Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2021, 13(11):01-10

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Optimization of Mechanical Properties of Combretum Dolichopetalum Fiber Reinforced High Density Polyethylene (HDPE) Composites

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ABSTRACT

High Density Polyethylene (HDPE) composites were prepared and developed by injection moulding method with mercerized and acetylated Combretum Dolichopetalum Fiber (CDF) at variable weight fraction of fiber (2.5 -7.5 %) and HDPE matrix (92.5 -97.5 %). This research work is aimed at optimizing the mechanical properties of CDF reinforced HDPE composites. The mechanical properties (tensile strength, flexural strength, impact strength and hardness) were optimally determined using developed quadratic polynomial equation of response surface methodology (RSM) with three level factorial design (3 - LFD) and analysis of variance. Under optimum production of the composites, untreated C. dolichopetalum fiber increased the tensile strength (31.429 MPa) and hardness (24.5 HR) with reduced flexural (19.256 MPa) and impact strength (256.7 kPa) while mercerized CDF improved the tensile strength, flexural strength, hardness and impact strength by 2.51, 28.98, 51.02 and 17.84 % of untreated composite, respectively. Acetylated CDF reduced the tensile and flexural strengths with improved the hardness and impact strength by 52.38 and 38.15% of untreated fiber - HDPE composites, respectively.

Keywords: *Vitex negundo Linn*; Leaves extracts; *Phytochemical analysis; Antibacterial activity*

INTRODUCTION

Combretum dolichopetalum “sun birds’ wine” plant extracts have been used in south eastern and western part of Nigeria in folklore medicine for treatment of urinary tract infection, indigestion and dysentery. Thus, disposal of Combretum Dolichopetalum Fiber (CDF) into environment after extraction of medicinal contents posed an environmental threat to the society, through increase in biomass and its application in composites preparation are scarce in literature. The advancement in standard of living coupled with the growing demand of environmental protection and technology sustainability has been a global concern. This requires application of ecofriendly lignocellulosic materials in the world today [1]. The fulfillment of economic requirements of numerous industries, through biodegradability of vegetable fibers as a supplement of ecosystem, cost effectiveness and efficient use are major issues in nation development. The numerous advantages of lignocellulosic fibers over traditional fibers include: low weight, low density, low cost, acceptable specific properties (such as modulus and strength per unit weight), recyclable, biodegradable, renewable and cause no skin irritation. High Density Polyethene (HDPE) is a class of polymer with poor physico - mechanical properties that majorly utilized in the production of domestic article. Presently, HDPE can be reinforced with different fillers or fibers of organic and inorganic origin with

different particle sizes. The reinforced fillers or fibers enhanced the performance of the composites through the transfer of stress between the reinforcing fibres and matrix. Matrix acts as a glue to hold the fibers together and protect fibers from mechanical and environmental damage. The use of natural fibers have been reported to be less attractive in composite applications due to some factors such as intrinsically dependent on grown area, maturity age of the plant, extraction method and conditioned prior to application. These factors to an extent cause reduction in properties of natural fibers compared to synthetic fibers. Another disadvantage is low interfacial adhesion between the fibers and polymer matrix which may truncate fiber potential as reinforcing agents owing to their hydrophilic nature. An effective corrective measure that has been used with significant success is chemical modifications which activate hydroxyl groups in fibers or induces new moieties that effectively interlock with the matrix. This resulted to increase in interfacial adhesion and mechanical properties of the composites [2]. Mokaloba and Batane reported that mercerization and acetylation of sisal fiber, respectively, improved the interfacial adhesion shear strength with polypropylene matrix by 173 and 435%, and tensile strength by 12.04 and 14.08 % untreated composites. Researchers have investigated the enhancement and efficiency of fibers strength and composites at ultimate conditions with the use of many chemical surface modifications such as mercerization which makes fibers to be less hydrophilic and promoting mechanical interlocking with the matrix; acetylation for substitution of hydroxyl group of the cell wall of fibers with acetyl group; thus reducing the hygroscopic nature of fibers and many others . Though, deviation from optimum can lead to excess delignification which reduced the tensile strength of Adenia labata and pineapple fibers as well as impact strength and hardness of the composites. Treatment with 2% NaOH caused decrease in tensile strength of pineapple fiber as reported by but increase in tensile strength of lady's finger fiber as reported. Thus, there is need to know optimal conditions of a specific fibers for its applications. Researchers reported that fibers treatment using NaOH, acetic anhydride and silane coupling agent improved the structural, mechanical and thermal behaviour of natural fiber reinforced polymer composites like HDPE, polypropylene, epoxy matrix at ultimate conditions of volume fraction of jute, green coconut, flax, basalt, areca and kenaf fibers. Though, mercerized henequen fiber makes insignificant difference in tensile strength but improve the flexural properties of HDPE composites. Optimization of natural fiber reinforced polymers (such as epoxy, vinyl ester, polyester, polypropylene, polyurethane, polyetheretherketone, Polyethylene-Terephthalate (PET) and HDPE) with soya stalk flour, oil palm empty fruit bunch, groundnut shell, kenaf, sisal, coir and jute fibers, wood on mechanical, thermal and turning parameters using Duncan analysis, simplex lattice design, and Taguchi method have been studied but requires large amount of experimental work in orthogonal array with the measurement of signal to noise ratio. In other to minimize waste of material in production and experimental effort, this research work seeks to optimize the mechanical properties of C. dolichopetalum fiber reinforced HDPE composites for enhancement of HDPE matrix applications [3].

