Bionanopolys

OITB NEWS NO. 5

CONTENT

EDITORIAL

BIONANOPOLYS AND THE TECHNICAL EVOLUTION OF 3D PRINTING WITH BIONANOMATERIALS

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3D printing has revolutionized material science, and its integration with bionanomaterials is opening up new possibilities in fields such as healthcare, packaging, and manufacturing. This development is supported and facilitated by Bionanopolys, an Open Innovation Test Bed (OITB) that bridges the gap between lab-scale innovations and industrial applications. By leveraging bionanomaterials such as cellulose nanofibers and nanolignin, Bionanopolys is refining bio-based products for real-world applications, also in 3D printing.

CHALLENGES IN 3D PRINTING WITH BIONANOMATERIALS

One of the primary technical challenges in 3D printing with bionanomaterials is ensuring print **fidelity and maintaining rheological properties**. For instance, cellulose nanofibers, though strong, can be difficult to disperse evenly in polymer matrices, which can affect the quality of 3D prints. Bionanopolys addresses these challenges by optimizing material behavior under extrusion, improving dispersion, and refining processing methods.

Additionally, **mechanical performance** is a critical issue. Bio-based nanocomposites often have lower strength and heat resistance than synthetic alternatives. To overcome this, Bionanopolys explores hybrid composites and *in-situ* monitoring to ensure high-quality, reliable prints for industries like medical devices and packaging.

INDUSTRIAL APPLICATIONS AND FEASIBILITY

Bionanopolys is also tackling the scalability of 3D printing with bionanomaterials. In fields like packaging, the project is developing 3D-printed nanocomposites with improved barrier properties to rival conventional plastics. The goal is not just prototyping but full-scale industrial production, and Bionanopolys' pilot plants are refining these processes to make 3D printing more efficient and viable for industrial use.

BRIDGING INDUSTRIAL GAPS

Regulatory compliance and standardization are other critical focuses for Bionanopolys. The project is aligning its materials and processes with European safety regulations, ensuring that industries can adopt these innovations confidently. By working with industry partners, Bionanopolys is creating clear roadmaps for adopting bio-based nanomaterials in practical, scalable applications.

While the future is promising, the real progress lies in the structured, technical solutions being developed to ensure these materials are practical and ready for widespread industrial use.

