



# Center for Innovative Biomaterial Education and Research

## Supplemental IREE Program

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### Abstract

This research exchange program was designed to address key national and international scientific issues in the expanding field of innovative nano-biomaterials derived from renewable biomass, focusing on lignocellulosics as the primary biomaterial of interest. Lee Goetz visited the research laboratories of Dr. Kristiina Oksman at Luleå University of Technology in the Division of Manufacturing and Design of Bionanocomposites (MADE) in Skellefteå, Sweden from May 15, 2007 to October 18, 2007 to participate in ongoing research.

### Introduction

The objective of this research visit to Dr. K. Oksman's MADE laboratory at Luleå University of Technology in Skellefteå, Sweden was:

First, to exchange information on the synthesis of crosslinked lignocellulosics.

Second, to prepare crosslinked cellulose nanowhiskers and to characterize the physical properties of these materials by employing the unique research expertise that the Oksman research group has developed in the field of nanocellulosic composites.

Third, to learn more about the European perspective of sustainability and green chemistry with an emphasis on nano-lignocellulosics produced from forest materials.



### Broader Impacts of the International Travel

The Oksman group utilizes lignocellulosic biomass and incorporates it into various matrices such as polypropylene, cellulose acetate butyrate, polylactic acid, polyvinyl alcohol and polyurethane to make composites. One goal of Oksman's group is to work with local industries and governments, such as Skellefteå Kraft, in the development of new products that use forest materials in consumer goods.

The Oksman MADE lab has available excellent instrumentation for the preparation and characterization of crosslinked cellulose nanowhisker materials. This included SEM, DMTA, TGA, impact tester, centrifuge, various fiber processing equipment, two extruders, injection molding, and rheology instruments at Skellefteå as well as access to various physical testing instruments and other SEMs at LTU – Luleå campus, all tailored towards nano-lignocellulosics.

Dr. Ragauskas visited and presented a seminar to the department on the process chemistry of the biorefinery and biomaterials, highlighting the growing interest and new advancements in the engineering of new biomaterials and biofuels from biomass. An extended group discussion resulted on the North American and European differences regarding environmental sustainability, life cycle analysis, and green chemistry.



### Conclusions

Following this exchange, Drs. Oksman and Ragauskas concurred on the need for further collaborative efforts, including future student research visits to focus on incorporating crosslinked cellulose nanowhiskers in composites. Future collaborations between Ragauskas and Oksman to advance the fundamental understanding of nanocellulosics, and on new properties yielded by crosslinking are also planned. The Oksman group's expertise in characterizing the materials meshes well with the Ragauskas' group expertise with lignocellulosic interactions. The work accomplished during this exchange will be used for Lee Goetz's thesis, with two publications in preparation.

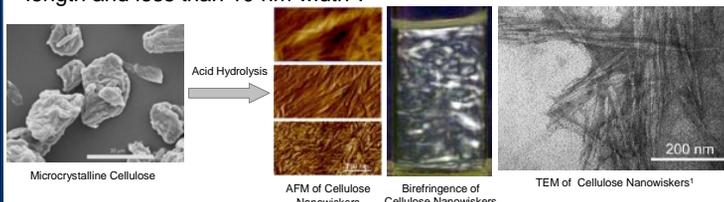
### Acknowledgements

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Thanks to Veeco for the AFM pictures.

### Research Activities and Accomplishments

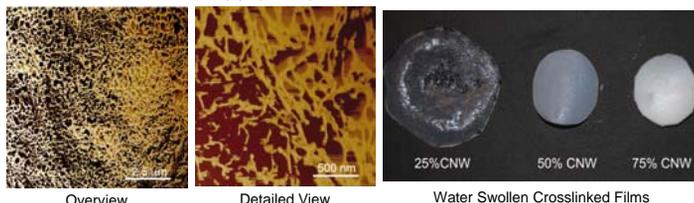
Cellulose nanowhiskers were prepared with slight modification to the production process designed by Bondeson and Oksman<sup>1</sup> to improve yield. Cellulose nanowhiskers are the crystalline rod portion of cellulose fibers extracted through a sulfuric acid hydrolysis process from microcrystalline cellulose. Typical dimensions are 200-400 nm length and less than 10 nm width<sup>1</sup>.



Successfully produced films of crosslinked cellulose nanowhiskers (CNW) with poly(methyl vinyl ether-co-maleic) – poly(ethylene glycol). Different concentrations of CNW (0-100%) were mixed with the matrix and cast on petri dishes. These cast films were crosslinked at elevated temperature (135°C) for 6.5 minutes.<sup>2</sup>

This study has documented for the first time the physical properties and ultra structure of crosslinked cellulose nanowhiskers, and the initial results have been written as a communication and a detailed manuscript is in preparation ('Preparation and characterization of crosslinked cellulose nanowhiskers').

The crosslinked CNW films were characterized for mechanical properties, water absorption, and morphology. The morphology of crosslinked PMA-PEG/CNW50 nanocomposites was studied using atomic force microscopy (AFM).



Preliminary results were reported at the BIOPOL 2007 Conference in Alicante, Spain in a poster.

### Discussion and Summary

- It was possible to prepare novel crosslinked cellulose nanowhisker composites.
- Mechanical properties of the CNW composites are influenced by the nanocomposite composition as well as the relative humidity. These materials swell in water and act as hydrogels.
- Future work will further develop these materials with a focus on increasing the crosslinking density, varying the percentage of nanowhiskers between 1 – 15% (by weight), and investigating their use as absorbers and potential medical applications.
- The need for novel sustainable processing chemistry, engineering and materials has taken on heightened interest in North America and Europe.

### References

- D. Bondeson, A. Mathew, and K. Oksman, Cellulose, (2006)13:171-180
- The Procter & Gamble Company. (1991). Poly(methyl vinyl ether-co-maleate) and polyol modified cellulosic fiber. US Patent 5049235