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EFFECT OF FILLER LOADING ON PHYSICO-MECHANICAL PROPERTIES OF POLYPROPYLENE FILLED WITH HURACREPTAN PODS COMPOSITE

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ABSTRACT

This work focused on the effect of filler loading on physico-mechanical properties of polypropylene filled with huracreptan pods composite. The composite samples were prepared by compounding and compression method according to the following compositions of polypropylene filled to huracreptan pods: 100:0, 90:10, 80:20, 70:30 60:40, and 50:50, in grams. The prepared samples were characterised in terms of their tensile strength, compression set hardness and impact strength. Results showed that huracreptan pods improved the tensile strength, compression set, hardness and impact strength of polypropylene composites. The result showed a drastic reduction in hardness at 30 wt% of 88 shore A, the compression set increased with increasing filler loading from 0 to 50wt% with 1.9 to 3.4%, the impact strength shows an irregular decreasing trend but 30 wt% and 50 wt% gave the highest impact of 0.6 J respectively, the water absorption was found to increase with filler loading up to 40 wt% (0.0 to 0.4%) but decrease at 50 wt% (0.3%), the tensile strength also decreased with increasing filler loading from 0 wt% to 50 wt% (0.855 to 0.656 N/mm^2). However, comparing the properties of the virgin polypropylene sample to the polypropylene filled with huracreptan pods, the properties of the filled composite is better than the unfilled polypropylene sample which is an indication of reinforcement and interfacial interaction between the polymer matrix and the filler. It can be therefore concluded that huracreptan pods is suitable for the production of polypropylene composites.

KEYWORDS

Huracreptan, polypropylene, tensile strength, impact test

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INTRODUCTION

From time immemorial man has always strive to make use of available materials at his disposal to better the environment around him and the society in general (Acvi & Dik, 2014). These efforts had led to various research works being carried out for decades by trying to find alternatives or substitutes for some material that appear to have outlived their existence. Composite materials are gaining popularity and great attention in the field of materials science and engineering. This is due to the fact that the synergism formed between the matrix and reinforcement produces materials with properties uniquely different from the individual constituent materials. The wide variety of matrix and strengthening materials allow the designer of the product or structure to choose an optimum combination of material properties.

The rising concern towards environmental pollution and control and on the other hand, the need for more versatile polymer-based materials has led to increasing interest in polymer composites filled with natural or organic fillers, i.e. fillers coming from renewable sources. These composites, can find several industrial applications (Antunes *et al.,* 2009). In addition, composite materials thus produced could be beneficial to many sectors particularly automotive sector due to increasing interests on energy efficiency and environment safety (Bledzeki *et al.,* 2008). There has been little development in the use of natural fibre or particulates reinforcement materials for polymeric composites (Chandramoha & Manninmathu, 2011).

Though findings have shown that natural fillers reinforced polymeric material provide material engineers with new groups materials that offer exceptional combination of mechanical properties that make them equivalent to steel application. Synthetic polymers such as isotactic polypropylene (i-PP) substitute metals in an increasing number of engineering applications. In the automotive sector, for example, polymers are favoured due to weight saving and hence fuel reduction. Moreover, polymers can be moulded at high speeds and low costs into complexly shaped parts. However, for many applications, the polymeric materials have to be reinforced to meet the demands on stiffness and strength. Often, continuous or short glass fibres are the reinforcing components. Unfortunately, glass fibres cause environmental problems in both mechanical as well as thermal recycling (incineration).

With increasing concern over the severe limitation of replacement of common polymers, polypropylene in greater amounts of its noticeable higher cost for this reason polypropylene is

often blended with cheaper bio-filler not only to reduce the overall cost but it is also results in decrease of the inherent brittleness and rigidity as well improvement of material ductility. In the hot-compaction process, i-PP fibres or tapes are consolidated by selective surface melting, and 'All-PP' composites are obtained possessing a high volume fraction of reinforcing components. These composites can be re-used via recycling and consequently environmental issues related to waste disposal are largely avoided. However, the present research objectives will focus on study of physico-mechanical properties of composites of polypropylene (PP) reinforced with huracreptan pods.

