Research and Innovation in the Pulp and Paper Chain

Past Experience , New Directions

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CELPA, Associação da Indústria Papeleira

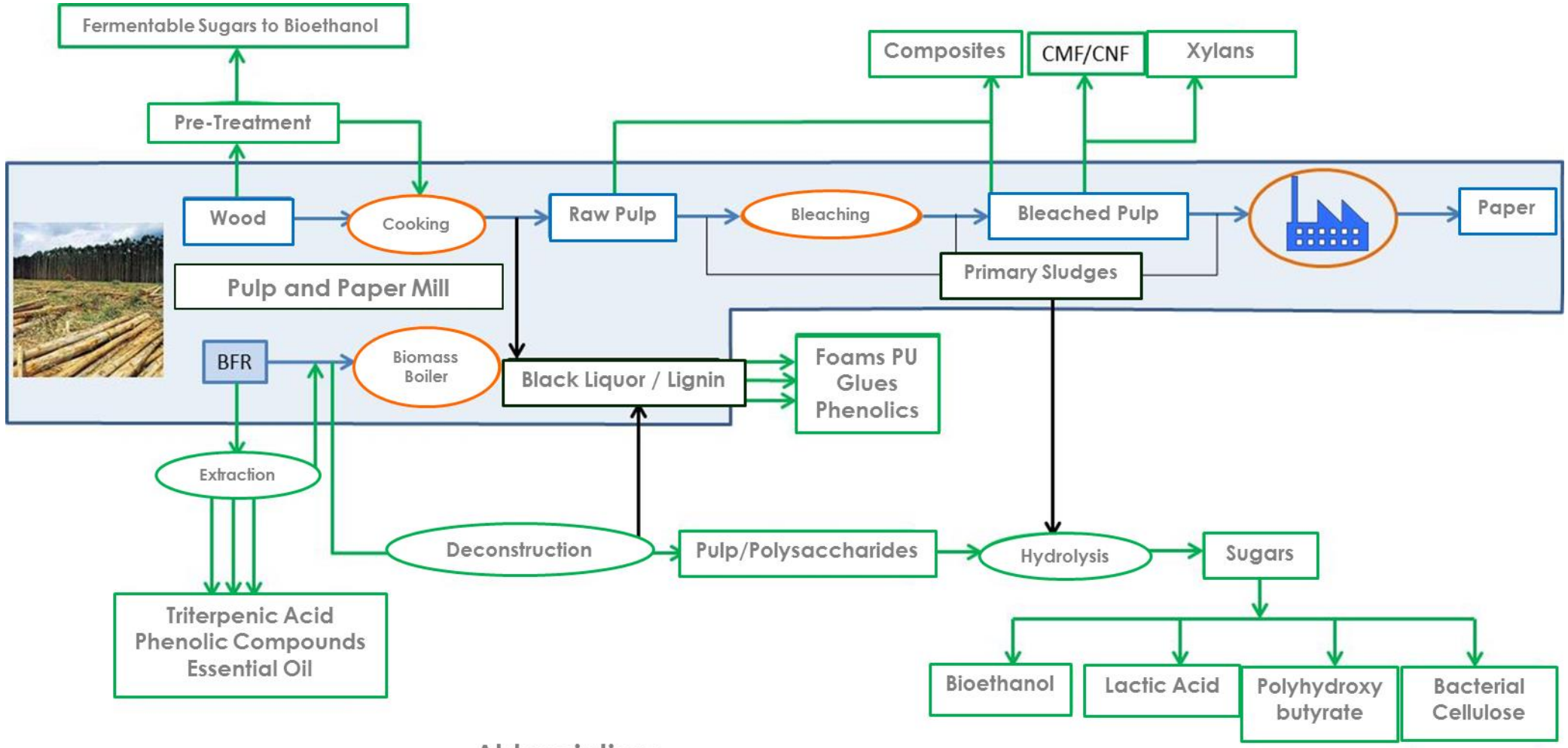
ISA, 26 January 2017

CELPA

- Caima Pulp Mill 1926
- 1958 Cacia Pulp Mill
- Socel Pulp Mill 1964
- 1967 Celbi Pulp Mill
- Inapa Indústria Nacional de Papéis, Paper Mill 1969
- 1984 Soporcel Pulp Mill
- Soporcel Paper Mill 1991
- **1996** **RAIZ -** Research Institute
  - Aveiro University
  - Beira Interior University
  - Coimbra University

Deep, well fundamented, sistematic and organized knowledge about specific morfologic and chemical caracteristics of the Eucalyptus Globulus wood and related impact on its Kraft cooking and bleaching processes as well as on the unique papermaking potential of this fiber.

Pulp and Paper Production Process and Research Lines in Biorefinery Processes / Products



Abbreviations

CMF/CNF - Micro / Nano fibrillated Cellulose

BFR - Residual Forest Biomass

Advanced Knowledge of the Chemical Constitution and Industrial Performance of *E. globulus* Wood

What have we learned?

Wood components chemical structure influence their performance during the Kraft cooking and bleaching, from a comparative perspective with other species of Eucalyptus as well as other hardwoods

- Chemical composition of *E. globulus* wood, in lignin, cellulose and hemicelluloses fractions, contributes to a higher Kraft cooking yield
- The particular *E. globulus* xylans (main hemicellulose constituent), chemical structure explains its greater stability and retention observed during the Kraft cooking process
- The *E. globulus* morphological structure, with a moderate vessel quantity and diameter, also contributes for its good cooking performance

Advanced Knowledge of the Chemical Constitution and Industrial Performance of *E. globulus* Wood

What have we learned?

Cooking conditions impact on the chemical characteristics of *E. globulus* Kraft pulps. Different cooking strategies and alternatives, allowing a selective delignification, were tested for polysaccharides retention increase during the production of *E. globulus* Kraft pulp.

