

# Nanoparticles

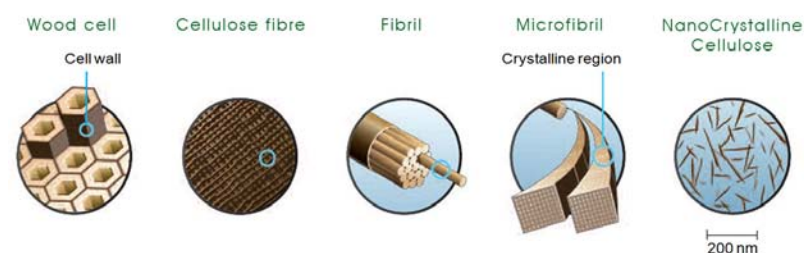
*“NCC is stronger and lighter than steel, and as with other nanoparticles, has unusual chemical, physical, optical, magnetic and electrical properties. NCC is capable of self-assembly, a process in which components form an organized structure as a consequence of specific, local interactions among the components themselves, without external direction.”*

## ... from the Forest?

Compared to other nanoparticles such as the well-known carbon nanotubes (CNTs), NanoCrystalline Cellulose (NCC) nanoparticles can be produced at a tiny fraction of the cost.

Cellulose is the primary structural component of green plants and trees and the most common organic compound on Earth; wood obtained from trees is 40–50% cellulose, which exists in both crystalline (ordered) and amorphous (disordered) forms.

NCC nanoparticles from wood consist of pure crystalline cellulose with a length of about 200 nm and a width of 10 nm.



NCC can be used in a number of applications, including reinforced polymers, coatings, paper and board products, drilling mud, specialty inks and more. ArboraNano is encouraging scientists and engineers to use their creativity in researching and developing applications for products based on NCC.

Nanofibrillated cellulose (NFC) and cellulose nanofilaments (CNF) are also wood-derived nanomaterials. However, unlike NCC, these materials are not composed of individual nanocrystals but of fibrils containing both crystalline and amorphous cellulose.

## ArboraNano

Canadian Forest NanoProducts Network

**To learn more about getting involved with ArboraNano, please contact:**

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# ArboraNano

Spring / Summer 2011



## Canadian Creativity at Work

Novel product development efforts underway in various industrial sectors

### INTERVIEWS

Brian O'Connor - Health, Safety and Environmental Aspects of NCC  
Hamdy Khalil - Green Products and the Automotive Industry

### FEATURED PROJECTS

Highly versatile mesoporous membranes  
Ultra-light weight green packaging products

## WHAT IS ARBORANANO?

ArboraNano is the Canadian Forest NanoProducts Network, founded by FPInnovations, NanoQuébec and the Government of Canada's Business-Led Networks of Centres of Excellence program.

The Network was created to provide new business opportunities for the Canadian economy using Canada's renewable forest resources to manufacture new value-added products. Scientists and engineers in industry, academia and institutions are working together to research and develop products based on a plant-derived nanomaterial called Nanocrystalline cellulose, or NCC. This can be used in many forms to create biocomposites, bioplastics, iridescent coatings, wear-resistant surface treatments and drug delivery systems – just to name a few applications.

### Members

Alberta Innovates - Bio Solutions  
Bell Helicopter Textron Ltd.  
FPInnovations  
Kruger Inc.  
McGill University  
Nanoledge  
NanoQuébec  
Noram Engineering & Constructors Ltd.  
Ontario BioAuto Council  
Université de Sherbrooke  
Université du Québec à Trois-Rivières  
Université Laval  
University of Alberta  
University of British Columbia  
Université du Québec en Abitibi-Témiscamingue  
Woodbridge Foam Corporation

### Industrial Partners

Akzo Nobel  
BASF  
Bio Vision Technology  
Cytec  
Groupe Laperrière & Verrault  
Handy Chemicals  
Marquis Alliance Energy Group Inc.  
Omya  
Tembec

### Academic Partners

Collège Ahuntsic  
Queens University  
University of Waterloo

### Government Partners

Alberta Innovates - Technology Futures  
Le Fonds québécois de la recherche sur la nature et les technologies  
Ministère des Ressources naturelles et de la Faune  
National Research Council - National Institute for Nanotechnology  
Natural Resources Canada  
Province of Alberta - NanoAccelerator

