RESEARCH EXPERIENCES IN BAGASSE PULP BLEACHING

Nancy Fernandez, Maria Elena Naranjo, Julio Alvarez, Olivia Sardifias and Manuel Serante

Cuban Research Institute of Sugar Cane Derivatives, Icidca, Havana

ABSTRACT

This paper shows a panoramic view of the investigations conducted by the Cuban Research Institute of Sugar Cane By Products (Icidca), during the last decade, to produce different quality pulps from bagasse.

The bleaching of high yield pulps with the use of hydrogen peroxide, hydrosulphite and sodium hypochlorite in single and combined stages has been studied.

The sequences of multi-stages bleaching for chemical pulps, using chlorine and its derivatives, has also been studied. The use of chlorine dioxide was put into emphasis due to its selective action.

The total coefficient variable, defined in the study, was used to calculate the total chlorine consumption as a function of the degree of pulp delignification.

Among the new technologies developed the application of oxygen/alkali as previous stage is the most important.

The feasibility of using bagasse efficiently for this purpose is shown by the results of the study.

INTRODUCTION

In the last decade, the Cuban Research Institute of Sugar Cane By-Products has dealt with the study of the optimum regiments in the pulp brightening and/or bleaching for the production of different quality papers, particularly newsprint, using sugarcane bagasse as raw material.

A brighter future for the paper industry is envisioned if the dissolving pulp program is carried out by “Project Cuba-9”.

Nowadays, bagasse is considered one of the non-wood fibrous materials with the highest industrial potential. However, constraints are present in relation to its morphological and chemical characteristics, thus it has been necessary to conduct further studies to obtain optimum results inspite of certain difficulties.
Researches on pulp bleaching has shown that it is not advantageous to always use the reported conditions for wood pulps as a logical consequence of the morphological differences between both raw materials.

The fundamental objective of this paper is to summarize the steps we have followed to obtain proper bleaching technologies for the production of different quality papers from bagasse.

We have worked on two fundamental lines during these years. These were:

Development and refining of technologies for bleaching chemical pulps which are suitable for the production of papers and brightening of high yield pulps to obtain newsprint which are durable and of good quality.

Efforts have been made for studies on bleaching with oxygen/alkali as one of the most prominent contributions in this field of technology. The possibility of using this agent represents an attractive option for chemical pulps from bagasse since it results in high quality pulps with notable reduction of environmental pollution and a decrease of chemical consumption.

Bearing in mind the world demands for the use of high quality bleached pulps, chlorine dioxide has been introduced in three or four stages bleaching sequence due to the selectivity of the reagent.

The works carried out have been supported by studies on characterization of sugarcane bagasse lignin by Fernandez. The methodology used is based on the experiment designs by Bacon and Henson. With a minimum of experience we were able to find the proper empirical models to characterize the processes efficiently.

**EXPERIMENTAL PROCEDURE**

To perform this work, some soda and sulphate chemical pulps of different delignification degrees and high yield pulps (mechanical and mechanical type) were used.

In all the experiments performed, the necessary quantity of pulps was taken (d.b.) and it was preheated at the working temperature in a thermostatic bath.

The bleaching liquor was prepared according to the methodology of each stage, as is described in 3-4, and was further mixed with the pulp. Finally, the physical-mechanical, chemical and optical properties were evaluated to characterize the bleached pulps.

The fundamental analysis techniques used were as follows:

Determination of the number of Permanganate (Tappi 214-M-50), viscosity (Tappi 230-M-50), brightness (Scan C 11-62), and number of color reversion (Scan),
RESULTS

All the work performed have been planned and the results were analyzed by means of statistical designs techniques of experiments according to Bacon and Henson\(^1\). The results have been processed by programs of multi-variable linear regression, obtaining in most cases, mathematical models which correspond to the behavior of the answers as a function of the independent variables.

In the case of high yield pulp brightening, the following responses were analyzed: final brightness, increase in brightness, post-color number, bleaching yield, retention times in each stage as well as the resistance and chemical properties of the pulps.

For the studies of chemical pulp bleaching, the responses mentioned above were analyzed, but given the degradation in this type of process, some other variables such as the decrease of pulp viscosity, bleaching efficiency and degradation index were also studied.

Chemical Pulp Bleaching

The best results obtained through the work performed regarding the multi-stage bleaching of bagasse chemical pulps are shown in Table 1.

