# Influence of water conductivity on the drainability of Eucalyptus bleached Kraft pulp

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# Influence of water conductivity on the drainability of *Eucalyptus* bleached Kraft pulp

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The drainage capacity of cellulose pulps is an indicator of the surface conditions of the fibers, as well a measurable efficiency index of a refining process. The drainability depends on the refining process and the water quality. Temperature, pH and conductivity of water influence the drainability by affecting fiber and fines swelling; bleached chemical pulps are more sensitive to these variations. According to ISO 5267-2, the Canadian Standard Freeness (CSF) method provides a measure of the rate at which an aqueous suspension of pulp may be drained using deionized water, in a similar manner to the determination of the Schopper-Riegler grade (SR°). As different studies show, the variation in freeness of pulps is higher at conductivities near to zero than at higher conductivities. The objective of this study was to verify this behavior in Uruguayan pulps and to establish the conductivity values where the freeness stabilizes. This work examines the performance of the CSF and the SR° while the conductivity of a dilute suspension of pulp varies. The sample used is a *Eucalyptus* reference pulp, which is a Kraft bleached pulp. The conductivity was changed by adding different amounts of Magnesium Sulfate to deionized water in the suspensions. As expected, the results show a remarkable increase on the drainability values while the conductivity rises until a maximum value where it remains almost constant, despite the uprising in the conductivity. This study may be indicating the convenience of a modified CSF and SR method with high water conductivity where the variations are minimized.

*Keywords: Canadian Standard Freeness, Schopper-Riegler, conductivity, Eucalyptus Kraft bleached pulp.*

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## INTRODUCTION

The typical characterization of pulps involves measuring the freeness or drainage capacity (or resistance) of cellulose pulps. The traditional methods to determine this property are the Canadian Standard Freeness (CSF) and Schopper-Riegler (SR), both having the same measurement principle (Hiltunen, 2000). The compressibility or compactness, the stiffness and partial density of the fibers suspended in the water are indirectly measured by these tests. Fibers subjected to beating are defibrillated and the fiber wall is plasticized, thus, the net or gel-filter cake of fibers dewaters less than unbeaten fibers (Sixta, 2006).

The temperature, pH, electrolyte content and hardness of the water are known to affect the measurement by affecting fiber and fines swelling (Hiltunen, 2000).

Therefore, the ISO standard for the CSF (ISO 5267-2) and SR (ISO 5267-1) require deionized or distilled water to avoid the influence of these factors. However, it is also well known that the instability in the determination due to low conductivity can be prevented by using water of a higher conductivity. Nevertheless, the behavior of the freeness varies depending on the raw material and process to fabricate the pulp (Huiren et al, 1993; Dienes et al, 2005).

In this work, we used this knowledge to establish the corresponding behavior of the freeness *versus* conductivity, in pulps made in Uruguay with *Eucalyptus* raw material.

## EXPERIMENTAL

### Materials

The sample used is a Uruguayan Eucalyptus reference pulp, which is a Kraft ECF-bleached pulp.

### Methods

Different Magnesium Sulfate ($MgSO_47H_2O$) solutions were prepared using deionized water and different quantities of the mentioned salt. Several concentration levels were prepared, in order to obtain different conductivities in each solution, covering a range from near 0 up to 4000µS/cm, according to SCAN-CM 68:05. Portions of pulp, corresponding to 30g of oven-dry matter were torn and then soaked during at least 4 hours in each magnesium sulfate solution previously mentioned. After that, they were disintegrated at 30000 revolutions according to ISO 5263-1 (Laboratory wet disintegration- Part 1: Disintegration of chemical pulps), using always each prepared water. Then suspensions of pulp with different conductivities were obtained and diluted to 10L. Samples for CSF determinations were taken from these final suspensions, considering the appropriate Temperature conditions required in ISO 5267-2 (Determination of drainability- Part 2:"Canadian Standard" freeness method). Figure 1 shows the equipments used.

