Study on Pinewood/Recycled Polypropylene Composite

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ABSTRACT

In this study, as the low cost of wood plastic composite (WPC) is generating a boom in the market of wood composites product, an attempt is made to fabricate WPCs with saw dust of pine wood flour which is wastages of wood/furniture industry. These composites (WPCs) are made using matrices of recycled polypropylene (rPP) with sawdust (Pine Wood flour) as filler. Corresponding WPCs are also made using virgin Polypropylene (vPP) for comparison with the recycled plastic based composites. WPC test samples were prepared from Pine Wood Flour (PWF) with a mesh size of 20-80 mesh size as the reinforcing material and H110 MA polypropylene (PP) and recycled PP as the matrix materials. WF was chemically modified by alkaline treatment methods to increase its adhesion to, and compatibility with, the polymer matrix. All varieties of these WPCs are made through melt mixing and injection moulding with varying formulations based on Polypropylene (PP), plastic form (recycled and virgin), wood flour content and addition of Maleated Polypropylene (MAPP). Mechanical properties and the water absorption are evaluated. To understand the changes in WPCs dimension stability and durability performance, incorporation of MAPP in composite formulation was done to strengthen interfacial bonding and hence improves the dimensional stability.

Keywords: *WPC, recycled polypropylene RPP virgin Polypropylene (VPP), Pine wood Flour, Maleated Polypropylene (MAPP)*

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1. INTRODUCTION

Wood and timber residuals incorporate any contaminated or uncontaminated, treated or untreated, solid or composite wood material. Sources of these materials are obtained from construction and demolition (C&D), commercial and industrial (C&I) sources and primary and secondary timber processing mills.

Wood-polymer composites (WPC) have gained a lot of importance in the last decade. Most recently, the WPC market has increased as there is increase in technology related machinery, material, and other various processing conditions. Applications for these composites include a variety of building products, consumer, industrial and automotive. Polymer composites made with different sources wood and natural fibers such as rice hulls, flax, hemp, jute, or kenaf. Most importantly, WPC do not have the typical problems that treated wood has in outdoor applications such as wrapping, twisting, cupping, and splitting. The wood-polymer composites are promoted as low maintenance products for outdoor applications.

In this paper, the effect of the coupling agents on the overall performance of WPC, with base materials VPP (Virgin Polypropylene) or RPP (Recycled Polypropylene) and Pine Wood Flour (PWF) has been used as reinforcement for the study.

IN this study, maleated grafted materials such as polypropylene is added in small percentages to the WPC to reduce the interfacial tension between the non-polar polyolefin matrix and wood filler and thereby enhance the mechanical properties of the polymer composites.

2. EXPERIMENTAL WORK

a. Materials:-

Polypropylene (H110 MA) provided by Reliance Industries Limited and Recycled PP of Injection grade provided by local supplier were used as a base materials for the study. Pine wood flour(PWF) has been used as a reinforcing material in this study which was collected from the local "Vishwakarma Furniture mill Naroda".Maleic Anhydrated grafted Polypropylene (OPTIM P-425) was provided by Pluss Polymers Pvt Ltd and used as a coupling agent in the study.

b. Chemical Treatment:-

- **Alkali Treatment: -** Pine wood flour (PWF) was immersed in 1% NaOH aqueous solution for 24 hrs at room temperature. The flour was removed from the alkali solution and then washed with 1 % dilute acetic acid solution and followed by washing with distilled water. The flour was then dried under direct sunlight for 24 hrs followed by oven drying at 80 °C for 24 hrs.

- **Chemical Modification is aimed at:**
  - Improving Adhesion between the fibre surface and the polymer matrix.
  - Also increases fibre strength.
  - Reduces water absorption of composites and improves mechanical properties of the composite materials.

3. COMPOUNDING AND SPECIMEN PREPARATION

Compounding (Twin Screw Extruder):- Twin screw extruder technique was used to prepare the Pinewood flour reinforced with Virgin Polypropylene (VPP) and Recycled Polypropylene (RPP). The operation conditions of the co-rotating twin-screw extruder compounding including extruder barrel temperature at different extruding zones, melt pressure, and screw speed employed for the compounding of both fibre and matrix (PP). The operating conditions of the extruder zone Z1, Z2, Z3, Z4,Z5 & die were set at 150°C, 170°C, 180°C, 190˚C, 200˚C and 190˚c at 276 screw rpm respectively.PWF + PP + MAPP (0-2-4-6-8 %) are fed through feeders at the extruder. The extruded strand coming out from the die head is then passed through a water bath and subsequently pelletized.

