BIOREFINERY: EUCALYPTUS WOOD XYLAN REMOVAL AND ITS IMPACT ON KRAFT PULP QUALITY

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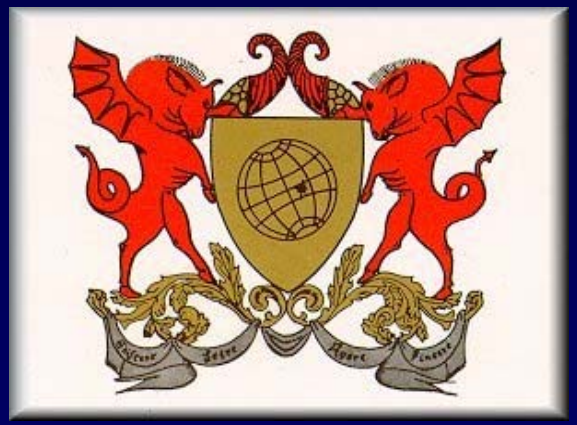

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Introduction

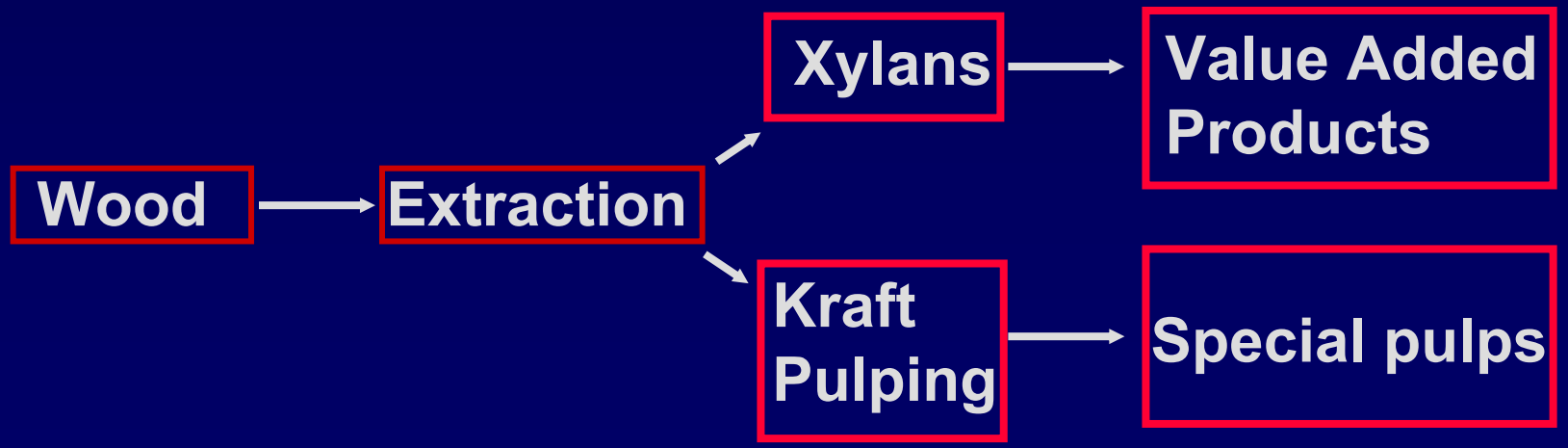
- Xylans are eucalyptus main hemicelluloses
- Xylans are prone to degradation during kraft pulping:
  - Low molecular weight
  - Branched and amorphous
  - Rich in reactive groups
  - Large amounts of reducing end groups in relation to cellulose on a weight basis
- However, they are protected by uronic acids.

Introduction

- A significant fraction of eucalyptus wood xylans is lost during kraft pulping
  - The loss reaches 50-60% (uronic acids and acetyl groups included)
- This large fraction of material consumes a significant amount of active alkali
- Xylans removal from HWD chips prior to pulping may improve kraft pulping economics → value added products such as biofuels, biopolymers, xilitol etc.
- Would this approach make sense for eucalyptus wood?

Introduction

- Xylans can be removed from wood chips by:
  - Extraction:
    - Autohydrolysis with water
    - Acid hydrolysis
    - Alkali leaching



Objectives

- ✓ Determination of proper conditions for removal of eucalyptus wood xylans with alkali and water;
- ✓ Determination of proper kraft pulping conditions for partially xylan depleted wood chips;
- ✓ Assess bleachability, quality and effluent load of kraft pulp derived from partially xylan depleted wood chips

7 year old *Eucalyptus dunnii*

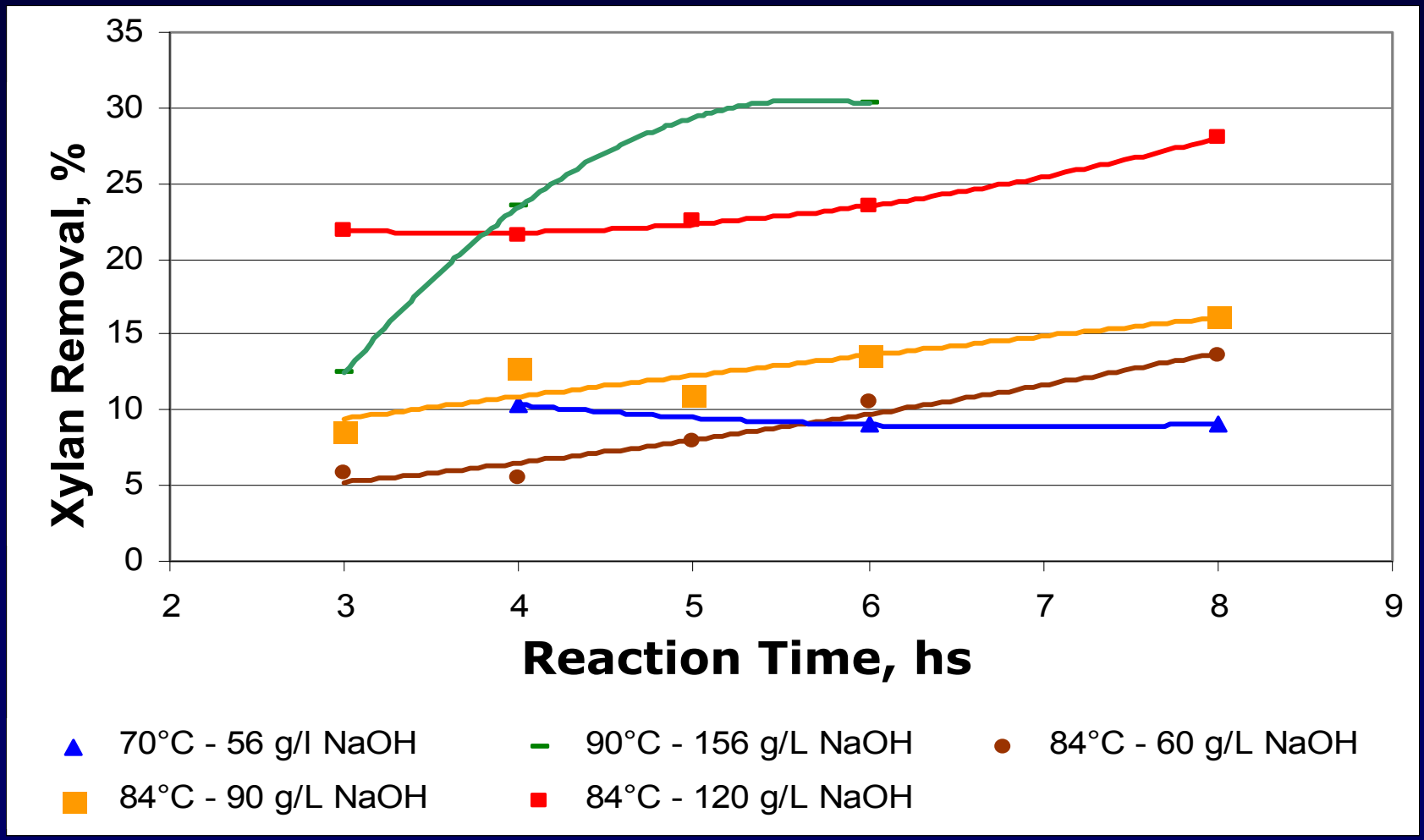
Wood Composition, %	Average of 10 trees
Total lignin	25.3
Glucans	46.9
Galactans	1.5
Manans	1.9
Arabinans	0.5
Xylans	**12.2**
Total Uronic Acids	4.8
Total Acetyl Groups	2.6
Total Extractives	2.1

