PRODUCTION AND CHARACTERIZATION OF POLYMER COMPOSITE FROM RECYCLED LOW DENSITY POLYETHYLENE AND MODIFIED *Eucalyptus globulus* SAWDUST FIBRE.

OLOWOKERE, J.A[1]*; AKPAN, U.G[2]; OKAFOR, J.O[2]; AUTA, S.M[2]

[1]Department of Chemical Engineering, Federal University Wukari, Taraba State, Nigeria.
[2] School of Infrastructure, Process Engineering and Technology, Federal University of Technology Minna, Niger State, Nigeria.
*Corresponding Author Email: joariolo2@gmail.com

Abstract

This work is centered on the production of polymer composite (PC) from recycled low density polyethylene (rLDPE) matrix and *Eucalyptus globulus* sawdust (EGS) fibre. The raw EGS fibres were chemically treated with sodium hydroxide at varying concentrations and time. An optimal cellulose yield of 74.6% was obtained at an optimum condition of 3% NaOH treatment for 2 h. This treated EG cellulose is then used as reinforcement in recycled low density polyethylene. The recycled polymer matrix and the EGS fibre were compounded and processed into a polymer composite using a two rolling mill with an automated compression moulding machine, operated at a temperature of 155^{0}C and pressure of 4Pa for 15 min. The mechanical properties of the treated polymer composite in terms of flexural strength (12.75MPa), tensile strength (10.64MPa), hardness (13.52MPa), elastic modulus (244.78MPa) and elongation (5.19%) recorded better outcome compared to the polymer composite produced from raw untreated EGS fibre. Similarly, the treated composite, recorded less water absorption capacity (0.92%) due to the positive effect of the chemical treatment on the EGS fibres, which reduces its hydrophilic property to moisture degradation. The PC produced can find application in indoor and outdoor purposes.

Key words: Cellulose content, *Eucalyptus globulus* sawdust, Mercerization, Polymer Composite, Mechanical properties and Water Absorption Capacity.

Introduction
Composites have continued to gain greater attention in research, in a bid to search for engineering materials with superior and durable properties. Smith, (2017) defined composite materials as a mixture of two or more relatively homogeneous materials which have been bonded together to produce a material with properties that are superior to the ones exhibited by the individual component materials. This synergistic outcome, obviously, is the driving force for the development of composites. Studies have shown that blend of agro-waste and plastics could form composites. By-products of agricultural produce such as husk, cobs and fibre constitute agro waste and they can be combined with plastic polymer (virgin or recycled) to obtain materials with superior properties for multi-functional application.

Fiber reinforced polymer composites are made of polymer resins such as polyethylene matrix using natural fibers such as sisal, jute, bamboo and sawdust as the reinforcement. Polymer matrices are reinforced with natural fibre to form polymer composite. in this case, the fibre which act as reinforcement give strength to the polymer composite, while the polymer matrix help to bind and keep the fibres together in their respective proper place, while helping to transfer stress or load between the reinforcing fibres. Similarly, some common polymer matrices include epoxy, polyethylene, polyester, phenolic, polyurethane, vinylester, polyether ether ketone (PEEK) which is widely in use (kopeliovich, 2010).
Availability of these natural fibres and ease of manufacturing is attracting researcher to try locally available inexpensive natural fibres as reinforcement material fibers in polymer matrix. The major disadvantage of natural fibre reinforced polymer composites (NFRPCs) is the incompatibility between the hydrophilic natural fiber and hydrophobic polymer leading to formation of narrow and weak interphase. This could also lead to the non-uniform dispersion of fibre within the matrix. This can be improved by either physical or chemical modification of the fibre or polymer. Various surface modifications have been developed in order to improve the composite (Abdullah, 2011). One of such modification method is alkaline treatment, commonly known as mercerization process.
Due to light weight, high strength, excellent corrosion resistance, and design flexibility of polymer composites, they are widely used in diverse fields such as civil engineering constructions, automobile, aerospace, ship building and in military hardwares and other areas of application (Parnas, 2001).
It is pertinent to note that, the mechanical and physical properties of natural fibre/polymer composites depend on a number of factors, such as fibre content, concentration of alkaline for treatment concentration, alkaline contact time with fibre, aspect-ratio of the fibres, fibre orientation. Other factors include particle size of fibre, dispersion level in the polymer matrix, fibre–polymer adhesion, processing technology, mixing time/speed, temperature and the use of external coupling agent (Sastra *et al*., 2005). This research is focused on the production of polymer composite from recycled low density polyethylene (rLDPE) and *Eucalyptus globulus* sawdust fibre.

Materials and Method
Materials
The materials used for this research work are: *Eucalyptus globulus* sawdust (EGS), recycled low density polyethylene (rLDPE) from empty used water sachet, sodium hydroxide (NaOH) and distilled water of analytical grade.

FUW Trends in Science & Technology Journal, www.ftstjournal.com
e-ISSN: 24085162; p-ISSN: 20485170; December, 2022: Vol. 7 No. 3 pp. 243 - 252

243

Sample collection and preparation of sawdust
Sawdust from *Eucalyptus globulus* wood was collected from Birnin-Gwarri forest in Kaduna State. Size reduction of the sawdust particles was carried out in a mill. It was then sieved and sun dried. Fine particle sizes ranging from 60 -100 mesh (250-150μm) was selected. It was further dried in an oven at a temperature of 80ºC for 24 h to further reduce the moisture content. This was stored for chemical treatment (Muhammad *et al.,* 2011).

