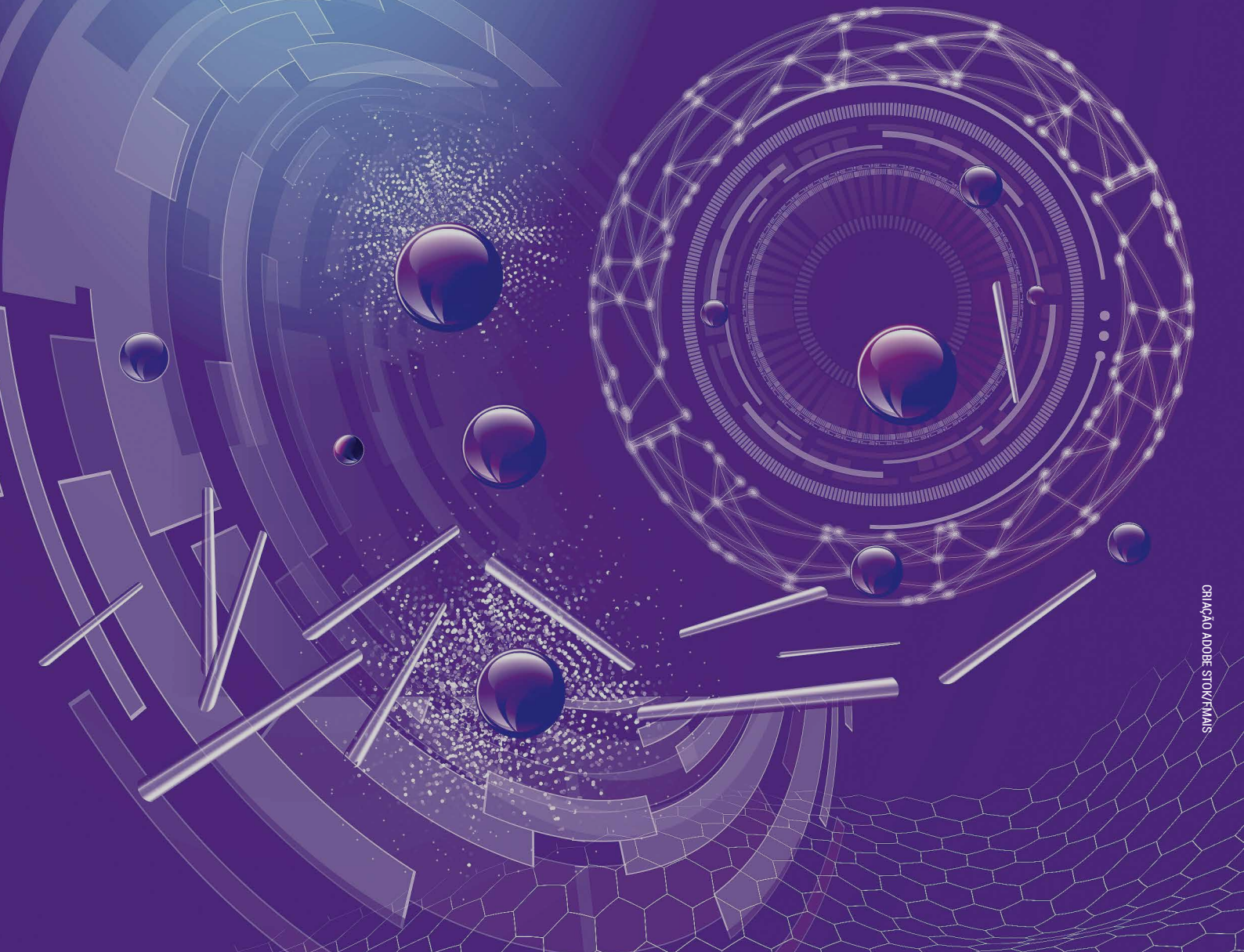
# NANOMATERIALS FROM THE FOREST BASE INDUSTRY OFFER A WIDE RANGE OF APPLICATIONS



CRIAÇÃO ADOBE STOK/FIMAIS

Current research fronts include methods for obtaining them, safety regarding their use and practical aspects about each existing and potential market

**BY CAROLINE MARTIN**
Special for *O Papel*

To address the potential of wood in the bioeconomy involves deep diving into the characteristics of the components that make up its structure, particularly those that are obtained at a nano scale. It is also important to clarify that nanoscience, nanomaterials and nanotechnology concepts are not exactly new, but new developments in this area make achieving the goals aspired for a more sustainable future more tangible.

According to professor Song Won Park of the University of São Paulo (USP), "nanotechnology can be simply defined as an understanding and an ability to manipulate matter ranging from 1 and 100 nanometers in size, which unique phenomena and structures enable new and interesting applications."