- Effective alkaline concentration at the maximum temperature has an impact on the total cooking yield (1-2%)
- The addition of anthraquinone also proved to benefit the yield (2%) through a greater xylans preservation. Other cooking additives were tested.
- An early interruption of the Kraft cooking (at the end of the main phase) and a subsequent delignification with O_2 is an attractive strategy for increasing polysaccharides in the *E. globulus* fiber

Advanced Knowledge of the Chemical Constitution and Industrial Performance of *E. globulus* Wood

What have we learned?

ECF (elemental chlorine free) bleaching of *E. globulus* Kraft pulp and sequence optimization

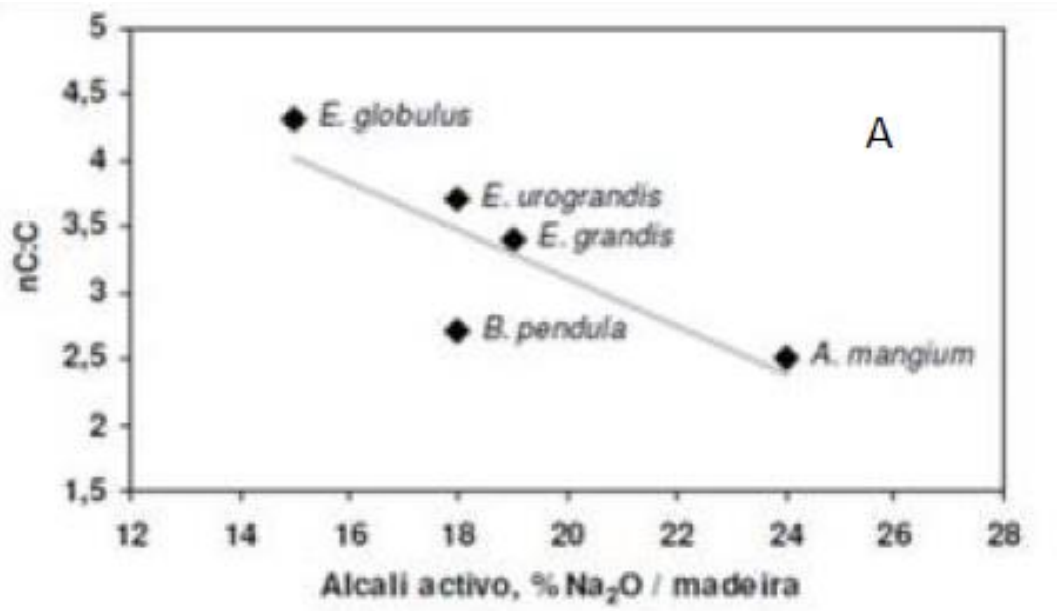
- Kinetic and estequiometric studies for each bleaching stage, pH and temperature impact, and role of the D0 stage for final delignification (microkappa) were deeply addressed.

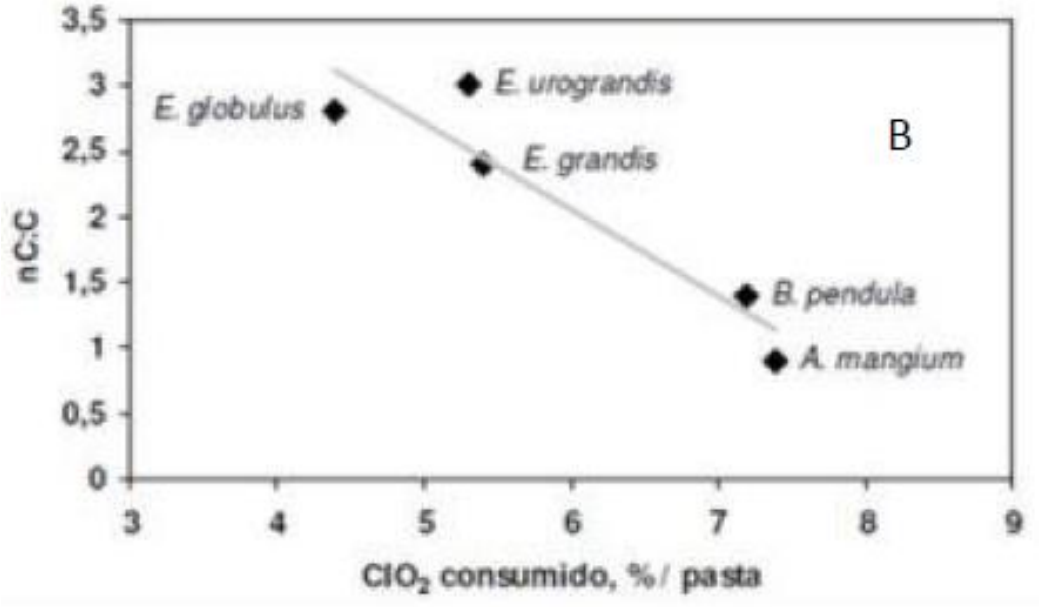
- At the stages D1 and D2 the chromophores are removed, the pulp bleaching is promoted to the desired degree of whiteness and its subsequent reversion by temperature, humidity and time is minimized.

- The influence of the chlorine dioxide charge distribution between the two stages of bleaching (D1 and D2) was studied, and the best distribution was identified to minimize the oxidant consumption at these two stages, ensuring the best whiteness development.

Advanced Knowledge of the Chemical Constitution and Industrial Performance of *E. globulus* Wood

What have we learned?





Relative ratio of non-condensed structures / condensed structures (nC: C) in the wood lignin and Kraft pulps, and cooking ability (A) and beaching (B), respectively

Further developments to improve yield, reduce environmental impacts, costs, preserve fibers and enhance papermaking potential

Modified Kraft Cooking

"<u>Lo-solids" and "compact" cookings with positive results due to:</u>

- The increase of the liquor to wood ratio with the consequent reduction of the alkalinity profile

- The increase of the digester capacity with the consequent increase of the cooking time

- The lowering and uniformity of the temperature and / or alkali profile, resulting in a less aggressive cooking

Further developments to improve yield, reduce environmental impacts, costs, preserve fibers and enhance papermaking potential

New ECF Sequences

- The application of several modified ECF sequences to *E. globulus* (acid pre-stage, *Dhot*, use of formic acid post D0, hydrogen peroxide in partial substitution of chlorine dioxide) has been studied

- The use of enzymes in bleaching has been lately considered, and is still ongoing

Why is E. Globulus fiber superb for Paper Making?

