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Comparative study of polyanionic cellulose (PAC) and starches from two improved cassava species

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ABSTRACT

This paper aimed at comparing the characteristics of starches from two improved cassava species with polyanionic cellulose (PAC) employed in the oil and Gas industry as fluid loss control agent for water based mud (WBM) formulation. Cassava starches were extracted traditionally from TMS 98/0505 and TMS 30572 species of fresh cassava tubers and characterized to establish the physicochemical properties. The properties were compared to those of PAC (active ingredient for fluid loss control in WBM. The analytical results showed the following; moisture content (4.11%, 4.94%), pH (7, 8), dispersion (both poly dispersed), bulk density (617.34kg/m^3, 943.4kg/m^3) and particle size distribution (both fine) for TMS 98/0505 and TMS 30572 respectively. The result indicated closer similarity between TMS 98/0505 and PAC, and may therefore be used partly with PAC or replace PAC in WBM formulation.

Keywords: cassava starch, Polyanionic Cellulose (PAC), water based mud

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INTRODUCTION

The drive for stronger economy and better living conditions for her citizenry has pushed the leadership of Nigeria in one of its national economic summit to launch her into being among the twenty (20) leading economies of the world by the year 2020. For this conceptual dream to be realistic, there is a strong and inevitable need to curtail material/product importation and look within the agricultural sector for raw materials for product manufacturing within the country. This is also in line with the current emphases on renewable energy sources globally owing to depletion of the non renewable resources and concern over increase in global warming/environmental pollution.

Consequently, researches are being conducted to source raw materials within the country especially from renewable resource materials. In response to this, starch from a renewable agricultural product (cassava varieties and cereals) is being researched. Cassava crop is extensively cultivated in the tropics with annual production exceeding 80 million tonnes (Ubbor et al, 2006). The International Institute for Tropical Agriculture (IITA) is also boosting cassava production in Africa with the development of cassava mosaic disease (CMD) resistant varieties (Udensi and Eke, 2000). Starch from cassava has unique properties that suggest possibilities for industrial as well as food applications; water & oil absorption capacity, pack bulk density and signs of emulsion tendencies (Donald et al, 2001 and Ubbor et al, 2006). These characteristics are similar to those of polyanionic cellulose (PAC) used for filtration control in drilling fluid. High bulk density of starch has been observed to be good physical attribute when determining mixing quality of particular matter (Niba et al, 2001). It gives an indication of the ease of dispersability and reduction of paste thickness while the emulsion tendency is the property reported to be advantageous to OBM.

MATERIALS AND METHODS

1.2.1 Materials

Two species of cassava (Tropical Manihot Species 30572 and 98/0505) aged 11 months were freshly harvested from the Agricultural Development Programme (ADP) Farm, Rumuodomaya Port Harcourt, Nigeria. Physical treatment operations - washing, peeling and grating were carried out on the two samples prior to starch extraction.

1.2.2 Method

a. Extraction, Purification and Concentration of Cassava Starch

The cassava starches from the two species were extracted using traditional method (Figure 1). The pulp mash grated by mechanical grater was mixed with three (3) litres of water for easy filtration. The pulp was placed unto a muslin/ nylon screen which was tied on a bucket and the mash was sifted through the muslin screen batch wise while water was added continuously to aid the screening. The pulp was further rinsed with water to extract as much starch as possible. The filtrate was allowed to settle under gravity for about 3 hours. The starch extract (filtrate) was mixed with water again to remove traces of impurities and contaminants. The mixture was subjected to filtration operations the second time and then concentrated using sack made of cloth.

The starch obtained were dried in an electric thermo- regulated oven at a temperature of $60^{o}C$ steadily for 3 hours to form cake and then sieved to reduce particle size to fine texture. The sieved powdered starch obtained were packaged and sealed at room temperature ($25^{o}C$) for further analysis.

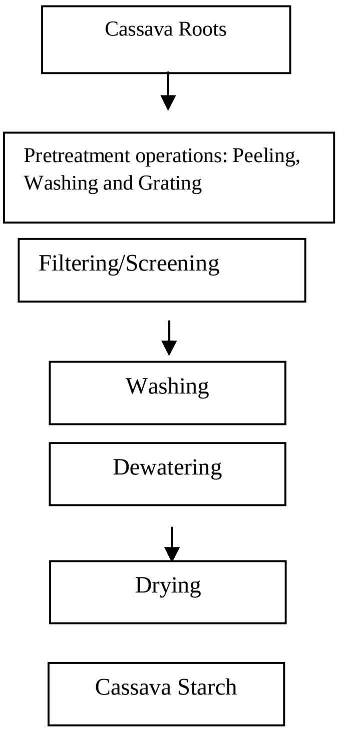

Figure 1: Flow diagram of Cassava Extraction Process

b. Physicochemical Property Measurements of Cassava Starches

The physicochemical properties of the two cassava starch samples (obtained from the two species) were measured as presented.

