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Production of Adhesives from Cassava Starch

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Abstract

The potentials of adhesives production from cassava starch were investigated. Adhesive products from *Manihot utilisima* and *Manihot palmate* were compared with a commercial adhesive. Based on the results obtained, equations developed for optimum process conditions that would yield products comparable to the commercial process. The products obtained using these conditions were found to have relatively improved pot-life. There no noticeable changes in the properties of the products for the first 21 days.

Key words

Adhesives, Cassava, Starch

Introduction

Cassava, a relatively unknown crop in the old world before the discovery of America is fast assuming the status of the saviour of the world, as it is now grown throughout the tropical world. It is second now only to potato as the most important starchy root crop of the tropics used for food and industrial purposes. In Nigeria, it is consumed raw or cooked, used for the manufacture of garri, starch flour and a variety of other items (Tonukari, 2004; Grace, 1977). The current drive towards earning foreign exchange from cassava products in Nigeria had raised more awareness on the importance of the crop.

However, the secondary product (cassava starch and milk) from the product of garri (the most important food item from cassava in Nigeria) is not properly utilized in most processing industries. These products are just drained off without any thought for their utilization especially in the rural areas. It is in the light of this and the fact that this cassava is readily available that these studies were conducted to investigate the possible utilization of cassava starch as a binding material (adhesive).

An adhesive is a substance capable of holding materials together by surface attachment with the ability to sustain the designed load requirement without deformation or failure (Anonymous, 1982). For an adhesive to be effective, there are two major characteristic requirements. The adhesive must be capable of impacting adequate bond between the two materials by principle of resistance to load shear, which implies creep static or time independent deformation under sustained load (Foschi, 1977). Other desired requirements are ease of application, reasonable setting time, resistance to moisture, aging, heat and fungal attack, non-staining and gap filling (Knight, 1984).

Although the key effect of solidified adhesives in the pore spaces may be low, cassava based adhesives could be readily made from by-products which would otherwise be wasted, hence giving a unique advantage of very low cost. The mode of action of adhesives is bonding between the adhesive and the product to be bonded. The fine, smooth texture, non-staining, non-poisonous nature of starch makes cassava adhesives a desirable choice particularly for domestic uses and most non-structural utilization of adhesives (FAO, 1983).

There are however, several problems associated with the use of starch as an adhesive. The most important of these is the stability of the product over time, hence very short pot-life. The main objective of this study, therefore, is the development of conditions that could ensure the stability of adhesives produced from cassava starch.

Materials and Methods

Two species of cassava, *Manihot utilisima* and *Manihot palmate* were obtained and used for the production of the starch. The debarked roots were washed, crushed, ground and milled. The paste obtained was collected in a fine filter bag and pressed. The seepage was collected and allowed to sediment. Decanting separated the sediment, starch-water mixture.

The resultant wet starch was weighed and tray dried under natural atmosphere to a constant weight.

2.5 g of the dry starch from *Manihot utilisima* in 50 cm^3 of 0.01M hydrochloric acid (HCl) solution was heated on a hot plate to a temperature of 100^o C with stirring. It was allowed to cool to a lower temperature and then stabilized. The procedure was also repeated with sample from *Manihot palmate*.

A portion of the adhesive so produced from *the Manihot utilisima* was taken in a container and at a temperature of 75^o C sodium tetra borate ($Na_2B_4O_7.10H_2O$) was added piece wise with stirring. The addition was continued until the product became sticky. This was repeated at various temperatures to determine the most suitable stabilization temperature and optimum suitable tetra borate requirement. The viscosity of the product was determined using the standard method of viscosity determination. The procedure was repeated using the sample from the *Manihot palmata*

Results and Discussion

The results of the production exercise carried out are presented in Tables 1 to 5. A commercial adhesive, trade marked Madona was analyzed for basis of comparison. The adhesive was found to have density of 1.03 g/cm^3 and viscosity of 4.76 x 10^6 g/ ms. The density of the produced adhesive was found to compare favorably with the commercial one. However, the viscosity varied with the amount of borax added as can be seen in Tables 3 and 4.

