MECHANICAL AND CHEMICAL CHARACTERISATION OF WOOD POWDER POLYMER COMPOSITES

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Abstract - *The market for wood-thermoplastic composite products is growing rapidly. Major markets are decking materials, pallets, and automobile and window components. Fuelled by the decreasing availability of solid wood relative to projected demands, both recycled wood and plastic materials are being investigated as substitutes. The combination of plastics and wood has been limited to polymers with lower melting point to avoid degradation of the wood materials. These include polypropylene, low and high-density polyethylene, polystyrene, and polyvinyl chloride. The wood is in fine powder form, which is produced from planer shavings and kiln dried mill residues. Many producers of wood-plastic lumber are seeking ways to improve the performance characteristics of their products. Although the wood-thermoplastic products industry has a significant history, technology is still being developed. Among the wide choice of polymer matrices that have been widely promoted, polypropylene and its composites have been highlighted as having the potential for such applications. Polypropylene is high performance thermoplastics, which have to date been associated with high performance devices, structural and load-bearing material in various fields including automotive, aerospace, electronics and marine industries. In addition to its superior mechanical properties, polypropylene also has other functional properties suitable for biomedical applications. Also it has high temperature performance, excellent wear and fatigue properties and its ability to be sterilized without much degradation. Young's modulus was seen to increase progressively with increasing wood content. It is anticipated that by incorporating particulate wood powder into the polypropylene matrix, the mechanical performance of the material, particularly the Young's modulus could be improved considerably. Furthermore, the presence of bioactive wood powder subsequently enhance implant fixation with proper provision for their interactions with the host tissue. Hence, the aim of this study is to highlight the structural property aspects of wood filled plastic composites. In the present paper, the results of experimental work, carried out on wood powder polymer composites, such as tensile test, chemical resistivity and VICAT softening temperature test, will present and discussed.*

Key Words: Tensile strength, Wood plastic composites, Chemical resistivity, VICAT softening temperature.

1.INTRODUCTION

A composite material is a combination of two or more chemically different materials with a distinct interface between them. The constituent materials maintain their separate identities (at least microscopically) in the composites, yet their combination produces properties characteristics that are different from those of the constituents. One of these constituents forms a continuous phase and is called MATRIX. The other major constituent is REINFORCEMENT in the form of fibres or particulates that is, in general, added to the matrix to improve or alter the matrix properties. The reinforcement forms a discontinuous phase that dispersed uniformly thought the matrix. The reinforcement matrix may be chemically treated or coated with a very thin layer to improve wetting of the reinforcement by the matrix as well as to control or enhance the interfacial bonding between the reinforcement and matrix.

Polypropylene is one of the most versatile consumer and industrial resins. It is widely used in automotive interior and under hood applications. House wares are full of PP from flowerpots to patio furniture to flexible-enclosable containers used for food storage. PP is used to package yogurt, cottage cheese, and other dairy products. It is listed as “possibly practical for composites” because although to date communities have rarely collected this material for recycling programs, some communities are beginning to separate out these PP packages for recycling. PP is especially amenable to use with wood. Its first large commercial scale application in a wood-plastic composite material was for automotive interiors. Today wood-filled PP is also used for flowerpots, tool handles, and a growing list of consumer goods.

2. EXPERIMENTAL PROGRAM

2.1 Tensile Test (ASTM D638): This test method is designed to produce tensile properties such as tensile strength, modulus of elasticity (Young’s modulus), %of elongation for control and specification of composite material. These data are useful for qualitative characterization, engineering design and research and development purposes. Testing was carried out on universal

Instron testing machine with standard specimens prepared according to ASTM (D638)

Tensile testing: A method of determining behavior of materials subjected to uniaxial loading which tends to stretch the material. A longitudinal specimen of known length and diameter is gripped at both ends and stretched at a slow, controlled rate until fracture occurs.

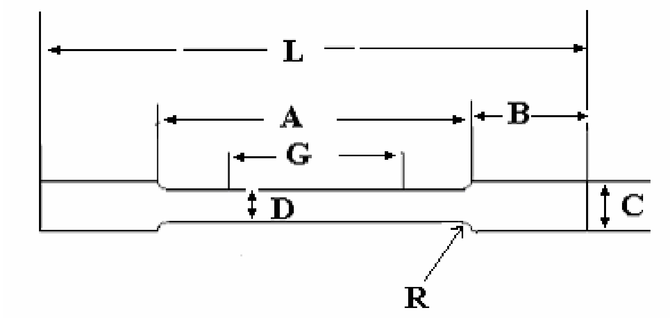

Fig.1. ASTM standard tensile specimen

Specimen specification:

