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Preliminary Studies on Reuse of Industrial Solid Waste- Case Study

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Abstract

In many of the optical product manufacturing industry, lenses for eyeglass are manufactured which are made up of polymer. So, the major component of waste generated in such type of industry is the polymer powder waste. Polymer is generally considered as inert material, it requires millions of years to decompose. The waste generated by this type of industries causes harmful effect on environment. The purpose of the study is to determine the Characteristics of waste generated and to find a suitable way to reuse the waste as filler in blending Wood Plastic Composite (WPC). Characterization of waste was carried out by SEM and XRD analysis. The sample was analyzed for the following parameters pH, conductivity, density, moisture content, solubility and the mechanical properties such as tensile strength and flexural yield were determined. It was found that the waste can be reused as partial filler material in blending WPC.

Keywords: *SEM, XRD, Wood Plastic Composite, Polycarbonate, Polypropylene, Wood fiber, Coupling Agent, mechanical properties.*

1. Introduction

Polymer is generally considered as inert material, it requires millions of years to decompose. Waste polymer powder is being used for land fill or it is incinerated. Today, discarded waste polymer has become a substantial burden on the landfills throughout the world and incineration though reduces the volume of waste and occupies less space, it causes atmospheric pollution. In many of the optical product manufacturing industry, lenses for eyeglass are manufactured which are made up of polymer. So, the major component of waste generated in such type of industry is the polymer powder waste. The waste generated by these type of industries causes harmful effect on environment. Therefore, recycling or reuse of polymer waste is one of the best ways to reduce the impact of environmental damage caused by waste. This study includes Characterization of the waste and study on reuse of waste as partial filler material in blending WPC. By this the negative impact on environment can be reduced.

2. Material and Methodology

The polymer sample used in this study was taken from one of the optical products manufacturing industry representative samples were taken. Waste was characterized by Scanning Electron Microscopy (SEM) and X-Ray Diffraction (XRD) analysis. Physical and chemical properties were carried out on the sample as per the standards. In order to study the effects of adding polycarbonate (PC) on the physical and mechanical properties of Wood Plastic Composite (WPC); composites were blended at varying wood content for 20% and 30%, varying polycarbonate content for 10% and 20%, varying Polypropylene (PP) content for 45%,55% and65% using coupling agent(CA) Maleic Anhydride Grafted Polypropylene (MAPP). Coupling agent concentration was kept at 5% to the weight of wood and 1% of additives (wax and Titanium dioxide). Formulations used for making composites are shown in the table 1.

2.1 pH Value:

The test method followed is as per IS:3025 (Part II)–1983. pH value was determined by using pH meter. pH values give whether the sample is acidic or alkaline in nature.

2.2 Conductivity, Density:

The test was carried by referring IS method.

2.3 Moisture content:

The test was carried by referring IS method. Moisture content has been determined by using gravimetric method.

2.4 SEM and XRD:

Morphology and composition of waste was determined by SEM and XRD analysis.

2.5 Wood sieving:

Untreated latana wood was purchased from the local market. It was ensured that the wood material free from any defects and fungal mould growth. The wood material was converted into chips using small scale wood chipper. The chips were dried in an oven for about 24 hours at 105^{0}c and then pulverized to fine particles. The wood powder was then used for compounding of latana wood plastic composite

Table 1: Formulations for composites preparation

Polycarbonate	Polypropylene	Wood fiber	Coupling agent
10%	65%	20%	5%
10%	55%	30%	5%
20%	55%	20%	5%
20%	45%	30%	5%

2.6 Preparation of composite:

Compounding of latana wood plastic composites was done using a 28mm co-rotating twin screw extruder. The extruder had six heating barrels. Temperature profile was kept from 150^{o}c to 165^{o}c throughout the experiments. The srew design and temperature profile of different section is shown in figure 1. Extruder system was started with pure pp at 110 rpm. After reaching steady conditions, feed was replaced with the pre mixed mixture of pp granules, wood powder, coupling agent, polycarbonate and additive. The product was recovered as strands of composite, passed through the water bath and subsequently fed to palletizer to obtain 3mm length granules. Palletized granules were oven dried at 85oc for about 24 hours. Composite granules were then injection molded according to ASTM standards for determining the mechanical properties.

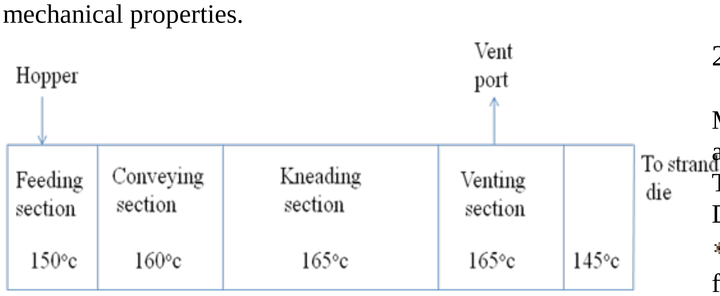


Fig. 1: Screw design and temperature profile of different sections

2.7 Sample preparation:

Composites were moulded into standard ASTM type specimen (ASTM D638 for tensile and D790 for flexural tests) using 60 ton L & T Demag make microprocessor controlled, closed loop injection molding machine. The temperature profile for moulding for composites are shown in table 2. The injection pressure was set at 80 bars and injection speed was set at 100 mm/s.
The prepared samples were left for cooling for about 24 hours before testing.

