

The Impact of Acidic Group Content and Location on the Beating Bonding Characteristics of Holocellulose Softwood Pulp (1997)

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The current industry trend is away from chlorine bleaching of chemical pulps and towards less selective bleaching agents such as ozone, peroxide, and oxygen. These bleaching agents can change the wet pulp and final sheet properties from those produced with chlorine or chlorine dioxide. Effective use of these pulps requires a fundamental understanding of how bleaching changes the pulp and sheet properties. Ozone, oxygen, and peroxide can directly oxidize the cellulose component of fibers and result in increased pulp carboxylic content. The effect of total acidic content on a pulp's ability to swell has long been known, as well as the subsequent impact on paper strength in the form of increased bonded area. There are also indications in the literature that acidic groups on fiber surfaces may impact specific bond strength. This current study sought to determine the impact of acidic group location on paper strength, both bonded area and specific bond strength. Practical implications of the study were examined through an investigation of a commercialized bleaching technology.

Distinct carboxylic distributions across fiber cell walls were artificially induced in both an ideal holopulp and a commercial bleached kraft pulp. A chloroacetic acid substitution technique was modified to produce the desired acidic group topochemistries. The modification involved controlling the state of fiber cell walls during the substitution reaction. If the fiber cell wall was in a collapsed state during the reaction, then surface carboxylic enrichment occurred. If the cell wall was in an expanded state, then substitution occurred across the entire cell wall. The level of substitution was controlled by both concentration of chloroacetic acid in the reaction medium and through in situ conversion of the chloroacetic acid to the more reactive iodoacetic acid form.

The topochemistry of acidic groups across fiber cell walls was confirmed by an SEM-EDS technique developed during this study. The novel aspects of this technique included "tagging" acidic groups with a tracer metal and using thin fiber cross sections in the SEM to increase spatial resolution. The x-ray peak to background ratios were determined for point scans across fiber cell walls. The peak to background ratios were taken to be proportional to metal, and thus carboxylic acid, concentration.

Three pulps were investigated; an ideal holopulp, a never dried commercial bleached kraft, and a dry lap bleached kraft. The first two pulps had distinct acidic group topochemistries induced with the chloroacetic acid substitution technique. The third pulp was subjected to various oxygen and peroxide bleaching conditions which simulated a commercial bleaching stage. These pulps were evaluated using established paper physics techniques to determine the impact on bonded area and specific bond strength. Pulps with artificially induced surface carboxylic enrichment showed improved strength properties attributed to an increase in fiber-to-fiber specific bond strength. Pulps with induced uniform carboxylic enrichment across the fiber cell walls displayed increased densification during wet pressing, but no increase in specific bond strength. The pulp bleached with oxygen or peroxide had an increase in carboxylic content across the stage. The bleached pulps also showed an increase in specific bond strength over the untreated control.

Distinct acidic group topochemistries can be induced in holopulp and kraft fibers, and the relative distribution of acidic groups can be confirmed. The spatial location of an acidic group in a fiber determines its effect on pulp and paper properties. Acidic groups on fiber surfaces act to increase specific bond strength. Oxygen and peroxide can increase the total acidic group content and measured specific bond strength in a bleached kraft pulp. This indicates that bleaching, at least with these agents, could be used to influence carboxylic content, and thus properties in the final sheet.