Chemical Treatment of Eucalyptus Globulus Sawdust
The prepared sawdust particles were dried in an oven for 24 h at 105ºC in order to be able to achieve a constant weight of 1-2% moisture content (Muhammad *et al.,* 2011). 100 g of sawdust each was taken and treated with sodium hydroxide according to the experimental design of two input factors and five level of treatment, as shown on Table 2.1. The treated sawdust was washed with enough distilled water

until when the pH of the solution attains neutrality to modify the sawdust particles in order to enhance better bonding and interaction with the polymer matrix. Thirteen (13) runs were carried out in all for the sawdust treatment. The run that was experimentally observed to have the optimum response of cellulose content was then stored and used as filler reinforcement for polymer composite production.

Table 2.1: Experimental Design Using Central Composite Design

Input Factors	-∝	-1	0	+1	+∝
Treatment Concentration (%)	0.88	1.5	3	4.5	5.12
Contact Time (hours)	0.59	1	2	3	3.41

Raw or untreated EG Sawdust (a)   Treated EG Sawdust (b)

Plate 2.1: Raw untreated (a) and Treated (b) EG Sawdust

Compounding and Production Process of Polymer Composite
The polymer composite (PC) was produced using two rolling mill machine and automated compression moulding machine. The two roll mill machine was operated to work and compound both the low density polyethylene matrix and reinforcing sawdust fillers at 155ºC for 4Pa. The two rollers in the mill are rotating in anticlockwise direction to each other.

Recycled low density polyethylene was loaded on the two roll milling machine to melt and flow at 155ºC. After which the reinforcing material EG sawdust fibre was mixed and compounded homogeneously with rLDPE for a period of 15 minutes on the machine. The hot molten compounded chewing- gum-like plasticized composite was transferred into a mould of dimension (100x165x3mm), and then placed inside an automatic compression moulding machine for it be pressed and cured in to a rectangular shaped composite for 5mins at 155ºC. The cured composite sample in the mould was allowed to cool before it was removed from the mould and labeled.

Tensile Strength Test
The tensile tests was carried out following American Society of Testing and Materials - ASTM D 638-01 (2002) using an Instron Universal tensile testing machine and each test was performed at a crosshead speed of 10 mm/min. For each test, three replicate samples was tested, and the average value reported.

Flexural Strength Test
Three points bending test was conducted following American Society of Testing and Materials - ASTM D 256 (2000) using the same testing machine mentioned above at the same crosshead speed. For each test, three replicate samples was tested, and the average value reported.

Hardness test
The hardness of the hybrid polymer composites were measured using a nanoindenter machine according to ASTM D785-98 (2002). For each test, three replicate samples were also tested and the average value reported.

Water Absorption Capacity Test
The water absorption capacity of the hybrid polymer composite was determined. The samples were air dried at 70°C until a constant weight is reached and recorded as (W_1), prior to immersion in a static deionized water bath for 72 hours. After this duration, the samples were removed and wiped properly with a towel, before it was reweighed as (W_2). Three replicate samples for each sample was used to

FUW Trends in Science & Technology Journal, www.ftstjournal.com
e-ISSN: 24085162; p-ISSN: 20485170; December, 2022: Vol. 7 No. 3 pp. 243 - 252

244

obtain the average value. The Water absorption capacity was calculated using equation 1.

Water absorption $\% = \frac{w_2 - w_1}{w_1} \times 100\%$ ………………..2.1

Where w_2 is the specimen weight after soaking and w_1 is the weight of sample before soaking (Muhammad *et al.,* 2011).

Results and Discussion
The chemical compositions of the raw untreated *Eucalyptus globulus* sawdust (EGS) is presented in Table 3.1

TABLE 3.1: Chemical Composition of untreated *Eucalyptus globulus* Sawdust (EGS)

Sample	Cellulose %	Hemi-cellulose %	Lignin %	Extractive %	Ash %
Untreated EGS	41.3	23.2	31.4	3.4	0.7

Untreated of Eucalyptus globulus Sawdust (EGS)
The chemical composition of these materials, are made up of cellulose, hemicellulose, lignin, extractives and ash. The extractives may include wax and oils. The cellulose content (41.3%) of the untreated EGS is the highest among other components and the lowest is ash with 0.7%. This result is similar to that obtained by Pereira *et al.,* (2013) on several species of EGS wood for charcoal yield, and for untreated sugar palm fibre by Hyas *et al*., (2017). In most cases, plant and fruit fibre have higher cellulose content than wood fibre (Khairiah and Khairul, 2006).
The results of the treated EGS is presented in Tables 3.2

TABLE 3.2: Chemical Composition of Treated *Eucalyptus globulus* Sawdust at different Treatment Concentration and Contact Time

Std Run	Factor 1 NaOH Treatment	Factor 2 Contact Time (h)	Responses Cellulose %	Hemi-cellulose %	Lignin %	Extractives %	Ash %
1	1.50	1.00	45.2	22.2	29.1	3.2	0.3
2	4.50	1.00	67.1	11.1	19.6	2.1	0.1
3	1.50	3.00	47.3	20.1	30.1	2.3	0.2
4	4.50	3.00	73.1	8.1	16.1	2.4	0.3
5	0.88	2.00	44.1	21.2	31.2	3.1	0.4
6	5.12	2.00	73.8	9.1	14.3	2.3	0.5
7	3.00	0.59	48.4	19.9	28.7	2.9	0.1
8	3.00	3.41	55.2	16.8	24.3	3.1	0.6
9	3.00	2.00	74.2	9.4	14.1	1.9	0.4
10	3.00	2.00	74.0	9.6	14.2	1.8	0.4
11	3.00	2.00	74.1	9.5	14.0	2.1	0.3
12	3.00	2.00	74.6	9.3	14.1	1.8	0.2
13	3.00	2.00	74.4	9.5	14.2	1.6	0.3

