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Effect of filler characterization on the properties of chemically treated groundnut shell

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ABSTRACT

Modification of fillers at varying concentrations of sodium hydroxide (NaOH) Solution and acetylating solutions were studied. The filler characteristics analyzed show that chemical treatment had adverse positive effects on the groundnut shell. The fibre reinforcing efficiency of the chemically treated groundnut shell filler were compared with that of the untreated filler observed in the fourier transform infrared.

KEYWORDS

Modification;
Shell;
Mercerization;
Acetylation;
Fourier;
Infrared.

INTRODUCTION

The renewed interest in the natural fibres has resulted in a large number of modifications to bring it at far and even superior to synthetic fillers. Because of such tremendous changes in the quality of natural fibres, they are fast emerging as a reinforcing material in composites[1] considering the high performance standard of composite materials in terms of durability maintenance and cost effectiveness, applications of natural fibre reinforced composites as construction material in creating built environment holds the enormous potential and are critical for achieving sustainability. Fowler et al[2] stated that materials from renewable resources are being sought as replacement and do not only act as reinforcement elements, but also the matrix phase of composite materials. It is not surprising, therefore, that more than 50% of all chemist, physicists, mechanical engineers and many material scientists are involved with research or development work with polymer composite. In its raw state, rubbers may not be good enough for any useful application, so there is the need for the addition of additives which help to enhance the properties. Today there are lots of researches going on the use of an alternative (local source) for it[3]. Advances are being made into the use of agricultural by products, such as rice husk, dika-nut shell, etc in rubber composite[4]. These materials are used in their raw form or they are modified before used. Groundnut shell is chosen because of its readily availability and also previous work has being done using ground shell by several researchers in their drive to find alternative replacement for carbon black. In recent years, the interest in using natural fibres in biocomposites has grown because they are lightweight, combustible, non, toxic, low cost and easy to recycle. On the other hands, lack of good interfacial adhesion and poor resistance to moisture absorption makes the use of natural fibres to be hygroscopic in nature; moisture absorption can result in swelling of the fibres which may lead to micro -cracking of the composite and degradation of mechanical properties. Chemical treatment of the fibres can stop the moisture absorption process, clean the fibres surface, and chemically modify the surface or increase the surface roughness, by decreasing the hydroxyl groups which may be involved in the hydrogen bonding within the cellulose molecule

MATERIALS

The major materials required in this work are shown in TABLE 1.

Fourier transform infrared spectroscopy

Machine: Fourier Transform Infra-Red Spectrometer, model: Subpart ZZZZ-MACT-320, manufactured by Pine Equipments Co. Ltd., U.S.A

METHOD

Mercerization process

Groundnut shells were pounded in a mortar to find particle size. After which, 40g each of were soaked in 5, 10,15, 20, 25, and 30% sodium hydroxide solutions for 1hour at room temperature. The solutions were then filtered ands thoroughly washed with distilled water, dry at room for 48 hours follow with oven drying at 110^{O}C for 2 hours.

Fibre – OH + NaOH -> Fibre – ONa + H_2O

Acetylation process

Pounded groundnut shells were immersed in 20% sodium hydroxide solution for 1hour at room temperature. The alkaline treated shells were then soaked in 5% glacial acetic acid for 1hour at room temperature. The solutions were filtered and 40gs each of the filtered groundnut shell were soaked in 5, 10, 15, 20, 25 and 30%s acetic anhydride containing one drop of concentrated sulphuric acid for five minutes. The solutions were than filtered again and thoroughly washed with distilled water; try at room temperature for 48 hours follow with oven drying at 70^{o}C for 2 hours[4].