Table 2: Injection moulding parameters for moulding composite

Filler content	Feed zone (^{o}c)	Barrel 1 (^{o}c)	Barrel 2 (^{o}c)	Barrel 3 (^{o}c)	Nozzle (^{o}c)	Cooling time (sec)
Pure pp	60	155	160	160	175	60
20% wood	60	165	170	170	175	60
30% wood	60	165	170	170	175	60

Fig. 2: Injection molded tensile and flexural strength specimen

2.8 Mechanical testing:

Mechanical tests (tensile and flexural) were performed using an universal testing machine (model AGIS10, 10 KN). Tensile tests were conducted in accordance with ASTM D638-94b, using specimen type 1 (dimension- 164.08mm * 13.5mm * 3.4mm). crosshead speed was 50mm/min. flexural strength was determined as per ASTM D70-92 with a support span of 100mm and a crosshead speed of 2.8 mm/min. specimen for flexure test had the dimension 126.58

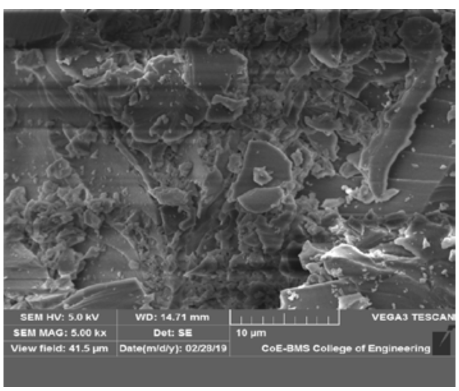
mm* 12.8mm * 6.68mm for each tests five replicates were tested.

3. Results and Discussion:

Table 3: Physical and chemical properties of waste sample

Form	Amorphous
Colour	White
pH	7
Conductivity	69 microsemin
Density	1.3 g/cm3
Moisture Content	36.3%
Solubility in distilled water	Not soluble
Solubility in 1N HCL	Not soluble
Solubility in 1N H2SO4	Not soluble
Solubility in 1N NaOH	Partially soluble

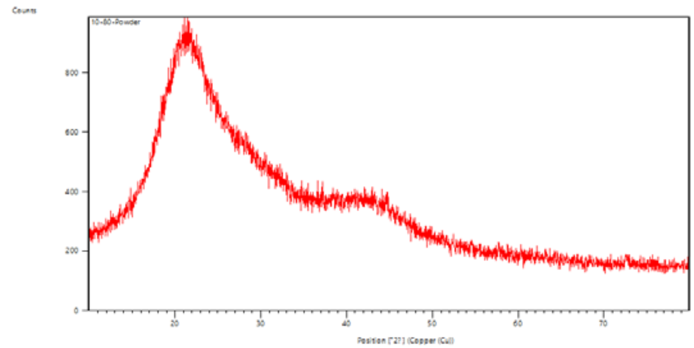
Fig.3: SEM Analysis of waste



SEM images of sample

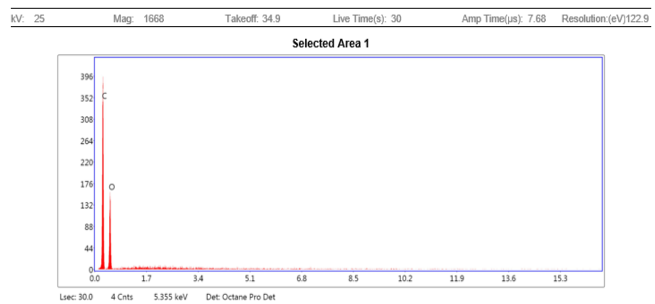
It was found that the waste is in amorphous form.

XRD Analysis



From the graph we can say that the waste contains compound made of carbon and oxygen

EDAX (Energy Dispersive Analysis X-Ray) Analysis



eZAF Smart Quant Results

Element	Weight %	Atomic %
C K	59.33	66.02
O K	40.67	33.98

Result of EDAX:

Weight% and atomic% of various elements present in the sample is determined.

