



Multifaceted research at the University of Maine

Editor's Note: This column is a continuation of TAPPI Journal's column series featuring research and researchers from pulp, paper, biorefinery and related schools and institutions

– Monica Shaw, Editorial Director

In this column, *TAPPI Journal* spoke with Dr. Adriaan van Heiningen of the University of Maine about current research activities there. He is the J. Larcom Ober Professor of Chemical Engineering, and his research interests include fundamental chemical engineering aspects of pulp production and forest biomass conversion processes. In particular, van Heiningen studies pulping, bleaching, recovery of pulping chemicals, and production of bio-based chemicals and biomaterials like acetic acid, biofuels, and nanocellulose. He studied at the State University of Groningen in the Netherlands and holds a Ph.D. from McGill University in Montreal, Canada. Here, we discuss van Heiningen's areas of research, as well as biorefinery projects at the university and his thoughts on the industry at large.

One of the research areas you are involved in at UMaine is increasing kraft pulp yield, a project that is funded by Agenda 2020. Can you describe some of your efforts in the area?

We're working to increase kraft pulp yield by more than 5% for both hardwood and softwood, although presently mostly softwood, by using a pretreatment step that includes an additive derived from the black liquor waste stream. So, it is an integrated process and wouldn't require new chemical purchases. We do attain an increase in yield and reduce the load on the recovery boiler, which is generally the bottleneck for increasing pulp production. We aren't quite at our ultimate goal yet, but we're getting closer. I believe it has near-term potential with very big economic consequences.

What is another area of research for you with a traditional pulp and paper focus?

We are working to extend oxygen delignification to 80% for



Dr. Adriaan van Heiningen with members of his University of Maine research group, from left to right: Asif Sharazi (Ph.D. graduate), Etienne Montet (M.S. student), Magriet van Heiningen, Dr. van Heiningen, Azadeh Pahlevanzadeh (Ph.D. student), Sefik Tunc (former laboratory manager), and Ravikant Patil (research scientist).

softwood—a significant improvement from the current maximum of 60%—which we can now get in two stages. We plan to use additives and achieve this goal while maintaining acceptable pulp strength. As far as the impact, going from 60% for softwood delignification to 80% means you have 50% less lignin or kappa no. to be removed during bleaching, which reduces the impact and the cost of bleach plant by a factor of two.

The oxygen delignification work is funded by International Paper (IP) and is therefore proprietary. The company is funding a Ph.D. student for four years. In addition to pursuing the process improvements, IP is also interested in fostering more U.S./homegrown Ph.D. students, so there is an educational aspect to the work as well.

UMaine's Forest Bioproducts Research Institute (FBRI), located at the former Old Town mill, focuses on creating and commercializing new forest-based bioproducts.

What are some of your efforts there?

Acetic acid production from an alkaline pretreatment step that is integrated into kraft pulping to make regular kraft

pulp is an area of focus for me, Dr. Joe Genco, emeritus professor, and Dr. Hemant Pendse, who leads the FBRI research team. Another area of research is modified Biofine treatment of lignocellulosic biomass to produce levulinic acid, which I work on with Dr. Clayton Wheeler and Dr. Pendse.

The Biofine process is a 1 ton/day pilot plant, operated in partnership with Biofine Technologies, that treats biomass with sulfuric acid that converts the C6 sugars (glucose and mannose) into levulinic acid, a platform chemical that can be used in the chemical industry to make all kinds of value-added products. Dr. Wheeler developed an additional process whereby the levulinic acid stream is converted together with calcium formate into a crude oil that can be distilled and hydrogenated to produce liquid transportation fuels. It is a very simple dry pyrolysis process, and it is of interest for the industry because the calcium recovery can be integrated with the lime cycle of the kraft pulp mill.

In addition to bioproducts, another non-traditional area of work in which UMaine is involved is nanocellulose. What are some of your activities in this field and how do you see its potential?

We're working on nanocellulose in several applications, including as a papermaking additive, coating additive, and as a building materials component. The persons involved include Mike Bilodeau, head of the UMaine Process Development Center (PDC), and Drs. Doug Bousfield and Mike Mason. I also study the use of nanocellulose as a structural component in polymer composites, with the focus to overcome the energy obstacle to remove the large amount of water from a nanocellulose suspension of about 3%.

