Modeling and Statistical Analysis of Ultimate Tensile Strength LDPE/Date Palm Wood Flour Composites

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***Abstract*– The effect of particle size and filler content on the ultimate tensile strength of Date palm wood flour-recycled low density Polyethylene composites was studied. The Date palm wood flour used as filler for low density Polyethylene at 4, 8, 12 and 30% wt of filler content. The study was carried out at different particle sizes of 150, 212, 250 and 300 µm of the fillers. The particle size of the corresponding filler, ultimate tensile strength was determined. A two-series factorial model which shows that the ultimate tensile strength of Date palm wood flour-Low density polyethylene composites can be predicted by substituting particle size and filler content. This model was formulated using experimental data in this research and with the aid of software C-NIKBRAN DATA analytical memory. The formulated model was validated using deviational and statistical Analysis. Based on the foregoing, it is strongly believed that the proximity of deviation and correlations from experiment and model-predicted results are indicative of the model validity.**

***Keywords*– Modeling, Date Palm, Ultimate Tensile Strength, LDPE and Composite**

I. INTRODUCTION

In previous years, inorganic materials have been used as fillers in polymer industry for production of composites. These inorganic materials include: titanium dioxide, calcium carbonate, zinc oxide etc. [1]. These materials face some problems such as high density, high cost of production, high cost of raw material procurement, not easily available, abrasive to the processing equipment, low specific properties and low insulating properties. This is why the research on the use of natural fibers (organic fillers) as a substitute was discovered to counter the defects of conventional material use in production of polymer composites [2]. Fillers find application in the polymer industry, almost exclusively to improve mechanical, thermal, electrical properties and dimensional stability [3]. The use of natural Fiber such as different plant Fibers (Fillers) and wood Fibers (Organic fibers) have the following advantages when compared with the inorganic fillers: Low density, low-cost, non-abrasive, availability from natural resources, relatively high strength and stiffness [4].

Due to these advantages natural fiber has over organic fillers that is why the main division of date palm parts which is the trunk was use in this work.

The use of palm products in the date producing areas was diffused in all sectors of the economy from agriculture, transport and construction, to domestic use and reaching out also into the urban centre [5].

The trunk's main use is for its wood, which intrinsically is not of high quality because of the coarse vascular bundles (monocotolydon!) but it has great tensile strength [6]. Its use is therefore geared to exploit this characteristic such as for poles, beams, rafters, lintels, girders, pillars, jetties and light foot bridges. For this purpose they can be used whole or split in half or quarters. Hollowed out half trunks are used as conduits for water, or at shorter lengths for mangers and troughs. Sawn into coarse planks they are made up into doors, shutters and staircases for houses [7].

Rustic furniture has also been made though trunk wood, because of its coarse vascular structure, is difficult to cut, finish and polish. Furthermore the trunk was used extensively in the supporting structures for water lifting be it in the Egyptian waterwheel [5].

II. MATERIALS AND METHODS

A. Collection and Preparation of Date Palm Wood Flour

The date palm wood was obtained from Nnamdi Azikiwe University Awka, permanent site Anambra State. The wood was sun-dried, Crushed and grind. The grind wood was sieved using a mechanical sieve of size 150, 212, 250 and 300µm.

Fig. 1: Date palm wood flour

B. Collection and Preparation Recycled Low Density Polyethylene

The recycled low density polyethylene (LDPE) plastic container was obtained from the refuse bin. The plastic was washed and sun- dried to remove impurities. The (LDPE) materials were cut to small sizes to enable the crushing machine accept the material after drying.

Fig. 2: Recycle low density polyethylene

C. Methodology

The date palm wood flour was the filler examined. The date palm wood flour of different weight percent were filled with remaining percentage of low density polyethylene (LDPE) respectively. The particle sizes of 150, 212, 250 and 300 µm were used to examine the size effect of date palm wood flour as fillers in the properties of LDPE.

