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Extraction of Soluble Sodium Silicate using Corn Cob Ash as a Silica Source

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ABSTRACT: *Extraction of soluble sodium silicate was carried out in this study using corn cob ash as silica source and alkali as soda source. Initially, received corn cob was burnt in open air to obtain the corn cob ash. The obtained corn cob ash was then placed inside refractory crucible and further heating was carried out inside muffle furnace at the temperature of 600^{0}C for 5hrs. The thermally treated corn cob ash was mixed with 3M conc. NAOH and boiled with a constant stirring in a heating glass vessel placed inside a thermostatic water bath at 80^{0}C for 4hrs and 90^{0}C for 3hrs respectively. Various analyses such as PH value, specific gravity, electrical conductivity, viscosity were conducted on the produced sodium silicate and the results were compared with the reference sodium silicate sample.*

Keywords: *corn cob ash, sodium silicate, PH, viscosity*

I. INTRODUCTION

Corn has been identified as one of the most planted staple food crop in the world. For every 100kg corn grain 18kg of corn cob is approximately produced according to International Grain Council, 824million tons of corn was produced worldwide in the year 2011. Corn has been found to be one of the prominent staple foods in Nigeria with an estimated annual production of 9.4million tons, the cobs produced from corn are mainly used as manure for agriculture production [1]. Corn cobs as mostly practice all over are either thrown out as waste to landfill or burnt, a process with low added value, adding ash to soil; causing environmental impacts [2]. Most corn cobs generated in Nigeria are either sent as waste to landfill or as low grade fuels which poses a serious threat not only in storage but also for disposal, for example the combustion of corn cob is contributing to an increase in the amount of CO_2 in the atmosphere causing greenhouse effect. CO_2 being one of the green house gases and can result in global climate change. It has been estimated that corn cob contains a high amount of SiO_2 (>60%) which is being occupied by useful land or treated as waste [3]. Silica has been successfully extracted from different agricultural materials like rice husk [4-5]. [6] Also prepared and characterized nanoSiO_2 from corn cob ash by precipitation method.

The production of Na_2SiO_3 basically comprises four main stages according to [7]: (i) calcinations of a mixture of Na_2CO_3 and natural Quartz or sand (SiO_2) in furnace at 1400^{0}C -1500^{0}C to produced a solid glass; (ii) Dissolution of the produced solid glass in a reaction vessel under high pressure and temperature to produced Na_2SiO_3 solution and impurities (not reacted silica); (iii) Optimal filtration depending on the purity desired, (iv)Evaporation of H_2O from the silicate solution for the production of solid sodium silicate.

Based on the energy consumption with burning fuel to reach high temperature of calcinations, this process is consider as being expensive besides production of air pollutants such as dust, Nitrogen and SiO_2 [7]. There is also a process different from the calcinations method used in industrial scale which is based on reaction of SiO_2 with concentrated sodium hydroxide (purity>99%) in autoclave, under high temperature and pressure as explained in some patents work [8-9].

This present work however extract soluble sodium silicate from corn cob ash (CCA) as silica source and concentrated NaOH as soda source using adapted method stated by [10]

II. MATERIALS AND METHOD

2.1. Combustion and heat treatment of corn cob into ash

The as-received corn cobs were first washed and dried, after drying it was placed inside a perforated cylinder pan for combustion into ash. 60g of the obtained ash was then placed inside an alumina crucible and put inside a muffle furnace and heated at a temperature of 600^{0}c for 5hrs to reduce the carbonaceous matter and increase the percentage of active silica content.

2.2. Chemical analysis of the corn cob ash (CCA)

The chemical analysis was carried out using Atomic Absorption Spectrometry at the National Research Institute, Zaria, Nigeria. From the results of the AAS analysis it shows that the CCA contains 58.01% SiO_2.

2.3. Weighing of the corn cob ash (CCA)

Two samples A and B measuring 15g each was weighed from the obtained corn cob ash which were later reacted with conc. NaOH and heated in a glass vessel at a temperature of 80^0C and 90^0C repectively.

2.4. Preparation of 3M NaOH

The preparation of 3M NaOH was carried out by firstly calculating the molarity of the sodium hydroxide pellet using the formula below.
Molarity = mass/molar mass x 1/ volume
Molar mass of NaOH = 32+16+1 = 40.
For example, to prepare one litre.
3 = mass/40 x 1/1
Mass = 3 x40 = 120g.
This means 120g of NaOH Pellets will be dissolved in one litre of distilled water.
The solution was achieved by dissolving the NaOH pellets inside a 500ml conical flask containing distilled water using stirring rod to stir it until the pellets dissolve totally.

2.5. Reaction in the heating bath

From literature, for every 10g of CCA, you react with 60ml of NaOH [11]. 90ml portion of the 3M NaOH was poured inside 250ml Erlenmeyer flask containing 15g weighed sample of CCA placed inside a thermostatic heating bath and the temperature set to 80^0c for 4hrs and 90^0C for 3hrs for samples A and B respectively with continuous stirring. The solutions were then allowed to cool to room temperature after the experiment. The solutions obtained from samples A and B were filtered using a Whatman No. 41 filter paper into separate 250ml round bottom flask and the residue left on the filter paper was discarded.

III. RESULTS

Table 1. Chemical Composition of the Corn Cob Ash at 600^0C for 5hrs

Al_2O_3	SiO_2	Fe_20_3	K_2O	Na_2O	MgO	MnO_2	CaO	LOI
9.2	58.01	3.05	4.1	4.94	4.1	3.2	10.4	3.0

Table 2. Analysis of the Produced Sodium Silicate and the Reference Sodium Silicate

	PH Value	Electrical conductivity µs/cm	Specific gravity g/cm^3	Viscosity Centipoises	Characteristics
Sample A at 80^0C for 4hrs	12.9-13.0	1068	0.8231	280	Syrupy liquid, high alkalinity
Sample B at 90^0C for 3hrs	12.7-12.8	1072	0.8509	400	Syrupy, alkaline liquid
Reference sample	8-13.0		1.39	830	Syrupy liquid

IV DISCUSSION

4.1. Corn Cob Ash Characterization

Table 1 shows the chemical composition of the CCA sample obtained using Atomic Absorption Spectrometry. The analysis revealed that inorganic content of this ash contains a good percentage amount of SiO_2 (58.01%) which actually justify its use as a source of silica for this research.

4.2. Analyses of the produced Na_2SiO_3

Table 2 shows the results for the various analyses conducted on the produced Na_2SiO_3 which were compared with the reference sample. The results showed that PH values for samples A and B ranges from 12.8-12.9 and 12.9-13.0 respectively; specific gravities are 0.8231 and 0.8509 respectively while the electrical conductivities are 1072 µs/cm and 1068 µs/cm for the two samples at 80^0C and 90^0 C respectively. The samples A and B has viscosities of 280 and 400 centipoises respectively while they both exhibited characteristic syrupy, high alkalinity liquid.

4.3. Clay deflocculation test

From the clay deflocculation test, it was observed that sample A required more drops before the effect can be seen in a slip compare to sample B. Both samples however works in deflocculation but not as potent as the reference sample. This might however be attributed to the low temperature employed in this research compare to reference sodium silicate produced industrially.

V. CONCLUSION

It can therefore be concluded from the various analyses conducted and in comparison with the reference Na_2SiO_3 that the product is actually sodium silicate solution. However, the only shortcoming is the issue of low viscosity which has to do with parameters such as temperature, amount of silica extracted from the CCA.

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