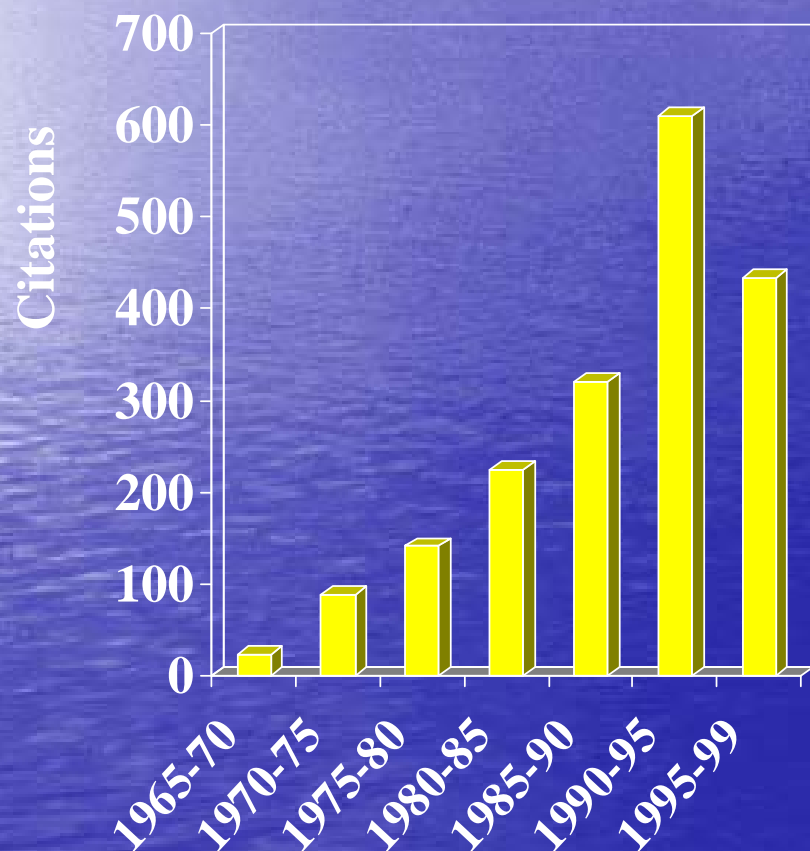


Improving Bleached Kraft Pulp Production via Integrated Kraft Pulping and O-Delignification Technologies

**Institute of Paper Science and Technology
Georgia Institute of Technology**

Oxygen Delignification: Background

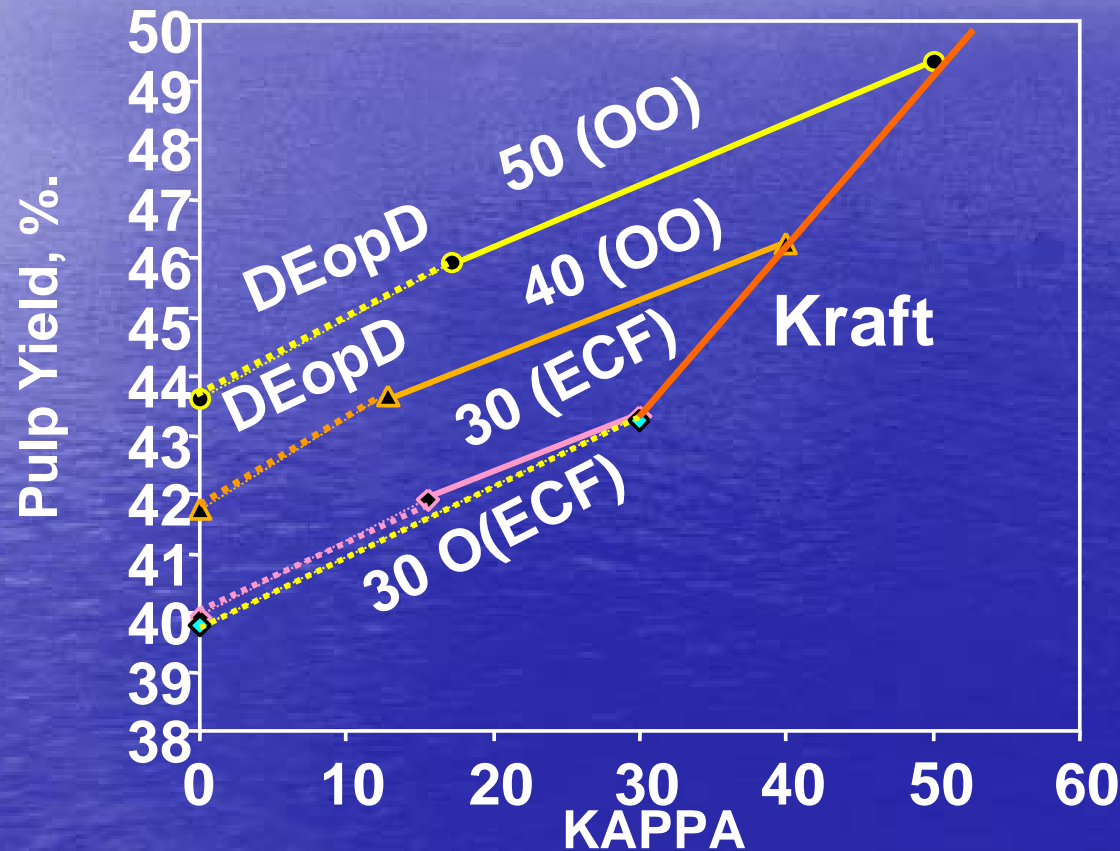


Literature

- 1960/70s
 - basic engineering & chemistry
- 1980/90s
 - process parameters, energy, environmental, pretreatments, fundamental chemistry, pulp properties
- 2000 -
 - yield, selectivity, process parameters, lignin/ carbohydrate chemistry, catalysts