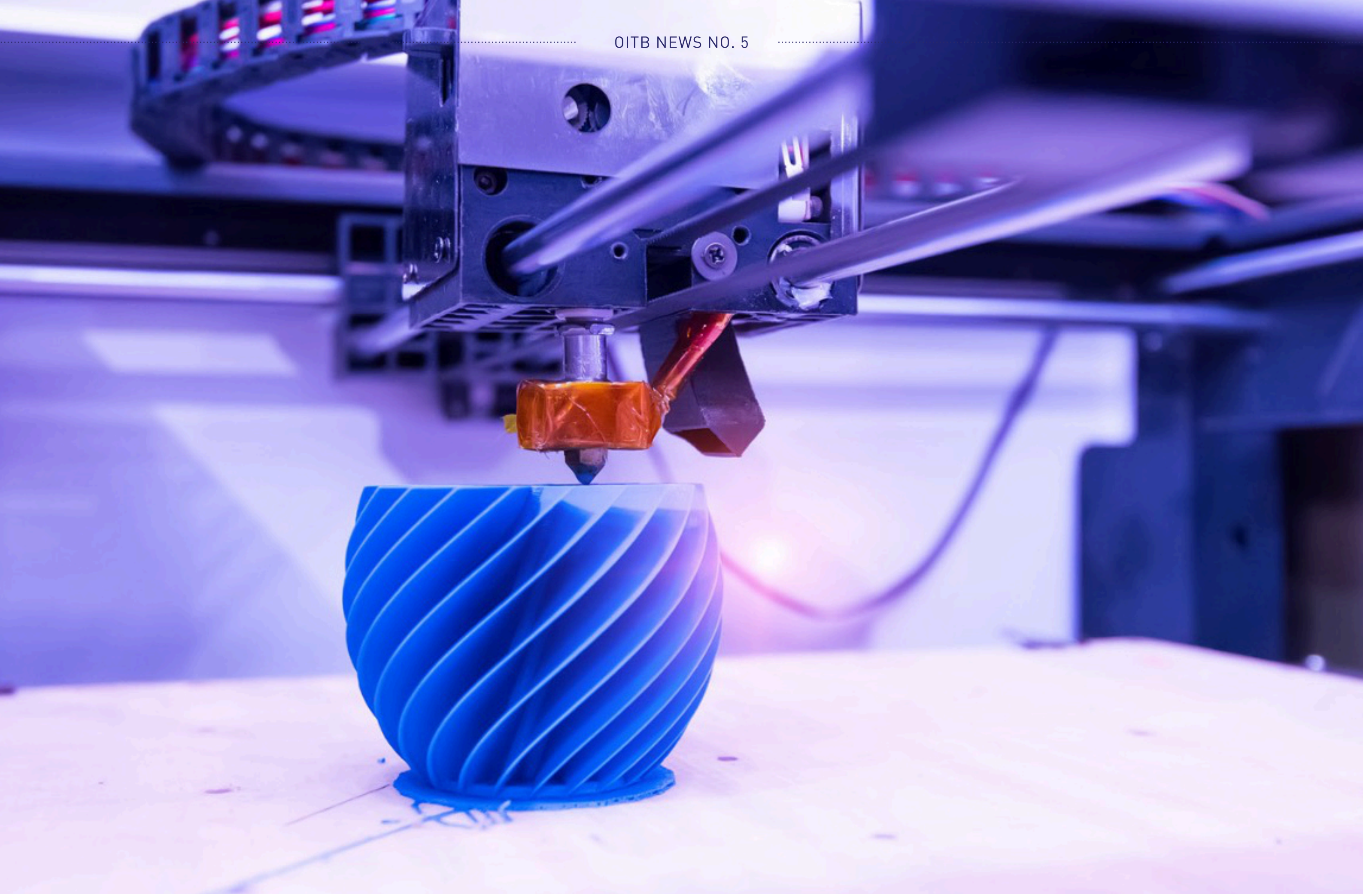
BUSINESS ADVISOR

HARNESSING 3D PRINTING FOR SUSTAINABILITY

LUKA DOBROVIĆ, PARTICULA GROUP LTD.

The intersection of 3D printing and sustainability is an extremely optimistic frontier in biotechnology and engineering. One of the key advantages of 3D printing is that it reduces wastage of materials to near zero. Whereas traditional manufacturing processes, especially subtractive manufacturing, create vast amounts of waste due to excess material that must be cut away, 3D printing or additive manufacturing builds objects layer by layer with the use of only required material. It saves resources and at the same time minimizes environmental impacts connected with both the production and disposal of waste. For industries that depend on expensive or rare materials—such as aerospace and healthcare—the savings are even deeper, affecting cost economy and lessening environmental degradation.

Flexibility within 3D printing can be extended to enable localized production, which bears strong implications for reducing carbon footprints. On-site manufacturing that 3D printing enables can reduce the need for transportation of goods over long distances, hence reducing greenhouse gas emissions. In addition, it includes production strategies that involve just-in-time production to minimize large inventories and energy consumption associated with storage and warehousing.



In biotechnology, 3D printing breaks new ground with bioprinting—making complex tissue structures that could revolutionize healthcare. In fact, it has huge potential to reduce dependency on animal testing, moving medicine toward more ethical and sustainable practices. Furthermore, the production of sustainable materials, such as biodegradable polymers and bio-based resins, contributes to environmental sustainability through 3D printing. These can be designed to break down safely into the environment, reducing the long-term ecological impact of products.

The flexibility and the versioning capacity that 3D printing offers are therefore as conducive to the practices of a circular economy as they are aligned with the demands of it. This would mean that in design, considerations of disassembly can be taken into consideration for easier material recycling at the end of a product's life. This also helps reduce the extraction of virgin materials and encourages the reusing of existing ones for a more sustainable industrial ecosystem.

As we advance in the application of 3D printing for sustainability, public education and engagement are crucial. Inspired by all the benefits this technology could bring, such are actions that may spur consumerism and investment in green innovation. What is really needed is simple and easily understandable information on the environmental benefits and societal impacts of 3D printing technologies. This then makes it crystal clear that 3D printing does offer exactly an opportunity to couple technological innovation with sustainability targets. Reducing wastes, optimizing supply chains, pushing bioprinting, and promoting a circular economy are only a few ways this technology can become incredibly useful in making a better future for all of us. 3D printing capacities must be further explored and extended so that it contributes positively to our environment and social landscapes.

