PREDICTING CTMP BLEACHABILITY USING WOOD SHAVINGS

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ABSTRACT

To predict the brightness reduction in a chemithermomechanical process as well as the bleachability of pulps produced from different species of wood raw materials there are, at present, no shortcuts available. Pulps have to be manufactured in pilot or mill scale and bleached; evaluating and predicting the bleachability has consequently been very resource consuming and thus expensive – until now!

Due to this, we have used a laboratory method based on 60x60 mm wood shavings making it possible to predict the bleachability of primarily chemithermomechanical pulps but also other mechanical pulps.

Our experiments showed that retention time and impregnation temperature appears to have no impact on the final brightness of birch shavings. When being subjected to a simulated chemithermomechanical pulp process, eucalyptus exhibited an increase in chromophore content before the bleaching stage. In addition, eucalyptus suffered from severe alkaline darkening. After the bleaching stage, the alkaline darkening diminished. A higher retention temperature resulted in lower brightness of the eucalyptus shavings compared to when using a lower retention temperature. Birch reached the highest final brightness levels and had a higher overall yield too.

Keywords: Wood shavings, Bleachability, CTMP, Birch, Eucalyptus.

INTRODUCTION

At present, the only way to gain knowledge of the bleachability and brightness reduction of mechanical and chemithermomechanical pulps (CTMP) along the process chain is to manufacture the pulps in pilot scale or full scale and after this bleaching trials can be performed. When it is necessary to investigate many different wood species in order to optimise chemithermomechanical pulping processes, it becomes very expensive and time-consuming. Information concerning light absorption, light scattering and brightness of native wood can be provided by optical measurements on thin wood sections[1,2]. The method can also be used to study light induced ageing[3], chromophore formation during refining[4], and bleaching kinetics[5]. Since there is no need for extensive sample preparation such as grinding, refining or sample dilution, process dependent effects on the brightness arising from for example mechanical action are eliminated[4,6,7]. Due to the simple experimental setup in laboratory scale, it is easy to cover a large experimental window. In addition, the shavings technique [5] makes it possible to directly measure the optical properties of the wood throughout a simulated process.

Therefore, the shavings technique was chosen for the present investigation to predict bleachability of chemithermomechanical pulps. Efforts were also made to evaluate the possibilities of using the initial brightness of the wood raw material as an indicator of the bleachability.

EXPERIMENTAL

Materials

The wood used in these experiments was sapwood from birch (*Betula verrucosa*) and eucalyptus (*Eucalyptus globulus*). The samples were stored at -18°C until thin shavings were prepared by using a Leica SM2000R microtome (Leica Microsystems, Wetzla, Germany). The size of the wood samples used in the preparation of the shavings was 4 x 6 x 6 cm. The shavings were cut radially to obtain a mix of both earlywood and latewood (see **Fig. 1**), thus achieving samples more representative to a pulp. The thickness of the birch shavings was approximately 70 μm with a grammage of 34-37 g/m^2. (As comparison it should be mentioned that conventional newsprint has a thickness of about 60 μm at 45 g/m2). In order to obtain intact shavings from the eucalyptus which is an extremely hard wood species, the wood sample was boiled in water for ten minutes prior to cutting. The thickness of the eucalyptus shavings was approximately 100 μm with a grammage of 82-104 g/m^2. After cutting, the shavings were dried in airflow at room temperature, and then stored at +8°C until used in the simulated CTMP process.

Fig. 1. Untreated (native) and bleached shavings of birch and eucalyptus respectively.

The heat-treatment equipment was comprised of a double-mantled stainless steel vessel pressurized with steam (see **Fig. 2**). The mantle was preheated to 100°C to ensure that the desired process temperature, 170°C, was reached within a few seconds. After steam treatment, cooling water was led thought the mantle to quickly cool the vessel to room temperature without wetting the shavings. The samples were taken out of the vessel within 30 seconds after the heat treatment was completed.

Earlier, this equipment has been used to optimise pre-treatments of birch CTMP, and to study the formation/elimination of chromophores in wood under mechanical pulping conditions.

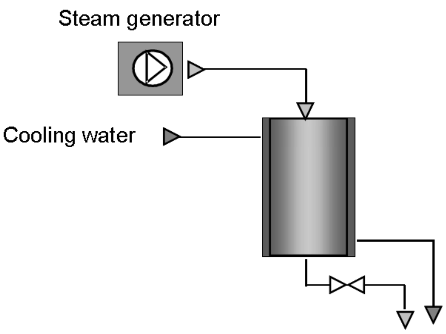

Fig. 2. Schematic picture of the pressurised steel vessel with cooling system. Figure from Reference (5).

