Studies On Twin Screw Compounding And Mechanical, Thermal & Electrical Properties Of Wood Flour Filled Abs

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ABSTRACT

ABS plastics was blended with wood flour (10,20 & 30%) using a Twin screw extruder. The mechanical, thermal and electrical properties of filled ABS were evaluated. In the mechanical properties, the flexural strength & modulus, hardness were found to be increased, while tensile strength, elongation at break, izod impact strength were lowered. In the thermal properties, melt flow index and flame resistance decreases while heat deflection temperature remains constant. The electrical properties like arc resistance, volume resistivity were also lowered due to the moisture absorbing characteristics of the wood flour. The density and water absorption were increased and the shrinkage was found to be reduced.

KEY WORDS : ABS, WOODFLOUR, TWIN SCREW COMPOUNDING, TESTING, PROPERTIES – MECHANICAL, THERMAL, ELECTRICAL PROPERTIES.

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1. INTRODUCTION

ABS is hard and tough material made from the combination of acrylonitrile, butadiene and styrene monomers. ABS is having very good impact strength, due to the butadiene content. ABS, also possess good chemical resistance due to the acrylonitrile repeat units. The styrene units provide the basic properties like hardness, rigidity, dimensional stability (1).

ABS is widely used in electrical & electronic housings like calculator housings, tape recorder housings, luggages, trays, etc. The blends of ABS with Polycarbonate (PC) is used for computer housings, portable mixer housings. The ABS with Polyvinylchloride (PVC) blends are useful as potable water pipes and electrical conduits. However the cost of ABS is higher than that of any of the commodity plastics. So our interest in this present study is to reduce the cost of the ABS by using wood flour.

Wood flour is a cheaper filler having good hardness and abundantly available from saw industries. Wood flour was used as a filler in High Density Polyethylene (HDPE) (2) and it was found that the mechanical properties like strength & modulus were increased. Wood flour also increases the mechanical properties of phenolic mouldings (3). The characteristics of wood flour was reported in the literature (4). Wood flour has lower density. It's general characteristics are excellent mouldability, good shock resistance with desirable electrical properties. Also posses good dimensional stability and water proof. The moulded products can be easily machined. Wood flour is a natural polymer obtained from tree plants. The tree plants contain about 50% cellulose which is bio-degradable. Hence the wood flour filled ABS will also be bio-degradable and eco-friendly. Also ABS contains unsaturated double bonds in the butadiene units which is photo-degradable. After / during photo – degradability of ABS resins in the outdoor, the bio-degradation will also taking place due to the wood flour. Hence, these materials will be considered as photo/ bio – degradable materials.

Natural fibre reinforced plastics are of more importance in the last few years. Wood plastics composites (WPC) are produced by thoroughly mixing of wood flour particles by melt blending with polymer resins. Wood plastics composites with

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either virgin or reprocessed plastics includes HDPE, LDPE, PVC, PP, PS and are reported in the literature. PE based WPC are by far the most common. Extruded WPC are formed into both solid & hollow profiles like decks. A large variety of injection molded parts also produced from automotive door panels to cell phone covers. PVC is self extinguishing, but has lower impact strength. ABS has better impact strength. Also, woodflour fibre filled ABS is not reported much. Hence, our interest in this present study is to blend the wood flour with ABS and evaluate their mechanical, electrical, thermal and physical properties.

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2. EXPERIMENTAL

2.1 Materials

ABS was to obtained from Bhansali Polymers Pvt. Ltd., Coimbatore. The melt flow index was 13.1 gms/ 10 min. The wood flour was obtained from a Saw mill industry in Chennai. Dioctyl Pthalate (DOP) was obtained from BDH Chemical Supplier, Chennai.

Methods

2.2. Twin Screw Compounding

A Twin screw compounding extruder (Nerstorrf, FRG) was used for the incorporation of filler in ABS. Initially a high speed mixer was used for the uniform mixing of filler with ABS in three compositions. The granules were thoroughly mixed with wood flour. 1% DOP was used as a sticking agent for wood flour with ABS granules, otherwise while mixing of wood flour with ABS granules, the wood flour was getting separated from ABS granules. The mixed raw materials were fed into the hopper of a twin screw compounding extruder.

In the Twin screw extruder, the wood flour was blended using the following temperature profile.

Zone	1	2	3	4	5	6	7	8	9	10
Temp. (^{0}C)	90	160	180	190	200	205	205	205	205	210

The extrudate was passed through a cooling water trough and then cut into granules which are used for making test specimens.

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2.3 Test specimen preparation and Testing

Test specimens were made as per ASTM D standards using, an injection moulding machine (Windsor SP 130). The temperature range in the barrel was 150 to 225^{0}C with an injection pressure of 20,000 PSI. The testings were done as per ASTM standards (5) for the following properties.