SERVICES IN SPOTLIGHT

NEW DEVELOPMENTS IN ADDITIVE MANUFACTURING PROCESSES USING BIO-BASED POLYMER NANOCOMPOSITES IN THE BIONANOPOLYS PROJECT

CESAR MAESTRO, MERCEDES SANTIAGO, CIDAUT

EXPLORING THE BENEFITS AND CHALLENGES OF ADDITIVE MANUFACTURING WITH PLASTICS

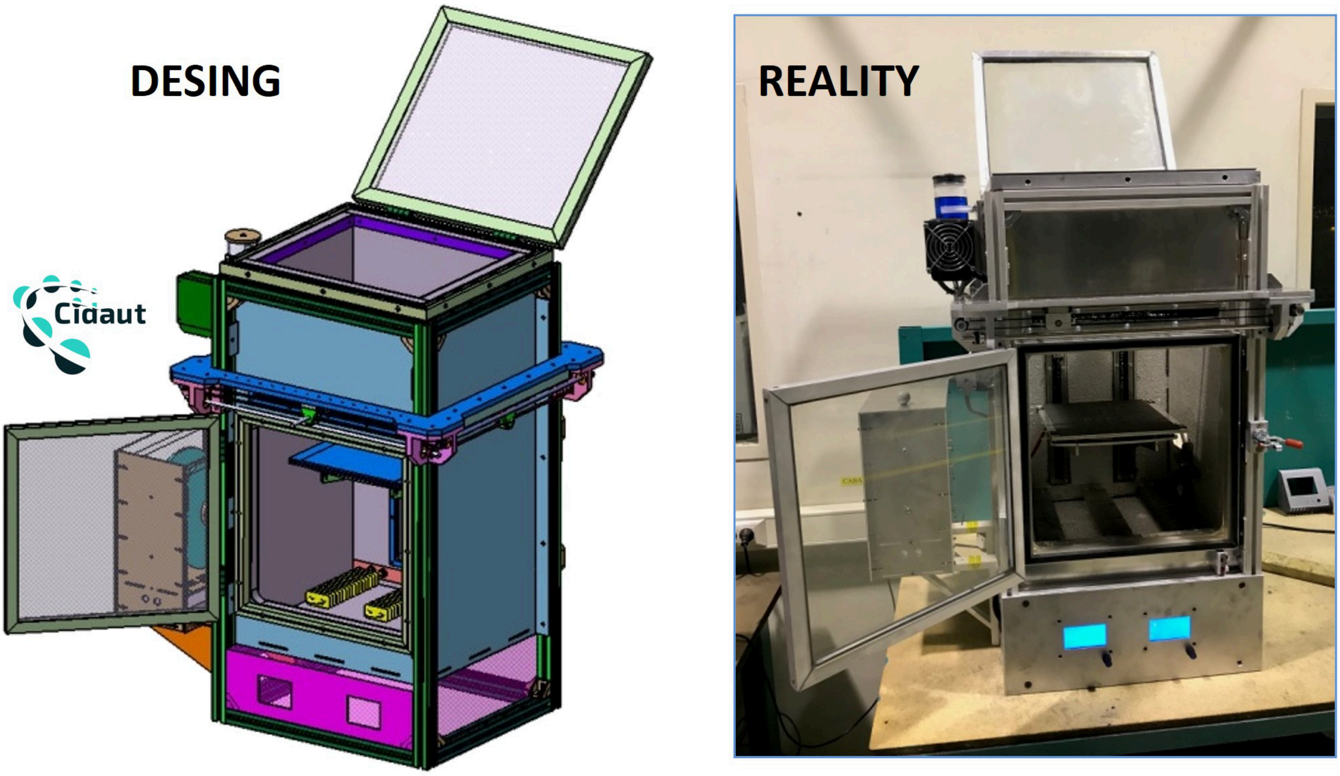
Additive manufacturing (AM), commonly known as 3D printing technology, is a revolutionary process that creates objects by adding material layer by layer, based on digital models. This contrasts with traditional subtractive manufacturing methods, which remove material to shape the final product. The use of additive manufacturing technologies in polymers has garnered significant interest due to numerous advantages over traditional plastic forming methods, such as the ability to create any geometry, the absence of molds or auxiliary tools, and customization, especially for short production runs. From an environmental perspective, additive manufacturing represents a cleaner and more environmentally friendly production method due to reduced energy consumption, as digitally manufactured parts weigh much less, and reduced storage and transportation costs since parts are designed digitally and manufactured as needed. Additionally, some additive manufacturing technologies allow for the recycling of a significant portion of the material used during the printing process.

One of the main challenges of products obtained by 3D printing is that these are generally weaker than those made using traditional techniques like injection molding, resulting in lower strength and modulus of elasticity. Key disadvantages include the presence of voids and inclusions due to improper material bonding, mechanical anisotropy from the layer-by-layer process, reduced resistance to external forces, surface roughness and imperfections, and deformation and residual stresses from uneven heating, especially in geometrically complex workpieces.

