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THE UTILIZATION OF MANGO SEED SHELL FLOUR AS REINFORCING MATERIAL FOR POLYPROPYLENE COMPOSITE

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Abstract: The waste generates from agro-waste fiber has huge quantity in Nigeria but the need for its full utilization is below average. The conversion of these wastes into polymer composite can lead to a new industrial revolution taking immerse advantages of these materials. This study investigated the influence of treated and untreated mango seed shell flour (MSSF) on the properties of polypropylene (PP) to manufacture mango seed shell flour-polypropylene composite (PP-MSSF). The MSSF was chemically modified with 5% wt NaOH solution at 4 h. The treated and untreated MSSF was injected in the PP at variant weight of 10, 20, 30, 40 and 50%, respectively. The compounding of MSSF and PP was done by the aid of injection molding machine. The manufactured PP-MSSF composite undergone mechanical test for the characterization of the composite. The variation of unmodified and chemically treated MSSF content was the main parameter in the properties of PP-MSSF composite. The results explained that the chemical modified MSSF displayed better properties than unmodified MSSF in the PP matrix by 26.28, 369.92, 58.97 and 465.71% for tensile strength, tensile modulus, flexural strength and flexural modulus, respectively. From the end result of this work, the produced PP-MSSF composite can be recommended in domestic application.

Keywords: MSSF, NaOH, mechanical properties, PP, MSSF-PP composite

Introduction

It has been confirmed that the increase of the application of agro-wastes in polymer composite is largely acceptable in all part of the world (Obasi, 2015; Thygesen *et al*., 2007; Yang *et al*., 2006; Dungani *et al.*, 2014). The agro-wastes accumulation in the society currently have led to researchers in engineering and science field of studies for the utilization in the different engineering material, composites and relate products (Dungani *et al*., 2014; Dungani *et al*., 2016). Agro-wastes have the merit of light, low cost and renewable when compare to traditional materials when apply as fillers (Abdul *et al*., 2010; Malkapuram *et al*., 2009). Agro-waste has capability of improving properties when used in composite production.

The use of agro-waste in composite has reward of retaining land for cultivation without requesting more land for planting purposes ((Eisentraunt, 2010; Shuhaida and Soh, 2016). Globally, effort has being put in place in order to ensure zero wastes for the conversion of the agro-wastes into wealth creation which is an ideal of modern industrialization (Shuhaida and Soh, 2016; Harun, 2014). Therefore, agro-wastes as fillers act as reinforcement to improve physio-mechanical and dimensional the stability when inculcate in the matrix of polymer (Abdul *et al*., 2010; Malkapuram *et al.*, 2009). Due to its enormous properties of MSSF for adoption in polymer composite, this is quite a substantial reason for accessibility of this fiber in polymer composite relevance.

A composite is regards as the synergy between agro-waste as fiber and matrix (polymer, metal or ceramics) to produce a substance which is unfamiliar in properties than its single components (Blezki and Gassan, 1999; Government *et al.*, 2019). Therefore, the intrinsic characteristic of a composite is proportional to the category of agro-wastes, content of the wastes, chemical modifying agents, size distribution arrangement of the wastes, nature of material used as the matrix, etc (Bogoeva- Gaceva *et al.*, 2007; Government, 2019).

However, considerations of more these factors are necessary for effective production of a composite that exhibits higher mechanical properties. The major setbacks occur when the agro-waste filler is not modifying by chemical means when uses for the manufacturing stages of composite. This emerges the predicament of incompatibility. The incompatibility leads to poor conjunction between the agro-waste filler and matrix, low resistance of the produced composite to acquire water absorption, the incapability of the end-product to push filler into the matrix, etc (Haristov and Vasileva, 2003; Nunez *et al.*, 2002).

This is one of the reason any agro-waste which plays the role as filler shall undergo chemical modifying process to ensure a better mechanical property after analysis of the composites (Rowell, 2005; Wu *et al*., 2000; Nachtigall *et al*., 2007). Furthermore, chemical treatment aid to eliminate unwanted components (hemicelluloses, lignin, waxes, pectin etc) in the agro-waste so that when infuses in the raw plastic after treatment to yield composite with better combination between polymer and the agro-filler phase (Netra *et al*., 2012).

Furthermore, many chemical processes have been adopted in composite production. This includes silane modification, acetylation, chemical bonding, alkalization etc (Netra *et al.*, 2012; Supri and Lim, 2009; Government *et al*., 2017). But, alkali treatment is one the common and cheapest method in treating filler for composite application. Examples of modifiers apply in alkali treatment are: NaOH, KOH, Ca(OH)2, etc. (Binod *et al*., 2010). The NaOH is the frequent use modifying agents for alkali treatment (Cotanaa *et al*., 2015; Zheng *et al*., 2009).