Particle Size Distribution
2.00 g each of the two starch samples were weighed and poured into separate pastry dishes. Distilled water in a beaker was employed to calibrate the mastersizer; the value of obscuration was noted. Each of the starch species were feed into the beaker that contained distilled water of the Malvern instrument mastersizer for the analysis. The result was automatically displayed on the printable screen and recorded.

Bulk Density
50.0g each of the two starch samples were weighed and poured into separate measuring cylinders containing water. Change in volumes were observed and recorded. The density of the starch samples were measured using Equation 1.

$$Density = \frac{Mass\ of\ Starch\ Sample}{Volume\ occupied\ Mass\ of\ Starch\ Samples} \qquad (1)$$

pH Values
20.0g each of the two cassava starch samples were weighed separately and 200ml of distilled was mixed with samples separately in a Hamilton Beach mixer cup with the aid of a magnetic stirrer to obtain homogenous mixture (complete dissolution). The pH of starch solutions were determined by dipping the indicator probe into the solution. Three repetitions were made for each of the samples and the mean value recorded.

Moisture Content
20.0g each of the two starch samples were weighed separately into a previously weighed pastry dishes. The starch samples in the pastry dishes were placed in temperature controlled oven, previously stabilized at 120^{o}C for 60 minutes. The samples were reweighed and replaced in the oven. The process was repeated at 60, 30 and 15 minutes until constant weights were achieved. The moisture contents of the starch samples were obtained using Equation 2 below.

$$Percentage\ Moisture\ Content = \frac{Mi-Mf}{Mi}\ X\ 100 \qquad (2)$$

Where:
M_i = Initial mass of starch sample (before drying)
M_f = Final mass of starch sample (after drying).

RESULTS AND DISSCUSSION

Starch Yield
46.5 kg of each of the two species (TMS 30572 and TMS 98/0505) of cassava tubers employed yielded 3.25 kg and 4.00kg of starch respectively. Higher percentage in water content was recorded by TMS 98/0505 as reported by NRCRI, (2010).

Physiochemical Properties
The physiochemical properties of the starched obtained were analyzed and compared to those of PAC. The physiochemical properties of the starches analyzed are as detailed in Table 1.

Table 1: Physiochemical properties of Cassava Starch

Parameter	TMS 30572	TMS 98/0505	PAC (Reference)
pH @ 25^{o}C	8	7.2	7
Moisture Content	4.94%	4.11%	< 7%
Bulk Density (kg/m^3)	943.4	617.3	641-881
Particle size Distribution	Fine	Fine	Fine
Dispersion	Poly Dispersed	Poly dispersed	Poly dispersed
Appearance	Whitish	Whitish`	Whitish

pH
The pH accounts for the acidic or basic nature of substances. The level of hydrogen cyanide (HCN) content in cassava is the basis for its toxicity. The cassava starch samples were in the ranges of 7.2-8 indicating neutral or slightly alkaline on the pH meter. TMS 98/0505 had a pH value of 7.2 indicating higher value of HCN content

compared to TMS 30572 with pH of 8. It was observed that TMS 30572 was alkaline in nature (pH = 8).The HCN contents in cassava is inversely proportional to the pH value. i.e the higher the content of HCN, the lower the pH value and vice versa (Sunday and Adannaya, 2010).

Bulk Density and Appearance

The values of bulk density of starch samples showed significant differences (Table 1); this corroborates with the work of Moorthy (2009). It was observed that starch from different varieties had large differences in bulk density depending on the specie source. However, both starch species were whitish in appearance conforming to literature (Moorthy, 2009).

Moisture Content

The moisture content of starch depends to a large extent on the method of drying and drying conditions (Shildreck et al. 1967). The moisture contents for the starch species analyzed were less than 5%.

Particle Size Distribution and Dispersion

The size of starch granule is important in determining the suitability of starch for certain applications, this also could improve and increase the binding and reduce the breakage of final product (Aprianita, 2010). The results of particle size distribution for the two starch species (TMS 98/0505 and TMS 30572) are detailed in Tables 2 and 3 respectively while Figures 2 and 3 showed the graphical representation of the particle size distribution for the starch species.