Mechanical Properties : Tensile strength, elongation at break, flexural strength & modulus, hardness, abrasion resistance.

Electrical Properties : Arc resistance, volume & surface resistivities

Thermal Properties : Melt flow index, heat deflection temperature, flammability

Physical Properties : Density , water absorption, shrinkage

The properties are reported in the Table I & Table II and also in figures 1 &2. The test specimens were conditioned as per ASTM D 618 at 23 ± 2^{0}C & 50 ± 5% relative humidity for 24 hrs.

3. RESULTS AND DISCUSSION

During the twin screw compounding of ABS with wood flour, the wood flour is not degraded or change into grey colour like other natural fibers such as bagasse. The results are given in the Tables I & II and in Figures 1-3.

TABLE – I Mechanical Properties of ABS & Wood Flour filled ABS

S.No.	Properties	Test Method ASTM	Unit	ABS 100%	10 % WF	20% WF	30% WF
1.	TENSILE STRENGTH	D 638	Kg/Cm^2	428.71	417.6	406.8	390.2
2.	ELONGATION AT BREAK	D 638	%	32.5	19.7	12.6	10.6
3.	FLEXURAL STRENGTH	D 790	Kg/Cm^2	619.38	641	642	643
4.	FLEXURAL MODULAS	0.790	Kg/Cm^2	21,995	25,718	29,282	41,738
5.	IZOD IMPACT STRENGTH	D 256	Kg-cm/cm	24	20	15.8	14.1
6.	ROCKWELL HARDNESS	D 785	R Scale	94	107	109	110
7.	ABRASION RESISTANCE	D 1044	Loss in grams/ 1000 cycles	0.067	0.073	0.075	0.078

Note : WF = Woodflour

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3.1 Mechanical Properties :

Tensile strength (Fig.1) of the filled materials are slightly reduced. Wood flour filled samples have slightly lower values than the Tensile strength value of ABS. The elongation was decreasing as the wood flour percentage was increased, due to the increase in rigidity and Hardness.

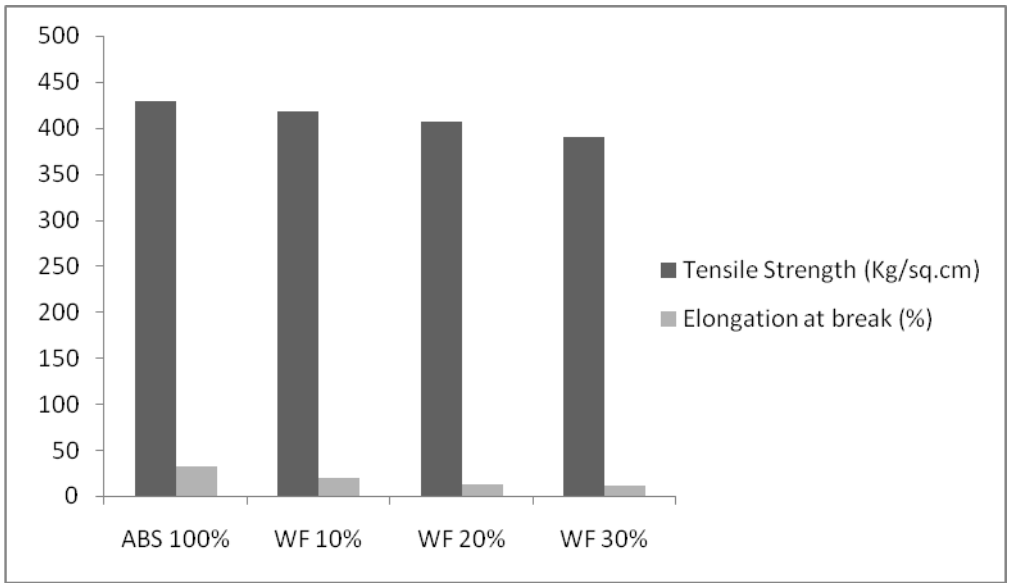

Fig 1 Tensile Strength & Elongation of ABS & ABS + Woodflour (10%,20%,30%)

The flexural strength (Fig 2A) & Flexural modulus (Fig 2B) were higher for all the formulations than that of ABS since the rigidity is higher due to the filler. The` Rockwell Hardness (R Scale) (Table-I) were also higher than that of ABS. But, the impact strength (notched) is lowered in all formulations (Fig 3). The impact strength can be improved by optimizing the process variable such as injection pressure, melt temperature, mould temperature and cooling time (6) to have better orientation of the polymer chains in the plastic products. The wood flour even though is a fibrous nature, it is not functioning like a rubber but behaves only like a particulate filler (4), hence, the impact strength was lowered (fig.3). Even though wood flour is having good scratch resistance, the abrasion resistance of the wood flour filled ABS were decreasing.