Xylan Removal by Alkali Leaching

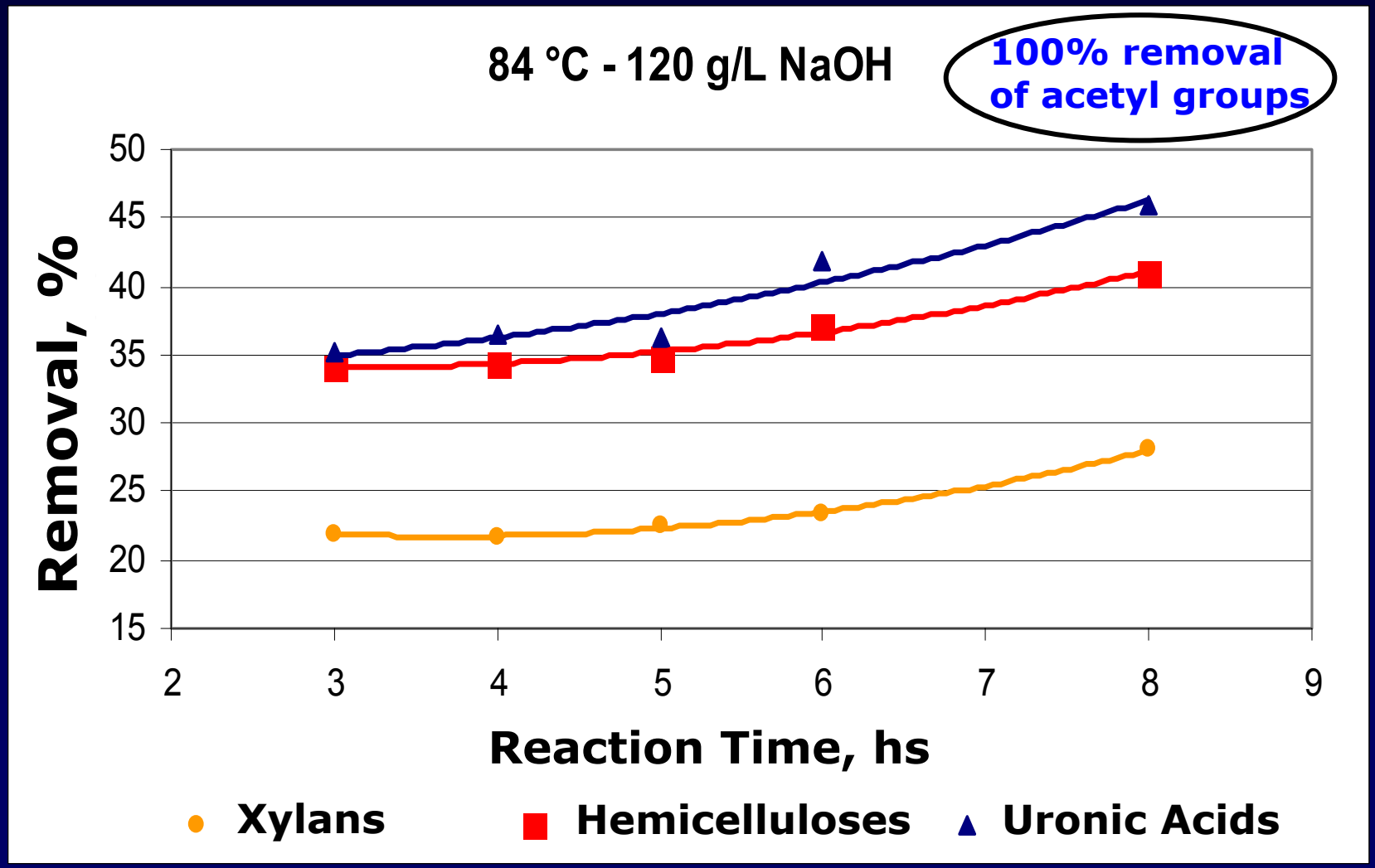
Alkali Leaching Conditions

- Chip saturation to 50-52% moisture: pre-vaporization
- Alkali leaching:
  - NaOH = 56, 60, 80, 90, 120 and 156g/L
  - Temperature = 70, 84 and 90°C
  - 3-8 hs

Alkali Leaching Results

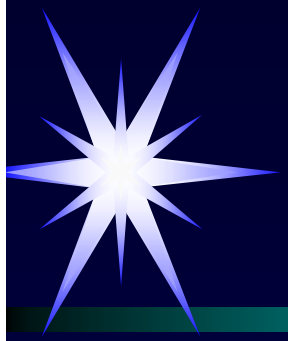


Alkali Leaching Results – Atmospheric



Alkali Leaching Results

- Acetyl groups are quickly removed (100% removal)
- Uronic acids removal up to 46%
- Xylan removal up to 28%



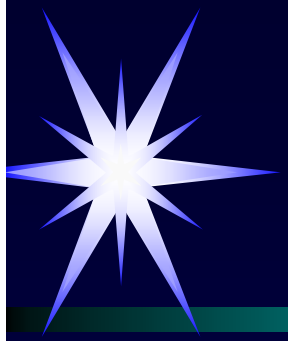
Pulping of Alkali Leached Chips

Pulping of Alkali Leached Chips

Cook #	Reference Chips	Alkali Leached Chips 84°C, 120 g/L NaOH, 5h
Time to Temperature, min	90	90
Time at Temperature, min	60	60
Temperature, °C	170	158
Sulfidity, %	37	37
Liquor: Wood	3:1	3:1
Active Alkali, %	16.5	5.6
Kappa Number	16.4	16.6
Total Yield, %	54.6	44.1
Screened Yield, %	54.5	44.1
Residual Alkali, g/L	7.5	7.3

Alkali Leaching Results

- Alkali leaching processes are not viable due to poor xylan removal and excess inorganic to handle in spent liquor;
- Besides, subsequent kraft pulping results in unusually low yield.