Fibre – OH + CH_3CO^- -> Fibre – $OOCH_3$ + H^+

Characterization of filler

Fourier transform infrared test

The Fourier Transform Infrared of the powdered samples will be carried out using the Fourier's Transform Infrared Spectrometer

RESULTS

Results of the test carried out are shown in TABLES 2 - 4

DISCUSSION

The chemical structure of the groundnut shell powder and the chemically treated groundnut shell powder components are shown in Figure 7 - 9; the FTIR spectra of groundnut shell powder show a strong characteristic carbonyl absorption peak at 1736.24cm^{-1}. This was attributed to the acetyl and uronic ester groups of the hemicelluloses or the carboxylate groups of the ferulic and p-coumeric acids of lignin and hemicellulose[5]. The peaks at 1509.29 and 1429.55 cm^{-1} in the groundnut shell powder show the aromatic C =C stretch of the aromatic rings of the lignin ([6,7]. 1653.43cm^{-1} C=C stretching confirm the presence of the lignin aromatic rings. Alcohols

TABLE 1 : Materials and their Sources

Materials	Sources
Groundnut Shells	Auchi, Edo State
Sodium hydroxide	British Drug House (BDH), England
Tetraoxo sulphate (Vi) acid	British Drug House (BDH), England
Acetic anhydride	Sigma Andriech, Germany
Glacial acetic acid	Sigma Andriech, Germany

TABLE 2 : Physico-chemical properties of the treated groundnut shell

Concentration (%)	Cellulose (%)	Moisture Absorption (%)	Lignin Content(%)	Thermal Stability (g/s)	Hemicellulose (%)	Density (g/cm^3)
5	[12.75] (14.43)	[8.90] (8.79)	[17.89] (16.08)	[2.8] (2.4)	[19.08] (16.65)	[0.91] (0.85)
10	[15.12] (17.56)	[8.60] (8.20)	[14.21] (13.55)	[2.5] (2.0)	[18.77] (15.12)	[0.71] (0.69)
15	[16.89] (19.24)	[8.55] (8.01)	[13.47] (11.23)	[2.3] (1.9)	[17.54] (13.31)	[0.62] (0.54)
20	[20.09] (24.33)	[8.50] (7.64)	[12.96] (10.07)	[2.1] (1.8)	[17.08] (12.75)	[0.56] (0.45)
25	[21.83] (26.22)	[7.20] (6.15)	[10.06] (9.98)	[1.9] (1.6)	[14.46] (11.88)	[0.50] (0.40)
30	[28.95] (32.11)	[6.10] (5.83)	[8.12] (7.66)	[1.7] (1.4)	[9.22] (7.35)	[0.45] (0.30)

Key: Acetylated Fibre ( ), Mercerized Fibre [ ]