# News Briefs

## NEW CANADIAN COMPANY CREATED BY JOINT VENTURE BETWEEN DOMTAR AND FPINNOVATIONS



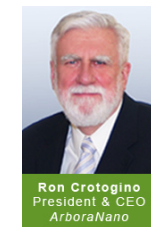
FPInnovations and Domtar Corporation formed a new joint venture company to build the world's first commercial-scale NanoCrystalline Cellulose demonstration plant (one metric ton per day) at the Domtar Windsor, Quebec pulp and paper mill site. Construction of the facility began last fall and is expected to be completed this year. The joint venture will explore the commercial viability of the production of NCC on a larger commercial scale.

## ARBORANANO EXPANDS ITS PROJECT PORTFOLIO

With a number of new projects recently approved for funding by the ArboraNano Board of Directors, the Network has now nearly completed committing its R&D budget.

The funding is distributed over various industrial areas including Aerospace, Automotive and the Forest sector and many important developments in a diverse range of products are expected. Some of these include coatings, paints and varnishes, paper and packaging materials, specialty inks and films, nanocomposites and nanofoams, and more.

For a complete list of ArboraNano's R&D projects involving many industrial and academic partners, please refer to p. 7.

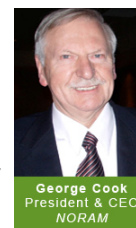


## ARBORANANO NETWORK DIRECTOR RECEIVES JOHN S. BATES MEMORIAL GOLD MEDAL DURING PAPERWEEK CANADA

In February 2011, the highest honour offered by the Pulp and Paper Technical Association of Canada, was awarded to ArboraNano President & CEO, Ron Crotagino, who has been associated with the forest products industry for more than 50 years, as a student, researcher, consultant, and teacher. Accepting the award, Crotagino said of his long career in pulp and paper: "Throughout my career, I kept getting hooked by incredibly interesting challenges, and the incredibly interesting people I've been able to work with."

## ARBORANANO BOARD MEMBER INDUCTED AS FELLOW IN CANADIAN ACADEMY OF ENGINEERING

George Cook, President of NORAM Engineering and Constructors Ltd., was inducted as a Fellow of the Canadian Academy of Engineering on June 2, 2011. He was cited as an innovator, entrepreneur and mentor, who has demonstrated exceptional leadership in developing novel process technologies and marketing these worldwide.



## ARBORANANO PLANS ITS ANNUAL GENERAL MEETING TO FACILITATE ATTENDANCE OF NANOTECHNOLOGY CONFERENCE

For the first time, ArboraNano has arranged for its AGM to be held outside of Canada in order to facilitate for its members the attendance of 2011 TAPPI International Conference on Nanotechnology for Renewable Materials. Both events will be held in Arlington, VA in early June.

While the ArboraNano AGM will focus on Networking and the presentation of technical accomplishments, the Conference will focus on several key thematic areas such as Nanocellulosics and Nanocomposites, Applications of Renewable Nanomaterials, Nanostructured materials by Self Assembly, Nanotech Coatings, Novel Nano-Enabled Functionalities, and Governmental & Environmental Issues.

Advances being made in nanotechnology in renewable materials and their widespread applications in many industries are the core interest of both the ArboraNano Network and the TAPPI Conference.

# Project Portfolio

ARBORANANO NETWORK'S DIVERSE R&D PROJECTS TARGET A VARIETY OF NANOTECHNOLOGICAL DEVELOPMENTS WITH COMMERCIAL POTENTIAL OF HIGH INTEREST TO CANADA'S MAJOR INDUSTRIAL SECTORS.