Table 4: tensile strength of the prepared sample (10% PC, 65% PP, 20% Wood and 5% CA)

	Tensile strength (N/mm^2)	Chord (N/mm^2)
Mean	24.3530	1407.80
Standard deviation	0.74446	15.3992

Table 5: tensile strength of the prepared sample (10% PC, 55% PP, 30% Wood and 5% CA)

	Tensile strength (N/mm^2)	Chord (N/mm^2)
Mean	26.5284	1755.53
Standard deviation	0.91942	48.1327

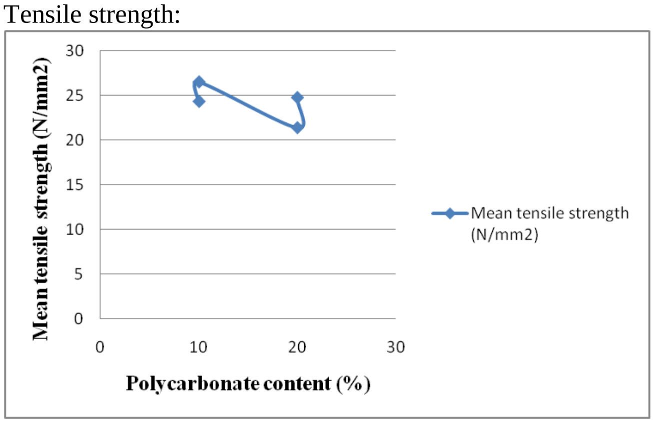
Table 6: tensile strength of the prepared sample (20% PC, 55% PP, 20% Wood and 5% CA)

	Tensile strength (N/mm^2)	Chord (N/mm^2)
Mean	21.4282	1544.41
Standard deviation	1.32753	93.7998

Table 7: tensile strength of the prepared sample (20% PC, 45% PP, 30% Wood and 5% CA)

	Tensile strength (N/mm^2)	Chord (N/mm^2)
Mean	24.7795	1915.22
Standard deviation	1.35084	113.569

Tensile strength:



Inference: The above graph shows the variation of tensile strength (N/mm^2) with varying in polycarbonate content (%). As the percentage of PC was increased there was decrease in tensile strength. It was found that at 10% PC, 55% PP, 30% Wood and 5% CA there was increase in tensile strength (26.5284 N/mm^2).

Table 8: Flexural yield of the prepared sample (10% PC, 65% PP, 20% Wood and 5% CA)

	Flexural yield (N/mm^2)	Elastic (N/mm^2)
Mean	36.0768	1506.50
Standard deviation	0.43875	58.5820

Table 9: Flexural yield of the prepared sample (10% PC, 55% PP, 30% Wood and 5% CA)

	Flexural yield (N/mm^2)	Elastic (N/mm^2)
Mean	339.5512	2102.03
Standard deviation	0.43128	125.521

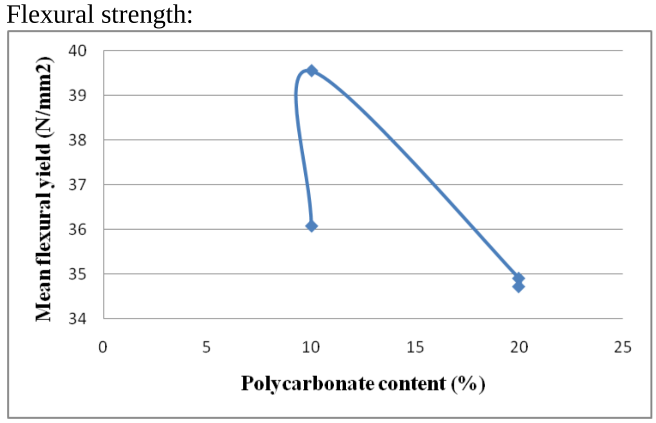
Table 10: Flexural yield of the prepared sample (20% PC, 55% PP, 20% Wood and 5% CA)

	Flexural yield (N/mm^2)	Elastic (N/mm^2)
Mean	34.722	1809.31
Standard deviation	2.68475	150.636

Table 11: Flexural yield of the prepared sample (20% PC, 45% PP, 30% Wood and 5% CA)

	Flexural yield (N/mm^2)	Elastic (N/mm^2)
Mean	37.9062	2222.27
Standard deviation	1.14904	148.157

Flexural strength:



Inference: The above graph shows the variation of flexural yield (N/mm^2) with varying in polycarbonate content (%). As the percentage of PC was increased there was decrease in flexural yield. It was found that at 10% PC, 55% PP, 30% Wood and 5% CA there was increase in flexural yield (39.5512N/mm^2).

4. Conclusions

From the results obtained from the study, it can be concluded that the polycarbonate can be reused in blending WPC. It was also shown that with the addition of PC there was increase in both tensile and flexural strength of the specimen. According to the test results a mixture of PC of 10%, polypropylene of 55%, wood fiber of 30% with 5% of coupling agent can be used as partial filler material in blending WPC. Reuse of polymer waste (PC) in blending WPC provides an economic contribution and also helps to protect the environment. It seems to be one of the feasible way to utilize the waste polymer.

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