MATERIALS AND METHODS

C. dolichopetalum plant was obtained from Bayaoje in Surulere Local Government Area of Oyo state, Nigeria. Fiber was extracted from plant stem using water retting method for 21days, washed every 3days, and dried at a temperature of 600°C for 2 hours after fiber was obtained. The dried fibers are designated as untreated C. dolichopetalum fibers (unCDF). The sodium hydroxide and acetic anhydride (analytical grade chemicals) used for fiber modification was supplied by Rovert scientific limited, Benin city in Edo state, Nigeria. HDPE matrix in pellet form was obtained from Eleme Petrochemical Company, Port Harcourt in River state, Nigeria.

Alkali and Acetic Anhydride Treatments

Strand of C. dolichopetalum fiber with average length of 150 mm and average diameter of 0.48 ± 0.03 mm was cut into 10 mm. The C. dolichopetalum fibers were treated with 14.19 % NaOH solution for 28 minutes and 14.66 % acetic anhydride solution for 86 minutes at room temperature as optimal treatment conditions reported. After extraction, washed with deionized water, then oven dried at 600C for 2 hours and tensile strength test was carried out by the method described.

Composite Preparation

The treated and untreated fibers, respectively, were mixed with HDPE pellet of density and melting point of 193^0C, respectively, as presented in Table 1. Mixture was processed by injection moulding method at temperature range of 1800°C – 2100°C

Table 1: Level of treated and untreated CDF - HDPE composites for coded and uncoded

	Ranges and level		
Variable	-1	0	1
W_f (%)	2.5	5	7.5
W_m (%)	92.5	95	97.5

Tensile Testing

Tensile test was conducted on a rectangular shape of randomly oriented *C. dolichopetalum* fibers-HDPE composites with a dimension of 100mm (span) x 25mm (width) x 3mm (thickness) using tenstometer machine (Model: M500-25KN, OL11 1NR) with a constant rate of transverse of the moving grip of 40 mm /min was used in evaluating the tensile properties [4].

Flexural Testing

3 – point flexural test was conducted on a rectangular shape of randomly oriented *C. dolichopetalum* fibers-HDPE composites with a dimension of 80 mm (span) x 25 mm (width) x 3 mm (thickness) using tenstometer machine (Model: M500-25KN, OL11 1NR) with a constant rate of 40 mm/min.

Impact Testing

Unnotched Izod impact test was conducted with cantilevered beam configuration on a rectangular shape of randomly oriented *C. dolichopetalum* fibers-HDPE composites with a dimension of 80mm (span) x 25 mm (width) x 3 mm (thickness) using tenstometer (Model: M500-25KN, OL11 1NR) at a constant rate of 40 mm /min.