CHALLENGES IN PRINTING BIO-BASED POLYMERS

Introducing bioplastics in additive manufacturing offers several benefits, including environmental sustainability using renewable resources and reduced waste, supporting a circular economy, and meeting growing market demand for sustainable products. However, the use of bio-based polymers in printing process is not very widespread due to several technical challenges that differ from those encountered with traditional polymer materials (commodities). These challenges include:

Material Properties: Bio-based polymers often have different mechanical and thermal properties compared to conventional plastics. This can affect their printability and the quality of the final product. For instance, they may have lower strength and durability, making them less suitable for certain applications without further material enhancements.



CIDAUT's 3D printer design and real equipment to produce 3D printed parts using filaments based on bioplastic nanocomposites

Processing Parameters: Bio-based polymers may require specific processing conditions to avoid issues like voids, inclusions, and poor layer adhesion. These problems are less common with traditional plastics but can significantly impact the performance of bio-based printed parts.

Environmental Sensitivity: Bio-based materials can be more sensitive to environmental factors such as humidity and temperature. This sensitivity can affect the printing process and the stability of the printed parts, leading to potential deformation or degradation over time.

Cost and Availability: The production and sourcing of bio-based polymers can be more expensive and less consistent compared to traditional plastics. This poses economic and logistical challenges, making it harder to adopt these materials on a larger scale.
Despite these challenges, ongoing research and development efforts aim to improve the properties and processing techniques for bio-based polymers. Projects like Bionanopolys are working to address these issues by developing innovative solutions and creating environments that foster collaboration between industry and research institutes and centers. These efforts are crucial for advancing sustainable materials and reducing our reliance on fossil fuels.

HOW THE BIONANOPOLYS PROJECT IS ADVANCING 3D PRINTING WITH INNOVATIVE BIO-BASED POLYMER MATERIALS

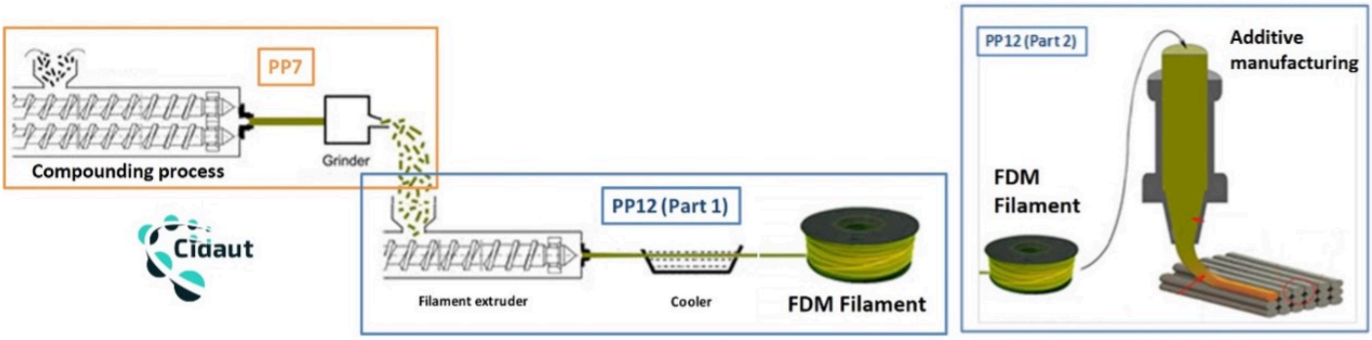
As part of the Bionanopolys project, CIDAUT's pilot plants (PPs) have enhanced their production processes and optimized the properties of the bio-based polymers to solve the challenges related to the printing process of these renewable materials. The 3D printing facilities at CIDAUT (PP 12), which include two distinct devices (a filament maker and a custom-built 3D printer), have been upgraded to successfully process nanocomposites from bio-based polymer matrices. To achieve this, CIDAUT has undertaken the following steps:

Filament Maker Upgrade (PP12, Part 1): The filament maker, comprising an extruder, cooling system, and spooler, was specifically upgraded by CIDAUT. The extrusion system was enhanced to process high-temperature and high-viscosity materials such as biopolyamides, expanding beyond the initial capability to process commodity polymers like PLA and ABS.

Custom-Built 3D Printer (PP12, Part 2): A new custom-built 3D printer was designed and manufactured with an enclosed chamber, where four different heated systems are properly managed: filament container, nozzle, bed and chamber. This new 3D printer ensures the printability of various thermoplastic bio-based nanocomposites, focusing on speed, dimensional accuracy, and surface appearance.