MATERIALS AND METHODS

Materials

Table 1: Materials and their sources

S/N	Materials	Sources
1	Polypropylene	NILEST, Zaria
2	Huracreptan pod	FGGC, Zaria
3	Lubricant (processing oil)	NILEST, Zaria

Equipment

The equipment used in the course of this research work is listed in Table 2 below.

Table 2: Equipment and their sources

S/N	Equipment	Manufacturer/Model	Sources
1	Two-Roll Mill	Reliable Rubber and Plastics Machinery Company, New Jersey, USA (Model 5189)	NILEST, Samaru – Zaria.
2	Hydraulic Hot Press	Carver Inc., Wabash, U.S.A (Model 3851-0)	NILEST, Samaru – Zaria.
3	Impact Tester	Ceast, Model 6957	NILEST, Samaru – Zaria.
4	HardnessTester	Muver Franscisco, Munoz Irles. (Model 5019)	NILEST, Samaru – Zaria.

Apparatus

The apparatus used in this work are weighing balance, stop watch, scissors, saw blade, molds, beaker**,** sieve with particle size 72µm.

Methods

Preparation and Characterization of Bio-Filler

Characterization:

The filler, which is huracretan pods particle was respectively prepared and characterized as follows:

Preparation of Sample:

The sample preparation was discussed according to the following processes.

- Processing of bio-filler (huracreptan pods)
- Compounding/Mixing of composite

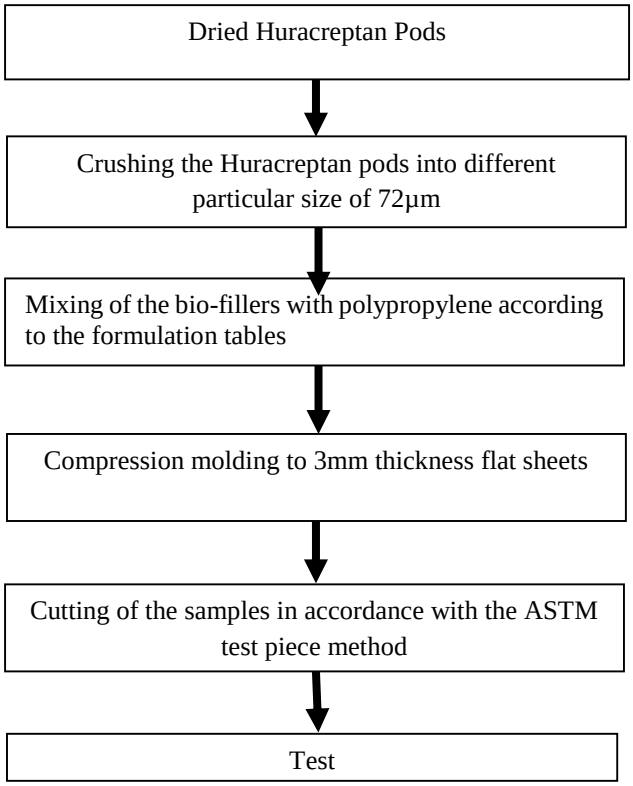

Figure 1: Processing of bio-fillers

Preparation of Polyproplene filled Huracreptan Composite:

The bio-fillers (huracreptan pod) particles of 72µm was mixed with the polypropylene resin using five filler loadings of 10%, 20%, 30%, 40% and 50% of the bio-fillers to produce the composites

using a two roll mill for compounding at 170°C. Also, a specimen of virgin polypropylene resin without the bio-fillers was produced to serve as control sample. After the compounding, on the two roll mill, the samples were compressed using the compression moulding machine with the help of the mould.

Formulation Tables

Table 3: Formulation table with particle size 75µm for huracreptan

S/No	1	2	3	4	5	6
SAMPLES	A	B	C	D	E	F
PP(%)	100	90	80	70	60	50
H. Creptan (%)	___	10	20	30	40	50

Mixing of Polypropylene with the Huracreptan pods (bio-fillers):

The mixing was done according to the ASTM method. The two roll mill was switched on and allow to pre-heat until it attained 170^0C, then the nip of the rolls was adjusted and tightened before the granules of the virgin polypropylene was fed in between the nip of the rollers. After total melting of the polypropylene, the filler (huracreptan particles size of 72µm) was added and cross-mixed diagonally. After the interfacial interaction between the polypropylene and the filler the nip of the rollers was adjusted to a desired thickness and the compounds were sheeted out for all the formulations.