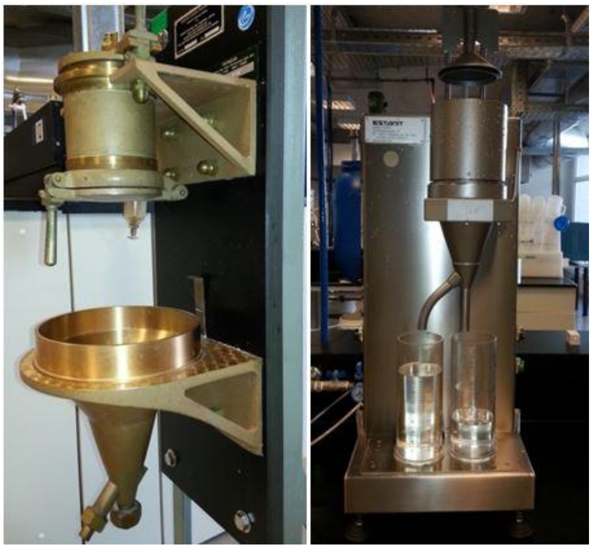

**Figure 1.** Left: Canadian Standard Freeness, Right: Schopper-Riegler

## RESULTS AND DISCUSSION

The figures 2 and 3 show the behavior of the Canadian Standard Freeness while the conductivity increases. In the case of the Figure 1, the plot represents the whole range studied; meanwhile, Figure 2 represents an amplified fragment of the Figure 1 in the range of 0 to 500 uS/cm, when the CSF begins to stabilize.

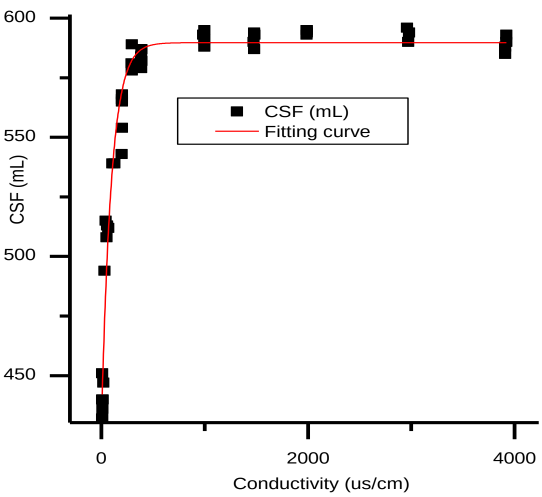


**Figure 2.** Canadian Standard Freeness versus Conductivity, whole range

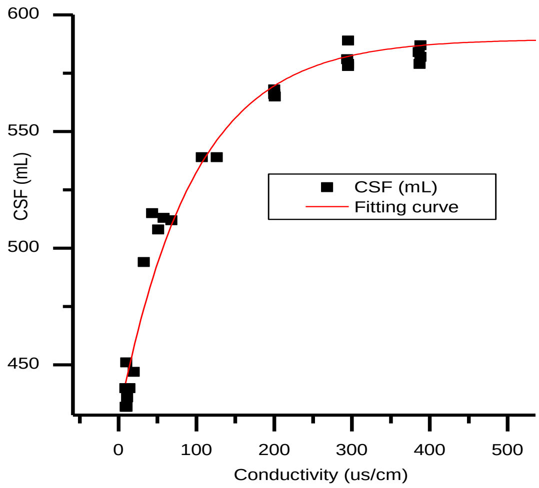


**Figure 3.** Zoom of Figure 2 in the range from 0 to 500 uS/cm in conductivity

The behavior of the CSF clearly shows a rapid increase in the range 0 to 400 uS/cm, which could be modeled as an asymptotic exponential function of the type (Equation 1)

$$y = a - b * c\hat{}x \qquad \text{Equation 1}$$

*y* represents the CSF, *x* is the conductivity and *a* is the maximum value. *b* and *c* represent curve parameters that in the case of the software used are identified as response range and rate, respectively. After fitting, the values obtained are shown in Table 1.

**Table 1.** Parameters of the Conductivity for the Canadian Standard Freeness curve and Schopper-Riegler (according to Equation 1)

| | A | b | c | $R^2$ |
|---|---|---|---|---|
| CSF | 590 | 162 | 0.990 | 0.972 |
| SR | 18,0 | -8.1 | 0.967 | 0.991 |

Another aspect to be noted is the conductivity when using a suspension of deionized water. The conductivity of the deionized water (without magnesium sulfate and without cellulose) was 2.5 uS/cm. After mixing this water with the cellulose, the conductivity raised until 11.30 uS/cm. As shown in the figures, this low conductivity has the bigger impact on the CSF. Using the equation 1, CSF at 2.5 uS/cm should be 432 mL, although the measure is not achievable in the practice; at the conductivity of 11.30 uS/cm the freeness is 445 mL of CSF. Therefore, the measure of CSF at very low conductivities affects the reproducibility of the method. Moreover, cellulosic fibers carry a negative charge that depends in several factors, as raw material, the presence of ionisable acidic groups in the carbohydrates and lignin present, and even the presence of ionic substances absorbed on the fiber due to the industrial process, which make a comparable measure of the CSF in the low range of conductivity not advisable (Banavath *et al.*, 2011). The degree of swelling is neutralized by the ion concentration, and in consequence the CSF value rises (Sixta, 2006).

