

Effect of Bark Flour Content on Mechanical Properties of Wood Plastic Composites

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Abstract: Using the residual materials of wood and wood industries to manufacture wood plastic composites (WPCs) is a major task for researchers. One of these residuals is bark which is produced in high quantities in wood industries. In this study, the effect of bark content on mechanical properties of wood plastic composites was investigated. Composites based on polypropylene, wood flour and bark flour from *Abies* wood and coupling agent were made by melt compounding and then injection molding. The mass ratio of wood flour to polypropylene was controlled at 50:50 for all formulations. For bark flour and coupling agent as variable factors, different levels of 0, 10, 20, 30% and 0, 2% were considered respectively. Results indicated that the flexural strength, flexural modulus and impact strength of polypropylene/wood flour composites decreased with increased of bark flour loading. Also, the mechanical properties of samples were improved by increase of coupling agent content.

Key words: Polypropylene • Bark flour • Compatibilizer • Extruder • Mechanical properties

INTRODUCTION

Wood plastic composites (WPCs) are defined as composite materials containing wood (in various forms) and thermoplastic materials. These materials are a relatively new family of composite materials, in which a natural fiber and/or filler (such as wood flour/fiber, kenaf fiber, hemp, sisal, etc.) is mixed with a thermoplastic such as polyethylene (PE), polypropylene (PP), poly (vinyl chloride) (PVC), etc. Compared with the traditional synthetic fillers, natural fibers present lower density, less abrasiveness, lower cost and they are renewable and biodegradable. Wood plastic composites are becoming more and more commonplace by the development of new production techniques and processing equipment [1-4].

Enforcement of new and stricter environmental policies has forced industries to search for new materials that can substitute the traditional composite materials consisting of a plastic matrix and inorganic fillers as reinforcement. Compared to the traditional synthetic fillers, natural filler/fibers present lower density, less abrasiveness, lower cost and they are renewable and biodegradable [5-6]. Using the residual materials of wood and wood industries to manufacture WPC is a major task for researchers. One of these residuals is bark which is produced in high quantities in wood industries. Collection

and disposal of this high amount of waste material presents some problems and costs for wood industries. In addition, small diameter round wood has considerable amount of bark which can influence wood plastic composites properties [5-6].

The environmental and disposal problems created by the accumulation of considerable volumes of bark in the forest industry and the increasingly scarce supply of wood and fiber resources are forcing the industry to seriously consider all possible utilization of bark as a raw material, particularly in the form of higher value products [6]. Various researchers have investigated the use of bark as raw material in the production of wood based panel such as particleboard, hardboard and medium density fiberboard (MDF) [6]. The results showed that the mechanical properties such as modulus of elasticity, bending strength and internal bond decreases by increasing of bark content. The thickness swelling and water absorption of MDF panels was not greatly affected by bark fiber content [6]. Bark consists of high amount extractives which are the principal physical and chemical contributors to surface inactivation, hence to poor wettability by adhesives [5]. Industrial sawdust collected from major woodworking facilities often contains considerable amounts of bark whose separation is not economically feasible. Because of chemical and structural

differences between wood flour and bark flour, it is necessary to study the effects of bark content on physical and mechanical properties of wood plastic composites. The aim of this research is to study the effects of bark content on mechanical properties of wood plastic composites and to evaluate the coupling agent performance.

MATERIALS AND METHODS

Polypropylene, V30S (MFI=18 g/10min, density=0.92 g/cm³) was supplied by Arak Petrochemical Co (Iran). Maleic anhydride grafted polypropylene (PP-g-MA) provided by Solvay with trade name of Priex 20070 (MFI=64 g/min, grafted maleic anhydride 0.1 Wt. %) was used as coupling agent. Abies wood flour (WF) and abies bark flour (BF) were used as reinforcing filler.

Before preparation of samples, wood flour and bark flour was dried in an oven at (65 ± 2)°C for 24 hours. Then polypropylene, wood flour, bark flour and coupling agent were weighed and bagged according to formulations given in Table 1. The mixing was carried out by a hake internal mixer (HBI System 90, USA). First the polypropylene was fed to mixing chamber, after melting of PP, coupling agent was added. At the two minute, the wood flour and bark flour fed and the total mixing time was 11 min. The compounded materials were then ground using a pilot scale grinder (WIESER, WGLS 200/200 Model). The resulted granules were dried at 105°C for 4 hours. Test specimens were prepared by injection molding (Eman machine, Iran). Finally, specimens were conditioned at a temperature of 23°C and relative humidity of 50% for at least 40 h according to ASTM D618-99 prior to testing.