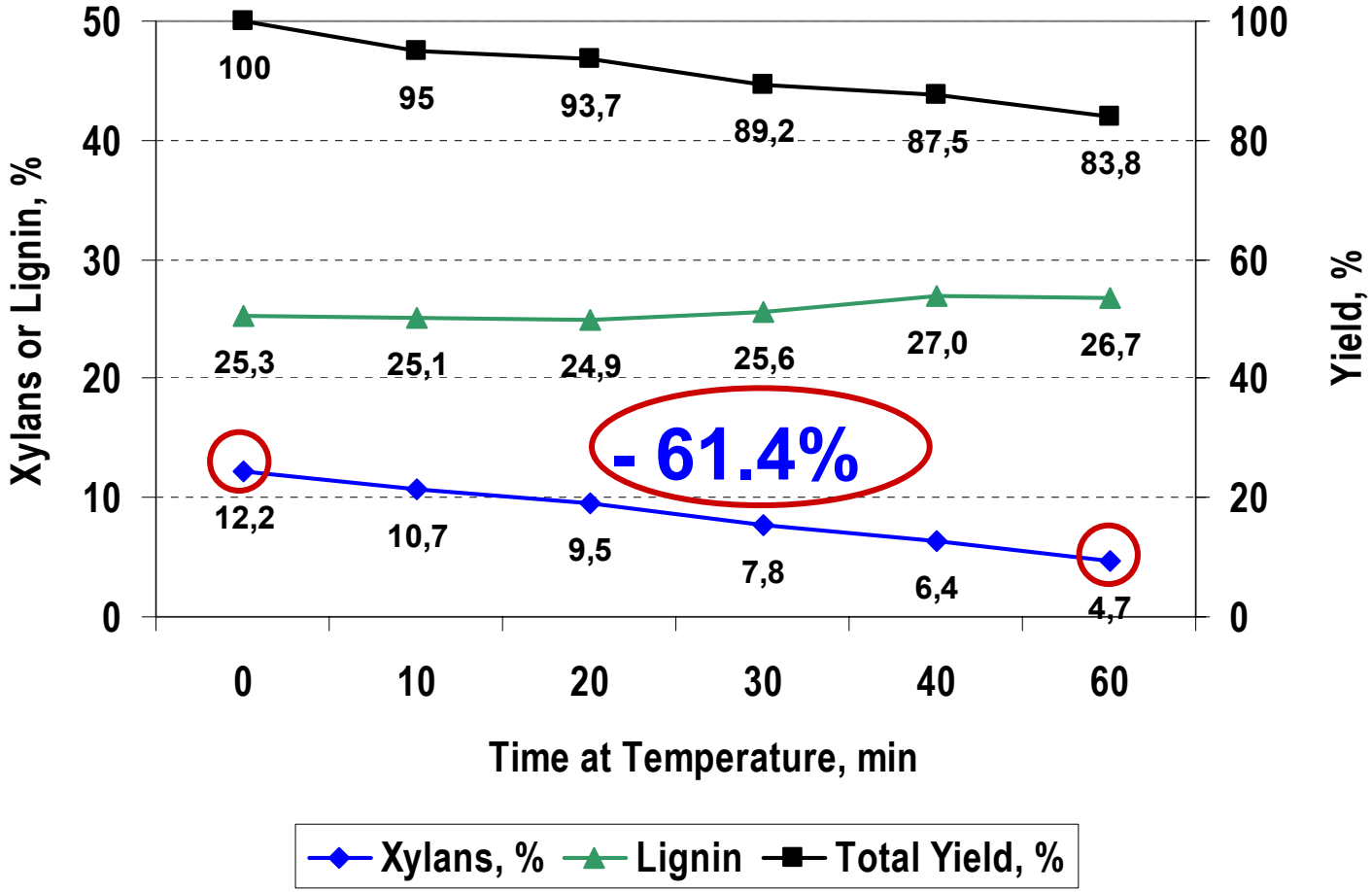


Xylan Removal by Autohydrolysis (PH) with Water

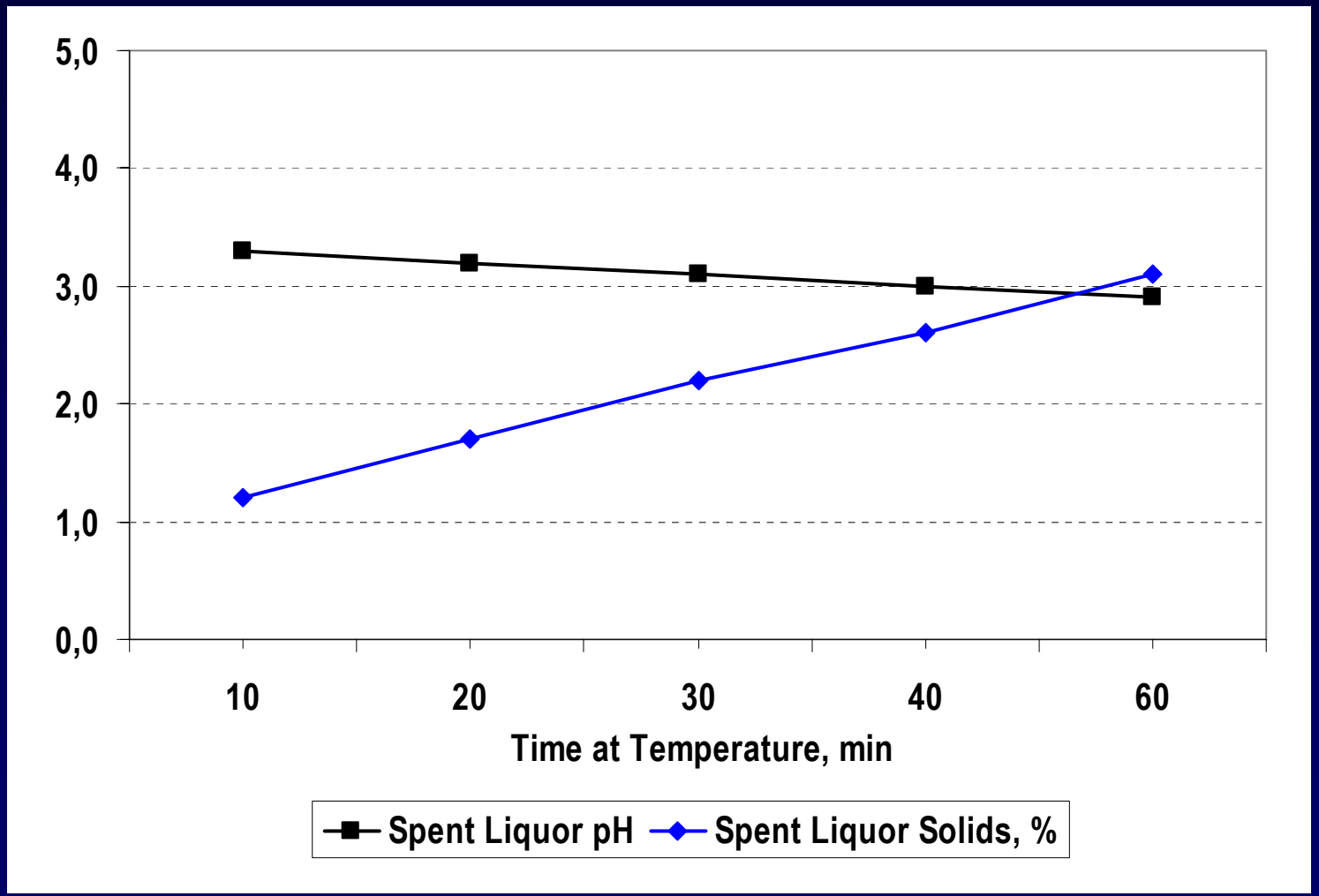
Autohydrolysis Conditions

- Water: Wood = 3.5:1
- Temperature : 165 °C
- Time to Temperature: 60 min
- Time at Temperature: 10, 20, 30, 40 and 60 min

Autohydrolysis Results



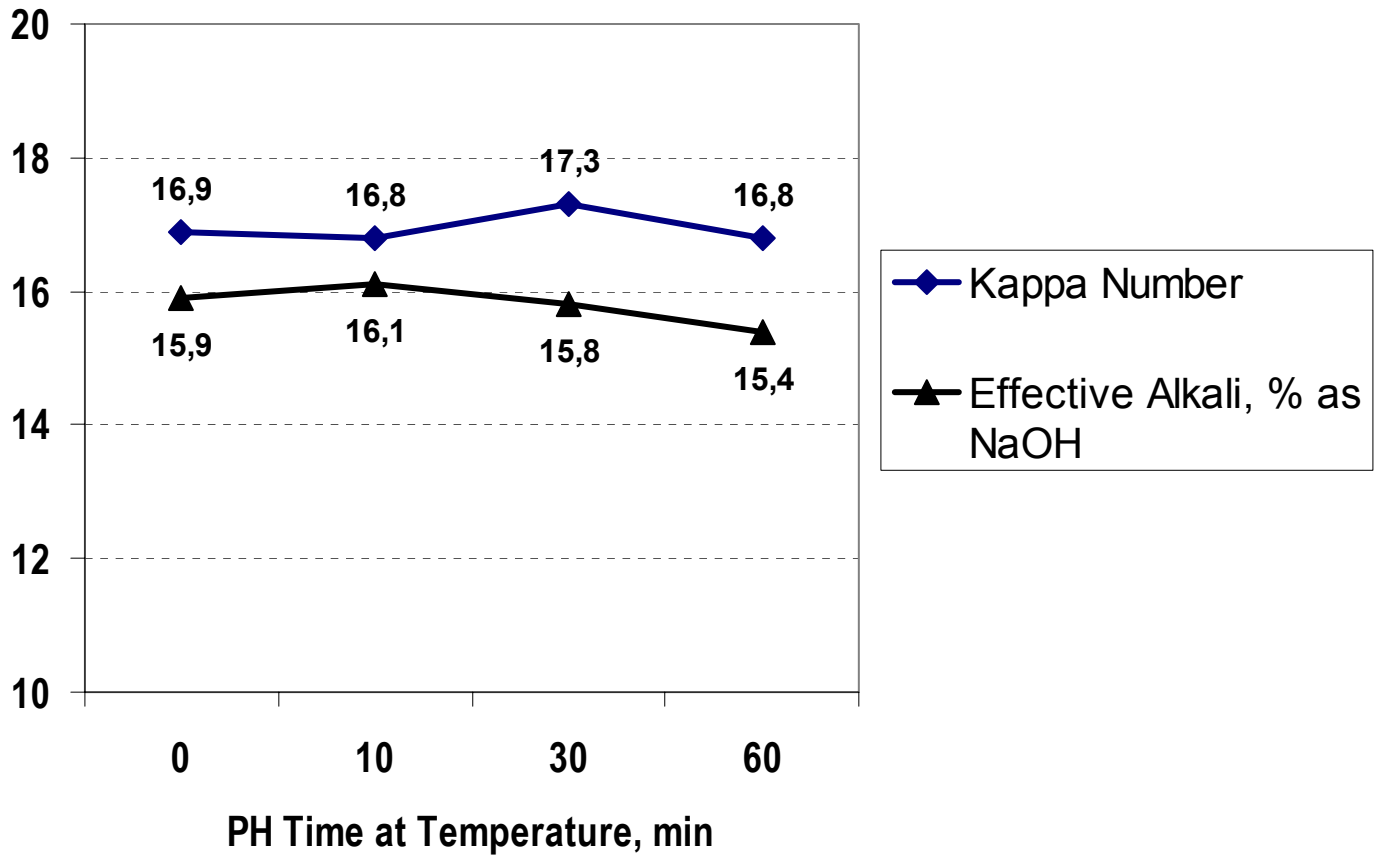
Autohydrolysis Results



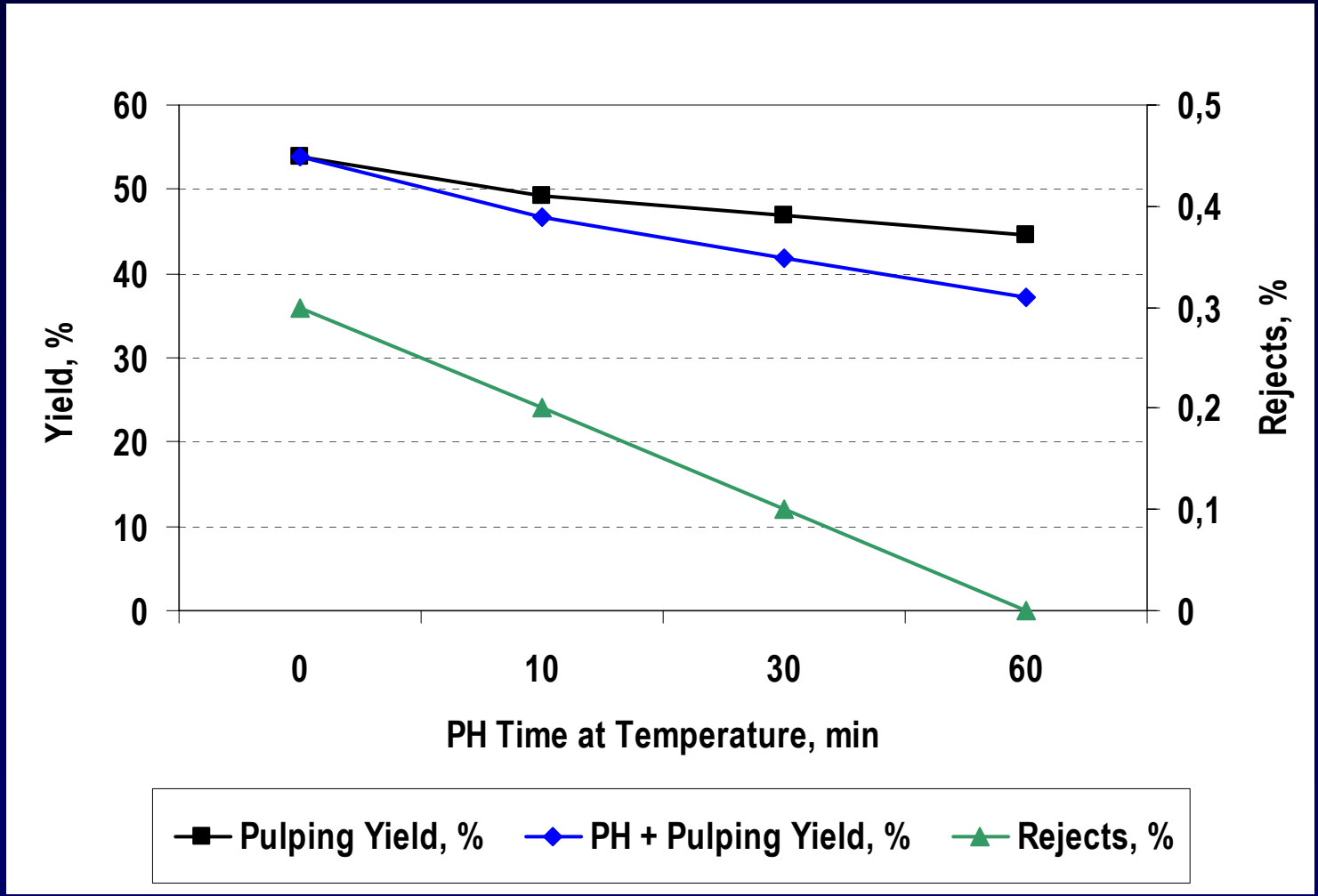
Lo-Solids Pulping Conditions

- The following cooking conditions were used on 500 g (dry weight basis) pre-steamed chips:
  - Impregnation zone: 112°C, 60 minutes, 45% of total active alkali, L/W = 3.5/1;
  - Upper coking zone: 155°C, 60 minutes, 30% of active alkali, L/W = 3.5/1;
  - Lower coking zone: 156°C, 120 minutes, 25% of total active alkali, L/W = 3.5/1.
- Total sulfidity of 37% and 680 H-factor

