INVESTIGATING THE CHEMICAL COMPOSITION OF COCONUT SHELL POWDER AND ASH FOR COMPOSITE REINFORCEMENT

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ABSTRACT

The replacement of the conventional composites materials with the use of natural resources which are environmentally-friendly had been the interest of many researchers over the last decade. Apart from the use of natural fibres as reinforcement in polymer matrix composites, fillers made from natural sources such as coconut shell, corn cobs, palm kernel shell, rice husk, has been confirmed to be potential material that can offer some good properties that can satisfy the requirements that are needed for some engineering applications. In this study, the potential of coconut shell powder and coconut shell ash were investigated for composite reinforcement. Fourier transform infra-red spectroscope was used to determine the chemical compositions of the samples. The results obtained revealed the presence of silicon oxide $SiO_{2,\ iron}$ (II) oxide (Fe_2O_3) and calcium oxide (CaO) in both coconut shell powder and coconut shell ash, demonstrating some comparable chemical properties to the conventional sources with the presence of some basic metals which are required to produce reinforcement materials with high strength, durability, light weight and corrosion resistance. The study hence concluded that coconut shell ash and coconut shell powder could be used as reinforcement in metals and other polymer matrix composites respectively that are required for engineering applications.

Keywords: Composite, Reinforcement, Infra-red, Matrix

1 INTRODUCTION

Coconut shell powder which is used for reinforcement consist of lignin and pentosanes and has recently gained lots of attention and acceptance as composite replacement in a wide variety of applications in the aerospace, construction and manufacturing industries lately owing to some special characteristics such as light weight specific stiffness, strength, uniform quality, good resistance to water, resistance to heat and fungal attack and the ability to create new surface finish [1]. This product is usually obtained from coconut shell which is free from contamination if coir pit is broken into small pieces and crushed with the aid of a hammer mill or as pounding machine and later fed into a pulverizing machine to produce a powdery substance. The powder obtained from the pulveriser are then fed into a cyclone and the parallel product is collected in a bag filter and subsequently fed into a vibrating sieving machine and packed according to mesh size requirements for various end uses. Coconut shell powder are used in applications such as a filler in the manufacture of thermostat moulding powders like Bakelite, synthetic resin glues or phenol formaldehyde, mosquito coils, incense sticks, plywood, laminating boards and as lost

circulation materials in oil well drilling [2]. Inadequate disposal of coconut shell after consumption of the fruit has tremendously aggravated the problem of solid waste management in Nigeria. This menace constitutes serious health challenges to both human and the environment. Harnessing the huge economic potential of coconut shell crop to obtain products such as coconut shell ash, coconut shell powder and activated charcoal which is highly essential in our mining, foundry and manufacturing industries has not been accorded full priority, hence there is the need for the continuous research on how best to harness this crop fully which will help in eliminating or reducing the hazards associated with its disposal. Coconut shell powder is a form of reinforcement used in a wide variety of applications, such as solid woods for domestic uses, production of furniture, as partial replacement for cement in construction activities [3]. Coconut shell particles are also used in solving drilling problems in the oil industries, they are also used as active carbon which is considered extremely effective for the removal of impurities in waste water, as fillers to improve mechanical properties of composites, synthetic glues and for medicinal purposes [4]. These among others have helped in reducing the indiscriminate disposal of the coconut shell after consumption of the fruit and the problem associated with its poor disposal. Coconut shell powder which is usually sourced from local Miller is a light brown material which has a bulk density of 0.7gcm-3 with varying thicknesses between 2-8mm and an approximate density value of 1.60g/cm^3 [5]. Coconut shell powder exhibits admirable properties such as low cost, renewable, high specific strength to weight ratio, low density, less abrasion to machine and it is environmentally friendly. Considering all these potentials, this study aims to investigate the elemental composition of coconut shell powder and ash for composite reinforcement.

2 METHODOLOGY

The materials used were un-carbonised coconut shell powder and coconut shell ash. The major Equipment used in this study include the Hammer mill, automatic vibratory Sieve, Mallet, furnace, weigh balance and the FTIR spectrometer.

2.1 Crushing Process

The Coconut shells which were obtained from Damaturu central market located at Abasha ward in Damaturu, local government area of Yobe State, Nigeria, were broken into pieces using sledge hammer in the mechanical engineering department of Federal Polytechnic Damaturu, Yobe State and was later pounded in a local mortal to reduce the particle size. Thereafter the broken pieces were grounded to powder with the aid of a Hammer mill, and sieved using an Automatic Vibratory Sieving machine with different Mesh sizes to obtain a fine powdery product. In this study, three different samples of Mesh sizes 0.45mm, 0.15mm and 0.9mm were collected and labelled respectively for the experimental analysis which was carried out at the multi-user laboratory of the chemistry department in Ahmadu Bello University Zaria, Nigeria to determine the chemical and elemental characteristics of the product with the aid of an Infrared Transform Spectrometer. This method is in line with the work of Obiokum et al [1].

