USE OF MILLET-STALK ASH AS AN ALTERNATIVE SOURCE OF POTASSIUM OXIDE IN GLASS PRODUCTION

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Abstract
Millet-stalk Ash (MAS), as a possible substitute for conventional refluxing agent, was investigated. MAS was used as a glass reflux because of the quality of its potassium oxide (K_2O) content. Analyses (qualitative and quantitative) applying the A.A.S. and N.M.R justify this experimentation. The result of the chemical analysis showed that the MSA sample contains 9.66%k_2O, 0.025%Na_2O, 0.16%CaO, 0.5%MgO and 0.03%Fe_2O_3. It is evident from the result of test melting that the addition of MAS reduces the melting temperature to a significant level from 1400^oC (for the sample without MAS) to 1200^oC (sample with MAS). This indicates that MAS has potential as an alternative source of potassium oxide (K_2O) for the Glass Industry.

Introduction
The design and development of a glass composition is based on certain considerations, such as the need for the glass to meet or exceed end-use requirements in terms of resistance to chemical attacks, thermal shock and mechanical durability of the glass, ease of melting homogenizing, forming and low or reasonable overall cost of production that permits successful marketing. The function of the glass technologist is to make use of available raw material in such a way as to satisfy these conditions (Akomolafe 2001).

The melting of Silica alone requires a very high temperature of about 1700 ±13 ^OC, but addition of alkali oxides like sodium oxide and potassium oxide lowers the melting temperature (eutectic action). Alkali Oxides are oxides of major elements (Group IA) and includes lithium, cesium and francium. The most commonly used are sodium oxide and potassium oxide. They are referred to as a mixture of oxides essential in the formation of glass. Analysis of wood ashes, including other vegetable ashes like grass, straw and millet stalk show that they contain oxides which are grouped as fluxes, amphoteric and acidic (Ewule, 2001). According to FAO (2007), there are nine species of millet in the world with total production of 28.38 million tons, out of which 11.36tons (40%) were produced in Africa. Nigeria produces about 40% of the millet produced in Africa (4.53 million tons) and, also more than 80% of the millet are produced in the Northern part of Nigeria due to their low rainfall and adverse weather condition (Obilana, 2002 cited in Uche et al, 2012). Nigeria is being rated as the second largest producer of millet in the world (FAO, 2007). Millet stalk ash (MSA) is produced from burning the stalk. The stalk is produced in large quantity due to large amount of millet cultivated which is almost consumed locally. Akande, 2002 reported that about 40% or the weight of the harvested millet is removed as husk from the stalk. The husk is sometimes used as landfill and seldom used as an admixture together with laterite in building mud houses or burnt and return to farm as manure. The husk is usually found in heaps, unused because of its availability everywhere in areas where its cultivated which results to environmental pollution along highways and rural areas.

There is general agreement on the interpretation of the two main types of soda-lime-silica glass. The high-magnesia, high potash type was produced using a soda-rich plant ash as a flux. The use of such ashes is widely recorded in traditional Near Eastern glassmaking, and later they were extensively imported into Europe to be used, for example, by the Venetian glass industry (Ashtor and Cevidalli 1983). Produced by burning halophytic plants (those adapted to growing in a saline environment) from the desert, or from a brackish water environment, such ashes are typically rich in both soda and lime, and also contain significant amounts of potash and magnesia (Brill 1970; Verità 1985). To make a glass from using such a material would have involved mixing an appropriate proportion of ash with a relatively pure source of silica, such as quartz-rich sand or crushed quartz pebbles. Glass of this type will be termed *soda ash* or *plant ash* glass. (Freestone et'al).

A lot of work has been carried out on the potential of ash as a source of raw material for the Glass and ceramic industries (Alemaka 2001, Okunna 1983 and Peters, 1997). This paper is focused on the use of millet stalk ash as an alternative source of potassium (K_2O) in glass production.

Methodology

Millet-stalk sample were gathered and collected from a farm in Madakiya, Kaduna State. For this work samples were cut to small bits for easy burning into ash at a temperature of about 500 ^{O}C for 1hr. the ash was then put in a crucible for determination of moisture content loss on ignition and ash content. Chemical analysis of the sample was carried out using AAS and NMR machines. The test melting was carried out using cristobalite electrical furnace.

Batch calculation Using Arithmetic Method and Testing

All calculations were based 100g of glass to be produced using potassium oxide obtained from ash content.

Basis for calculation

The batch composition chosen was based on the analysis and also the different possible formation for lead glasses (see Table II below).

Test Melting

The potassium oxide used was from the millet-stalk ash, the silica was sourced locally and was analysed at the Geological Survey Department, Kaduna and the other raw material used was industrial litharge as the source of lead. The batch contain millet-stalk ash as the source of potassium oxide was thoroughly mixed inside a crucible and fired at 1200^{o}C for two hours in an electric furnace.
These batches were prepared and fired at a temperature range of 1200^{o}C and 1400^{o}C.

From Table iv It can be observed that among the different oxides that were determined potassium oxide (K_2O) has the highest composition (9.66%). This could be attributed to the quality of the ash in terms of the oxide. It was also responsible for the decrease in temperature of the test piece. The test piece produced from the millet stalk was observed to be clear, transparent with slight greenish coloration which could be as a result of the Fe_2O_3 iron content of the sample (0.33%).
Table v however, shows how the quantity of the millet-stalk used in the batch changed the melting temperature of the test piece. Continued increase of the millet- stalk resulted in the corresponding decrease in the temperature of the piece produced. This however is in agreement with the existing theories in glass manufacture (Austin 1984).

Conclusion

From the chemical analysis, result of the test melting and observed physical appearance of the melted piece, it can be concluded that ash from millet –stalk has a good potential as a fluxing agent for glass manufacture. However, the quality of the glass despite its greenish coloration can be improved for the production of glassware by decolorization.

RESULTS AND DISCUSSION

Millet stalk

Carbonized Millet Stalk

Millet Stalk Ash

Test melted Pieces

Table I: composition of Batch Materials

Quantity of Raw Material (g)	Raw material	SiO_2	K_2O	NaO	CaO	MgO	Fe_2O_3	Al_2O_3	PbO
61	Sand	60	0.07	0.012	0.17	0.12	-	0.59	-
154.55	Ash	-	14.93	0.39	0.25	0.80	0.05	-	-
35.84	Litharge	-	-	-	-	-	-	-	35
Total			15	0.51	0.42	0.9	0.05	0.59	35

Table II: Chosen composition of Batch

S/N	Glass Component	Quantity (g)	Source
1	SiO_2	60	Quartz
2	K_2O	15	Millet ash and quartz
3	PbO	35	Industrial Litharge

Table III

Percentage MSA introduced	Temperature (^oC)
100	1200
50	1300
0	1400

Results

Summary of the result of Chemical Analysis of the Ash

Table iv: From Millet Stalk

Oxide	Percentage	
K_2O	9.66	
Na_2O	0.25	
CaO	0.16	
MgO	0.52	
Fe_2O_3	0.03	
Moisture content	6.31	
Loss on Ignition	83.01	
TOTAL	99.94	= 100

Table V: Chemical Analysis of Sand and Ash

Raw material	SiO_2	K_2O	Na_2O	CaO	MgO	Fe_2O_3	Al_2O_3
Ash	-	9.66	0.25	0.16	0.52	0.03	-
Sand	98.11	0.12	0.19	0.23	0.20	-	0.97

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