Many paper companies ask us to test nanocellulose as a papermaking additive in our PDC mechanical refining pilot plant, and Drs. Bousfield and Bilodeau have obtained a significant grant for the application of nanocellulose in several important products. I believe nanocellulose will be an important future product for our industry. An important breakthrough was the reduction in energy requirement for producing nanocellulose by mechanical refining pioneered by the UMaine PDC. A number of companies are getting involved by producing their own nanocellulose, including Sappi. Because of its special properties, I think nanocellulose has an important future as a new product or papermaking and coating additive for the industry.

You have described both traditional and non-traditional pulp and paper studies at UMaine.

Which of these areas receives the most research funding? Do students gravitate more toward traditional or non-traditional studies?

Our funding is about 50/50, meaning that both traditional and non-traditional areas of study are significant. As for students, they probably gravitate more towards the biorefinery side.

I am so grateful that a number of companies are stepping forward to fund traditional research at the universities—in this case through Agenda 2020, but also direct funding to involve the university in developing new technologies. Most funding for traditional pulp and paper projects is coming from companies and most of the funding for the biorefinery project comes from federal government organizations.

In Maine, the pulp and paper industry used to be very strong, but not so much today. Has that changed the kind of students you have? Are they from all over the world or from the U.S.?

Yes, the industry has changed significantly in Maine, and a number of mills have closed because generally they were making products for which the market is shrinking. However, kraft mills have stayed and expanded. I also hope we could get a large investment and replace some these closed mechanical pulping operations by one huge softwood kraft pulp mill like they have just completed in Finland and Sweden. This hope is based on the knowledge that Finland and Sweden have a similar climate as Maine and we have the wood resources available. Unfortunately, so far this hasn't happened.

Regarding undergraduate students, we still get many local students but also now more from other states, attracted by the Pulp and Paper Foundation. It is true that most of them won't necessarily be employed in Maine, but they go all over the U.S., and most of them have jobs before they graduate. The pulp and paper educational program supported by the Pulp and Paper Foundation is still going very strong.

On the graduate, post-graduate and post-doctoral levels, we have about 25 students/researchers. We have a number of American graduate students, but most of the post-graduate research is done by international students from all over the world.

What are the primary pulp and paper related laboratories at UMaine?

We have bench-scale labs in the main building for chemical and biomedical engineering in Jenness Hall, and then we have the pulp and paper facilities in the PDC at the back of Jenness Hall, which has been there for around thirty years. We also have the Technology Research Center (TRC), which is a 40,000-ft² facility located in the former warehouse of the pulp mill in Old Town, Maine, and which was established about five years ago funded by a large grant of the Maine Technology Institute and by private contributions. The TRC houses floor scale testing equipment, including the very large Biofine pilot plant. The TRC allows us to take the research out of our Jenness Hall labs and demonstrate and validate it at industrially relevant scales to help rapid commercialization for the industry.

How do you feel about the overall direction of the pulp and paper industry, especially in developed areas like the U.S. and Europe where digital technologies are the norm?

I am actually quite optimistic about the industry. Printing and writing products will continue to decrease, although they won't disappear, but other products will become much more important, such as packaging and hygiene products. In a way, the industry will become more competitive, because we make kraft pulp at larger and larger scales, have become very energy efficient and are a net energy/electricity exporter, and transform a renewable resource into biodegradable products. Thus, the industry is changing its product mix, and at the same time becoming more efficient by increasing scale and using improved technology. This is happening both here and in Europe, although Scandinavia is moving a bit more quickly, as they tend to upgrade more regularly than we do. **TJ**

Don't Miss PEERS 2017

November 5-8, 2017

Hilton Norfolk THE MAIN • Norfolk, VA



Co-Located With
IBBC 2017 International
Bioenergy &
Bioproducts
Conference
November 7-9, 2017 • Norfolk, Virginia

Maximizing Success Through Innovation

Register by October 6 and Save! www.tappipeers.org



Keynote Speaker

Robert C. Tiede
Executive Vice President and Chief Operating Officer
Sonoco Products Company

- Mill Special Discount: Up to 10 employees on one registration!
- Over 100 Peer-Reviewed Technical Presentations
- New Technology Showcase
- 10 Conference Tracks
- Roundtable & Panel Discussions
- Workshops
- Committee Meetings
- Multiple Networking Opportunities
- Hot Topics Breakfasts

Platinum Sponsors



Silver Sponsors