Physical-Mechanical Test

i. Impact strength (ASTM D- 256)
ii. Water uptake (ASTM D- 570-98 (2005)
iii. Tensile test (ASTM D412)
iv. Hardness test (ASTM D412, 1983).
v. Compression Set (ASTM D395, 1983)
vi. Water Absorption Test (ASTM D- 570-98 (2005)

RESULTS AND DISCUSSION

Physico-mechanical Test

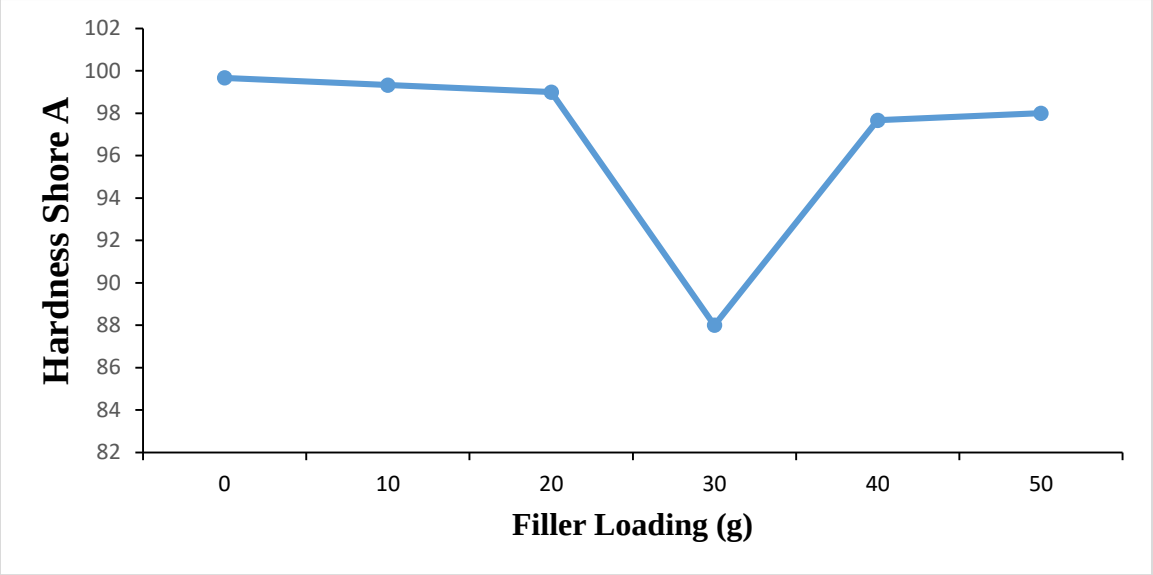

Figure 2: Hardness test (ASTM D412, 1983)

Figure 2 shows the effect of filler loading on the hardness test of polypropylene filled-huracreptan pods composites. Hardness as measured in the study is the relative resistance of the surface of the samples to indentation by an indentor of specified dimension under a specified load. It is generally known that fillers increase the hardness of polymer materials. From the results obtained, the hardness decreases from 99.67 Shore A to 88.00 Shore A. This result is expected because as more filler gets into the polypropylene matrix, it helps to reduce the brittleness of the polymer thereby reducing the hardness too and improve ductility of the composite.

However, the drop in hardness at 30% beyond the optimal threshold is a result of reduced interfacial interaction between the filler particles and the polypropylene matrix. This weak cohesion between filler and resin generally weakens the composite and have been shown to negatively impacts virtually all mechanical properties of the composite of which hardness is

inclusive as reported by Thomas *et al*. (2012). Furthermore, the presence of the filler may have improved the matrix surface resistance to indentation as reported in Li *et al*. (2007). The increase in hardness of the materials with increase in filler loading may be as result of irregular distribution that caused the formation of agglomeration in the composites.