Nanoscience is the study of material properties at the nanoscale in particular, and focuses on the unique and size-dependent properties of material in solid-state. "For such, new synthesis methods are required to produce materials on a nanoscale. Equally important are the techniques with new characterization approaches," said Park.

Nanomaterial, in turn, is a more disseminated and broader term than nanoparticles, and depends on the technological sector that produces it, as well as on the types of nanotechnological applications that are made. "A material can be considered a nanomaterial when presented in a much smaller dimension than its usual size, it exhibits in its external dimensions or in its internal structure new characteristics that were not so evident in a larger size," said Park, who stresses that the growing interest in the use of renewable materials is reflected in the increased interest in nanomaterials originating from biomass and, consequently, forest-based.

ABTCP IMAGE BANK

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The main nanomaterial produced by the forest base industry comes from cellulose fibers. From them, superfines, microfibrillated cellulose (MFC), nanofibrillated cellulose (NFC) and cellulose nanocrystals (CNC or NCC) are obtained. "It was as of 1981 that studies and patents for the production of nanocellulose became more consistent. Today, there are more than 225 companies, institutes and universities actively involved in research related to it," said Park.

Also according to USP's professor, MFC is a smaller-sized cellulose fiber than the original pulp fiber, but with its microfibrils extremely enlarged and exposed, generally presenting a diameter between 25 and 100 nanometers and lengths varying above 1,000 nanometers. NFC is more refined than MFC, containing finer longitudinal splits, 5-20 nanometers in diameter and lengths above 1000 nanometers, are branched, which subsequently promotes entanglement between particles, or network-like structures. In contrast CNCs are rod-like particles that are nanoscale in both length (typical range 25 to 350nm) and width (typical range 5 to 20nm), with aspect ratios of less than 50nm, having tapered ends, no branching, and showing no entanglement.

The forest base industry has another nanomaterial of great potential, said Park. "There is a group of polyphenol macromolecules generically called lignin, which is, in fact, a compound of lignins from different origins. Nanolignin, for example, comes in particles of 10 to 100 microns, has a high surface area and increases the physical properties of lignin, in addition to being able to be functionalized through reactions with other compounds, for different characteristics, during its production process — which has raised considerable commercial interest."

Park says that nanomaterials like nanolignin or nanocellulose are not just an extremely small-sized lignin or cellulose. "Due to the fact that they are presented on a nanometric scale, they have properties and qualities not previously revealed in materials on a mesometric scale. Therefore, these

materials are not alternatives to an existing material, but rather a material that opens up new characteristics when used, either as an additive or as a main material," he said.

The USP professor points out that there are different sources for obtaining cellulose and lignin — and from these raw materials there are different paths for obtaining nanolignin and nanocellulose. "In addition, the operation of a given manufacturing process has low reproducibility in products. This means that it is necessary to consider that there are nanolignins and nanocelluloses, not a single class of nanomaterials," he said, explaining that for each application there are different nanomaterials that need to be tested.

Another important aspect about nanomaterials has to do with health. "So far, there is no evidence of health hazards from the use or manipulation of nanolignins and nanocelluloses as an end material, but those interested in entering this segment should always follow current regulations and research," said Park.

Robert Moon, Materials Research Engineer at USDA Forest Service (United States Department of Agriculture), is encouraged by the findings of many ongoing environmental, health, and safety (EHS) studies. "Today, it is now well established that the as produced highly refined pulp and CNs, which are not subsequently chemically modified, are safe to use. More work is always needed in EHS, but this latest development helps remove the fear of using CNs, and thus will subsequently help promote greater levels of research, development, and utilization of CNs in the pulp/paper/packaging industries, as well as in other new application arenas."

"Since cellulose nanomaterials have several current uses and future applications are being studied, this segment can become an important opportunity to expand products with greater added value in the cellulose industry. However, to tread in a safe direction, two important aspects must be considered: the environmental impacts related to the production of nanocellulose and the most suitable application for the grade produced," said Adriana Ribeiro, Research Consultant II and Chemical Analysis and Synthesis Coordinator at SENAI's Biosynthetic and Fiber Innovation Institute (ISI B&F). "Environmental impacts mainly depend on the chemical modification and the mechanical treatment path used in the production process. Therefore, one must take into account the presence of chemical reagents during the process, due to the possible generation of effluent or the concern of obtaining the greenest nanocellulose possible, maintaining its initial characteristics," she said.