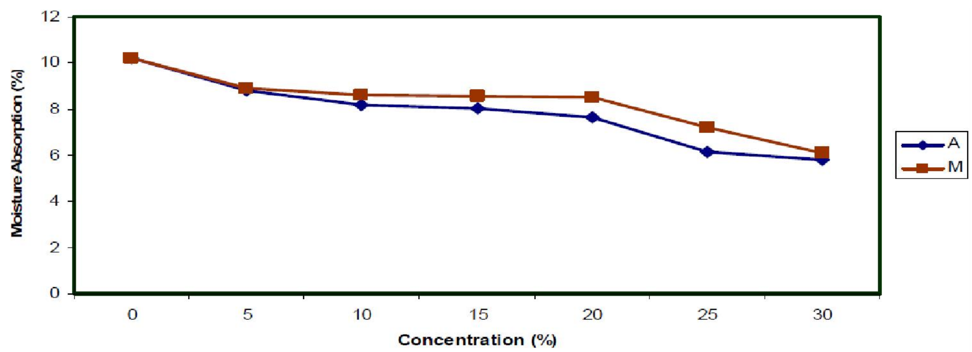

Figure 1 : Moisture absorption of the treated groundnut shell fillers

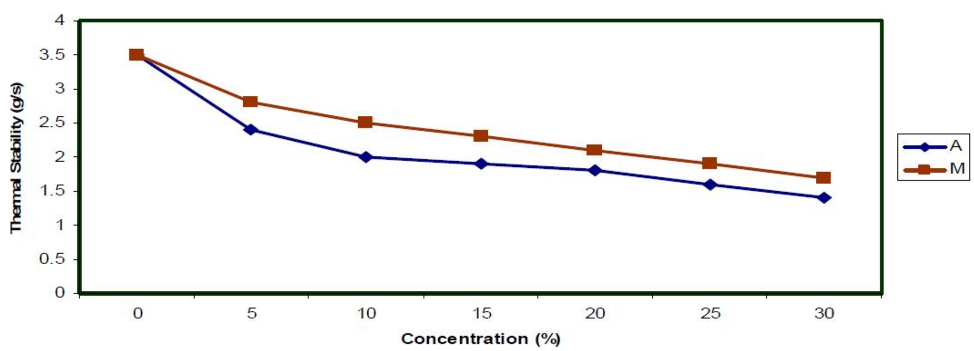

Figure 2 : Thermal stability of the treated groundnut shell fillers

and phenols produce characteristics infrared bands the to O-H stretching at 3417.90cm^{-1} and C-O stretching at 1257.80 and 1033.92cm^{-1} which are both sensitive to hydrogen bonding[5,8].

The FTIR spectra of acetylated groundnut shell powder shows the removal of pectins, lignin and hemicelluloses resulting from the varnishing characteristic band at 1736.24cm^{-1} (carbonxylic groups), prominence of 1605.51cm^{-1} (acetyl group) and reduction in the intensity of 1257.80cm^{-1} (methyl ester groups). 1509.29 and 1429.55cm^{-1} (aromatic C=C stretch) indicating the treatment had removed some amount of pectin, lignin and hemicelluloses. Equally this was in accordance with the chemical changes in the surface and it's crystalline in literature[9].

The results in TABLE 2 shows that the weight of the acetylated groundnut shell and that of the untreated after taking the bulk density of both are almost the same 0.49g/cm^3 for the acetylated and 0.5g/cm^3 for the untreated shell. This is due to the treatment given to the acetylated powdered shell. The density de-