The date palm flours were filled at 4, 8, 12 and 30% by weight of the filler content respectively. Each of the filler and polyethylene were mixed at the different percentage composition of the flour at the corresponding particle size. Each of the mixture was injection molded using injection molding machine at Ekenedilichukwu workshop, Onitsha. The composites which were produced were allowed to cool at room temperature before taking for ultimate tensile test.

Fig. 4: LDPE/Date palm composite

D. Testing of Tensile Specimen Properties

The tensile test was carried after conditioning to relative humidity 65% and room temperature of 23°C using universal tensile matest machine manufactured by Richard parker Ltd, Sheffield, England (model no. INSTRON 3366) located at Socotherm Nigeria Ltd. Onne Rivers State accordance with ASTM D638.The test was performed at cross-head speed of 5mm/min. The dimensions of tensile test specimen size for ASTM used were 3mm x 12.5mm x 60mm. The specimen were placed in the grips of the machine and pulled until there was failure. The ultimate tensile strength was determined

E. Modeling of the Experimental Results

This was done using the software C-NIKBRAN Analytical Data memory.

III. RESULTS AND DISCUSSION

A. Modeling of the Ultimate Tensile Strength (UTS) for LDPE/Date Palm wood Flour varies with filler content and particle size

Table1: Model formulation

Filler Content (%)	Particle Size (µm)	Exp (MPa)
4	150	9.83
8	212	9.82
12	250	9.8
30	300	9.5

$$\beta = -Nx2 + Sx - \theta r + V \qquad (1)$$

This model was formulated using experimental data in Table 1 and with the aid of software C-NIKBRAN.

Where N, S, θ, K are equalizing constants 0.000015, 0.0056, 0.00025 and0.00205 respectively and v is idealing constant 9.3132 determined using C-NIKBRAN**.**

Introducing *the values of N, S*, θ, v and K into equation (1) gives:

$$\beta = -0.000015x2 + 0.0056x - 0.00025r2 + 0.00205r + 9.3132 \qquad (2)$$

$$\beta = the\ model\ for\ the\ ultimate\ tensile\ strength\ for\ Date\ palm\ wood\ flour$$

$$Where\ \beta\ = UTS, x = particle\ size, r = filler\ content.$$

The model is an expression which shows that the ultimate tensile strength of Date palm wood flour could be obtained by substituting particle size and filler content. This is two-series factorial model. By considering the particle size and filler content, the ultimate tensile strength (UTS) of the material can be predicted.