CIDAUT's 3D printer design and real equipment to produce 3D printed parts using filaments based on bioplastic nanocomposites
On the other hand, in order to improve the mechanical and thermal behaviour of the bio-based polymers from which the 3D printing filaments are obtained in PP 12, CIDAUT is working on the development of bio-based polymer formulations reinforced with bio-based nano-additives by **compounding process (PP 7)**. In order to achieve effective dispersion of the bio-based nanoadditives and thus an improvement of the bionanocomposite properties, an optimization process was performed in the compounding facilities of CIDAUT, based on a proper combination of barrel segments, screw design and feeding points, adjusting the amount of mechanical mixing through the optimization of the dispersive and distributive mixing elements along the screw profile, enhancing the shear stress.

Through these advancements, CIDAUT has significantly improved the production of 3D printing filaments and parts from bio-based polymers with enhanced properties, contributing to the overall success and innovation within the Bionanopolys project.



Scheme of production of 3D printed parts using bioplastic nanocomposites with improved properties at CIDAUT facilities.

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USER VOICES

LOGOPLASTE INNOVATION LAB'S MISSION

PEDRO SANTANA, LOGOPLASTE INNOVATION LAB

The Logoplaste Innovation Lab (ILAB) is an independent business unit of the Logoplaste Group, established in 2000, and is dedicated to the research and development of high-performance plastic packaging solutions. ILAB's mission is to provide Sustainable Human-Centered Innovation, applying creativity to solve complex challenges and delivering desirable, feasible, and viable solutions to its partners.

Drawing inspiration from nature, ILAB embraces an innovative approach that views nature as a model, a measure, and a mentor, fostering more sustainable designs. Additionally, ILAB is continuously searching for the safest and most sustainable raw materials to enhance packaging and manufacturing processes. With the capability to produce quick physical prototypes, ILAB enables its designers and engineers to test multiple iterations, ensuring better-informed product decisions within time and budget constraints. In essence, ILAB is committed to driving sustainable innovation in plastic packaging, pushing the boundaries of what's possible in the industry.

WHAT IS YOUR USE CASE ABOUT?

In this project Logoplaste Innovation Lab (ILAB) played a pivotal role in advancing the development of two cutting-edge rigid packaging solutions. These solutions were meticulously designed to be 100% compostable, thereby aligning with the overarching sustainability goals of the project and pushing the boundaries of what is possible in eco-friendly packaging.

As part of Work Package 7, ILAB embarked on the development of UC13, a bottle intended for personal care products utilizing the extrusion blow molding (EBM) process. The primary objective was to enhance the bottle by incorporating active nanocapsules, which were expected to extend the shelf life of the product by up to 30% compared to the biodegradable base material. However, despite significant efforts, the desired bottle could not be produced using this technology due to the material's insufficient rheological properties, which rendered it unsuitable for EBM. Nevertheless, this endeavor was far from fruitless; it provided the ILAB team with invaluable insights and a deeper understanding of how to process such advanced materials. The knowledge gained from this experience has laid a solid foundation for future research and development, ensuring that subsequent projects will benefit from the lessons learned.

ILAB's Extrusion Blow Molding pilot line

On the other hand, ILAB achieved success with UC14, a bottle for food applications, such as sauces, produced by injection stretch blow molding (ISBM) process. This bottle was successfully reinforced with nanoclays, significantly enhancing its barrier properties. Although the project aimed to also incorporate nanocellulose into the bottle's composition, this proved unfeasible within the constraints of the current development phase. Nonetheless, the advancements made in UC14 demonstrate capacity to push the envelope in sustainable packaging innovation using bionanomaterials. UC13 and UC14 underwent rigorous development processes. For both cases, this process began with a conceptual design, which was then meticulously refined and validated through a series of technical evaluations. These included the creation of detailed production drawings, and the final prototype was subjected to a battery of packaging engineering tests, such as dimensional control, product weight assessments, load resistance evaluations, and drop tests.

The culmination of these efforts resulted in a packaging solution that not only meets high standards of performance but also makes a significant contribution to the project's sustainability objectives, paving the way for future innovations in compostable packaging.

ILAB's Injection Stretch-Blow Molding pilot line

UC14 final prototype

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LET'S MEET AND INTERACT

UPCOMING EVENTS 2024

12-14 NOVEMBER 2024

BIONANOPOLYS BIOMAC WORKSHOP

DEDICATED OITBS FOR SUSTAINABLE BIONANOMATERIAL PRODUCTION

Stakeholder workshop for the biotech community in Austria

www.bionanopolys.eu

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