Hardness Testing

A standard Rockwell tester was used with steel indenter to measure the hardness of the test specimen according to ASTM E – 18. Load of 150kgf was applied for each measurement on the specimen with parallel flat surfaces of the avail of the apparatus and minor load (15 kgf) was applied by lowering the steel ball onto the surface of the specimen. The dial was adjusted to zero on the scale under minor load and the major load (150 kgf) was immediately applied by releasing the trip lever. After 15 second the major load was removed and Rockwell hardness was recorded [5].

Data Analysis

Response surface methodology (RSM) with 3 – LFD of Design of Experiment (DoE) software version 6.0.8 (2002 East Hennepin ave., Suite 480 Minneapolis, MN 55413, stat Ease, Inc.) was employed for statistical analysis, modelling to understand the interaction between matrix and fiber, and to determine optimum contents of two independent variables with mechanical properties based on treatments conditions so as to minimize waste of materials and experimental effort for effective composite production.

RESULTS AND DISCUSSION

Experimental results obtained using RSM of 3 – LFD was presented in Table 2 for mechanical properties of both unCDF -, mCDF - and aCDF - HDPE composites. Table 2 shows the results of the response surface models for unCDF – HDPE composite production in the form of analysis of variance (ANOVA) for tensile strength, flexural strength, hardness and impact strength in actual units as presented in equations 1 – 4 respectively.

Table 2: ANOVA of response quadratic model of mechanical properties of HDPE composite with unCDF

Source	Sum of Squares	DF	Mean Square	F Value	Prob > F	R^2	Adj R^2	Pred R^2	Adeq Precision
Tensile strength									
Intercept	922.0599	5	184.412	35000000	< 0.0001	1	1	1	16635.58
W_f	919.9628	1	919.9628	180000000	< 0.0001				
W_m	1.5445	1	1.5445	296838	< 0.0001				
W_f^2	0.128	1	0.128	24591.1	< 0.0001				
W_m^2	0	1	0	0.00228	0.96326				
W_fW_m	0.4246	1	0.4246	81611.9	< 0.0001				
Flexural strength									
Intercept	57.4511	5	11.4902	49.1623	< 0.0001	0.9723	0.9525	0.721	18.7406
W_f	16.3393	1	16.3393	69.9096	< 0.0001				
W_m	0.0002	1	0.0002	0.00101	0.97549				
W_f^2	39.6687	1	39.6687	169.727	< 0.0001				
W_m^2	1.4325	1	1.4325	6.12921	0.042475				
W_fW_m	0.0104	1	0.0104	0.04443	0.83906				
Hardness									
Intercept	3.13	5	0.63	36560000	< 0.0001	1	1	1	22486.81
W_f	0.94	1	0.94	54610000	< 0.0001				
W_m	2.2	1	2.2	12820000	< 0.0001				
W_f^2	0.000349	1	0.000349	20384	< 0.0001				
W_m^2	0	1	0	0	1				
W_fW_m	0.000433	1	0.000433	25237.33	< 0.0001				
Impact strength									
Intercept	124182.1	3	41394.05	102.879	< 0.0001	0.9717	0.9622	0.8813	29.426
W_f	119149.3	1	119149.3	296.13	< 0.0001				
W_m	2955.841	1	2955.841	7.34636	0.023981				
W_fW_m	2077.035	1	2077.035	5.1622	0.049198				

$$T_s = -0.5671 + 0.318W_f + 0.462W_m - 0.0319W_f^2 + 1.048x10^{-5}W_m^2 - 0.052W_fW_m \quad (1)$$

$$F_s = -1019.9 - 5.931W_f + 21.937W_m + 0.6046W_f^2 - 0.1152W_m^2 - 0.00815W_fW_m \quad (2)$$

$$H = -0.036 - 0.017W_f + 0.25W_m - 1.66X10^{-3}W_f^2 + 1.001X10^{-15}W_m^2 - 1.66X10^{-3}W_fW_m \quad (3)$$

$$I_s = 953.2 - 290W_f - 9.3516W_m + 3.646W_fW_m \quad (4)$$

The response models for tensile, flexural strength and hardness were quadratics, and 2 – factors with interaction between the fiber and HDPE matrix fractions for impact strength with $p < 0.0001$ for all the model as suggested by DoE. The goodness of fit of the model may be checked by the determination coefficient (R^2) of tensile strength (1.000), flexural strength (0.9723), hardness (1.000) and impact strength (0.9717) which explain 100, 97.23, 100 and 97.17 % of the observed variability, respectively, while 0.00, 2.77, 0.00 and 2.82% represent the residue which cannot be explained. The *adj.* R^2 and *pred.* R^2 were reasonably in agreement and satisfactory for confirming the significance of the models.