B. Comparison of UTS as obtain from experimental and model-predicted Results Date palm wood (Model)

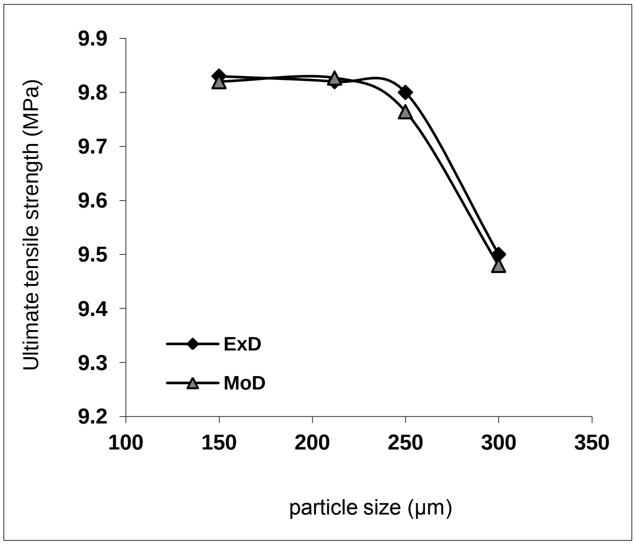

Fig. 5: UTS for experimental and Model-predicted on particle size

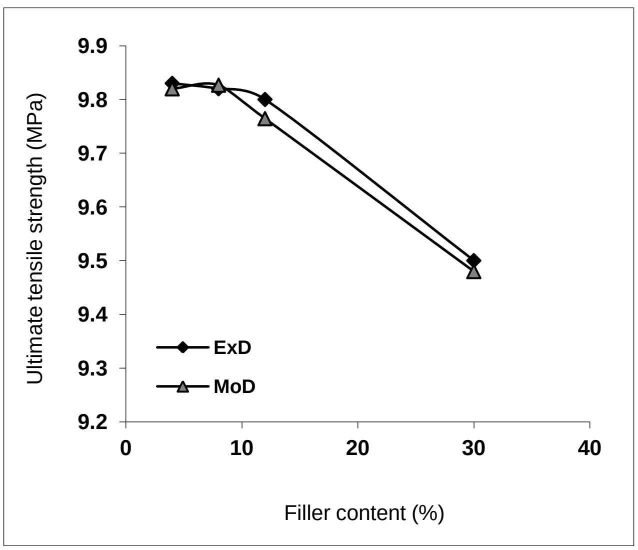

Fig. 6: UTS for experimental Model-predicted on filler content

Fig. 5 and Fig. 6 show ultimate tensile strength as obtained from experimental and model- predicted on particle size and filler content respectively on Date palm wood flour (Model) obtained using Table 2.

C. Model validation

The formulated model was validated using deviational and statistical Analysis. Deviational analysis involves direct analysis and comparison of model-predicted values and those obtained from experiment for equality or near equality. Statistical analysis involves evaluated the correlations between process variables.

Deviation (Dv) (%) of model-predicted values from the experimental values is given by:

$$Dv = \left[\frac{MoD - ExD}{ExD}\right] \times 100 \qquad (3)$$

Where,

Table 2: Comparison of UTS as obtain from experimental and model-predicted results on Date palm wood

Filler Content (%)	Particle Size (µm)	Exp (MPa)	MoD (MPa)	DV(%)	CF(%)
4	150	9.83	9.8199	-0.10	+0.10
8	212	9.82	9.8266	+0.07	-0.07
12	250	9.8	9.7643	-0.36	+0.36
30	300	9.5	9.4797	-0.21	+0.21

$$MoD = Model - predicted\ values$$

$$ExD = Experimental\ results$$

Correction factor (Cf) is the negative of the deviation i.e.,

$$Cf = -Dv \qquad (4)$$

Therefore,

$$cf = -100\left[\frac{MoD - ExD}{ExD}\right] \qquad (5)$$

Introduction of the corresponding values of cf from equation (5) in Table 2 into the model gave exactly the corresponding experimental values. Results of deviational analysis were shown in Table 2 shows that the derived model valid since the model deviations from experimental values are generally quite within the acceptable range.

Analysis and comparison between these values reveal deviation of model-predicted values from those of the experiment as in Table 2. The maximum deviation (from experimental results) evaluated from the Model was 0.36 %.This was found to be very low and generally quite within the acceptable range. This gave confidence level of 99.64 %. This necessitated the introduction of correction factor as in Table 2 to bring the model-predicted values to those of the experimental values.