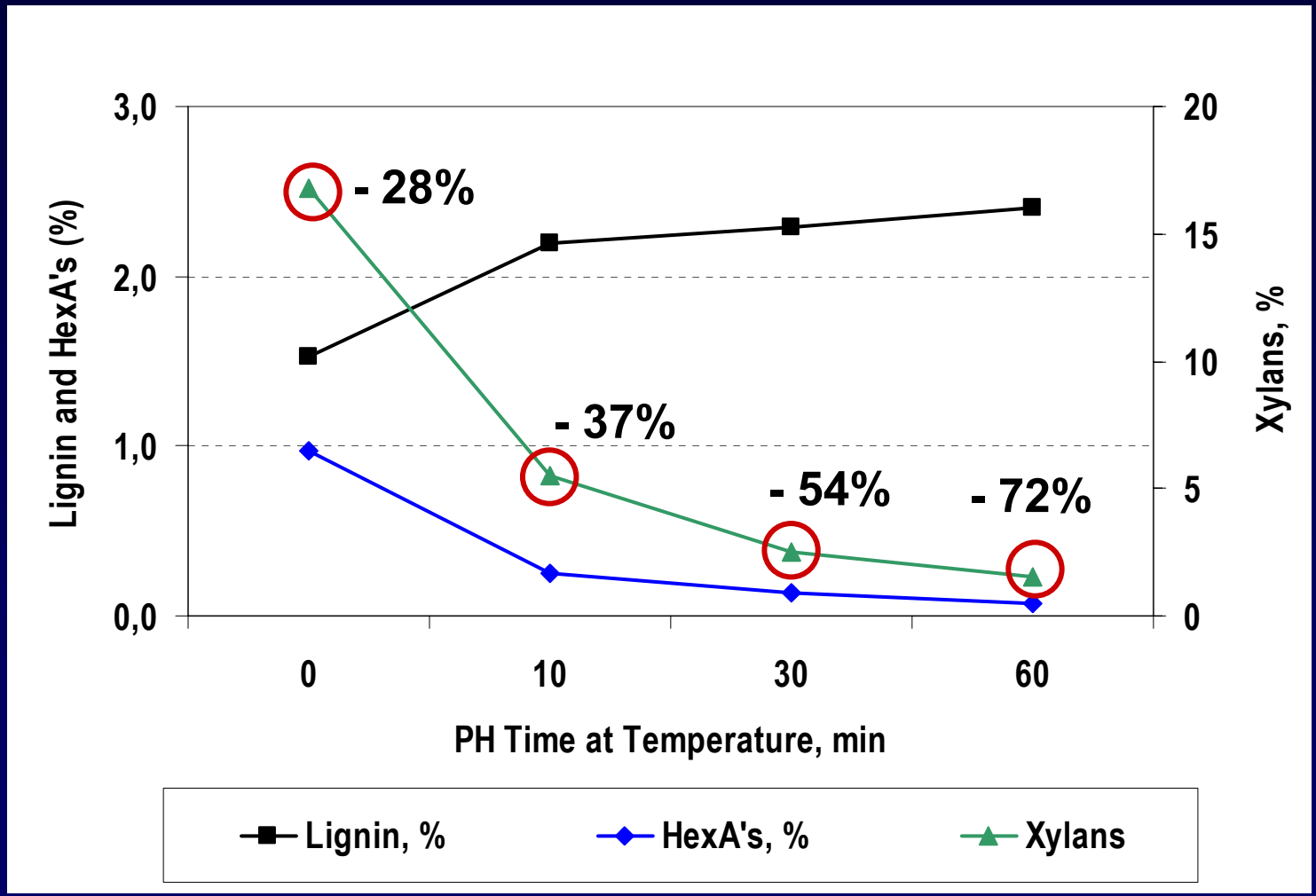
Kraft Pulping Results



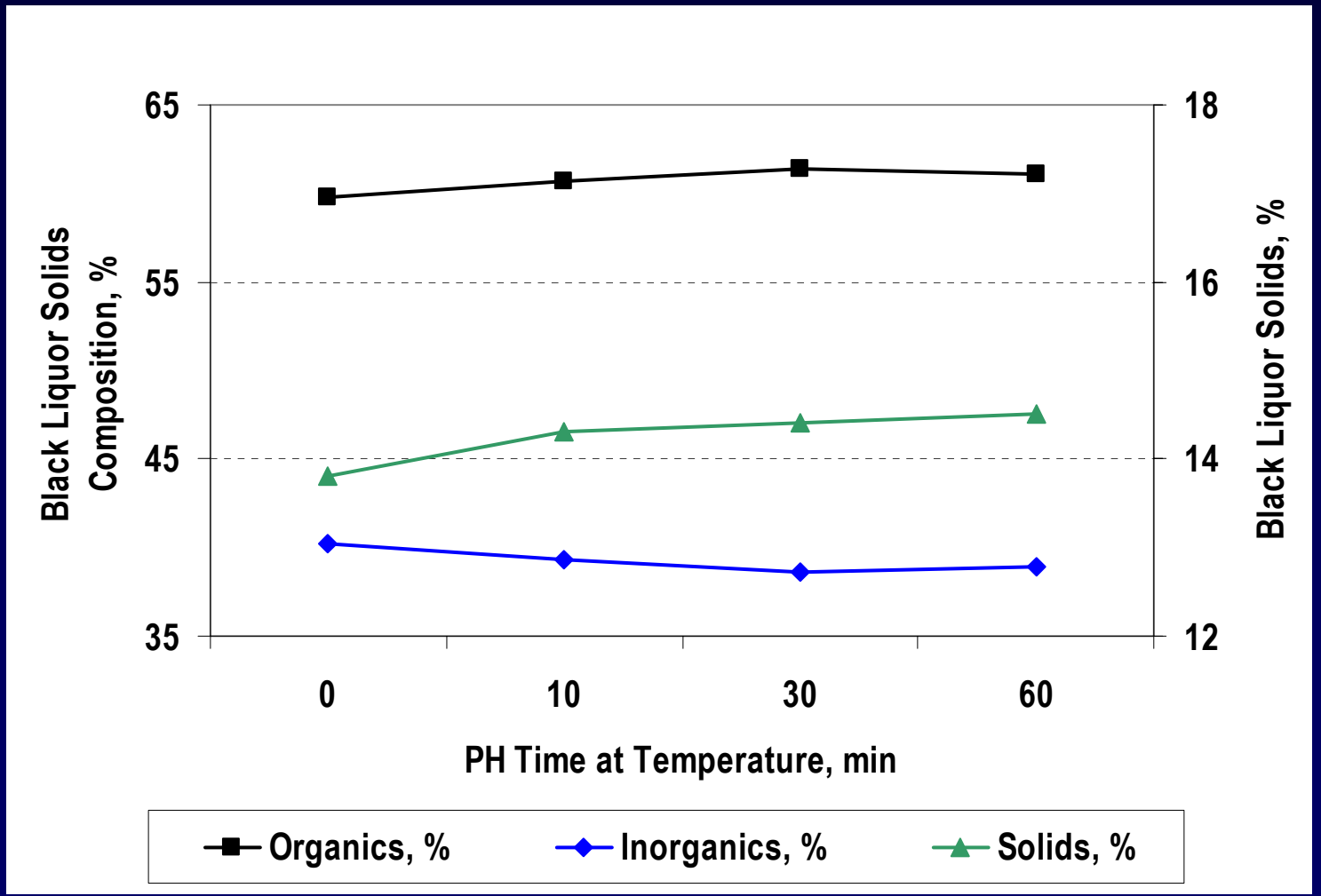
Kraft Pulping Results



Kraft Pulping Results



Kraft Pulping Results

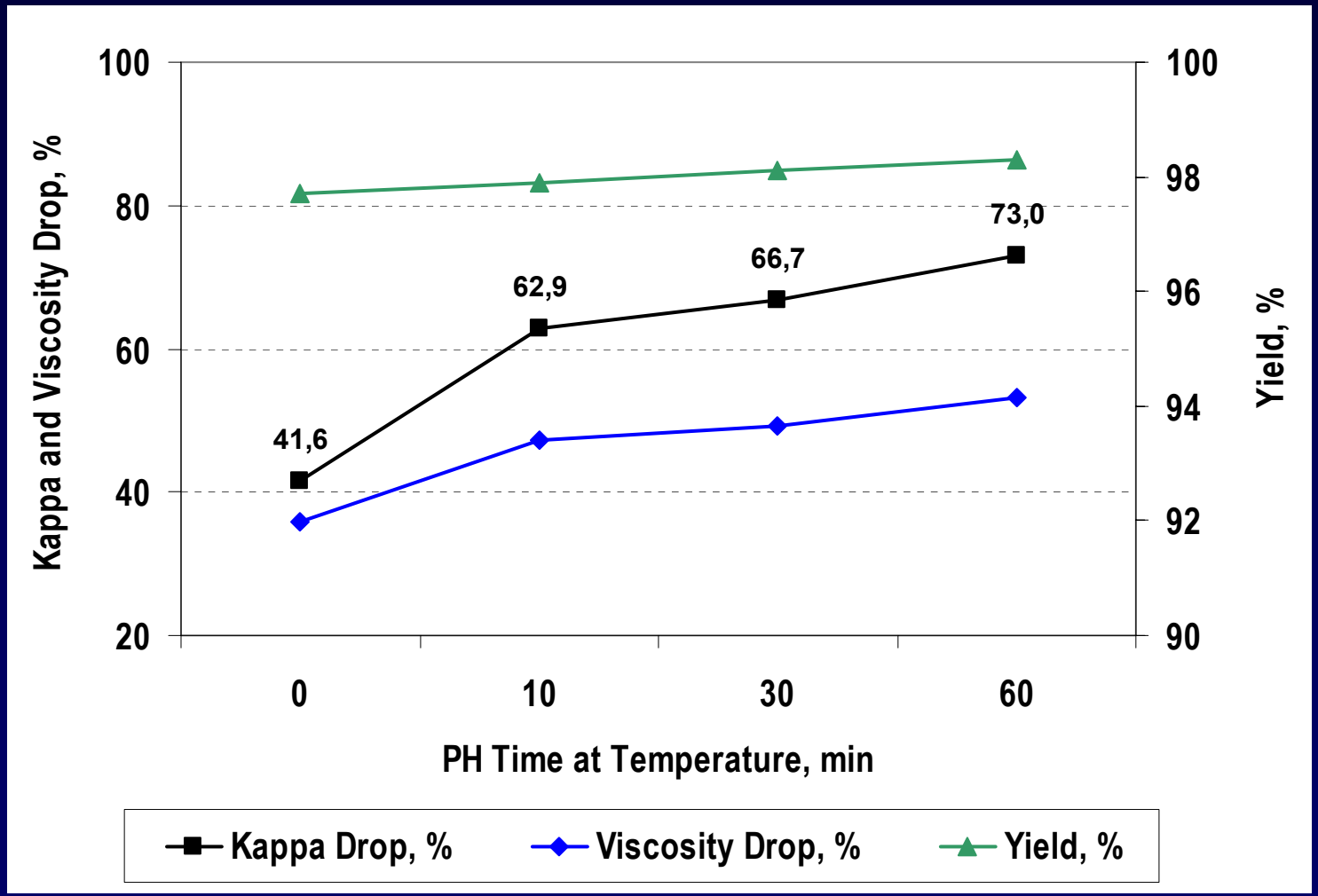


Oxygen Delignification Results

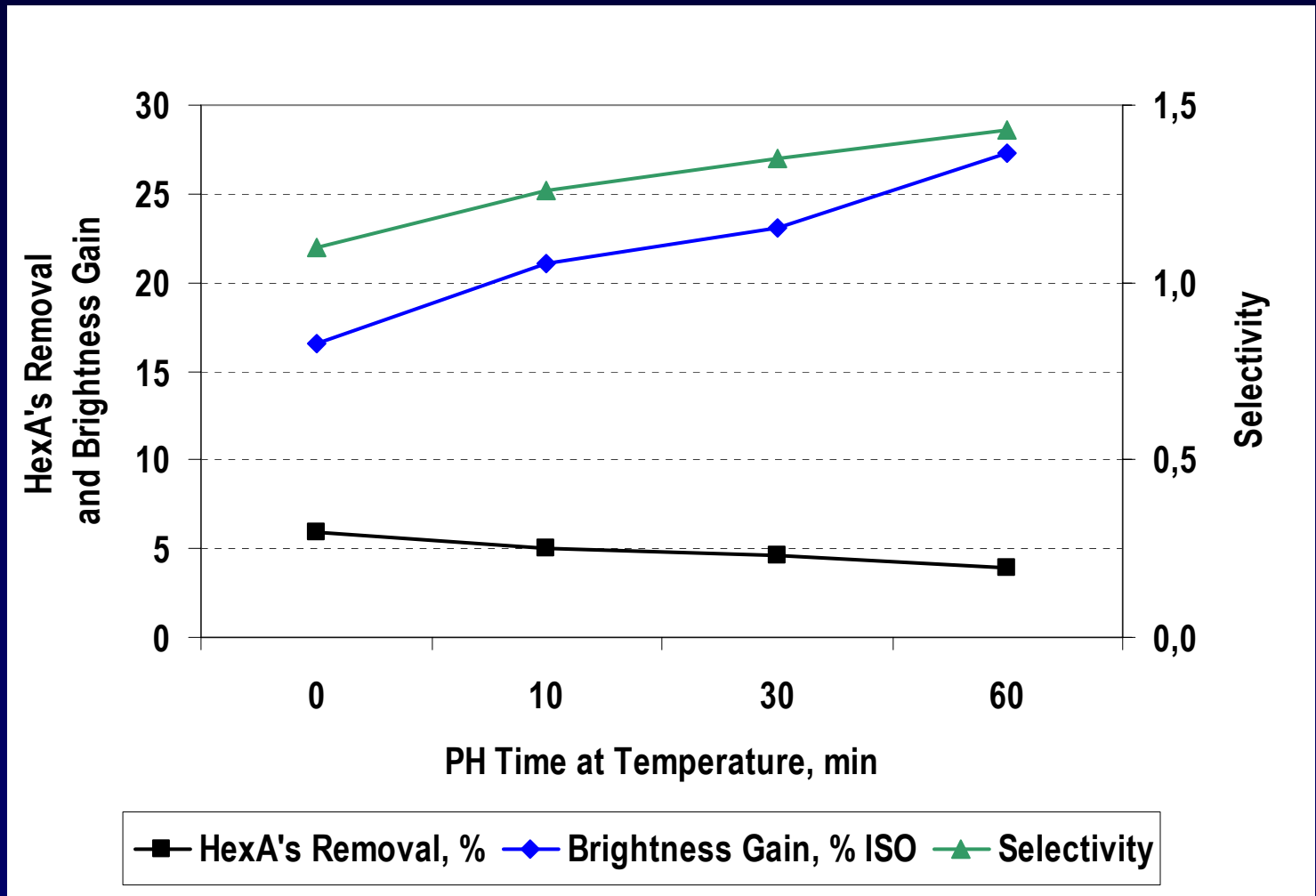
General Oxygen Delignification Conditions

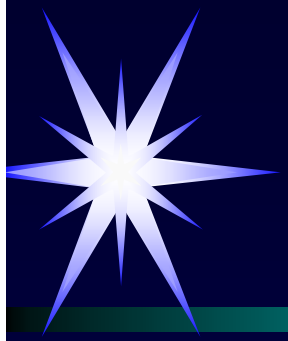
- The following double-stage (O/O) oxygen delignification conditions were used on 300 g (dry weight basis) kappa 16-17 pulps:
  - Temperature = 90/100°C ;
  - Pressure: 600/400 kPa;
  - Time: 15/60 min
  - Consistency: 12/11%
  - NaOH = 2/0 %
  - O_2 = 2.2/0 %