Table 2: Particle size distribution for TMS 98/0505

ID: tms 0505	Run No: 1	Measured: 22/6/2011 11:49AM
File: 900AULT	Rec. No: 2	Analysed: 22/6/2011 11:49AM
Path: C:\SIZERMU\DATA\		Source: Analysed
Sampler: Internal		Measured Beam Obscuration: 10.4 %
Presentation: 4OHD	Analysis: Polydisperse	Residual: 0.909 %
Modifications: None		
Conc. = 0.0174 %Vol	Density = 1.000 g/cm^3	S.S.A.= 0.7501 m^2/g
Distribution: Volume	D[4, 3] = 65.65 um	D[3, 2] = 8.00 um
D(v, 0.1) = 6.05 um	D(v, 0.5) = 30.19 um	D(v, 0.9) = 175.92 um
Span = 5.627E+00	Uniformity = 1.747E+00	

Mesh No	Aperture um	Volume In%	Volume Below%	Mesh No	Aperture um	Volume In%	Volume Below%
10	2000	0.00	100.00	60	250	3.21	98.07
12	1700	0.00	100.00	70	212	4.21	94.86
14	1400	0.00	100.00	80	180	5.47	90.65
16	1180	0.00	100.00	100	150	5.74	85.18
18	1000	0.00	100.00	120	125	4.99	79.44
20	850	0.00	100.00	140	106	4.49	74.45
25	710	0.00	100.00	170	90	4.30	69.96
30	600	0.00	100.00	200	75	3.45	65.66
35	500	0.00	100.00	230	63	2.94	62.21
40	425	0.00	100.00	270	53	2.56	59.27
45	355	0.04	100.00	325	45	2.65	56.71
50	300	1.88	99.96	400	38		54.06
60	250		98.07				

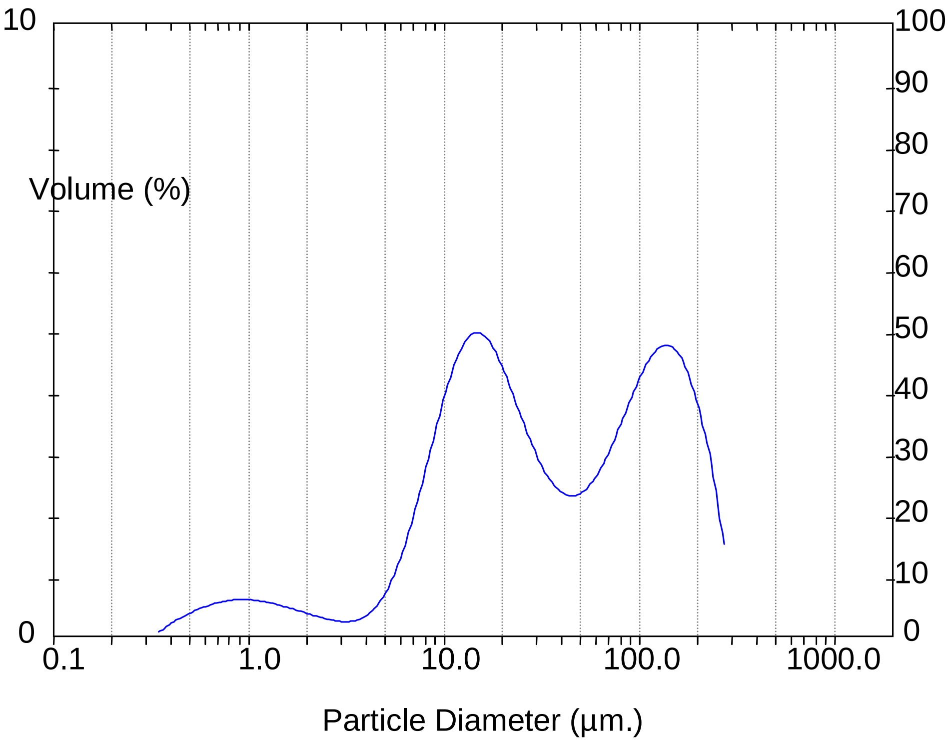

Figure 2: Graph of Particle Diameter Vs Particle Volume (TMS 98/0505)

Table 3: Particle size distribution for TMS 30572

Result: Sieve ASTM E11:61 Table

ID: tms 35072 Run No: 1 Measured: 22/6/2011 12:09PM
File: 900AULT Rec. No: 3 Analysed: 22/6/2011 12:09PM
Path: C:\SIZERMU\DATA\ Source: Analysed

Sampler: Internal Measured Beam Obscuration: 10.9 %
Presentation: 4OHD Analysis: Polydisperse Residual: 0.538 %
Modifications: None

Conc. = 0.0171 %Vol Density = 1.000 g/cm^3 S.S.A.= 0.7772 m^2/g
Distribution: Volume D[4, 3] = 40.36 um D[3, 2] = 7.72 um
D(v, 0.1) = 6.30 um D(v, 0.5) = 20.03 um D(v, 0.9) = 105.13 um
Span = 4.935E+00 Uniformity = 1.477E+00

