Feasibility of Synthesizing Potassium Carbonate Powder from Plantain Peels for Possibly Soap Making

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Abstract

The lack of chemical plants for the manufacture of simple chemicals such as NaOH, KOH and K_2CO_3 in most part of sub-Saharan African countries leads to high cost of importing these chemicals which make them less readily available for many industrial purposes. An investigation was carried out using waste plantain peels to produce potassium carbonate for industrial purposes such as paper making, glass making, soap making etc. The elemental composition analysis result of ashed plantain peel shows K(42.16%), Al(1.773%), P (0.758%), Ca (0.162%) and some other Trace elements (52.817%). The thermal decomposition of the product was investigated using Thermo gravimetric Analysis (TGA) which indicates the stability and decomposition status of produced. The purity morphology of the synthesized product shows major peaks attributed to potassium carbonate which assign JCPDS file number {98-1435} and minor silica {14-1303}. Finally, FTIR analysis was carried out which shows the band ranges of compounds present in the produced silica which includes: OH (2500- 3500Cm^{-1}), K - O (624 Cm^{-1}), Si-O (427 Cm^{-1}). The application of the synthesized product was recommended as a potential candidate in soap making industries.

Keywords: Biomass, byproduct, chemical, potassium.

1. INTRODUCTION

Plantain belongs to the family Musaceae and the genus Musa. It is a perennial herbaceous plant, 2 to 9 m tall, with an underground rhizome or corm. The principal species are *Musa paradisca* (French plantain), *Musa acuminata* (Gross Michel and Cavendish) and *Musa corniculata* (Horn plantain). The cultivars of plantain are French plantain, French horn plantain, false horn plantain and horn plantain.

Plantain thrives on a wide range of tropical and sub-tropical climates. It requires an optimum temperature of 30°C, mean monthly rainfall of 100 mm, pH 4.5 and 7.5 and sandy loam soils (Ayenimo *et al.*, 2010). Plantain originated in South India and moved to South East Africa, from where it spread to Central and West Africa, it is believed to be the oldest cultivated fruit in West and Central Africa (Ogazi, 1996; Ekunwe and Ajayi, 2010).

In Nigeria, good quality banana/plantain is produced mainly during the month of October to February every year yet the demand for banana/plantain is all year round (Babayemi *et al,* 2011). As noted by Akinyemi *et al* (2010), forest soils, good for cocoa, palm and rubber production, are also the main soil types in the plantain and banana producing regions of Nigeria. Plantain production is mainly in the Southern states of Nigeria, which include Akwa-Ibom, Cross River, Akwa-Ibom, Imo, Enugu, Rivers, Edo, Delta, Lagos, Ogun, Osun and Oyo states (Ogazi, 1996).

Maturity standards for plantains are less precise than they are for bananas. Several different external and internal fruit characteristics can be used to determine plantain maturity. These include fruit diameter, age of the bunch, angularity of the fruit, length of the fruit, and peel color. The stage of maturity for harvest depends on the intended market destination (Asaolu, 2000). Locally marketed plantains can be harvested at a more advanced maturity stage compared to export market fruit. Export market destined fruit should be harvested the day before or the same day of shipment (Ogazi, 1996). Plantain maturity is related to the diameter of the fingers. This is determined by measuring the diameter of the fruit at its mid-point.

About 70% of sub-Saharan African population are rural dwellers and biomass derived energy is the major source of energy used by these rural dwellers. The lack of chemical plants for the manufacture of simple chemicals such as NaOH or KOH in most sub-Saharan African countries leads to high cost of imported chemicals making them less readily available to the rural poor. A need exists for efficient use of renewable biomass resources including biomass wastes as a feedstock to produce heat and chemicals especially for

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Combustion is the main process for using biomass energy directly (Anderson, 2011) with resultant production of ash byproducts. The combustion of biomass produces ash from where potassium oxide may be extracted. The plantain peel or biomass is burned in a naked flame to make very white ash. In this way, all of the potassium salts is converted to potassium oxide which is a lot cheaper than the commercial KOH. It has been observed that the ash-derived potash gives a promising future as a sustainable source of raw material for potash-based industries.(IITA, 2015; Happi, 2007; Izofuo and Omuaru, 2012).