The truth is that companies are investing in the development of new bio-based products that represent more sustainable alternatives to traditional products. "Investments in innovation are aimed at adding value to forest products and making better use of secondary industrial flows, developing value chains and producing high added-value bio-based products, such as wood-based nanocelluloses. However, transitioning from low added value products to high added value products can be a challenge in a forestry bioeconomy. A precise characterization of the nanocellulose obtained is essential to find an application that's compatible with these characteristics. It isn't always possible to shape a 'product or ingredient' for a specific purpose, especially when we consider that the pulp and paper industry already has well-defined processes. It is important to first understand the market need and, based on an ingredient well defined in terms of its properties, target it to a specific application where it will fulfill its role," said Adriana.

Understanding the ways for obtaining new grades, preserving their initial characteristics, like biodegradability, and

PERSONAL ARCHIVE

**Moon: "Some of the more promising application areas for CNs has been barrier/separation membranes, batteries, biomedical, catalytic supports, cements/concrete, cosmetics/personal care, drilling fluids, flexible electronics, food coatings, inks, paper/packaging, and polymer reinforcement."**

PERSONAL ARCHIVE

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evaluating the economic feasibility of the process is another fundamental aspect for expanding the portfolio of applications. "This has to do with increasing the scientific community's knowledge and, consequently, investments in research," said ISI B&F's coordinator.

In Park's perspective, the future contemplates an important decision: "nanomaterial manufacturers will have to choose, in each case, whether they behave as manufacturers of off-the-shelf commodities or whether they will participate in the engineering solution of their buyers, detailing the physical mechanisms and chemicals that their nanomaterial presents in each application. It is a matter of choosing the business model to be adopted, which also involves internal technical capabilities," he said about next steps.

## Practical applications already point to future steps

According to professor Deusanilde de Jesus Silva of the Federal University of Viçosa (UFV), over the last 15 years, several studies have been carried out abroad and in Brazil with the goal of enabling processes to obtain nanomaterials and developing applications based on their use. "We already know that these nanostructures have properties that can help improve existing materials and develop new ones, in addition to the advantages of being from renewable sources, of being present in large quantities in nature and of their sources being relatively cheap and accessible. The challenge, however, is to obtain them in pure form from technically and economically viable processes," she said.

Obtaining nanofibrillated cellulose involves deconstructing the biomass by physical processes (top-down), obtaining good yields and a mixture of fibrillated cellulose, in which the physical treatment's intensity will determine the proportion between materials of micro and nano dimensions. In turn, nanocrystalline cellulose extraction processes involve deconstructing lignocellulosic biomass (chemical, biological or both, also top-down) and constructing these structures from bioactive agents (bottom-up).

The moment is truly exciting to be working with cellulose nanomaterials, believes Moon. "They are no longer a scientific curiosity but are still "young" in terms of new materials development," he said. "Pulp and paper industries are producing various forms of highly refined pulp (aka cellulose microfibrils) and using them in their own product lines. They can scale-up production volume and tailor the level of fibrilization as needed for their own internal use.

PERSONAL ARCHIVE

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KATIA PICHELLI


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When they have technical issues, they solve them internally and can go to technical conferences to see what is new as the CN technology advances," he said about the current context.

Also according to Moon, the scope of CN research, development, and utilization continues to expand globally across several general categories, such as, additives, colloids, coatings/films, hydrogels/foams, production, and template structures. "In recent years, some of the more promising application areas for CNs has been barrier/separation membranes, batteries, biomedical, catalytic supports, cements/concrete, cosmetics/personal care, drilling fluids, flexible electronics, food coatings, inks, paper/packaging, and polymer reinforcement. These have benefited from improved capabilities in characterization, surface modification, rheology, and the incorporation of CNs into various manufacturing processes. The key to mastering more challenges will be to further develop our fundamental understanding of using these materials, combined with the applied engineering needed to scale-up this technology to increase volumes," he said.

Globally, there has been continued research and development studies in the production of CNs from eucalyptus pulp. FiberLean Technologies, of Cornwall, UK invented a scalable process to produce cellulose microfibrils (CMF) from various cellulose sources including eucalyptus pulp. "By providing specialized griding modules for on-site use and procedures for producing CMF from eucalyptus pulps, it can provide greater flexibility for industry to fine tune development of eucalyptus-based CMFs production and their use in their product lines. Eucalyptus pulp manufacturers are producing various forms of highly refined pulp and using them in their own product lines and perhaps looking for new market areas for these materials," said Moon, pointing out that Brazil is leading efforts in this front.

