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On the Investigation of the physico-mechanical Properties of Composites Based on Wood Flour/Linear and Branched LOW DENSITY POLYETHYLENE

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ABSTRACT

The objective of this stud y was to evaluate the influence of wood fiber content (15, 30 and 45 percent) and molecular structure of polymer on the physical and mechanical properties composites from linear Low Density Polyethylene (LLDPE) and low density Polyethylene (LDPE). The polyethylene and saw dust were properly mixed and injection molded. The results obtained show that the water absorption increased significantly, finally, the thickness swelling increased with increasing wood fiber content. The mechanical properties tests were carried out. There is decreasing tensile strength value and as the saw dust loading increased in the polymer matrix. However the flexural strength increased as the weight fraction of the saw increased. Hence LLDPE are better than LDPE for use with saw dust.
KEY WORDS: Low Density Polyethylene, Composite, Injection Molding, Mechanical properties, Physical properties

INTRODUCTION

In recent years, the use of natural fibers as reinforces and/or fillers in the manufacture of fiber thermoplastic composites has been of great interest, particularly in structural and automotive industry. Wood based composite have been used for several years, but high densities of these composites, compared to natural wood, limit some applications of these engineered materials (Guo 2006). The strategy of select low density polymer can be a good solution to overcome this disadvantage in applications where high strength is not required.

The first key point for the production of acceptable WPC is the compatibility between wood and the host polymer matrix. Wood is hydrophilic in nature (high surface tension), which reduces its compatibility with the hydrophobic polymeric material (low surface tension) during composite preparation. To solve this problem, reactive functional groups may be incorporated into the synthetic polymer as compatibilizers, for enhancing the miscibility of the two polymers and for improving the overall mechanical properties of the blend. These reagents are compatible with the polymeric matrix and can also react with the hydroxyl groups of the fiber, forming covalent bonds. The modification of polyethylene (PE) should also provide increased polymer stiffness, while the PE should protect wood fibers against moisture absorption. Low density polyethylene (LDPE) and linear low density polyethylene represents the majority of thermoplastics currently used as packaging materials. The molecular structure of the polymer plays an important role in properties such as physical and mechanical properties of the final product, so the polymer selection can be very important. LLDPE is different from LDPE in the molecular structure, such as branching structure, molecular weight distribution and chemical composition distribution, and also in higher section, the characteristic structure and the solution properties of LLDPE are describe in comparison with LDPE. LDPE has long-chain branching mainly but LLDPE is a linear polymer with short chain branching. The aim of this study was to investigate the influence of polymer type on the physical and mechanical properties of low density polyethylene/wood flour composite.

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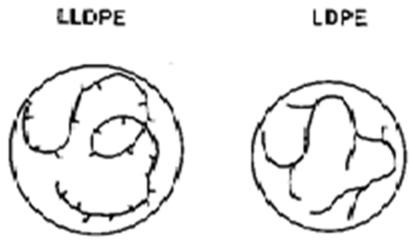

Fig.1:Schematicallyillustrationofmolecular structure of LLDPE and LDPE

Experimental

Materials: LLDPE (grade 209AA) and LDPE (020) were provided as granules by Bandar Imam Petrochemical Company. The LLDPE and LDPE density0.92 and0.910of respectively. Wood flour (60 mesh size) was used as filler. Maleic anhydride grafted polyethylene (PE-g-MA) in two grade with melting point 124 ^{o}C and density .922 g/cm3 for LDPE and with melting point 120 ^{o}C and density .918 g/cm3 for LLDPE provided from Krangin Co.

Method

Composite preparation: Before preparation of sample, wood flour was dried in an oven at 65±2 oC for 24 h. Then the component of each sample (LLDPE, LDPE, MAPE and wood flour) were pre-mixed to prepare homogeneous compounds according to formulations given in table 1 and were blended in a counter-rotating twin-screw extruder (Dr. Collin System) at a screw speed of 80 rpm at 175 oC. The compounded materials were then grinded to prepare the granules using a pilot scale grinder (WIESER, WGLS 200/200 model). The mix was removed from the mixing bowl, cooled in water and granulated into pellets. The pellets were dried at 105 oC for 24 h before injection molding. Test specimens were prepared by an injection molding machine at 190 oC and a pressure of 10 MPa according to standard ASTM D638. The specimens were stored under controlled conditions (50% relative humidity and 23 oC) for at least 40h before testing. The content of materials are shown in below table.