Alkaline (NaOH) Treatment of Eucalyptus globulus Sawdust (EGS)
The alkaline (NaOH) treatment of *Eucalyptus glubulus* sawdust presented some physical changes in the aspect of colour, appearance and texture. Upon alkalization (mercerization), the fairly pink appearance of the raw sawdust changed to orange, while the natural fibre texture became coarse and rough in handling. This is similar to the observation of Lee *et al.,* (2009).
The chemical composition of the treated EG sawdust as shown in Table 3.2 also comprise cellulose, hemicellulose, lignin, extractives and ash. On analysis, the alkaline treatment of the EG sawdust at different concentrations of 0.88%,1.5%, 3.0%, 4.5%, 5.12%, and contact time of 0.59, 1, 2, 3, 3.41 hours according to the experimental design reveal that the cellulose content increases with increase in alkaline concentration and contact time. While the hemicellulose, lignin, ash and extractive components were found to decrease with increasing alkaline concentration. However, the highest cellulose content obtained for EGS was 74.6% at experimental design conditions of 3% alkaline treatment concentration and contact time of 2 hours. The observed increase in the cellulose content is probably due to the fact that some of the hemicellulose have been exposed, broken down, and then converted into cellulose due to its amorphous nature and branch-character, as a result of the mercerization process. The same observation was also made by Amie *et al*., (2013) and Valadez-Gonzalez, (1999). Similarly, other non-cellulose components (lignin, extractives and ash) have continued to decrease in % composition with increase in NaOH concentration as shown in Table 3.2. This is an indication that these components progressively dissolve in the alkaline solution, and are washed off, as also observed by Jie and Fumei, (2011).

Generally, the modification of natural fibres such as EGS through mercerization (alkalization) process, help to

FUW Trends in Science & Technology Journal, www.ftstjournal.com
e-ISSN: 24085162; p-ISSN: 20485170; December, 2022: Vol. 7 No. 3 pp. 243 - 252

245

minimize their moisture absorption affinity, which is a threat to the durability and mechanical properties of polymer composites. This alkaline modification is achieved by breaking the hydrogen bonds existing between cellulose and other natural fibre components such as hemicellulose and lignin. Also, free hydroxyl groups in the natural fibres intending to bond with water molecules are eliminated

(Dittenber and GangaRao, 2012). The EGS fibres with the optimum response based on the experimental design conditions was characterized and used for polymer composite production.

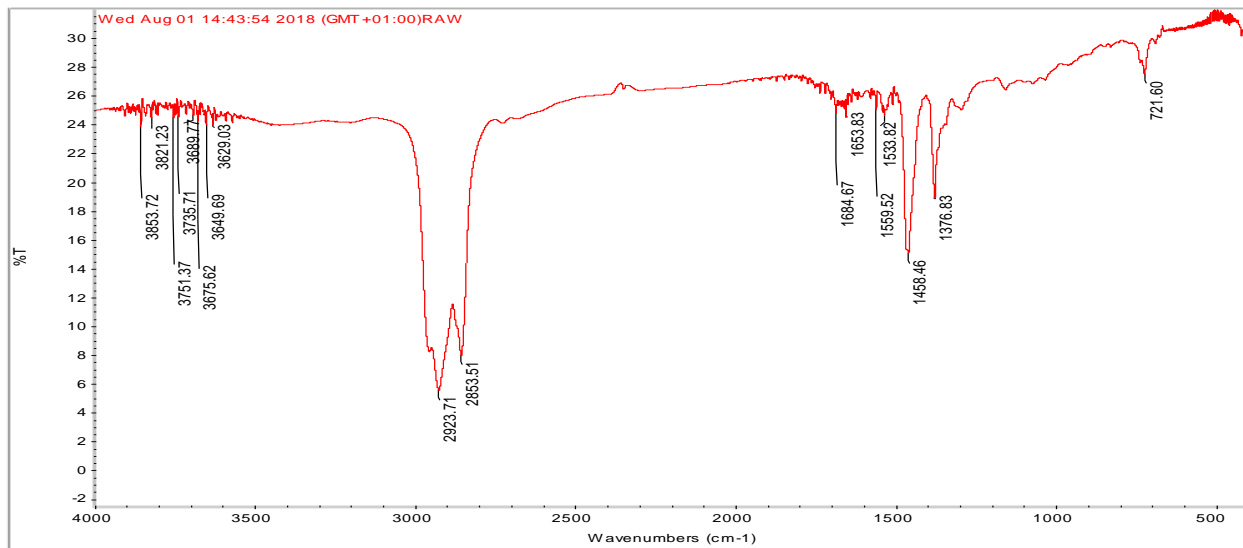The FTIR Spectra for raw (untreated) and treated EGS is presented in Figure 3.1 and 3.2 respectively.