The insignificant model terms (W_m^2 for tensile strength, and W_m and W_fW_m for flexural strength) could be considered to have no effect on the tensile strength and flexural strength response models of equations 1 and 2, respectively. This is in agreement with the report. Moreover, the developed models were fit and may be used for design applications since *adequate precision > 4.*

In the case of mCDF – HDPE composites, the developed response models for tensile strength, flexural strength, hardness and impact strength, respectively, are represented by equations 5, 6, 7 and 8;

$$T_s = -501.79 + 72.576W_f + 6.318W_m - 1.0932W_f^2 - 0.01373W_m^2 - 0.5397W_fW_m \quad (5)$$

$$F_s = -864.09 + 10.658W_f + 17.879W_m - 1.312W_f^2 - 0.0946W_m^2 + 0.03186W_fW_m \quad (6)$$

$$H = 1019.5 - 6.6807W_f - 20.86W_m - 0.26593W_f^2 + 0.11007W_m^2 + 0.092W_fW_m \quad (7)$$

$$I_s = 212.44 - 102.06W_f + 3.419W_m + 10.206W_f^2 - 1.931x10^{-5}W_m^2 - 0.14W_fW_m \quad (8)$$

The models were quadratics for mechanical properties. The high value of R^2 with a magnitude 0.9870, 0.9867, 0.8767 and 0.9998 for tensile strength, flexural strength, hardness and impact strength, respectively, indicates the good fitness of the models. It may be used for design application since *adequate precision > 4* based on the ANOVA analysis of the responses presented in Table 4. However, based on the p - value estimated, W_m^2 for tensile strength, W_m, W_m^2 and W_fW_m for flexural strength, W_m^2 and W_fW_m for hardness, and W_m^2 for impact strength were insignificant model terms due to $p > 0.05$. The closeness of R^2, *adj.* R^2 and *pred.* R^2 indicates reasonable agreement and satisfactory of equations 5, 6 and 8 with experimental data. For hardness property, pred. R^2 is negative which implies that the overall mean is a better predictor of the response than the model represented by equation 7 which is not based on predicted data. Hence, pred. R^2 may be ignored since the R^2 and *adj.* R^2 are closer. Similarly, the developed response models for tensile strength, flexural strength, hardness and impact strength of aCDF – HDPE composites, respectively, represented by equations 9, 10, 11 and 12 were quadratics and ANOVA are presented in Table 5.

$$T_s = -2846.1 - 43.534W_f + 62.333W_m + 1.5396W_f^2 - 0.3327W_m^2 + 0.2716W_fW_m \quad (9)$$

$$F_s = 57.676 + 2.1919W_f - 1.2721W_m - 0.218W_f^2 + 0.00691W_m^2 + 0.000392W_fW_m \quad (10)$$

$$H = -11.879 + 5.3193W_f + 0.2317W_m - 0.5411W_f^2 - 0.00012W_m^2 - 0.0188W_fW_m \quad (11)$$

$$I_s = -7093.2 + 289.68W_f + 139.34W_m - 28.967W_f^2 - 0.7317W_m^2 + 0.1565W_fW_m \quad (12)$$

Models were fit and may be employed for any design applications due to high value of R^2 with magnitude of 0.9418, 0.9971, 1.0000 and 0.9994, respectively, for tensile strength, flexural strength, hardness and impact strength and *adequate precision > 4* as presented in Table 5. The model terms W_m, W_m^2 and W_fW_m for tensile strength, W_m^2 and

W_fW_m for flexural strength, W_m^2 for hardness, and W_m, W_m^2 and W_fW_m for impact strength were insignificant since $p > 0.05$.