Table 1-Material content

Treatment	WF content (%)	MAPE(%)	LDPE or LLDPE (%)
1	15	3	82
2	15	3	82
3	15	3	82
4	30	3	67
5	30	3	67
6	30	3	67
7	45	3	52
8	45	3	52
9	45	3	52

Measurements: Water absorption tests were carried out according to ASTM D-7031-04. Three specimens of each formulation were selected and dried in an oven for 24 h at 102 ±3 oC. The weight and thickness of dried specimens were measured to a precision of 0.001 g and 0.001 mm, respectively. The specimens were then placed in distilled water and kept at room temperature. For each measurement, specimens were removed from the water and the surface water was wiped off using blotting paper. Weight and thickness of the specimens were measured after 2, 24, 240 and 720 hour. The value of the water absorption in percentage were calculated using following equation1.

$Wa_t (\%) = (W_t-W_o) / W_o * 100$ (1)

Where W_t and W_o, are the weights of the specimen before and after immersion in water, respectively.

The values of the thickness swelling in percentage were calculated using equation. 2.

$Ts_t (\%) = (T_t - T_o) / T_o * 100$(2)

Where TS_t is the thickness swelling at time t, T_o is the initial thickness of specimens and T_t is the thickness at time t.

Mechanical property tests

The tensile, flexural strength tests were conducted with an Instron universal testing machine (model 4486) with a cross-head speed 5 mm/min according to the ASTM standard D638 and D790 respectively for the LLDPE and LDPE/WF composites. All tests were performed at room temperature (23 oC) at a relative humidity of 50%, and three samples were tested for each treatment.

RESULT AND DISCUSSION

The results of the of polymer type and WF content on the water absorption and thickness swelling of wood plastic composites are shown in table2 and table3 which vary depending upon the polymer type and polymer loading. As water absorption percent and thickness selling with increasing of WF were the increased.

Table2- Water absorption content relatively increase the percentage of WF

Polymer type	WF content	Water absorption (%)			
LDPE		2 h	24 h	240 h	720 h
	15	.4	.5	1.47	2
	30	.4	1	1.8	2.1
	45	.6	1.7	3.07	3.6
LLDPE	15	.4	.5	1.13	1.38
	30	.4	1	1.88	2.13
	45	.5	1.2	2.25	2.63

Table3-Thickness content relatively increase the percentage of WF

Polymer type	WF content	Thickness Swelling (%)			
LDPE		2 h	24 h	240 h	720 h
	15	0	1	2.2	2.9
	30	.4	1.2	6	7.4
	45	.9	1.9	10	11
LLDPE	15	0	.1	1.8	2.5
	30	.4	.9	4.7	6.3
	45	1.1	1.1	8	10

This result can be reported in two categories. The first is based on the hydrophilic nature of WF as water absorption increase with increasing WF (San. H, et al. 2008, Tajvidi., et al, 2006).And second item was affected from difference of molecular structure of polymer between LLDPE and LDPE. As the LLDPE has linear structure and improve the bending properties. In LDPE polymer because of having a branching structure connections between the polymer and the WF particles is irregular and side branches keeps them from connect to WF. But in LLDPE linear structure possible to provide regularly connections and consequently provides better physical properties.

Mechanical properties

Molecular characteristics of LLDPE are different from those of LDPE in spite of similar density of both polyethylene. Accordingly it is very important that the mechanical properties of both polymers are compared with each other and differences are made clear.

Tensile strength

As the figure 1 show tensile strength of wood composites increased slightly as the sawdust loading increased to 30%, the reason for this related the high tensile strength of wood particles (Jacquemin et al, 2009). As the saw dust loading increased to 45%, the poor interfacial bonding between the reinforce and the matrix polymer caused the tensile strength of the composite to reduce. The slightly decreased in tensile strength may also be attributed to increase in the interfacial area as the particles content increased, which resulted in worsening the interfacial bonding between the particles(hydrophilic) and matrix polymer(hydrophobic) . Also the reduction in tensile strength may be due to agglomeration of the filler particles in the polymer matrix which form a domain that look like a foreign body in the matrix or simply the result of physical contact between adjacent aggregates (Sreekala et al, 2000).

