Property Modification of Composites between Poly(vinyl chloride)/ Low-Density Polyethylene Polymer Blends Reinforced by *Hevea brasiliensis* Sawdust

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Abstract

Composites samples were prepared from PVC/LDPE blend, compatibilized by PA20 (methyl methacrylate-co-butyl acrylate copolymer), and reinforced by rubber-wood sawdust. Because of the poor compatibility of the composites, Silane A-137 (Octyltriethoxy silane), Silane A-1100 (γ-aminopropyltriethoxysilane) or MAPE (maleic anhydride-grafted-polyethylene) were introduced. It was found that the addition of Silane A-137, Silane A-1100 or MAPE improved tensile, flexural and impact properties of the composites. Silane A-137 or MAPE tended to give better improvement in the mechanical properties of the composites than Silane A-1100. Besides, the addition of either Silane A-137 and MAPE or Silane A-1100 and MAPE into the sawdust/PVC/LDPE composites was also studied. Moreover, morphological and thermal properties of the composites were examined using SEM, DMA and TGA techniques.

Keywords: Polymer blend, Poly(vinyl chloride), Composite, Wood sawdust, Mechanical properties

1. Introduction

Poly (vinyl chloride, (PVC)) is one of the most widely used thermoplastics in packaging and construction applications. PVC/PE blend has been utilized in several applications such as blister packing, electric cable sheathing, but its mechanical properties and service performance are much inferior because of their phase incompatibility [1].

One of the most common method to improve the mechanical properties of the incompatible blend is to add a suitable compatibilizer. Previous work [1] has shown that mechanical, morphological and thermal properties of the PVC/LDPE blend were significantly improved by addition of poly(methyl methacrylate-co-butyl acrylate, PA20). Among other fillers used for such polymeric products, wood fibers become an important class of the reinforcing materials. They

show many advantages including low density, little demand during processing, biodegradability, high stiffness and relatively low price [2]. However, wood fibers are incompatible with the polymer due to their hydrophilic character which results in uneven dispersion in the composites, thus a poor stress transfer between the matrix and the filler and unsatisfactory properties of the final produced [3].

This study focused on improving interfacial adhesion of the wood sawdust and PVC/LDPE blend compatibilized by PA20, through the use of coupling agents, i.e. silane coupling agents and maleic anhydride-grafted-polymer.

2. Experimental

Melt-blending of PVC with LDPE was performed using a single-screw extruder (Thermo Haake Poly Drive). The obtained extrudates were further compounded in a two-roll mill (Lab Tech Engineering, LRM 110) before transferring into a compression molding machine (LabTech Engineering, LP20). Silane A-137, Silane A-1100 and MAPE coupling agents were added into the samples. The content of the coupling agents was maintained at 3%wt of sawdust for both single and mixed coupling agents. Morphology of the composites was examined from the fractures samples. Thermal properties of the composites were studied by DMA and TGA.

3. Results and discussion

It can be seen in Table 1 that tensile and flexural and impact properties of the composites increased with the addition of the coupling agents, i.e. Silane A-137, Silane A-1100 and MAPE. This is due to the physical and/or chemical linkages formed between the sawdust reinforcement and the PVC/LDPE matrix by the use of the coupling agents. When different coupling agent types were compared, it was found that MAPE and Silane A-137 gave better improvement of the mechanical properties than Silane A-1100.

In addition, mechanical properties of the sawdust/PVC/LDPE composites using Silane A-137:MAPE showed greater mechanical property enhancement than those of Silane A-1100:MAPE as shown in Table 2. This was consistent with the mechanical properties of the composites using only Silane coupling agent or MAPE.