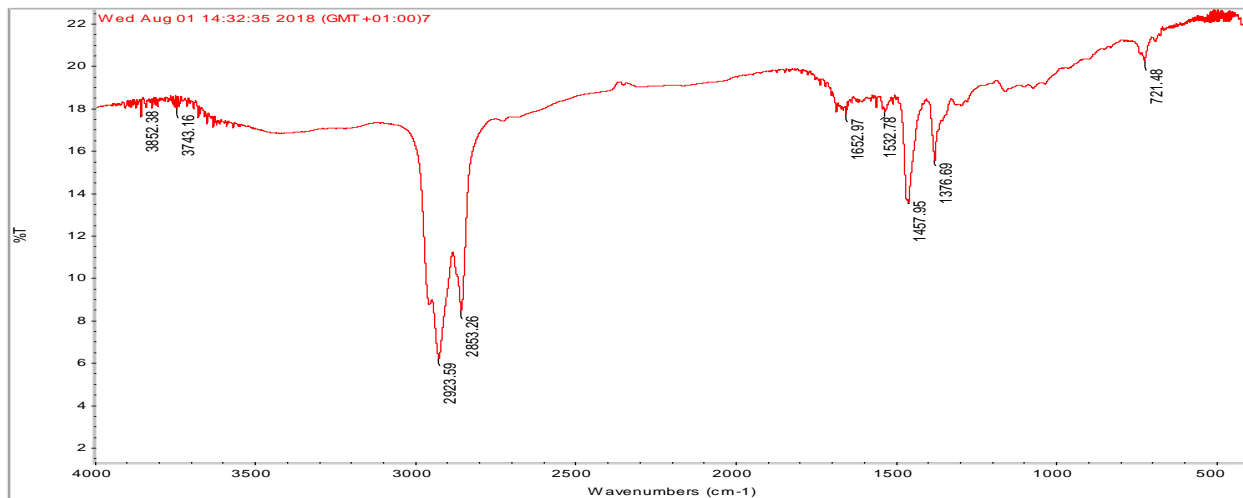**FIGURE 3.1: FTIR Analysis for Raw (Untreated) *Eucalyptus globulus* Sawdust**

FIGURE 3.2: FTIR Analysis for Treated *Eucalyptus globulus* Sawdust

FTIR for Raw and treated EG Sawdust

Figure 3.1 presents the FTIR information of raw *Eucalyptus globulus* sawdust (EGS). The absorbance region is within the fingerprint skeletal vibration region to single bond stretch region (500 cm^{-1} - 4000cm^{-1}). Three major chemical constituents namely cellulose hemicellulose and lignin were observed from the raw EGS result based on their designated spectral. Beginning from the single bond stretch, 8 hydroxyl (OH) group peaks in the range of 3853.72 –3629.03cm^{-1}

were observed. This functional group is evident in most natural fibres having cellulose and hemicellulose as part of their chemical compositions. This report is similar to (Jabar 2017 and Hyas *et al.,* 2017). The presence of these OH groups proves the hydrophilic nature of cellulose and hemicellulose in raw EGS. These OH groups are held together by hydrogen bond. This hydrophilic character can actually pose a challenge for raw EGS fibres to be used as a suitable and compactible reinforcing material with

FUW Trends in Science & Technology Journal, www.ftstjournal.com
e-ISSN: 24085162; p-ISSN: 20485170; December, 2022: Vol. 7 No. 3 pp. 243 - 252

246

hydrophobic polymer resin in composite application. In this same Figure 3.1, alkane C-H peaks were observed at 2923.71 and 2853.51 cm^{-1}. This is also an indicative presence of hydrocarbons in raw EGS as also reported by Khalil *et al.,* (2001). Further observations reveals that C=C double bond stretch groups and variable C=C aromatic rings are present indicating the presence of aromatic attribute of lignin component as observed at (1684.67 – 1653.83 cm^{-1}) and (1559.52 – 1533.82 cm^{-1}) respectively. Also aliphatic chloro compounds C –Cl stretch peaks is seen at a wavelength of 721.60 cm^{-1}.

It is important for raw fibres to be subjected to chemical treatment for it to be suitable for paper and composite application. The FTIR information on Figure 3.2 for the treated EGS at different concentrations for 1 to 2 h exposes more hydroxyl groups present in the cellulose and hemicellulose components compared to that present in the raw EGS. This is as result of the washing away of the insoluble lignin component at the initial stage of the treatment process. Though, continuous treatment time

