



AUTOMOTIVE

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COATINGS & INK

PAPER & BOARD

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MEMBRANES

HEALTH

Seeing Trees in a Brand New Light

Canadians partner up to develop nano-inspired products

INTERVIEWS

Craig Crawford - Auto sector investing in bio-based materials

Clive Willis - The big challenge of naming small particles

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.
CelluForce
FPInnovations
INRS - Institut Armand Frappier
Kruger Inc.
Marquis Alliance Energy Goup Inc.
McGill University
Nanoledge
NanoQuébec
NORAM Engineering & Constructors Ltd.
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Ontario BioAuto Council
Queen's University
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University of Waterloo
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Natural Resources Canada
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Tissue Regeneration Therapeutics Inc.
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News Briefs

ARBORANANO LAUNCHES FIVE NEW PROJECTS

ArboraNano is pleased to announce that in September 2011, the Board of Directors approved five new projects for ArboraNano funding. All projects are also supported by university partners and CelluForce, the world leader in the commercial development of NanoCrystalline Cellulose (NCC). The projects all aim to use or modify NCC for diverse applications. The new projects include the Network's first two projects in the biomedical field, as well as two projects in the area of composites for automotive and food packaging applications. As a result of the launch of these projects, ArboraNano gained two new Network Members, the University of Waterloo and INRS-Institut Armand Frappier.

ARBORANANO COMPLETES ITS FIRST R&D PROJECT

Kruger Inc., a major North American producer of publication papers and other wood products, and Bio Vision Technology, a Nova Scotia biotech firm supplying carboxylated NCC manufactured in a single-step procedure, established a R&D collaboration in 2011. With support from ArboraNano, a 6 month project was launched to evaluate the feasibility of substituting Bio Vision Technology's NCC for the fossil fuel-derived latex used in the production of certain grades of Kruger paper. The effect of this substitution on the final product quality was systematically quantified following laboratory and pilot-scale trials. The project was completed in Q3/2011, and was led by Kruger's Manager of Product Development, Dr. Balázs Tolnai, with technical support from Bio Vision Technology.

ARBORANANO AND TAPPI TO CO-HOST CONFERENCE

ArboraNano and Tappi will unite their efforts to co-host the 2012 Tappi International Conference on Nanotechnology for Renewable Materials. The conference will be held at the Hyatt Regency Montréal from June 5-7, 2012. The Program Chairs include Dr. Ron Crotogino (ArboraNano Network Director), Dr. Patrice Mangin (Université du Québec à Trois-Rivières) and Dr. Robert Moon (USDA Forest Service).

Abstracts from participants working in research, development and deployment of renewable materials enhanced by nanotechnology are being sought. Also of interest are contributions related to trends in emerging markets for renewable nanomaterials, and other aspects of nanotech products including law, policy, economics and environmental health and safety. The principal themes of the conference are:

- Nanocellulosics and nanocomposites
- Applications of renewable nanomaterials
- Nanostructured materials by self assembly
- Nanotech coatings and novel nano-enabled functionalities
- Environmental, health and safety issues for nanomaterials
- International standards for nanocellulose

For further information and to submit an abstract, please visit www.tappinano.org.

ARBORANANO A MEMBER OF NEWLY CREATED FIBRE NETWORK

ArboraNano is one of eight forest R&D networks that make up FIBRE, the Forest Innovation by Research & Education. FIBRE, created in 2011, is a new organization devoted to building synergies among the forest R&D networks in support of the priorities of Canada's vital forest sector innovation system. Each network provides unique and novel innovations to sustain and transform Canada's forest sector. Further information about FIBRE and the forest networks can be obtained from the FIBRE spokesperson, Dr. Theo van de Ven (theo.vandeven@mcgill.ca).



Interview

NANOTECHNOLOGY PAVES THE WAY FOR A GREENER DRIVE

Craig Crawford has served on numerous government and industry committees and non-profit boards that have advocated support for bio-based industries in both Canada and the United States. He has acted as a consultant to the federal and Ontario governments on the bioeconomy and wrote a framework for developing biobased industries in Canada.

Craig Crawford
President & CEO
Ontario BioAuto
Council

Q – WHAT IS THE PURPOSE OF THE ONTARIO BIOAUTO COUNCIL?