Oxygen Delignification Results



Oxygen Delignification Results



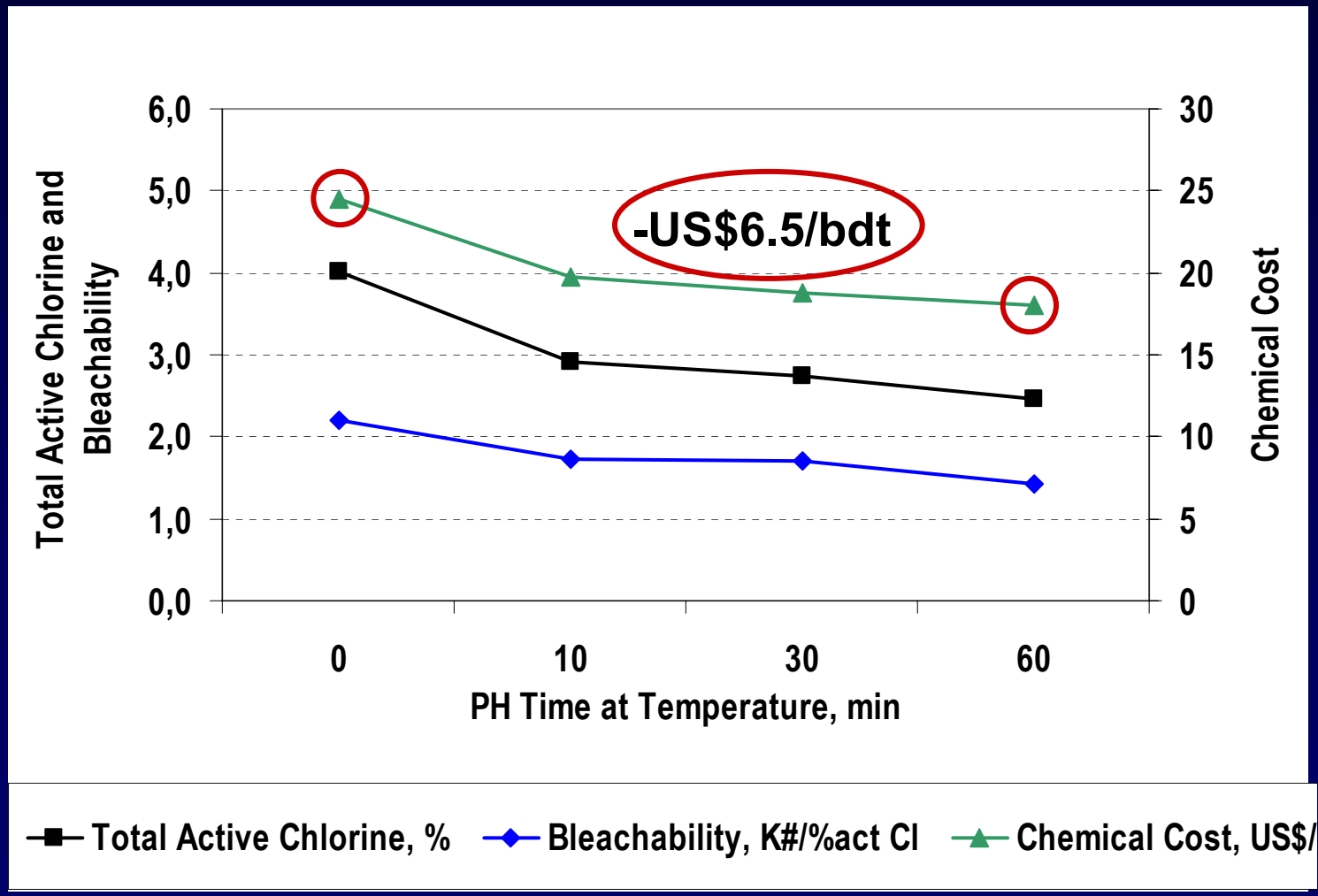


Results of Bleaching with the D_{HT}(PO)DP Sequence

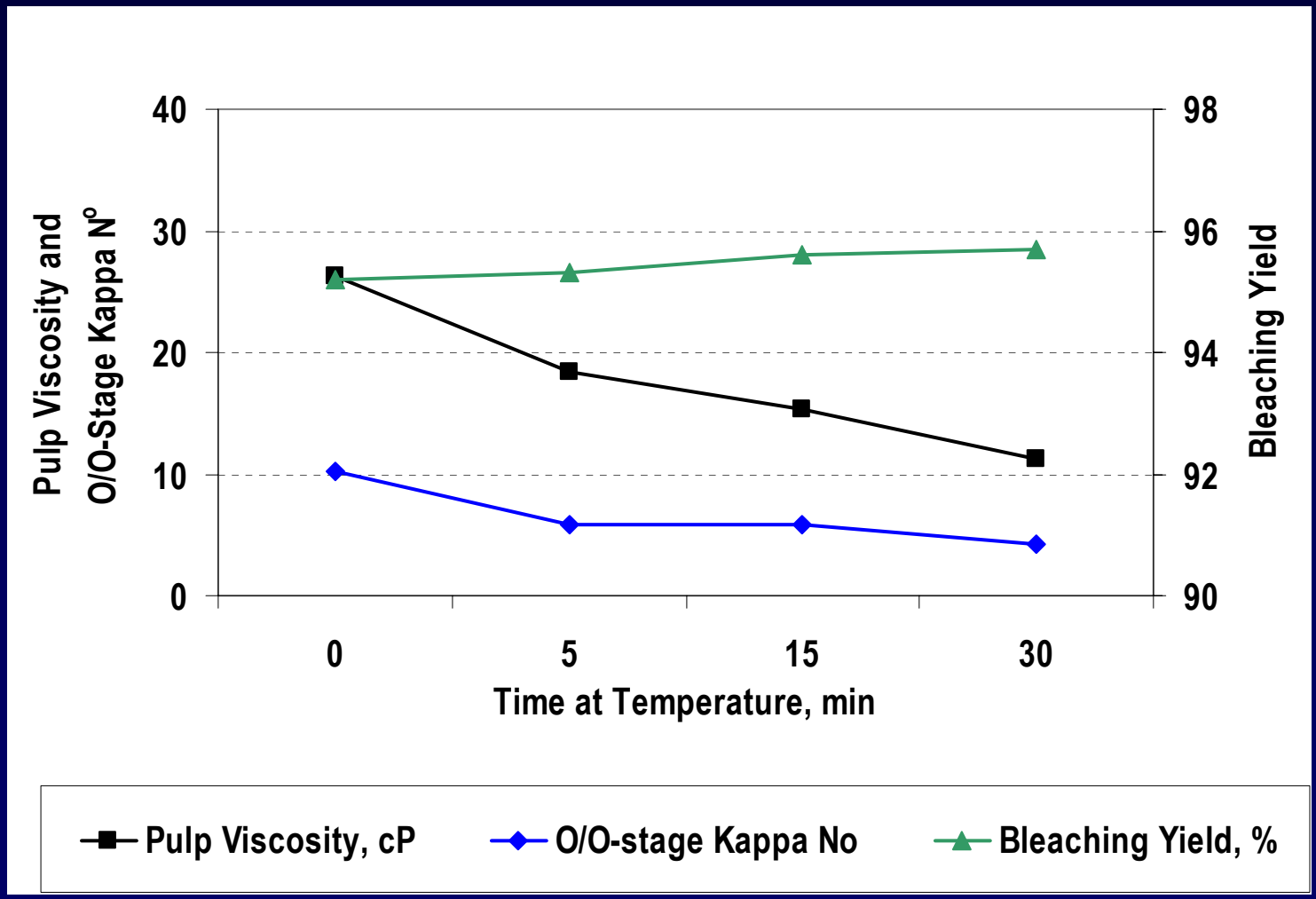
General Bleaching Conditions

Stage	Const., %	Time, min	Temp., °C	Pressure, bar	End pH
D_{HT}	10	120	95	-	2.8
(PO)	10	120	90	500	10.5
D	10	120	85	-	4.5
P	10	120	85	-	10.5

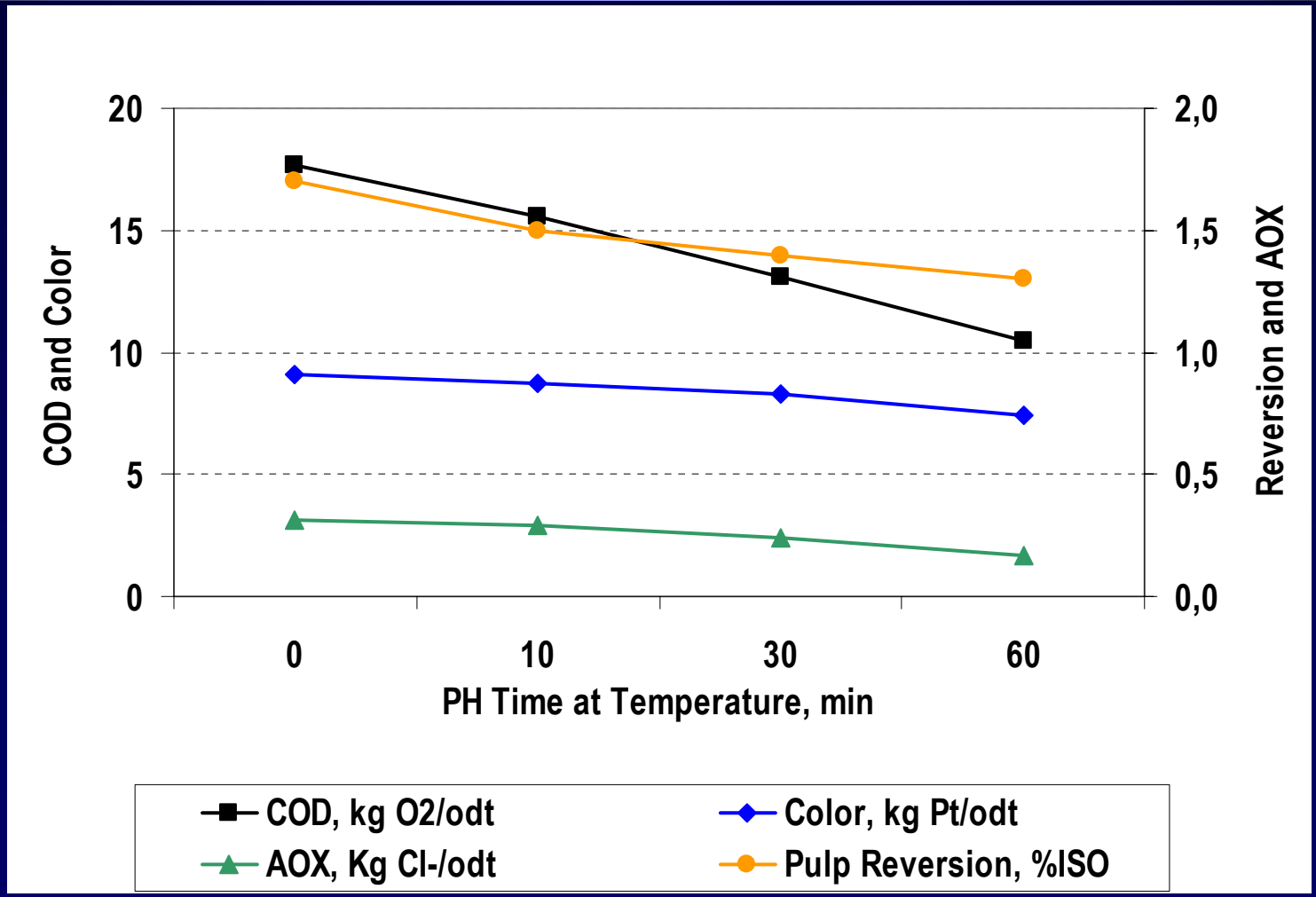
Bleaching Results (90% ISO brightness)

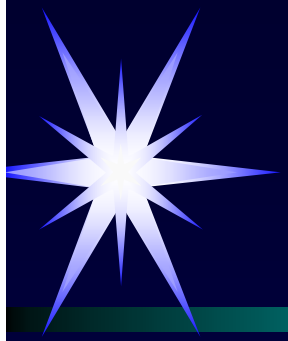


Bleaching Results (90% ISO brightness)