- Wood-derived nano enhancements for aerospace products

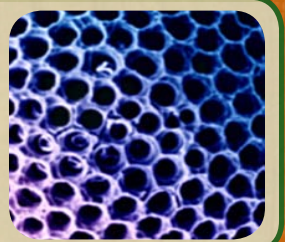
- Multilayer coatings for wood
- Opaque nanocomposite coatings for wood
- Use of NCC in clear coatings
- Nanoparticle enhanced wood finishing oil



- Use of NCC in automotive & construction products
- Graft modified NCC/Polyurethane foam
- NCC-reinforced polypropylene foam



- Nanoporous NCC membranes

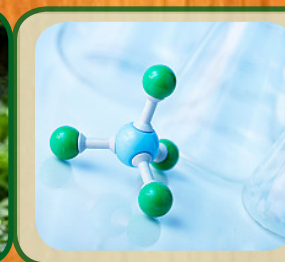


- NCC-based inks for reinforced security and color



- Use of NCC as a loss circulation material in drilling fluids

- Functionalized paper structured with nano-additives
- Use of NCC in latex coating for paper
- Cellulose nanofilament-reinforced paperboard packaging



- Multiscale modelling of NCC nanocomposites, gels and foams
- Molecular modelling of NCC optical properties
- Compatibilization of NCC for dispersion in matrices
- Optimization of nanoparticle dispersion

# Interview



**Brian O'Connor**  
Program Manager,  
Environment  
FPInnovations

## NCC PASSING NON-TOXICITY TESTS WITH FLYING COLORS

Dr. Brian O'Connor is the Program Manager for the Environment and Sustainability Group at FPInnovations. He has a Doctorate in Organic Chemistry from McGill University in Montreal, and conducted Post Doctoral work at Purdue University. He joined Paprican, (now part of FPInnovations) in the Air Emissions Group in 1988. He was named FPInnovations Environment Program Manager in 2006. His group focuses on regulatory compliance, emerging issues, technical support and cost reduction for Canadian pulp and paper mills.

### Q – CAN YOU DESCRIBE THE WORK YOUR GROUP IS DOING THAT IS RELATED TO NANOCRYSTALLINE CELLULOSE (NCC) AND WHY IT IS IMPORTANT TO FPINNOVATIONS?

A - NCC research started with our pulp and paper operations located in McGill University. They were studying NCC for, I guess, 20 years on the bench because it is quite a fascinating little molecule. In the last several years, our scientists in the Pointe Claire facility were able to bring up production to one to two kilograms per week, which led to the ability to examine different markets and products. We became involved as they were looking into scaling up and various market opportunities, in order to conduct the environmental assessment work that was required to evaluate the toxicity of NCC and to work on getting it regulated for sale and use in Canada. In Canada, it is the Canadian Environmental Protection Act where this is being regulated under the "New Substances Notification Regulation". This is where any new substance has to go through a number of testing criteria before it is allowed to be used in Canada. NCC is a new compound because it is sufficiently different from cellulose that it triggers this "New Substances Notification Regulation". The first thing we did is we formed partnerships with universities and, actually, Environment Canada scientists that are working on nanomaterials. This led to an ecotoxicological characterization of NCC that was published this last year in Nanotoxicology. We are also working with Environment and Health Canada in order to perform the testing that needs to be done on the mammalian side and to cover consumer applications. This is what we have been actively working on in the past few years. Another critical parameter that requires study is the fate of the NCC in the consumer products. Does it migrate or leach out and are consumers going to be exposed to any NCC? This is where a lot of our current effort is being placed.

### Q – WHEN FPINNOVATIONS DECIDED TO SCALE UP THE PRODUCTION OF NCC FROM A LABORATORY CURIOSITY TO A COMMERCIALLY VIABLE PRODUCT, WHAT ACTION PLAN WAS DEVELOPED TO ADDRESS OCCUPATIONAL HEALTH AND SAFETY CONCERNS?

A - Actually we are moving quite well on that. In Canada, Federal regulations do not cover occupational health and safety issues because it is a provincial jurisdiction. Because our plant is going to be in Windsor, Quebec, we are dealing with the CSST in Quebec and their research arm, which is called the IRSST. They have come up with a best management guide for dealing with nanomaterials in the workplace. We are also following the work of NIOSH in the United States, which is the National Institute for Occupational Safety and Health. They also have a procedure for dealing with nanomaterials. We have all the necessary equipment to measure exposure levels and conduct a risk assessment. A risk assessment is based on exposure potential and the toxicity of the material. To date, everything about NCC shows that it is very non-toxic and we are now obtaining representative data concerning exposure es-

timates. If a material is relatively non-toxic and the exposure potential is minimal, then there is minimal risk. So, it is about managing risk. We have a program going on right now where we are dealing with both, in terms of our facility here in Pointe Claire, Quebec and the facility that is under construction, to make sure that we follow those guidelines and ensure worker safety.