A - Our mission is to make the auto sector in Ontario a world leader in using bio-based materials from the forestry and agriculture sectors. Over time, that mission has expanded to include marketing bio-based technologies that the auto sector has developed to other sectors like packaging, construction, and even clean-tech like solar and wind.

Q – WHAT LED TO THE CREATION OF THE ONTARIO BIOAUTO COUNCIL?

A - Back in 2007, the auto parts makers were experiencing really dramatic increases in the cost of their raw materials. Bio-based materials offered an alternative and sometimes, a cheaper source of raw materials than conventional petrochemicals or petrochemical-based plastics. More recently the drivers have been enhanced product performance and toxic chemical reduction. What we are finding is new bio-based high performance fibres can be used in plastic composites to reduce vehicle weight. Non-toxic bio-based chemicals can help industry comply with new regulations controlling toxic chemical emissions.

Q – SO WHAT IS YOUR ROLE IN THE ONTARIO BIOAUTO COUNCIL?

A - My role as CEO is to try to help bring together all the major players in the value chain going from forestry and agricultural producers to chemical and plastics suppliers to downstream customers in the automotive and manufacturing sectors.

Q – YOU WERE A STRONG SUPPORTER OF ARBORANANO FROM THE BEGINNING. WHAT WAS YOUR MOTIVATION FOR THIS?

A - I thought that the ArboraNano Network was structured for success. The focus of ArboraNano is on high performance nanocellulose crystals and that type of high performance fibre could potentially provide transformative benefits to the auto sector in more durable coatings and super lightweight plastics. Also, the Network is industry driven. It has brought together universities, government labs and industry in a way that gives private sector members on the Board great flexibility when selecting projects for funding. We also like that ArboraNano brings to-

gether different industry sectors. That kind of multi-sectoral approach addresses the need to aggregate market demand and be able to quickly achieve economies of scale on new bio-based products. It also helps to reduce duplication. If we can pool our efforts, we can avoid duplication and really make more efficient use of taxpayers' dollars.

Q – IN YOUR OPINION, WHAT IS THE POTENTIAL FOR BIO-BASED MATERIALS FROM THE FOREST SECTOR FOR APPLICATION IN THE AUTO SECTOR?

A - I think there are many opportunities. NCC is one very important one. We've also funded forest microfibre technology and we are also interested in using lignin as a low cost precursor for carbon fibre. If we could make low cost carbon fibre, we could dramatically reduce the weight of cars. It could be up to 40 to 50 percent. Forestry can play a really big role, not just in transforming itself by using these new materials to develop new markets, but it could also provide real economic benefits to other sectors.

Q – WHAT WOULD IT TAKE TO GREATLY ACCELERATE THE INCORPORATION OF BIO-BASED MATERIALS INTO AUTOMOBILES?

A - I think we are at the point where we need grants for new product development. We've got many technologies that are nearing commercialization now and we need to shift focus to product commercialization.

Q – DO YOU FEEL THAT THE BUSINESS-LED NATIONAL CENTRE OF EXCELLENCE PROGRAM IS A GOOD VEHICLE FOR DELIVERING ON YOUR EXPECTATIONS?

A - As a Business-led National Centre of Excellence, ArboraNano comes at its research from a market-pull perspective. So it is really industry driving the bus. I think it is a good vehicle for delivering on our expectations. I think based on my experience with ArboraNano, NSERC deserves a great deal of credit for launching these Business-led NCE programs.

Q – HOW WELL HAS ARBORANANO TAKEN ADVANTAGE OF THE NEW BUSINESS-LED NCE APPROACH?

A - Overall, I think it has done an excellent job. I think we have a really great Board of Directors and a first rate secretariat led by our CEO, Ron Crotagino.

Q – THE MANDATE OF THE ARBORANANO NETWORK IS COMING TO AN END IN MARCH 2013. WHAT SUGGESTIONS WOULD YOU HAVE TO BUILD ON THE MOMENTUM THAT HAS BEEN CREATED THUS FAR?

A - What we are experiencing now are some real synergies and a sense of teamwork at ArboraNano. I personally would like to see NSERC fund the ArboraNano Network for another four years to keep this momentum going.