New quality criteria based on two parameters

- **The number of fibers per mass unit, impacting the paper structure/formation, surface regularity, smoothness and opacity**

- **A second parameter based on the cell walls thickness, and its relation with the fibers cross-section**

  - Compressibility
  - Drainability
  - Drying
  - Bulk, stiffness
  - Compressibility in printing

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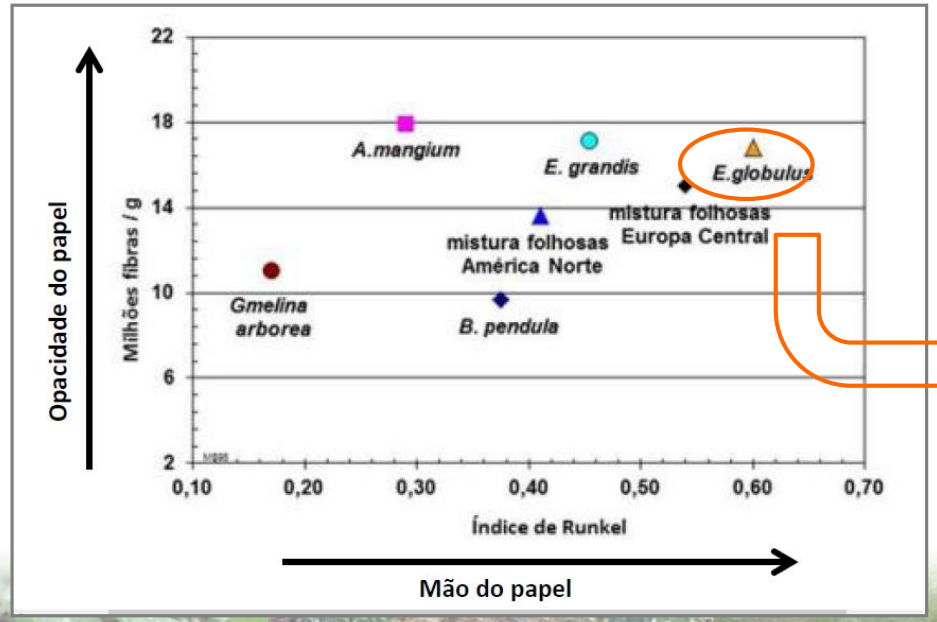
Fibre Stiffness

- Ratio of fiber width to cell wall thickness (Runkel coefficient)
- Hemicellulose content
  - Raw material (wood)
  - Technology

Well-developed cooking and bleaching technologies

Improved rigidity, bonding and dimensional stability

A new short fibers quality factor was developed

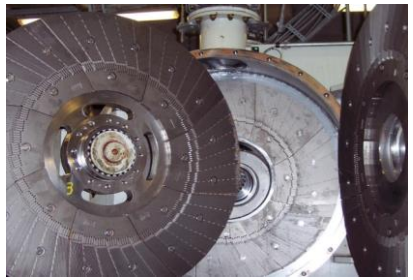


When applied to different hardwoods, allows evaluating their relative position on their papermaking ability to produce fine paper

Advantages of using this pulp in the production of fine paper, even when compared with other species of eucalyptus

What Was Learned and Done for Treating the *E. globulus* Fiber in Order to Enhance Paper Properties and to Prevent it´s Deterioration

Mechanical Pulp Refining



- The *E. globulus* species, with an adequate relationship between the fiber cross-sectional dimensions (wall thickness versus fiber diameter - Runkel Coefficient), exemplarily accepts the mechanical treatment effort of refining to adequate levels of mechanical strength without major loss of the bulk when comparing with other species congeners of Eucalyptus and even of other hardwoods

- Lab and mill-scale refining trials, testing different geometry of refiner discs, cutting lengh, specific edge load (refining intensity, W.s/m), net refining energy (Kwh/t), refiners load repartition, refiners lines set-up, inlet pressure and consistency, variable refining speed, etc.

What Was Learned and Done for Treating the *E. globulus* Fiber in Order to Enhance Paper Properties and to Prevent it´s Deterioration

Enzymatic Pre-treatment of Pulp for Refining

Possibility for energy consumption optimization through the pulp pre-treatment with enzymes

The results:

- ✓ 20 – 25 % reduction in Total Refining Power Consumption
- ✓ Less compact sheet structure, higher bulk
- ✓ Improvement in drainability, lower °SR

Study of ink-paper interactions in printing processes, inkjet, offset and digital

Goals and methodology

- Understanding ink-paper interactions
- Identification of major technical quality parameters
- Influence on subjective print quality
- Evaluation model development for other printing techniques

Paper samples:
- Different types

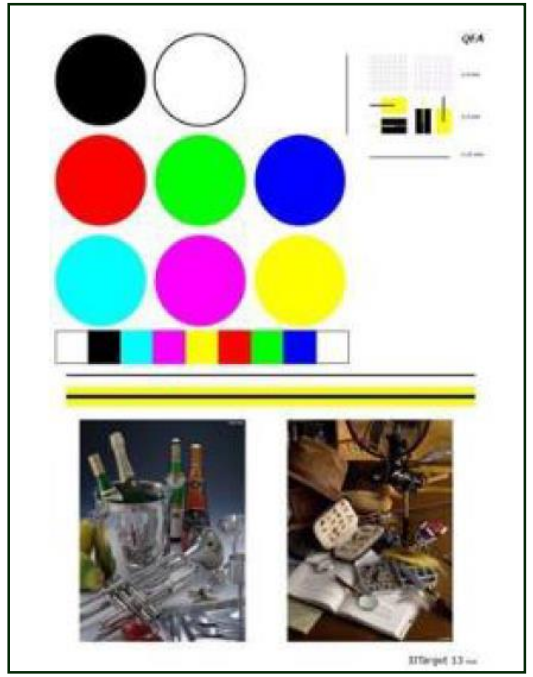
+

Printers on the market:
- Different ink type technologies
- Injection volumes and frequencies