Table1. Production of Adhesive using Manihot utilisima

Weight of dry starch (g)	Volume of 0.0117 HCl (ml)	Volume of adhesive produced (ml)	Density of product (g/cm^3)
2.50	50.00	38.30	1.026
2.50	50.00	38.50	1.024
2.50	50.00	38.00	1.023
2.50	50.00	38.20	1.024

Table 2. Production of Adhesive using Manihot palmate.

Weight of dry starch (g)	Volume of 0.0117 HCl (ml)	Volume of adhesive produced (ml)	Density of product (g/cm^3)
2.50	50.00	39.00	1.026
2.50	50.00	38.50	1.024
2.50	50.00	39.00	1.028
2.50	50.00	39.00	1.126

Table 3. Stabilization of adhesive from Manihot utilisima.

Volume of starch (ml)	Quantity of borax (g)	Temperature (^oC)	Viscosity of adhesive (x 10^6 cp)
25.00	0.150	75	8.06
25.00	0.126	70	6.60
25.00	0.100	65	5.09
25.00	0.080	60	3.70

Table 4: Stabilization of the adhesive from Manihot palmate

Volume of starch (ml)	Quantity of borax (g)	Temperature (^{o} C)	Viscosity of adhesive (x 10^6 cp)
25.00	0.150	75	14.24
25.00	0.125	70	11.01
25.00	0.110	65	9.18
25.00	0.070	60	1.48
25.00	0.043	55	0.50

Table 5. Relationship between time and viscosity of adhesives

	Time (days	0	1	3	5	7	15	21
Viscosity (x 10^6 cp)	*Manihot utilisima*	4.685	4.684	4.684	4.684	4.684	4.681	4.678
	Manihot palmata	4.753	4.753	4.745	4.706	4.730	4.670	4.580

A plot of the temperature and viscosity against quantity of borax are shown in Figures 1 and 2. Using the viscosity of the commercial adhesive as a reference, the optimum temperature and borax requirements for stable adhesive with reduced retro gradation were determined from the curves. These conditions were used to produce adhesives which were stabilized and these results are shown in Table 5.

