Study on the hydrogen peroxide in paper fibre bleaching: model construction and verification

Giorgio Tofani¹, I. Cornet¹, S. Tavernier¹
¹Biochemical Green Engineering and Materials (BioGEM), University of Antwerp, Faculty of Applied Engineering, Antwerp, Belgium
E-mail: giorgio.tofani@uantwerpen.be

Problem Statement
• Paper for recycling is composed of different fibres with dissimilar reactivity to the bleaching.
• Wood pulped fibre types: chemical (pulped using chemicals), mechanical (pulped using rotating discs at high T/P) or semi-mechanical (combination of chemical and mechanical pulping).
• Target: evaluate the prediction of ISO Brightness after bleaching by hydrogen peroxide of cellulose fibre mixtures.

Methodology of bleaching by $\text{H}_2\text{O}_2$
• Part 1, Screening: virgin fibres of Kraft (unbleached chemical pulp), TMP (thermo-mechanical pulp), CTMP (chemo-thermo mechanical pulp) and Bleached (bleached chemical pulp). 50% $\text{H}_2\text{O}_2$ on dry mass of fibres. Variables: number of additions - reaction time;
• Part 2, Model bleaching: best bleaching sequence (part 1) on 30 model samples with known virgin fibre composition.
• Part 3, Real-life sample bleaching: industrial samples with known composition were bleached using same “best” bleaching sequence.

Part 1, Screening

![Figure 1: ISO Brightness before and after bleaching sequences of virgin fibres; P50: H$_2$O$_2$ addition, 50% w/w oven dried fibres (odf), P25x2: H$_2$O$_2$ addition 25% w/w odf for two times, P10x5: H$_2$O$_2$ addition, 10% w/w odf for five times](image)

The best compromise is the P10x5 sequence. The major improvement is observed on the Kraft fibres.

Part 2, Model bleaching

Multivariate linear regression ($Y=\beta_0+\beta_1X_1+\beta_2X_2+\beta_3X_3+\beta_4X_4$) for P10x5 sequence.

The independent variables were ratios of the virgin fibres and brightness as dependent variable.

<table>
<thead>
<tr>
<th>Step</th>
<th>R square</th>
<th>Intercept</th>
<th>Kraft ($X_1$)</th>
<th>TMP ($X_2$)</th>
<th>CTMP ($X_3$)</th>
<th>Bleached ($X_4$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start</td>
<td>0.932</td>
<td>74.051</td>
<td>-0.602</td>
<td>-0.156</td>
<td>-0.247</td>
<td>0.000</td>
</tr>
<tr>
<td>P10(1)</td>
<td>0.943</td>
<td>80.376</td>
<td>-0.581</td>
<td>-0.130</td>
<td>-0.166</td>
<td>0.000</td>
</tr>
<tr>
<td>P10(2)</td>
<td>0.952</td>
<td>84.925</td>
<td>-0.447</td>
<td>-0.150</td>
<td>-0.182</td>
<td>0.000</td>
</tr>
<tr>
<td>P10(3)</td>
<td>0.937</td>
<td>86.325</td>
<td>-0.336</td>
<td>-0.163</td>
<td>-0.166</td>
<td>0.000</td>
</tr>
<tr>
<td>P10(4)</td>
<td>0.915</td>
<td>88.244</td>
<td>-0.279</td>
<td>-0.195</td>
<td>-0.175</td>
<td>0.000</td>
</tr>
<tr>
<td>P10(5)</td>
<td>0.884</td>
<td>88.284</td>
<td>-0.213</td>
<td>-0.196</td>
<td>-0.185</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Correlations >0.88. Bleached fibres do not influence the bleaching. Instead, other three types of fibres have a negative effect on brightness.

Part 3, Real-life sample bleaching

![Figure 2: Comparison between predicted and measured ISO brightness for real-life samples](image)

The model covers the trendline but predicts higher values. There are variables not taken into account that influence negatively the bleaching.

Conclusion

The model is not exhaustive in predicting the bleaching of real-life samples.

Two possible causes:
1) Contaminants/additives not present in the model samples;
2) “Hornification” (Figure 3): the fibres are wet when repulped. When dried, peroxide cannot bleach the internal layers of the fibres.

![Figure 3: Representation of the hornification process. A: virgin fibre (cross section) is pulped; B: fibres during drying; C: dried fibre after recycling, completely collapsed](image)

1 S. Adamopoulos and J.V. Oliver, Wood and Fiber Science. 2006, 38(4), 567-575