Optimizing ECF Bleaching Technologies with a Mini-O
Oxygen Delignification

Chemical Usage of North American Bleach Plants

Improved environmental and operating cost performance
O Delignification: Background

Literature
- 1960/70s
  - basic engineering & chemistry
- 1980/early 90s
  - process parameters, energy, environmental, pretreatments, fundamental chemistry, pulp properties
- Late 1990’s
  - yield, selectivity, process parameters, lignin/carbohydrate chemistry, catalysts
Oxygen Delignification

Increased interest in one and two-stage oxygen delignification
An Alternative Approach

- **Mini-O**
  - Removes less lignin
  - Less capital
  - Easily retrofitted

- **Enhanced Mini-O**
  - Greater lignin removal
  - Multiple stages
  - $\text{H}_2\text{O}_2$ and/or $\text{ClO}_2$
Mill Application

- McKenzie
  - Cook to normal target
    - Reduce lignin with $O_2$
    - Sodium hydroxide instead of oxidized white liquor

- Low AOX pulps
  - No production loss
  - No recovery bottleneck
  - 25% delignification
Recent Studies

- Compared O systems
  - O, OO, mini-O

- Split the caustic charge in a \((E+O)D(E+O)\)

- Delignification
  - Lowest for mini-O
    - 13-25%, depending on caustic addition
Recent Studies

- Viscosities
  - O vs. (E+O)D(E+O)
    - Same delignification at 3.5% as O at 1.5%
  - Improved viscosity
(E+O)
(E+O+P)
(E+O)D(E+O)*
Delignification Results
Mini-O Delignification Studies

Research Objective

- Examine impact of carryover
- 26.3 Kappa SW kraft
- Determine
  - Physical properties
  - Selectivity
- Contribute to future mini O-delignification road map to improve performance
### Mini-O Delignification: Experimental Design

#### Bleaching Sequences
- $(E+O)(E+O)$
- $D(E+O)$
- $(E+O)D(E+O)$
- $D(E+O)(E+O)$

#### BL Carryover
- No carryover
- 2 kg/ton
- 10 kg/ton
## Experimental Conditions

<table>
<thead>
<tr>
<th>Stage</th>
<th>O-Press./psi</th>
<th>% NaOH</th>
<th>Temp./°C</th>
<th>Time/min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(E+O)</td>
<td>90</td>
<td>1.25</td>
<td>80</td>
<td>20</td>
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10% consistency

MgSO₄: 0.10%
Impact of Carryover

- Carryover decreases delignification
- Increased levels
  - Decreased response
- Splitting (E+O)
  - Improved response
Impact of Carryover

- Viscosity loss
  - Increases as function of carryover

- Carryover
  - May introduce transition metals

- Placement of (E+O)
  - Affects viscosity loss
Impact of Carryover

- Selectivity
  - Decreases as function of carryover

- Carryover
  - May introduce transition metals

- Placement of (E+O)
  - Affects selectivity
Mini-O with $\text{H}_2\text{O}_2$ Studies

Research Objective

- Examine impact of carryover
- Three SW kraft pulps
  - 26.3 Kappa pre-$\text{O}_2$
  - 24.3 Kappa pre-$\text{O}_2$
  - 8.9 Kappa post-$\text{O}_2$
- Determine
  - Physical properties
  - Selectivity
- Contribute to future mini O-delignification road map to minimize capital and enhance performance
# Mini-O with H₂O₂ Delignification: Experimental Design

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<tr>
<td>• O</td>
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<td>• Pre-Oxygen</td>
</tr>
<tr>
<td>• (E+O)<em>D(E+O)</em></td>
<td>– 24.2 kappa</td>
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<tr>
<td>• D(E+O)<em>(E+O)</em></td>
<td>• Post-Oxygen</td>
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10% consistency  
BL carryover: 10 kg/ton 
$H_2O_2: 0.5\%$  
$MgSO_4: 0.10\%$
Mini-O Reinforced with H₂O₂

- Carryover at 10 kg/ton
  - Decreased response

- Pre-O₂ vs. Post-O₂
  - Decreased response in post-O₂

- Delig. Response
  - Proportional to H₂O₂

- (EO)*D₀.05(EO)*
Mini-O Reinforced with H$_2$O$_2$

- **Carryover at 10 kg/ton**
  - Generally decreases viscosity loss

- **Pre-O$_2$ vs. Post-O$_2$**
  - Greater loss for pre-O$_2$ pulp

- **Increased H$_2$O$_2$**
  - Increased viscosity loss
Mini-O Reinforced with H$_2$O$_2$

- Carryover at 10 kg/ton
  - Generally decreases selectivity

- Pre-O$_2$ vs. Post-O$_2$
  - Greater selectivity for pre-O$_2$ pulp
Mini-O Reinforced with H₂O₂

- Carryover at 10 kg/ton
  - Generally decreases brightness response

- (EO) vs. (EOP)
  - Exiting bleaching stage

Diagram showing % Brightness Gain with different conditions:
- D0.20(EOP)
- D0.20(EO)
- (EOP)/0.05/EOP
- (EO)/0.05/EOP
- D0.05(EOP)
- D0.05(EO)

Legend:
- Pre-O2
- Post-O2 with c/o
- Pre-O2 with c/o
Conclusions
Mini-O Delignification: Implications

- Promising technology
- Benefits of enhanced poor man’s O
- Superior performance with pre-$\text{O}_2$ pulps when compared to post-$\text{O}_2$ pulps
- $\text{H}_2\text{O}_2$ in last stage of $(\text{EO})^*\text{D}(\text{EO})^*$
  - Increased bleaching performance