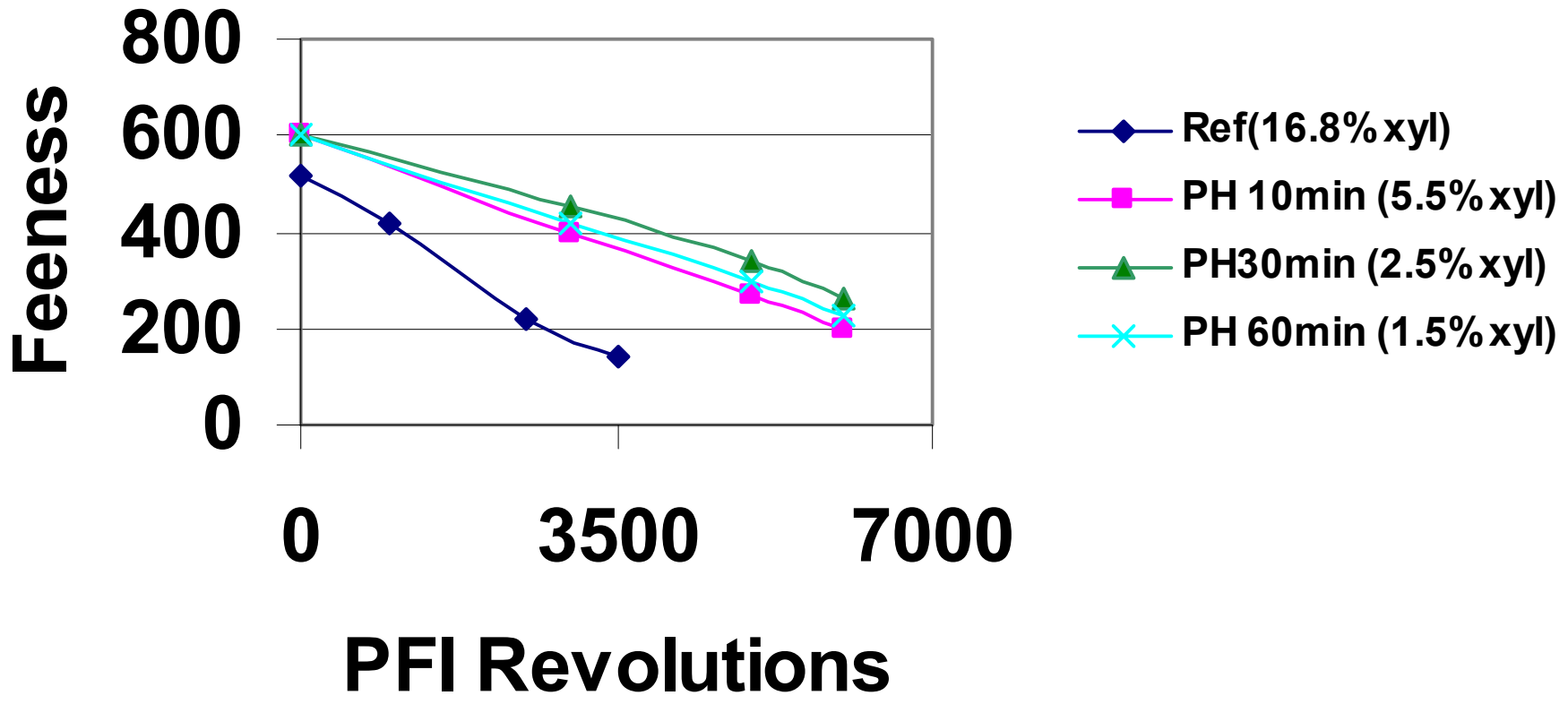
Effluent Load and Pulp Reversion (90% ISO brightness)



