CHARACTERIZATION AND ENHANCEMENT OF CARBOXYL GROUPS IN SOFTWOOD KRAFT PULPS DURING OXYGEN DELIGNIFICATION (2006)

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Abstract: This study first examined the kinetic changes of fiber carboxyl group content in bulk fiber, polysaccharide, and residual lignin of oxygen delignified pulps during one-stage oxygen delignification of a low kappa (32.5) kraft pulp. The carboxyl group contents determined in different chemical components of oxygen delignified pulps were used to establish the distribution of carboxyl groups in lignin and pulp polysaccharide and decouple the responses from residual lignin and polysaccharide. Following this study, two high kappa (~ 49.0) SW kraft pulps prepared were delignified through two-stage oxygen delignification. Fiber carboxyl group profiles of these pulps were elucidated to investigate the effect of lignin content of incoming unbleached kraft pulps on fiber carboxyl group formation. Due to a limitation to enhance fiber carboxyl groups only by parameter optimization during one- and two-stage oxygen delignification, a catalytic oxidation program was developed to enhance fiber carboxyl group content by 52.2 – 116.0% employing 0.10 - 0.18% of a bismuth ruthenium pyrochlore oxide catalyst during oxygen delignification. The mechanism of fiber carboxyl group formation through the catalytic oxidation was proposed. The main factor on carboxyl group formation in pulp carbohydrate was identified to follow the order: NaOH > oxygen pressure> reaction temperature through a 3-factor at 3-level (L933) orthogonal experimental design and the optimal conditions were found at 2.5% NaOH, 85-100° C, and 800-960 kPa O_2 during the catalytic oxidation.

ECF bleaching study was also conducted on these pulps with higher amount of fiber carboxyl group enhanced at early pulping and oxygen delignification processes. The bleaching results demonstrated that the early-stage enhanced fiber carboxyl groups were partially retained through ECF bleaching. Additionally, fiber carboxyl groups of fully bleached kraft pulps were ~ 20% different from typical bleaching protocols, depending on bleaching chemicals used and the bleaching sequences such as DEDED, (D+C)EDED, ODEDD, and OQPZP. This study finally demonstrated that an increase of fiber carboxyl groups by 17.4-62.1% through chemical oxidation resulted in reduced fiber curl, increased fiber WRVs, 4.3-25.5 % increase in paper tensile index at comparable pulp viscosity; and 4.4 -30.1% increase in paper dry tensile stiffness.