Journal of Chemistry and Chemical Sciences, *Vol.9(1), 16-22, January 2019*
(An International Research Journal), *www.chemistry-journal.org*

ISSN 2229-760X (Print)
ISSN 2319-7625 (Online)

Effect of Wood Flour Mesh Size on Mechanical Properties of Wood Flour Polypropylene (WFPP) Composites

Vinay Kumar and Hemant Kumar*

Department of Chemical Engineering,
Sant Longowal Institute of Engineering and Technology (SLIET),
Longowal, Distt. Sangrur -148106 (Punjab) INDIA.
*Department of Chemistry,
Sant Longowal Institute of Engineering and Technology (SLIET),
Longowal, Distt. Sangrur -148106 (Punjab) INDIA.
*email: hemantk1331@gmail.com.

(Received on: December 26, 2018)

ABSTRACT

Wood flour was used as filler in polypropylene, a commodity plastic for making thermoplastic composites by the process of extrusion and compression molding. Adhesion between wood flour and polypropylene was improved by using maleic anhydride polypropylene (MAPP) compatibilizer and optimum level was 1.5% (weight basis) resulting improvement in mechanical properties such as as tensile, impact, flexural and hardness. Improvement in mechanical properties was found by using higher (finer) mesh size wood flour powder. Composites thus prepared have applications in building and automobile industries.

Keywords: Flexural Strength, Maleic Anhydride poly propylene (MAPP), Polypropylene (PP), Tensile Strength, Wood Flour.

INTRODUCTION

Polypropylene (PP) is a light weight polymer and has good mechanical properties to meet requirements of household and industrial sectors. Decrease in mechanical properties such as tensile and impact of PP was found by addition of wood flour (WF). It is due to the incompatible nature of wood flour and polypropylene (PP) as wood flour is hydrophilic and PP is hydrophobic[1-2]. Researchers have used various and coupling agents and compatibilizers such as maleic anhydride polypropylene (MAPP), Epolene G-3003, silane, and poly methylene poly phenyl isocyanate (PMPPIC) for improving adhesion between PP and wood flour[3-6].

The effect of length to diameter (L/D) ratios of fiber on the properties of wood plastic composites (WPC) was studied. Composites were processed on extrusion and injection molding machines and higher modulus of elasticity (MOE) was reported by addition of wood fibers to high density polyethylene (HDPE). Fiber L/D ratio have a positive effect on mechanical properties but reduced the water absorption[7]. Further, the effect of fiber variability, size, and content on mechanical and physical properties of wood plastic composites was studied. Better mechanical strength and stiffness in composites was found with higher fiber loading and (L/D) ratios but elongation and energy required to break were reduced. The effect of fiber size on water uptake was minimized, but increased with higher fiber content[8].

Wood plastic composites (WPCs) were prepared by using recycled polypropylene (RPP) and wood flour[9]. Effect of wood flour particle size, coupling agent, lubricant and a mass ratio of wood and RPP was studied. Higher tensile and flexural strength of the WPC was reported by the use of finer wood flour particle but with lower water swelling. Use of compatibilizer (MAPP) and lubricant (zinc stearate), both gave optimum results in WPCs at 3% loading. The addition of compatibilizer improved the mechanical properties and reduced the swelling. Excess amount of lubricant increased the water swelling significantly, but reduced the mechanical properties of wood plastics composites (WPCs).

Wood flour due to its lower cost and abundant availability is a useful filler for making WFPP composites. In the present studies, weight % of MAPP was optimized to get the best mechanical properties in composites. Further, effect of mesh size of wood flour on mechanical properties of composites was carried out. Detailed studies of mechanical properties is very useful for exploring new applications of these materials in domestic, building, automobile, and sport fields.

EXPERIMENTAL PROCEDURE

Materials: 1. Polypropylene: It was procured from M/S Reliance industries (Grade AM 120N) and following properties were measured:

- Moisture Content (ASTM D789) : 0.039 %
- Viscosity Average Molecular Weight (ASTM D 2857-95) : $26{,}592\times10^{-3}$ kg /mole
- Tacticity : 7.8%
- Melt Flow Index (ASTM D 1238): 19.92×10^{-5} kg /s
- Tensile strength (ASTM D 638):29 MPa
- Hardness SHORE D (ASTM D 2240): 63.75

2. Wood Flour: It was obtained locally and screened manually by metal sieves to get the powder of 15,25,35,45 mesh. Some of the measured properties are :