Table 3: ANOVA of response quadratic model of mechanical properties of HDPE composite with mCDF

Source	Sum of Squares	DF	Mean Square	F Value	Prob > F	R^2	Adj R^2	Pred R^2	Adeq Precision
Tensile strength									
Model	705.9466	5	141.189	105.978	< 0.0001	0.987	0.9776	0.8674	32.4964
W_f	148.5077	1	148.508	111.471	< 0.0001				
W_m	38.4135	1	38.4135	28.833	0.001041				
W_f^2	473.4992	1	473.499	355.412	< 0.0001				
W_m^2	0.0203	1	0.0203	0.0153	0.90517				
W_fW_m	45.5058	1	45.506	34.157	0.000634				
Flexural strength									
Model	242.559	5	48.512	105.172	< 0.0001	0.9869	0.9775	0.8804	22.1538
W_f	11.866	1	11.861	25.7254	0.00144				
W_m	0.1852	1	0.1852	0.4016	0.54643				
W_f^2	229.384	1	229.384	497.299	< 0.0001				
W_m^2	0.9649	1	0.9649	2.0919	0.19133				
W_fW_m	0.1586	1	0.1586	0.3438	0.57608				
Hardness									
Model	32.3435	5	6.4687	9.9546	0.00439	0.8767	0.7886	-0.1276	11.5106
W_f	13.5	1	13.5	20.7749	0.00261				
W_m	9.8817	1	9.8817	15.2067	0.0059				
W_f^2	6.3323	1	6.3323	9.7447	0.01681				
W_m^2	1.3071	1	1.3071	2.0114	0.19907				
W_fW_m	1.3225	1	1.3225	2.0352	0.19674				
Impact strength									
Model	20059.24	5	4011.8486	7478.087	< 0.0001	0.9998	0.9997	0.9981	224.0564
W_f	6634.506	1	6634.506	12366.72	< 0.0001				
W_m	276.448	1	276.448	515.299	< 0.0001				
W_f^2	13145.23	1	13145.225	24502.7	< 0.0001				
W_m^2	0	1	0	0	1				
W_fW_m	3.0643	1	3.0643	5.7118	0.04817				

The 3 – D response surface plot of 3 – LFD models revealed the effects of weight fraction on mechanical properties of unCDF - , mCDF - and aCDF - HDPE matrix composites, respectively, based on the maximum desirability

obtained as illustrated in Figure 1(a), (b) and (c). The optimum weight fraction of fiber 3.00, 3.70 and 4.50 w% with 97.5, 97.5 and 96.12% matrix (HDPE) were obtained for unCDF- HDPE, mCDF -HDPE and aCDF –HDPE composites, respectively, which based on optimal properties as presented in Table 4. It can also be observed in this study, that the ratio between values of fiber–matrix for material property values obtained differs for composites using treated fibers and the untreated fiber. The choice of these optimal weight fractions for the models was based on highest desirability obtained. The desirability indicated the combined mechanical properties (tensile strength, flexural strength, hardness and impact strength) of the composites.