Methods

Process

To simulate typical CTMP process conditions, the shavings were treated according to the following procedure:

- “washing” for 15 minutes at 70°C
- removal of washing water
- “presteaming” for 10 minutes at ~100°C
- “impregnation” with sodium hydroxide and sulphite for 1 minute (sulphite was excluded when eucalyptus was used).
- removal of excess fluid
- “retention” for 5/15 minutes at 70/90°C
- “refining” at 170°C for 2-3 seconds
- “washing” for 15 minutes at 70°C
- “drying” in airflow at room temperature

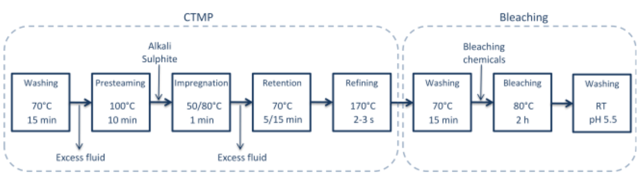

Fig. 3. Schematic picture of the simulated process conditions, which the shavings were subjected to.

Bleaching

All shavings were subjected to the following bleaching conditions. The shavings were put in a plastic bag together with the bleaching chemicals. The chemicals used were sodium hydroxide 30 kg/t, hydrogen peroxide 40 kg/t, DTPA 10 kg/t and silica 20 kg/t. The filled plastic bags were then placed in a water bath for 2 hours at 80°C. When the bleaching was completed the shavings were washed in milli-Q water and the pH was adjusted to 5.5 with sulphuric acid. Finally the shavings were dried in airflow at room temperature.

RESULTS AND DISCUSSION

Birch shavings – influence of impregnation, retention and alkali

Table 1 displays the results for birch shavings when process parameters such as impregnation temperature, alkali charge and retention time are varied. Retention time and impregnation temperature showed to have no significant impact on the measured brightness. As seen in **Table 1**, the higher alkali charge resulted in some (slight) alkaline darkening before bleaching, though, after bleaching, this gave the highest final brightness, which can to some extent be explained by the lower yield of these shavings (due to dissolution of coloured substances) .

Table 1. Impact of impregnation temperature, alkali charge, retention time on brightness and yield of birch.

Impregnation Temp (°C)	Alkali Charge (kg/t)	Retention Temp (°C)	Retention Time (min)	Brihtness (% R457)		Yield (%)
				Before bleaching	After bleaching	
50	10	70	5	40.1	83.5	85
50	10	70	15	39.5	83.7	85
80	10	70	15	39.8	83.6	85
80	20	70	5	38.8	84.6	83

Birch and Eucalyptus shavings – influence of retention temperature and alkali

Conditions: Retention time 15 minutes, impregnation temperature 80°C, retention temperature 70/90°C, alkali charge 10/20 kg/t.

Table 2. Impact of alkali charge and retention temperature on light scattering and light absorption coefficients when simulating the CTMP process.

Wood Species	Alkali Charge (kg/t)	Retention Temp (°C)	Light scattering (R457)		Light absorption (R457)	
			Native	Before bleaching	Native	Before bleaching
Birch	10	70	20.1	18.8	6.6	7.0
Birch	20	70	19.2	18.3	6.9	7.7
Birch	10	90	19.3	18.5	7.4	6.8
Birch	20	90	19.4	18.2	7.2	7.2
Eucalyptus	10	70	14.4	14.5	5.2	7.2
Eucalyptus	20	70	13.3	11.9	5.4	9.7
Eucalyptus	10	90	15.5	13.2	6.4	7.4
Eucalyptus	20	90	15.7	14.2	6.2	10.1

Regarding birch, a minor increase in chromophore content was seen before bleaching when using the lower retention temperature (see **Table 2**). During bleaching, a lot of the chromophores were eliminated, which resulted in an overall decrease in light absorption and thus a higher brightness (see **Fig.4**).

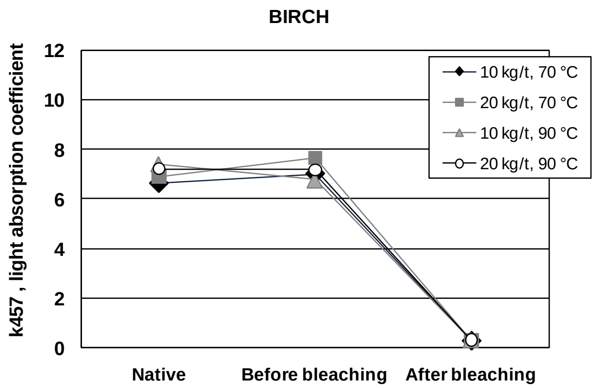

Fig. 4. Influence on light absorption coefficient of birch shavings during simulation of different CTMP process conditions.

When it comes to eucalyptus, the alkali charge has a larger impact on the light absorption and brightness before bleaching. The higher alkali charge resulted in severe alkaline darkening, which is seen in **Fig. 5** as an increase in light absorption. Altering the retention temperature had no impact on the light absorption.

