TJ SUMMARIES

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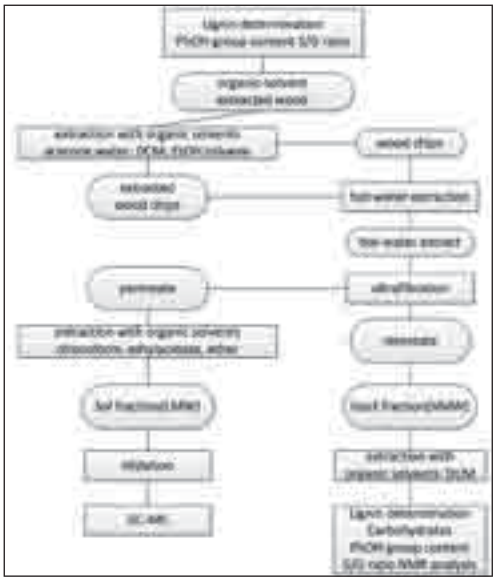
BIOREFINERY

Increasing the value of a biorefinery based on hot-water extraction: Lignin products

Biljana M. Bujanovic, Mangesh Goundalkar, and Thomas E. Amidon

A biorefinery based on hot-water extraction may produce a range of high-value products from lignin isolated from extracts of hardwoods, including carbon fibers, thermoplastics, and oxygenated aromatic compounds. Existing processes focus primarily on the quality of cellulose and result in a severely modified and contaminated lignin of relatively low value. Lignin produced in more flexible biorefinery operations is more uniform and less contaminated than currently available industrial lignins, opening the door for broader applications of lignin and lignin products. The results of isolation and characterization of lignin dissolved during hot-water extraction and some potential applications of this lignin are discussed.



Experiments performed to study modification of noncarbohydrate wood constituents during hot-water extraction (HWE) with model species sugar maple [*Acer saccharum*].

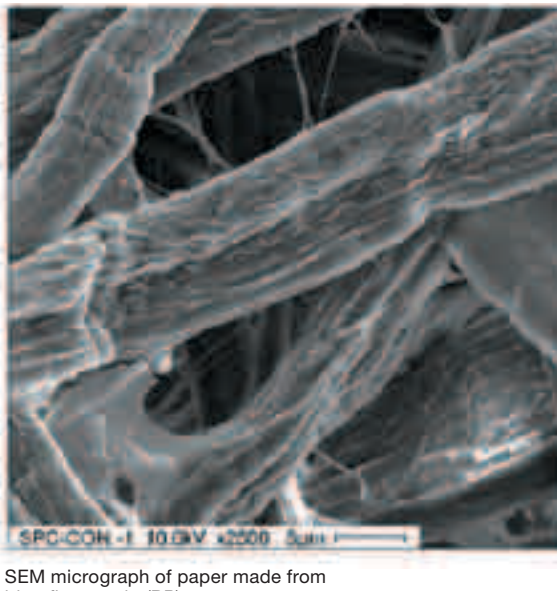
ADDITIVES

Novel blend of biorenewable wet-end paper agents

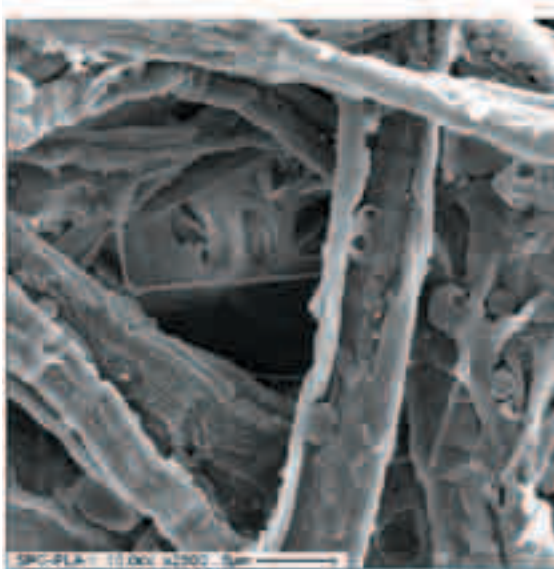
Chen Gong, Asif Hasan, Biljana M. Bujanovic, and Thomas E. Amidon

Recent studies have shown potential for a designed biorefinery product, polylactic acid (PLA), to increase the strength-to-weight ratio of paper produced from conventional kraft pulp and kraft pulp made from hot-water extracted hardwoods (biorefinery pulp). These results indicated that after surface-treatment with 2% PLA (per oven-dry [o.d.] fiber basis), paper made from sugar maple biorefinery pulp could be equivalent to or even greater in strength than paper made from sugar maple conventional kraft pulp, while retaining its higher bulk.