Oxygen Delignification: Background

Increased interest in one and two-stage oxygen delignification



Benefits:

Improved extent of delignification

Increased pulp yield with respect to extend pulping

Reduced organic load to recovery furnace

High Selectivity Oxygen Delignification Experimental Conditions Results



High Selectivity Oxygen Delignification Kraft Cooking Conditions

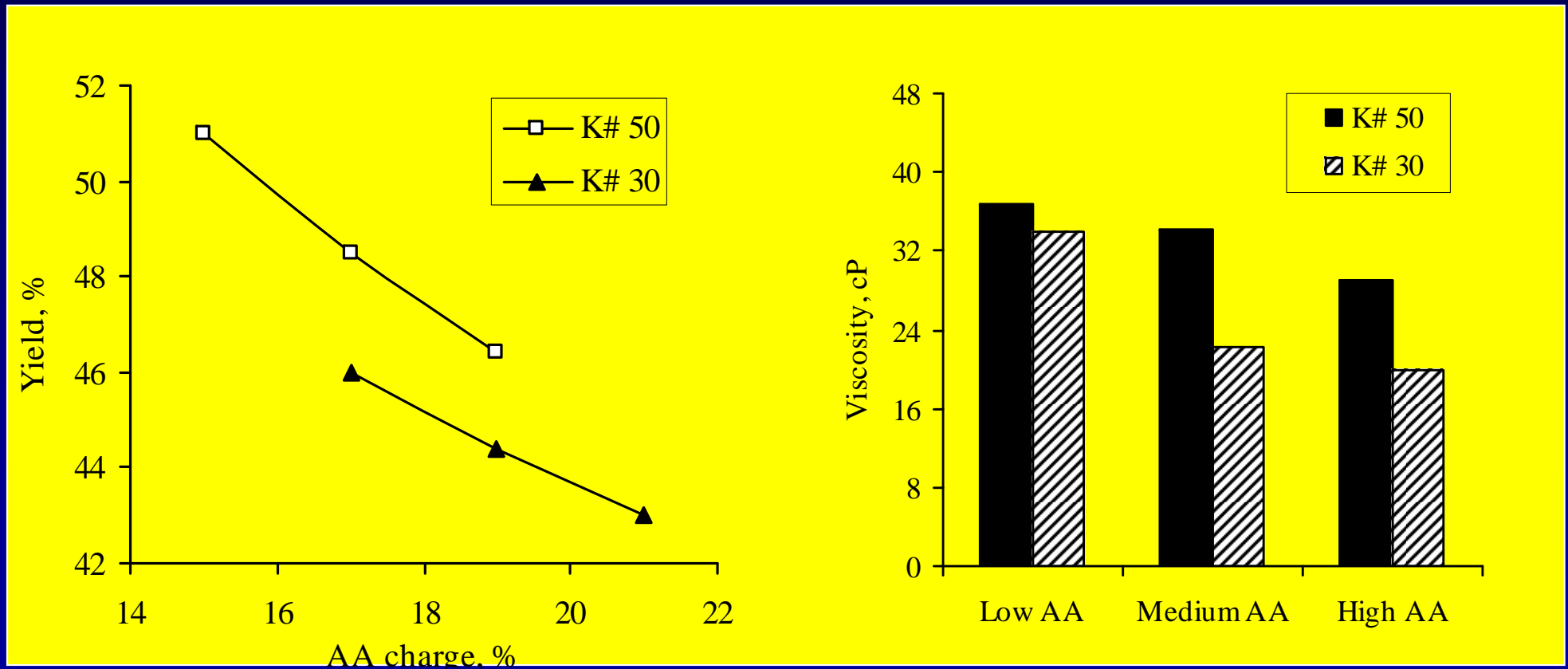
Softwood Kraft Pulping For Conventional and High Kappa Number Pulps*

| | Conventional kappa pulping | | | High kappa pulping | | |
|-----------|----------------------------|-----------|-------|--------------------|-----------|-------|
| | Active Alkali (AA) | H- Factor | Kappa | Active Alkali (AA) | H- Factor | Kappa |
| Low AA | 17% | 2200 | 30.0 | 15% | 1650 | 49.6 |
| Medium AA | 19% | 1800 | 30.2 | 17% | 1400 | 49.5 |
| High AA | 21% | 1250 | 30.1 | 19% | 1060 | 48.0 |

* M&K digesters, temp. 170 °C, sulfidity 25%, liquor/wood 4:1.