<table>
<thead>
<tr>
<th>Property</th>
<th>Sequence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CED</td>
</tr>
<tr>
<td>Freeness (°SR)</td>
<td>23.0</td>
</tr>
<tr>
<td>Brightness (Elrepto)</td>
<td>85.6</td>
</tr>
<tr>
<td>Absorption Coefficient (cm(^2)/g)</td>
<td>2.9</td>
</tr>
<tr>
<td>Bleachability Number</td>
<td>47.7</td>
</tr>
<tr>
<td>Post Color Number</td>
<td>1.3</td>
</tr>
<tr>
<td>Viscosity (Cp)</td>
<td>27</td>
</tr>
<tr>
<td>Tear Factor</td>
<td>78</td>
</tr>
<tr>
<td>Breaking length (m)</td>
<td>–</td>
</tr>
<tr>
<td>Retention Time (Hr)</td>
<td>5-6</td>
</tr>
<tr>
<td>Cellulose (%)</td>
<td>–</td>
</tr>
<tr>
<td>Pentosan (%)</td>
<td>–</td>
</tr>
</tbody>
</table>

Through the comparative analysis, we can realize which are the most technologically suitable sequences for the production of good quality bagasse chemical pulps.
CEH and CED Sequences

In the study of the sequences it was shown that in both cases, the fundamental variable was the total coefficient of the chlorine, which had a marked influence upon the brightness and the final viscosity.

We should point out the following aspects in the analysis of these sequences: the brightness results (86 Elrepto) were similar in both cases and the improvement in the physical properties of the bleached pulps with CED sequence was obvious as a result of a greater value of the Tear Factor (78 units) and final viscosity (27 cp). This is logical provided the bleaching stage with chlorine dioxide is more selective than that of hypochlorite.

Generally, it is observed that the chemical requirements in this sequence are fewer than the requirements for a similar wood pulp bleaching.

For both sequences, the best results in resistance properties were obtained when a high percent of chlorine distribution was used. Besides, a high pH in the hypochlorite stage is also needed in using the CEH scheme.

CEHD and CEDH Sequences

These sequences were studied in order to achieve higher brightness levels without affecting the properties of the bleached pulps.

In these cases the brightness level for both was similar (88 Elrepto). There was a slight increase in viscosity, Tear Factor and Breaking Length in pulps with CEDH sequence.

On the other hand, it was found that even if the product consumption is increased for CEDH bleaching the levels of application are lower than those required to achieve a similar brightness level of the wood pulp bleaching.

O/A CED Sequence

The utilization of oxygen in the multistage bleaching processes had a significant importance provided that (according to Gajdos and Eachus) the O/A bleaching is one of the most accepted process by contemporary researchers. In fact, some factories have begun using it.

Hence, we have dedicated great efforts to define the possibilities of using this chemical agent in the bagasse pulp bleaching. It has not been easy. Bagasse is a short fiber raw material which is susceptible to degradation before energetic chemical agents.

Our first experience have led us to determine the optimum Kappa number to define the fundamental variables, as well as the most suitable working levels in the O/Z stage.
After the optimal conditions in the oxygen stage were defined, this studies on multistages began with mainly O/Z CDEH and CDED, since the semi-bleached pulp for paper was of high quality, although comparatively, the obtained brightness (53 Elreptto) and viscosity (25-30 Cp) were highly satisfactory when oxygen is used.

The results for the multi-stage bleaching using O/Z showed that the chlorine percentage was also the variable of highest incidence in the quality of the pulp.

It must be said that with this process, the chemical reagent obtained decreases by 50% of the process applied in a conventional bleaching scheme.

As presented in Table 1, the bleached pulp quality with the sequence O/A CDED was slightly higher if compared with the conventional schemes in four stages. This work could show advantages in the bleaching process with oxygen application for bagasse chemical pulps.

High Yield Pulp Brightness

The results of bagasse pulp brightness, using different oxidant and/or reducers reagents are shown in Table 2.

First, we will analyze how chemi-mechanical pulps behave when different brightener agents were used.