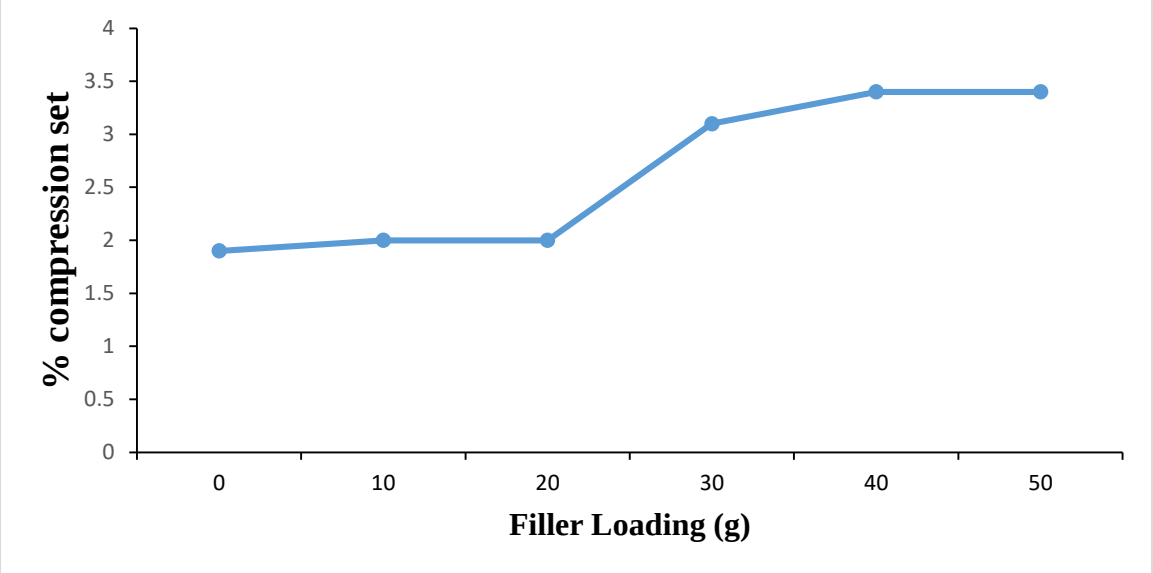

Figure 3: Compression set

Figure 3 shows the results obtained for the effect of filler loading on the compression set of polypropylene filled-huracreptan pods composites. From the results obtained, it can be seen that the filler loading increased, the percentage (%) compression also increases. But in the case of sample B and C with filler loadings of 10 wt% and 20 wt% respectively, the percentage (%) compression set is the same with 2.0% increment and the same was applicable to sample 5 and 6 with the filler loading 40 wt% and 50 wt% with 3.4% increment.