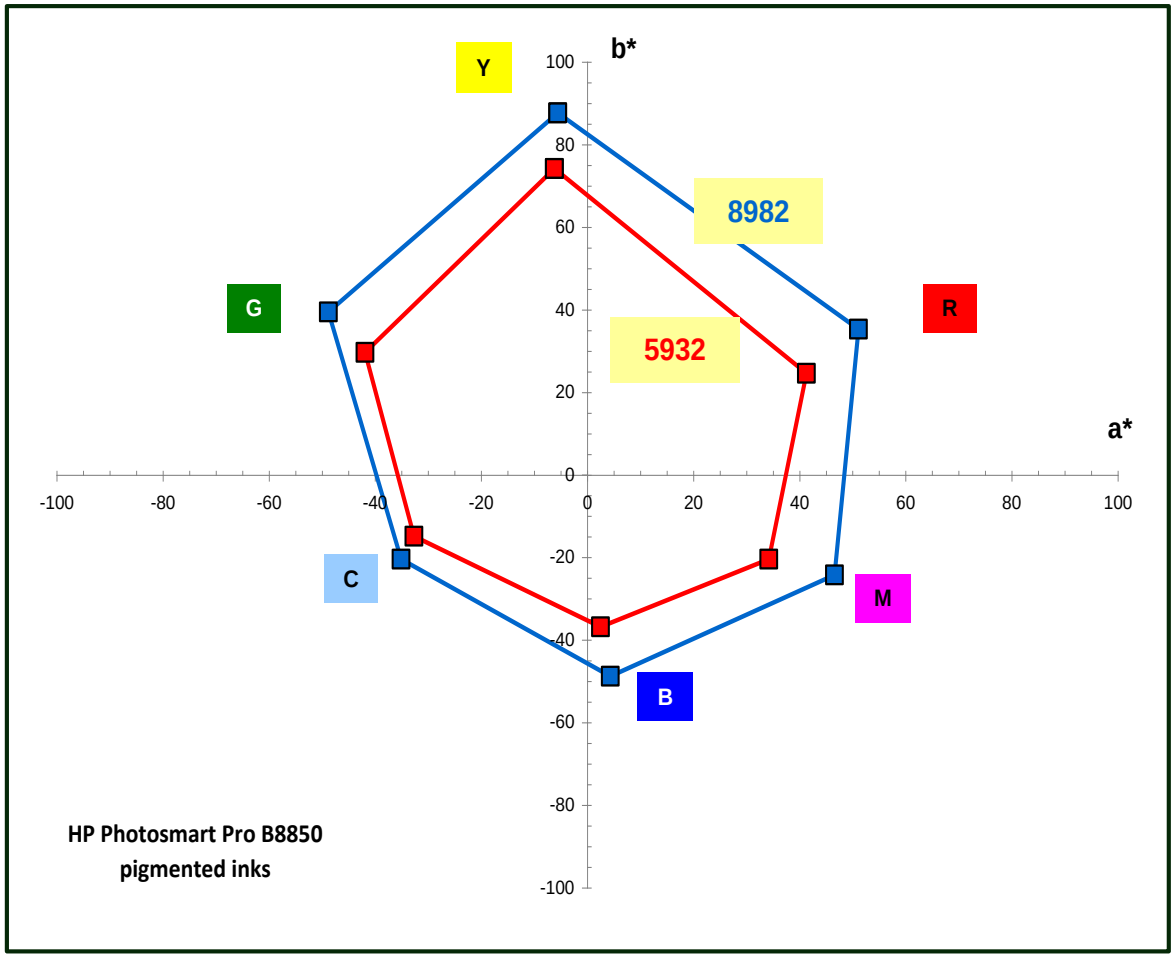
Characterized by intrinsic characteristics of surface micro topography and surface chemical properties

Printed material

- Optical Densities
- Gamut Area
- Print through
- Quality of Line (blurriness, raggedness, intercolor bleed) and Point (circularity)



Gamut Area



Printing quality parameter correlating to color reproduction capacity
Area associated with the graphical representation of a* and b* CIE color coordinates of primary (Magenta, Cyan, Yellow) and secondary colors (Red, Green, Blue)

Study of ink-paper interactions in printing processes, inkjet, offset and digital

Parameter correlations with printing quality had been defined

Inkjet printing tests

Positive Correlation with

- ✓ Gamut area
- ✓ Cyan optical density
- ✓ Black optical density for color reproduction
- ✓ Print through

Negative Correlation with

- × Ink spreadness
- × Raggedness of the black line
- × Intercolor bleeding (black and yellow)
- × Circularity of the magenta dot

Ink-paper interaction offset printing

Positive Correlation with

- ✓ Final bonding level

Negative Correlation with

- × Topographic variables associated with a predominance of deep valleys and surface anisotropic surface texture
- × Lack of bonding (vessel picking issues)
- × Paper roughness

Toner adhesion in digital printing

Positive Correlation with

- ✓ Total energy of the surface (E Total) and its dispersive component (E disp)
- ✓ Grammage
- ✓ Thickness
- ✓ Opacity
- ✓ Stiffness

