EVALUATION OF BAGASSE ASH FOR APPLICATION IN GLASS MANUFACTURE

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ABSTRACT

Bagasse ash results from burning bagasse, a matted cellulose fiber residue from sugarcane that has been processed in sugar mills. In this paper, Bagasse ash has been chemically characterized in order to evaluate the possibility of its use in glass manufacture. The result of X-ray fluorescence (XRF) showed the ash to contain SiO_2 - 31.67%, K_2O - 31.41%, P_2O_5 - 8.14%, MgO - 4.89%, CaO - 3.92%, Na_2O - 3.17%, Fe_2O_3 - 1.23% the ash was normalized as no LOI was carried out. Qualitative and quantitative X-ray diffractometry (XRD) for determination of composition and presence of crystalline material, showed the presence of silica in free and various combined states and potassium magnesium carbonate. Scanning electron microscopy (SEM/EDS) at 100µm and 300µm showed clusters of spherical and rod-like microstructure at different spectra.

Keywords: *Silicates waste, Bagasse Ash*

INTRODUCTION

In recent years, research interest has been directed towards the need of low cost alternatives to raw materials needed in production and manufacture sectors. In this case, the high presence of silica in bagasse ash, as well as oxides of potassium, sodium, magnesium, phosphorus and calcium has necessitated the interest in bagasse ash research. Although, the number of possible glass composition is unlimited, the bulk of commercial glasses are based on silica which is a primary glass former [1-3].

Sugarcane bagasse ash (SCBA), is a product of combustion of bagasse. The sugarcane is crushed and the juice extracted resulting in bagasse [4] an industrial waste which is being used worldwide as fuel. The combustion yields ashes containing high amounts of unburned matter, silicon, potassium, aluminium and phosphorus oxides as the main components [5-8].

Castaldelli et al. [9] in their work demonstrated that sugarcane bagasse ash is an interesting source for preparing alkali-activated binders; it is composed mainly of silica. They further suggested that this by product can be used as a mineral admixture in mortar and concretes [1-2].

Analysis of wood ashes, including stems of plants, grass, straw and millet stalk are grouped as fluxes of the amphoteric and acidic type [10]. The most common fluxes are the alkali oxides e.g. Na_2O and PbO. Most windows in offices and houses and container glasses contain soda. Potassium oxide is also used extensively in commercial glasses [3]. This research therefore intends to look into the suitability of bagasse ash for use in glass making.

MATERIAL AND METHODS

Sample Preparation

Sugarcane bagasse obtained from Unguwar Wakili, Zangon Kataf Local Government Area of Kaduna State, was subjected to burning, which was carried out in two stages. The first stage being an open air firing followed by a controlled firing in a muffle furnace at 700ºC at a resident time of 2hrs.

The sugarcane bagasse ash (SCBA) obtained was ground in a porcelain mortar and screened with the aid of a mechanical electric sieve shaker, a set of standard US/BSS sieves meeting the requirement of Tek-907k. The ash which passed through a sieve of mesh size 0.4mm was collected and used for the study.

The sample was subjected to various characterization techniques to determine the chemical composition, crystalline pattern and microstructural configuration, using X-ray Fluorescence (XRF), X-ray Diffraction (XRD) and Scanning Electron Microscopy (SEM)/ Energy Dispersive X-ray spectrometer (EDS), respectively.

Determination of Chemical Composition

X-ray Fluorescence (XRF) analysis was used to determine the chemical composition. The sample was prepared with boric acid as powder briquettes. 1g of the sample was mixed with 6g lithium tetra borate flux to make stable formula for trace elemental analyses; the sample was then mixed with PVA binder and pressed into pellets. SCBA sample was analyzed for Silica, Lime and oxides of Sodium, Magnesium, Potassium, Aluminium, Phosphorus, Sulphur, Titanium, Chromium, Iron amongst others.

Determination and Identification of Crystal Phases
X-Ray diffraction (XRD) method was employed for the determination and identification of crystal phases; this was done using a back loading technique. This was carried out using a PAN analytical X´pert pro powder diffractometer with X´celerator detector and a fixed divergence slit type.

The various phases formed were determined using X´pert High Score Plus Software. Phases identified are shown in (graphical representations) Figure 2 and Table 2.

Morphological study
Scanning Electron Microscopy, equipped with an Energy Dispersive Spectrometer (SEM/EDS) model number JEOL JSM 7500F was used to examine the microstructure. A small quantity of the sample was placed on the sample holder, then transferred into the machine. The sample was irradiated to produce emissions that were translated into a micrograph for morphological identification.