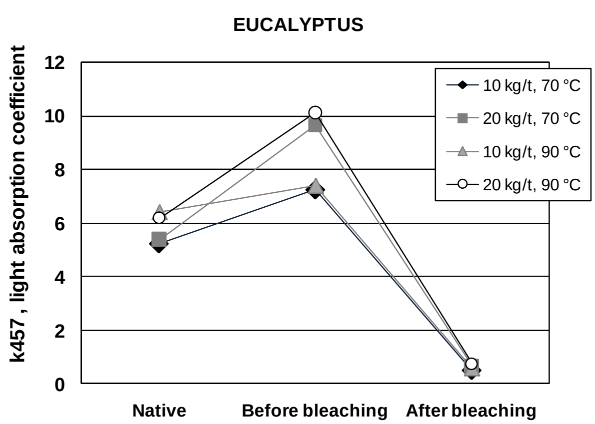

Fig. 5. Influence on light absorption coefficient of eucalyptus shavings during simulation of different CTMP process conditions.

Birch and Eucalyptus shavings – Calculated brightness (R457)

Shavings from birch and eucalyptus were subjected to the same simulated CTMP process with the exception that no sodium sulphite was used in the impregnation of the eucalyptus shavings. The amount of sodium hydroxide in the impregnation was 10 or 20 kg/t, and the retention temperatures tested were 70 and 90°C.

Since the light scattering of the wood shavings are low compared to the scattering coefficients in a CTMP pulp, the brightness of the shavings was recalculated to brightness values relevant for printing papers.

k was measured on air dried shavings using an Elrepho 2000 spectrophotometer, and *s* was set to 50 to simulate paper properties. The brightness was recalculated using **Eq. 1.**

$$– \quad – \quad – \qquad (1)$$

As can be seen in **Fig. 6,** increasing the alkali charge led to alkaline darkening both for birch and eucalyptus, but to a significantly larger extent for the eucalyptus. The more prominent alkaline darkening of eucalyptus might be caused of the lack of sulphite in the impregnation, but also the disparity in chemical composition of the two wood raw materials. After bleaching of the shavings, the alkaline darkening was diminished, and in the case of birch, almost vanished.

When increasing the retention temperature the birch shavings showed an increase in brightness level before bleaching, probably due to increased dissolution of organic substances. After bleaching, the brightness was at a similar level for both retention temperatures (see **Fig. 6**). Conversely, eucalyptus exhibits a decrease in brightness when increasing the retention temperature. Moreover, the differences in brightness become somewhat larger after bleaching of the shavings.

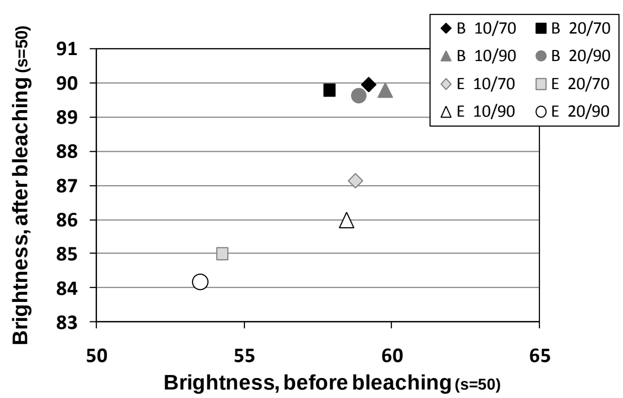

Fig. 6. Impact on brightness, before and after bleaching of birch and eucalyptus shavings, when altering the alkali charge and the retention temperature.

On the whole, all samples reached similar brightness values before bleaching, with the exception of the eucalyptus treated with the higher alkali charge. After bleaching of the shavings, birch was not only brighter, but in addition also reached the highest brightness levels. In addition, birch had a much higher yield (83-86%) compared to eucalyptus (71-76%).

The method with shavings could be used to observe brightness loss when the conditions are varied in the CTMP-process. It can also be used to predict the bleaching potential of different wood species, after these treatments. Since some species have very different morphological and chemical compositions both between trees and within a tree, it may be hard to get precise forecasts of their response to chemical treatments.

Using shavings, it is possible to predict the response to chemical treatments and the bleaching potential of a certain wood raw material. The study should be performed at wood material with known age, harvesting time etc. It is not possible to use shavings if the wood raw material consists of chips with varying age, varying harvesting times and varying harvesting sites.

CONCLUSIONS

After being subjected to the simulated CTMP process, eucalyptus displayed an apparent increase in chromophore content. Moreover, eucalyptus suffered from severe alkaline darkening when using the higher alkali charge.

Employment of calculated brightness values established alkaline darkening for both birch and eucalyptus shavings when increasing the alkali charge. After bleaching of the shavings, the alkaline darkening was diminished, and in the case of birch, almost vanished. Retention temperature has little or no impact on the final brightness. As to birch, impregnation temperature and retention time have no impact on the measured brightness. Birch shavings have a higher overall yield and reached the highest final brightness levels compared to the eucalyptus shavings.

Using this technique with shavings, it is possible to study and predict the potential of a known homogen wood raw material

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