Park agrees that the unique characteristics that Brazil's forest base sector possesses — a highly verticalized model focused on its commodity — give local players excellent conditions to actively participate in this market. The predicted trend is that, even if the end product that uses nanomaterials returns to Brazil as a market product, the country should emerge as an exporter. "Even if Brazilian companies have a stake in specialized companies abroad, in their pursuit of internationalization, they will have to learn to sell these products in markets with a very different dynamic than the commodities market, such as pulp and paper, which they are familiar with," said USP's professor about the challenge involving the highly projected, yet incipient, gains.

According to Washington Luiz Esteves Magalhães, Nanotechnology Researcher at Embrapa Florestas, the potential of the country's industry is huge as it already stands out as a cellulose pulp producer. The path to follow should be biorefinery, with the forest base sector using nanotechnology as another tool to increase profitability. "Since biorefinery solutions differ for each company size and are also linked to their core business in the market, it is important to note that nanocellulose should have applications for each situation. For some companies, it will be necessary to find high-volume markets, such as fertilizers and biocide additives for agribusiness or civil construction. Another alternative is to think about applications in small compounding pharmacies, where small volumes of nanocellulose could be manufactured in loco. Average size volumes of nanocellulose could be transported once economically-viable dewatering technologies are developed," he said about ongoing possibilities.

## Klabin and Suzano expand research lines in the area

Exploring the potential of cellulose nanomaterials in the packaging industry, Klabin stands out as one of the Brazilian players leading research in the area. Since it works with pine and eucalyptus, the company is dedicated to deepening its lines of research in all sorts of raw materials,

informs the company's Industrial Research and Development Manager, Silvana Meister Sommer. "Our nanotechnology line is based on MFC, which represents a world to be explored, starting with in-house application opportunities, with our papers being combined with the cellulose we produce. It is a focus that has been going on for more than a decade at Klabin. However, since 2017, with the structuring of the Technology Center in Telêmaco Borba (PR), we have dedicated a lot of effort to MFC-related research."

Introduced in 2022, Klamulti, a paperboard made with MFC that combines print quality and high mechanical resistance, is intended for multipack beverage packaging. The product is one of the examples already present on the market. "This is a technology that has come to stay and, given its good performance and competitive advantages, we want to expand its applications to other products. We have a sequence of tests taking place with all sorts of paper that Klabin manufactures and on other paperboards, since we believe that there are opportunities in multiple fronts," said Silvana.

She informs that Klabin also earmarks efforts and investments for the potential that MFC presents outside the company. It is worth remembering that, during the Covid-19 pandemic, a partnership between Klabin, cosmetics group Apoteka and Senai led to the development of a 70° INPM gel alcohol sanitizer using MFC as a thickener. This successful experience led Klabin to extend the use of MFC in a new cosmetics line. "In another partnership, we support the Kind Beauty brand in using MFC as the protagonist of cosmetics launched so far, making this the first practical application outside of Klabin's core business," said Silvana.

In view of the countless potential and maturity level of the developments it is leading, Klabin inaugurated at the end of 2019 its Center of Pilot Plants in Telêmaco Borba (PR). The purpose of the center is to simulate a production unit where studies and tests are carried out on various research fronts. "Our pilot plant has an MFC production capacity of 1 ton/day. Today, it already operates at maximum capacity, delivering two products to the market and prospecting other new ones. We have advanced, for example, in using MFC in applications that ultimately return back in-house, such as adhesives used with paperboard boxes. Our medium and long-term efforts include the construction of one or more industrial plants to increase the scale of Klabin's opportunities and applications," said Silvana about ongoing research and the strategic planning behing it.

Klabin's work fronts also include cellulose nanocrystals (CNC), through a partnership with Israeli startup


KLABIN DISCLOSURE

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KLABIN DISCLOSURE

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Melodea Bio Based Solutions. The goal is to use CNC to produce paper and packaging, leveraging new business opportunities. "Many markets are eager for more natural solutions that substitute inputs of fossil origin. And this purpose is closely connected with the need to seek new partners to consolidate our next developments," said Silvana.

She informs that 2022 was a turning point for Klabin, as the company began to report good results from the investments made in recent years. "We also advanced considerably in the search for startups, universities and different partners, and we started to delve into expertise that is not ours. This certainly magnifies our advantages of developing the full potential of our range of fibers."

With the purpose of renewing life through trees, Suzano also stands out among the top players making use of nanotechnology. In practice, the company uses its ability to design, manipulate, process and produce materials on a scale that can be 100,000 times smaller than the thickness of an A4 sheet of paper to maximize the use of its certified eucalyptus plantations, delivering sustainable product options to society.

MFC production is one portfolio diversification example reveals Heloisa Ramires, Research and Development Executive Manager at Suzano. "MFC has led Suzano to tap different markets, such as textiles. In partnership with Spinnova of Finland, Suzano formed the Woodspin joint venture in 2021, focused on producing textile fibers with its microfibrillated cellulose," she said, informing that the partnership will enable Suzano to set up its first unit this year outside Brazil for the pre-commercial production of MFC.