Potash has found world-wide domestic and commercial applications in the pulp and paper, flat glass and chemicals industries (Yu *et al.*, 2002) The potash from plantain peels is used for local (black) soap production and traditionally used as a cleansing agent (FAO, 2006) Hence, the present work is aimed at using renewable biomass wastes (plantain peels) as a feedstock to produce heat and chemicals (Potassium oxide) for industrial applications.

This work is an attempt to set a bench mark by using K_2CO_3 from renewable locally sourced biomass materials (plantain peels) for many future industrial applications in our rural areas. Potassium carbonates thus obtained would help to reduce over-dependence on the commercial potassium carbonates which most times is very difficult to come by especially in rural areas where it is needed to produce soap, biodiesel and other household uses. Results are reported on the purity and quality nature of the potassium carbonate produce from the plantain peel which will serve as a good candidate in soap making, biodiesel and so many other uses.

2. METHODOLOGY

Material Processing

Waste peels of plantain collected in bulk were sourced from roasted plantain seller in Tipa garage, Tanke area, Ilorin South Local Government Area of Kwara State, Nigeria. The cleaning was done mechanically using distilled water and air-dried at room temperature. The cleaned plantain peels were then subjected to size reduction by crushing with mortar and pestle followed by pulverization into three different particle sizes: -110+95, -95+63 and -63+55 μm.

Sample Characterization

The crushed plantain peel was analyzed using X-ray diffraction (Philip ZX 1419 XRD) at Geological Survey Centre, Malali, Kaduna, Nigeria, scanning electron microscopy and energy dispersive spectroscopy at electron unit of the University of Cape Town, South Africa, applying FEI Nova-nano SEM 230 couple with EDS detector designed by FEI, Eindhovan, Holland, respectively.

Physico-Chemical parameter analyses

Determination of pH

•One gram of plantain peel ashed sample was weighed into 100 mL of water in a beaker then stirred for 5 mins, then was allowed to settle for 15 mins before the pH of the supernatant solution was determined. The pH was determined using pH meter, the solution was monitored and pH was recorded for 5days and average pH recorded.

Moisture Content Determination

An empty crucible was weighed and marked W_1, and then 1 gram of ash sample was weighed into the crucible and marked W_2. The ash sample and crucible that was marked W_2 was put in an oven and heat by 80^0C for 2hours, after which the sample was removed and put into desiccators and allowed to cool. The sample after cooling was weighed and marked W_3. The moisture content MC was determined using relation:

$$MC = (W2 - W1)/(W3 - W2) \qquad (1)$$

Determination of Loss of Mass On Ignition (LOMOI)

Both ashes plantain peel and potash product was characterized for moisture content was transferred into a muffle furnace and calcined for 2 hours at 500°C – 600°C .The sample was allowed to cool in the desiccators, it was weighed and marked W_4. The LOMOI was determined by relation:

$$HOMOI = (W3-W4)/W3 - W2 \qquad (2)$$

Calcinations of Waste Plantain Peel Sample

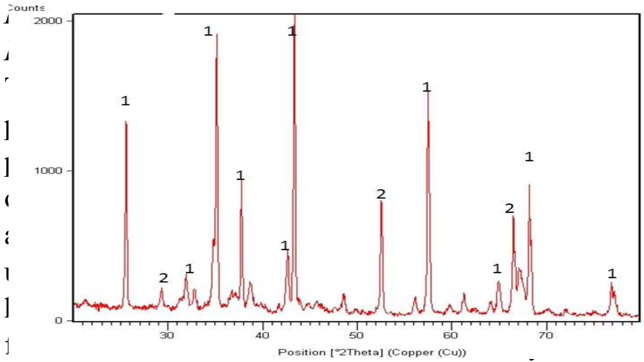
The peels were subjected into bone dried process in an oven at 100 °C for period of 24 hours to constant weight. The bone dried peels were placed in an open pan and heated till the peel ignited. A glass rod with insulated rubber was used to turn the burning peel, thus ensuring uniform combustion which lasted for three hours. The ashed sample was homogenized by grinding using mortar and pestle and particle sizing using ASTM sieve (Onyegbado et al., 2002, Baba *et al*., 2014).