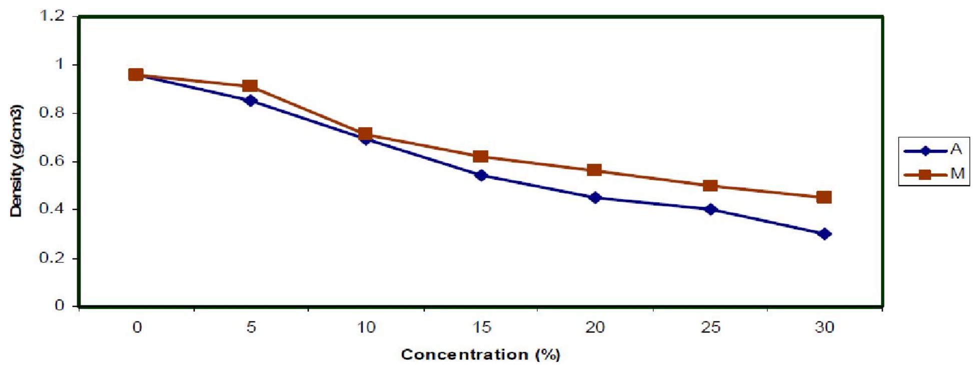

Figure 3 : Density of the treated groundnut shell fillers

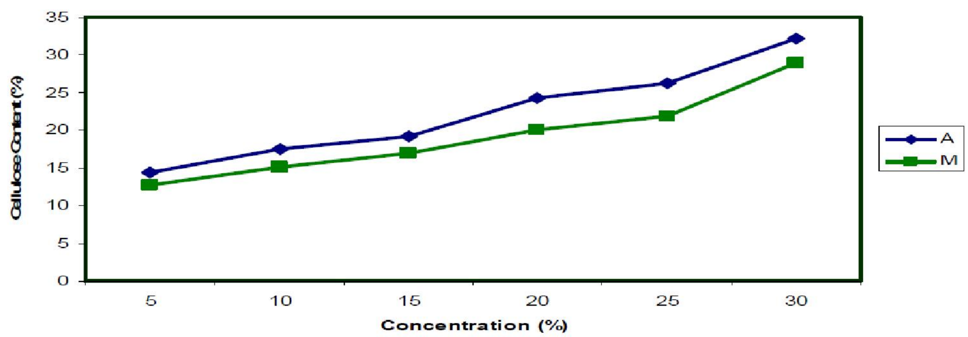

Figure 4 : Cellulose content of the treated groundnut shell fillers

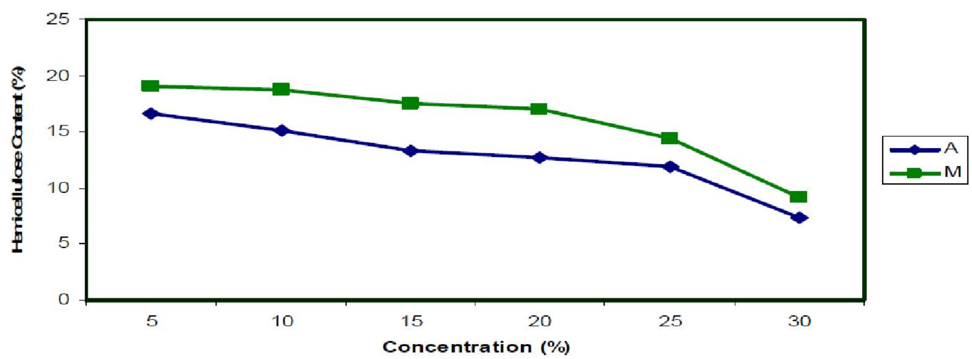

Figure 5 : Hemicellulose content of the treated groundnut shell fillers

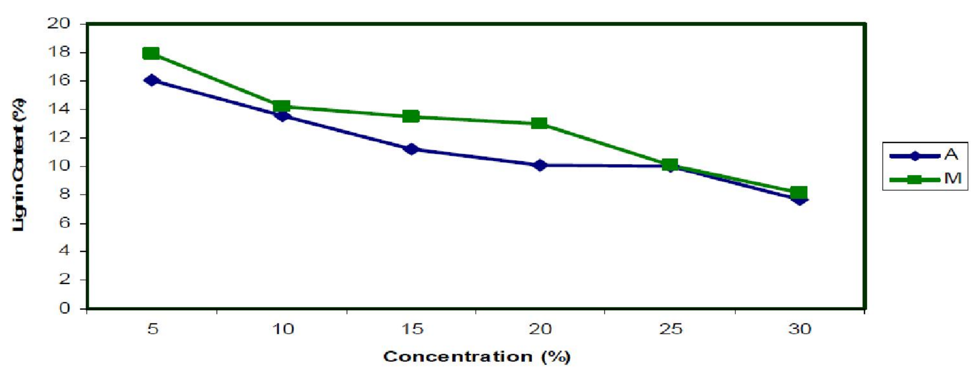

Figure 6 : Lignin content of the treated groundnut shell fillers

creases with increased in concentration. There was decrease in the moisture absorption for the acetylated treated shells. Reduction of about 50% moisture up take for acetylated jute fibres has been reported by Bleezki and Gassan[10].

The materials tested were assumed to be thermally homogeneous. The heat flow showed the rate of consumption of the material as a function of time.