The flexural tests were measured according to the ASTM D790, using an Instron machine (Model 1186, England), The tests were performed at crosshead speeds of 5mm/min. A Zwick impact tester (Model 5102, Germany) was used for the Izod impact test. All the samples were

notched on the center of one longitudinal side according to the ASTM D256. For each treatment level, five replications were tested.

The statistical analysis was conducted using SPSS programming (Version 16) method in conjunction with the analysis of variance techniques. Duncan multiply range test was used to test the statistical significance at $\alpha = 0.05$ level.

RESULTS AND DISCUSSION

The statistical analysis showed that the bark flour and coupling agent content had significant effects on the mechanical properties of wood plastic composites.

Figure 1 show that the flexural strength of wood plastic composites decreased with increasing of bark flour content. It seems the weak bonding between the hydrophilic filler and the hydrophobic matrix polymer obstructs the stress propagation and causes the tensile strength to decrease as the bark flour loading increases [1-4, 7-8]. As can be seen in this figure, the flexural strength of the composites increased with increasing of coupling agent content. It is well established that presence of coupling agent enhances the interface adhesion between bark flour and polymer matrix and brings better encapsulation of wood particles by the plastic which consequently results in higher flexural modulus [9-10].

Figure 2 show that the flexural modulus of wood plastic composites decreased with increasing of bark flour content. The reason of that could be relate to bark has a lower modulus than wood. The modulus of bark almost is 50% of modulus of wood. As can be seen in this figure, the flexural modulus of the composites increased with increasing of coupling agent content. It is well established that, with increase of the coupling agent content, indicating enhanced compatibilization between bark flour and PP matrix [9-10].

Table 1: Composition of the Studied Formulations

Polypropylene Content (Wt. %)	Wood Flour Content (Wt. %)	Bark Flour Content (Wt. %)	Coupling Agent Content (Wt. %)
50	50	0	0
48	50	0	2
50	40	10	0
48	40	10	2
50	30	20	0
48	30	20	2
50	20	30	0
48	20	30	2

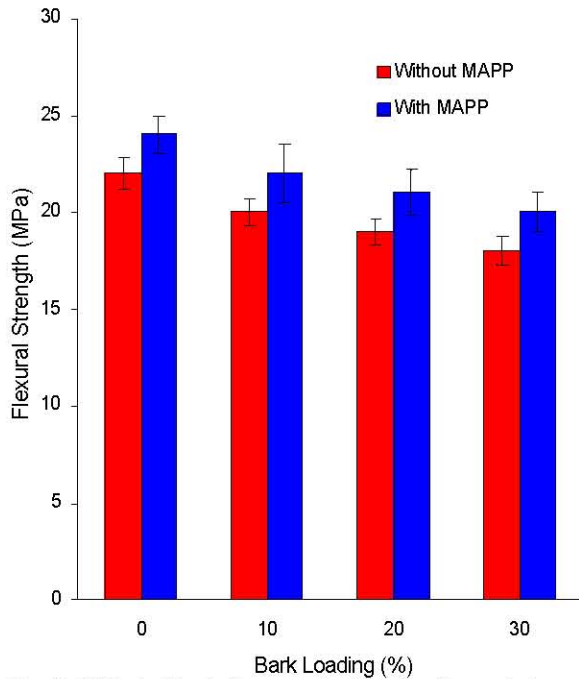


Fig. 1: Effect of bark flour content on the flexural strength of wood plastic composites

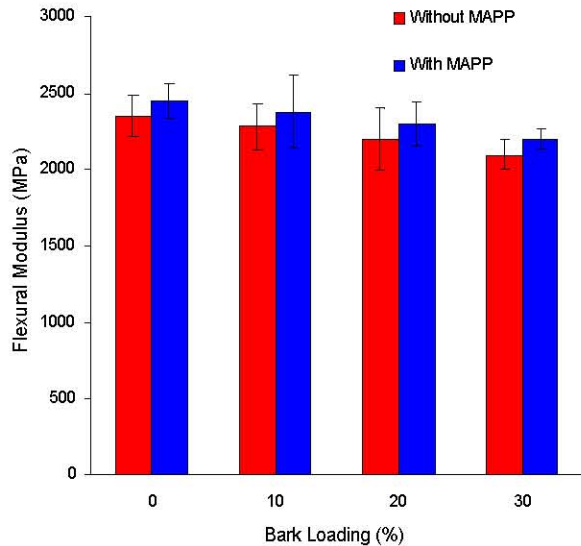


Fig. 2: Effect of bark flour content on the flexural modulus of wood plastic composites

