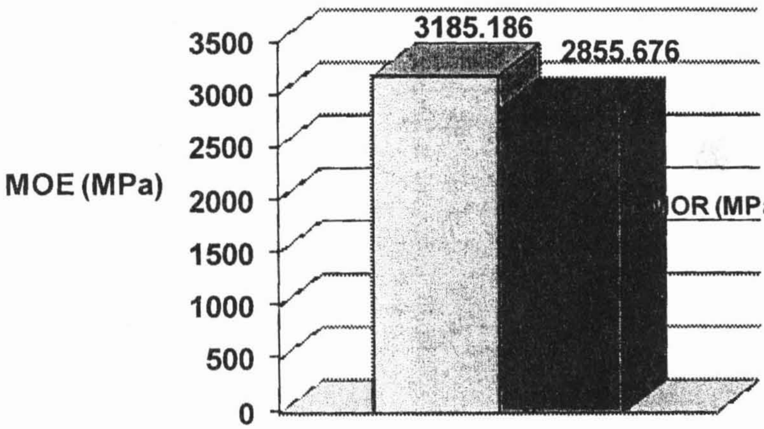

Figure 9: Tensile strength (MOE)

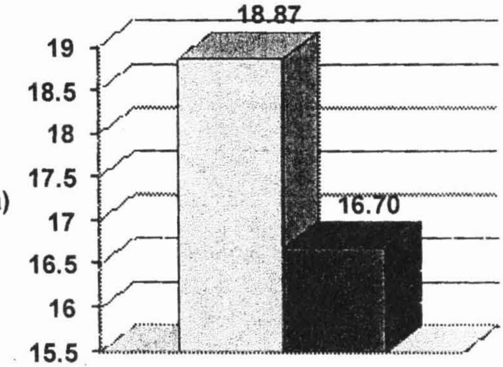

Figure 10: Tensile strength (MOR)

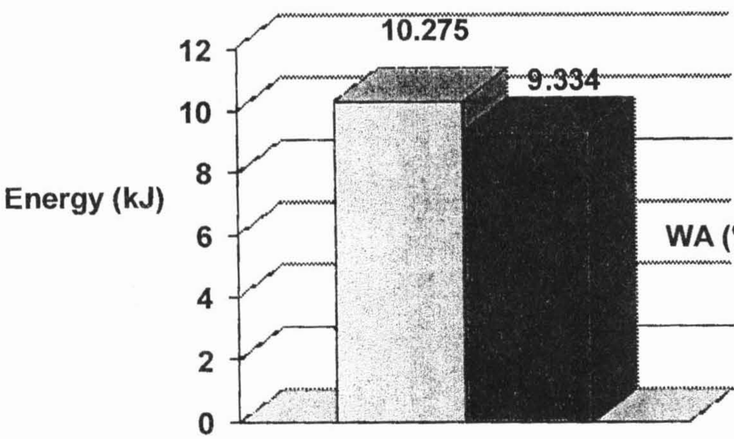

Figure 11: Impact strength

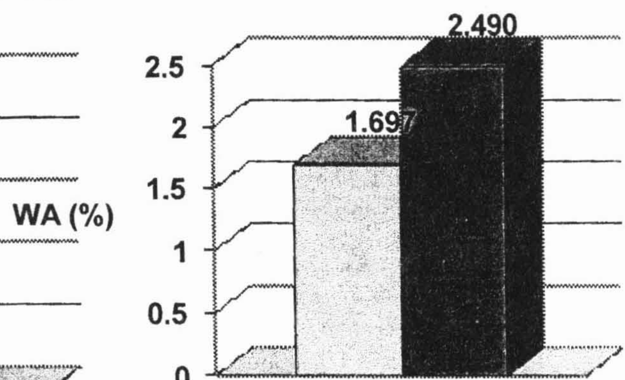

Figure 12: Water absorption

50% of EFB and Coconut Husk

30% of EFB and Coconut Husk

Conclusions

Agricultural fibers have been successfully utilized in a variety of composite panels, most notably conventional composite panels and inorganic-bonded composites. Thermoplastic composites are a newer area of lignocellulosic utilization. It is anticipated that interest and commercial development will continue in this area. More than enough agricultural fiber residues are available to support composite manufacturing needs, although the agro-based materials may not have a suitable geographical distribution to provide an economically feasible endeavor.

Lignocellulosics are attractive material sources for composites because they are lightweight, economical, and require low amounts of energy for processing. In addition, their growth, use, and disposal are generally considered environmentally friendly.

Based on the results of the filler loadings, board contains less wood and more plastic such as 30 % of filler loadings is the best sample to make a wood plastic composite. This is because if too much sawdust in such board, it will cause several problems that we had been proven already. For instance, based on MOE testing, sample that contains more sawdust is less elastic compared to sample that has less sawdust. It contains more plastic materials. According to their thickness swelling test, it had been proven that sample that contains more wood will expand more compared to sample that contain less wood, as occurred in certain wood composite manufacturing such as thermoplastic composite. So, the amount of plastic mixed with sawdust is important to increase the strength of certain board making.

It can be concluded from the findings that sawdust from EFB and coconut husk can be considered as a solution to cover the shortage of raw materials to produce wood thermoplastic composites. In addition, it can minimize the waste of wood and make it become more useable to several purposes such as board making.

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AMRAN SHAFIE, PROF. DR. SUHAIMI MUHAMMED, MOHD JAFNI HASHIM. Universiti Teknologi MARA Pahang. amran453@pahang.uitm.edu.my, prof.suhaimi@gmail.com, jafni_jeff@ymail.com.