- Bulk density (ASTMD 1895) : 150 kg/m^3
- Ash content (ASTMD 2584) : 9.59 %
- Moisture content (ASTM D 789) : 9.02 %

3. Maleic anhydride grafted polypropylene (MAPP): Compatibilizer was supplied by M/S Pluss Polymers Private Limited, Gurgaon and its grade was P 406

Methodology: Wood flour was preheated in oven at 373 K to remove moisture. Polypropylene along with wood flour and MAPP was fed in a single screw extruder and temperature setting was: 463 K, 473 K, 483 K, 473 K. After getting the uniformly mixed granules from the extruder, granules were kept in the mold. Mold halves were kept in compression molding machine at following process conditions:

Processing temperature: 473 K

Heating time: 900 s

Cooling time: 1200 s

Clamping pressure: 590.5×10^4 kg/m^2

After proper heating and cooling of the mold, it was opened and composite sheets of 0.155 m× 0.155 m× 0.003 m were produced. The sheets were cut to prepare samples for carrying out tensile (ASTM D368), impact (ASTM D 256) and flexural (ASTM D 790)and hardness(ASTM D 2240) tests.

Universal testing machine (UTM) [Capacity: 50 KN) , supplied by M/S Ashian Engineers Company India, New Delhi was used for performing the tensile test. Gauge length was fixed at 50×10^{-3} m and testing speed was set at 83×10^{-5} m/s. The sample size in flexural test was 0.100 m× 0.0127 m×0. 003m and test was performed on the same UTM by three point loading. The Izod impact tester used was supplied by Prolific Engineers, Noida, and unnotched sample size was 0.0635 m×0.0127× m×0.003 m. MODEX Shore D hardness tester, supplied by Material Testing Instrument was used for hardness measurement and sheet of 0.155 m× 0.155 m× 0.003 m prepared by compression molding was used.

Following experiments were conducted:

1. By varying the percentage of MAPP compatibilizer (1.5, 3, 4.5 and 6%)
2. By varying the mesh size of wood flour (15, 25, 35 and 45)

RESULTS AND DISCUSSION

Results for mechanical properties of wood flour polypropylene composites by varying the % of compatibilizer are given in Table 1.

Improvement in tensile strength of WFPP composites by adding compatibilizer was studied. It is due to better chemical bonding between PP and WF[10]. Flexural strength also showed similar behavior as tensile strength. It is due to the improved adhesion between the PP and WF by use of compatabilizer[11]. Use of MAPP improves the wetting which is evidenced by the almost complete absence of holes around polymer matrix[11]. Better dispersion achieved by use of MAPP enhanced the impact strength of WFPP composites. Hardness was also better in the composites due to better crystallinity achieved in the composites by use of MAPP.

At higher percentage of MAPP, (beyond 1.5%), decrease in all mechanical properties was noticed. Beyond 1.5%, MAPP did not participate in interfacial adhesion between PP and WF as percentage of WF was kept constant[12]. With higher MAPP loading, interfacial adhesion between WF and PP becomes weaker [12]. Therefore, both tensile and flexural strength of WFPP composites were decreased. Further, the addition of MAPP beyond 1.5% result brittle failure, which lowers the impact strength of composites [13]. It is due to strong interfacial bonding which makes debonding between matrix and wood flour difficult resulting lower fracture energy absorption. Excess use of MAPP decreases the frictional forces between filler and PP resulting low frictional shear responsible for lower impact strength. Decrease in hardness was noticed beyond 1.5 % MAPP in the composites. Results are justified as it has a proportional relationship with tensile strength.

Therefore, 1.5 % (on weight basis) is the optimum level of MAPP for getting improvement in mechanical properties of WFPP composites as shown in Table 1. Therefore, its percentage was fixed at 1.5% in further studies.

Results of varying mesh size of wood flour on mechanical properties (tensile, flexural, impact strength and hardness) of WFPP composites are given in Figures 1-4. Higher tensile strength was observed with the finer mesh size of wood flour as shown in Figure 1. Small particle size provides larger area for interaction with PP resulting better interfacial adhesion accountable for higher tensile strength in composites[13]. The same trend was observed for flexural strength with finer mesh size powder as shown in Figure 2. Results are theoretically justified as it has a proportional relationship with tensile strength[14]. Improvement in the impact strength was noticed with the finer mesh size of WF as shown in Figure 3. With coarser particle size, high stress concentration along interface results which enhance the possibility of a crack initiation, resulting lower impact strength in WFPP composites [15]. Better hardness of wood flour polypropylene composite was found with finer wood flour particles as shown in Figure 4. Finer mesh size (smaller particles) of wood flour reduces the gap between particles, and improves the compactness and cohesiveness in composites resulting better hardness.