In addition to this front, Suzano's R&D&I and Business Development teams have led MFC into different applications, like paper, packaging, civil construction products and cosmetics, where it performs various functions like reinforcement agent or natural rheological modifier.

Lignin is another bioproduct that Suzano has experienced the benefits of particle nanotechnology. "In this case, studies at laboratory scale with external partners have sought to expand

SUZANO DISCLOSURE

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VALMET DISCLOSURE


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even further the already known and commercially applied potential of Suzano's lignin (Ligflex) on adhesives and elastomers, among other applications," said Heloisa. "In summary, with the help of state-of-the-art technologies, Suzano has offered society options for materials that can partially or totally replace products of fossil origin, enhance performance of existing materials through additives and lead to the creation of completely new products," she said.

Still according to Suzano's Research and Development executive manager, the company has very clear goals regarding the incorporation of new bioproducts made from eucalyptus in the market, which invariably involves the use of all kinds of technologies, including nano. "Thus, in addition to continuing being the world's largest hardwood market pulp producer, Suzano also aims to become one of the most important companies in the world to offer sustainable options across all industries through its bioproducts."

Coupled with the commercial lignin unit in Limeira (SP), Suzano is taking another step towards this consolidation through the above-mentioned joint venture. "We believe in the potential of Brazil's research and development and have invested in several sectors through partnerships with renowned universities and institutes, as well as our own laboratories and pilot plants. We currently have two laboratories with nanomaterial analytical capacity, in addition to three pilot plants linked to the development of bioproducts in Brazil, Canada and Israel," said Heloisa.

She says that the technical challenges linked to using nanotechnology in bioproducts from the forest base industry generally begin in the early stages of development, that is, at the laboratory scale. "The challenge resides in determining and identifying the appropriate technologies to measure and characterize the unique properties of micro/nanomaterials, since most technologies focus on characterizing meso and macromaterials. As a result, there is a need to create new standardized, regulated and recognized protocols that validate these measurements and characterizations. When shifting from laboratory to industrial scale, these challenges become even more complex, since many of the techniques developed in laboratory are not applicable to industrial processes as is the case, for example, with electronic microscopy. This brings a high level of complexity to the online control of these processes," she said, adding that Suzano, in partnership with associations, research institutes and other companies, has conducted pioneering studies that use different technologies to ensure that its products have all the requirements to truly be sustainable options for society.

As supplier of large equipment that comprise Klabin and Suzano's pilot plants, Valmet focuses on improving and optimizing the creation and processing of MFC. "In addition, we work in partnership with our customers to help them apply and use MFC, considering that the technologies have a lot of room to develop the process for obtaining it and for niches and applications in the market," said the company's Sales and Technology Manager, Roberto Franchini.

According to him, Valmet has conducted processes and installed lines with greater production capacity thanks to its own evolution and the applications that customers have been developing. "We have observed the consolidation of new products and markets, demanding an increase in production and product quality every day, in addition to process optimizations to meet specific applications. We also work with our customers, who are the main drivers for developing demand versus available technologies. In parallel, we conduct R&D at our own facilities in partnership with several universities around the world," he said.

In Franchini's vision, the natural development of technology strengthens relations and dialogue with the market and its players. "The emergence of new markets creates space for continuous development due to the specific characteristics of each product and those that directly affect the design

and application of each line, that is, the development of nanotechnology to meet specific needs. Valmet believes that in the coming years processes will be more and more dedicated to different products."

In this evolutionary path, Valmet not only tracks but also creates market trends through the development and technological evolution of its partnerships and robust investment in human capital and company values. "This revolution is not just Valmet's vision, but also of its customers and market demands, especially for bioproducts. In addition to developing technology and people globally, Valmet invests in the local demands of each region, product and their characteristics. As technologies and market demands grow, the development and qualification of professionals are goals Valmet already holds as value, being a crucial touch point to ensure its continuity as world leader in this technology," said Franchini, demonstrating that Valmet works to drive the bioeconomy across different strategic fronts.

## Union of efforts accelerates practical developments

The interaction between the academic and industrial worlds has always been present in the pulp and paper industry. However, the potential offered by nanomaterials creates opportunities to further strengthen this already positive relationship. "Brazilian universities have professionals capable of developing cutting-edge research and the sector has countless possibilities to invest in research in the area in partnership with local institutions. We already have works detailed more in-depth in congress publications, magazines, scientific initiation reports, theses and dissertations," said UFV's professor Deusanilde.