Synthesis of potassium Carbonate powder

Eighty grams (80 g) of the ashed sample was boiled in 400 mL distilled water for 40 minutes in a further attempt to ensure maximum extraction of the alkali. Subsequently, the slurry was filtered using filter paper to obtain the alkali containing extract. The spectrophotometric analysis of the extract for metallic ion was carried out using flame photometer. The obtained extract was subjected to evaporation to dryness to obtain off white powder product. The resulting powder was subsequently kept in plastic bottle for further analysis by scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS), and X-ray diffraction (XRD) analyses, respectively in order to examine the purity morphology of the synthesized potassium carbonate product.

3. RESULTS AND DISCUSSION

Physicochemical Analysis Results



sample obtained is 43.56 % which indicates volatile compound in raw plantain peel (Grupta and Wiese, 2006).

pH determination

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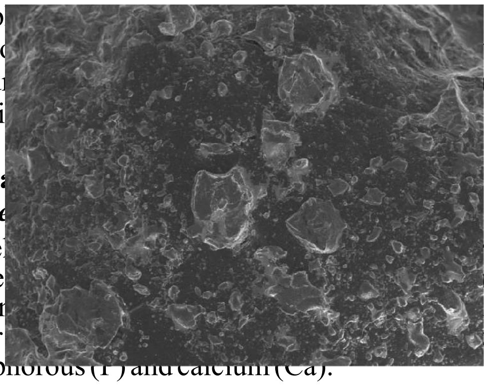


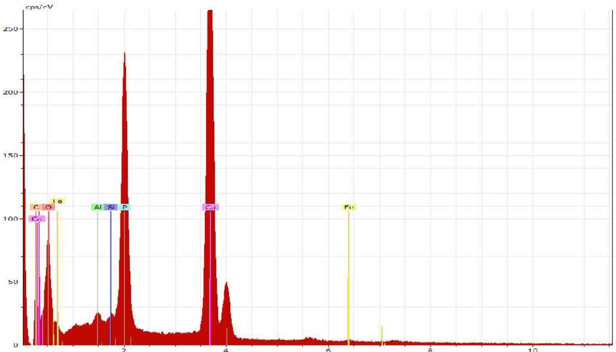
Chara...

Elem...

The e... X-ray fluore... m (K), silico... ement. Other... cludes: Phosphorous (P) and calcium (Ca).

Table 2: X-ray fluorescence showing the Elemental Composition of ashed peel

Element(s)	Intensity	Content
Si	0.4259	1.477
Al	0.0588	40773
K	0.0651	42.890
P	0.0102	0.758
Ca	0.0115	0.162



consist predominantly of potassium carbonate (KCO_3) {49-1085} and silica (SiO_2) {13-0126}.

Figure 1: XRD diffractogram of ashed plantain peel (1) KCO_3 {49-1085} (2) SiO_2 {13-0126}

Structural morphology by SEM and EDS

The SEM micrograph of the pulverized plantain peel calcined is depicted in Fig. 2.

Figure 2: ... plantain peel

The anal... ed plantain peel (Fi... no specific morphol... sizes and shapes that accompany the dense surface. The quantitative analysis of the pulverized plantain peel is presented in Figure 3.

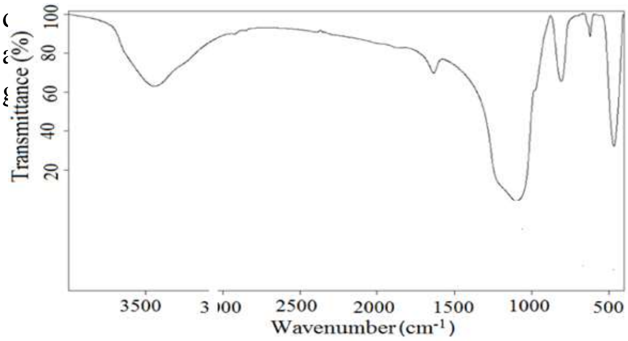
Figure 3: EDS spectral of ashed plantain peel at 650°C

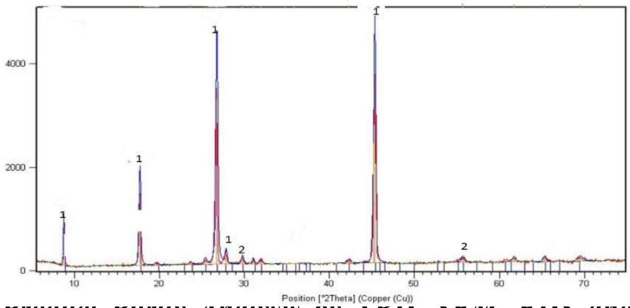
This analysis with respect to the EDS spectra as shown in Figure 3 indicated that only potassium (K), silicon (Si), and aluminium (Al) are the significant element present in the sample.