TABLE 2. Properties obtained for brightened high yield pulps

<table>
<thead>
<tr>
<th>Property</th>
<th>Brightness (Elreptto)</th>
<th>Opacity (%)</th>
<th>Post Color Number</th>
<th>Burst Factor</th>
<th>Breaking Length</th>
<th>Retention Time (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemi-Mechanical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PEROXIDE</td>
<td>57-62</td>
<td>93-95</td>
<td>1-2</td>
<td>34-36</td>
<td>1,800-2,100</td>
<td>2-3</td>
</tr>
<tr>
<td>HYDROSULPHITE</td>
<td>58-60</td>
<td>94-96</td>
<td>3-4</td>
<td>33-35</td>
<td>2,000-2,200</td>
<td>0.5-1.0</td>
</tr>
<tr>
<td>PEROXIDE-HYDRO</td>
<td>65-67</td>
<td>93-95</td>
<td>1-2</td>
<td>33-35</td>
<td>1,800-2,000</td>
<td>2.5-3.5</td>
</tr>
<tr>
<td>SULPHITE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HYPOCHLORITE</td>
<td>55-57</td>
<td>93-95</td>
<td>14-20</td>
<td>34-36</td>
<td>1,900-2,100</td>
<td>1-2</td>
</tr>
<tr>
<td>Mechanical pulp:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PEROXIDE</td>
<td>58-60</td>
<td>94-96</td>
<td>2-3</td>
<td>15-37</td>
<td>1,400-1,600</td>
<td>1.5-2</td>
</tr>
<tr>
<td>HYDROSULPHITE</td>
<td>60-62</td>
<td>95-96</td>
<td>3-4</td>
<td>15-17</td>
<td>1,300-1,500</td>
<td>0.5-1.0</td>
</tr>
<tr>
<td>PEROXIDE-HYDRO</td>
<td>65-67</td>
<td>93-95</td>
<td>3-4</td>
<td>15-17</td>
<td>1,400-1,600</td>
<td>1-2</td>
</tr>
<tr>
<td>SULPHITE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Hydrogen Peroxide

The hydrogen peroxide consumption is the most incident variable on brightness increase once the other parameters in this process are kept in the conventional working levels.
TABLE 3. Ranges applied for chemical pulp Bleaching

<table>
<thead>
<tr>
<th>Chlorination</th>
<th>Alkaline Extraction</th>
<th>Hypochlorination</th>
<th>Chlorine dioxide</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumption %</td>
<td>1.3 - 3.3</td>
<td>1 - 2</td>
<td>0.6 - 2.0</td>
</tr>
<tr>
<td>Consistency %</td>
<td>2.5 - 3.0</td>
<td>10 - 12</td>
<td>10 - 12</td>
</tr>
<tr>
<td>Temperature (°C) Ambient</td>
<td>60</td>
<td>40</td>
<td>50 - 70</td>
</tr>
<tr>
<td>pH</td>
<td>3 - 3</td>
<td>11 - 12</td>
<td>9 - 12</td>
</tr>
<tr>
<td>Time (min)</td>
<td>40 - 60</td>
<td>60 - 120</td>
<td>100 - 120</td>
</tr>
</tbody>
</table>

Alkalinity and temperature inside on the retention time needed to achieve a determined brightness level.

Hydrogen peroxide consumption in the study increased brightness linearly so an increase of 10-15 units at this stage was obtained. This guaranteed an acceptable final brightness (57-62 Elreptto) for newsprint from bagasse chemi-mechanical pulps in no more than three hours.

The post color number (Tappi method) was kept between units 1-2.

Sodium Hydrosulphite

We have emphasized the temperature influence, chemical consumption and pH.

The results have shown that temperature between 70 and 80°C, a low consumption of hydrosulphite and pH 5.5 increased brightness by 10 units with about 45 minutes retention time.

In Fig. 1 the pH and temperature effect upon brightness increase has been plotted.

In the above mentioned figure, we have verified the optimum conditions for bleaching with hydrosulphite. The color reversion number was comparatively higher (3-4 units) than that expected in bleaching with H₂O₂.

Peroxide Hydrosulphite

This two stage bleaching sequence was mainly used to achieve a significant brightness increase (18-20 Elreptto). A final brightness of 65-67 units (Elreptto) was reported.

The fundamental variables of this process were percentage hydrogen peroxide applied to the 1st stage and temperature in the hydrosulphite stage.
One of the particularities of this brightening scheme is given by the low post color number observed in these pulps, (1-2 units) (Tappi method).

**FIGURE 1.** Brightness vs. temperature at different pH using sodium dithionite

**FIGURE 2.** Brightness vs. hypochlorite percent at different pH.
Sodium Hypochlorite

This bleaching sequence on a stage was studied to achieve similar increments to those reported on hydrosulphite provided that the hypochlorite is a cheap reagent and is produced locally.

In this case, it was verified that the higher brightness increments were obtained when pH and the consumption were both kept between 10-12, respectively.