Mesh No	Aperture um	Volume In%	Volume Below%	Mesh No	Aperture um	Volume In%	Volume Below%
10	2000	0.00	100.00	60	250	1.22	99.30
12	1680	0.00	100.00	70	210	1.56	98.08
14	1410	0.00	100.00	80	177	1.87	96.51
16	1190	0.00	100.00	100	149	2.18	94.65
18	1000	0.00	100.00	120	125	2.49	92.47
20	841	0.00	100.00	140	105	2.89	89.98
25	707	0.00	100.00	170	88	3.21	87.09
30	595	0.00	100.00	200	74	3.25	83.89
35	500	0.00	100.00	230	63	3.69	80.63
40	420	0.00	100.00	270	53	4.13	76.94
45	354	0.04	100.00	325	44	4.01	72.81
50	297	0.66	99.96	400	37		68.80
60	250		99.30				

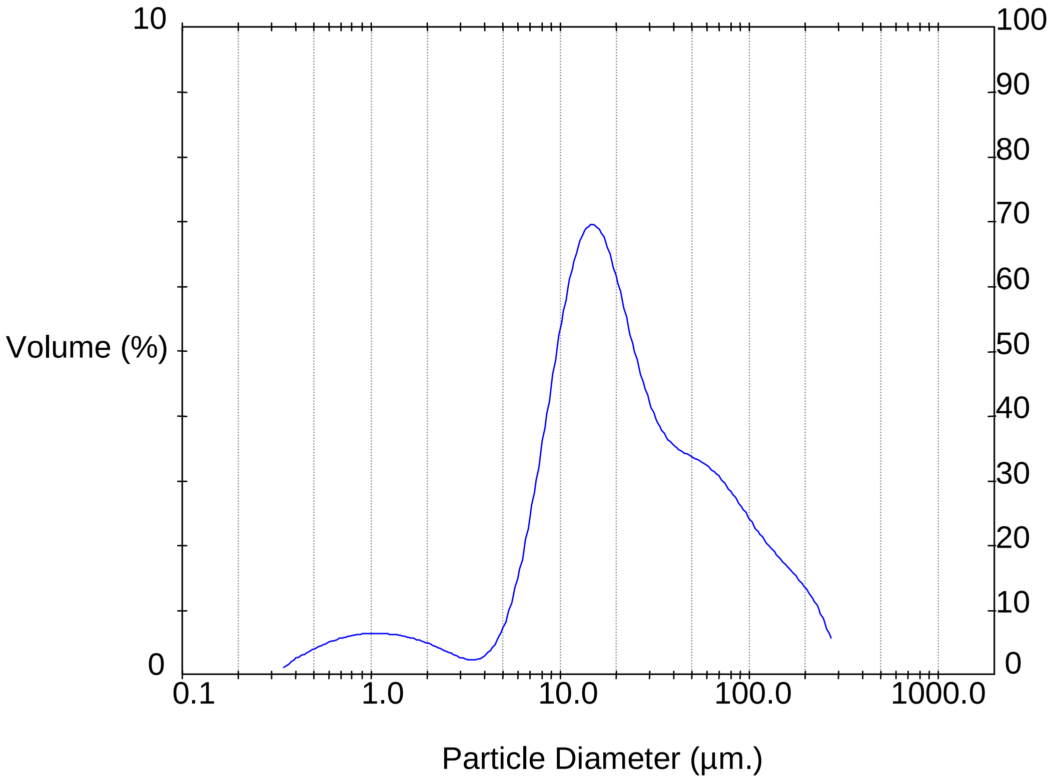

Figure 3: Graph of Particle Diameter Vs Volume Particle (TMS 30572)

Figures 2 and 3 (plots of particle diameter vs particle volume) shows that the starch sample of TMS 30572 had about 70% of its volume with particle diameter in the range of 10 – 20 µm while that of TMS 98/0505 had about 50% of its volume with particle diameter in the range of 10 – 20 µm. Tables 2 and 3 also indicate that both starch samples are poly dispersed which refers to the level of homogeneity of the sizes of the particles. It has been observed that cassava starch is polydispersed as this contributes to its ability of giving clear paste (IITA, 2005). From literature, it is found that cassava starch could have a value as high 81.5–89.5% (Onitilo et al, 2011).

CONCLUSION

The result of the properties of the starch from the two cassava species measured shows that TMS 98/0505 has closer similarities in terms of pH value and bulk density to the reference (PAC) compared to the TMS 30572. Consequently, starch obtained from the former could be employed wholly or as partial substitute for PAC as fluid loss control agent in the formulation of the water based drilling fluid

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