Figure 3 show that the impact strength of wood plastic composites decreased with increasing of bark flour content. It is well established that, the impact properties are affected by the crack initiation and crack propagation mechanism between the filler and the matrix polymer. This is likely due to the fact that the wood particles acted as stress concentrators and decreased the impact strength [7-8, 11]. As can be seen in this figure, the impact strength

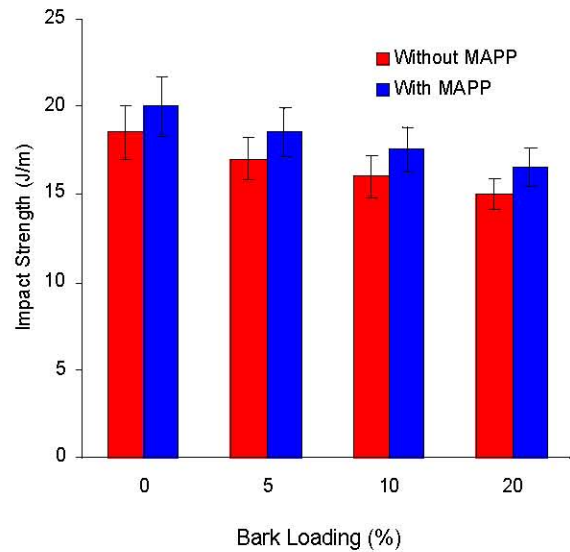


Fig. 3: Effect of bark flour content on the impact strength of wood plastic composites

of the composites increased with increasing of coupling agent content. The enhancement in the impact strength could be attributed to the more homogeneous dispersion of the fiber resulting from the increasing wettability of the fiber with increasing concentration of the coupling agent that leads to more uniform distribution of the applied stress and requires more energy for the fiber debonding and subsequent fiber pull out as these are the causes of impact failure of the composites [9-10].

CONCLUSION

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

- The statistical analysis showed that the bark flour and coupling agent content had significant effects on the mechanical properties of wood plastic composites.
- The flexural strength, flexural modulus and impact strength of polypropylene/wood flour composites decreased with increased of bark flour loading.
- The mechanical properties of samples were improved by increase of coupling agent content.

REFERENCES

1. Tajvidi, M., 2005. Static and dynamic mechanical properties of a kenaf fiber-wood flour/ polypropylene hybrid composite. *J. Applied Polymer Sci.*, 98: 665-672.

2. Takasae, S. and N. Shiraishi, 1989. Studies on composites from wood and polypropylene. *J. Applied Polymer Sci.*, 37: 645-659.
3. Rowell, R.M., A.R. Sandi, D.F. Gatenholm. and R.E. Jacobson, 1997. Utilization of natural fibers in plastic composites: Problem and opportunities in lignocellulosic composites, *J. Composite*, 18: 23-51.
4. Selke, S.E. and I. Wichman, 2004. Wood fiber/polyolefin composites, *Composites: Part A.*, 35: 321-326.
5. Kiaefarm, A., 2008. Effect of bark content on physical and mechanical properties of wood plastic composites. Ms.C Thesis, Tarbiat Modarres University.
6. Kazemi Najafi, S., A. Kiaefar and M. Tajvidi, 2009. Effect of Bark Flour Content on Hygroscopic Characteristics of Wood-Polypropylene Composites. *Wood Science and Technol.*,
7. Qin, T.F., 2002. Effect of wood powder content on properties of wood powder/ polypropylene composites. *China Wood Industry*, 16(5): 17-20.
8. Stark, N.M., 2003. Effects of wood fiber characteristics on mechanical properties of wood/polypropylene composites, *Wood and Fiber Sci.*, 35(2): 167-174.
9. Mahlberg, A., 2001. Transcrystalline interphases in natural fiber/ polypropylene composite; Effect of coupling agents. *J. Composites Interface*, 7(1): 31-43.
10. Nitz, H., P. Reichert, H. Römling and R. Mülhaupt, 2000. Influence of compatibilizers on surface hardness, water uptake and the mechanical properties of poly (propylene) wood flour composites prepared by reactive extrusion, *Macromolecules Material Engineering* 276/277: 51-58.
11. Oksman, K. and C. Clemon, 1998. Mechanical properties and morphology of impact modified polypropylene-wood flour composites, *J. Applied Polymer Sci.*, 67(9): 503-1513.