Several scholars have experiment many agro wastes in polymer composite for mass production. This consists of peanut shell (Obasi *et al*., 2015; Zaahab *et al*., 2010), cocoa husk pod (Chun *et al*., 2013), coconut shell (Salmah *et al*., 2013), oil palm waste (Malkapuram *et al*., 2009; Abdul Khali *et al*., 2010), rice husk etc (Yang *et al*., 2004; Yang *et al*., 2006; Yang *et al*., 2007). However, this present study uses mango seed shell flour (MSSF) in reinforcement PP matrix which is totally absent in previous works for polymer composite applications.

This recent work involves the use of new agro-waste (MSSF) to reduce the cost of filler for composite production, compared the effect of treated and untreated MSSF in the PP matrix for the utilization in domestic application.

Materials and Methods

Preparation of MSSF

The mango seed shell was sourced in Wapan-Aku in Wukari Local Government Area of Taraba State of Nigeria. The seed was dried in the sun after elimination of the non-fiber content for 8 hours in 7 days. It was further crushed, ground and sieved to 150 µm.

Purchasing of NaOH and PP

The 98% purity NaOH is manufactured by LOBA Chemie Laboratory reagents and fine chemicals Pvt. Limited, Mumbai, India. The NaOH was gotten in Ogbete Main Market, Ogbui, Enugu State. The homo-polymer polypropylene with brand name HPIG110 specifically used for injection molding process is the production of Indorama Eleme Petrochemical limited, Rivers State. The PP possesses melt flow index at 230°C /2.16 Kg of 11gm/10 min with a density of 9 g/cm^3.

Pre-treatment of the MSSF

The MSSF was soaked with 5% NaOH concentration for 4 hours, rinsed with distilled water and further sun-dried for 8 h.

Composite production

The pretreated and untreated MSSF at variant filler weight 10, 20, 30, 40 and 50% was fused into PP matrix. The compounding MSSF and PP matrix was done at Ekenedirichukwu work, Onitsha, Anambra with aid injection molding machine. The MSSF-PP composite produced were tested using ASTM specification.

Mechanical test of MSSF-PP composite

The MSSF-PP composite was subjected to tensile and flexural test using universal testing machine (tensometer BSS1610 model no. 8889 manufactured by Hounsfield tensometer limited). The analysis of mechanical test was carried in University of Nigeria Civil Engineering Workshop, Nsukka Enugu State of Nigeria. The composite was tested according to ASTM standard (ASTM, 1990).

Results and Discussion

Figure 1(a) illustrates the influence of MSSF weight on the properties of MSSF-PP composite for untreated (UT) and treated (TT) MSSF. It can be noticed that the raw PP displayed a lower tensile strength during the infusion of UT MSSF into PP matrix. This observation could be as result of weak interaction of MSSF and PP matrix. Moreover, the inclusion of TT MSSF into the PP matrix which shows an increment better than the raw PP and further experience a fall in the tensile strength of MSSF-PP composite. The maximum tensile strength of MSSF-PP composite was witnessed at 10% weight content of TT MSSF with about 26.28% strength greater than the raw PP. This could be due to the increase in interfacial area of the composite during the addition TT in the PP matrix. This has been discussed by previous studies (Iklef *et al.*, 2012; Supri and Lim, 2009; Obasi, 2015; Stark and Berger, 1997).

Fig 1(b) presents the variation of MSSF content on the tensile modulus of MSSF-PP composite. The MSSF-PP composite tensile modulus exhibits a sharp increment during the addition of both UT and TT MSSF in PP as the weight content of MSSF increases from 10 to 50%, respectively. The tensile modulus of MSSF-PP composite was higher than the raw PP by 272.18 and 369.92% when the UT and TT of MSSF were injected into PP, respectively. This occurrence is due to when MSSF embeds in PP matrix, there is the generation of voids which infringe movement in the polymer phase, therefore, enhances stiffness of the composites leading to the increase in the tensile modulus of the composites. However, the TT MSSF shows an improvement than UT and raw PP because of removal of impurities in the MSSF that shows better compatibility between the MSSF and PP. The results toe the trend of previous studies (Rahman *et al.*, 2010; Rahman *et al.*, 2015; Obasi, 2015; Salmal *et al.*, 2013; Government *et al.*, 2017).

