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Effect of Calcium Carbonate ($CaCO_3$) on Mechanical Properties of Polypropylene (PP) Reinforced Rice Husk (RH)

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Abstract

In this work, ground rice husk reinforced polypropylene was manufactured to investigate the effect of carbonate calcium with different ratio of rice husk (RH) on the mechanical properties such as (hardness, impact resistance and tensile strength) of polypropylene (PP). RH was added in the PP as filler with the variation of weight percentage (2%, 4%, 6% and 8%) and used constant ratio of calcium carbonate (5%) . These properties were estimated. The results show that the (hardness, impact resistance and tensile strength) reduced with the increased of filler content until 6% from weight percentage of RH and after that increased. calcium carbonate improved the mechanical properties of polypropylene at weight percentage (6% wt RH).

Keywords: Polypropylene (PP), Rice husk (RH), $CaCO_3$, Mechanical properties.

INTRODUCTION

The utilization of composite materials are economical and efficient for many engineering applications. Matrix materials in polymer composites consist of thermo-plastics or thermo-sets. whilst several kinds of fibers are used as strengthened filler in the composites . So the thermoplastic resins reflected much interest because of their mechanical advantages as intrinsic recyclability, easy fabrication, good moisture resistance and high toughness. Fibers improve the mechanical properties for the polymer composites [1,2,3]. Many of agricultural crop remnant are produced about the world each year. Little amount of these residues are used as fertilizer or domestic fuel and the remainder scald in the agricultural field. Thus produce air pollution. As a result, this problem can be solved by using these residues to strengthening polymer composites. Natural fibers are one of the important materials which can used instead of artificial materials for the energy maintenance and least weight applications. The applications of these fibers such as construction, automobile, packaging, different load bearing and storage devices applications. They are biodegradable, vastly available, environmentally cordial, low density and cheap[4,5,6].

LITERATURE REVIEW

The used of rice husk as strengthening for plastic composites by analyzing its uses, properties and application as well as the process involved is investigated by **Nwosu-Obieogu Kenechi**.[7].

According to **Mohd Shahril Ezuan Mustapa** the effects of maleic anhydride grafted polypropylene (MaPP) and Ethylene 1-octene copolymers (EOC) on the mechanical characteristic of polypropylene rice husk composites. The outcome from experimental work shows the flexural strength improve about 35% when blend 4 wt% (MaPP) with 30 wt% rice husk. While 20 wt% (EOC) in the composites show increased impact properties for the compound but decreased the flexural modulus[8].

Rice husk reinforced polypropylene-based composites with sodium hydroxide (NaOH) solution (1wt%) as treated were prepared by **Ismat Z. Luna**, to research the mechanical properties of the composites after addition of (NaOH). The results show improvement the mechanical properties of these composites [9].

EXPERIMENTAL WORK

Matrix Material:-

Polypropylene pallet used as the matrix material with a melting temperature (160^{o}C) and density (0.9 g/cm^3). The important properties of PP are presented in Table 1.

Table 1 Polypropylene property

Elongation (%)	200–700
Tensile modulus (105)	1.6–2.3
Burning rate	Slow
Effect of alkalis	Resistant
Effect of organic solvents	Resistant below 80 °C
Clarity	Opaque
Specific gravity	0.90–0.91

Rice Husk (RH):-

The rice husk fiber was used in weight percentages (2,4,6 and 8%) from the rice storage fields in Hilla city. This fibers

consist of 75-90% organic substance such as cellulose, lignin etc. and the remainder mineral ingredients such as alkalis, silica and trace elements. While other constituents of these fibers are available with bulk density of 96-160kg/m^3 and less than 1% of rice husk (RH), such as Al_2O_3, K_2O, CaO, Na_2O, MgO, Fe_2O_3[10].The granular size is 600 µm.

Composite Fabrication:-

The rice husk fibers were separated from undesirable foreign materials by washing process. RH was sun dried for three days and then ground with hand grinding machine. The ground rice husk was then sieved to get very smooth fine textured particles with granular size 600 µm . After that the different ratio of ground RH were stirred with 5 % concentration of calcium carbonate ($CaCO_3$) and soaked for 2 hours. The next process was drying the rice husk in oven at 110°C for 1 hours to expel humidity. PP pellets and RH were mixed at various percentages as shown in (Table 2). After that this mixture were blended by using twin screw extruder with a screw speed 15 rpm at 160°C for 10 minutes. Then the extrusion process was repeated for three times to obtained on the homogeneous blending of the RH and PP. The hot pressing was the last stage of the fabricated composites in this work. Hot pressing was achieved for 5 minutes at 150ºC, finally cooled the mixture under room temperature to cut according to ASTM standard for mechanical testing.

