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THE EFFECTS OF HYDROGEN PEROXIDE BLEACHING ON THE STRENGTH PROPERTIES OF RAPHIA HOOKERI CHEMI-MECHANICAL PAPER

INI A. UTUK
Department of Industrial Technology Education
University of Uyo, Akwa Ibom State

UBONG I. UDOAKPAN, PhD
Department of Forestry and Wildlife
University of Uyo

ASUQUO J. OTOYO
Department of Mechanical Engineering
Akwa Ibom State University

ABSTRACT:

The effects of hydrogen peroxide bleaching on the strength properties of Raphia hookeri Chemi-mechanical Paper (CMP) had been investigated. The raphia piassava were reduced to match-stick sized chips manually. The raphia chips were impregnated with a mixture of sodium hydroxide and sodium sulphite for 30 minutes. The chips were beaten and refined to a freeness of 202 CSF. Half of the stock was bleached using 1.39% hydrogen peroxide on Borne-dry (BD) pulp. The bleached and unbleached R. hookeri pulp were formed into paper sheets and tested for physical strength properties. The result showed that there was 17.51% brightness gain for the bleached R. hookeri CMP. Secondly, there was slight reduction in the tear strength (from 880 to 778.67mN), tensile strength (from 20.05 to 2.01 kNm^{-1}) and percentage stretch (from 2.56 to 1.83) of the bleached R. hookeri CMP due to the effects of hydrogen peroxide on the fibres.

KEYWORDS: Raphia hookeri, Piassava, Pulping, Chemi-Mechanical Paper (CMP), Strength properties, bleaching.

INTRODUCTION:

Raphia hookeri are found randomly in the forest zone of Southern Nigeria. Four species of raphia which commonly exist in Nigeria include: Raphia sudanica, Raphia hookeri, Raphia vinifera and Raphia regalis (Keay, 2000). Odeyemi (2007) stated that R. hookeri, R. sudanica and R. vinifera grow in quantities that could support pulp and paper industry in Nigeria. Raphia thrives naturally in swampy areas. The Nigerian Institute for Oil Palm Research (NIFOR) had perfected the plantation cultivation of R. hookeri which grows to maturity between four to eight years (Odeyemi, 2007). R. hookeri are often tapped for palm wine, palm front, palm leaves and raphia piassava. The piassva are the cord-like strands of raphia extracted from the stem and petiole of the plant (Odeyemi, 2007).

Paper and allied products could be made virtually from any fibrous plant (Langer and Hill, 2002). The suitability and adaptability of any fibrous raw material for paper making depend on a number of factors namely; its availability in sufficient quantity, beatability, fibre geometry and intrinsic strength, percentage pulp yield, physical and chemical characteristics of the raw material, to mention but a few (Britt, 2007). Local sourcing of raw materials for pulp and paper making, from lesser known species of wood has made several researchers to carry out work in this respect. Akpabio, Essien and Eka (2007) carried out extensive studies on Nypa fruiticans (Nypa palm). Akpabio (2017) researched on the use of plantain (Musa paradisiaca) and banana (Musa sapientuum) plants for paper making. Utuk, Udofia and Uko (2019) evaluated the suitability of elephant grass (Pennisetum purpureum) for paper making.

Paper making is the art of producing a sheet material used for writing, printing, wrapping, packaging etc. usually made by draining cellulose fibres from a suspension in water (Usoro and Utuk, 2017). In order to make paper conventionally, the raw materials are reduced into chips, and processed to obtain pulp. Pulping is the process of defibering wood chips to obtain pulp. Pulping could be done using any of these three broad methods: (i) mechanical pulping (ii) chemi-mechanical pulping and (iii) chemical pulping. Chemi-mechanical pulping, according to McGovern (2007), is a two-stage process using: (i) chemical energy with and without heat energy and (ii) mechanical energy to cause separation of the fibres of ligno-cellulosic materials. The pulp fibres are usually beaten and refined in a slurry, to the required freeness, followed by bleaching and chemical addition to obtain the stock. The prepared stock are processed on an endless wire mesh to produce wet 'paper web' which would be dried and calendared to the required caliper to produce the paper. Chemi-Mechanical Paper (CMP) is one obtained from chemi-mechanical pulp. The objective of this study therefore, is to determine the effects of hydrogen peroxide bleaching on the strength properties of Raphia hookeri Chemi-mechanical paper.