Negative Correlation with

- × Paper roughness

⇩

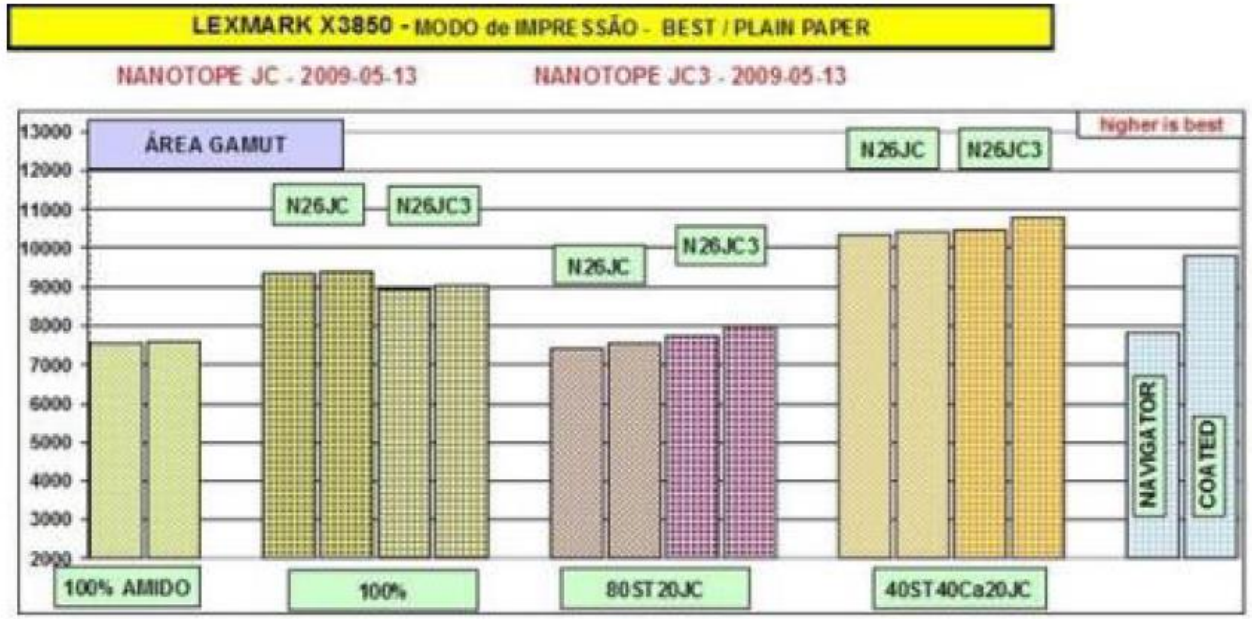
Product development projects: paper for inkjet, offset and digital printing

Study of ink-paper interactions in printing processes, inkjet, offset and digital

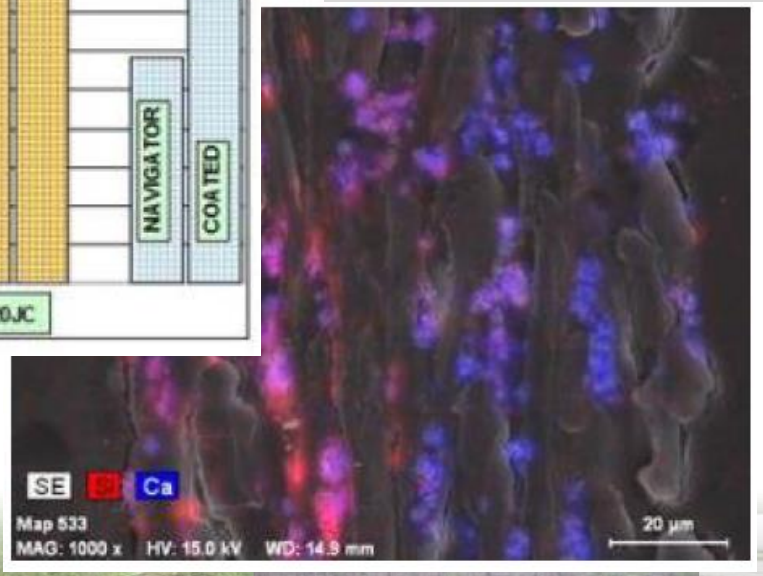
New Surface Treatment for Printing Quality Improvement

Several surface treatment formulations were tested and applied

- 100% of the product on the paper surface
- Several formulations with cationic starch, nanocomposites, calcium carbonate, …



- ✓ Improvement of the color reproduction capacity (area gamut)
- ✓ Strong synergy between additives, allowing the increase of gamut area by 35%.

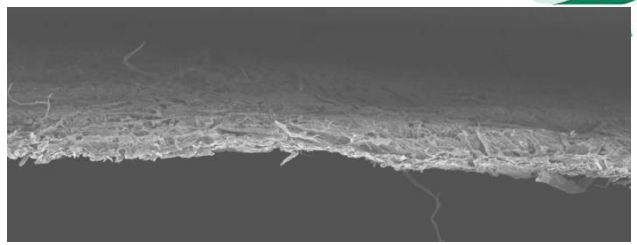


Silicium and calcium distribution in the paper sheet cross section

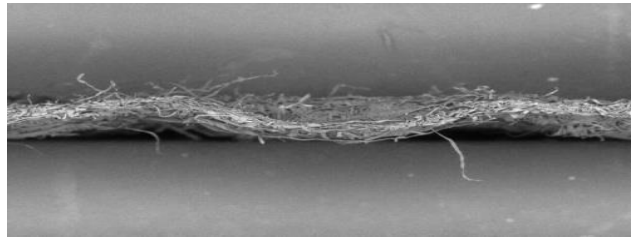
Meanwhile, in the TISSUE TECHNOLOGY SIDE……

Tissue Paper Production Technologies

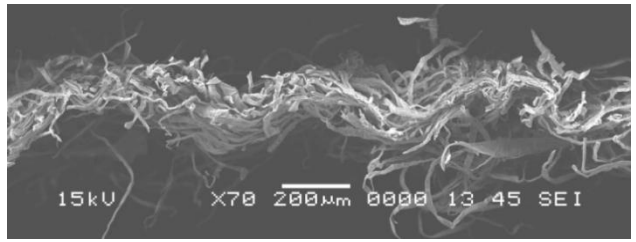
❖ Crescent former DCT (Dry Crepe Tissue): “traditional” production technology offered by all selected suppliers – new equipment developed for bulk and paper quality increase and/or energy saving (two layer head-box, shoe press, steel Yankee)



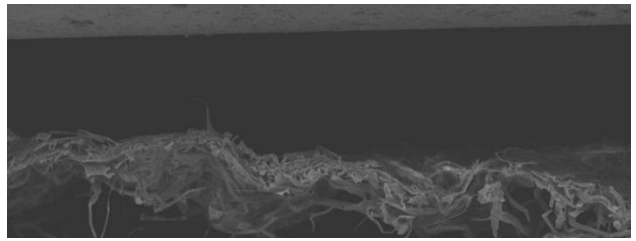
❖ VOITH TissueLev™: standard crescent former DCT machine with Voith Nipco Flex T™ shoe press and additional felt enhancing the water removal (energy savings) and the paper bulk. Slightly higher (1%÷3%) CAPEX Vs. DCT.