duration above 2 h led to the dissolving of the hemicellulose component with consequent reduction in the OH groups, due to branched character of hemicellulose as well as the breakage of the hydrogen bond situated between cellulose-hemicellulose and cellulose-lignin. It was also observed that treatment time duration up to 1 h brought about emergence of new carbonyls C=O groups which can be aldehyde, ketone, carboxylic acid and ester at a wave number range of 1772.88 – 1718.15 cm^{-1}. Similarly, there are emergence of nitrile (C≡ N) groups, aliphatic Bromo (C-Br) and Iodo (C-I) functional groups at 2281.40 and 686.70 and 516.65 cm^{-1} respectively as a result of the alkaline treatment. Furthermore, alkaline treatment time duration that exceeded 1 h led to the disappearance of nitrile and aliphatic bromo functional groups. It can then be deduced that a longer treatment time duration has a significant effect on treatment of EGS; while a high alkaline concentration within this design of experiment range will have deteriorating effect on EGS only when the treatment duration is beyond 3 h.
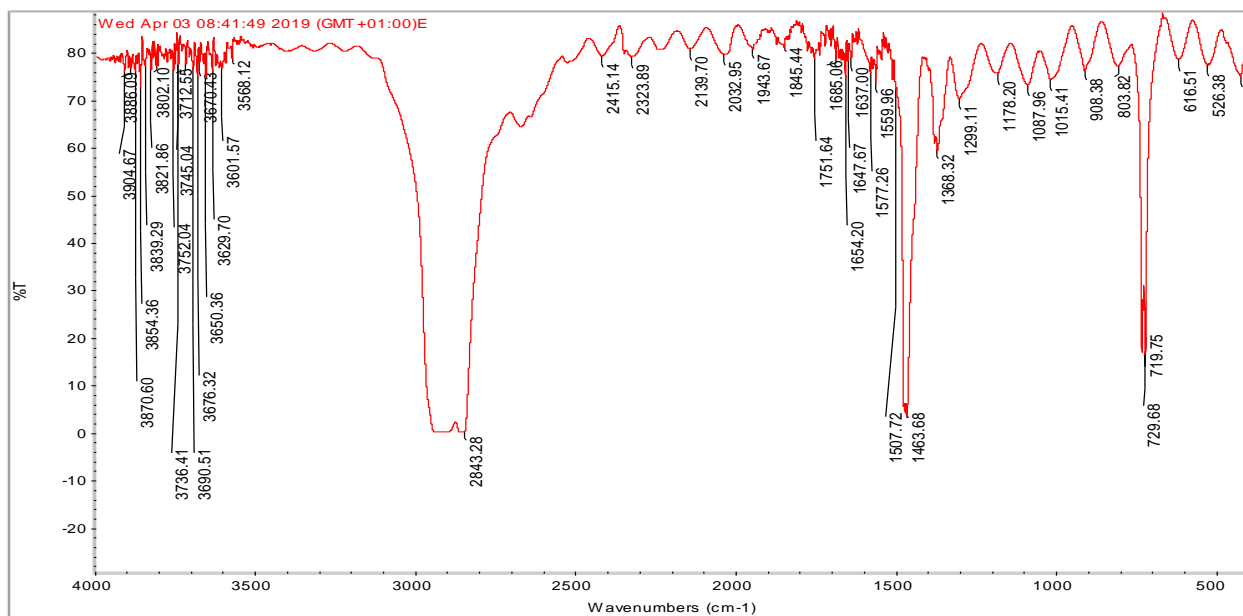

Figure 3.3: FTIR spectra for Recycled Polyethelene (PE)

The FTIR result for recycled polyethelene (PE) on Figure 3.3 reveal a strong broad C-H peak at 2843.28 cm^{-1}. There are clusters of phenolic functional groups ranging from 3904.67 – 3568.12 cm^{-1}. These phenolic compounds represent the antioxidant and additive that are added during processing of PE in order to enhance stabilization and antiblocking (minimization of the adhesion of adjacent polymer film). C-Cl peak is observed at 729.68cm^{-1} and other halide groups (C-X). There are also alkene peaks at 1654.20 – 1637 cm^{-1}. These peaks are features of polyethelene compound. Variable alkene C=C double bond aromatic ring stretch also appeared at 1577.26 – 1507.72 cm^{-1}.

Statistical Analysis of the Alkaline Treatment Process for EGS Fibre
This section presents the ANOVA, measure of central tendencies, model equation and optimum parameters of EGS treatment cellulose content.

Table 3.3: ANOVA for EGS Cellulose Response Surface Quadratic Model

source	Sum of Squares	df	Mean square	F value	p- value prob>F

FUW Trends in Science & Technology Journal, www.ftstjournal.com
e-ISSN: 24085162; p-ISSN: 20485170; December, 2022: Vol. 7 No. 3 pp. 243 - 252

247

Model	1538.89	5	307.78	6.77	0.0131	significant
A-treat conc	493.01	1	493.01	10.84	0.0133	
B-contact time	248.83	1	248.83	5.47	0.0519	
AB	132.25	1	132.25	2.91	0.1319	
A²	193.48	1	193.48	4.25	0.0781	
B²	544.70	1	544.70	11.97	0.0105	
Residual	318.41	7	45.49			
Lack of fit	318.18	3	106.06	1828.63	<0.0001	significant
Pure error	0.23	4	0.058			
Cor.Total	1857.31	12				

Referring to Table 3.3, the model F- value of 6.77 signifies that the model is significant. There is only a 1.31% chance that a "model F-value" of this magnitude could probably occur as a result of noise. Values of "prob >F" that are less than 0.05 indicate a significance in their model terms. In this case, A and B^2 are significant model terms since the values of their "prob>F" is less than 0.05 as shown in Table 3.3; while values above 0.05 depicts otherwise. In this case also, the model term AB which is 0.1319 is not a significant model term in relation to "prob>F".

The lack of fit F-value is significant. This actually influences the fitness of a model. "The coefficient of determination (R-squared) (R^2) is 0.8286 which is an indication that only 82.86% of the variability in the experimental data can be explained by the model. while the adjusted R-squared is 0.7061.

The model equation for the EGS cellulose response in terms of coded factors is presented in equation 3.1

Given that A = Treatment Concentration and B = Contact Time

Then Cellulose = $74.26 + 7.85A + 5.58B - 5.75AB - 5.27A^2 - 8.85B^2$ -----------------------3.1

Equation 3.1 is valid within the range of 1.5 to 4.5% treatment concentration and contact time of 1 to 3 h.

