paper Penaîn

New market niches for the Pulp and Paper Industry waste based on circular economy approaches



Circular Case 4, Chemical Sector



- Overview of the paperChain project
- Overview of CC4 project activities
 - Involved companies
 - Ethanol production from fiber rejects
 - Wood based cellulose for cellulose ether production
 - Ethyl chloride from ethanol
 - Evaluation of wood based cellulose in Bermocoll® production



THE PAPERCHAIN PROJECT. DEMONSTRATIVE NATURE





THE PAPERCHAIN PROJECT. THE VALUE CHAIN. PARTNERS AND STAKEHOLDERS









CC1. Aveiro. Portugal

Valorisation of Paper Industry's causticizing residuals (<u>i.e.</u> lime mud, <u>slaker</u> grits and green liquor dregs) as secondary raw materials for concrete and asphalt manufacturing







CC2. Zaragoza, Valencia (Spain).

Valorisation of ash produced in the energy recovery from paper waste produced by Recycling Pulp mills as alternative binder for soil stabilization works in road projects.







CC3. Eslovenia

Valorisation of deinking paper sludge and <u>waste</u> <u>paper</u> ash produced by Recycling Pulp mills for the rehabilitation and slope stabilization of landslides in Railway lines.









CC5. Garpenberg, Sweden

Valorisation of green liquor dregs produced by the Pulp industry as reactive sealing layers for acid rock drainage mitigation in mine waste deposits.



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Circular Case 4, Chemical Sector









Nouryon

paper Chain

Sekab









Ethanol Fermentation, PFD





13

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Hydrolysis/Fermentation of Fiber Rejects paper@Chain











Pulp for cellulose ethers

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First stage - Pilot scale investigation

- Pilot scale test run at MoRe Research
- Investigate suitability of Domsjö pulp in cellulose ether trials
 - pilot testing at Nouryon
- Full scale trials at Domsjö Fabriker, 7 cooks in total
- Different conditions used in the consecutive cooks



Photo 1. Wood Chips from pilot cooking trial

Pulp viscosity is important for cellulose ethers. Other variables that are also important to follow are brightness, kappa number, and hemicelluloses.











Synthesis of ethyl chloride, PFD



Simplified process diagram







Ethyl Chloride Pilot Plant

- Construction is finished
- Programming of control system is finished
- Risk assessment completed
- Successful trials for production of ethyl chloride
- Final work with fine tuning the process
 - Flow rate
 - Ratio of HCI:Ethanol
 - Temperature
 - Distillation trials
 - Catalyst evaluation

Summary of trial runs



 $HCl + Ethanol \xrightarrow{Catalyst+heat} Ethyl chloride + Diethyl ether + Water$

Diethyl ether is undesirable but small amounts acceptable

Sampling point	Ethyl I chloride	Diethyl ether	Ethanol V	Water	Other/ unknown	Reactor temp (avg) [°C]	Ethanol [ml/h]	Molar ratio HCI/EtOH
Product vessle	73%	22.0%	2 1%	0%	4.5%	325	100	0.4
reflux	83%	11.2%	2%	0%	4.4%	314	100	0.6
reactor	24%	2.4%	30%	34%	8.7%	314	100	0.6
reflux	65%	1.9%	6%	25%	2.6%	314	100	0.8
reactor	48%	1.8%	17%	22%	11.2%	314	100	0.8
reactor	53%	1.7%	13%	21%	11.2%	317	100	0.8
reflux	39%	0.8%	2%	57%	1.7%	317	100	0.8
reflux	58%	1.1%	6%	33%	1.9%	313	80	0.98
reactor	33%	1.3%	20%	36%	9.1%	313	80	0.98
Product vessle from 25 h run	94%	2.7%	1%	1%	1.3%	310-320	100-80	0.8



Cellulose Ether Production







Nouryon pilot plant







Evaluation of Aditya Birla cellulose at Nouryon pilot plant



- Trials has been done with Aditya Birla cellulose at Nouryon pilot plant
- Product is evaluated dissolved in a water solution at 1% concentration of the cellulose ether

Results:

Parameter	Pilot batch	Specification limits
Viscosity (cP)	515	500 - 800
NaCl (%)	2,9	0-6
Moisture (%)	1,5	0-4
Gel content (%)	5,5	0-3
Transparency (%)	82	Min 80%
S60 (%)	95	Min 85%

Conclusion:

Aditya Birla cellulose need to be improved further, with regards to gel content (insolubles). Viscosity (DP) and transparency are borderline properties that needs to monitored carefully.





Summary

Ethanol production

- Knot rejects and fines (fiber rejects) successfully hydrolysed to a monomeric sugar stream
- Sugar stream fermented to ethanol

Cellulose for cellulose ether production

- Pilot scale trials to evaluate conditions to be used in scaling up
- Seven full scale trials performed to evaluate new cooking conditions
- Samples for analysis and production tests from full scale tests

Ethyl Chloride production

- Demonstration rig constructed
- Safety assessment performed
- Multiple test runs at different feed rates and molar ratios of HCI/EtOH
- Different catalysts evaluated
- One test run for 25 h to test stability of process

Bermocoll pilot production

- Wood based cellulose used for Bermocoll production
- Evaluation of the produced Bermcoll



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