High Selectivity Oxygen Delignification Kraft Cooking Results

Softwood Kraft Pulps Conventional and High Kappa Number

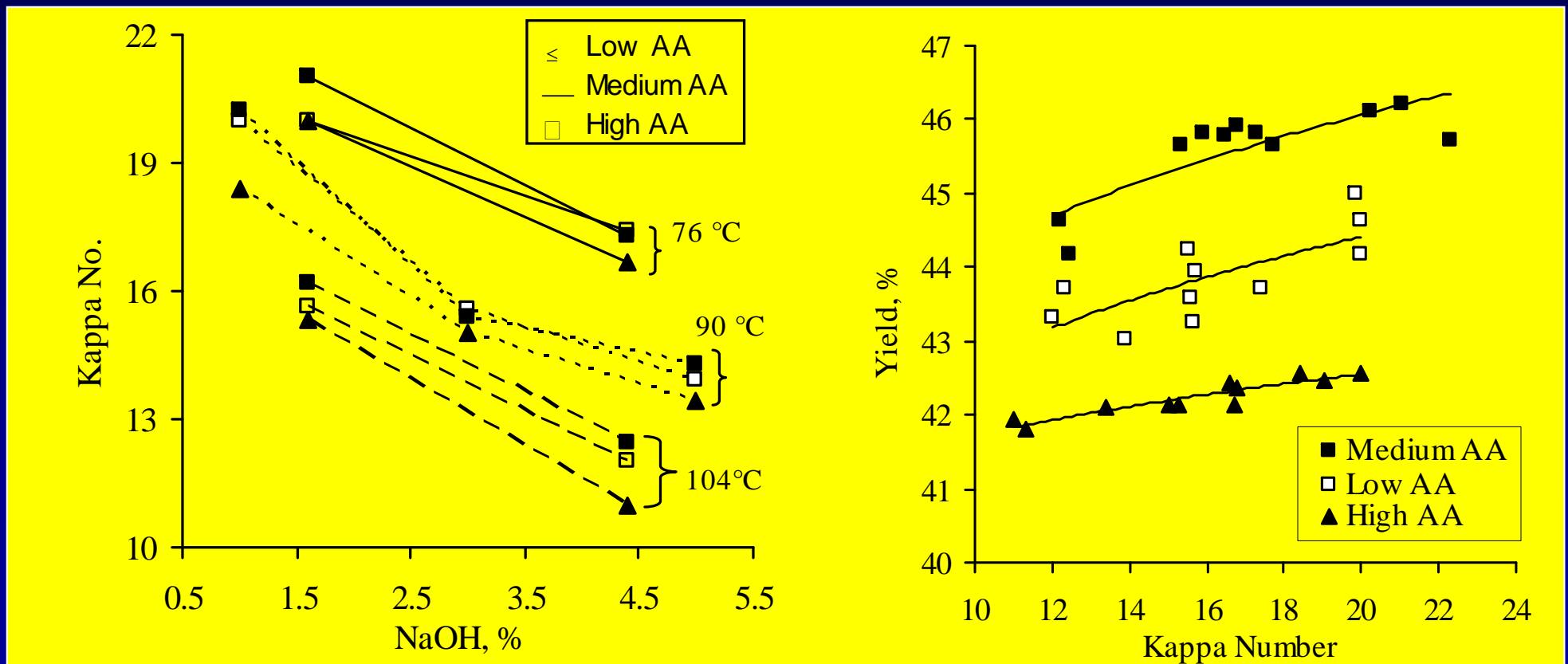


High kappa pulps: Higher yield/viscosity
Low AA: Improved yield/viscosity

High Selectivity Oxygen Delignification

Results:

O Conditions: SW Kraft Pulp, Kappa 30, O₂ Press: 40 psig, 0.05% MgSO₄, Med csc, Rxn Time: 60 min.