Gauge Length (G) = 55.5mm
Width (D) = 12.7mm
Thickness (T) =3.00mm
Radius of Fillet (R) =3.8mm
Overall Length (L) =174.4mm
Length of reduced section (A) =100mm
Length of grip section (B) =37.1mm
Width of grip section (C) =19.1mm

2.2 CHEMICAL RESISTIVITY TEST (ASTM D543-67)

The chemical resistivity of composite samples was carried out according to the ASTM D543-67 method. The selection of test conditions are taken into account, the manner and the duration of contact with the reagents, the temperatures of the systems and other performance factors involved in the particular applications. The selected reagents for measuring the chemical resistance are 10% sodium hydroxide (NaOH), Potassium permanganate ($KMnO_4$), salt solution (NaCl), Benzene, Ethyl acetate, Hydrochloric acid (HCl), Nitric acid (HNO_3).

Test procedure:

The composite of required dimension were cut and weighed accurately. The samples were immersed in a wide mouthed reagent bottle along with the reagent for 7 days in the standard laboratory atmosphere. The samples were hung so as to avoid any contact with the walls or the bottom of the reagent bottle. After 7 days the specimen were removed individually from the reagent bottle and gently wiped with the tissue paper and reweighed. The difference in weights and thickness were calculated, which in turn gives the idea about the resistance of samples to various chemical reagents.

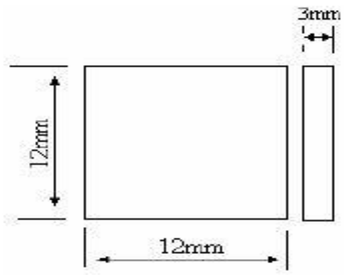

Fig.2 Specimen for Chemical Resistivity test

2.3 VICAT SOFTENING TEMPERATURE (ASTM D 1525)

VICAT softening point is the temperature at which a flat ended needle of $1mm^2$ cross section will penetrate a thermoplastic specimen to a depth of 1mm under specified load and uniform rate of temperature rise. Data obtained by this test method may be used to compare heat softening qualities of thermoplastic materials. This test is useful in the areas of quality control, development and characterisation of materials.

3. Results and Discussion

3.1 Tensile Test

The results of the tensile test for different compositions of the wood – polypropylene are as shown in the figure below.