RESULTS AND DISCUSSION

Chemical Analysis
The chemical composition of Bagasse ash (as determined by XRF) shown in Table 1, the ash contain SiO_2 31.67%, K_2O 31.41%, P_2O_5 8.14%, MgO 4.89%, CaO 3.92%, Na_2O 3.17%, Fe_2O_3 1.23%, Al_2O_3 1.49% the ash was normalized as no LOI was carried out. Si O_2 is a glass network former which can readily form a single component glass. A vast bulk of commercial glasses are based on silica as the glassformer. While silica itself forms excellent glass, with a wide range of applications, the use of pure silica for production of windows, containers, bottles and other commercial applications would be very expensive due to the high melting temperature (< 2000^{o}C) required to produce vitreous silica. K_2O 31.41% and Na_2O 3.17% are alkali oxides and network modifiers, replacing silica by alkali oxides causes the thermal expansion coefficient α of the resulting glass to increase, producing more non-bridging oxygen, which break the connectivity of the glass network, softening the structure of glass. They met the need of the requirement for addition of flux in order to reduce the processing temperature to within practical limits as well as leading to a decreased cost of glass formation. 8.14% P_2O_5 a glass network former which, just like SiO_2, can readily form a single component glass. 1.23% Fe_2O_3 is an indication of high iron content in the ash, this is way above the permissible 0.1-0.3% Fe_2O_3 content for production of colorless glass. Fe_2O_3 is a common impurity that also acts as an unintentional colorant in silicate glasses.

Crystallization Phases and Microstructural Configuration
A qualitative and quantitative XRD analysis result as shown in Figure 1 and Table 2 revealed that bagasse ash contains silica in its free state as well as in combined state. Figure 2 shows Silica to have the highest peak. The primary minerals present are Calcium Silicate Ca_2SiO_4, Moissanite SiC, Potassium Magnesium Carbonate $K_2Mg(CO_3)_2$, Potassium silicate K_4SiO_4, Fosterite Mg_2SiO_4, Potassium Silicate $K_2Si_4O_9$ and Quartz SiO_2, in quantities that suggest a near balance in their proportions.

The SEM analysis given in Figure 3a and 4a show an interlocked mass of agglomeration of particles which are mostly spherical with a few rod like presentations. The EDS analysis in Figures 3b show a high presence of Si, O, Mn, Mg and K and 4b show presence of Si, O, Mn, Mg and K further revealing the major elemental composition of the mineral present in Bagasse ash at spectrum 1.

Table 1. Chemical composition of Bagasse Ash determined by XRF

Oxides	BA
SiO_2	31.67
Na_2O	3.17
CaO	3.92
Mg0	4.89
Al_2O_3	1.49
K_2O	31.41
Fe_2O_3	1.23
SO_3	0.21
TiO_2	0.21
P_2O_5	8.14
BaO	0.14
SrO	0.04
ZrO_2	0.06
Cl	11.06
ZnO	0.12
MnO	0.25
CuO	0.01
Cr_2O_3	0.01
CdO	0.01
HfO_2	0.01
Rb_2O	0.09
Br	0.01

Table 2. Quantitative XRD Analysis of Bagasse Ash

Chemical Formula	Compound Name	SCORE
$Ca_2 Si O_4$	Calcium Silicate	20
Si C	Moissanite-4\ITH\RG, syn	16
Si O_2	Silicon Oxide	19
$K_2 Mg (C O_3)_2$	Potassium Magnesium Carbonate	15
$K_4 Si O_4$	Potassium Silicate	5
Mg2 Si O_4	Forsterite	14
$K_2 Si_4 O_9$	Potassium Silicate	11