The predicted optimum cellulose response contour plot and the overlay plot for EGS is presented in Figure 3.4 and 3.5 respectively.
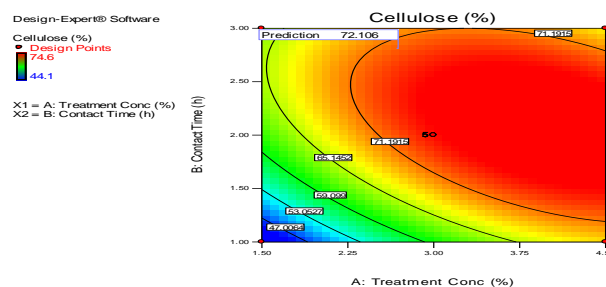

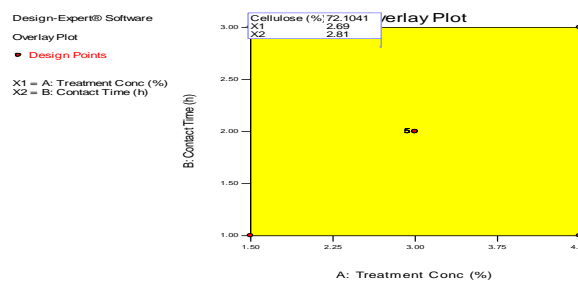**Figure 3.4: Predicted Optimum Cellulose Response Contour Plot for EGS**

Figure 3.5: Overlay Plot for Cellulose Response for EGS

Figure 3.4 and 3.5 present the optimum treatment conditions that give the optimum composition of cellulose and other non-cellulosic chemical composition of the EGS. The predicted optimum alkaline treatment concentration is 2.69% at a contact time of 2.81 h, to give a cellulose composition of 72.1041%.

Characterization of the Polymer Composite Properties
The polymer composite (PC) was produced and characterized by determining its mechanical property (flexural strength, tensile strength and hardness), water absorption capacity and the functional groups present within the PC.

Table 3.4: Mechanical Properties of the EGS Polymer Composite (PC) based on Experimental Formulation

Expt. Formulation		Untreated Polymer Composite			Treated Polymer Composite		
rPE (wt %)	EGS Fibre (wt%)	Flexural strength (MPa)	Tensile strength (Mpa)	Hardness (MPa)	Flexural strength (MPa)	Tensile strength (MPa)	Hardness (MPa)
100	0	10.1	**10.48**	10.17	10.10	10.48	10.17
95	5	10.7	10.33	10.53	11.02	10.56	11.54
90	10	10.85	9.75	10.74	11.55	10.59	12.79
85	15	10.97	9.53	11.21	**12.75**	**10.64**	**13.52**
80	20	11.01	9.45	12.02	11.99	10.17	13.12
75	25	**11.56**	9.20	**12.70**	11.82	9.94	12.91
70	30	10.03	8.71	12.04	11.50	9.49	12.68
65	35	9.88	8.65	11.17	10.36	9.04	12.27
60	40	9.13	8.31	10.73	9.94	8.95	10.99
55	45	8.89	8.24	7.51	9.46	8.73	9.64
50	50	7.99	8.10	6.62	8.78	8.69	9.38

Table 3.4 present the mechanical properties of the untreated and treated EGS PC, according to the experimental formulation. These properties include flexural strength, tensile strength and hardness. For the untreated polymer composite, the maximum optimal flexural strength and hardness property was recorded at a rPE-EGS fibre ratio of 75/25wt%. Beyond this point, a gradual decrease was observed. This is as a result of the agglomeration of the EGS fibre content which does not promote homogeneity within the PC. However, the tensile strength value continued to depreciate with increase in EGS fibre content, this is because of the presence of high lignin content within the EGS fibre which does not promote good adhesion and

Effective load transfer under stress. A similar trend is also observed with the treated PC. Though in this case, the flexural strength, tensile strength and hardness obtained were higher than that of the raw or untreated PC. This is a clear manifestation of the positive effect of the chemical treatment of the EGS fibre with NaOH. This has assisted in advancing the cellulose content at the expense of the lignin content to the barest minimum. It was also observed that lesser treated quantity of EGS fibre content of 15 wt% was used to produce PC with a relative high mechanical property in comparism to raw EGS fibre. This is an indication that chemically treated EGS fibre help to reduce wastage of reinforcing materials in PC production due to the refinement of EGS fibre.

Table 3.5: Optimum Mechanical Properties of the Control, Raw Untreated and Treated EGS Polymer Composite

SAMPLES	FLEXURAL STRENGTH (MPa)	TENSILE STRENGTH (MPa)	HARDNESS MPa	ELASTIC MODULUS MPa	ELONGATION %
100wt% rPE CONTROL	10.1	10.48	10.17	218.67	29.79
UNTREATED COMPOSITE (75/25wt%)	11.56	9.20	12.70	239.27	4.58
TREATED COMPOSITE (85/15wt%)	12.75	10.64	13.52	244.78	5.19

The best and optimum set of mechanical property parameters were extracted and recorded in Table 3.5, the treated EGS fibre polymer composite has higher flexural strength than the untreated EGS fibre. This is also observed by Rezaur *et al*

2010, Lou *et al* 2007 and Mohammad *et al* 2011. This is due the strong interfacial bond initiated by the rough surface of the treated EGS fibre, in bonding with the rLDPE matrix. The tensile strength of the treated EGS composite is 15.65%

FUW Trends in Science & Technology Journal, www.ftstjournal.com
e-ISSN: 24085162; p-ISSN: 20485170; December, 2022: Vol. 7 No. 3 pp. 243 - 252

249

higher than the untreated EGS composite. this is an indication of the positive effect of the chemical treatment process on the EGS fibre and its composite. while the hardness the hardness property of the treated EGS composite has improved by 6.46% in comparism to the untreated EGS composite. Though, they are slightly lower than the control sample which has no fibre. This is because better adhesion between the fibre and polymer matrix has been initiated by the mercerization process. All of these observations are also recorded by Mohammad *et al* 2011. Similarly, the treated composite also shows better elongation property of 13.32% than the untreated composite. this is because, there is ease of load or energy transfer within the composite initiated by the treated fibre.