❖ Valmet NTT™ (New Textured Tissue): in a crescent former with Valmet ViscoNip™ shoe press the tissue web is shaped on a patterned belt surface, creating (depending on the fabric pattern) a plain or three dimension [textured] sheet with higher bulk and absorption Vs. DCT’s one. Higher (30%÷35%) CAPEX, energy (10%÷20%) and chemical (20%÷100%) consumptions Vs. DCT.



❖ VOITH ATMOS™ (Advanced Tissue MOlding System): web is formed on a structured fabric and most of the dewatering occurs by air flow with minimized mechanical pressing for high bulk and softness paper (plain or structured) depending on fabric structure. Higher (~35%) CAPEX, energy (20%÷35%) and chemical (20%÷100%) consumptions Vs. DCT.

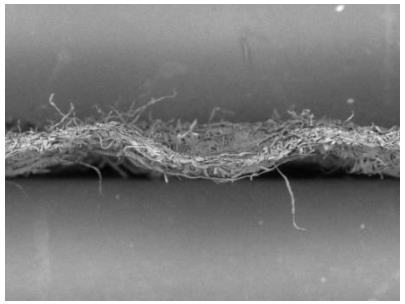


❖ TAD (Thru Air Dried): “top” technology where the web is formed on a solid roll, then gently dewatered while the paper structure results determined before final drying by hot air through the sheet resulting in a high bulk and very high absorption fully structured paper. Very high (~80%) CAPEX, energy (95%÷150%) and chemical (~100%) consumptions Vs. DCT.

The NTT technology (by Valmet): textured tissue

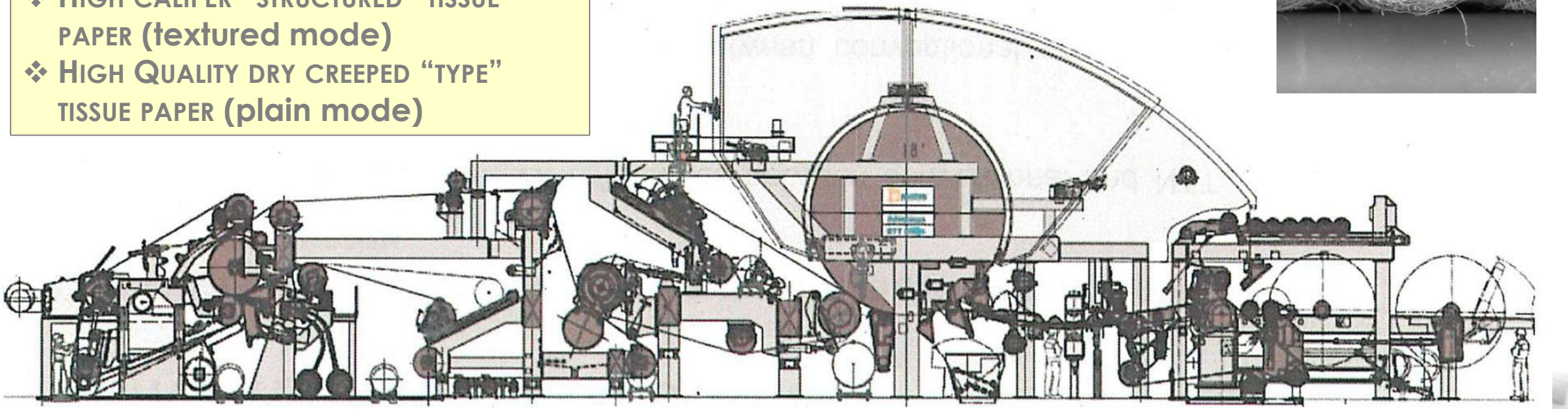
- The web is formed upwards from the head-box and the press section is an individual part before the Yankee cylinder; the nip is equipped with a Valmet ViscoNip™ shoe press. Tissue sheet is shaped on a patterned belt surface, creating a three dimension sheet

- Changing the used fabric pattern it can produce plain (similar to DCT standard one) and textured paper

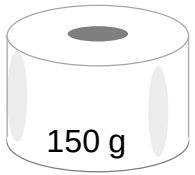


Source: Valmet – Typical Advantage NTT200

- ❖ HIGH CALIPER "STRUCTURED" TISSUE PAPER (textured mode)
- ❖ HIGH QUALITY DRY CREEPED "TYPE" TISSUE PAPER (plain mode)

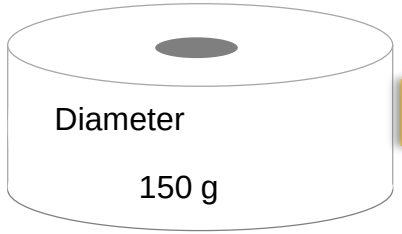


The NTT technology (by Valmet): textured tissue



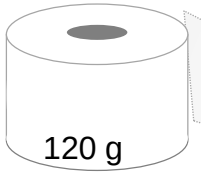
DCT
Embossed

A



20% volume increase

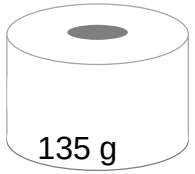
B



20% fiber saving

Length

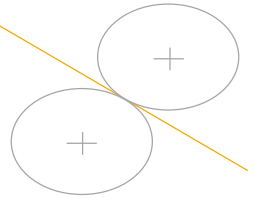
C

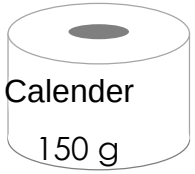


Basis Weight (g/m^2)

10% fiber saving

D





Quality

- ⇨ *Smoothness*
- ⇨ *Bulk Softness*

Packaging Developments : bio-based packaging materials for food and beverage applications. Beyond recycling !