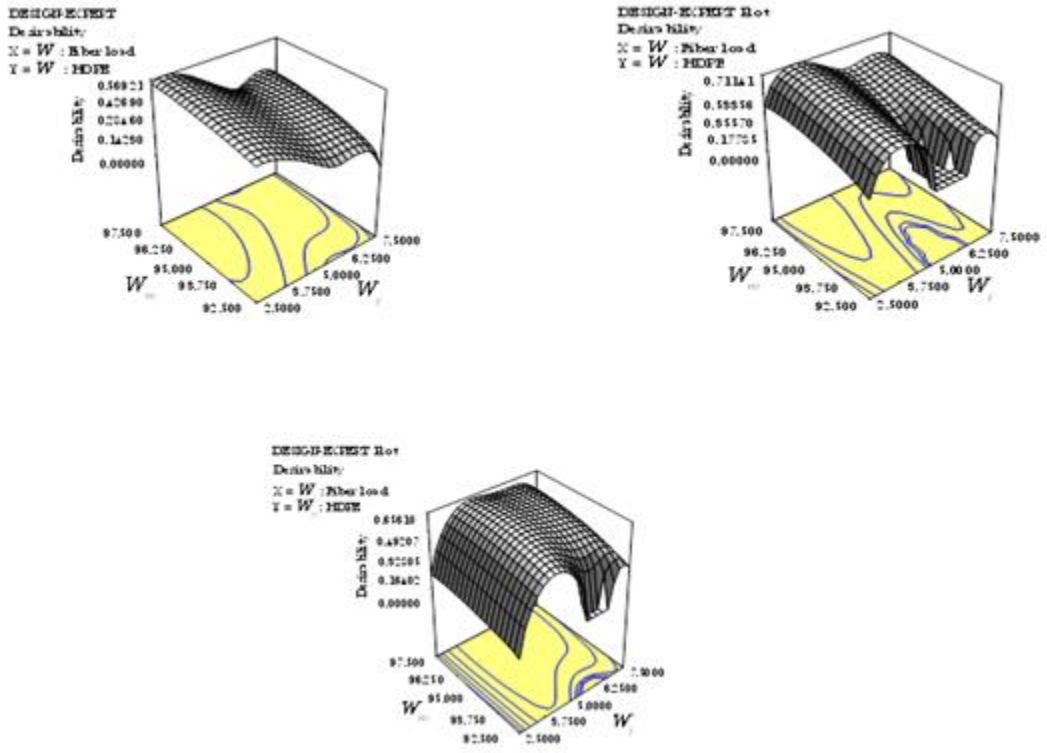

Figure 1: 3 - D Response surface of mechanical properties of *C. dolichopetalum* fiber – HDPE composites (a) untreated (b) mercerized and (c) acetylated fiber.

Developed models and optimal responses for average of three samples for unCDF -, mCDF - and aCDF-composites are presented in Table 5. It can be observed that unCDF and mCDF increased the tensile strength of HDPE matrix by 27.66 and 30.87 % of HDPE matrix, respectively, while that of acetylated reduced by 1.18 % of HDPE matrix with considerable error. This shows that mercerization of CDF increased the tensile strength by 2.51% of unCDF – HDPE composites at optimum weight fraction of fiber and matrix which may be due to increase in interfacial bonding of the fiber. This indicated that the use of mercerized CDF for HDPE composites possess higher degree of effectiveness compared to alkali and xylene modified henquen fiber with no noticeable improvement in tensile strength of HDPE composites as reported by Herrera - Franco and Valadez-Gonza´lez as a load carrying material. It can be observed that unCDF, mCDF and aCDF, respectively, reduced the flexural strength of the HDPE composites

by 189.38, 100.38 and 423.99% of HDPE matrix. This is in contrast with report of Herrera - Franco and Valadez-Gonza´lez and Meysam.

Table 4: ANOVA of response quadratic model of mechanical properties of HDPE composite with aCDF

Source	Sum of Squares	DF	Mean Square	F Value	Prob > F	R^2	Adj R^2	Pred R^2	Adeq Precision
Tensile strength									
Model	489.3218	5	97.8644	22.6402	0.000345	0.9418	0.9002	0.4082	13.2813
W_f	205.1607	1	205.161	47.4624	0.000234				
W_m	8.7909	1	8.7909	2.0337	0.19688				
W_f^2	251.9067	1	251.907	58.2767	0.000123				
W_m^2	11.9395	1	11.9395	2.7621	0.14047				
W_fW_m	11.524	1	11.524	2.666	0.14653				
Flexural strength									
Model	6.015	5	1.203	473.911	< 0.0001	0.9971	0.995	0.9731	49.4349
W_f	0.0906	1	0.0906	35.6722	0.000557				
W_m	0.0656	1	0.0656	25.8608	0.001423				
W_f^2	5.8537	1	5.8537	2305.985	< 0.0001				
W_m^2	0.0051	1	0.0051	2.0266	0.19757				
W_fW_m	0	1	0	0.0095	0.92525				
Hardness									
Model	147.694	5	29.5389	32848.39	< 0.0001	1	0.9999	0.9996	489.2124
W_f	107.261	1	107.261	119278.5	< 0.0001				
W_m	3.4214	1	3.4214	3804.686	< 0.0001				
W_f^2	36.957	1	36.9569	41097.58	< 0.0001				
W_m^2	0	1	0	0.0018	0.96705				
W_fW_m	0.055	1	0.055	61.2035	0.000105				
Impact strength									
Model	116343.9	5	23268.79	2175.909	< 0.0001	0.9994	0.9989	0.995	101.0862
W_f	8293.222	1	8293.222	775.515	< 0.0001				
W_m	45.6284	1	45.6284	4.2668	0.077717				
W_f^2	107943.5	1	107943.5	10094	< 0.0001				
W_m^2	57.7561	1	57.7561	5.4009	0.053082				
W_fW_m	3.8259	1	3.8259	0.3578	0.56859				