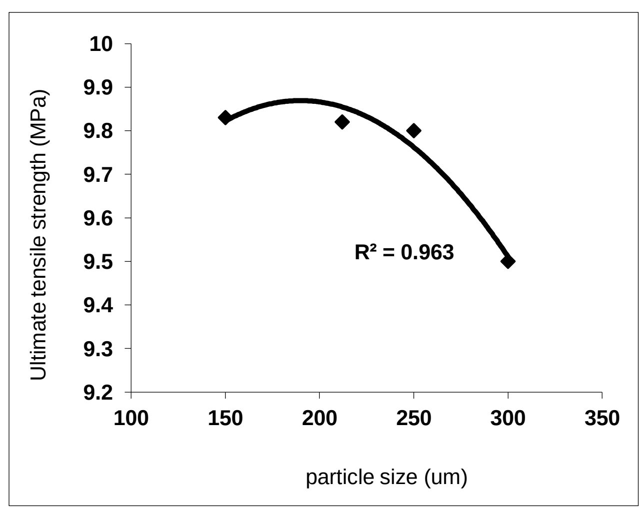

Fig. 7: Experimental

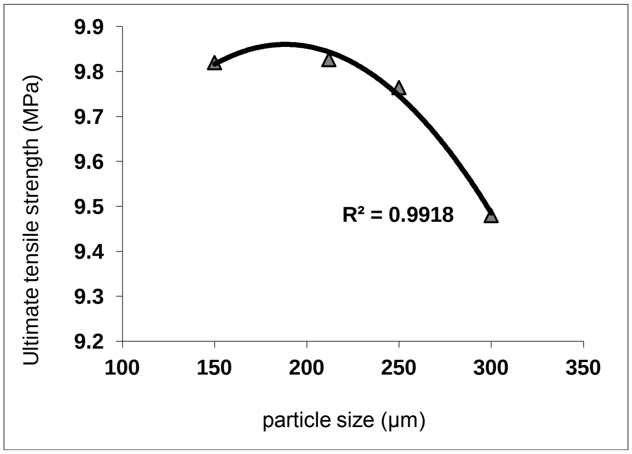

Fig.8: Model

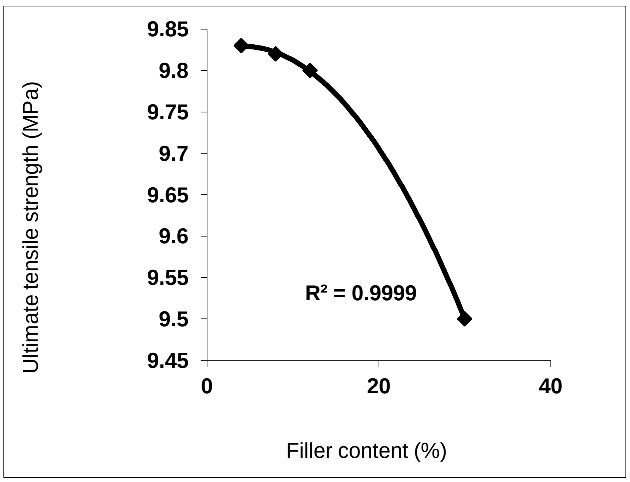

Fig. 9: Experimental

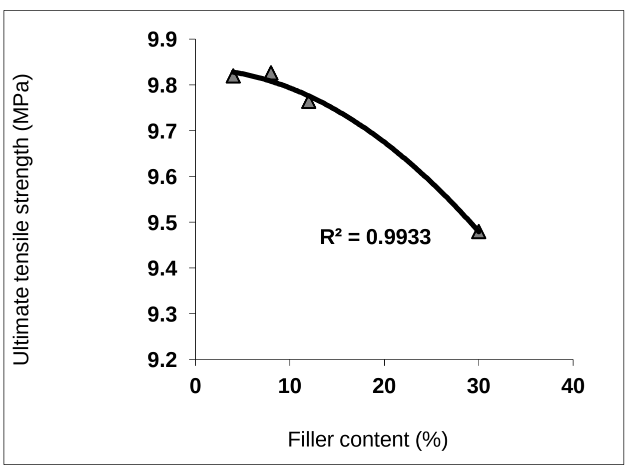

Fig. 10: Model

Fig. 7 and Fig. 8 show correlations between particle size and UTS (ultimate tensile strength) as obtained from experiment and derived model respectively using Table 2.

Fig. 9 and Fig. 10 show correlations between filler content and UTS for the model as obtained from experiment and derived model respectively using Table 2. The correlations between particle size and UTS for the Model as obtained were 0.963 and 0.991 as obtained from experiment and derived model respectively. Similarly, correlation between filler content and UTS for the same model as obtained in Table 2 also gave 0.999 and 0.993 as obtained from experiment and derived model respectively. Based on the foregoing, it is strongly believed that the proximity of correlations from experiment and model-predicted results are indicative of the model validity.

IV. CONCLUSION

Model and experiment results for ultimate tensile strength LDPE/Date palm wood were closed; it means that the model equation was valid.

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