Plate 3.1: 100wt% Recycled Polyethylene Matrix (Control)

Plate 3.2: 75wt% rLDPE reinforced with 25wt% Raw Untreated EGS

Plate 3.3: 85% rLDPE Reinforced with 15% Treated EGS

TABLE 3.6 Water Absorption Capacity (WAC)

Samples	Water Absorption Capacity %
100% Recycled PE matrix (Control)	0.38
Untreated Fibre Polymer Composite	2.52
Treated Fibre Polymer Composite	0.92

Table 3.6 presents the water absorption capacity test which lasted for 72 hrs. This was calculated using Equation 2.1. The WAC was carried out on the untreated polymer composite, treated polymer composite, as well as the recycled polyethylene matrix (control). The treated composite sample recorded less water absorption capacity compared to the untreated polymer composite. This positive observation is due to the reduction in the OH group present in the treated EGS fibre, by virtue of the chemical treatment or mercerization, which strengthens the interfacial bond between the EGS fibre and rLDPE polymer matrix, for better reinforcement in the treated composite. This has also increased the resistance of the treated EGS fibre to water absorption as stated by Leu *et al.,* 2012. Futhermore, yellow colouration was observed in the distilled water that was used for the water absorption capacity test. This is an indication that some lignin content in the EG sawdust have dissolved into the distilled water.
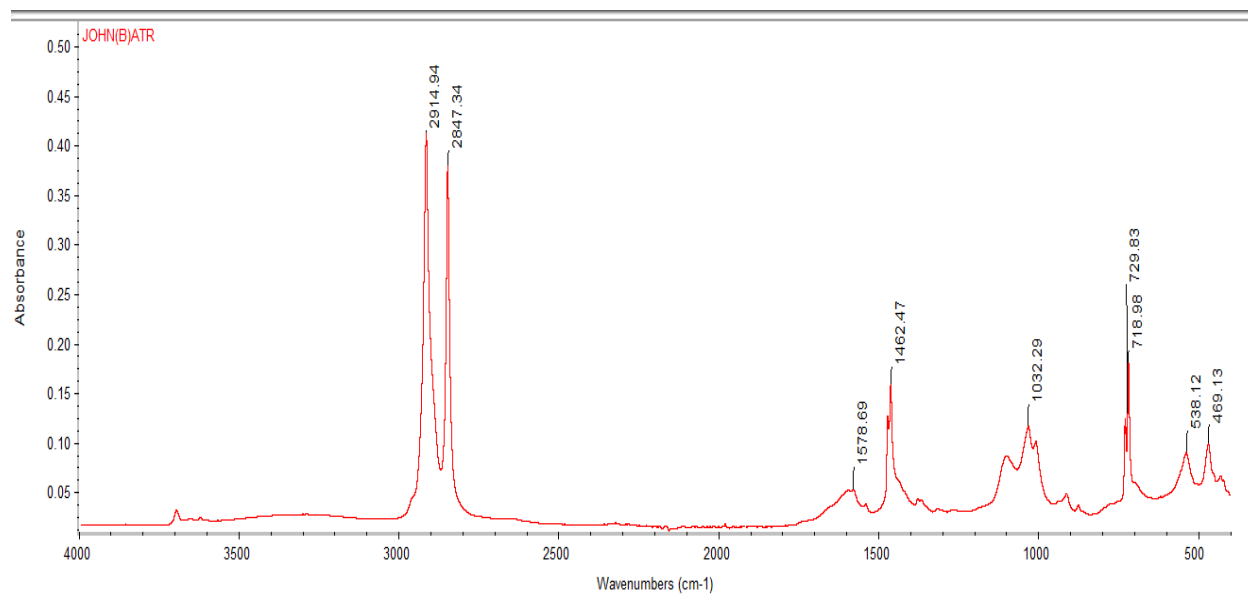
FUW Trends in Science & Technology Journal, www.ftstjournal.com
e-ISSN: 24085162; p-ISSN: 20485170; December, 2022: Vol. 7 No. 3 pp. 243 - 252

250

Figure 3.6: FTIR Spectra for the Treated EGS Reinforced Recycled polymer composite

Figure 3.6 presents the FTIR result of the treated EGS reinforced recycled polymer composite, showing its peaks. This PC however has the best mechanical property in this work. The presence of C-H bond which is a property of the presence of hydrocarbon in both the EG sawdust and the LDPE polyolefin is visible at the sharp peaks of 2914.942 and 2847.33 cm^{-1} respectively. Also, there exists the presence of aromatic ring at 1591.68 and 1462.49 which is an indicative of the presence of lignin component in relative amount based on the effect of mercerization. Hyas *et al.*, 2017 further confirmed this observation. There are absence of OH groups in the polymer composite which were initially present due to water molecule in the untreated and treated EG fibre at relative amount, before they were used as reinforcement. This absence however, may be due to the heat of processing generated from the processing equipment, leading to the evaporation of the water molecules containing the OH functional group.

Conclusion
Polymer composite was produced by reinforcing recycled LDPE with *Eucalyptus globulus* (EG) sawdust. The EG sawdust fibre was chemically treated with NaOH to improve its cellulose component for better adhesive and reinforcing capacity within the polymer composite. The mercerization process of the EG fibre show that an optimal and maximum cellulose content of 74.6% was obtained at 3% NaOH concentration for a period of 2 hr. Results obtained from the mechanical property of the PC produced shows that the treated EG PC possesses better flexural, tensile, hardness and elastic modulus strength values compared to the untreated EG PC. This is same with elongation. This is because of the effective load transfer promoted by the EG fibre. Similarly, the treated EG reinforced polymer composite recorded much lower water absorption capacity (WAC) in comparism to the untreated EG reinforced PC.

