



CHEMICAL COMPOSITION ANALYSIS OF COCONUT SHELL POWDER AND ASH FOR COMPOSITE REINFORCEMENT

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ABSTRACT

The use of natural resources which are environmentally friendly to replace the conventional composites materials had been the interest of many researchers lately. Beside the use of natural fibres as reinforcement in polymer matrix composites, the use of 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 to satisfy the requirements needed for some engineering applications. In this study, the potential of coconut shell powder and coconut shell ash were investigated. Fourier transform infra-red spectroscope was used to determine the chemical compositions of the samples. The results obtained revealed that coconut shell powder and coconut shell ash demonstrated comparable chemical properties to the conventional composites. The presence of some basic elements which are required to produce reinforcement materials with high strength, durability, light weight and corrosion resistance were confirmed. The results obtained revealed that coconut shell powder and coconut shell ash could be used as composites and other polymer matrix that are required for engineering applications

1.0 Introduction

Coconut shell powder used for reinforcement consist of lignin and pentosanes. It has recently gained lots of attention and acceptance as composite reinforcement in a wide variety of applications in the aerospace, construction and manufacturing industries. Recent investigations show that 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 (Obiukum *et al.*, 2016). 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, (Sumatila and Jigar, 2018). 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 in order to eliminate or reduce the hazards associated with the present mode of 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, (Obiukwu *et al.*, 2016). 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, (Salman, 2015). These among other uses 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 (Leman *et al.*, 2017). 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.

2. Materials and Methods

2.1 Materials and Equipment

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

2.2. Methods

2.2.1 Crushing Process

The Coconut shells was obtained from Damaturu central market located at Abasha ward in Damaturu, local government area of Yobe State, Nigeria. It was 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 at Ahmadu Bello University Zaria, Nigeria to determine the chemical and elemental characteristics of the product with the aid of an Infrared Transform Spectrometer.

Mallet was employed to reduce the sizes of the coconut shell into smaller pieces, before it was taken to the hammer mill shown in Figure 1 for further crushing and grinding operation.

This very important equipment was used to crush the coconut shell aggregates into suitable fine flour by repeated blows for use as specimen in the study.



Figure 1: Hammer Mill



Figure 2: Automatic Vibratory Sieve

2.2.2. Sieving Process.

The coconut shell particles were sieved to obtain coconut shell powder with the aid of an automatic vibratory sieving machine. This process lasted for about 2 hours and the samples with the required particle sizes were collected and labelled according to the mesh size.

The Automatic vibratory was used to characterize the coconut shell powder into finely divided substance as required for this study. It consists of different meshes as shown in Figure 2. This powder is usually obtained from coconut shell which is free from contamination. The coir pit is broken into small pieces and crushed with the aid of a hammer mill or as a pounding machine and later fed into a pulverizing machine to produce a powdery substance. The powder obtained from the pulveriser is 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.

2.2.3. Weighing Process

This process was carried out to obtain the required weight of the individual samples. 3 kg was used for this study to ensure uniformity. The three samples were labelled accordingly and later packaged in an airtight plastic container before it was taken to the laboratory for the test.

The electric weigh balance that was used to weigh each of the sample sizes used for the study is shown below



Figure 3: Automatic Weigh Balance.

2.2.4. Ash Process

The process used to obtain the ash was by burning coconut shells in an open 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 equipment 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. (Udhayasankar and Karthikeyan, 2015)

The sieve sizes ranged from 355-63 μ m. The coconut shell powders retained in the pan below 70 μ m, were used for the analysis, in line with the work of Bello *et al.* (2015).



Figure 4: Local Cooking Stove



Figure 5: Coconut Shell Ash

2.2.5. Fourier Transform Infrared (FTIR) 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 contaminants. 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 is a grey powdery substance which is usually obtained by burning coconut shell powder in a furnace which is regulated at a certain temperature. Figure 1 presents a sample of the coconut shell ash.