PROJECTS IN THE AUTO SECTOR

- Preparation of Nanocrystalline Cellulose–Polycarbonate Nanocomposites **NEW**
- Investigating NCC as potential unique performance enhancing agent in polymer systems used in the manufacturing of Automotive & Construction Products
- Graft-modified NCC/ Interpenetrating Networks
- Nano-Reinforced Foams from Nanocrystalline Cellulose and Thermoplastics



Interview



Clive Willis
President
CWIC Inc.

NOMENCLATURE IS NO NANO MATTER

Dr. Clive Willis established himself as a private consultant after having served in several positions at the Vice President level at the National Research Council of Canada, including that of Vice-President of Research. Dr. Willis has served on a number of boards and committees at regional, national and international levels including co-chairing the National Technology Table as part of the National Climate Change Process. Dr. Willis played a key role in establishing a number of not-for-profit, innovation-driven coordinating organizations including, most recently, NanoQuébec, where he assumed the role of Director General. Dr. Willis provides a range of government, private sector, and not-for-profit experience related to innovation, science and technology.

Dr. Willis provides a range of government, private sector, and not-for-profit experience related to innovation, science and technology.

Q – NANOCELLULOSE HAS BECOME A SUBJECT FOR INTENSE RESEARCH IN NORTH AMERICA, EUROPE AND JAPAN. IT SHOWS GREAT PROMISE IN A WIDE RANGE OF APPLICATIONS, PARTICULARLY IN THE DEVELOPMENT OF PRODUCTS MADE FROM RENEWABLE RESOURCES. CANADA HAS TAKEN A LEADERSHIP ROLE IN DEVELOPING A COMMERCIAL PROCESS FOR MANUFACTURING NANOCRYSTALLINE CELLULOSE (NCC). WHAT STEPS MUST BE TAKEN TO ENSURE THAT THIS MATERIAL CAN BE APPLIED IN GLOBAL MARKETS?

A - NCC has very good potential for improving materials in many industrial sectors from paper making, resource extraction, aerospace, medicine, and so on. There is a need to prove production methods but perhaps a more urgent need to demonstrate the value of NCC in many of the sectors of application. This will require international acceptance of NCC as a valuable but safe and well understood nanomaterial. It will require international standards to ensure appropriate nomenclature, measurement and characterization as well as for security of human health and the environment so that commercial trade is facilitated, not only for NCC but also for products enhanced through NCC. It will also require ensuring a general awareness of NCC, its potential and its safe utilisation for many communities including the general public.

Q – WHAT STEPS TOWARDS THIS HAS CANADA TAKEN SO FAR?

Canada, through Cellulforce, FPInnovations, and the Canadian Standards Association (CSA) as well as through the support of federal and provincial agencies has started a broad front of activities to address the challenges laid out above. With regard to the important work of developing international standards, Canadian experts are working towards developing standards initiatives through TAPPI and ISO programs, with the assistance of the CSA.

Q – WHAT IS THE ISO PROCESS AND HOW STRONG IS CANADA'S ROLE IN THIS PROCESS?

A - ISO develops international standards but does not deal with certification, which tends to be a national process that can reference ISO standards. They are developed by a collectivity of nations through consensus and can fairly be called "globally harmonized standards". Thus the regulations and certification processes that reference them provide a strong commonality across nations and facilitate trade in those materials and products that respond to the ISO standards. Canada, through the formal relationship established by the Standards Council of Canada and by the participation of Canadian expertise on the ISO Technical Committees through the programs supported via the CSA ensures appropriate Canadian strength. For NCC, this work will be done through ISO TC229 (nanotechnologies) where there is already a

strong Canadian presence that will be further enhanced when work on NCC starts, hopefully in the latter part of 2012. Also Canada has responsibility for the convenorship of one of the four working groups that constitute TC229.

Q – WHAT OBSTACLES DO YOU SEE AND HOW CAN THESE BE OVERCOME?

Growing competitive interest elsewhere in the world will require an increased, sustained effort both on standards development and on exploring promising domains of application of nanocellulose.

Q – CAN YOU DESCRIBE THE ROADMAP FOR THE ISO PROCESS?