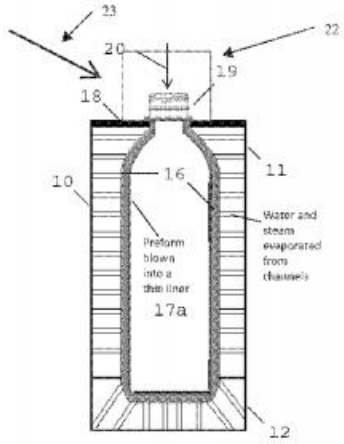
Similar to their fossil fuel based counterparts but with much lower carbon footprint, using natural wood fibers.

The Bio-based recycable packaging

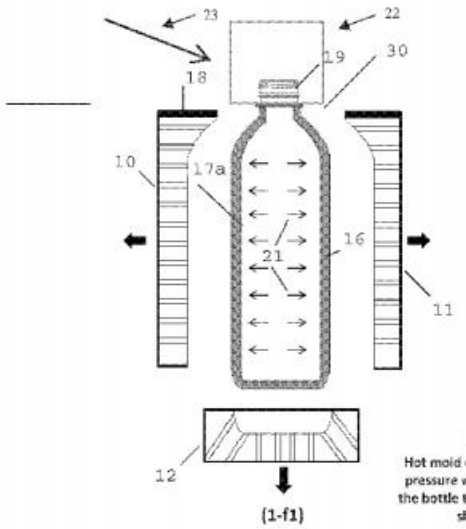
Patent Application: WO 2013192260 A1

A method of producing a pulp molded article with an internal liner, the method comprising (1) forming a wet pulp layer on a surface of a mold cavity; (2) heating the wet pulp layer, (3) dewatering the wet pulp layer by expanding a thermoplastic parison by blow molding to press the wet pulp layer against the surface of the mold cavity and to form an expanded thermoplastic liner and a dewatered preform and (4) forcing the expanded thermoplastic liner into contact with the pulp layer on cooling

Applicant: Pepsico, Inc.



(1-e)
The preform expands to press & dry the pulp layer and create a thin liner layer, which has a tendency to shrink due to heat abuse



(1-f1)

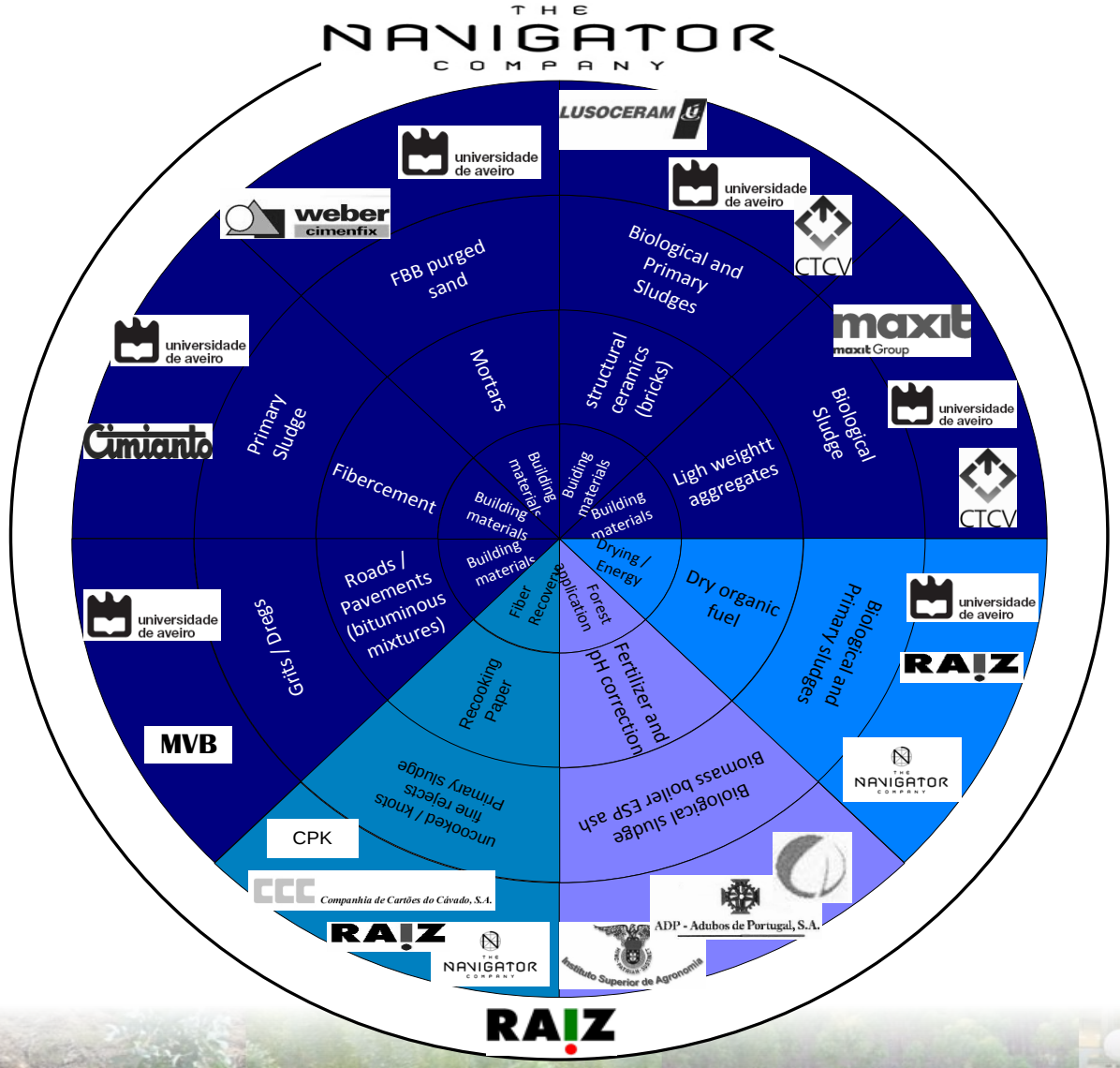
(1-e)
Hot mold opens but a small pressure will be retained in the bottle to avoid the plastic shrinkage.