The Fourier Transform Infrared (FTIR) spectrometer Figure 6 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 about 10,000 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 4000 cm^{-1} to 400 cm^{-1} , representing a molecular fingerprint of the sample making the FTIR analysis a great tool for chemical identification. (Abdulkadir et al., 2016)

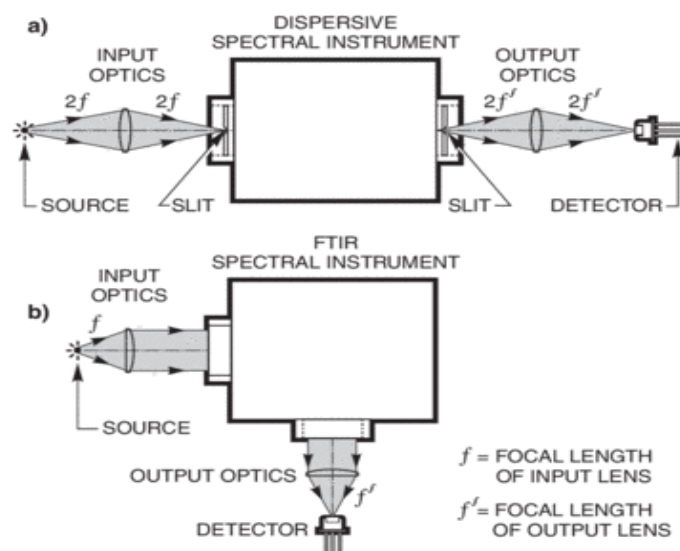


Figure 6: Schematic Diagram of FTIR Spectrometer F510

3. Results and Discussion

3.1 Chemical Composition of Coconut Shell Powder

Table I presents the result chemical composition of coconut shell powder obtained from FTIR test.

Table I Chemical Composition of Coconut Shell Powder

| SN | Compound | Full Name | Concentration |
|----|--------------------------------|-----------------------|---------------|
| 1 | Wax(g) | - | 5 |
| 2 | C | Carbon | 11.00% |
| 3 | K ₂ O | Potassium oxide | 1.36% |
| 4 | SiO ₂ | Silicon dioxide | 0.89% |
| 5 | Cl | Chlorine | 0.89% |
| 6 | Fe ₂ O ₃ | Iron(II) oxide | 0.45% |
| 7 | MgO | Magnesium oxide | 0.42% |
| 9 | Na ₂ O | Sodium oxide | 0.31% |
| 10 | CaO | Calcium oxide | 0.26% |
| 11 | MoO ₃ | Molybdenum (VI) oxide | 0.19% |
| 12 | S | Sulphur | 0<LLD |
| 13 | Al | Aluminium | 0<LLD |
| 14 | P | Phosphorous | 0<LLD |

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. The presence of 11% Carbon and 0.89% silicon dioxide make coconut shell powder and coconut shell ash to offer significant stability in terms of insulation, thereby making it suitable for manufacturing of electronic chips and in the aerospace industries. Potassium oxide at 1.36 % Carbon, iron (II) oxide 0.45%, magnesium oxide 0.42%, sodium oxide 0.31%, calcium oxide 0.26 %, Molybdenum (VI) oxide 0.19%, Sulphur and Phosphorus having 0 concentration less than the lower level detection (LLD). The composition of Aluminium in this composition, (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, 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.

3.1.1 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;

Table 2: Chemical Composition of Coconut Shell Ash

| S/No | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------------|------------------|--------------------------------|--------------------------------|-------|-------|-------|-------------------|-------------------------------|------------------|-----------------|
| Oxide | SiO ₂ | Al ₂ O ₃ | Fe ₂ O ₃ | CaO | MgO | MnO | Na ₂ O | P ₂ O ₅ | K ₂ O | SO ₃ |
| Content | | | | | | | | | | |
| Percentage (%) | 33.61 | 24.31 | 16.12 | 4.861 | 1.790 | 0.891 | 0.901 | 0.311 | 0.741 | 0.861 |

From the result presented in Table 2, the coconut shell ash contains 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 Abba-Aji et al. (2019). 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.

4. Conclusion

The analysis of the FTIR experiment was successfully conducted on coconut shell powder and coconut shell ash. The chemical compositions of the coconut shell ash revealed the presence of SiO_2 , Al_2O_3 and CaO . This offer some essential properties making it suitable for automobile and other engineering applications. Coconut shell powder consists of sodium dioxide and other elements presented in the results making it suitable for reinforcement and other applications. From the results, it is clear that both coconut shell ash and powder could be used as composite materials. The development and use of this product has the potential to gradually replace the convectional composites which are fast depleting should it 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

From the study conducted on chemical composition of Coconut Shell Powder and Coconut Shell Ash using FTIR method, the following are the recommendation.

1. Adequate attention should be given to the utilization of coconut shell-based products and other agricultural based waste as this will open up new avenues for both academicians and industrialist to design a sustainable module for the future of natural fibres,
2. More studies should be carried on other natural fibres so as to explore further on the development of composite materials.

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