Preparation and Analysis Of Crosslinked Lignocellulosic Fibers And Cellulose Nanowhiskers with Poly(Methyl-Vinyl Ether Co Maleic Acid) – Polyethylene Glycol to Create Novel Water Absorbing Materials

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The search for cellulosic based products as a viable alternative for petroleum-based products was the impetus for covalently crosslinking lignocellulosic fibers and nanocellulose whiskers with poly(methyl vinyl ether) co maleic acid (PMVEMA)– polyethylene glycol (PEG). The lignocellulosics used were ECF bleached softwood (pine) and ECF bleached birch kraft pulp. The crosslinking of the PMVEMA to hardwood and softwood kraft ECF bleached pulp fibers resulted in enhanced water absorbing pulp fibers where the PMVEMA is grafted onto the surface of the fibers. The main goal was to determine how to improve water absorption and retention of these fibers. The crosslinking was initiated both thermally and via microwave irradiation and the water absorption and water retention was measured as the percent of grafted PMVEMA. This was the first application of microwave crosslinking of pulp fibers with the goal of creating water absorbing pulp fibers. Ultimately, the water absorption values ranged from 28.70 g water per g dry crosslinked pulp fiber (g/g) to 230.10 g/g and the water retention values ranged from 26% to 71% of the water retained that was absorbed by the crosslinked pulp fibers. The microwave initiated crosslinked fibers had comparable results to the thermally crosslinked fibers with a decreased reaction time, from 6.50 min (thermal) to 1 min 45 sec (microwave).

Cellulose nanowhiskers, crystalline rods of cellulose, have been investigated due to their unique properties. These range from physical properties including nanoscale dimensions, low density, high surface area, mechanical strength, and surface morphology to their surface chemistry and numerous reaction possibilities, to the practical in that they can be made from a variety of local renewable biodegradable cellulose sources – both woody and non-woody resources. The incorporation of cellulose whiskers into a matrix has been conducted by different mixing methods, primarily via solution casting and extrusion. Prior to this study, the crosslinking of cellulose whiskers incorporated with the matrix via solution casting of liquid suspensions of whiskers and matrix had not been explored. The hypothesis to be investigated was that incorporating cellulosic whiskers with the PMVEMA-PEG matrix and crosslinking the whiskers with the matrix would yield films that demonstrate unique properties when compared to prior work of crosslinking of PMVEMA-PEG to macroscopic ECF bleached kraft pulp fibers.

Solution cast composites of cellulose nanowhiskers-PMVEMA-PEG were crosslinked at 135 °C for 6.5 min and analyzed for crosslinking, thermal stability, strength and mechanical properties, whisker dispersion, and water absorption and uptake rates. The whisker-composites demonstrated unique properties upon crosslinking the whiskers with PMVEMA-PEG, especially the elongation at break and tensile strength upon conditioning of the final materials at various relative humidities. In addition, the whiskers improved the thermal stability of the PMVEMA-PEG matrix. This is significant as methods of improving processing thermal stability are key to developing new materials that utilize cellulose whiskers, PMVEMA, and PEG. This thesis addresses the hypothesis that cellulose nanowhiskers that are crosslinked with a matrix can create new whisker-matrix composites that behave differently after

crosslinking. Prior to this thesis project, no-one had addressed the covalent crosslinking of the whiskers with the matrix. This thesis also tests the hypothesis that water absorption and retention can be improved by grafting PMVEMA-PEG to the surface of ECF bleached kraft pulp hardwood and softwood fibers via microwave initiated crosslinking.