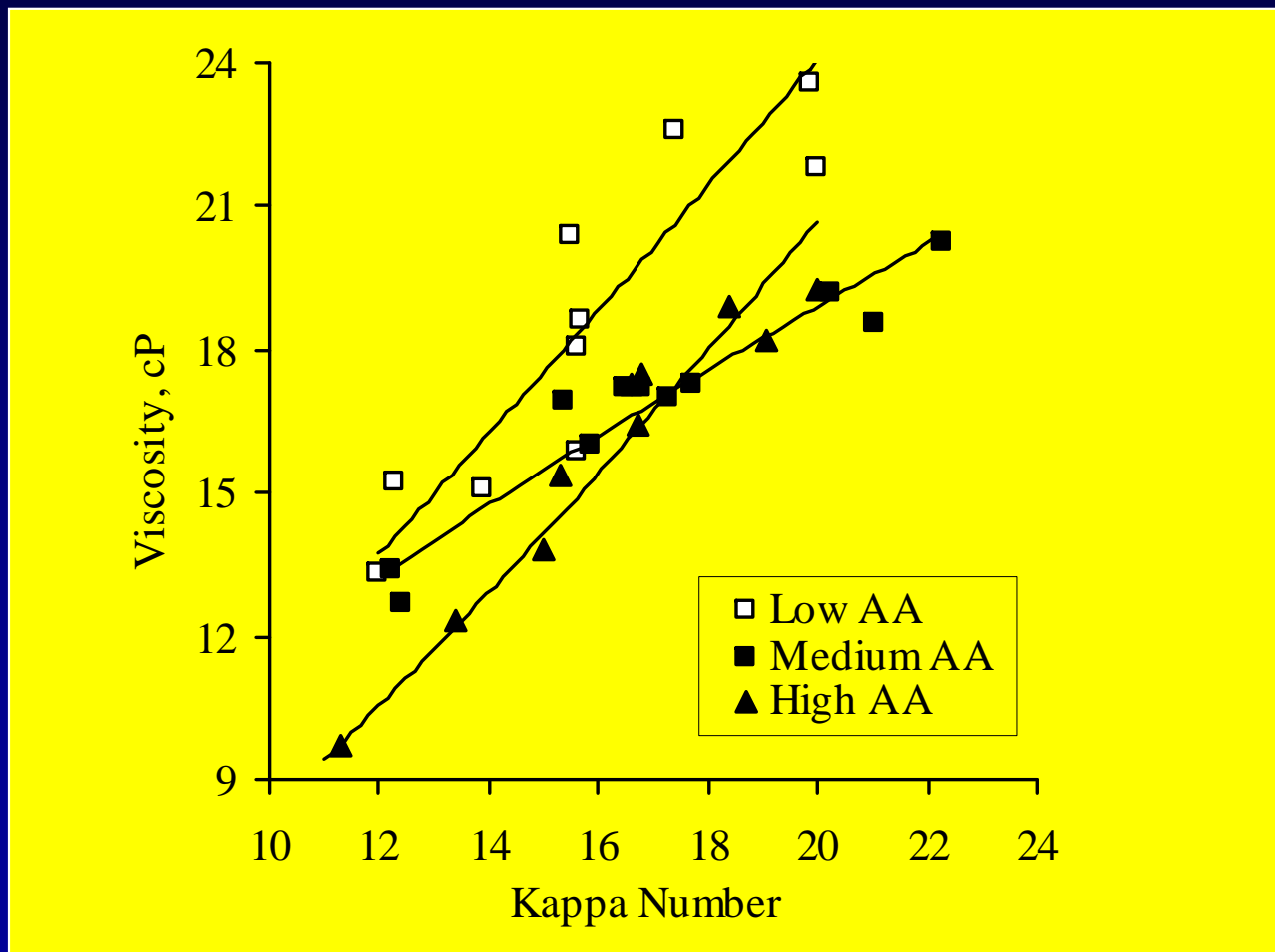


High AA Kraft Pulp More O-Bleachable at Various Temperatures
Medium AA Kraft Pulp Provides Improved Pulp Yields!

High Selectivity Oxygen Delignification

Results:

O Conditions: SW Kraft Pulp, Kappa 30, O₂ Press: 40 psig, 0.05% MgSO₄, Med csc, Rxn Time:60 min.

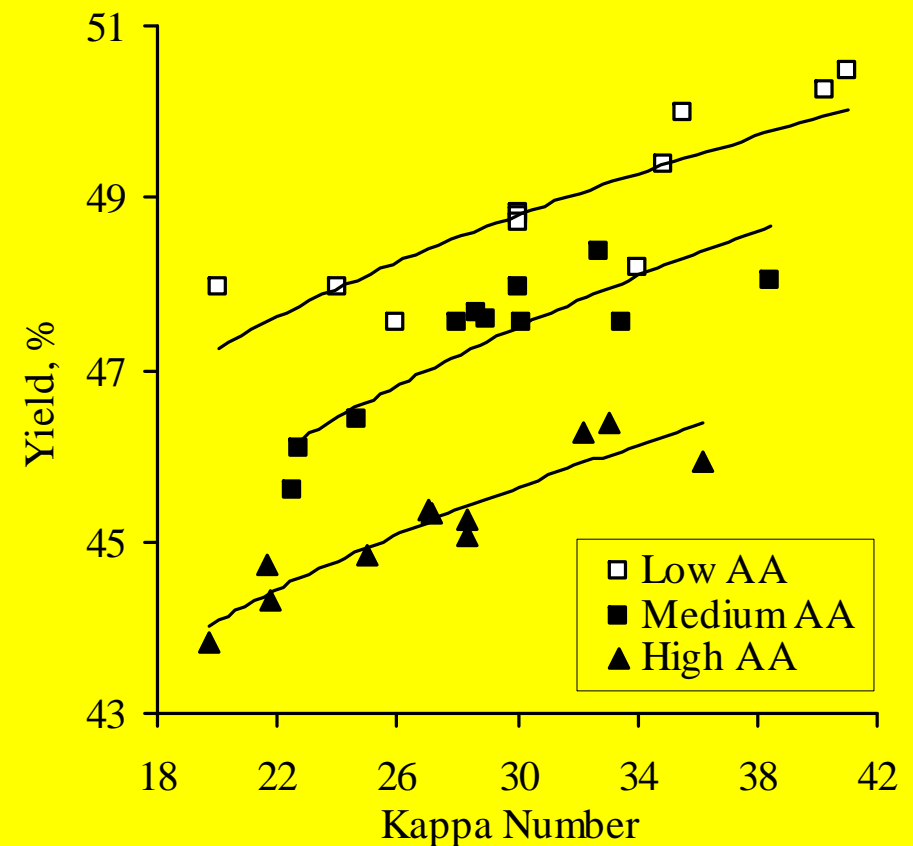
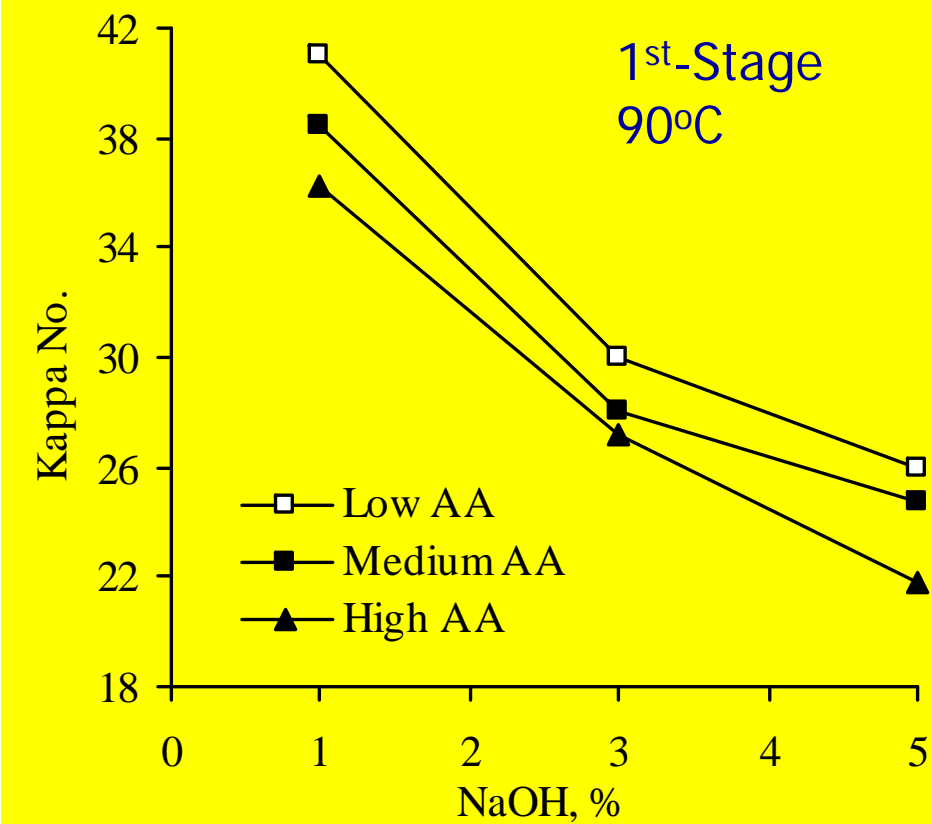