Potassium carbonate product analysis results

Powdery analysis

The potash powder obtained from co-precipitation process is shown in Figure 4 showing a white powder with coarse texture in feeling. This appearance as compare with commercial potash gave same appearance and later characterized for purity to justify the purity nature of the product. For this study, the initial volume of silica used was 2.3 g which is the Bulk density, after the tapping process 2.1 gcm^{-3} of silica produced was obtained. Moisture sorption capacity is the time required for moisture content of the film to reach equilibrium. Water sorption increase when the relative humidity increased. 2.01 g of the produced potash was used for this study, whereby 2.2 g of the potash was obtained. Swelling capacity of the silica is

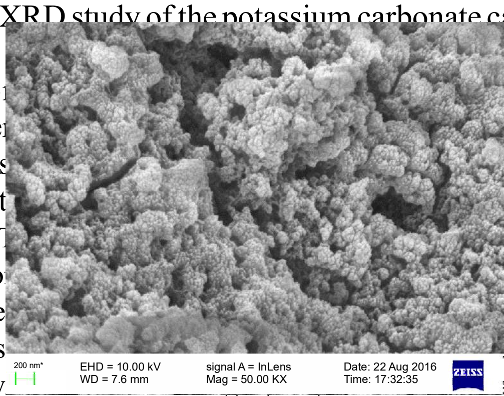




Product Purity Analysis by XRD, SEM, EDS and TGA

The XRD study of the potassium carbonate carried out ... owed amo... milar obse... where potas... peel was t...

... potash or co... peaks prese... for α-potas... ensity show... al and analysis of its crystallite by the Reitveld's method gives a value of 37 nm. The SEM micrograph of product emanated from potash hydrothermally extracted from waste plantain peel gave a wool structure amorphous



arrangement of the product (Figure 7). The SEM micrograph of the sample also shows a different morphology from the previously ashed plantain peel sample that was calcined at 650°C. Uniformed rour ... ing the cher ... port the sing ... The α- pota ... mercial requ ... -potash crys

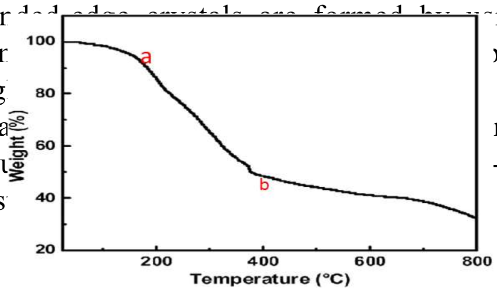


Figure 5: FT- IR spectra of product (KCO_3)

Figure 6: XRD difractogram of product from ashed plantain peel (1) KCO_3(2) SiO_2.

Figure 7: SEM image of product from ashed plantain peel (200 nm magnification)

TGA study of the precipitated potassium carbonate indicated two distinctive high rates of weight loss zones i.e. at 200°C and 800°C. The first zone (a) was referred to as due to dehydration or dehydroxylation and the second zone (b) due to calcinations reaction. These effects result in the increased porosity (Figure 8).

Fig.8: TGA Spectrum of synthesis potash powder

4. CONCLUSION

The elemental composition by XRF of ashed starting a material shows element which includes: K of 43 % composition, Al of 1.78 % compositions, P of 0.98 % composition. Potassium gave the highest % composition which makes ashed the preferable material for the production of potash. The result obtained indicates that pure potash had been produced from waste plantain peel, the characterized product shows that a good quality of potash had been produced as compared to commercial potash. Biomass materials are common waste materials in our environment. The use of biomass material also aid waste material utilization and control. The produced potash is therefore recommended as a potential candidate to use in soap industries.

5. ACKNOWLEDGEMENT

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