The optimum conductivity to measure the CSF should be evaluated in terms of the subsequent tests to be applied to the cellulose. E.g., if the pulp is going to be evaluated by making laboratory handsheets, the added salt could be affecting some of the properties. Therefore, a good practice would be to add the minimum amount possible, i.e. where the CSF is stable despite a significant change in the conductivity. For the pulps studied, this value is achieved after 500 uS/cm.

**Schopper-Riegler**

The Schopper-Riegler (SR) behavior was also studied. In this case, as shown in figures 4 and 5, the SR stabilizes approximately at 150 uS/cm, a much lower conductivity value than CSF. Applying the same fitting as equation 1, the parameters obtained are shown in Table 1 (obviously, the °SR decreases when the conductivity is increased, explaining the negative value of the *b* parameter). The value of SR stabilization is concordant with the studies made by Huiren *et al.* (1993).

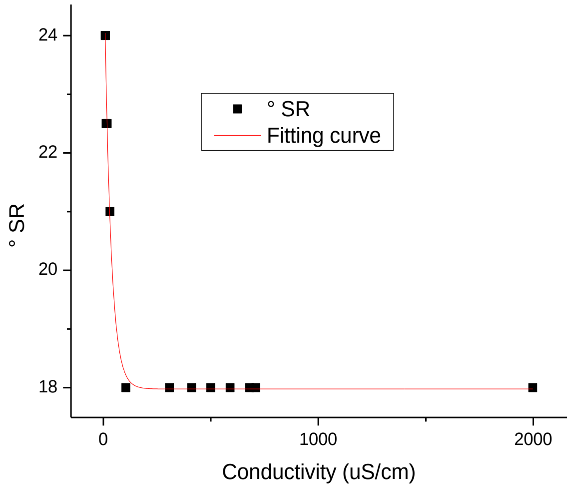


**Figure 4.** Schopper Riegler versus Conductivity, whole range

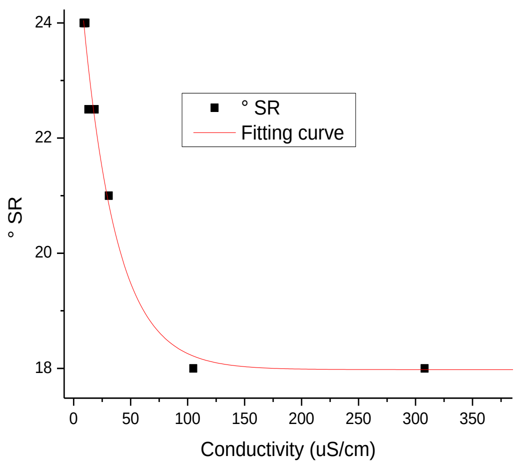


**Figure 5** Zoom of Figure 3 in the range from 0 to 350 uS/cm in conductivity

There are a number of possible explanations for this differential behavior compared to the CSF that should be investigated in further studies. Although nowadays it is widely used for the control of chemical pulps, the CSF was developed for the control of groundwood pulp and there might be some false freeness values with the presence of fines (Tappi 227, 1999). In consequence, an explanation could be found by the presence of more fines retained in the SR wire screen, which has a lower pore diameter compared to the CSF wire screen. Besides, the CSF has 3 grams of pulp in the liter used to do the test, in comparison with the 2 grams in the case of the SR. The higher amount of pulp could be more affected by the electrolytes found in the suspension, affecting in turn the swelling of the fibers. An interesting discussion can be found in the work made by Swodzinski and Doshi (1986). Nevertheless, the freeness *versus* the conductivity at different refining levels could also give some valuable information.

Finally, the experience in our laboratory after controlling the CSF and SR tests under high conductivity (around 600 µS/cm) resulted in a calculated uncertainty of 5 % in the determinations. Meanwhile, a calculated uncertainty in the determinations under low conductivity measurements would result in an error close to 10 %, due to the inherent variability in the cellulose pulp, equipment and operators *plus* variability due to small oscillations in the conductivity of the water. Therefore, this duplication in the uncertainty of the determination could be avoided by using high conductivity water.

## CONCLUSIONS

1. The amount of salt, and therefore the amount of electrolytes in water affect the freeness test significantly.
2. The freeness of the pulp studied (hardwood ECF-bleached Kraft pulp) stabilizes after a conductivity value where it remains constant.
3. The CSF is more sensible to the conductivity variation than the SR; the point of stabilization in the case of the CSF is 500 uS/cm, while in the case of the SR is around 150 uS/cm.

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