Sampling (Injection Molding):- Injection Molding is a manufacturing process for producing parts from pellets. The compounded material is fed into barrel, mixed and forced into mold where it cools and hardens to the configuration of mold cavity.

Table 1.1 Compositions of Batches

Batch No.	Base Plastic	Plastic Percentage	Wood Flour Percentage	MAPP content (%)
1	VPP	70	30	0
2	RPP	70	30	0
3	VPP	70	30	2
4	VPP	70	30	4
5	VPP	70	30	6
6	VPP	70	30	8
7	RPP	70	30	2
8	RPP	70	30	4
9	RPP	70	30	6
10	RPP	70	30	8
11	VPP	100	0	0
12	RPP	100	0	0

4. RESULTS AND DISCUSSIONS

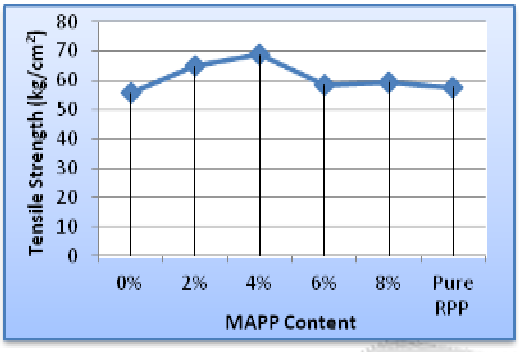

Fig. a) Tensile Strength (kg/cm^2) of RPP/PWF composites

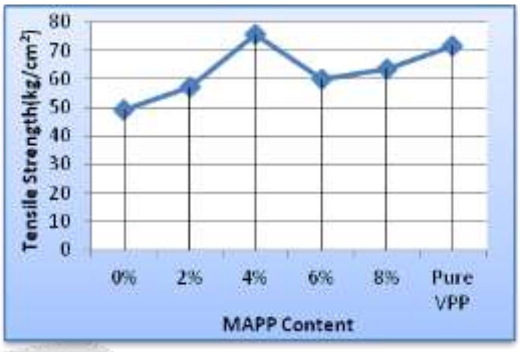

Fig. b) Tensile Strength (kg/cm^2) of VPP/PWF composites

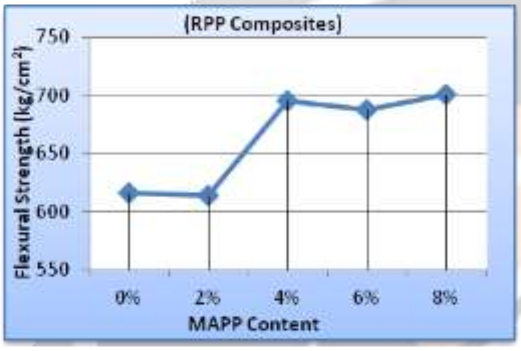

Fig. c) Flexural Strength (kg/cm^2) of RPP/PWF composites

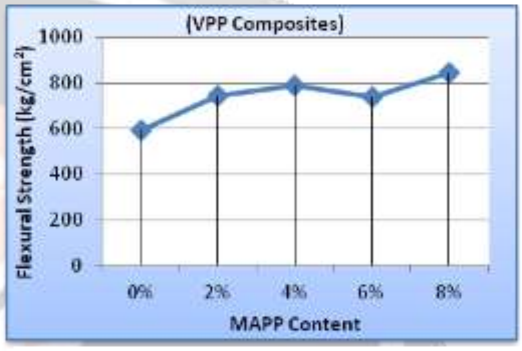

Fig. d) Flexural Strength (kg/cm^2) of VPP/PWF composites

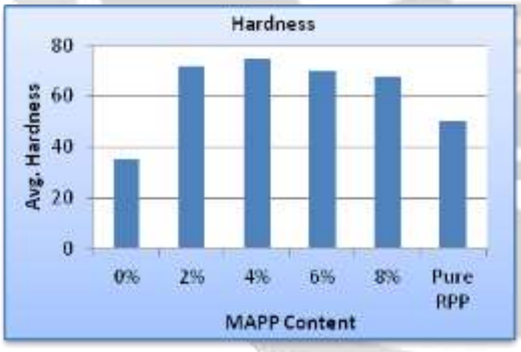

Fig. e) Hardness of RPP/PWF composites

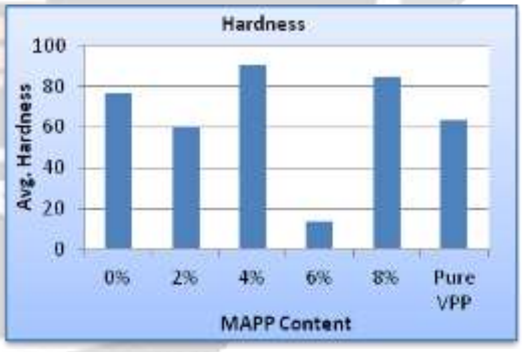

Fig. f) Hardness of VPP/PWF composites

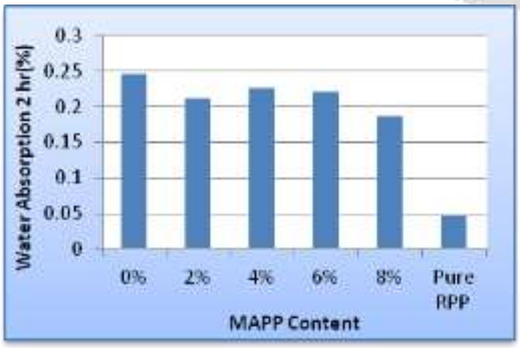

Fig. g) Water Absorption of RPP/PWF composites for 2 hrs

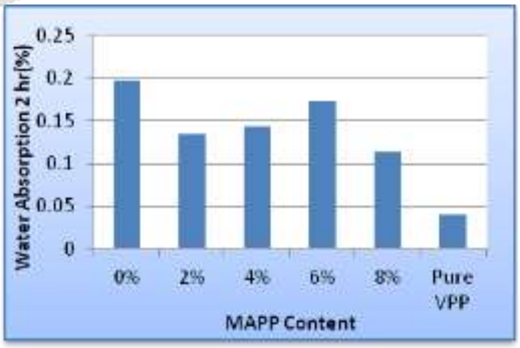

Fig. h) Water Absorption of VPP/PWF composites for 2 hrs

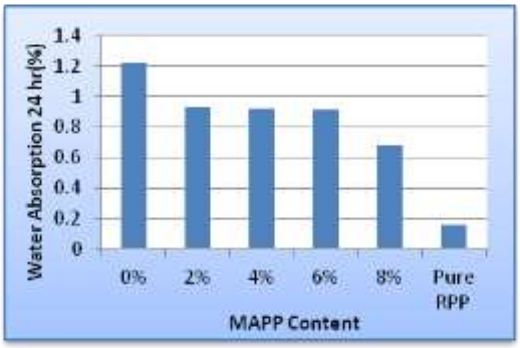

Fig. i) Water Absorption of RPP/PWF composites for 24 hrs

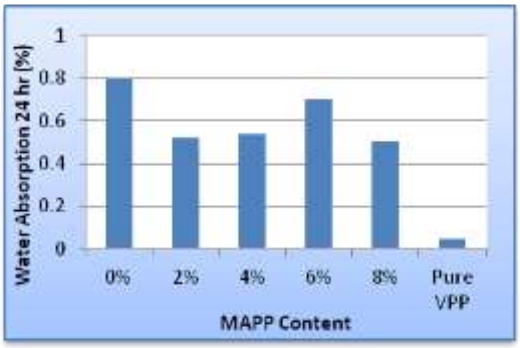

Fig. j) Water Absorption of VPP/PWF composites for 24 hrs

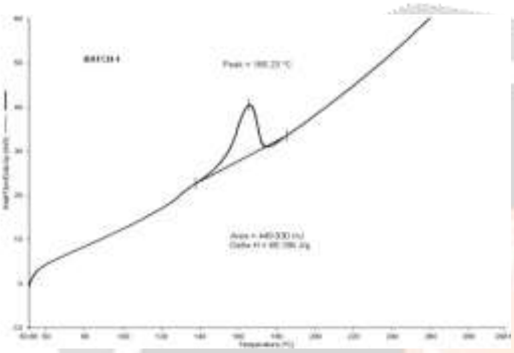

