AU J.T. 13(4): 258-260 (Apr. 2010)

Investigation of Alpha-Cellulose Content of Agro-Waste Products as Alternatives for Paper Production

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Abstract

The cellulose content of agro-waste such as rice husk, maize cub, sorghum stalk and groundnut shell was experimentally determined using standard procedures, such as defattening, scouring and alpha cellulose test. The alpha cellulose content obtained for the various agro-wastes used are rice husk 43.33%, maize cub 62.96%, sorghum stalk 47.36% and groundnut shell 65.20% as against the alpha cellulose content of wood which is 63%. Ash contents determined for each of these products were also done and the results obtained are rice husk 1.5% maize cub 0.09%, o.09%, sorghum stalk 0.149% and groundnut shell 0.3%. These results confirmed that agro-wastes are possible alternatives to wood in paper making industry.

Keywords*: pulp, agro-waste, defattening, scouring, alpha-cellulose.*

Introduction

The early history of paper focuses on papyrus, which is the oldest known plant to be written on, and never includes a discussion of wood pulp. However, the industrial revolution saw the invention of faster printing machines, and increase in the demand for paper. These caused paper makers to turn to sources of pulp that was plentiful and relatively easy to process. Hence, wood soon became the most popular source of pulp for paper. In fact, it is now the source of approximately 95% of the world's paper. Wood still remains the main sources for paper and paper demands are expected to rise. Forests are coming under increasing attack from production demands and environmental stresses. This attack leads to deforestation and desertification and their attendant consequences. There seems to be a general lack of knowledge of the fact that alternatives to tree based papers currently exist in a class of products collectively referred to as "tree paper".

The search for the alternatives dates back to 1957 when the United States Department of Agriculture (USDA) began a comprehensive study to find alternatives sources for paper production. This study stemmed from acute shortage of fiber for paper production as a fall out from the World War II. Kenaf fiber has been established as potential replacement for wood fiber in paper production. This replacement is not only to be found in Kenaf fiber, but also in other non-wood agro-wastes. These include seaweed, banana stalk, groundnut husk, corn stalk, sorghum stalk, rice husk, coffee beans residues as well as multiple types of agricultural or manufacturing residues and recycled papers. However, it has to take confirmatory tests to ascertain this claim and also to know to what extent or the amount of paper that could be produced from these alternatives sources. (Belayachi and Delmas 1997; Britt 1970; WRF 1997).

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Materials and Methods

Materials

The agro-waste materials used for the research work are rice husk, corn stalk, sorghum stalk and groundnut husk, all obtained from Girei Development Area of Adamawa State, Nigeria.

Methods

Mechanical Treatment

1. Rice husk - this is sieved to ensure that no rice particle goes along the husk during subsequent treatments.
2. Corn stalk grinded in a mill into smaller particles and before grinding, the bark of the corn stalk was peeled.
3. Sorghum stalk - the bark was peeled and grinded into small particles.
4. Groundnut husk - the shell obtained after the nut was shelled off.

Defattening

Each of the samples obtained were dried in an oven at 150^{o}C and powdered. The defatted powdered samples were made pectin free (depectinization) by refluxing with 0.5% ammonium oxalate for 4-8 hours, filtered, washed with water and dried scouring. (Doric 1950; Roberts 1991; Casey 1983).

Scouring

A 1.0g sample of the defatted fiber was weighed for each of rice husk, corn husk, sorghum stalk and groundnut husk into separate 250ml beaker and 150ml of 3% solution of NaOH in 1:2 liquor ratio for 1 hour at boiling temperature for the extraction of cellulose. (Doric 1950; Roberts 1991; Casey 1983).

Alpha cellulose

Samples from scouring were treated with 17.5% of sodium hydroxide (NaOH) solution in 1:2 liquor ratios for 1 hour at boiling temperature for the extraction of alpha cellulose.

The following Eqs. 1 and 2 are used to determine the percentages of alpha cellulose content and ash contents in the samples (Doric 1950; Roberts 1991; Casey 1983):

$$\alpha \text{ cellulose } (\%) = [(\alpha - CC) / W_i] \times 100, \quad (1)$$

$$\text{ash } (\%) = [(W_i - W_d) / W_i] \times 100, \quad (2)$$

where:
% = Percentage;
α = Alpha;
CC = Cellulose content;
W_i = Initial weight of sample; and
W_d = Dry weight of sample.

Results and Discussion

The agro-wastes samples which were used for this research proved to be adequate for paper making. The samples had obvious weight loss due to the removal of impurities such as lignin and dust. However, the coluors of the samples still remained the same, rice husk still brown, maize husk still grey, groundnut shell still black and sorghum stalk still grey. Table 1 shows that more impurities were removed during scouring procedure as further weight loss was experienced. Nevertheless, there was a change in the colours of the samples - rice husk became dark brown, maize husk became pale grey, groundnut shell became black and sorghum stalk became bright grey. Table 2 shows a sharp reduction in weight loss as experienced during alpha cellulose determination of samples and this connotes a sharp removal of all the possible impurities. At this point, the unstable beta cellulose was also removed along with other impurities. According to Roberts (1991), the general accepted percentage of alpha cellulose for rice husk, maize husk, groundnut shell and sorghum stalk are 43%, 63%, 65.75% and 48%, respectively. The percentages of alpha cellulose obtained in this research are rice husk 43.33%, maize husk 62.96%, groundnut shell 65.20% and sorghum stalk 47.36%. It is therefore deduced that this research has an equal rating with the acceptable standard.

Conclusion

The results obtained from determination of ash content in each of the samples used show that the maize has the lowest ash content of 0.9% and rice has the highest ash content of 15% as shown in Table 3. The ash colour of samples used is shown in Table 4. It is then obvious that rice husk has more impurities than maize husk, therefore maize husk is better option for paper making than rice husk.

References

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Table 1. Result of scouring test.

Sample	Initial weight (g)	Final weight (g)	Weight loss (g)
A (groundnut shell)	42.44	25.00	17.44
B (maize husk)	33.00	13.50	19.50
C (rice husk)	42.10	18.00	24.10
D (sorghum stalk)	32.60	19.00	13.60

Table 2. Result for alpha-cellulose test.

Sample	Initial weight (g)	Final weight (g)	Weight loss (g)	Percentage of alpha cellulose (%)
A (groundnut shell)	25.00	8.70	16.30	65.20
B (maize husk)	13.50	5.00	8.50	62.96
C (rice husk)	18.00	10.20	7.80	43.33
D (sorghum stalk)	19.00	10.00	9.00	47.36

Table 3. Result for ash content procedure.

Sample	Initial weight (g)	Final weight (g)	Weight loss (g)	Percentage of ash content (%)
A (groundnut shell)	10.00	9.70	0.30	3
B (maize husk)	10.00	9.91	0.09	0.9
C (rice husk)	10.00	8.50	1.50	15
D (sorghum stalk)	10.00	9.85	0.149	1.49

Table 4. Ash colour of samples used.

Sample	Color
A (groundnut shell)	Black
B (maize husk)	Grey
C (rice husk)	Brown
D (sorghum stalk)	Black