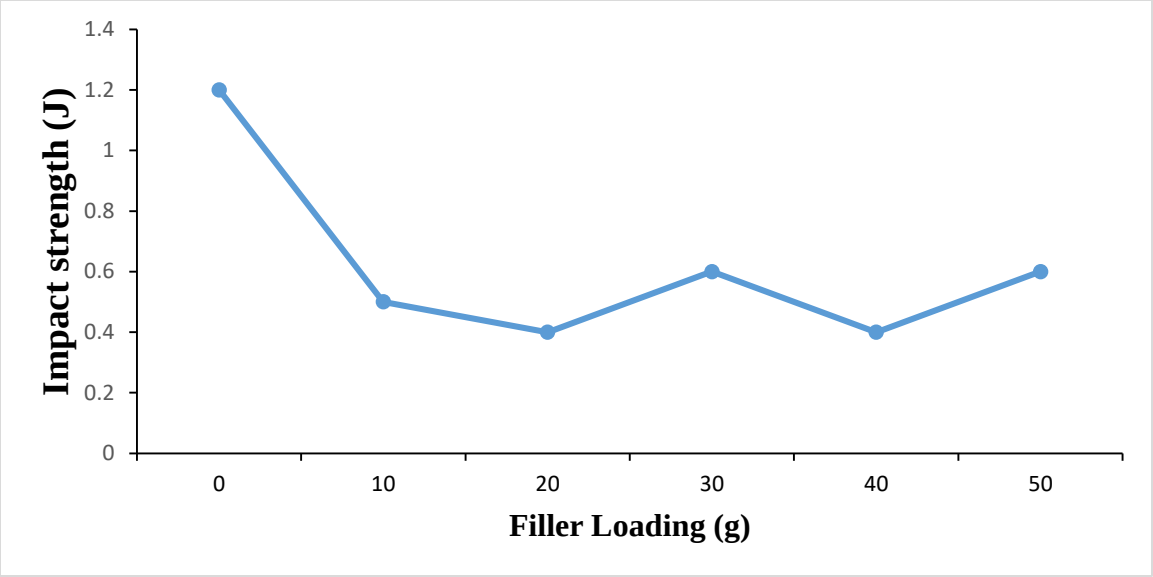

Figure 4: Impact strength **(**ASTM D- 256**)**

Figure 4 shows the effect of filler loading on the impact strength of polypropylene filled-huracreptan pods composites. The result shows that the control sample has the highest impact strength of 1.2 J/mm, which reduced to 0.5 J/mm at 10 wt%, the 30 wt% and 50 wt% has similar impact value of 0.6 J/mm. The impact strength shows that the increase in huracreptan pods leads to decrease in impact strength. This trend could be traced to the particle size (72µm) of the filler, improving the core of the matrix as reported in Migneaut *et al.* (2008).

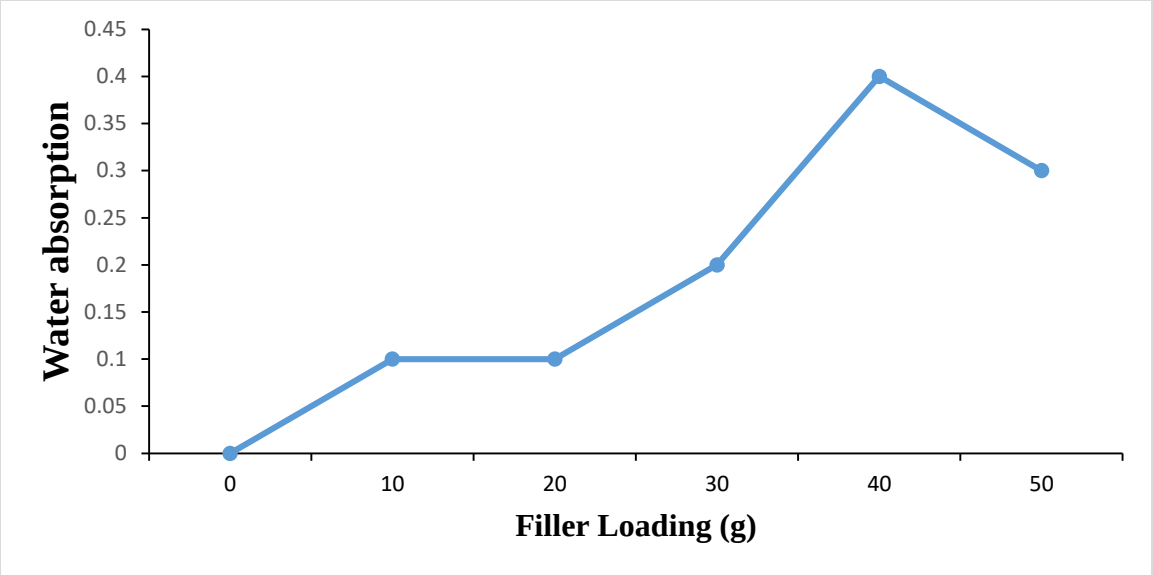

Figure 5: Water uptake (ASTM D- 570-98 (2005)

Figure 5 Shows the effect of filler loading on the water absorption of polypropylene filled-huracreptan pods composites. The result indicates clearly that control sample did not absorb water while the remaining samples absorbed water to small extent from sample B (10 wt%) of 0.1%, sample C (20 wt%) of 0.1%, sample D (30 wt%) of 0.2%, to sample E (40 wt%) of 0.4% but dropped at sample F (50 wt%) of 0.3%. The absorption observed could be traced to the hydrophilic nature of the filler Muhammed *et al*. (2013). Increase in moisture/water absorption leads to weakening of the interfacial bond, thus causing a reduction in the mechanical properties of the composites. Decreased with the incorporation the huracreptan pods. More huracreptan pods in the composite thereby indicates a greater susceptibility of the composite to moisture intake as reported in Venkateshwaran *et al*. (2019).