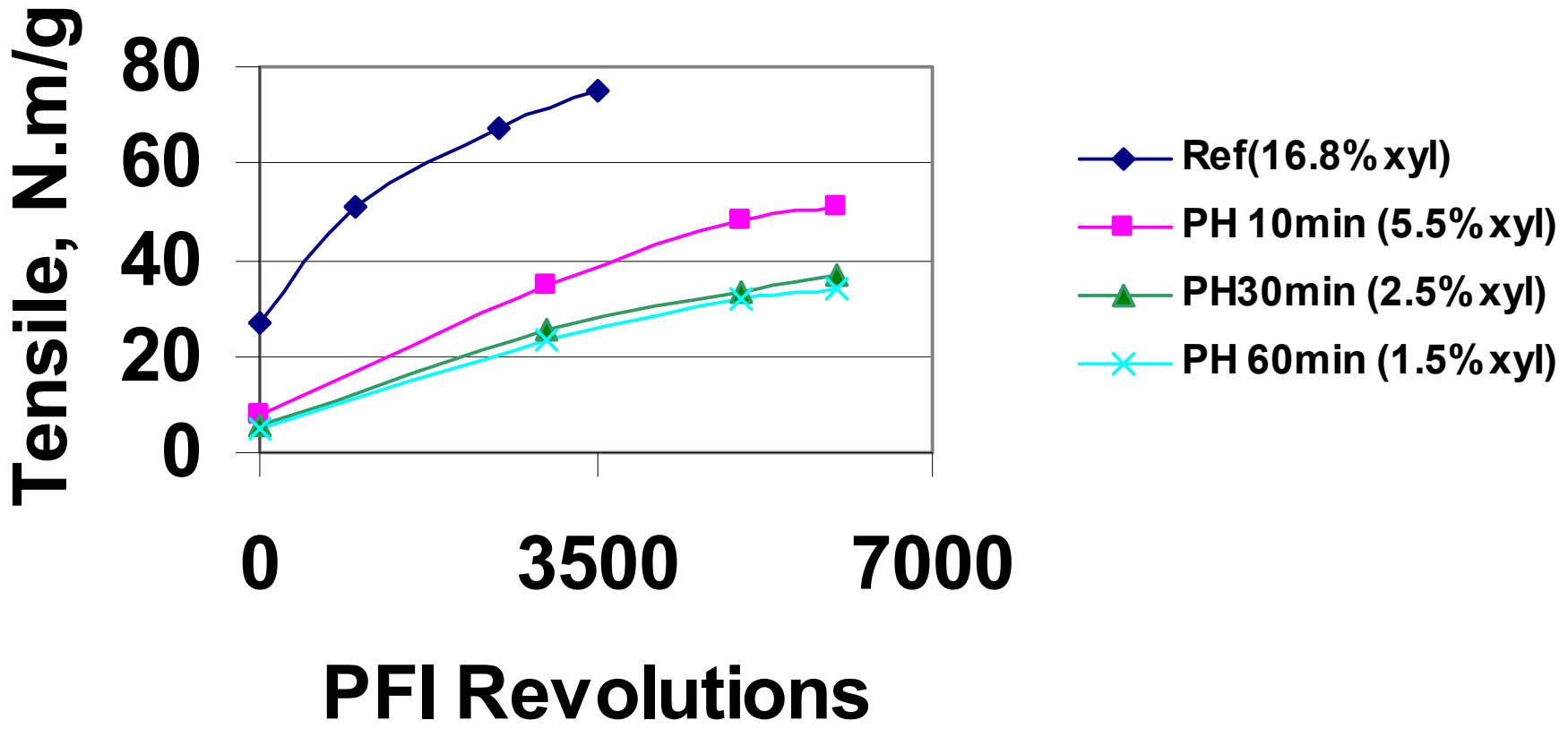


Pulp Refinability and Properties

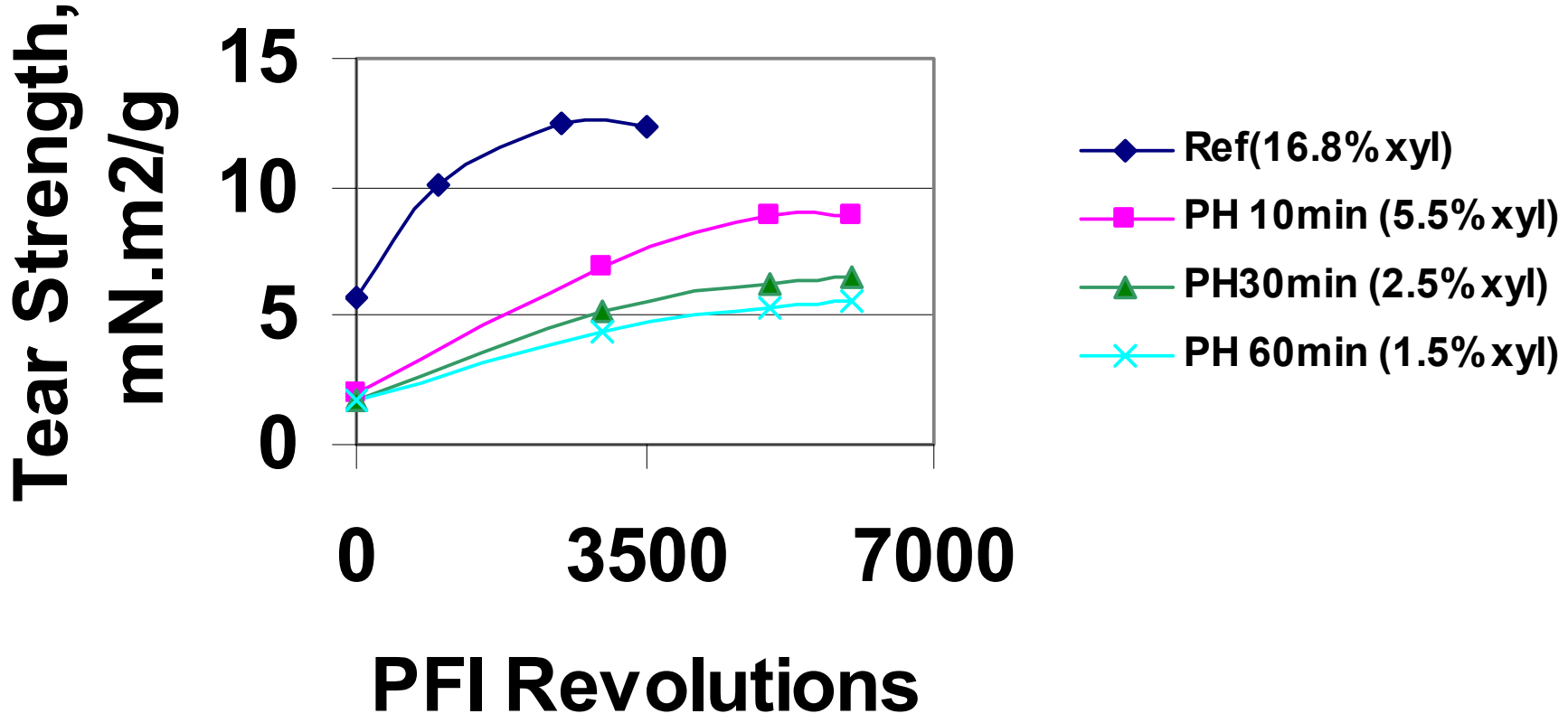
Refinability



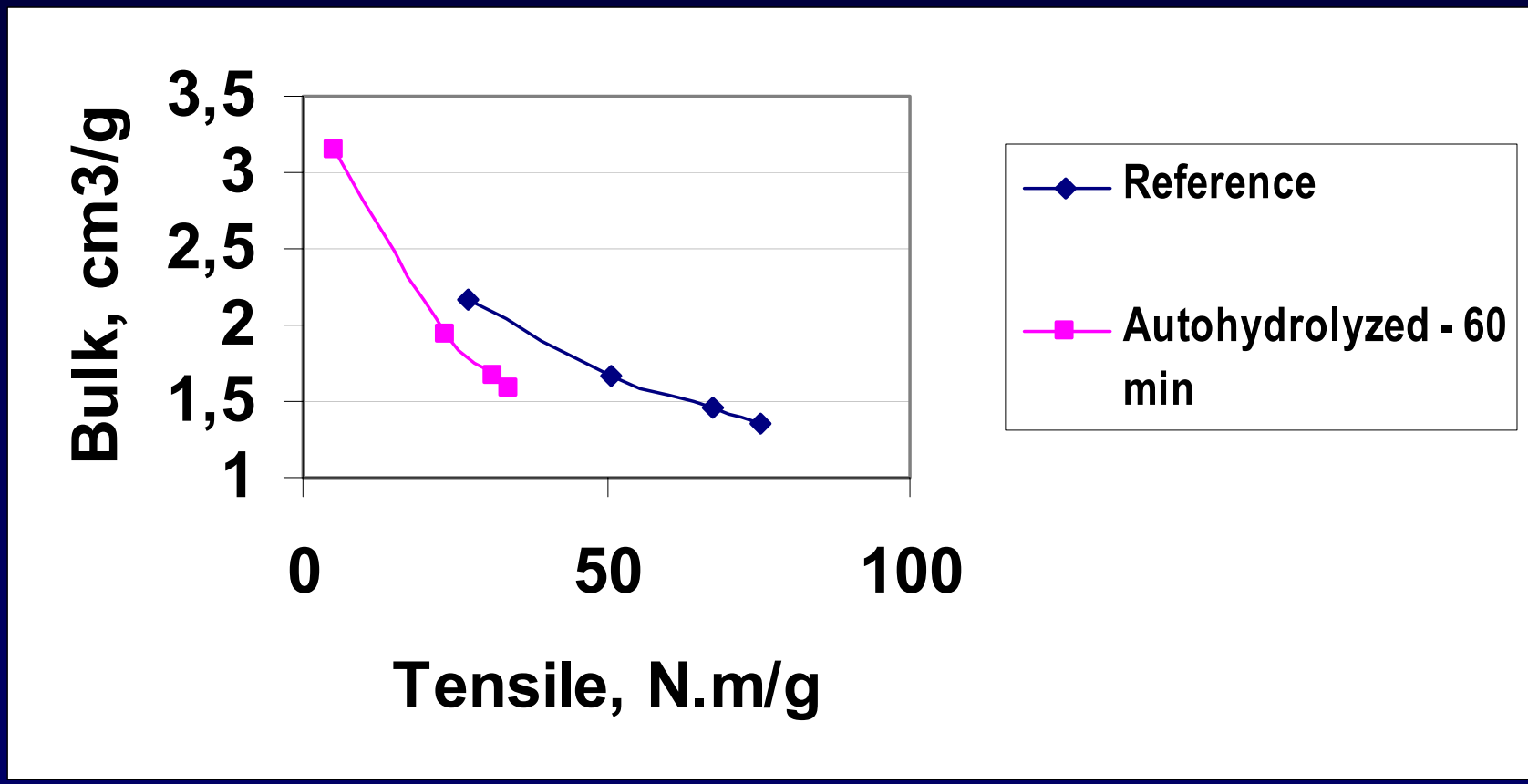
Tensile Strength



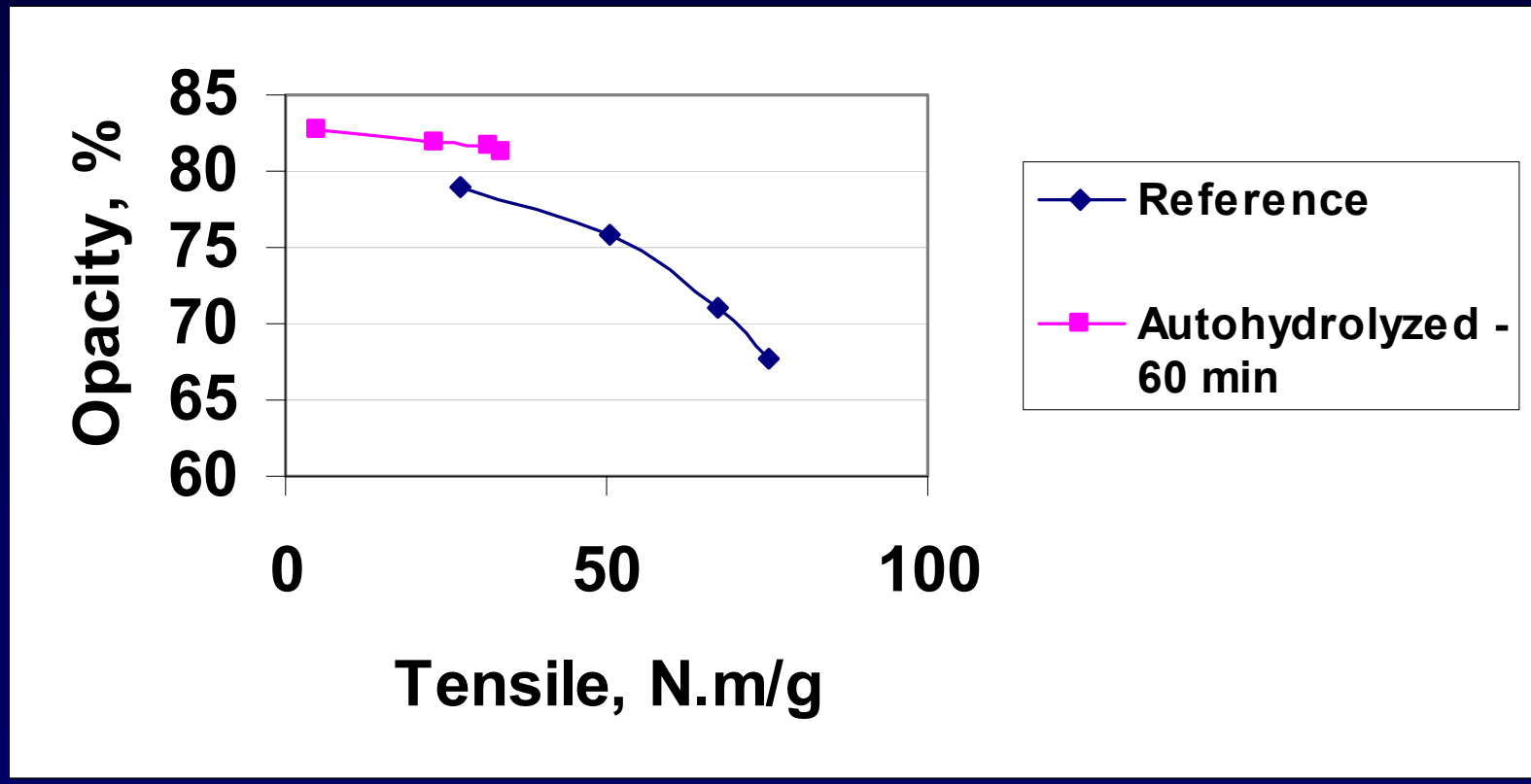
Tear Strength



Bulk


Bulk, cm3/g
3,5
3
2,5
2
1,5
1
0
50
100
Tensile, N.m/g
Reference
Autohydrolyzed - 60 min

Opacity


Opacity, %
85
80
75
70
65
60
0
50
100
Tensile, N.m/g
Reference
Autohydrolyzed - 60 min

Concentration Issues

- Distillation process at end of ethanol fermentation requires energy
- Minimum ethanol concentration desired = 3%
- Assuming 3.5 :1 liquor to wood ratio
- Assuming all 7.5% xylose removed is recovered
- Assuming conversion rate of 45% → 1% ethanol after fermentation (too low)

Conclusion

- Process is not viable due to low pulp quality / refinability and lousy ethanol recovery;
- For the Brazilian scenario, sugar cane is a much more viable feed stock.

Acknowledgements

- Federal University of Viçosa
- Brazilian Cientific Agency – CNPq
- Brazilian Industry Biorefinery Cluster