Therefore by increasing the size (finer mesh) of wood flour, mechanical properties of WFPP composites keeps on increasing.

Table 1: Effect of Compatibilizer % on Mechanical Properties of WFPP Composites

Composition in gram (PP/WF/MAPP)	Tensile Strength (MPa)	Flexural Stress (MPa)	Impact Strength (J/m)	Hardness
105/45/0	13.88	58.74	31.66	82.16
105/45/2.25	18.20	114.52	66.66	83.54
105/45/4.5	18.14	109.96	53.33	83.22
105/45/6.75	15.46	106.94	36.66	82.68
105/45/9	15.12	102.94	33.33	82.44

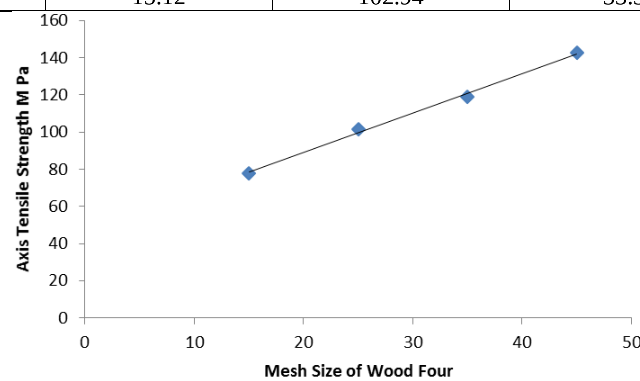

Figure1: Effect of Mesh Size of Wood Flour on Tensile Strength of WFPP Composites

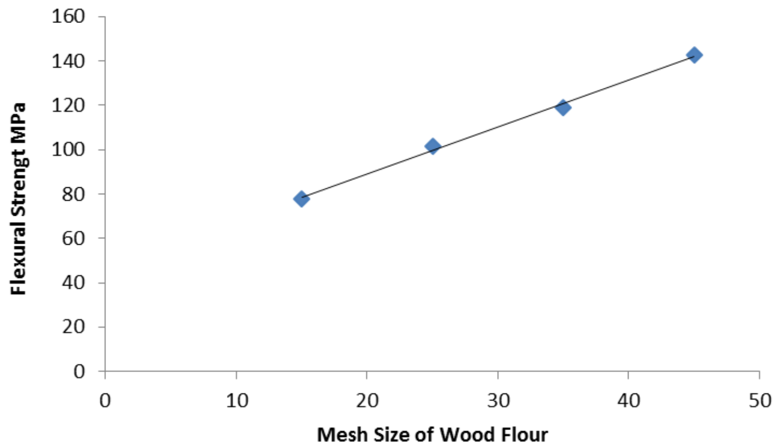

Figure 2: Effect of Mesh Size of Wood Flour on Flexural Strength of WFPP Composites

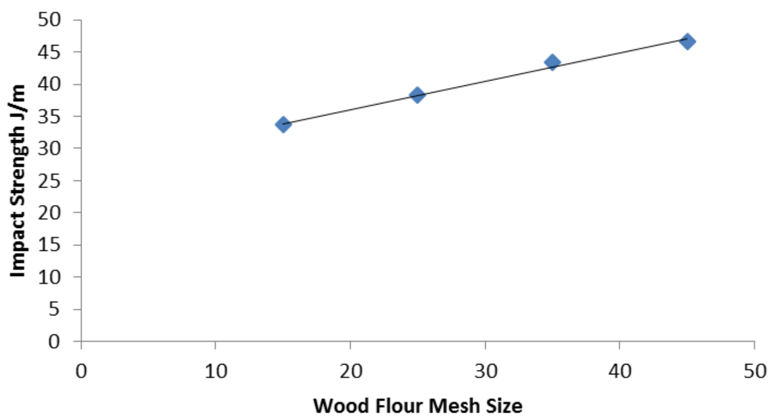

Figure 3: Effect of Mesh Size of Wood Flour on Impact Strength of WFPP Composites