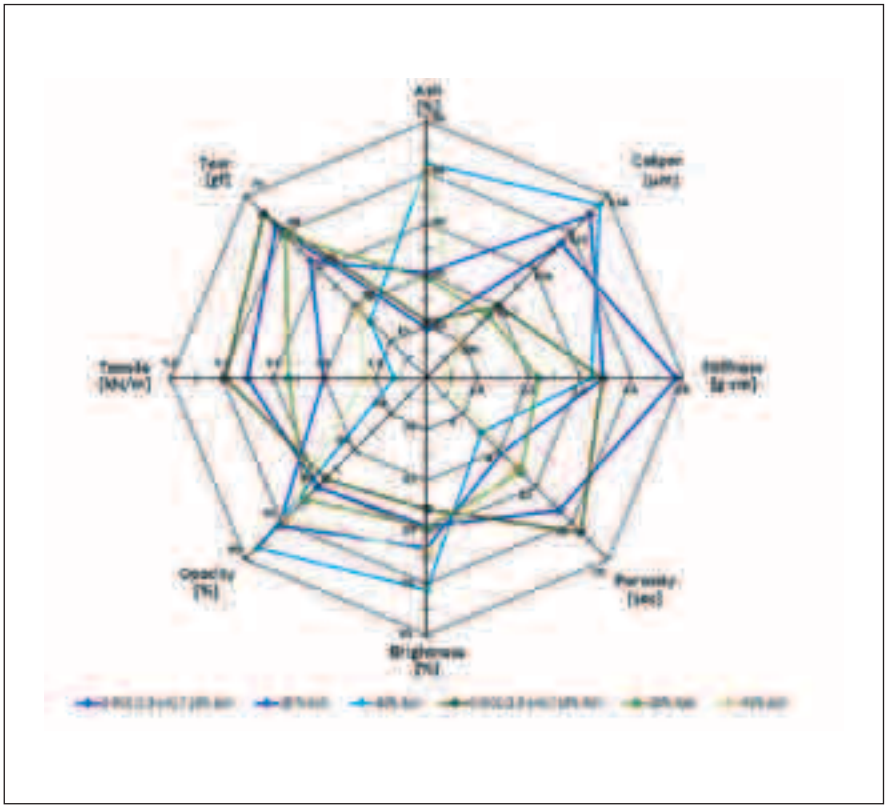
In the current study, the researchers present the results of reinforcement of the pulps with PLA applied in the wet-end in combination with a known environmentally



SEM micrograph of paper made from biorefinery pulp (BP).



SEM micrograph of paper made from biorefinery pulp and treated on the surface with PLA (2% based on o.d. fibers).



Comprehensive effect on handsheet properties; comparison between cationic ground calcium carbonate (1.5 µm) and scalenohedral precipitated calcium carbonate (1.9 µm).

friendly dry strength agent, cationic starch. The preliminary results obtained with amylopectin-based starch of relatively high nitrogen content (starch B) were encouraging since strength, including wet strength and stretch, of paper reinforced with a blend of 0.5% starch B and 0.5% PLA was higher than strength of paper reinforced with 1% starch B. Moreover, based on the compatible strengths of paper reinforced with 0.6 % PLA-starch B blend (1/5) and of paper reinforced with 1% starch B, the researchers hypothesize that there is a synergistic effect of PLA and starch B on tensile strength of paper.