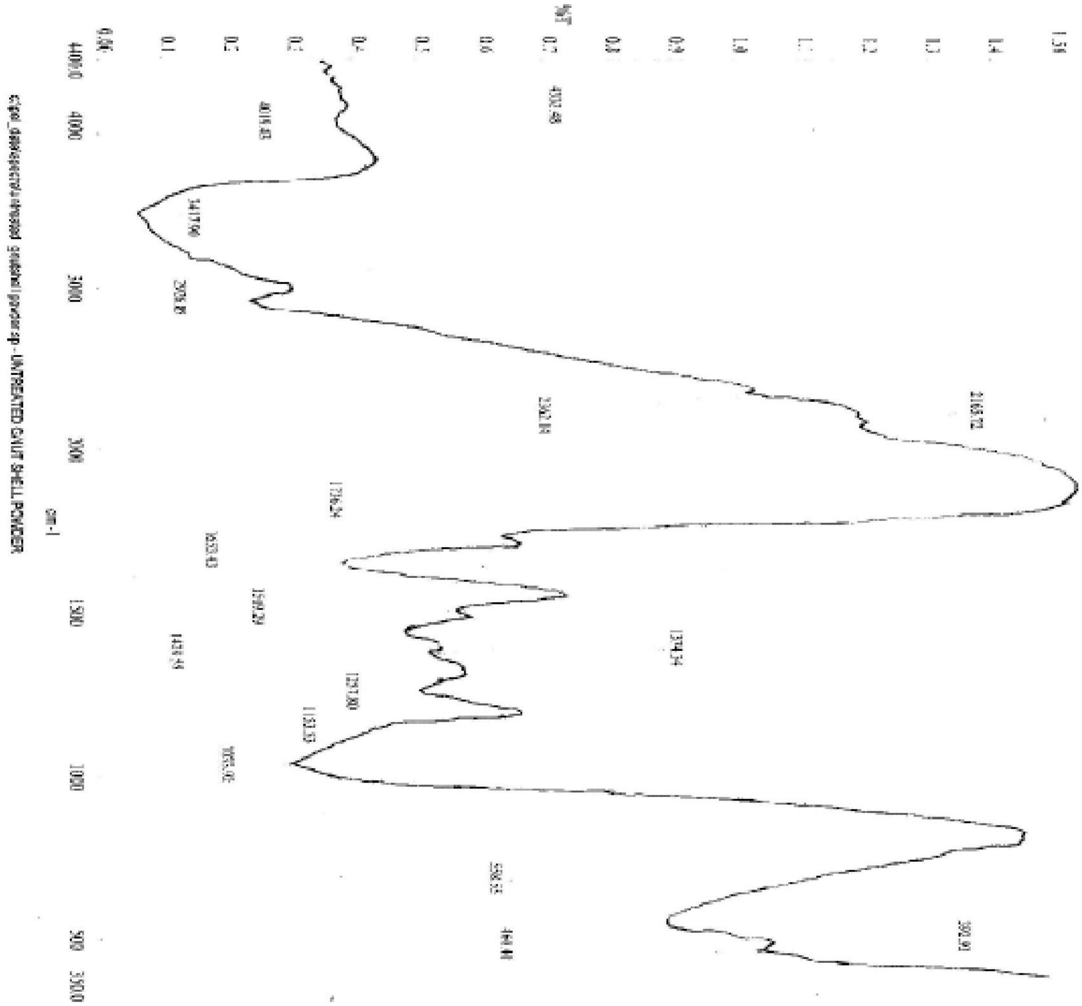

Figure 7: FTIR of untreated groundnut shell fillers

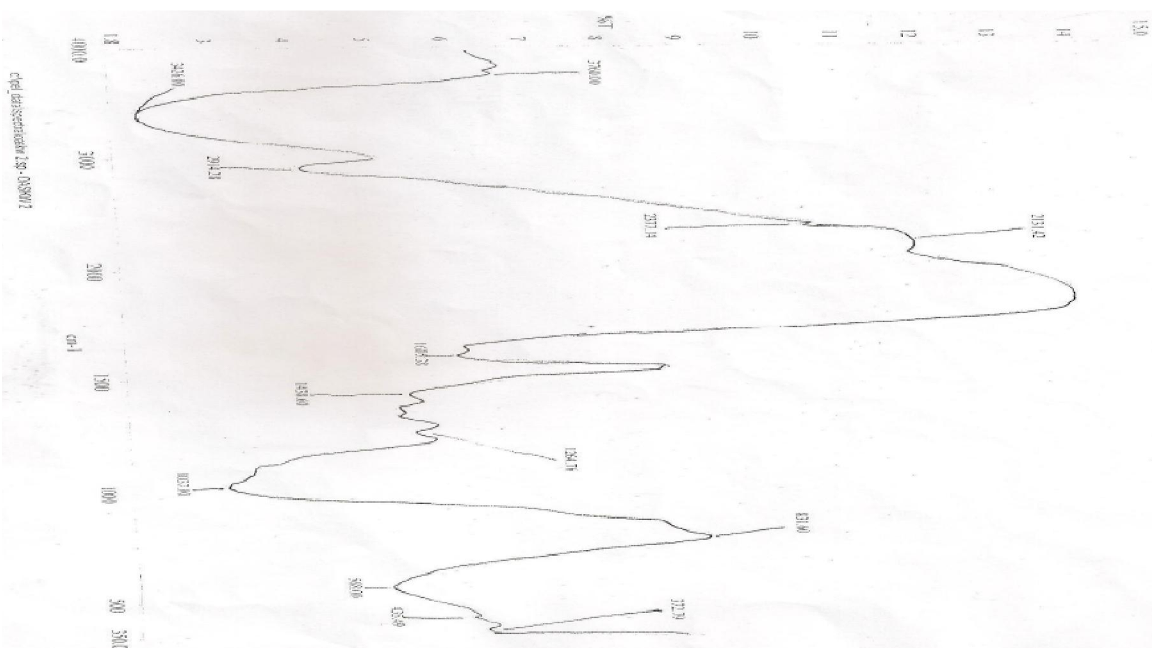