Table 2: Composition details for samples.

Samples of Composites	Composition (weight %)	
	Polypropylene (wt.%)	Rice Husk (wt.%)
S1	100	0
S2	98	2
S3	96	4
S4	94	6
S5	92	8

MECHANICAL PROPERTIES

Hardness test:-

Shore D was uitalized for calculating the hardness of the specimens, thickness of samples at least more than (3mm) which must have smooth surface and not be exposed to mechanical vibrations therefor the prepared samples according to ASTM (D 2240). The shore D device involve aneedle that is positioned vertically to the specimen for period about half aminut.To register an accurate reading, the average of three values measured from various sites of each specimen is estimated.

Impact test :-

Charpy impact test involve the use of hammer blow that will be delivered to the sample until reaches to breaking point. The sample is positioned in such away that both of it's ends are fixed in position and the blow is dielvered to the middle part. Samples of impact device has a dimensions of (10*55*3mm)according to ASTM (D4812). The apparatus used in this test is manufactured by (Testing Machines ,Inc , Amityville New York). The following equation can be used to calculate the impact strength (I.S.):

I.S. =Uc/A

Uc: the fracture energy (Joule) from Charpy impact device.

A: the area of the samples (m^2) (cross-sectional).

Tensile test:-

The WDW-5E machine used to perform the tensile strength tests. The specifications of this machine are:-

- Load cells: 0.5 - 5 KN.
- (0.5 - 500 mm/min) crosshead speed.
- (500 mm/min) return speed.
- (0.1%) crosshead speed accuracy.
- Testing type: tension and bending.

The speed (5 mm/min) and load (5KN) were used in this test.

RESULT AND DISCUSSION

Hardness test: -

Hardness test was performed using shore D. The influence of rice husk percentages on hardness values are shown in fig.(1). Figure (1) show that the rice husk content until (6 wt% RH) will decrease the hardness of the substance due to elastic deformation i.e. the bonding between the molecules become irregular. As the stiffness of this composite is lower than neat PP, so composites became soft than neat PP this finding is in agreement to **Ismat Z. Luna** [9]. After (6% RH) the hardness value increased because of the stiffness composite increment, this similar with results which reported by **Kannan Rassiah** [11].

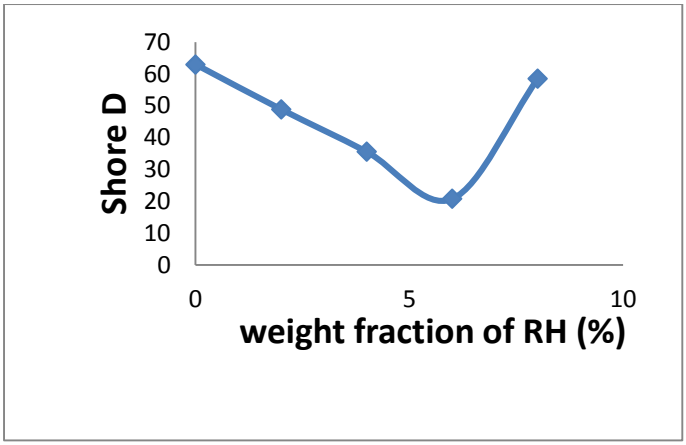

Figure (1): The effect of rice husk (RH) weight fraction on the shore D hardness.

Impact test:-

Impact test was carried to the samples by charpy method at room temperature. Figure (2) show the impact strength is reducing when rice husk percentage increase until (6%RH) in composite. It is similar to studies by **M. Razavi** [12]. After (6% RH) the impact strength value increased because of the stiffness composite increment.