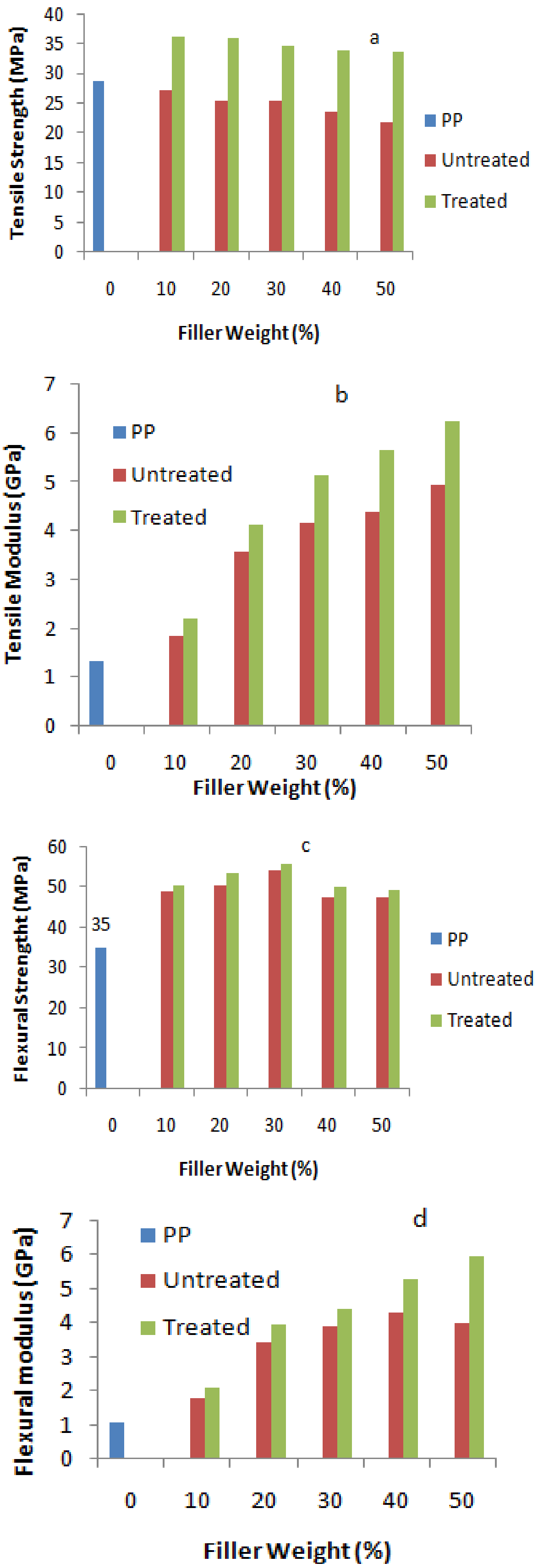

Fig. 1: Effect of MSSF content on the (a) tensile strength (b) tensile modulus (c) flexural strength (d) flexural modulus of MSSF-PP composite

Fig1(c) displays the influence of MSSF content on the flexural strength of MSSF-PP composite. The flexural strength of MSSF-PP composite indicates an increase for the addition of UT and TT MSSF in the PP from 10 to 50 %, respectively. The flexural strength of MSSF-PP composite registered a gain than the raw PP by 34.51 and 39.94% as UT and TT MSSF were mixed in PP matrix, respectively. The amplification of flexural strength during inclusion of UT and TT MSSF in PP is as result of the MSSF strength in polymer matrix which makes the composite to resist bending. Nevertheless, the MSSF-PP composite confirmed outrageous improvement in flexural strength at 30% blending of UT and TT MSSF in PP higher than the raw PP by 53.91 and 58.97%, respectively. The TT MSSF-PP composite incurred better bending strength than UT MSSF-PP composite. This is due to elimination of non-cellulosic material in MSSF after immersion in NaOH solution which creates stronger bond between the MSSF and PP matrix. The result presented in this research toe the format of previous scholars (Rahman *et al*., 2010; Rahman *et al*., 2015; Obasi, 2015; Salmal *et al*., 2013; Government *et al*., 2017).

Figure 1(d) presents the influence of MSSF content on the flexural modulus of MSSF-PP composite. It can be ascertained as MSSF weight increases from 10 to 50%, the MSSF-PP flexural modulus also rapidly improved. During the inclusion of UT and TT MSSF in PP matrix, the flexural modulus of MSSF-PP drastically upgraded than raw PP by 280.95 and 465.71%, respectively. Larger flexural modulus of TT MSSF-PP composite emerged than UT MSSF-PP composite. This is due to the production of free hydroxyl group in the MSSF after treatment which brings out the better bonding when slots in the PP matrix which further improves the bending stiffness of the composite. These patterns of results were observable by prior scholars (Rahman *et al*., 2010; Rahman *et al*., 2015; Obasi, 2015; Salmal *et al*., 2013; Government *et al*., 2017; Stark and Berger, 1997; Zaini *et al*., 1995).

Conclusion

The study had succeeded in projecting new filler (MSSF) from agro-waste which is cost effective for additive in the production of MSSF-polymer composite. NaOH treatment of MSSF aided the union of the MSSF and PP phase which in turn improved the mechanical properties of MSSF-PP composite. The outcome generated from this work shows that the MSSF-PP composite is a potential engineering material which can be recommended for iAbdul Khalil HPS, Bhat AH, Jawaid M, Amouzgar P, Ridzuanand R & Said MR 2010. Agro-wastes: Mechanical and physical properties of resin impregnated oil palm trunk core lumber. *Polym. Compos*., 31: 638-644.

Conflict of Interest

The authors declare that there is no conflict of interest related to this study.

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