MATERIALS AND METHODS

R. hookeri piassava were obtained from three locations namely; Watt market in Calabar municipality, Akpan Andem main market in Uyo Local Government Area and Itam market in Itu Local Government Area. The raphia piassava obtained in cord-like form were cut manually into uniform length of 3.5 cm using sharp scissors and matchet to produce match-stick sized chips. 800g BD chips were pressed in the Moore hydraulic press for 15 minutes prior to impregnating with 5 litres of hot sodium hydroxide and sodium sulphite for 30 minutes. The impregnated chips were beaten and refined to fibrillate the fibres. The pulp was screened and washed. A portion of it (50g BD pulp) was bleached using 1.39% hydrogen peroxide on BD pulp.

The bleach liquor was constituted, using TAPPI Standards (2008), by adding the following in sequence to 761ml hot water (60^0C):

5% Diethylene Triamine Pentaacetic Acid (DTPA) w/w - 76mls

45% Sodium trioxosilicate(iv) salt (Na_2SiO_3) w/w - 38mls

2% Magnesium tetraoxosulphate (vi) heptahydrate ($MgSO_4.7H_2O$) w/w - 48.4mls

17% Sodium tetraoxosulphate(iv) salt ($NaSO_4$) w/w - 39.1mls

45.5% Hydrogen peroxide (H_2O_2) w/w - 37.5mls

The bleached pulp were washed using distilled water and then with sodium meta sulphite to neutralize and stop further reaction of the peroxide. Diethylene Triamine Pentaacetic Acid (DTPA) was employed in the bleach liquor as a sequestrant for the transition metals (Dence and Omori, 2005).

RESULTS AND DISCUSSION:

The cellulosic fibres obtained after pulp milling are generally not suitable for paper sheet formation. These raw fibres were further beaten and refined to transform the relatively long, smooth, stiff fibres into shorter, fibrillated, hydrated more flexible fibres with increased surface area.

Table 1: Prepared stock for paper sheet formation

Quantity	**Unit**	**Stock**
Consistency	%	2.8
Freeness	CSF	202
pH		7.3
Temperature	^{0}C	28

Source: Fieldwork, 2005.

Table 1 shows the condition of the prepared stock of unbleached R. hookeri chemi-mechanical pulp. The stock was beaten to a freeness of 202 Canadian Standard Freeness (CSF) at a consistency of 2.8%. The freeness of pulp is the extent of work done on the fibres during beating/refining (Utuk, Udofia, and Uko, 2019). Beating of the pulp increases the surface area of the individual fibres, thereby increasing the strength of the resultant paper. This is because the strength of paper depends on the increased bonding area of the pulp due to external fibrillation of fibre walls (Britt, 2007).

Table 2: Pulp bleaching for Paper making

Quantity	**Values**
% Peroxide on BD pulp	1.39
% Consistency of unbleached pulp	26.9
% Brightness of unbleached pulp	26.93
% Brightness of bleached pulp	44.44
% Gain in brightness	17.51

Source: Fieldwork, 2005.

Bleaching is essentially the process of brightening unbleached pulp to the desired brightness, intended for fine paper making. Table 2 shows that the brightness of unbleached pulp was 26.93%. 1.39% hydrogen peroxide on BD pulp yielded a brightness of 44.44%, showing a gain of 17.51% brightness. The rate of brightness increases with peroxide concentration. The total alkalinity of the bleach liquor should be high enough to ensure adequate concentration of hydro peroxide anion throughout the course of bleaching as dictated by the equation:

$$H_2O_2 + NaOH \longrightarrow Na^+ + OOH^- + H^+ + OH^-$$

The pH at which the brightness stoichiometry becomes unfavourable is dependent on the peroxide charge. An increase in peroxide charge lowers the pH at which the stoichiometry becomes unfavourable (Dence and Omori, 2016). The hydro peroxide ions oxidizes the colour of the pulp, thereby brightening the resultant pulp according to the equation below:

$$OOH^- + \text{Colour} \longrightarrow \text{Oxidized Colour} + OH^-$$

The brightness response of chemi-mechanical pulp to peroxide had been found to be enhanced by increasing the consistency of the pulp (Britt, 2007).Consequently, less peroxide was consumed as the pulp consistency was increased to 26.9%. Strunk and Meng (2009) found out that wood from many geographical regions contain more than 100 parts per million (ppm) of manganese which is sufficient to cause significant decomposition of hydrogen peroxide during bleaching. Dence and Omori (2005), found out that the decomposition of peroxide during pulp bleaching was catalyzed primarily by compounds of heavy metal such as iron, copper, nickel and manganese and by the enzyme, catalase, as shown below:

$$H_2O_2 \xrightarrow{\text{catalyst}} 2H_2O + O_2$$

This reaction is not desirable from the standpoint of peroxide consumption. Hence, it was deactivated by the application of chelating agents such as DTPA and magnesium sulphate. The latter also acted as a stabilizer in the bleaching liquor. In addition, sodium silicate was used as a buffer and stabilizing agent whereas sodium hydroxide was used primarily to provide the alkaline environment required for the bleaching process.