A - It's simply a priority/time schedule for action. For nanocellulose, we hope to start formal ISO discussions in mid-2012 for action on terminology and nomenclature and on measurement and characterization.

Q – WHAT IS TERMINOLOGY AND NOMENCLATURE?

A - Terminology in TC229 is the development of a common vocabulary using a taxonomic terminological approach. That vocabulary will eventually become the basis for scientific papers, patents, and regulations and trade. If you don't use the same words, you don't know what you are buying and you don't know how to write a contract, and so on. Nomenclature is simply naming materials and products. So that is to identify what is in products when you sell them and that's what you write in regulations when you are controlling these products.

Q – WHAT IS MEASUREMENT AND CHARACTERIZATION?

A - It's the physical and chemical measures to characterize objects. This pertains to size, optical properties, and so on. The key is to have an agreed protocol for measurement and measurement instrumentation, so that everybody, when they do these measurements, gets the same answer.

Q – WHAT ARE ENVIRONMENT, HEALTH AND SAFETY?

A - It is the guidance given by the ISO process on the actions necessary to ensure safety of human health and the environment. This guidance is closely linked to discussions within the Organization for Economic Cooperation and Development (OECD) working parties on the development of regulations. There are a fairly standard set of methods out there and we have to go through these standard methods for NCC.

Q – WHAT IS MATERIAL SPECIFICATIONS?

A - Material specification is the information necessary to define the content of samples of materials. A material specification will indicate how well a sample will perform according to the various characteristics you've measured in the measurement and characterization section.

Q – HOW CRITICAL IS PARTICIPATION IN THE ISO PROCESS TO CANADA'S COMPETITIVENESS?

A - Urgent, international action is required to facilitate trade in nanocellulose products. Canada has a privileged position for the moment because we have had NCC in development for a few years. Through ArboNano, I would suggest that we are ahead of the world in exploring the various applications, and that is largely because we have access to good, well-characterized, samples of NCC. So, we have an advantage but that advantage will certainly be challenged.

Health sector

NCC REGULATORY UPDATE

Brian O'Connor
Program Manager, Environment
FPIInnovations

Since the previous newsletter, the team has been extremely busy completing the research required to support the regulatory submission to Environment Canada to allow for the manufacture and use of NCC in consumer products in Canada. We are pleased to announce that all of the testing has been completed and the submission was made on December 22, 2011. The suite of mammalian, mutagenicity and carcinogenicity testing of NCC all showed no effect at the highest dose tested, which is in line with all of the other testing that has shown NCC to be non-toxic in nature. The process for determining the fate and potential migration of NCC from consumer products definitely presented an analytical challenge due to the organic nature of NCC and the low detection limits that were required. Fortunately we were able to overcome these challenges and the initial results demonstrated that NCC is stable in consumer products and is not expected to migrate out from these products. In summary, all of the testing has shown NCC to be a nanomaterial of low concern and we are expecting a positive response from Environment Canada, regarding our regulatory submission, early in January 2012.



PROJECTS

NEW

Encapsulation of natural antimicrobial agents into poly(lactic acid) nanocrystalline cellulose (PLA-NCC) supramolecular composite films for improving shelf-life of food products.

NEW

Pharmaceutical Applications of NCC

NEW

Modification, Functionalization and Application of NCC in Personal Home Care, Coating and Biomedical Systems

MARKET STUDY – POTENTIAL OF NCC FOR MEDICAL APPLICATIONS

A preliminary market study to assess the opportunities for nanotechnology in healthcare was carried out by ArboraNano in 2011, with a view towards assessing opportunities for NCC. The primary applications of nanotechnology in the health sector are Therapeutics (5%), Analytical Tools and Instruments (17%), Medical Materials and Implants (19%), Diagnostics (19%), and Drug Delivery (40%). The US demand for medical products derived from nanotechnology is projected to increase by over 17% per year, reaching \$75 billion in 2014 and \$149 billion in 2019. A significant portion of this demand is expected to be related to nanodrugs, with projections of \$59 billion in 2014 and \$118 billion in 2019. The market study reviews the potential of nanodrugs by therapeutic class, and also reviews the developing trends in other medical products.