### Q – WHAT HAS THIS EFFORT REPRESENTED AS COMPARED TO THE OVERALL INVESTMENT IN THE DEVELOPMENT OF NCC?

A - When FPInnovations started this with the NRCan funding about three years ago, the environmental assessment was identified as a key area and approximately 20 percent of the overall budget was earmarked for this type of work. It was important to conduct this work in conjunction with the other R & D work in order to be able to address any potential issues as they arose. So, I think we are moving fairly well . . . we are almost at the end and the timing, in terms of regulatory approval, should be aligned with the plant start-up that is expected to produce one tonne per day in early 2012.

### Q – WHAT GOVERNMENT AND REGULATORY AGENCIES ARE INVOLVED IN THIS PROCESS?

A - In Canada it is under CEPA, the Canadian Environmental Protection Act, which involves both Environment Canada and Health Canada working on that file together. In the States, you have to go through the Environmental Protection Agency to import the material for use and then if your use involves food and drug applications, you have to go through the Food and Drug Administration (FDA).

### Q – WHAT FINDINGS CAN YOU SHARE ABOUT THE SAFETY OF NCC?

A - NCC is about as toxic as table salt. The toxicity results for NCC are also very similar to what is known for microcrystalline cellulose (MCC). MCC is a smaller form of cellulose that has dimensions in the range of microns, or approximately 100 times larger than NCC. MCC is non-toxic and has numerous consumer applications such as thickening agents in ice creams, use in the pharmaceutical industry to add density to medications to make pills, etc. So, everything to date shows that NCC is very similar to something that has been used in the market for years and years and is really non-toxic. So everything certainly seems very promising and given the nature of the material, we don't expect it to be toxic. Preliminary work with dermal, in terms of irritation on the skin, came back and said that it has an irritation index of zero, which means that it is not irritable at all. For the initial feeding study with rats, there was no impact whatsoever at the highest dose tested. So, everything is coming back to be very, very positive in terms of any potential toxicity issues with NCC.

### Q – THE JOINT VENTURE BETWEEN FPINNOVATIONS AND DOMTAR IS SCHEDULED TO PRODUCE ONE TONNE PER DAY OF NCC BEFORE THE END OF THE YEAR. WHAT REGULATIONS AND PROCEDURES DO YOU HOPE TO HAVE IN PLACE AT THAT TIME?

A - The timeline is going to be tight. The ecotoxicology has been completed and published. We have been, in the last year, working on the mammalian toxicology, which we send out to certified consultants and contracted labs that routinely run these kinds of tests. To date, Environment Canada has allowed for the use of NCC in paints and coatings up to 10 tons per year. For consumer applications, they gave us a list of additional testing that is required. We are in the position right now where we are sending a new batch of NCC out for the full range of mammalian testing. We are looking for regulatory approval right about the same time that the plant is commissioned and starts to get up and running.

# Featured Project

## CELLULOSE FILAMENT-REINFORCED PACKAGING PRODUCTS

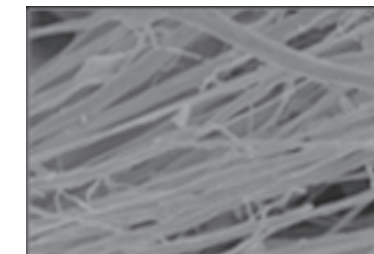
Sustainability a major driving force in developing ultra light-weight green packaging materials to replace fossil fuel-based alternatives

### Makhlouf Laleg, Principal Scientist, FPInnovations

The increased focus on sustainability has created pressure to reduce the amount of packaging and related transportation costs. Thus, manufacturers of folding paperboard boxes, corrugated paperboard containers and molded pulp fiber products are faced with the challenge of reducing the weight of the packaging materials without reducing their ability to protect the product being packaged. Properties of paramount importance include compression strength and bending stiffness, which are a function of the packaging material weight and which can easily be degraded by moisture and humidity. Thus, the manufacture of ultra-light weight materials is difficult due to the lack of technologies to simultaneously control moisture resistance, bonding and density.