The reduction of the OH group occasioned by the chemical treatment is responsible. This shows that the chemical treatment has a positive effect on the PC produced. Though, the hemicellulose, lignin, ash and extractive components were found to decrease with increasing alkaline treatment concentration. Also, OH groups decreased to a minimal as a result of the mercerization process through the breaking down of H$^+$ bonds.

Conflict of Interest
The authors in this work have no conflict of interest.

Reference
Amie, S; Justin, S; Edward, J.W. (2013). Methods for Biomass Compositional Analysis.Online version at http://mprl-series.mpg.de/proceedings/2/.

Abdullah, A.M. (2011). "Study of Mechanical Properties for Polyester Reinforcement by Date Palm with Maleic, NaOH and Hcl Chemical Treatments". Journal of Engineering and Technology, No. 11, Issue 28.

Dittenber, D.B; GangaRao, H.V.S. (2012). Critical Review of Recent Publications on use of Natural Composites in Infrastructure. Compos A Appl Sci Manuf;43: 1419–29.

FUW Trends in Science & Technology Journal, www.ftstjournal.com
e-ISSN: 24085162; p-ISSN: 20485170; December, 2022: Vol. 7 No. 3 pp. 243 - 252

251

Hyas, R.A; Sapuan, S.M; Ishak, M.R; and Zainudin, E.S. (2017). Effect of Delignification on the Physical, Thermal, Chemical and Structural Properties of Sugar Palm Fibre. Bioresources. Com. 12(4), 8734 – 8754.

Jie, L; and Fumei,W. (2011). Influence of Mercerization on Micro-Structure and Properties of Kapok Blended Yarns with Different Blending Ratios. Journal of Engineering Fibres and Fabrics, Volume 6, Issue 3. http://www.jeffjournal.org.

Jabar, J.M. (2017). The Effect of Surface Modification on Chemical Composition of the Oil Palm and Coir Fibres. International Journal of Advanced Research in Chemical Sciences (IJARSC), Vol. 4, Issue 1, PP 13- 21.

Khalil, H.P.S.A., Ismail, B., Rozman, H.D., and Ahmad, M.N. (2001). The Effect of Acetylation on Interfacial Shear Strength between Plant Fibres and various Matrices. Eur Poly J 37:1037–1045.

Khairiah, B; and Khairul, A.M.A. (2006). Biocomposites from Oil Palm Resources. *Journal of Oil Palm Research*. (Special Issue-April): 103-113.

Kopeliovich, D. (2010). Classification of Composite Material. Retrived fromwww.substech.com.

Leu, S.Y; Yang, T.H; Lo, S.F; Yang, T.H. (2012). Optimized Material Composition to Improve the Physical and Mechanical Properties of Extruded Wood–Plastic Composites (WPCs). Construction and Building Materials, 29, pp.120–127.

Lou, C.W; Lin, C.W; Lei, C.H; Su, K.H; Hsu, C.H; Liu, Z.H; and Lin, J.H. (2007). "PET/PP Blend with Bamboo Char-coal to Produce Functional Composites," *Journal of Materials Processing Technology*, Vol. 192-193, pp. 428-433. doi:10.1016/j.jmatprotec.2007.04.018.

Lee, B.H; Kim, H.J; and Yu, W.R. (2009). Fabrication of Long and Discontinuous Natural Fibre Reinforced Polypropylene Biocomposites and their Mechanical Properties, Fiber and Polymers. Vol. 10, pp. 83-90.

Muhammad, A.M.M; Sinin, H; Muhammad, R.R. (2011). Treated Tropical Wood Sawdust- Polypropylene Polymer Composite: Mechanical and Morphological Study. Journal of Biomaterials and Nanobiotechnology, 2, 435-444. doi:10.4236/jbnb.2011.24053, (http://www.SciRP.org/journal/jbnb).

Rezaur, M.D; Rahman, M.D; Nazrul-Islam, M.D; and Monimul, H. (2010). "Influence of Fiber Treatment on the Mechanical and Morphological Properties of Sawdust Reinforced Polypropylene

Composites," *Composites*: *Part A*, Vol. 18, No. 3, pp. 1739-1747.

Parnas, R.S. (2001). Liquid Composite Molding.Handbook of Bioplastic and Biocomposite Engineering Applications. Srikanthpilla (Ist Eds.),*43-74*.Scrivener publishing *LLC*.

Pereira, B.L.C; Carneiro, A.C.O; Carvalho, A.M.L; Colodette, J.C; Olivera, A.C; and Fonts, M.P.F. (2013). Influence of Chemical Composition of Eucalyptus Wood on Gravimetric Yield and Charcoal Properties. Bioresources ,8(3) 4574 – 4592.

Smith, P. (2017). Construction and Building Materials, Vol 24:12 pp 2446 -2454.

Sastra, H.Y; Siregar, J.P; Sapuan, S.M; Leman, Z; and Hamdan, M.M. (2005). Flexural Properties of Arenga Pinnata Fiber Reinforced Epoxy Composites. *American Journal of Applied Sciences*. (Special Issue): 21-24.

Valadez-Gonzalez, A. (1999). "Effect of Fiber Surface Treatment on the Fiber-matrix Bond Strength of Natural Fiber Reinforced Composites,"*Composites Part B: Engineering,* vol. 30, pp. 309-320, 1999.