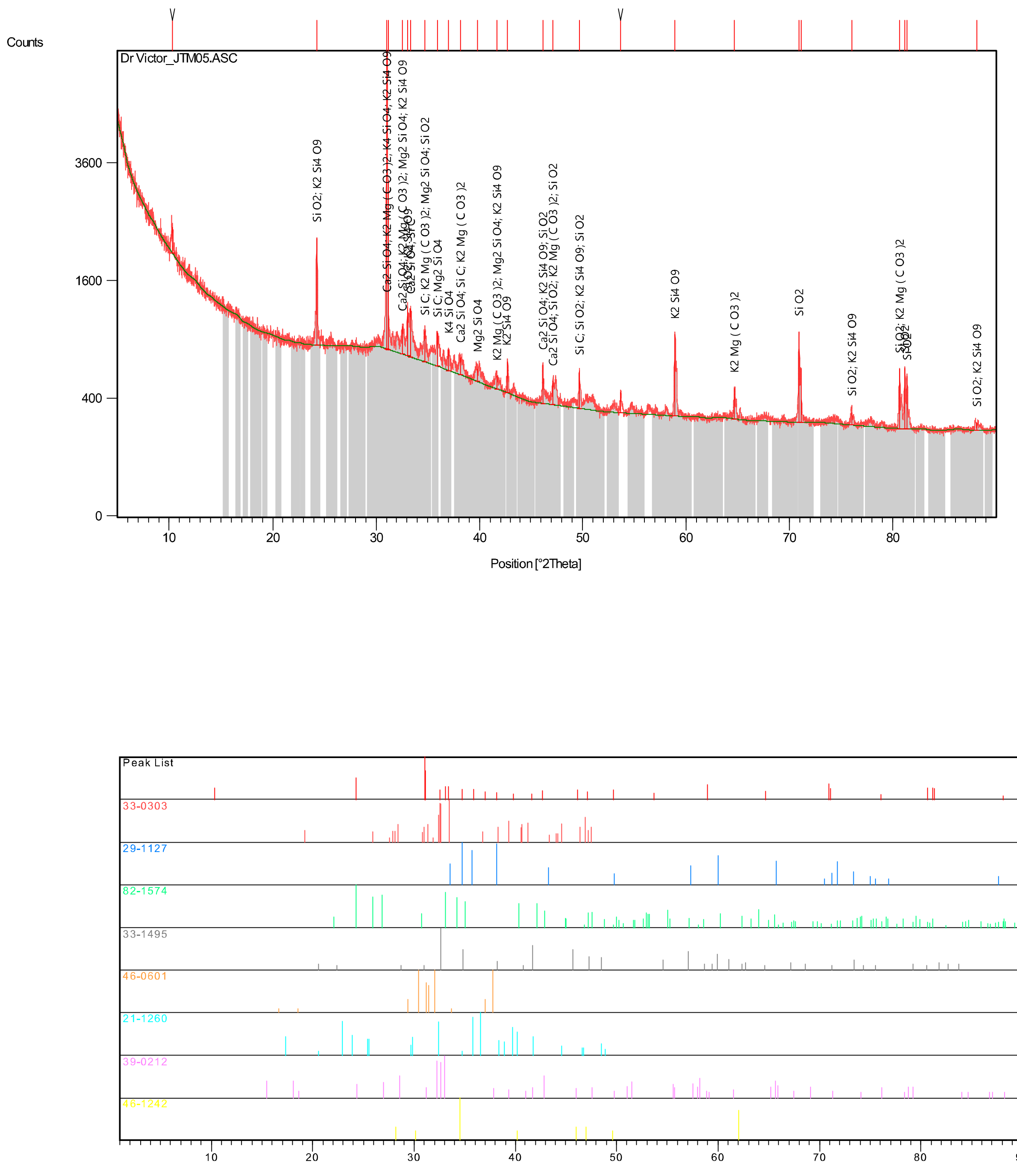

Figure 1. Qualitative XRD Analysis of Bagasse Ash

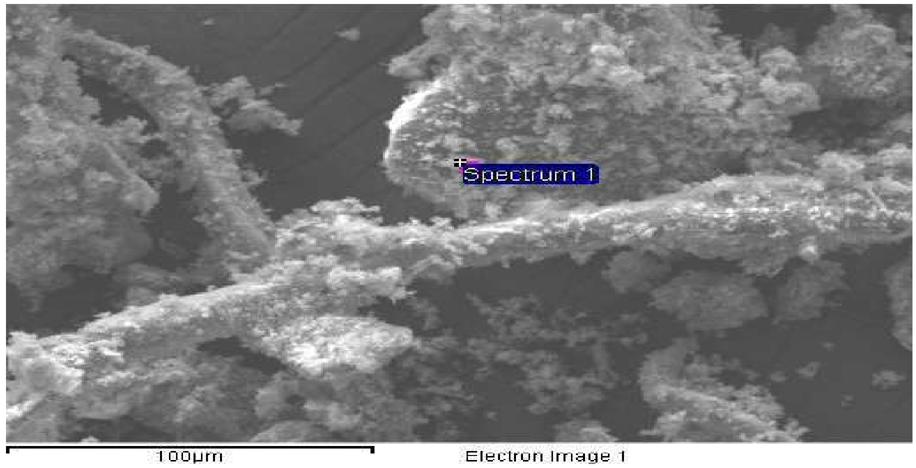

Figure 3a. SEM micrograph showing an agglomeration of irregular spherical dusty patterns

