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Influence of Maleic-Anhydride-Polypropylene (MAPP) on the Physical Properties of Polypropylene/Sawdust fir flour Composite

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ABSTRACT

To improve the interfacial compatibility between sawdust fir flour and polypropylene (PP), the effects of maleic anhydride-grafted polypropylene (MAPP) on the Short-term physical properties of sawdust fir flour /PP composites were investigated. For this purpose, water absorption and thickness swelling of samples was determined at different levels of MAPP content. The results showed that the water absorption and thickness swelling of composites was lowered with the increase in MAPP content. Additionally, from these results, we can conclude the addition of MAPP improves its water absorption and thickness swelling property.
KEYWORDS: Sawdust fir flour, Polypropylene, water absorption, thickness swelling, Composite.

INTRODUCTION

Wood plastic composite (WPC) is typically comprised of wood or other natural lignocellulosic fibers in a thermoplastic matrix [1-2]. These products have found their way into consumer, automotive, and construction applications, and are experiencing tremendous growth in exterior residential construction applications. The introduction of WPCs in the decking market is mainly responsible for this growth [3 and 4]. In order to produce wood polymer composites, natural fibers are added to thermoplastic polymers. During the last decade, wood plastic composites (WPC) have gained extensive applications in construction materials and automobile parts [5]. The natural fibers which are used to reinforce the thermoplastics are basically comprised of wood, cotton, cotton fibers, hemp (cannabis fiber), jute (Indian cotton), sisal fiber and cane fibers [6]. Advantages of using these fibers in composites are their light weight, high quality, low cost, annual renewability, good mechanical properties, reduced energy consumption and environmental friendliness [7]. Lignocellulosic materials are used in the WPCs as natural fillers and reinforcement, in powder or fiber forms. Lower bulk density, compatibility with the environment, recycling potential as well as low costs are the main reasons for the application of the lignocellulosic materials in the WPCs [8]. Hydrophilicity of those materials and incompatibility with the non-polar plastic polymers and Water absorption and thickness swelling are the most important problems in the production wpcs and exposed to environmental conditions thus, determining their end use applications [9]. Water absorption can deteriorate both mechanical properties and dimensional stability in such composites. Therefore, hygroscopic characteristics have to be taken into account as limiting parameters in the design of WPCs with regard to their final applications [10, 11]. Maleic anhydride polypropylene (MAPP) is a kind of compatibilizers commonly used in WPCs. MAPP has low surface energy and is expected to give good compatibility between the wood and the polymer by formation of stronger linkages in the interfaces and reducing WPCs surface Tension and water absorption. Bonding between the wood and the polymer is quite weaker when a compatibilizer has not been applied [12]. Among different compatibilizers, MAPP is known as a good one and has also been used for hybrid composites made from fibers and polypropylene [13]. The aim of this study was to investigate the short-term water absorption and thickness swelling behavior of Polypropylene reinforced with Sawdust fir flour.

MATERIALS AND METHOD

Wood Flour

Sawdust fir flour was from Moein Industry Co. (Iran). The particle size of Sawdust fir flour was 60 meshes.

Polymer matrix

The polypropylene (PP) with a melt flow index (MFI) of 9 g/10 min at 190°C was obtained maroon Co., Iran, and was used as the matrix polymer.

Coupling Agent:

Maleic anhydride grafted Polypropylene (MAPP) provided by Javid Kimiya Sepahan Co. with a density of 0.9 g cm^{-3} (MFI 15-30 g/10min, grafted maleic anhydride 1 wt %) was used as coupling agent.

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Before sample preparation, sawdust fir flour was dried at (70±5) ˚C for 24 h. Then PP, sawdust fir flour, and MAPP were weighed and bagged according to formulations given in Table 1 and then mixed in a co-rotating twin-screw extruder (Collin) at the Iran Polymer and Petrochemical Research Institute. Sawdust fir flour, granules of Polypropylene, were properly mixed with the coupling agent and then poured into the funnel of the extruder. The compounded materials were then ground using a pilot scale grinder (WIESER, WGLS 200/200 model). The resulting granules were dried at 105 °C for 24 h.
Test specimens were prepared with a laboratory press was employed to press samples and cast them at 200°C under 25 MPa pressure for 5 min. In order to avoid the creation of bubbles inside the samples, deaeration was repeated several times. The samples were finally separated using a puncher to avoid the formation of cracks. The specimens were stored under controlled conditions (50% relative humidity and 23˚C) for at least 14 day prior to testing.

Table 1. Composition of the studied formulations.

Sample Code	PP Content (wt%)	Sawdust fir flour Content (wt%)	PP-g-MA Content (wt%)
1	50	50	0
2	48.5	48.5	3
3	47	47	6

Measurements
Water absorption tests were carried out according to ASTM D-7031-04. Six specimens of each formulation were selected and dried in an oven for 24 h at 102±3ºC. 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 thicknesses of the specimens were measured after 2 and 24 hours immersion. The values of the water absorption in percentage were calculated using the following equation 1.

$$WA\ (t)\frac{W(t)-W(o)}{W(o)}\times 100 \qquad (1)$$

Where WA (t) is the water absorption at time t, W_o is the oven dried weight, and W (t) is the weight of specimen at a given immersion time t.
The values of the thickness swelling in percentage were calculated using equation. 2.

$$TS\ (t)\frac{T(t)-T(o)}{T(o)}\times 100 \qquad (2)$$

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.