In the view of USP professor Park, the desire to intensify interaction is reciprocal. However, the exchange requires constancy. "To become familiar with a company's demands, which will generate research proposals, in-person and close up monitoring of the researcher's work by the company is paramount. This proximity is what will result in considerations about possible research paths. With this, the scientific research has a clear purpose and desired results."

Another important consideration made by Song refers to techniques for measuring the evolution of technological research, which differ from the Key Performance Indicators (KPI) of business enterprises and, at the same time, are not like KPIs of scientific development agencies. "It has to do with the need to monitor the evolution of innovation work," said USP's professor.

Embrapa Florestas stands out in this context with an extensive line of research in nanotechnology. Specifically speaking of cellulose nanostructures, Magalhães, a Nanotechnology Researcher at the institution, informs that the main assets, in different stages of development, are healing membrane, gelling agent for 70% alcohol, packaging additives (films with barrier, antioxidant and biocide properties), slow-release fertilizers, sanitizers (against coronavirus, bacteria and fungi), filters, airgel, films with anti-flame propagation properties, disposable sensors, additives in mortar and additives in resins (ureic and phenolic).

He agrees that ties between academia and the private sector have intensified in recent years, but there is still room for more. "We need to develop the innovation culture in a more robust way. Intellectual property issues, for example, still represent an obstacle and make partnerships difficult. Academia advocates more resources from the public sector to finance research and development, although I think that the best would be for academia and companies to find other funding solutions, with the State financing only a part, at first," said Magalhães.

With a consolidated academic background, from undergraduate to postdoctoral, Adriana has been

KATIA PICHELLI

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## ABTCP's Biorefinery and Nano Technical Committee focuses on understanding opportunities for using microfibrillated cellulose and lignin

With the goal of leveraging the agenda and debates related to biorefinery and nanomaterials in the forest base industry, the Brazilian Pulp and Paper Technical Association (ABTCP) combined the works spearheaded by the Biorefinery and Nanotechnology Technical Committees (TCs) in the beginning of 2023. "Given that bioproducts from forest-based biorefinery have a wide range of applications, including nanomaterials, came the challenge to unify the two TCs. In addition to potentializing discussion opportunities of common themes, it is also a means of optimizing the participation of members who, for the most part, are the same representatives in the two TCs," said Maria Teresa Borges Pimenta, Technological Cooperation and Funding Manager at Suzano and current Coordinator of ABTCP's Biorefinery and Nano Technical Committee.

SUZANO DISCLOSURE

Maria Teresa emphasizes that the Technical Committee's work is not targeted only at discussing and evaluating materials/ nanomaterials opportunities, but rather a broader perspective of applications for bioproducts originating from forestry biorefinery

In 2023, the Biorefinery and Nano TC intends to focus on communication to reinforce the culture and understanding of opportunities for using microfibrillated cellulose (MFC) and lignin for different applications in different markets, including new materials. The Committee will also focus on discussing and analyzing the opportunities for regulating these bioproducts on a sector basis, in partnership with the entities responsible. "In order for new products or potential substitutes for existing products to reach the market, in addition to research, development and innovation, it is necessary to ensure their certifications and regulations. As such, this joint work gives us the opportunity to offer society sustainable solutions, while a sector-based positioning boosts opportunities to enter new or existing markets," said Maria Teresa.

In addition to regulations, other points to be considered are technical discussions, with opportunities for interlaboratory experiments, with the aim of developing analytical methodologies and standardized protocols together with technical-standards associations, aimed at the standardized characterization of bioproducts. Additionally, partnership opportunities with universities and research centers will be evaluated, both in Brazil and abroad, for the development of network projects.

Also according to ABTCP's Biorefinery and Nano TC coordinator, meetings with the participation of TC members take place every two months in-person or online. Other events such as round tables, lectures and technical meetings, also involving an external audience composed of researchers, professors, companies in the sector, could be held between these bimonthly meetings, depending on the needs and topics discussed. She emphasizes that the Technical Committee's work is not targeted only at discussing and evaluating materials/nanomaterials opportunities, but rather a broader perspective of applications for bioproducts originating from forestry biorefinery.

SUZANO DISCLOSURE

**"We created the Talents for Innovation Program in 2022, in partnership with USP, where we present real problems to be discussed and worked on by students in the classroom, with mentoring from experienced Suzano professionals," said Heloisa**

following the growing interaction between academia, research institutions and companies. "It is not new that universities and research institutes walk hand in hand with the private sector. But, to be analyzed accurately, this issue needs to be based on metrics, such as the number and impact of articles published in indexed scientific journals and the number of patent applications. And even so, it may not be fair to use such parameters, since the number of articles published may be irrelevant in relation to the number of articles submitted that have an innovative character. And when it comes to patents, this metric may be even more undersized, since besides analyzing the number of patent applications, it is also necessary to measure the number of patents granted and the success rate of applications," said Adriana building on the point also raised by Park.