Post O viscosity results: LAA > Med. AA > HAA

High Selectivity Oxygen Delignification

Results:

OO Conditions: SW Kraft Pulp, Kappa 50, O₂ Press: 40 psig, 0.05% MgSO₄, Med csc, Rxn Time:60 min.



Post O viscosity results: Low AA Favored

High Selectivity Oxygen Delignification Kraft Cooking Conditions

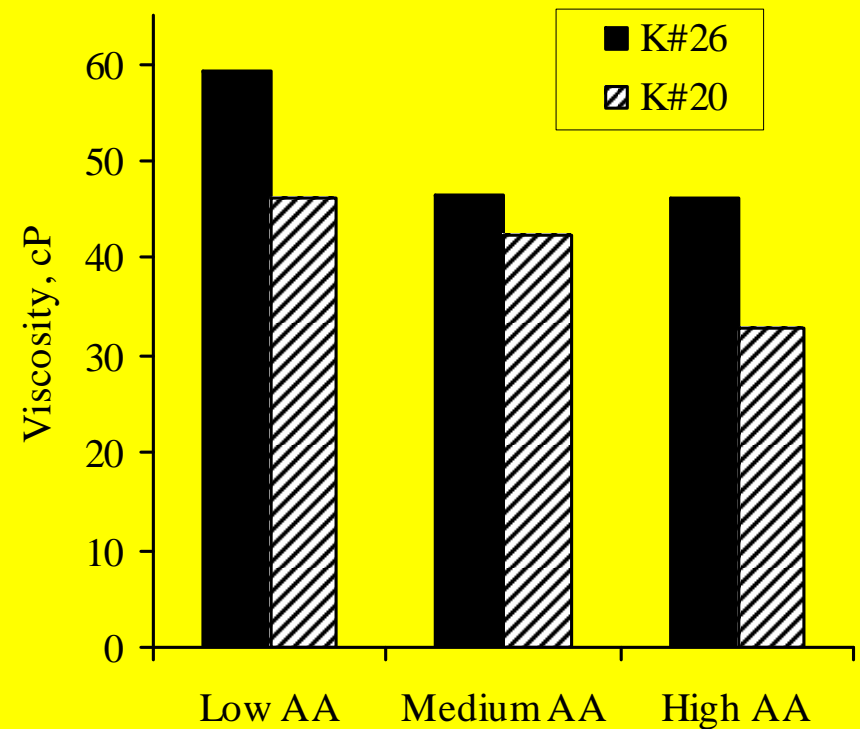
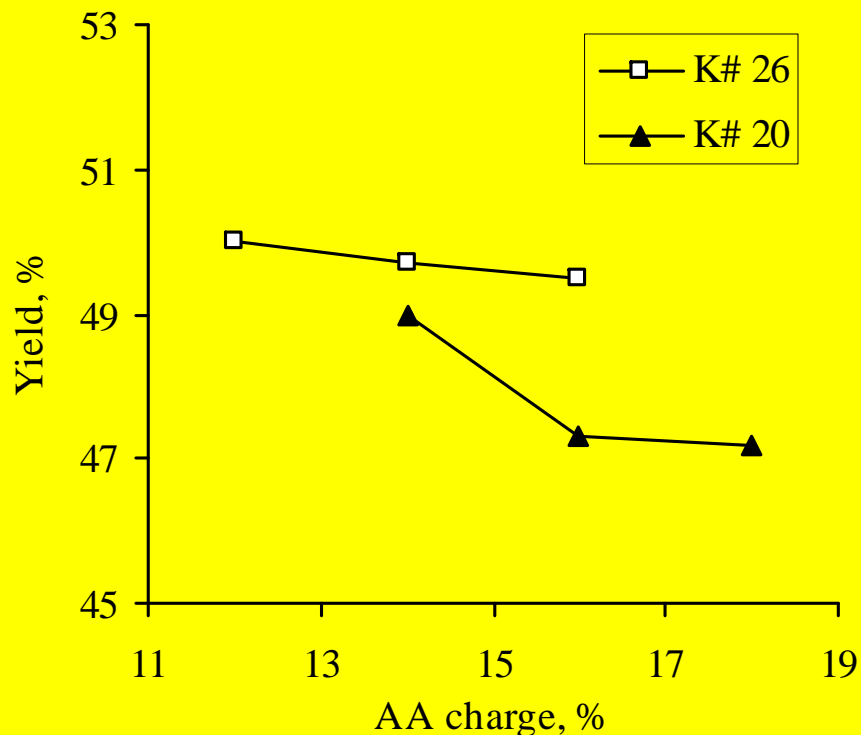
Hardwood Kraft Pulps Conventional and High Kappa Number