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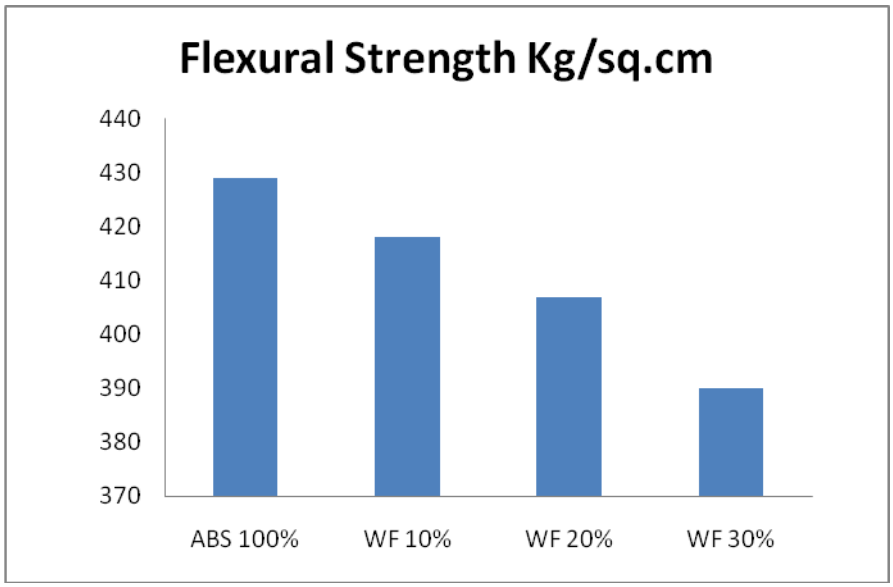

Fig 2A Flexural Strength ABS & ABS + Woodflour (10%,20%,30%)

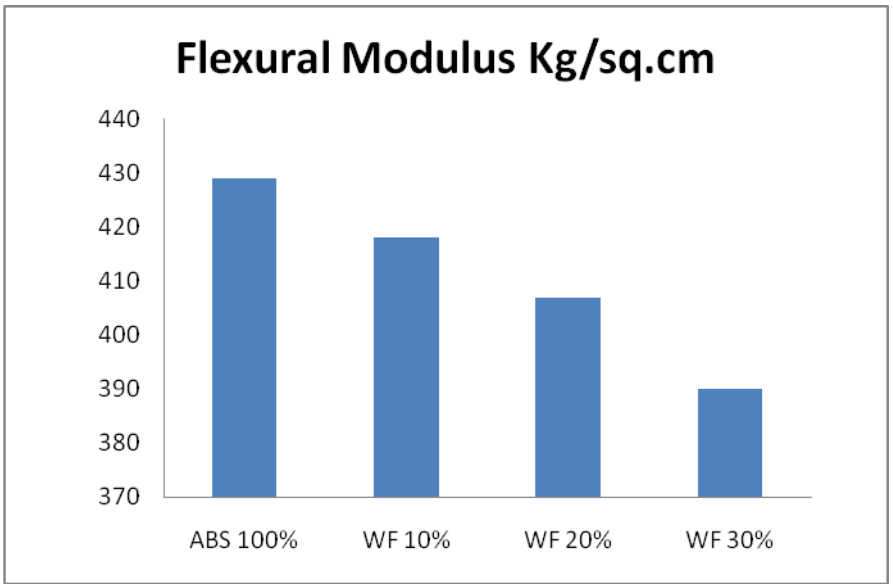

Fig 2B Flexural Modulus ABS & ABS + Woodflour (10%,20%,30%)

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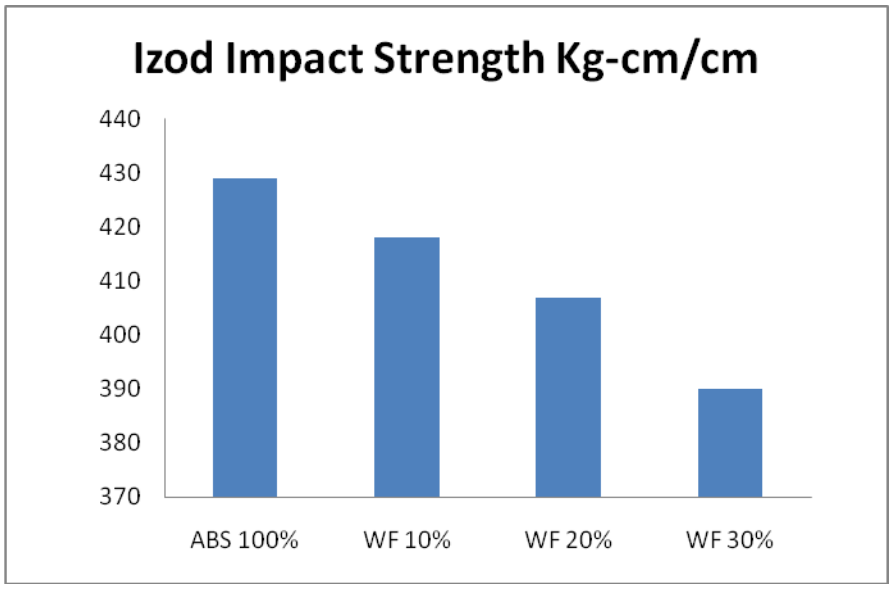