Still according to ISI B&F's coordinator, other metrics could be adopted, such as joint labs (laboratories shared by universities and companies), startups and spinoffs (business model and launch of a product or service). "The results of these alliances are closely linked to investments in the research and development of nanotechnology products so that more practical materials with unique applications continue to evolve. It is essential that these technologies transcend the limits of the laboratory and help solve society's current challenges," she said, arguing that the production of scientific research must go through a strategic sequence of activities to be implemented in new products, processes or services. "Purposes must be closely aligned so that the solution created satisfies the company's needs and for sales to happen, which must also be in line with consumer desires."

Focusing on the latest practical developments, Adriana informs that ISI B&F has collaborated on two R&D projects centered on enhancing eucalyptus nanocellulose. "In partnership with Zynux and Embrapa Florestas, ISI B&F developed curative films made from eucalyptus nanocellulose with the aim of bridging the gap in the technological field regarding continuous and large-scale processes for producing films (or membranes or nanopapers) solely from MFC suspensions. The process developed aimed to be a practical process, with a smaller number of high-efficiency and short-time stages, enabling its reproduction on an industrial scale," she said about the development of the production process of nanocellulose dressings in a large-scale continuous process that generated a patent filing with the National Institute of Industrial Property (INPI).

Additionally, ISI B&F has carried out research in the cosmetics and sensor fields, using nanocellulose and other biomaterials as ingredients in their development, always in conjunction with large companies in the sector as partners. "It is important to mention that many of these projects were only possible thanks to Embrapii's work. As an Embrapii unit, the Institute has access to a large ecosystem of innovation and non-reimbursable resources, which allows us to conceive and carry out innovative and complex projects with a high level of delivery and organization, in addition to facilitating the idea's execution through funding from Embrapii, reducing the financial contribution of partnering companies," said Adriana.

Based on targeted prospecting, continues Adriana, ISI B&F identifies players in the innovation ecosystem that are references in these niches to establish technological and scientific partnerships. "The prospecting of opportunities and partnerships is done through a structured and regular process, which facilitates connecting with the innovation ecosystem. As such, we have partnered with universities, research centers, governments and companies in Brazil and abroad. In addition to cooperation projects, we use several development lines in an attempt to share risks and investments."

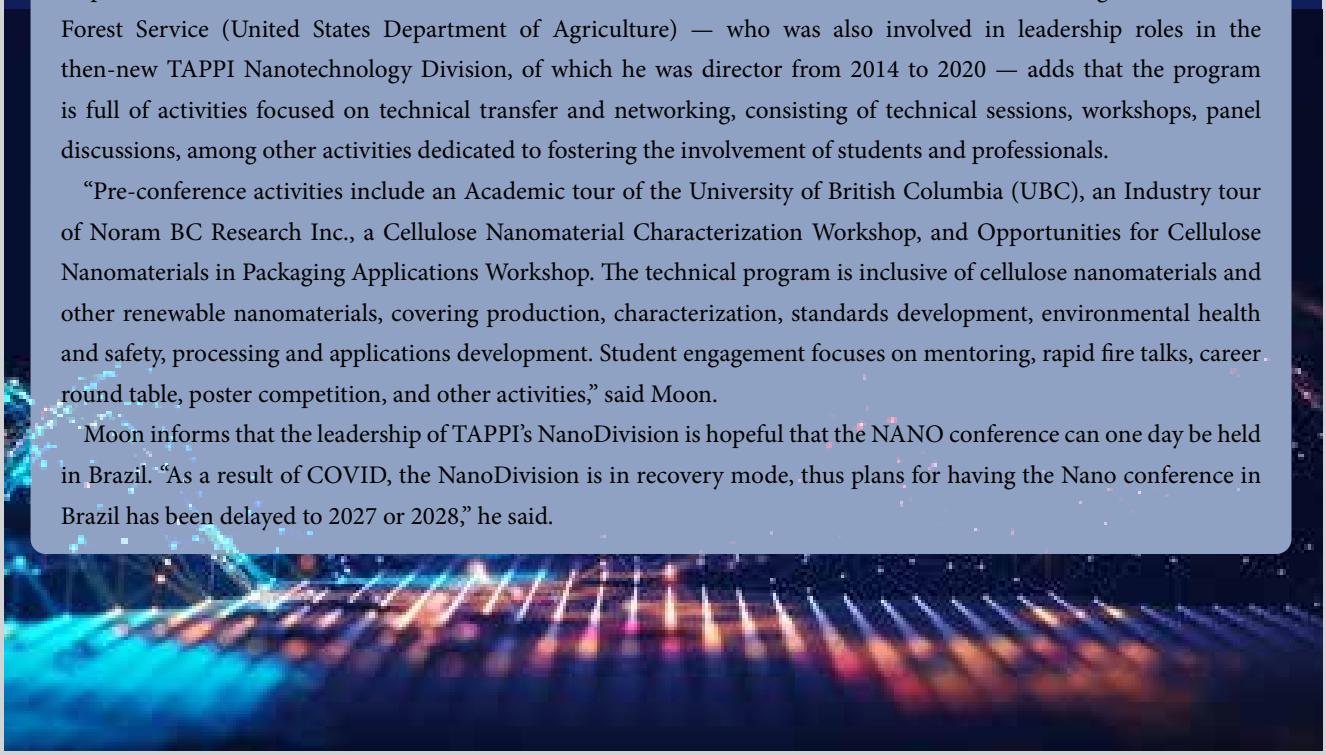
Another successful path is research grants. Suzano has fellows with complementary backgrounds working in various areas of the company, contributing knowledge to innovation projects. "Grant holders develop projects in-house and also at partner universities