Table 5: Validated result of mechanical properties of *dolichopetalum* fiber – HDPE composites

Sample	W_f (%)	W_m (%)	Experimental value	Predicted value	Error (%)
			Tensile strength (MPa)		
HDPE	0	100	24.619	24.619	0
UnCDF - HDPE	3	97.5	31.429	30.152	4.063
mCDF - HDPE	3.7	97.5	32.219	30.897	4.103
aCDF - HDPEc	4.5	96.12	24.328	24.372	0.181
			Flexural strength (MPa)		
HDPE	0	100	27.114	27.114	0
UnCDF - HDPE	3	97.5	9.3696	8.891	5.383
mCDF - HDPE	3.7	97.5	13.531	12.911	4.802
aCDF - HDPEc	4.5	96.12	5.1745	4.8269	7.201
			Hardness (HR)		
HDPE	0	100	21	21	0
UnCDF - HDPE	3	97.5	24.5	23.9	2.343
mCDF - HDPE	3.7	97.5	37	35.8	3.268
aCDF - HDPEc	4.5	96.12	32	30.4	4.869
			Impact strength (kPa)		
HDPE	0	100	859.3	859.3	0
UnCDF - HDPE	3	97.5	256.7	235.32	8.329
mCDF - HDPE	3.7	97.5	302.5	295.8	2.215
aCDF - HDPEc	4.5	96.12	357.2	326.46	8.606

However, mercerization of CDF improved the flexural strength by 44.41 % of unCDF - HDPE composites, while acetylation of CDF reduced the flexural strength by 44.77 % of unCDF – HDPE composites. The incorporation of unCDF increased hardness of composites by 16.67% of HDPE matrix and improved by mercerization and acetylation with 51.02 and 30.61 % of unCDF – HDPE composites, respectively, and it may be attributed to increased interfacial adhesion between the fiber and matrix. This is in agreement with the report and Azeez and Onukwuli . Contrarily, unCDF reduced the impact strength of the matrix by 70.12 % of HDPE matrix while mercerization and acetylation of fiber increased the impact strength by 17.84 and 39.15 % of unCDF – HDPE

composite, respectively, at optimum conditions of the HDPE composites production. This change in properties may be attributed to interfacial bond between fibers and matrix, orientation of fiber and morphological change . The error obtained at optimum production of unCDF -, mCDF - and aCDF – HDPE composites may be considerably accepted for tensile strength, flexural strength, hardness and impact strength in validation of this study. Though, the error might be due to uncontrollable factors (such as aspect ratio, climatic change, soil properties of fiber source) that are not considered in this work.

CONCLUSION

It can be drawn from optimum production of composites that mercerization of *C. dolichopetalum* fiber improved the tensile strength, flexural strength, hardness and impact strength of the HDPE composites but reduced flexural and impact strength compared with HDPE matrix while acetylation reduced the tensile and flexural strengths with increase in hardness and impact strength of the composites. The optimal conditions of composites production for untreated, mercerized and acetylated CDF and HDPE matrix weight fraction were (3.0 and 97.5%), (3.7 and 97.5%) and (4.5 and 96.12 %) respectively. At optimal level of HDPE composites, mercerized fiber hit the targeted parameters of 30 and 50% improvement of the matrix for tensile strength and hardness, respectively, with 50% reduction in impact strength. Though, flexural strength obtained below the expected value of 10% of HDPE matrix.

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