Fig 3 Izod Impact Strength of ABS & ABS + Woodflour (10%,20%,30%)

3.2 Thermal Properties

Since the rigidity & hardness is higher, the heat deflection temperature should be higher. But, the HDT values are slightly lower than that of ABS except for the 10% wood flour filed ABS which is similar to that of ABS (80 C) (Tab II). The MFI was lower than that of ABS since the particulate filler (wood flour) will restrict the flow of the ABS polymeric resins, so the above trend was obtained (Table-II). The wood flour was burning characteristics, so the flammability will be increasing. The average rate of burning as per ASTM D 635 standard was slightly higher for all the formulations that that ABS. if, flame retardants like Aluminium Trihydrate(ATH) is used in these formulations, the rate of burning can be reduced.

3.3 Electrical Properties

Due to hydrophilic nature of the wood flour the moisture absorption of the wood flour filled ABS will be higher. So the volume resistivity (Table-II) and surface resistivity were lower than that of ABS. Similarly, the Arc resistance was also lower for all the formulations (Table –II).

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TABLE – II Thermal, Electrical and Physical Properties of ABS & Wood Flour filled ABS

S.No.	Properties	Test Method ASTM	Unit	ABS 100%	10 % WF	20% WF	30% WF
1.	MFI	D 1238	gms/10 min	13.1	12.28	10.7	10.3
2.	HDT at 264 psi	D 648	C	80	80	78	75
3.	FLAMMABILITY	D 635	Cm/min	3.43	3.44	4.14	4.63
4.	ARC RESISTANCE	D 495	Secs.	181	132	126	109
5.	VOLUME RESISTIVITY	D 257	Ohm-cm	$3.39x10^{15}$	$3.39x10^{15}$	$2.12x10^{15}$	$1.41x10^{15}$
6.	SURFACE RESISTIVITY	D 257	Ohms	$6.4x10^{13}$	$2.7x10^{13}$	$1.07x10^{13}$	$7.2x10^{12}$
7.	DENSITY	D 792	g/cc	1.05	1.09	1.12	1.14
8.	WATER ABSORPTION	D 576	%	0.2	0.25	0.39	0.50
9.	SHRINKAGE	D 955	%	0.345	0.173	0.136	0.089

Note : WF = Woodflour

3.4. Physical Properties

The Density of the wood flour filled ABS was slightly higher than that of ABS (Table II). The water absorption of wood flour filled ABS was higher due to the hydrophilic nature of the wood flour (Table-II). The shrinkage of the wood flour filled ABS was lower than that of ABS. The filler, wood flour will reduce the formation of sink marks during molding the wood flour filled with ABS. So, the shrinkage was lowered in all the formulations.

Wood Flour filled ABS can be used for many applications depending upon end use requirements cheaper products like window panels, door panels which can be replacing the wood based products. Micro-cellular products can be made with blowing agents for making lighter weight from products like window panels & supports.

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Wood flour is a natural polymer obtained from tree plants. The tree plants contain about 50% cellulose which is bio-degradable. Hence the wood flour filled ABS products will also be bio-degradable and eco-friendly when disposed in environments. Also ABS contains unsaturated double bonds in the butadiene units which is photo-degradable. After or during photo-degradability of ABS resins in the outdoor the bio-degradation will also taking place due to the wood flour. Hence these materials will be considered as photo/biodegradable materials. Also these products can be recyclable or incinerated like other thermoplastics.

4. CONSLUSION:

The wood flour filled ABS was having higher flexural strength, flexural modulus & Rockwell hardness. The tensile strength was slightly lowered. However, the impact strength was much lowered because the rigidity was higher. However, the impact strength may be adequate for many applications. The flammability was increased. The arc resistance, volume resistivity were also lowered, since the water absorption was higher. The shrinkage was reduced due to the filler, wood flour. Cheaper products can be made with optimum mechanical properties with adequate electrical insulation and thermal properties using wood flour filled ABS material.

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