GreenBottle and Ecologic's paper bottles can be split apart after use and be recycled with paper. The non-barrier liners can be recycled with grocery bags. Tetra Pak's one-piece molded paper Evero bottles for shelf stable milk can also reportedly be recycled with paper.

Stretchable paper can replace plastic in 3D packages

A new project will examine how the pilot plant, FEX, can be developed into a test bed for manufacture of highly stretchable paper and board products.

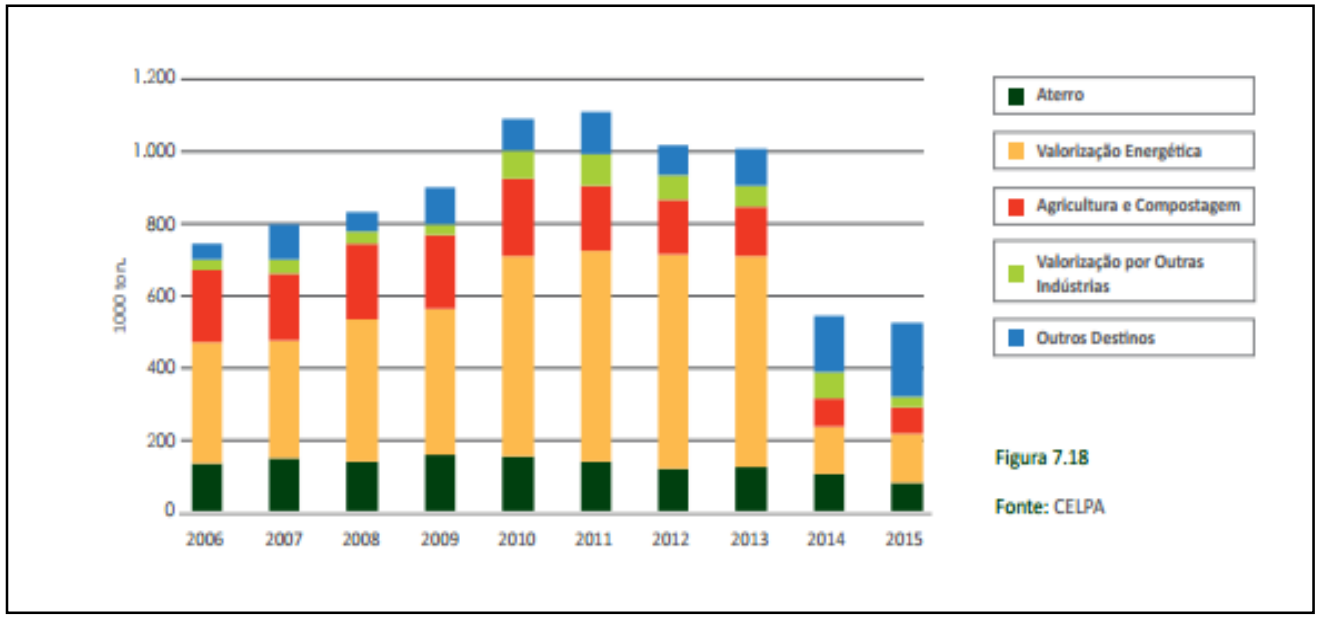
Circular Economy in the P&P Industry
An Industrial Symbiosis



Solid Waste - Minimization Measures/Study of Potential, Internal and External Applications

The pulp and paper industry represents about 8% of the national industrial production and originated, in 2015, around 500,000 tons of solid waste

Analyze and study actions to implement a circular economy



P & P solid waste destination in Portugal (CELPA Statistical Bulletin 2015)

Aplications Developed by Residue Type

Residue	Aplication
Biomass Boilers Fluidized Sand Bed	Civil Construction/Grout Incorporation Road Pavements
Biomass Boilers Ashes	Forestry and Agricultural Applications Composting Cement Production
Lime Sludges	Alkalinizing Soil Correction
Biological Sludges	Organo-Mineral Fertilizers Manufactoring Energy Recovery Ceramic Building Materials Incorporation Expanded Clay Production

The challenges !

InPaCTus

Microfibrillated cellulose as surface and / or internal resistance agent

To study the use of micro/nanofibrillated cellulose as an additive in the paper production to increase its internal strength, without impairing the sheet drainability, while finding a compromise to increase the retention; and also as an additive for formulations of paper surface treatment to increase its surface resistance.

Recent developments of commercial paper coatings evaluation and their characterization

Coating formulations producing higher value papers with lower environmental impact, with high performances in terms of printing quality.

Papers with new functionalities induced by surface photopolymerization

To develop and optimize new paper functionalization strategies by (photo) superficial polymerization. Evaluate the potential of the functionalized papers in several applications; namely in functional packaging, multifunctional papers (including printing and writing papers), super-absorbent papers.

Papers with support functions for sensors and controlled release

Contributing for obtaining a new generation of paper with sensory properties and retention capability of a wide range of substances; To develop functionalized paper with the ability for a controlled release of essential oils, both in the aroma component and as improving antioxidant properties.

The Age of (wood) Fiber!

Natural, Renewable, Recycable , Sustainable Resource

MUITO OBRIGADO !

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