Table 1. *Mechanical properties of the sawdust/ PVC/LDPE composites using 3%wt of different coupling agents*

Mechanical properties	No Silane or MAPE	Silane A-137	Silane A-1100	MAPE
Young's modulus (MPa)	92	284	271	338
Tensile Strength (MPa)	7.6	11.7	10.0	12.3
%Elongation at break	5.6	8.8	7.9	8.6
Flexural strength (MPa)	19.0	28.5	26.5	32.4
Flexural modulus (MPa)	914	1568	1351	1607
Impact strength (kJ/m^2)	1.3	3.2	3.1	2.9

Morphology of the composites (Figure 1) was examined by SEM. The SEM micrographs of the composites with Silane A-137, Silane A-1100 or MAPE the improved presented the interfacial adhesion between the PVC/LDPE matrix and the sawdust reinforcement. Beside, wetting phenomena can be observed in the composites using the coupling agents (Figure 1 (b)-1 (d)).

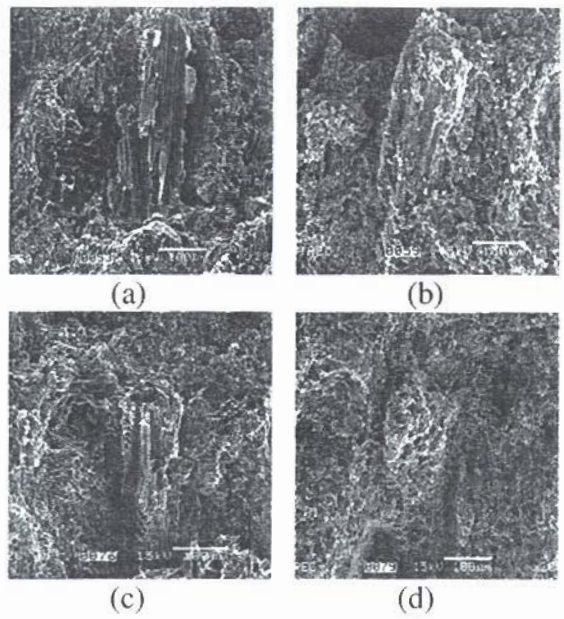

Figure 1. *SEM micrographs of sawdust/PVC/LDPE composites using (a) no Silane or MAPE (b) Silane A-137 (c) Silane A-1100 and (d) MAPE*

Table 2. *Mechanical properties of the sawdust/ PVC/LDPE composites using mixed coupling agent system*

Mechanical properties	1%:1% Silane A-137: MAPE	1%:1% Silane A-1100: MAPE
Young's modulus (MPa)	262	221
Tensile strength (MPa)	12.9	10.1
%Elongation at break	7.4	7.2
Flexural strength (MPa)	29.6	25.3
Flexural modulus (MPa)	1277	1103
Impact strength (kJ/m^2)	2.7	2.6

Thermal properties of the composites (Table 3) were examined by DMA and TGA. The result showed slight decrease of T_g and slight increase of T_d indicating the reinforcement of the composites by the use of the three coupling agents.

4. Conclusion

Composites from PVC/LDPE blend reinforced by rubber-wood sawdust were prepared and modified using three different coupling agents (Silane A-137, Silane A-1100 or MAPE). It was found that mechanical properties of the composites were improved with addition of Silane or MAPE into the composites. Moreover, Silane A-137 and MAPE showed greater effect on mechanical property enhancement than Silane A-1100. Wetting phenomena was also observed in the composite samples, regardless of the types of the coupling agents. In addition, the slight decrease of T_g and slight increase of T_d of the composites incorporated with Silane A-137, Silane A-1100 or MAPE were obtained.

Table 3. *Glass transition (T_g) and thermal decomposition (T_d) temperatures of the the sawdust/ PVC/LDPE composites*

Samples	T_g (°C)	T_d (°C)
PVC/LDPE/PA20/SD	88.2	230
+ Silane A-137	86.5	237
+ Silane A-1100	87.4	231
+ MAPE	86.0	235
+ (1%:1%) A137:MAPE	86.5	232
+ (1%:1%) A1100:MAPE	85.8	239

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