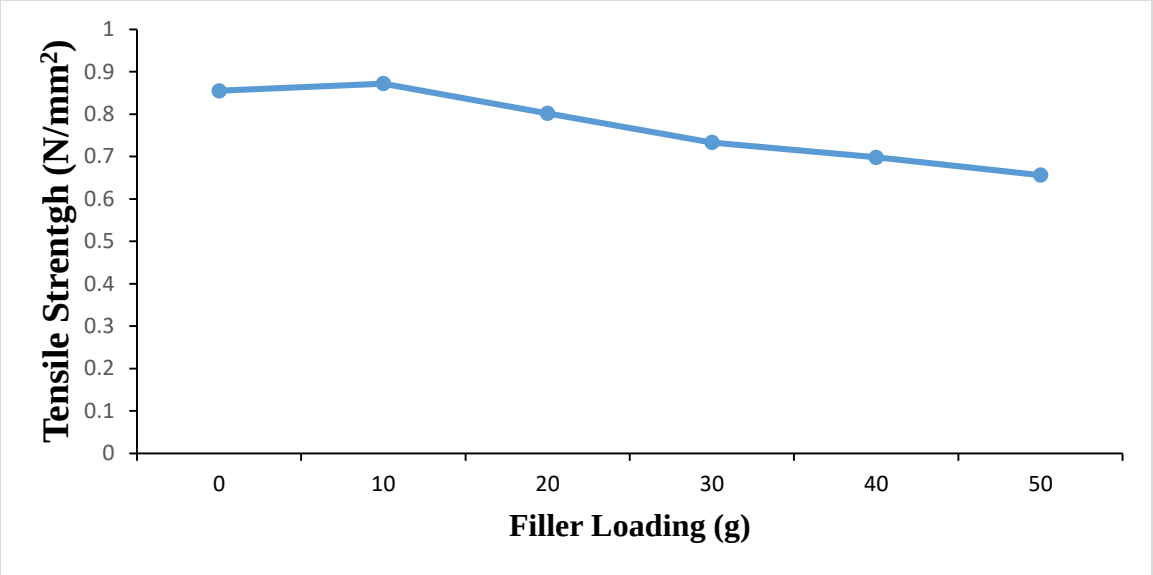

Figure 6: Tensile test (ASTM D-412)

Figure 6 Shows the effect of filler loading on the tensile strength of polypropylene filled-huracreptan pods composites. The result obtained shows that as the filler loading increases there is reduction in the tensile strength, it also indicates that as the filler loading increases from 0-50 wt% respectively, the material tends to elongate less from 0.87 N/mm^2 to 0.66 N/mm^2 respectively. On the other hand, the progressive decrease in tensile strength of the composite may be attributed to an improper distribution of the filler in the matrix, thereby decreasing its tensile strength, similar result obtained by Fowomola and Akindahunsi (2007).

CONCLUSION

In this study, effect of filler loading on physico-mechanical properties of polypropylene filled with huracreptan pods composite were successfully investigated. It was observed that the hardness decreases from 99.67 Shore A to 88.00 Shore A and a drastic reduction occurred at sample D (30 wt%) of 88 Shore A which could result from poor bond interaction between the filler particles and

the polypropylene matrix at sample D. The compression set increased with increasing filler content, sample E (40 wt%) and F (50 wt%) had the highest compression set of 3.4%.

The impact strength showed that the control sample has the highest impact strength of 1.2 J/mm, which reduced to 0.5 J/mm at 10 wt%, meanwhile, the 30 wt% and 50 wt% has similar impact value of 0.6 J/mm. The moisture absorbed increased with increasing filler loading and composites with a higher composition of filler absorbed more moisture than those with a lesser amount of fillers. The sample with 40 wt% filler had the highest absorption of 0.4% achieved after just 24 hours.

The tensile strength shows that as the filler loading increases, corresponded to reduction in the tensile strength, it also indicates that as the filler loading increases from 0-50 wt% respectively, the material tends to elongate less from 0.87 N/mm^2 to 0.66 N/mm^2 respectively. The developed composite can be utilised for domestic and engineering applications in humid climes where mechanical properties is required.

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