The consumption and pH effect upon brightness increase are both reflected in Fig. 2, where it is observed that both variables were highly interacting.

Although brightness increase using hypochlorite in a stage is suitable for the newsprint production, in this case, the brightness reversion was a serious problem. This has been shown after performing the dried and wet color reversion tests, because for both methods, the bleaching effect can be revoked by aging.

Mechanical Pulp Brightening

The scheme mentioned above for chemi-mechanical pulp brightening were applied to the mechanical pulp. The results were very satisfactory for this type of pulp (Table 4).

Generally, a little disadvantage regarding chemi-mechanical pulp was related to the brightness reversion which was slightly higher for the mechanical pulp in all cases.

TABLE 4. Ranks applied for high yield pulp brightening

<table>
<thead>
<tr>
<th></th>
<th>Peroxide</th>
<th>Hydrosulphite</th>
<th>Hypochlorite</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumption (%)</td>
<td>0.8–1.5</td>
<td>0.5–1.5</td>
<td>10–12</td>
</tr>
<tr>
<td>Consistency (%)</td>
<td>10–12</td>
<td>3–5</td>
<td>10–12</td>
</tr>
<tr>
<td>Temperature (°C)</td>
<td>60–70</td>
<td>70–80</td>
<td>40</td>
</tr>
<tr>
<td>pH</td>
<td>10–12</td>
<td>5–6.5</td>
<td>10–12</td>
</tr>
</tbody>
</table>

CONCLUSIONS

The investigations carried out over years have shown that bagasse pulps either for newsprint or high quality paper production, are bleached satisfactorily using any of the schemes discussed in this paper, without difficulties.

In the production of high quality papers, there are some alternatives, distinguished by the quality of chlorine dioxide application in three and four stages, mainly due to its high viscosity and tear factor.
In the present stage, the utilization of oxygen is a very important achievement as chemical bleaching stage which has been satisfactorily applied to the bagasse chemical pulp, thus, obtaining comparative values to some other conventional schemes, regarding the optical and resistance properties and decreasing the environmental pollution problems and the chemical reagent demands in the following bleaching stages by 40-50 percent.

In addition to this, the post color number reversion reported for these pulps was 1.5-2 units so it can be assured that they are very steady with aging and that chemically, its composition corresponds with that found for raw pulps.

Regarding pulp brightness for newsprint production, the results are specially advantageous when hydrogen peroxide is used, not only because the brightness increase which allows to obtain a 58-60 pulp (Elrepto) but also because of the color stability with age.

In this sense, the hydrosulphite is also a very suitable option by means of which a final brightness of about 56-58 (Elrepto) is obtained. Brightened pulps however, are relatively nonsteady with hydrogen peroxide.

Through the combination of both stages, we can obtain a chemi-mechanic pulp with a 66-68 final brightness Elrepto, which means an answer to the paper demand when brightness is not a fundamental factor but the printing properties are an important aspect of this type of pulp.

Finally, it has been shown that the hypochlorite is not a satisfactory variant for bagasse brightening schemes due to the marked brightness reversion it suffers with aging.

Besides, these results may be extrapolated to mechanic pulp although we must make it clear that these superficial schemes do not alter the resistant properties which are kept after bleaching.

REFERENCES


4. (1972). Caracterizacion de la Lignin de Bagazo. Trabajo
EXPERIENCIAS EN EL BLANQUEAMIENTO DE PULPAS DE BAGAZO

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RESUMEN

Este estudio muestra una vista panorámica de las investigaciones realizadas en el Instituto de Pesquesas de Subproductos de la Caña de Azúcar de Cuba, (ICIDCA) durante la última década, para producir diferentes calidades de pulpás de bagazo.

El blanqueamiento de alto rendimiento fue estudiado peroxido de hidrogeno hidrosulfato y hypoclorito de sodio en etapas unicas combinadas.

Fue estudiada la secuencia de blanqueamiento en pulpás químicas usando clorito y sus derivados, dando enfasis al uso del dioxido de cloro debido a su accion selectiva.

El uso de coeficientes variables definidos en este trabajo, permite calcular el consumo total de cloro en funcion del grado de “delignificación” de la pulpa.

Además, nuevas tecnologías fueron estudiadas, siendo la mas importante, la aplicación de oxígeno/álcali como etapa presica al multi-estado.

La posibilidad de usar el bagaso con este proposito en un eficiente metodo es mostrado por los resultados.