The hypothesis was tested using pulps of different lignin content (Norway spruce thermomechanical pulp [TMP], hardwood unbleached kraft pulp, and softwood bleached kraft pulp). Tensile strength increased for papers made from these pulps. The effect was pronounced in the case of lignin-rich pulps, where tensile strength in the presence of 0.6% PLA-starch blend (1/5) exceeded that in the presence of 1% starch B.

FILLERS

Application of calcium carbonate for uncoated digital printing paper from 100% eucalyptus pulp

Klaus Doelle and John J. Amaya

In this study, 13 varieties of calcium carbonates were used to prepare handsheets for the detailed analyses of structural, optical, and strength properties. The samples included nine varieties of precipitated calcium carbonate (PCC) (two rhombic and seven scalenohedral, covering a particle size range from 1.2 µm to 2.9 µm) and four varieties of ground calcium carbonate (GCC) (three anionic and one cationic, with a particle size range of 0.7 µm to 1.5 µm)]. From the results, the researchers determined that the optimal calcium carbonate for uncoated digital printing paper made from eucalyptus pulp is scalenohedral PCC with a particle size of 1.9 µm, because of its positive effects on caliper, stiffness, brightness, and opacity.

CONVERTING

Delamination in the scoring and folding of paperboard

Doeung D. Choi, Sergiy A. Lavrykov, and Bandaru V. Ramarao

This paper describes a finite element simulation of paper mechanics applied to the scoring and folding of multi-ply carton board. The study's goal was to provide an understanding of the mechanics of these operations and the proper models of elastic and plastic behavior of the material that enable us to simulate the deformation and delamination behavior.

The researcher's material model accounted for plasticity and sheet anisotropy in the in-plane and z-direction (ZD) dimensions. The researchers used different ZD stress-strain curves during loading and unloading. Material parameters for in-plane deformation were obtained by fitting uniaxial stress-strain data to Ramberg-Osgood plasticity models and the ZD deformation was modeled using a modified power law. Two-dimensional strain fields resulting from loading board typical of a scoring operation were calculated. The

Delamination pattern after folding of a single ply sheet: a) the maximum ZD tensile strength is 275.6 kPa and maximum shear stress is 5512 kPa; b) the maximum ZD tensile strength is 689 kPa and maximum shear stress is 2756 kPa.

strain field was symmetric in the initial stages, but increasing deformation led to asymmetry and heterogeneity. These regions were precursors to delamination and failure. Delamination of the layers occurred in regions of significant shear strain and resulted primarily from the development of large plastic strains. The model predictions were confirmed by experimental observation of the local strain fields using visual microscopy and linear image strain analysis. The finite element model predicted sheet delamination matching the patterns and effects that were observed in experiments.

BIOREFINERY

Fractionation of wood polymers by carboxymethylation: Exploring the strategy

Shang-Ning Chien, Thomas E. Amidon, and Yuan-Zong Lai

This study explored the feasibility of fractionating wood polymers in situ by carboxymethylation to yield the carboxymethyl derivatives of cellulose, hemicelluloses, and lignin for potential industrial applications. The initial water-soluble materials formed were a mixture of hemicelluloses and cellulose, and also contained some lignin (3%–5%). Interestingly, the water-insoluble residue after another carboxymethylation treatment gave essentially a cellulose product containing less than 1% of residual lignin. Thus, the bulk of wood lignin is less reactive than the polysaccharide components under typical carboxymethylation conditions. Also, a hot water preextraction or dilute acid pre-treatment of wood samples was found to significantly enhance the reactivity of the cellulose component. A preextraction approach would facilitate cellulose preparation and also provide the flexibility to convert the extracted hemicelluloses to other bio-based fuels or materials.

BIOREFINERY

Pretreatment technologies for biological and chemical conversion of woody biomass

Yang Wang and Shijie Liu

Typical biochemical production processes using woody biomass feedstocks consist of four major steps: pretreatment, hydrolysis, fermentation, and separation. Pretreatment remains the most important step in biomass conversion. This paper reviews available pretreatment technologies for woody biomass bioconversion, focusing on those with commercial potential. The most interesting aspect of this research is that compared to other pretreatment methods, steam explosion, liquid hot-water, and SPORL, or their variations, have potential for commercial purposes.