Figure 8 : FTIR of mercerized groundnut shell fillers

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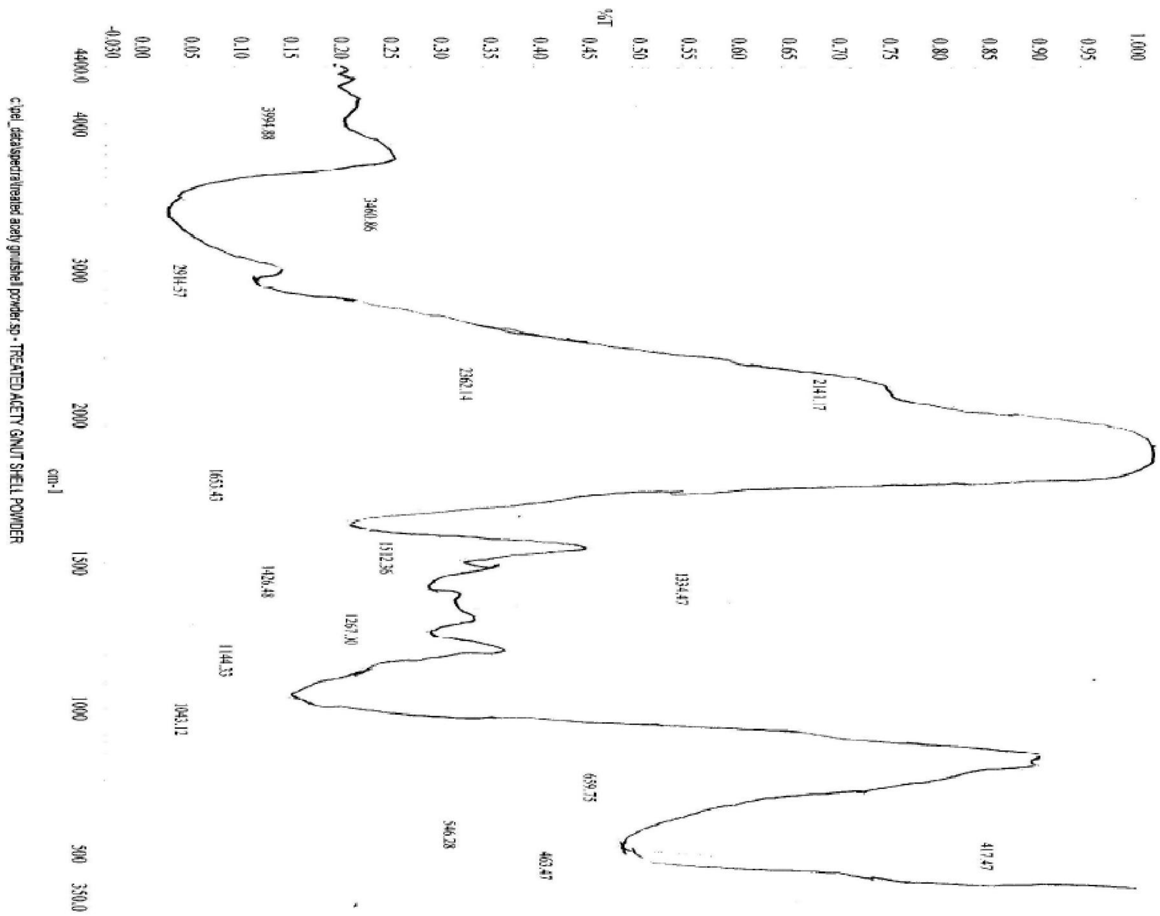