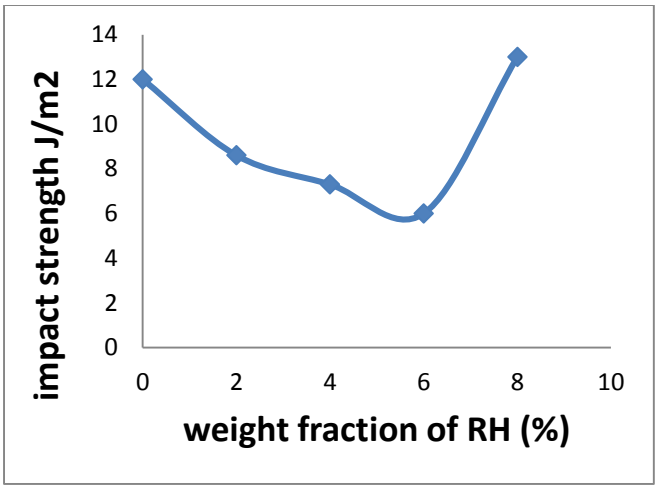

Figure (2): The effect of rice husk (RH) weight fraction on impact strength.

Tensile test:-

Tensile test was achieved to the samples by tensile test machine. Figures (3) and (4) show the effect different ratio of rice husk on tensile strength and elastic modulus. Fig (3) shows the tensile strength reduced for the specimens with increment of rice husk ratio. Because when the rice husk ratio increase the stress concentration increment and effective matrix cross section reduction. It is similar to studies by **R. Santiagoo** [13]. But after (6 wt% RH) show improvement in tensile strength and that return to the compatibility of $CaCO_3$ with RH in the composite.

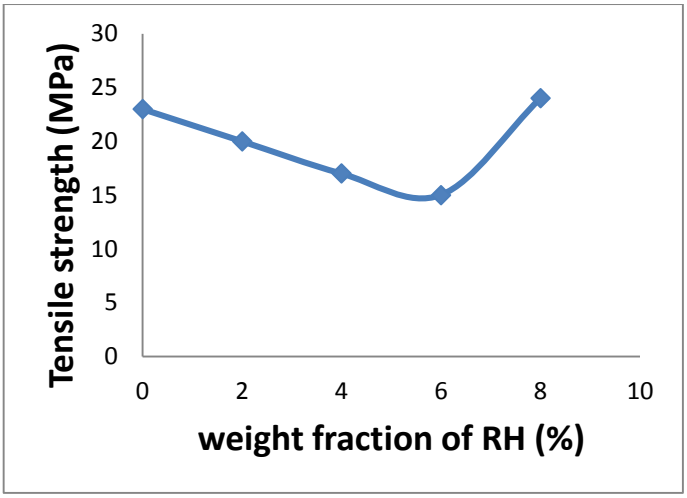

Figure (3): The effect of rice husk (RH) weight fraction on tensile strength.

Whereas figure (4) displays increment in elastic modulus for samples with increasing rice husk ratio. Due to the addition of these fibers to composites tends to strongly increase in rigidity. Some authors have also related the increase in composites rigidity with the reduction of polymer chains movement in the presence of these fibers.

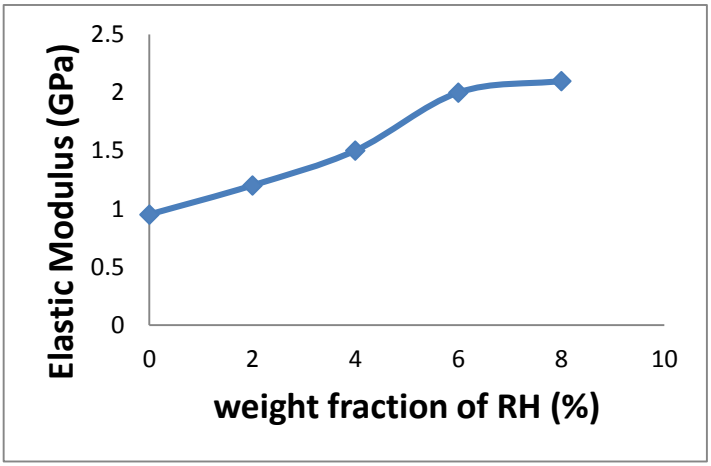

Figure (4): The effect of rice husk (RH) weight fraction on elastic modulus.

CONCLUSIONS

This experimental investigation on mechanical properties (hardness and impact resistance and tensile strength) of PP/RH composites treated by $CaCO_3$ have led to the following specific conclusions:

1- The (tensile strengths, hardness and impact resistance) slightly reduced, however they were improved in the presence $CaCO_3$ after (6 wt%RH) .

2- Calcium carbonate ($CaCO_3$) coupled composites showed more homogeneous morphology due to the better compatibility among the filler and the matrix.

3- The best percentage of RH was after (6wt.%), this percent suitable to use in different applications.

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