Drs. Gilles Dorris and Makhlouf Laleg of FPInnovations believe they have the solutions to solve this problem. They have developed two innovative approaches that promise to open the door to a major transformation of the Canadian paper industry. The first involves impregnating wood fibers with reactive polymers, leading to rigid, cohesive and humidity resistant sheets with superior properties.



The second involves a new cellulose product called cellulose filaments, which have been found to greatly improve inter-fiber cohesion strength, tensile strength, stretch, and rigidity of the end product, in addition to substantially decreasing sheet permeability while providing resistance to humidity. The cellulose filaments are much longer than nano fibrillar cellulose (NFC) and nano crystalline cellulose (NCC), and are extremely thin in diameter with a high aspect ratio (up to 2,000).

In a project supported by ArboraNano, FPInnovations, NRCan, MRNF, and BASF, lightweight linerboards will be developed using the pilot paper machine at FPInnovations. The technology will be validated on a commercial paperboard machine and also with a 3D molded-fiber packaging converter.

## In the pipeline



### INVESTIGATING NCC AS POTENTIAL UNIQUE PERFORMANCE ENHANCING AGENT IN POLYMER SYSTEMS USED IN THE MANUFACTURING OF AUTOMOTIVE & CONSTRUCTION PRODUCTS

The objectives of the project led by Dr. Hamdy Khalil from Woodbridge Foam Corporation, a global supplier to the automotive industry, will be to explore the use of nanocrystalline cellulose (NCC) as a product performance-enhancing additive in polyurethane foam and construction products.



### NANO-REINFORCED FOAMS FROM NANOCRYSTALLINE CELLULOSE AND THERMOPLASTICS

Université Laval, Woodbridge Foam Corporation and FPInnovations are collaborating to investigate the use of nanocrystalline cellulose (NCC) for the development of improved foam properties obtained with less severe and more cost-effective manufacturing conditions. The project will be led by Dr. Denis Rodrigue of Université Laval.



### THE COMPATIBILIZATION OF NCC FOR DISPERSION IN OTHER MATRICES

This FPInnovations project, led by Dr. Jean Bouchard, aims to develop industrially viable approaches to improve the compatibility of NCC with various polymer matrices through chemical modification or by using an agent which has affinity for both the nanomaterial and the matrix.



### IMPROVING THE PERFORMANCE OF FINISHING OILS WITH NANOPARTICLES

Dr. Ahmed Koubaa, of Université du Québec en Abitibi-Témiscamingue (UQAT) will assess the potential of various nanoparticles to create wood finishing oils having the ability to improve the durability of wood surfaces. The work will be carried out in collaboration with Tembec and FPInnovations.

# Interview



**Hamdy Khalil**  
Global Technical  
Director for  
Research &  
Product  
Development  
*Woodbridge Foam  
Corporation*

## COMMERCIAL GREEN PRODUCTS DERIVED FROM FOREST MATERIALS HAVE STRONG ADVOCATE WITHIN CANADIAN AUTOMOTIVE INDUSTRY

Dr. Hamdy Khalil is Global Director for Research and Development and Product Development for The Woodbridge Group, a privately-owned Canadian company with a global presence in the automotive industry. He has been involved in automotive research and development for the past 20 years. The Woodbridge Group supplies interior parts to the automotive industry. He is also a member of the Scientific Committee of Arboranano, a member of the Board of Directors of the Centre for Research & Innovation in the Bio-economy (CRIBE) located in Thunder Bay, Ontario, and a member of the Board of Directors of the Ontario BioAuto Council. Dr. Khalil is also an adjunct Professor at the University of Guelph.

### Q – WHO ARE WOODBRIDGE'S CUSTOMERS?

A - Woodbridge is considered as a both a second and first tier to supply the automotive industry OEM's, which is the automotive manufacturers around the world.

### Q – HOW IS WOODBRIDGE POSITIONED IN THE CANADIAN, NORTH AMERICAN AND GLOBAL MARKETPLACE?

A - Woodbridge is a global company that has 64 sites around the world and we are anywhere where cars are being made. We are in China, in Thailand, in Korea, Japan, Brazil, Mexico, Argentina, Egypt, France, Belgium, Germany, UK, and Australia.