## TAPPI Nanotechnology Conference includes an extensive program and combines technical and networking activities

The Technical Association of the Pulp and Paper Industry's (TAPPI) annual Nanotechnology conference will be an in-person event held in Vancouver, Canada, June 12-16, 2023. Robert Moon, Materials Research Engineer at USDA Forest Service (United States Department of Agriculture) — who was also involved in leadership roles in the then-new TAPPI Nanotechnology Division, of which he was director from 2014 to 2020 — adds that the program is full of activities focused on technical transfer and networking, consisting of technical sessions, workshops, panel discussions, among other activities dedicated to fostering the involvement of students and professionals.

"Pre-conference activities include an Academic tour of the University of British Columbia (UBC), an Industry tour of Noram BC Research Inc., a Cellulose Nanomaterial Characterization Workshop, and Opportunities for Cellulose Nanomaterials in Packaging Applications Workshop. The technical program is inclusive of cellulose nanomaterials and other renewable nanomaterials, covering production, characterization, standards development, environmental health and safety, processing and applications development. Student engagement focuses on mentoring, rapid fire talks, career round table, poster competition, and other activities," said Moon.

Moon informs that the leadership of TAPPI's NanoDivision is hopeful that the NANO conference can one day be held in Brazil. "As a result of COVID, the NanoDivision is in recovery mode, thus plans for having the Nano conference in Brazil has been delayed to 2027 or 2028," he said.



and research centers. As a successful example of this initiative, in a project with Suzano as part of of the CNPq MAI/DAI public invitation, a doctoral student from the Federal University of Paraná's Agroforestry Nanotechnology Group (GNanoAgro / LCNano / SisNANO Network, MCTI) won the national and international stages of the Blue Sky Young Researchers and Innovation Awards 2022-2023," said Heloisa.

Suzano also collaborates with universities and research centers in Brazil and abroad, providing samples to be used in research projects, and supports the development of researchers in graduate school. "With the goal of identifying potential talents, engage and develop future professionals within the context of a large company, we created the Talents for Innovation Program in 2022, in partnership with USP, where we present real problems to be discussed and worked on by students in the classroom, with mentoring from experienced Suzano professionals. As incentive to the pursuit of solutions to the challenges proposed, the company awarded the best works and gave the two best students a 12-month scientific initiation scholarship," said Heloisa.

"Even though we have expert researchers working at the company's research centers, we know that we cannot achieve all objectives alone and, therefore, we truly believe in partnerships. We have achieved significant progress and successful results through partnerships with different research institutions from Brazil and abroad, including ones involving shared intellectual property. Some partnerships advance more quickly, depending on the technological partner's profile," said Suzano's Research & Development executive, making a positive assessment of ongoing joint work fronts.

Shifting the focus to strategies for accelerating this process even more, in addition to prospecting opportunities via traditional development lines, Heloisa says that the company launched, in partnership with Suzano Ventures – Corporate Venture Capital (CVC) – and SENAI, the global call (Bio) solutions: the future starting with trees. Unprecedented in the sector, the goal of the call was to attract and boost new partnerships with various players in the Brazilian and international innovation ecosystem. "In total, 99 proposals were received involving the participation of 101 institutions. Through initiatives like this, we can evaluate new ideas, meet new partners, as well as leverage the company's project portfolio," she said. ■