| | Conventional kappa pulping | | | High kappa pulping | | |
|-----------|----------------------------|-----------|-------|--------------------|-----------|-------|
| | Active Alkali (AA) | H- Factor | Kappa | Active Alkali (AA) | H- Factor | Kappa |
| Low AA | 14% | 1000 | 19.6 | 12% | 3600 | 26.8 |
| Medium AA | 16% | 650 | 19.3 | 14% | 900 | 24.2 |
| High AA | 18% | 500 | 19.9 | 16% | 550 | 26.5 |

* M&K digesters, temp. 170 °C, sulfidity 25%, liquor/wood 4:1.

High Selectivity Oxygen Delignification Kraft Cooking Results

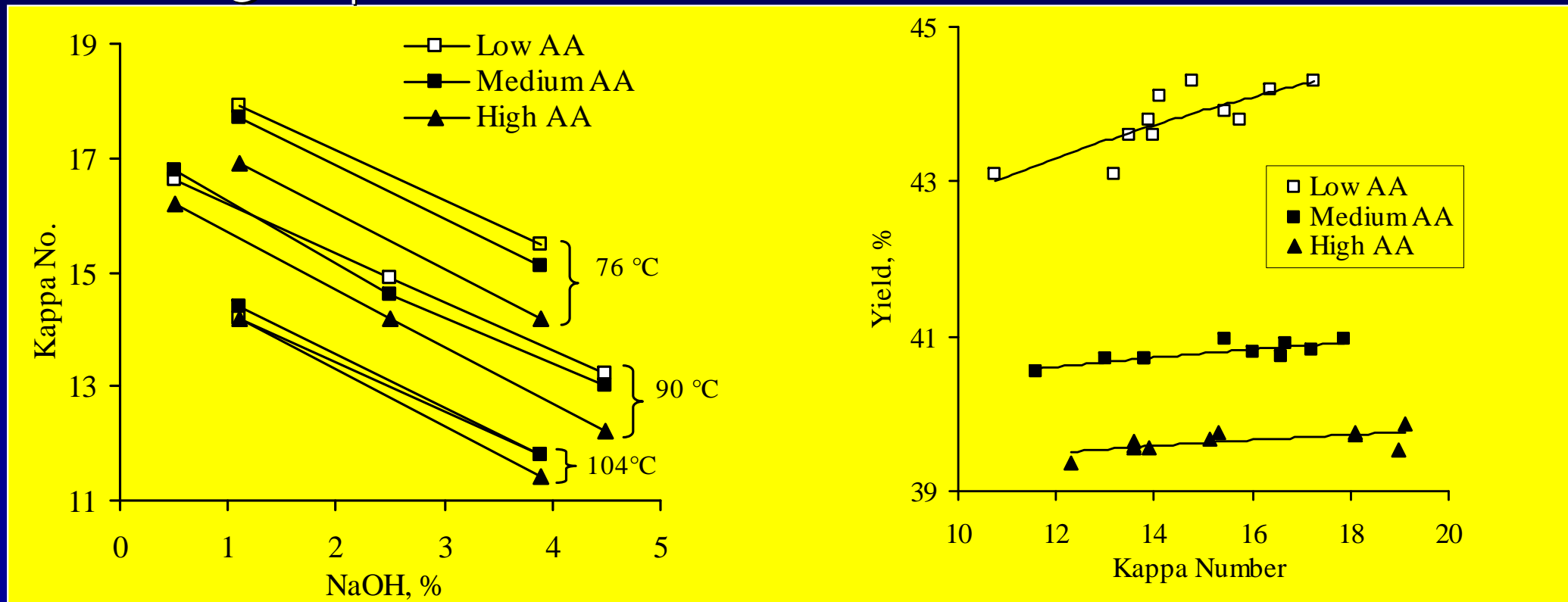
Hardwood Kraft Pulping For Conventional and High Kappa Number Pulps*