Figure 9 : FTIR of acetylated groundnut shell fillers

TABLE 3 : Infra-red characteristics of untreated groundnut shell powder

Wave number (cm^{-1})	Functional Group	Characteristics
3417.90	Alcohol O-H	Stretching
2926.85	Methylene Asymmetric C-H	Stretching
2362.14	Combination C-H	Stretching
2165.72	Combination and Overtone O-H	Stretching bands
1653.43	C=C	Stretching
1429.55	Methylene	Stretching
1153.53	In-Plane C-H	Stretching
1033.92	In-Plane C-H	Stretching
558.55	Out of plane C-H	In plane bending
460.40	= C – G	Bending
392.93	Out of plane C-H	Stretching
3417.90	Alcohol O-H	Stretching
2926.85	Methylene Asymmetric C-H	Stretching
2362.14	Combination C-H	Stretching
2165.72	Combination and Overtone O-H	Stretching bands

It shows that chemical treatment can increase the thermal stability of the treated shell as a result of the consumption rate of the material per minutes i.e. burning test[11, 12]. The reason for these is the fact that chemical treatment confers on the shell powder hydrophobicity and increase tensile strength of the

TABLE 4 : Infra-red characteristics of the treated groundnut shell powder

Wave number (cm-1)	Functional Group	Characteristics
3460.86	Alcohol O-H	Stretching
2914.14	O-H	Stretching
2362.14	Combination C-H	Stretching
2141.17	Combination and overtone O-H	Stretching bands
1653.43	C=C	Stretching
1426.48	C-O-H	In plane bending
1334.47	Methyl symmetrical C-H	Bending
1300 – 1000	Aliphatic C-O	Stretching
Wave number (cm-1)	Functional Group	Characteristics
3460.86	Alcohol O-H	Stretching
2914.14	O-H	Stretching

material.

The results of the chemical constituents presented in TABLE 2 and Figure 4 - 6 show a progressive decrease in percentage of lignin and hemicellulose while there was a significant increase in percent of the cellulose content. This is expected because more lignin and hemicellulose are gradually removed as a result of the chemical treatment thereby increasing the yield of cellulose in the fibre.

CONCLUSION

The preliminary results of the assessment revealed that groundnut shell is hydrophilic due to the presence of the hydroxyl group from cellulose and lignin. Chemical treatment reduces the hydrophilicity of the fibre by decreasing the hydroxyl groups in the fibres. It also shown that groundnut shell is a potential substitute for glass fibres, based on the fact that chemical treatment of groundnut shell have achieved some degree of success in making a superior interface, mechanical properties and sorption behaviour. Most of the chemical treatment from literature reviewed indicates decrease in the strength properties at high concentration levels because of the disintegration of the non-cellulosics materials. Mercerization and acetylation studied from this communication shows that at low concentration, treatment lead to strong covalent bond formation, increase fibre matrix adhesion and thereby enhancing the composite strength.

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