A comprehensive database of 430 Healthcare Nanotechnology companies around the world was created. An analysis of these revealed that 2/3 of these companies could be classified as Nano-Startups, with more than half of their portfolios characterized by life science products/technologies with nanotechnology components. The other 1/3 of the companies, typically well-established in the pharmaceutical and medical/biotechnology devices sector, were classified as Nano-Adopters, with less than half of their portfolios involving nanotechnology products.

The majority (94%) of the companies were in North America and Europe. The North American domination in the development of healthcare nanotechnologies is clear, with twice as many companies as Europe and approximately twice as many patents in this field. For both Nano-Startups and Nano-Adopters, the market study assessed the number of companies involved in the various nanotech medical applications. While North America has a strong focus on Drug Delivery, European companies are more oriented towards Diagnostics, and Medical Materials and Implants.

Thus, the leadership position of North America in the Healthcare field, combined with strong university research, advanced technology transfer and bigger venture capital funds compared to Europe explains the greater number of companies and Nano-Startups, and the development of a wider range of new medical products based on nanotechnologies. Given this climate and the properties of NCC, North American opportunities for NCC in Drug Delivery as well as certain other medical applications seem most promising.

Project Portfolio

PROJECT TITLES

YEAR 1	NCC-based inks for reinforced security and color
	Fundamental and applied approaches to optimise the dispersion of nanoparticles in different media: Application to wood coatings
	Multi-layer coatings for the wood industry
	Opaque aqueous nanocomposite coatings for wood
	Molecular modeling of nanocelluloses
	Use of NCC as an additive in clear coatings
	Investigating NCC as a loss circulation material in drilling fluids
	Mesoporous paper: New nanoporous membranes from NCC
YEAR 2	Nano-reinforced foams from NCC and thermoplastics
	Improvement of finishing oil performance through the addition of nanoparticles
	Functionalized mechanical paper and board grades using NCC/NFC/nanopigment structuring
	NCC as unique performance enhancing agent in polymer systems used in the manufacturing of automotive & construction products
	Substitution of fossil fuel based latex with NCC
	Multiscale modeling of chemically-modified NCC for rational design of NCC-based nanocomposites, gels, foams
	Cellulose nanofilament-reinforced paperboard packaging products
	Graft modified NCC/Polyurethane interpenetrating networks
YEAR 3	Wood derived nano-enhanced aerospace products
	The compatibilization of NCC for dispersion in other matrices
	Using NCC in adhesives
	Application of NCC for high-performance textiles
	NCC-reinforced polycarbonate for automotive applications
	Encapsulation of natural antimicrobial agents into PLA-NCC films for protection of food products
	Modification, functionalization and application of NCC in personal home care, coating and biomedical systems
	Pharmaceutical applications of NCC
New Processing Methods for chiral nematic structures	

FUNDING



7% aerospace



20% automotive



21% forest products



11% oil & gas



41% varia

Update

INTERNATIONAL CONFERENCE ON NANOTECHNOLOGY FOR RENEWABLE MATERIALS

Enthusiasm about the potential of forest nanomaterials to create a wide range of new products and business opportunities was clearly evident among the 200 delegates who attended the 2011 TAPPI International Conference On Nanotechnology for Renewable Materials, held June 6-8 in Arlington, VA.

Announcements about new capacity to produce a variety of nanocelluloses (NCC, CNC, NFC, MFC) for product development and commercialization were made. These new investments underscore the resolve of the forest products industry to be a major player providing renewable materials for the growing global demand for green products.

FPIINNOVATIONS (Pointe-Claire, QC) has started a new pilot facility to boost its production of NCC to 10 kg/week.

THE US FOREST SERVICE'S FOREST PRODUCTS LABORATORY (Madison, WI) has the capacity to produce 35-50 kg/day of CNC.

THE US FOREST SERVICE is collaborating with the University of Maine (Orono, ME) to build a 500 kg/day NFC plant.

INNVENTIA (Stockholm, Sweden) announced "The world's first pilot plant to produce nanocellulose", with a production capacity of 100 kg/day of NFC.