High kappa pulps: Higher yield/viscosity; Low AA: Improved yield/viscosity, *the improvement in total yield was not as significant as compared to SW*

High Selectivity Oxygen Delignification Results

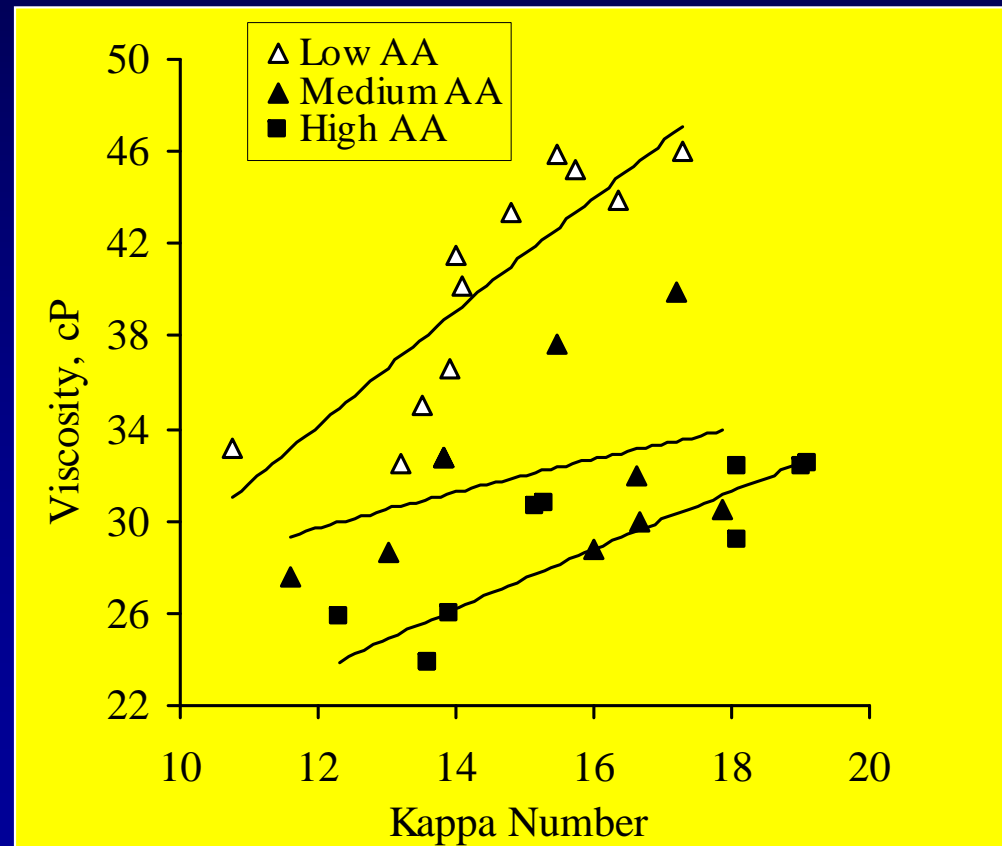
O Conditions: HW Kraft Pulp, Kappa 20, O₂ Press: 40 psig, 0.05% MgSO₄, Med csc, Rxn Time: 60 min.



High AA pulp exhibits improved O bleachability
Low AA: Improved O yield

High Selectivity Oxygen Delignification Results

O Conditions: HW Kraft Pulp, Kappa 20, O₂ Press: 40 psig, 0.05% MgSO₄, Med csc, Rxn Time: 60 min.



High AA pulp exhibits improved O bleachability

Low AA: Improved O viscosity

High Selectivity HW Oxygen Delign. Kraft Pulping Results

Kraft Pulping^a of Hardwood Employing Cooking Temperature 160 °C to 19 Kappa.

| Active Alkali (AA) | H Factor | Kappa # | Total Yield, % | Rejects, % |
|--------------------|----------|---------|----------------|------------|
| Low AA: 14% | 1050 | 19.0 | 50.2 | 0.70 |
| Medium AA: 16% | 650 | 18.5 | 48.4 | 0.90 |
| High AA: 18% | 500 | 19.0 | 47.4 | 1.40 |

Table 2: Kraft Pulping^a of Hardwood Employing a Cooking Temperature of 170 °C to 19 Kappa.

| Active Alkali (AA) | H Factor | Kappa # | Total Yield, % | Rejects, % |
|--------------------|----------|---------|----------------|------------|
| Low AA: 14% | 1000 | 19.6 | 50.0 | 1.0 |
| Medium AA: 16% | 650 | 19.3 | 48.2 | 1.1 |
| High AA: 18% | 500 | 19.9 | 47.3 | 1.5 |

High Selectivity HW Oxygen Delignification 160° vs. 170° C

Oxygen Delignification^a of 19 Kappa HW Kraft Pulps (Kraft Cooking Temp: 160 °C)

| Active Alkali (AA) | Kappa # | Rejects, % | Screen Yield, % | Overall Yield, % |
|--------------------|---------|------------|-----------------|------------------|
| Low AA: 14% | 14.6 | 0.5 | 90.1 | 45.5 |
| Medium AA: 16% | 14.2 | 0.7 | 91.2 | 44.5 |
| High AA: 18% | 14.0 | 1.0 | 92.1 | 44.0 |