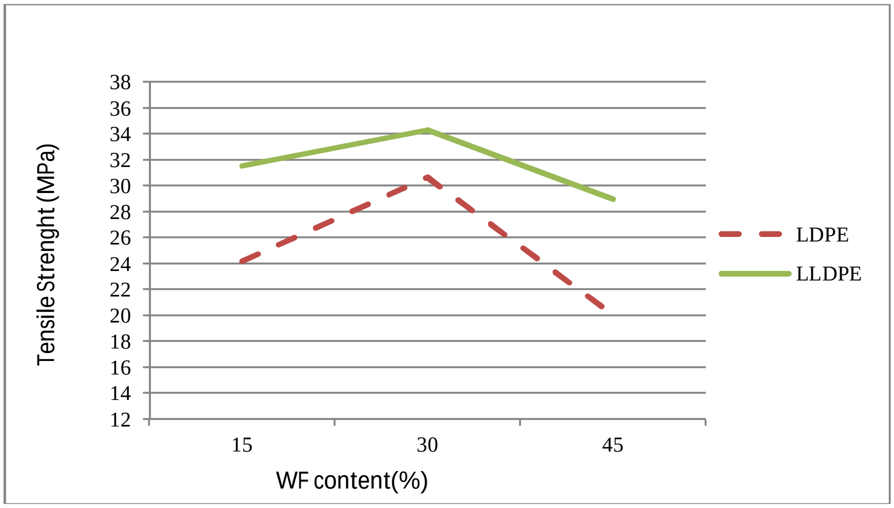

Figure 1.Tensile strength of wood composites

LDPE has the most excessive branching. This causes the low density to have a less compact molecular structure which is what makes it less dense. LLDPE has a significant numbers of short branches. Because it has shorter and more branches its' chains are able slide against each other upon elongation without becoming entangled like LPDE which has long branching chains that would get caught on each other. This gives LLDPE higher tensile strength and higher impact and puncture resistance than the LDPE.

Bending strength

The bending strength increased linearly with increasing sawdust content. It is a common knowledge that the addition of reinforce to thermoplastics increases the strength (Figure 2).

The increase in bending strength with increasing sawdust loading is expected since the addition of reinforce increases the stiffness of the composites, which in turn decreases the elongation at break. Also the increase of strength may be attributed to the ability of filler in fibrous form to carry more tensile load (Thwe and Liao, 2000). This mechanism will strengthen the polymer-fiber interface. It will hold them together and increase their resistance to deformation. This has been observed somewhere with oil Palm wood flour (Zani, et-al 1995). Maximum bending strength exhibited the same trend the bending modulus and tensile modulus.

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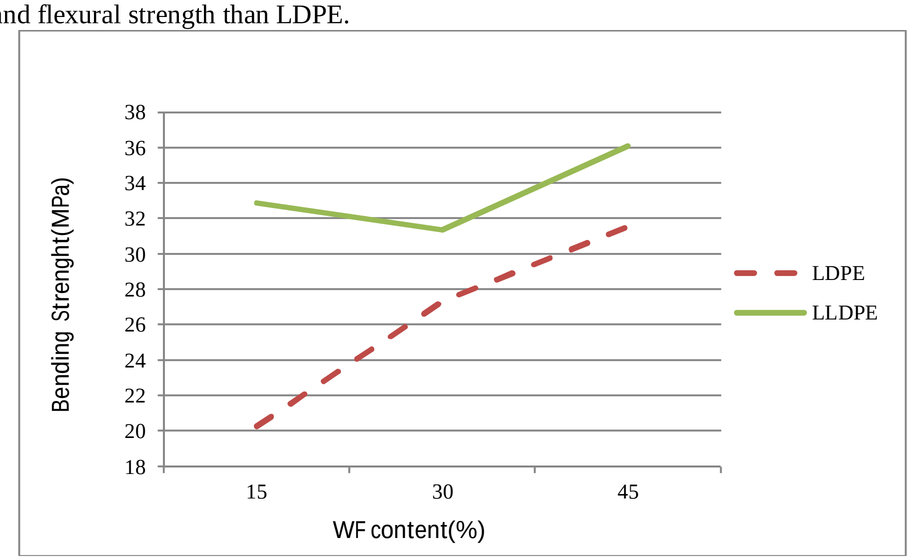

Figure 2.flexural strength of wood composites

Conclusions

The experimental results of our study indicate the water absorption and thickness swelling of composites was increased with the increase in WF content.

The tensile properties obtained are in agreement with the results obtained from the analysis of the hardness and impact strength.

Flexural strength increases with increase in saw dust particles in the LLDPE matrix.

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