2.2 Sieving Process

The coconut powder obtained after the crushing and grounding of the coconut shell was sieved so as to separate the wanted product from the unwanted ones with the aid of an automatic vibratory sieving machine. This process lasted for about 2 hours only and the required samples were collected and labelled according the required mesh size. This is in agreement with work of Bello et al [3].

2.3 Weighing Process

This process was carried out to obtain the required weight of the individual samples in this case 3 kg used for this study to ensure uniformity. The three samples were labelled according and later package in an air tight plastic container before it was taken to the laboratory for the test. This method was reported by Leman et al [5].

2.4 Ash Process

The process used to obtain the ash was by burning coconut shells in an open local domestic stove in an operation which lasted for 3 hours. The resultant ash product which was grey in colour was subsequently taken to the laboratory to also determine its chemical and elemental characteristics in order to compare its result with the result obtained from the result of the analysis done on the coconut shell powder. This is in line with the work of Bello et al [3].

2.5 Fourier Transform Infrared Test

The FTIR spectroscopy is an established technique for quality control when evaluating industrially manufactured material. A change in the characteristics pattern of absorption bands usually indicates a change in the composition of the material or the presence of contamination. This technique is usually used for analysing the chemical composition of smaller particles, typically 10-50 microns. Coconut shell is located in between the coconut flesh and coconut husk. This shell is naturally created to protect the inner part of the coconut. The coconut shells were broken into pieces and grounded into powdery form which was used as the first sample. Coconut Ash otherwise known as activated charcoal is a grey powdery substance which is usually obtained by burning coconut shell powder in a furnace which is regulated at a certain temperature. Plate 1 presents a sample of the coconut shell ash.

Plate 1. Coconut Shell Ash

2.6 FTIR Spectrometer

The Fourier Transform Infrared (FTIR) spectrometer Figure 2, is an instrument which acquires broadband Near Infra-Red (NIR) to Far Infra-red (FIR) spectra. Unlike dispersive instruments such as grating monochromatic or spectrograph, FTIR spectrometers collect all wavelengths simultaneously. The FTIR instruments send infrared radiation of about10, 000 to 10 cm^{-1} through a sample, with some radiation absorbed and some transmitted. The absorbed radiation is converted into rotational and or vibrational energy by sample molecules. The resulting signal at the detector presents as a spectrum, typically from 4000cm^{-1} to 400cm^{-1}, representing a molecular fingerprint of the sample making the FTIR analysis a great tool for chemical identification.

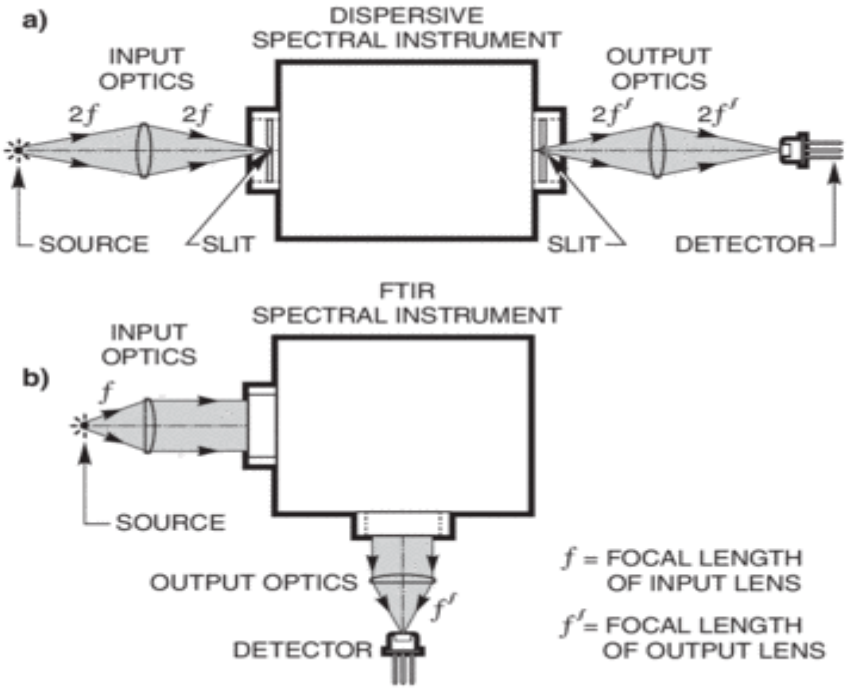

Figure 1. Schematic Diagram of FTIR Spectrometer

2.7 Hammer Mill

This very importance equipment was used to crush the coconut shell aggregates into suitable fine flour by repeated blows for use as specimen in the study. Plate 2 is a pictorial representation of the hammer mill used in the study. This procedure was reported by Bello et al [3].

Plate 2. Hammer Mill

2.8 Automatic Vibratory Sieve

The Automatic vibratory (Plate 3) was used to characterized the coconut shell powder into finely divided substance as required for this study.it consist of different meshes as shown below. This method was also reported by [1, 3, 7].