Fig. k) DSC curve of VPP+30% PWF

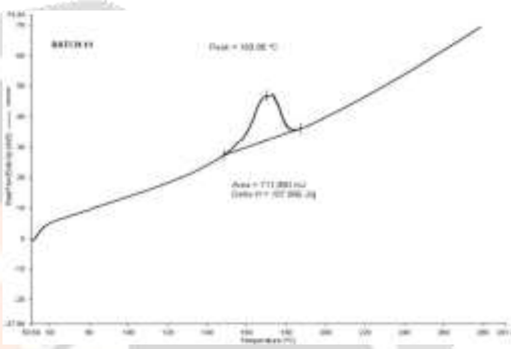

Fig. l) DSC curve of Virgin PP

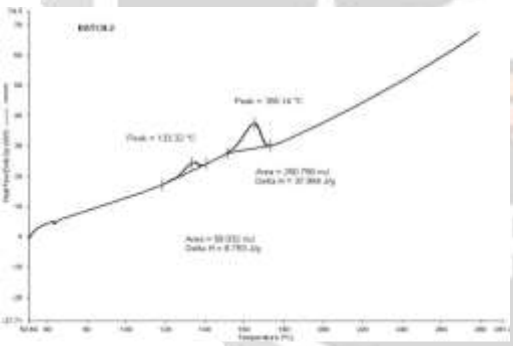

Fig. m) DSC curve of RPP+30% PWF

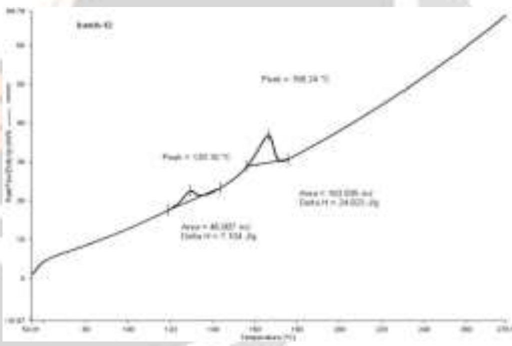

Fig. n) DSC curve of Recycled PP

Table 1.2: Melt Temperature of Various Batches

Batch	Melt Temp(°C)
VPP	**169.88**
VPP+30 % PWF	**165.23**
RPP	**166.24**
RPP+30 % PWF	**165.14**

Figure a) and b) show that in both the cases of VPP/PWF composite and RPP/PWF composite tensile strength increases with increase in MAPP content from 0% to 4% and there is gradual decrease with increase in MAPP content. It is clear that tensile strength is highest at MAPP content of 4%.

Figure c) and d) show that flexibility is uneven as per the content of MAPP. Flexibility is higher at 4% and 8% of MAPP content in both the cases of RPP/PWF and VPP/PWF composites.

Figure e) and f) show that hardness of composite is maximum at 4 % content of MAPP in RPP/PWF composite and VPP/PWF composite compared to any other MAPP content variant.

Figure g), h), i) and j) show that water absorption is least at 8% MAPP content in both RPP/PWF composite and VPP/PWF composite. Water absorption was carried out by soaking specimen for 2 hr and 24 hr at 55 ˚C at oven.

Figure k), l), m) and n) shows the DSC curve of pure material and composite material and suggest that the melt temperature, after incorporating of pine wood flour, remain close to that of pure material.

5. CONCLUSIONS