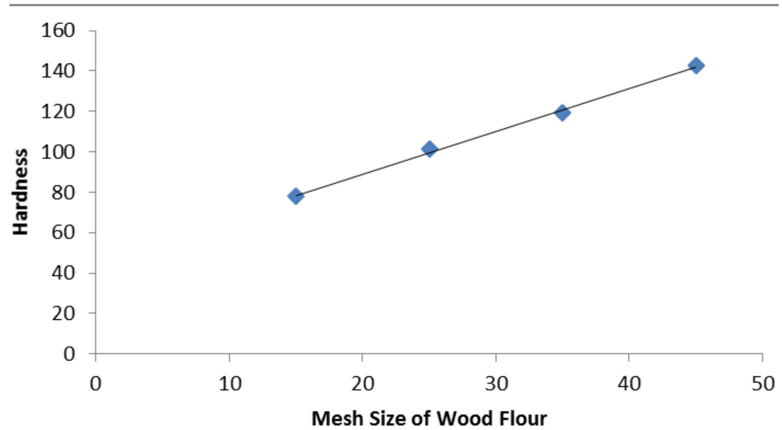

Figure 4: Effect of Mesh Size of Wood Flour on Hardness of WFPP Composites

CONCLUSION

WF is a potential material for PP for development of thermoplastic composites. MAPP at 1.5% (weight) is very effective in improving the adhesion between WF and PP. Finer mesh size of wood flour significantly improves the mechanical properties such as tensile, impact, flexural and hardness of WFPP composites. WFPP composites thus prepared are light in weight, economical, and have good mechanical strength. These mechanical properties could be utilized in domestic, building, automobile, electronic and sport industries for applications such as mats, door, slab, laminate, door shutter, door panel, dashboard, back rest, seat cushion, tennis racket, laptop cases.

ACKNOWLEDGEMENT

Author is thankful to Mr. Sandeep Panwar, M.Tech. student for helping me in doing this work.

REFERENCES

1. Caraschi J C., and Leao A., Woodflour as Reinforcement of Polypropylene, *Mat Res*, 5, 405-409 (2002).
2. Yang H S, Wolcott M. P., and Kim., Properties of lignocellulosic material filled polypropylene bio-composites made with different manufacturing processes, *Polym Test*, 25, 668–676 (2006).
3. Krzysik A M., and Youngquist. JA., Mechanical and physical properties of air-formed wood-fiber/polymer-fiber composites, *Int J Adhes Adhes*,11, 235-240 (1991).
4. Lee S Y, Yang H S, and Kim H J., Creep behavior and manufacturing parameters of wood flour filled polypropylene composites, *Compos Struct*, 65 , 459-469 (2004).
5. Nachtigall S M B, Cerveira G S and Rosa S M L, New polymeric-coupling agent for polypropylene/wood-flour composites, *Polym Test*, 26 , 619–628 (2007).
6. Raj RG, Kokta BV and Daneaulta C, A comparative study on the effect of aging on mechanical properties of LLDPE-glass fiber, mica and wood fiber composites, *J Mater Sci*, 25, 1851-1855 (1990).
7. Migneault S , KoubaaA ,FErchiquiF., Effects of processing method and fiber size on the structure and properties of wood-plastic composites, *Composites Part A*, 40, 80-85 (2009).
8. Bouafif H, KoubaaandA, and Perre P , Effects of fiber characteristics on the physical and mechanical properties of wood plastic composites Part A, 40, 197-198 (2009).
9. Leu SY, Yang TH and Lo SF, Optimized material composition to improve the physical and mechanical properties of extruded wood-plastic composites (WPCs), *Constr Build Mater*, 29, 120-127 (2012).
10. Kuo PY, Wang SY, and Chen JH, Effects of Manufacturing Processes on the Mechanical Properties of Wood Plastic Composites. Forest Products Industries, *Mater Des*, 30, 3489-3496 (2009).

11. Kong YU and Zhou W H, Influence of an optimized fibre coating on interfacial and mechanical properties of glass fibre/polypropylene composites, *J Wuhan Mater Sci*, 17, 62-65 (2002).
12. H Baker, Handbook: Properties and Selection: Nonferrous Alloys and Pure Metals, ASM International (1990).
13. Kang I A, Lee SY and Oung SY., Nanocellulose reinforced PVA composite films: Effects of acid treatment and filler loading, *J Korean Wood Sci Technol*, 37, 505-516 (2009).
14. V. Shah, Handbook of Plastics Testing Technology,. Wiley and Sons, 23 (1984).
15. Stark N M and Rowlands RE, Effects of Wood Fiber Characteristics on Mechanical Properties of Wood/Polypropylene Composites. Wood and Fiber Science, *Wood Fiber Sci*, 35, 167-174 (2003).