ALBERTA INNOVATES – TECHNOLOGY FUTURES (Edmonton, AB) is building a pilot facility to produce 100 kg/day of NCC.

BIO VISION TECHNOLOGY INC. (New Minas, NS) anticipates producing 4 tons/year of NCC using a process developed at NRC's Biotechnology Research Institute.

CELLUFORCE (Windsor, QC) will become the first commercial producer of NCC in early 2012 with a production target of 1 tonne/day. (The official opening of this demonstration plant is scheduled for January 26, 2012.)



Innovation to produce products taking advantage of these new nanomaterials is going on in universities, research institutes and industry around the world. Of special interest are the unique properties of forest nanomaterials that can be used for high-performance films, coatings, foams, textiles, paper and board, adhesives, bio-nanocomposites, catalysts, battery separators and many other products. Research to modify, adapt and compatibilize forest nanomaterials for the various applications in a cost-effective manner is in high gear. Competition is strong as many global players are trying to develop a leadership position in this renaissance of the forest products industry.

Despite the tremendous potential of forest nanomaterials, consumer perception, regulations and product safety are of high concern and the forest products industry is sparing no effort to address these issues. Nearly 25% of the considerable R&D budget devoted by FPIinnovations for the development of NCC was spent on environmental testing, to ensure the safety of this material when it enters the market (see Dr. Brian O'Connor's NCC Regulatory Update on page 5).

Following the conference, a workshop was convened to develop a roadmap for the development of international standards for nanocellulose (see Dr. Clive Willis' interview on page 4).

The annual TAPPI International Conference on Nanotechnology has become the premier event for tracking progress in forest nanoproducts innovation. This year, ArboraNano, NanoQuébec, FPIinnovations and PAPTAC are already busy working with TAPPI since the 2012 TAPPI International Conference on Nanotechnology will be held for the first time in Montréal, from June 10 to 14, 2012.

2012 TAPPI INTERNATIONAL CONFERENCE ON
Nanotechnology for Renewable Materials
June 4 - 7, 2012 • Hyatt Regency Montréal
Montréal, Québec, CANADA • www.tappinano.org

The banner features a green background with a stylized leaf graphic on the left side. The text is in white and green. The TAPPI logo is on the right.

Arbora BUZZ

FROM OUR MEMBERS AND PARTNERS

"NORAM has built a global business in the chemical and resource sectors, and our work with early-stage technologies is often guided by insight into areas where existing synergies could open up new commercial opportunities. Our work with ArboraNano and our university partners provides us with an opportunity to go one step further, and extend our technology horizon to embrace even wider possibilities in those areas which we would deem to be our core competences. In short, **ArboraNano is building "stretch" into Canadian innovation.**"

George Cook
CEO & President
NORAM Engineering & Constructors Ltd.

"ArboraNano has facilitated collaboration between university and industry, and between two very different industry sectors that are both very important to the Alberta economy. In addition, it has brought together funding from industry as well as federal and provincial sources. Bridging all of these gaps within the framework of this new funding initiative was a remarkable accomplishment. We are excited by the opportunities we see for the products we are developing under this program, and **we are encouraged by this new approach for risk sharing in innovation represented by the BL-NCE program.**"

Jay Brockhoff
VP Technical Services
Marquis Alliance Energy Group Inc.

"Kruger Inc. supported ArboraNano's application for BL-NCE funding in 2008. This program was well conceived, timely, and the proposed network addressed an urgent need in our industry to reach out and create new partnerships that will help us derive greater value from our forest resources. We have now made use of this program to develop a new high-value paper grades using nanocrystalline cellulose to replace additives that are traditionally derived from petroleum sources. With the sharp downturn in the economy in 2009, the timing was right to undertake this development, but the resources to support this initiative were very scarce.

The BL-NCE support for semi-commercial pilot-trials, and the networking with BioVision Technology Inc. and NRC provided the essential catalysts that enabled us to go ahead with this product development initiative at this critical time. Our experience confirms that this imaginative new program initiative, which is driven by industry needs, is **an effective tool for bridging the gap between university discovery and commercial value creation.**"

Balázs Tolnai
Manager, Product Development
Kruger Inc., Industrial Products Division

ArboraNano

Canadian Forest NanoProducts Network

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

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