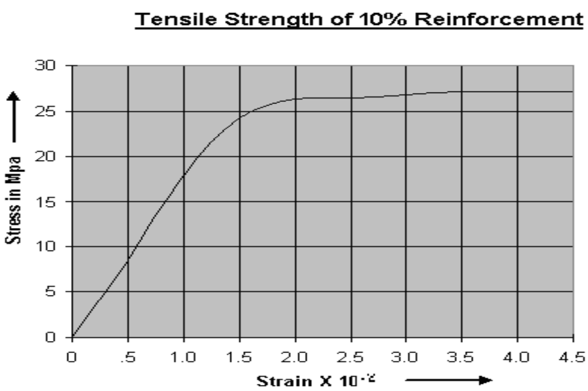

Fig.2 Stress v/s Strain curve for 10% WPC

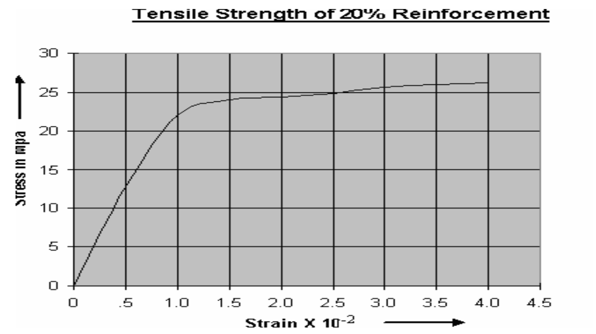

Fig.3. Stress v/s Strain curve for 20% WPC

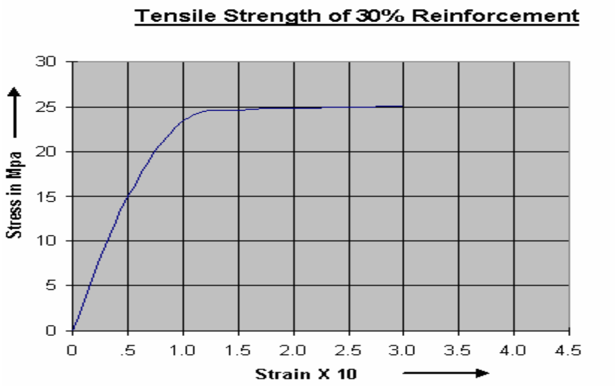

Fig.4 Stress v/s Strain curve for 30% WPC

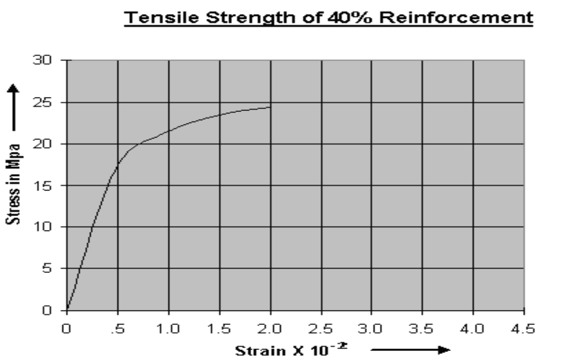

Fig.5 Stress v/s Strain curve for 40% WPC

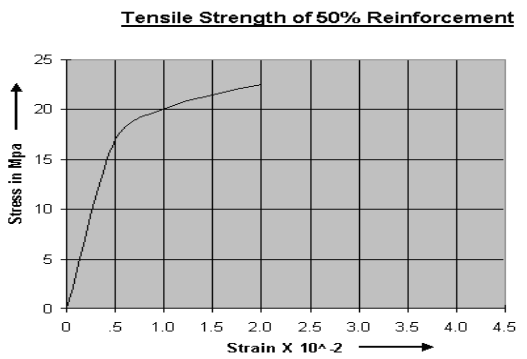

Fig.6 Stress v/s Strain curve for 40% WPC

Figure 2 to figure 6 shows that the stress is directly proportional to strain, when the load is applied, but the variation is not constant throughout. The stress strain relationship varies as the proportion of wood powder and polypropylene proportions. The measured tensile strength properties wood powder – polypropylene were determined and results obtained are shown in the graph. The tensile strength varies in case of wood powder – polypropylene material for different composition lies between 27.13 MPa to 22.65 MPa.

3.2 Chemical resistivity test

After exposure to seven different reagents for seven days, the specimens were examined for changes in physical properties, such as weight and dimensions, however slight changes in weight data and thickness (Table-1) of wood powder and polypropylene specimens were observed.

Table 1 Chemical resistivity test readings

Chemical name	Change in Weight (gm)					Change in Thickness (mm)				
	10%	20%	30%	40%	50%	10%	20%	30%	40%	50%
Sodium Hydroxide(NaOH)	0.03	0.02	0.02	0.00	0.07	0.0	0.05	0.02	0.00	0.02
Potassium permanganate(KmnO4)	0.01	0.04	0.01	0.07	0.10	0.02	0.06	0.03	0.02	0.07
Salt Solution(NaCl-10%)	0.01	0.01	0.04	0.00	0.07	0.07	0.05	0.00	0.00	0.02
Benzene	0.00	0.03	0.02	0.04	0.08	0.03	0.00	0.01	0.02	0.03
Ethyl Acetate	0.00	0.03	0.02	0.02	0.09	0.05	0.00	0.01	0.02	0.02
Hydrochloric Acid(HCl)	0.03	0.04	0.03	0.05	0.06	0.06	0.00	0.05	0.03	0.03
Nitric Acid(HNO3)	0.03	0.07	0.01	0.03	0.07	0.00	0.01	0.02	0.9	0.10

From the table-1, it is noticed that the changes in weight data show that the Wood-Polypropylene composite reacts with the reagents like Hydrochloric Acid, benzene, Ethyl Acetate and Nitric Acid very slightly and hence wood – polypropylene composite can be used for pump housing, impellers, valves bracket and load-bearings parts.

3.3 VICAT softening temperature

The VICAT softening temperature test results obtained by the VST equipment are tabulated for varying compositions of wood powder and polypropylene as shown in the table 2.

Table 2 VCAT softening temperature

% Of Reinforcement	VST °C
10	165
20	168
30	173
40	178
50	183

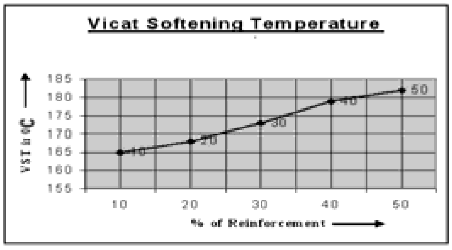

Fig.7 VICAT Softening Temperature for different % of WPC

The VST values of wood powder and polypropylene lies between 160^0 C and 185^0 C, the improvement in the VST was observed as shown in the figure 7. The increase in wood powder composition increases the VST.

4. CONCLUSIONS

- The results showed that the wood powder content influence tensile and flexural properties.
- The young's modulus of wood powder composites compared with pure polypropylene was higher or comparable.
- Tensile strength lowered on addition of wood powder.
- The addition of wood powder can result significant material cost savings, as wood powder is available at cheaper price than the expensive glass fibre and other inorganic additives.
- WPC offers a range of advantages against the main competing materials-wood and PP.

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