Table 3: Paper quality testing

Quantity	**Unit**	**Unbleached R. hookeri CMP**	**Bleached R. hookeri CMP**
OD grammage	gsm	60.3	60.3
Moisture content	%	13.3	13.3
Tear strength	mN	880	778.67
Tear index	$mNm^2 g^{-1}$	14.59	12.91
Tensile strength	$kN m^{-1}$	2.05	2.01
Tensile index	$Nm g^{-1}$	34.00	33.33
Stretch	%	2.56	1.83
Brightness	%	26.93	44.44

Source: Fieldwork, 2005.

Table 3 shows the paper quality of the unbleached and bleached R. hookeri CMP. The strength of paper made from R. hookeri piassava were remarkable. At the grammage of 60.3gsm, the unbleached R. hookeri CMP had tear strength of 880 mN, tensile strength of 2.05 $kN m^{-1}$ and the corresponding tear and tensile indices of 14.59 $mNm^2 g^{-1}$ and 34.00 $Nm g^{-1}$ respectively. The bleached R. hookeri CMP had tear strength of 778.67 mN, tensile strength of 2.01 $kN m^{-1}$ and the corresponding tear and tensile indices of 12.91 $mNm^2 g^{-1}$ and 33.33 $Nm g^{-1}$ respectively. The percentage stretch of the unbleached R. hookeri (2.56) was higher than that of bleached R. hookeri (1.83). These results reveal that hydrogen peroxide bleach had slightly reduced the strength properties of R. hookeri CMP due to its effect on the fibres.

CONCLUSION:

The effects of hydrogen peroxide bleaching on the strength properties of R. hookeri CMP had been examined. The study concluded that the application of hydrogen peroxide had enhanced the brightness of R. hookeri CMP from 26. 93% to 44.44% and had slightly reduced the strength properties of the resultant paper.

RECOMMENDATIONS:

Based on the findings of the study, the following recommendations are made:

1. Bleached Raphia hookeri CMP could be used for writing grades of paper, such as exercise books.
2. Bleached Raphia hookeri CMP could be used for printing grades of papers such as newsprint and literal work.

REFERENCES:

1) Akpabio, U. D, Essien, U. C. and Eka, O. U. (2007). Chemical composition of the kernel of Nypa Fruiticans (Nypa palm) and its application of confectionery preparation. Global Journal of Pure and Applied Sciences 13(4): 513 - 516.
2) Akpabio, U. D. (2017). Paper making: The catalyst for national development. Uyo: University of Uyo Press Ltd.
3) Britt, K. W. (2007). Hand book of pulp and paper technology. New York: Van Nostrand Reinhold Company.
4) Dence, C. W. and Omori, S. (2016). A survey of hydrogen peroxide bleaching of mechanical and chemi-mechanical pulp – factors affecting brightness. TAPPI Journal, 170(2): 120 – 125.
5) Keay, R. W. (2000). Nigerian trees. Apapa: Nigerian National Press Ltd.

6) Langer, R. H. and Hill, G. D. (2002). Agricultural plants. London: Cambridge University Press.
7) McGovern, J. N. (2007). Semi-chemical pulping technology. USA: University of Wisconsin Press Ltd.
8) Odeyemi, S. O. (2007). An investigation on the manufacture of chemical pulp from raphia palm. Journal of Chemical Society of Nigeria, 5(2): 120 – 128.
9) Strunk, W. G. and Meng, T. (2009). Status Report: Pulp bleaching with hydrogen peroxide during refining. Pulp and Paper International, 18(2): 111 – 115.
10) TAPPI Standards (2008). Technical Association of Pulp and Paper Industries (TAPPI) Standards, 40(1): 142.
11) Usoro, A. D and Utuk, I. A. (2017). Wood technology. Ibadan: Penmark Publishers.
12) Utuk, I. A., Udofia, A. E. and Uko, E. R. (2019). Evaluation of the suitability of elephant grass (Pennisetum purpureum) for paper making. Journal of Forestry, Environment and Sustainable Development, 5(1): 7 – 11.