### Q – WHAT ARE THE MAJOR DRIVERS IN DEVELOPMENT ACTIVITIES AT WOODBRIDGE WITH RESPECT TO POLYMER COMPOSITES AND GREEN POLYMER COMPOSITES?

A - The major drivers are what I have coined as the Automotive Ten Commandments. These Ten Commandments For Automotive Products are cost effectiveness, greener, cleaner, thinner, stronger, comfortable, acoustical, low or zero carbon footprint, recyclable, and derived from sustainable, renewable, and secure resources. These are the drivers that really dictate the success of both the renewable and the green offering to the automotive manufacturers.

### Q – IS "GREENING" THE AUTOMOTIVE/TRANSPORTATION SECTOR A SOUND BUSINESS PROPOSITION?

A - It is very sound because it is in demand by the automotive manufacturers as long as it doesn't cause them to incur extra cost.

### Q – IS "GREEN" ENOUGH OF A VALUE PROPOSITION ON ITS OWN?

A - I would say it is because if Company A has a product and Company B has a product, and Company A has a green product and Company B has a product based on fossil fuel, Company A will get the business and B will not. However, all other stringent automotive specifications have to be met.

### Q – HOW WOULD YOU ASSESS THE ROLE OF FOREST NANOMATERIALS AND FOREST BIO-POLYMERS IN THE WOODBRIDGE STRATEGY?

A - The role, actually, is very, very important and very critical as it represents a Canadian sustainable advantage and it will give us a comparative advantage that would be very difficult for us to have without having these products available to us to work with.

### Q – HOW WILL USING NCC AND OTHER FOREST-DERIVED MATERIALS INFLUENCE THE COMPETITIVENESS OF WOODBRIDGE IN THE NORTH AMERICAN TRANSPORTATION SECTOR AND GLOBAL MARKETS?

A - I would say the successful use of these products would provide Woodbridge with a competitive advantage. At the end of the day, it is the proprietary and differentiated product that we strive to develop to offer to our global customers.

### Q – REGARDING THE PATH TO THE MARKET, HOW QUICKLY COULD A REFORMULATION OF ONE OF YOUR PRODUCTS ENTER THE MARKETPLACE, GIVEN A POSITIVE VALUE PROPOSITION?

A - We believe that this could be done within six months if major hurdles are not encountered. It all depends on the qualification process that a given OEM selects to use for the introduction of change.

### Q – HOW ARE YOU INVOLVED IN DEVELOPING CANADA'S CAPACITY TO COMMERCIALY PRODUCE AND MARKET NCC?

A - I have a very, very strong personal interest in seeing the forest industry become a very strong competitive Canadian advantage. I have given presentations and given talks, and written articles, and now I am a member of the Scientific Committee for Arboranano and on the Board of Directors for CRIBE, and that is why I am very, very interested in seeing these products designed and implemented. The use of Canadian resources, specifically forestry, agriculture, and biomass, must be considered as a national duty ... a national strategic advantage that we must capitalize on.

### Q – AS NOVEL PRODUCTS GO, HOW WOULD YOU RATE THE POTENTIAL FOR NCC, GIVEN YOUR HISTORY IN RESEARCH AND DEVELOPMENT WITHIN THE AUTOMOTIVE INDUSTRY?

A - We hope that it will give the benefits that we believe it should. We are all working towards that but I would rate it very highly.

### Q – HOW HAS WOODBRIDGE BEEN INVOLVED IN THE DEVELOPMENT AND INCLUSION OF GREEN PRODUCTS IN THE AUTOMOTIVE INDUSTRY?

A - We have actually pioneered the green chemistry in automotive. We were the first to introduce green products in the products that we make like the headrest, the armrest, the automotive seat cushions, the headliners, the acoustical products, and all of that ... we were the first to introduce renewable resources in these products. We started in 1996. This is long before it became fashionable.