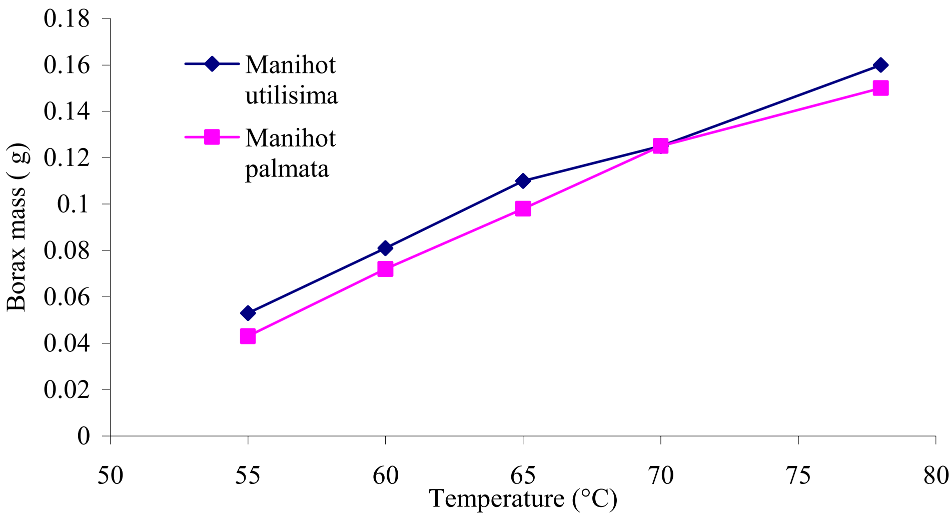

Figure 1. Relationship between temperature and mass of borax

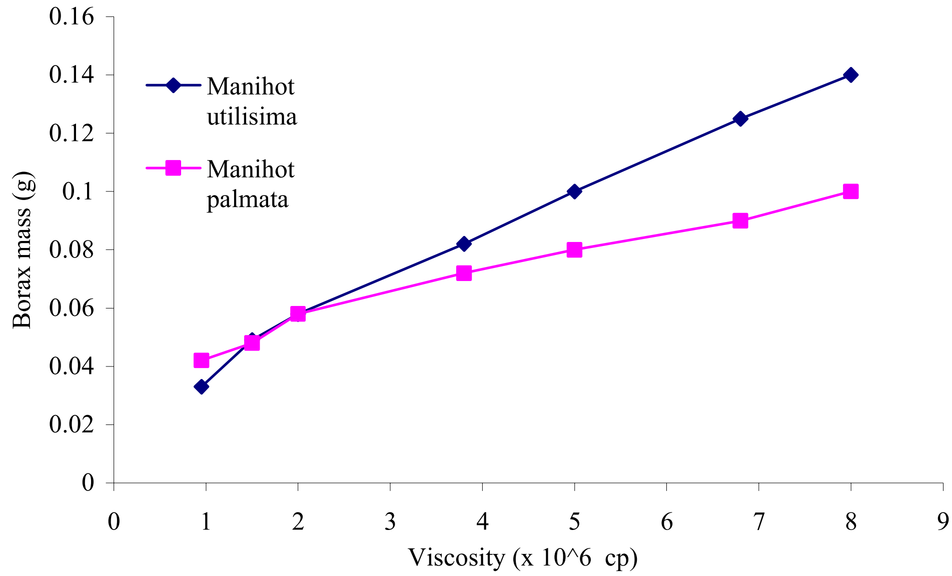

Figure 2. Relationship between Viscosity and Borax mass

It was discovered that adhesive produced from *Manihot utilisima* retained a longer stability than that from *Manihot palmate*. This could be attributed to effect of higher cyanide content of Manihot utilisima. The hydrogen cyanide (HCN) could react with the sodium salt produced from the stabilization. The reaction is as shown in the equation (1) below:

$$(C_6H_{10}O_5)_n \xrightarrow[heat]{HCl} (C_6H_{10}O_6) + HCl + HCN(by-product)$$

$$(C_6H_2O_6)_n + NaB_4O_7.10H_2O \longrightarrow C_6H_{12}B_4O_{11} + \frac{1}{2}O_2 + (Na_2O + 10H_2O) \quad (1)$$

$$HCN + NaOH \longrightarrow NaCN + H_2O$$

The salts could have negative effect on the adhesives when not adequately removed.

Though the pot-life was only three weeks, it is an improvement in this direction taking into cognizance the fact that adhesives from starch are highly suitable and retro graduates readily (Ihekoronye and Ngoddy, 1985).

From the graphs, the following equations can be deduced for optimum comparative conditions.

For *Manihot utilisima*:

$$T = 200x + 44 \quad (2)$$

$$\mu = 56.67X10^7x - 1.1334X10^6 \quad (3)$$

$$\text{Hence } \mu = 2.72X10^5T - 1.13X10^6 \quad (4)$$

For *manihot palmate*:

$$\mu = 7.73X10^5T - 3.95X10^6 \quad (5)$$

From equations (4) and (5), for a given viscosity, the optimum temperature required to get the viscosity will easily be obtained and hence the borax quantity for the stabilization will be deduced from the graph.

Conclusion

Cassava starch that is readily available has been used to produce non-structural adhesives. Certain conditions that could give optimum production had been specified using the data obtained. The adhesives produced from starch of two varieties of cassava are fairly stable on addition of a chemical stabilizer. The optimum temperature and stabilization material for the production could be deduced from the graphs and the equations developed. Cassava starch therefore could be good source of cheap and readily available adhesives, thus saving the industries from spending foreign exchange on importation.

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