- Water absorption was carried out by soaking specimen for 2 hrs and 24 hrs at 55 ˚C in the oven. Result obtained suggests that water absorption is least at 8% MAPP content in both RPP/PWF composite and VPP/PWF composite.
- Here Impact strength of pinewood flour containing composites and pure plastics were observed and compared. It showed that impact strength of the composite in any cases is less than the non-composite material i.e, impact strength decreases with increase in PWF content in the system.
- In both the cases of VPP/PWF composite and RPP/PWF composite tensile strength increases with increase in MAPP content from 0% to 4% and there is gradual decrease with increase in MAPP content. It is clear that tensile strength is highest at MAPP content of 4%.
- Hardness of composite is maximum at 4 % content of MAPP in RPP/PWF composite and VPP/PWF composite compared to any other MAPP content variant. But Hardness at MAPP 4 % content of VPP/PWF composite is the highest than any other batches. Hardness was measured at hardness scale R.
- HDT of RPP/PWF composite increases with increase in MAPP content from 0% to 4%. It might be due to the improvement in interfacial bonding achieved to increasing content of MAPP.
- In almost the entire test, RPP/PWF composite showed good and very resembling properties to that of VPP/PWF composite. So hereby, it can be concluded that RPP base composite can be good and promising alternative to that VPP base composite with proper content of compatibilizer and hence reducing the cost of the product.

6. REFERENCES

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