### Q – WHERE ARE YOU CURRENTLY SOURCING YOUR MATERIAL?

A - We are sourcing that from North American manufacturers. Unfortunately, in Canada, it is still in its infancy but that is why my constant interest in really driving to achieve a national strategy to consider the Canadian advantage of forestry and biomaterials and biomass as a critical sustainable Canadian advantage that should be part of the national technical/innovation strategy for Canada.

# Featured Project

## MESOPOROUS CELLULOSE MEMBRANES

Growing demand for membranes and materials with well-defined porous structures creates opportunities for nanocrystalline cellulose (NCC)

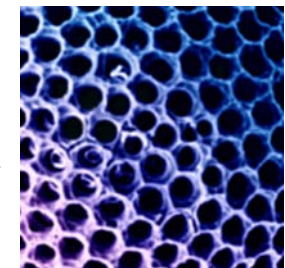
### Mark MacLachlan, Associate Professor, University of British Columbia



By exploiting the unique properties of nanocrystalline cellulose (NCC) from wood pulp, a team led by Dr. Mark MacLachlan at UBC and involving FPIInnovations researchers has developed for the first time a unique method to prepare thin glass films with a mesoporous chiral nematic structure.

These films permit selective light reflection at specific wavelengths across the visual and near-infrared spectrum. When the glass films are wet, they become colorless, but they resume their "color" (ability to reflect light at a certain wavelength) upon drying. The enormous interest in the new glass materials is related to their potential as coatings, tuneable reflective filters in smart windows, chiral catalysts in synthesis, optical sensing devices, molecular separation filters and displays.

NCC is only one of many naturally occurring substances that have a 'handedness' enabling them to interact very specifically with matter or light, and using some of the previously developed approaches Dr. MacLachlan is now turning his efforts to replicating the helical features responsible for this in other mesoporous (pore size 2–50 nm) films.



Specifically, in a new project supported by ArboraNano, Dr. MacLachlan in collaboration with Noram Engineering and Constructors Ltd. and FPIInnovations will attempt to develop highly ordered, porous materials that are made of cellulose. These materials will have high surface area and chirality and the research team intends to investigate their potential for various applications, including separations, packaging, drug delivery, and environmental remediation.

Existing porous materials are generally not made from renewable resources and are difficult to customize; new films and membranes with well-defined mesoporosity that are based on cellulose will open up significant new opportunities in the field of materials science, and will represent an entirely new class of materials.

## In the pipeline

### SUBSTITUTION OF FOSSIL FUEL-BASED LATEX WITH NCC FOR LWC PAPER

Kruger Inc., a Canadian wood products company and Bio Vision Technology Inc., a Canadian supplier of nanocrystalline cellulose (NCC) will collaborate on a project aimed at substituting NCC for the latex currently used in the coating formulation for lightweight coated (LWC) paper. While latex is usually derived from petrochemicals, NCC obtained from renewable resources is independent of the price of oil and more environmentally friendly. The research will be led by Dr. Balazs Tolnai from Kruger.



### FUNCTIONALIZED MECHANICAL PAPER AND BOARD GRADES USING NCC/NFC/NANO-PIGMENT STRUCTURING

Led by Dr. Patrice Mangin, this project is a collaboration between Université du Québec à Trois-Rivières and GL&V, a leading global provider of technological solutions used in pulp and paper production. The aim of the project is to use innovative equipment provided by GL&V to apply nanocrystalline cellulose (NCC) and nanofibrillated cellulose (NFC) to the surface of paper in a way that maximizes retention. The improved strength and surface properties will create new paper grades from mechanical pulp.

### MULTISCALE MODELING OF THE STRUCTURE AND THERMODYNAMICS OF CHEMICALLY MODIFIED NCC FOR RATIONAL DESIGN OF NCC BASED NANOCOMPOSITES, GELS, & FOAMS

Dr. Andriy Kovalenko from the University of Alberta will lead this modeling effort that will focus on the effects of various compatibilization approaches for the incorporation of NCC into a range of matrices. The modeling efforts will be carried out in collaboration with the National Institute for Nanotechnology, to aid the progress of three other ArboraNano R&D projects led by Dr. Mark Andrews from McGill University, Dr. Yaman Boluk of the University of Alberta, and Dr. Hamdy Khalil from Woodbridge Foam Corporation.