Oxygen Delignification^a of 19 Kappa HW Kraft Pulps (Kraft Cooking Temp: 170 °C)

| Active Alkali (AA) | Kappa | Rejects, % | Screen Yield, % | Overall Yield, % |
|--------------------|-------|------------|-----------------|------------------|
| Low AA: 14% | 14.9 | 0.4 | 89.0 | 44.7 |
| Medium AA: 16% | 14.6 | 0.6 | 90.0 | 43.7 |
| High AA: 18% | 14.2 | -- | 91.2 | 43.8 |

High Selectivity HW Oxygen Delig. Kraft Pulping High Kappa

Kraft Pulping of Hardwood Employing Cooking Temperature 160 °C to 25 Kappa.

| Active Alkali (AA) | H Factor | Kappa # | Total Yield, % | Rejects, % |
|---------------------------|-----------------|----------------|-----------------------|-------------------|
| Low AA: 12% | 2500 | 25.0 | 52.4 | 3.0 |
| Medium AA: 14% | 900 | 25.0 | 51.9 | 4.2 |
| High AA: 16% | 550 | 26.0 | 51.8 | 5.2 |

Kraft Pulping of Hardwood Employing a Cooking Temperature of 170 °C to ca. 25 Kappa.

| Active Alkali (AA) | H Factor | Kappa # | Total Yield,% | Rejects, % |
|---------------------------|-----------------|----------------|----------------------|-------------------|
| Low AA: 12% | 3600 | 26.8 | 50.0 | 4.9 |
| Medium AA: 14% | 900 | 24.2 | 49.7 | 5.5 |
| High AA: 16% | 550 | 26.5 | 49.6 | 5.8 |

High Selectivity HW Oxygen Delignification

First Stage of OwO Delignification^a of High Kappa HW Kraft Pulps Prepared at 160 °C

| Active Alkali (AA) | Kappa # | Rejects, % | Screen Yield, % | Overall Yield, % |
|---------------------------|----------------|-------------------|------------------------|-------------------------|
| Low AA: 12% | 16.1 | 1.4 | 91.1 | 47.2 |
| Medium AA: 14% | 15.8 | 2.8 | 90.8 | 45.8 |
| High AA: 16% | 15.2 | 3.6 | 91.0 | 44.5 |

First Stage of OwO Delignification^a of High Kappa HW Kraft Pulps Prepared at 170 °C

| Active Alkali (AA) | Kappa | Rejects, % | Screen Yield, % | Overall Yield, % |
|---------------------------|--------------|-------------------|------------------------|-------------------------|
| Low AA: 12% | 16.0 | 3.1 | 91.4 | 44.2 |
| Medium AA: 14% | 15.8 | 3.8 | 90.3 | 43.0 |
| High AA: 16% | 15.3 | 4.5 | 90.4 | 42.6 |

High Selectivity HW Oxygen Delignification

2nd Stage of OwO Oxygen Delignification^a of High Kappa HW Kraft Pulps Prepared at 160 °C

| Active Alkali (AA) | Kappa # | Overall Yield, % |
|--------------------|---------|------------------|
| Low AA: 12% | 10.6 | 45.8 |
| Medium AA: 14% | 11.8 | 45.2 |
| High AA: 16% | 11.7 | 44.1 |

2nd Stage of OwO Oxygen Delignification^a of High Kappa HW Kraft Pulps Prepared at 170 °C

| Active Alkali (AA) | Kappa | Overall Yield, % |
|--------------------|-------|------------------|
| Low AA: 12% | 11.0 | 43.6 |
| Medium AA: 14% | 12.1 | 42.5 |
| High AA: 16% | 12.0 | 42.2 |



Conclusions

High Selectivity Oxygen Delignification

Conclusions



Practical variations in digester control have a tremendous impact on the oxygen bleachability of conventional kappa and high-kappa softwood kraft pulps, and on conventional hardwood pulp

Low AA softwood kappa #30 pulp has an average improvement of 2% in yield and 4 cP in viscosity in comparison to high AA pulp for the oxygen delignification

As well, an average improvement of ~3% in yield and 3 cP in viscosity for low AA high kappa #50 pulp post oxygen delignification

Low AA hardwood kappa #20 pulp had an average improvement of ~4% in yield and 6~12 cP in viscosity compared to high AA pulp post oxygen delignification



Acknowledgements

IPST Member Companies
U.S. Department of Energy

arthur.ragauskas@gatech.ipst.edu

Upcoming Bleaching Event

2005 International Pulp Bleaching Conference Stockholm June 14-16, 2005

- Demands on bleach pulp
- Impact of bleaching on Pulp
- Effect of cooking, O-delignification and washing on process costs and bleaching performance
- Low-cost mill conversions to address environmental regulations
- Recent mill/research bleaching advances
- Bleach plant filtrate recycle control and deposits avoidance
- Additional Topics

Extended Abstract Due Sept 1, 2004

Final Manuscript March 1, 2005

More Info: [Peter Axegard/Program Chair – peter.axegard@strfi.se](mailto:peter.axegard@strfi.se)

Program Committee: Richard Berry, Torbjorn Brattberg, Christina Chirat, Jorge Colodette, Agneta Fuhrmann, Makoto Iwasaki, Art Ragauskas, Tadas Macas.....



Thank You

Questions