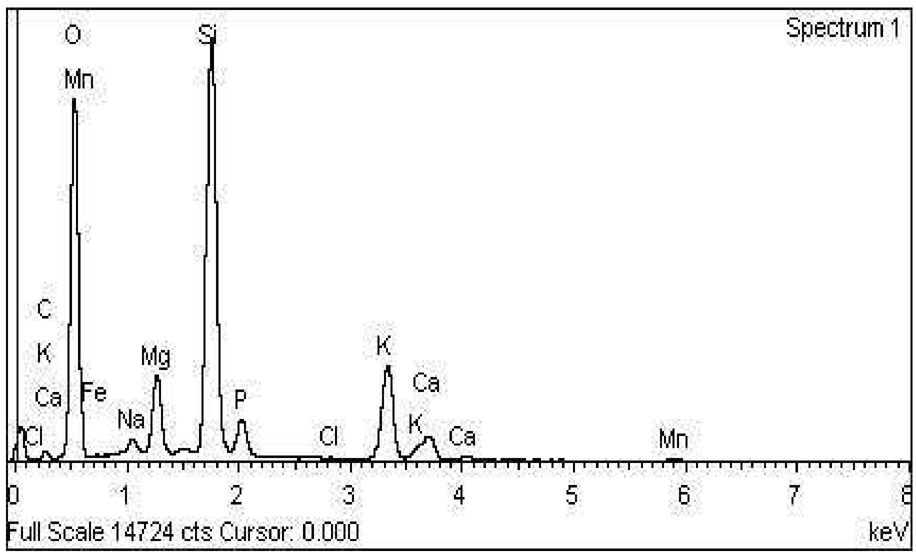

Figure 3b. EDS Analysis of Bagasse Ash showing the elements present at spectrum 1

Figure 4a. SEM micrograph showing an agglomeration of disordered patterns

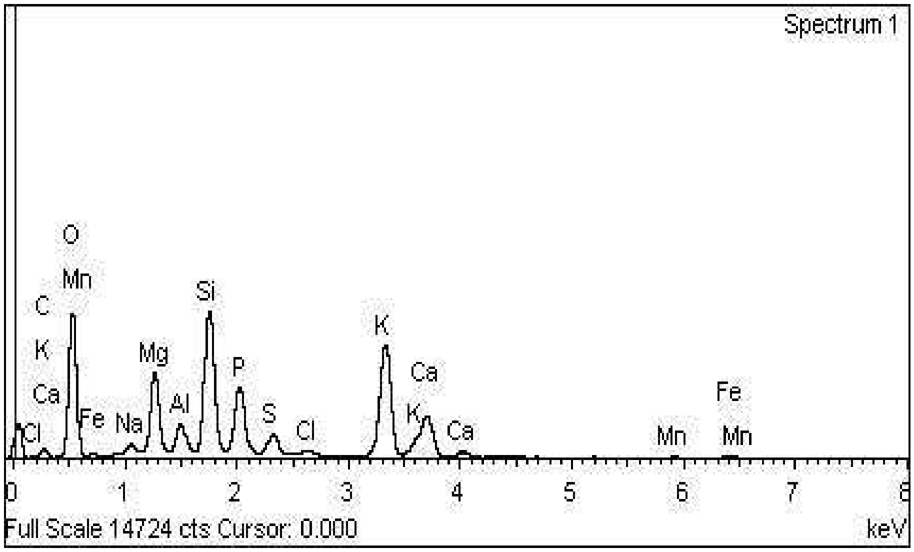

Figure 4b. EDS Analysis of Bagasse Ash showing the elements present at spectrum 1

CONCLUSION

The results of the analyses have shown Bagasse Ash to be a good source of Silica 31.67% and Potash 31.41%, with an ability to form a Silicate Glass (Potassium Silicate System), in the presence of glass modifiers. When used alongside other glass forming oxides, it will be an excellent fluxing agent in glass making by major reductions in the viscosity of the melt and the glass transformation temperature, this will reduce the energy used, thereby lower the cost in glass production. The ash also has a relatively high content of Fe_2O_3, though an impurity, will aid in the production of colored glasses. Bagasse Ash is therefore, a good source of Silica and Potash for the making of Alkali Silicate Glasses.

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