Statistical Analysis
The statistical analysis was conducted using SPSS programming (Version 11.5) method in conjunction with the analysis of variance (ANOVA) techniques. Duncan multiply range test (DMRT) was used to test the statistical significance at $\alpha = 0.05$ level.

RESULT AND DISCUSSION

The results of an ANOVA indicated that the MAPP content had significant effects ($p < 0.05$) on the physical properties of composites.

The effect of MAPP content on the water absorption and thickness swelling of wood plastic composites is shown in figures 1 and 2. Figure 1 and 2 shows the values of the water absorption and thickness swelling for the composites, which vary depending upon the MAPP loading. Figure 1 and 2 also shows that the water absorption and thickness swelling decreased with of MAPP increasing. A significant improvement in physical properties (water absorption and thickness swelling) was achieved using MAPP as a coupling agent for composites.

The improvement in physical properties may be attributed to the hydrophilic anhydride groups of MAPP, which are prone to compatibilizing with hydrophilic Wood Flour, thereby promoting the dispersion and surface wetting of Wood Flour in the matrices.

In addition, anhydride groups can react with the hydroxyl groups of Wood Flour and form ester bonds, improving the interfacial adhesion between the matrices and fillers [14].

These results clearly revealed that the use of MAPP coupling agent had a beneficial effect on the water absorption and thickness swelling of the composites. This may be explained, first, by the promoted

dispersion of sawdust fir flour in the plastic matrices and by the improved interfacial adhesion between the sawdust fir flour and matrices.

Second, these results may have occurred because the improved interfacial adhesion slowed down the water diffusion rate between the sawdust fir flour through interfacial defects [15]. Last but not least, the reduced amount of hygroscopic hydroxyl groups in the sawdust fir flour polymers due to the esterification with anhydride groups contributed to the reduced water absorption and thickness swelling.

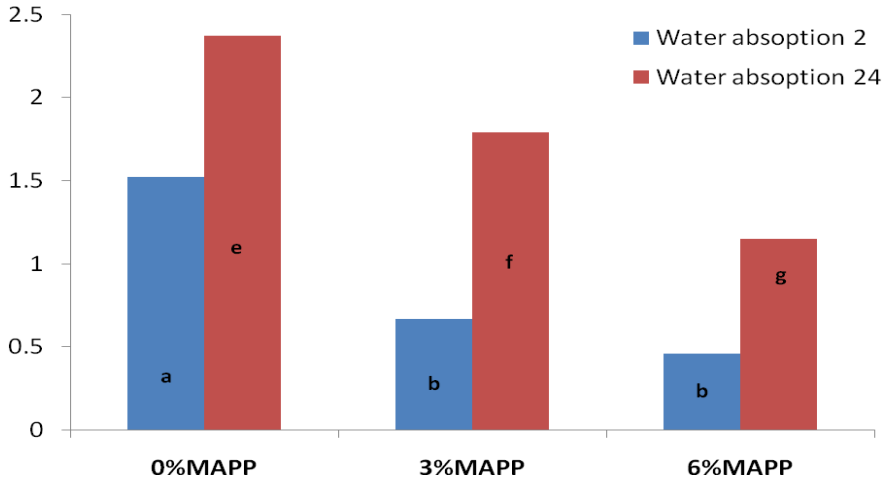

Figure1. Effect of MAPP content on the water absorption (small letters indicate statistically indistinguishable classes for Duncan ranking of the averages values at a confidence interval of 95%)

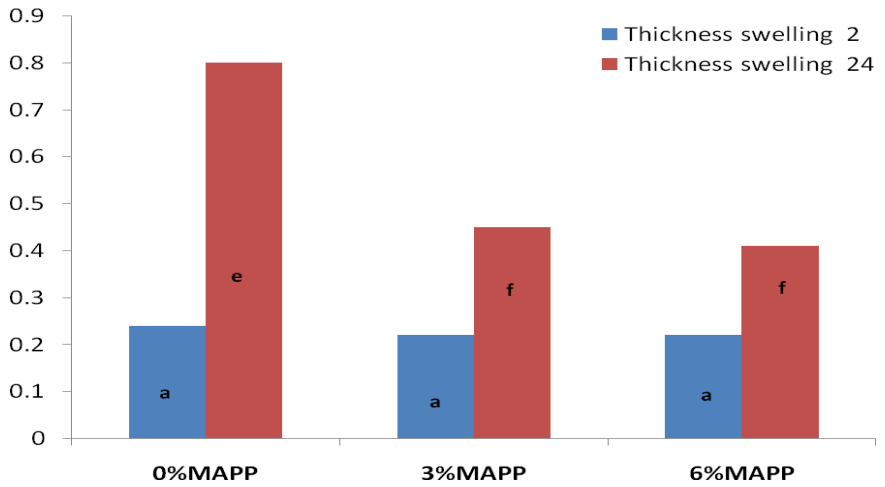

Figure 2. Effect of MAPP content on the thickness swelling (small letters indicate statistically indistinguishable classes for Duncan ranking of the averages values at a confidence interval of 95%)

Conclusion

The following conclusion could be drawn from the results of the present study:

1. The water absorption and thickness swelling of composites was lowered with the increase in MAPP content. Additionally, from these results, we can conclude the addition of MAPP improves its water absorption and thickness swelling property.

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