Plate 3. Automatic Vibratory Sieve

2.9 Automatic Weigh Balance

The electric weigh balance shown in Plate 4 was used to weigh each of the sample sizes used for the study.

Plate 4. Automatic Weigh Balance.

2.10 Mallet

This equipment was employed to reduce the sizes of the coconut shell into smaller pieces, before it was taken to the hammer mill for further crushing and grinding operation.

2.11 Local Cooking Stove

This equipment (Plate 5) was used to burn the coconut shell in an open environment to obtain the ash which was used as the second specimen in this research work.

Plate 5. Local Cooking Stove

3 RESULTS AND DISCUSSION

3.1 Chemical Composition of Coconut Shell Powder

Coconut shell powder is a by-product obtained by crushing and grinding coconut shell into powder.it is organic in nature and similar to hard woods in terms of chemical composition though the lignin content is higher while the cellulose content is lower. The chemical composition of coconut shell powder dependents on several factors such as age and varieties. Following the FTIR experiment conducted on coconut shell powder, Table 1 presents the chemical composition of coconut shell powder. The result of the chemical composition of coconut shell powder obtained by concentration are, wax 5% this accounts for the reason why it is being used for maturing of coils, creams, air purifiers, Carbon 12.0%, silicon dioxide 0.88%. which makes coconut shell powder and coconut shell ash to offer significant stability in terms of insulation thereby making it to use in the manufacturing of electronic chips and in the aerospace industries, with Potassium oxide at 1.35 % Carbon, iron(II) oxide 0.50%,magnesium oxide 0.43%, sodium oxide 0.33%, calcium oxide 0.25 %, Molybdenum(VI) oxide 0.20%,Sulphur and Phosphorus have 0 concentration less than the lower level detection (LLD), Coconut shell powder and shell ash will offer good reinforcement properties for most engineering applications because of the presence of iron II Oxide because it is insoluble in water and all ordinary solvents, soluble in acids thereby making it very suitable for use as dyes or pigments in pottery, glasses production and for automobile applications. The composition of Aluminium in this composition i.e. (0<LLD), accounts for good ductility, softness, corrosion resistance and high electrical conductivity of coconut shell powder and coconut shell ash made products such as foils and cables. Potassium oxide equips CSP with high thermal conductivity property making it suitable for glass and optic and ceramic production. The Sodium oxide in CSP makes it a suitable material that can replace conventional composites in the manufacture of ceramics because it makes CSP to offer a great density to weight advantage. Finally, the presence of sodium dioxide in CSP makes it suitable for the partial replacement of cement in construction activities because it does not react with other composites material. This result is in line with the work of Abdulkadir et al [7].

Table 1. Chemical Composition of Coconut Shell Powder

SN	Compound	Full Name	Concentration
1	Wax(g)	-	5
2	C	Carbon	12. 00%
3	K2O	Potassium oxide	1.35%
4	SiO2	Silicon dioxide	0.88%
5	Cl	Chlorine	0.88%
6	Fe2O3	Iron(II) oxide	0.50%
7	MgO	Magnesium oxide	0.43%
9	Na2O	Sodium oxide	0.33%
10	CaO	Calcium oxide	0.25%
11	MOO3	Molybdenum(VI) oxide	0.20%
12	S	Sulphur	0<LLD
13	Al	Aluminium	0<LLD
14	P	Phosphorous	0<LLD

3.2 Chemical Composition of Coconut Shell Ash

The result of the FTIR experiment conducted on coconut shell Ash which was obtained by burning coconut shell in a local cooking stove to determine the composition is presented in Table 2. From the result presented in Table 2 also showed that coconut shell ash contains some main metals such as silica, potassium,

zinc, calcium, and silicon iron which are crucial in order to mix with other materials to offer great thermal conductivity, excellent density to weight ratio, high resistance to corrosion, thermal stability, great flexural strength, durability, and the ease with which it can formed into complex shapes. These results are in agreement with the work of Udhayasankar, [6], Obiukum et al., [1] and Sumatilal and Jigar, [2]. This has made it a potential material for most engineering applications such as additives, filler, water purification, energy generation, activated carbon and as reinforcements and for fabrication of aluminium matrix composite for the automobile industry.

Table 2. Chemical Composition of Coconut Shell Ash

S/No	1	2	3	4	5	6	7	8	9	10
Oxide Content	SiO2	Al 2O3	Fe2O3	CaO	MgO	MnO	Na2O	P2 O 5	K2O	SO3
Percentage (%)	33.61	24.31	16.12	4.861	1.79	0.891	0.901	0.311	0.741	0.861

5 CONCLUSIONS

The analysis of the FTIR experiment conducted on coconut shell powder and coconut shell ash in order to determine their chemical compositions, revealed that these natural materials possesses some essential properties that are required for most engineering applications, hence the development and use of it to gradually replace the convectional composites which are fast depleting should be given adequate attention. Also, if these natural fibres are adequately utilized, it will help in reducing the problem of environmental pollution while increasing the market value of coconut waste.

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