BIOMAC

European Sustainable Biobased Nano Materials Community

An open innovation test bed for the upscaling, the market-readiness and the production of Nano structured bio-based materials (NBM).

Open call handbook

biomac@chem.auth.gr

Table of contents

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No. 952941

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INTRODUCTION

In this section you will understand what an Open Innovation Test Bed is (OITB) and how BIOMAC has developed this concept.

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What is an Open Innovation Test Bed?

Open Innovation Test Beds (OITBs) are entities, established in at least three Member States or Associated Countries, offering access to physical facilities, capabilities and services required for the development, testing and upscaling of nanotechnology and advanced materials in industrial environments. The objective of the Open Innovation Test Beds is to bring nanotechnologies and advanced materials within the reach of companies and users in order to advance from validation in a laboratory (TRL 4) to prototypes in industrial environments (TRL 7).

Open Innovation Test Beds will upgrade existing or support the setting of new public and private test beds, pilot lines, and demonstrators. The aim is to develop, test and upscale nanotechnologies and advanced materials for new innovative products and services in some specific domains.

The Horizon 2020 programme has funded the BIOMAC project to develop one brand new OITB. This will offer its services free of charge to 5 parties, which will be chosen via an **Open Call** (and the related evaluation procedure). More details on the Open call are provided in this handbook.

What is so special about OITBs?

1. They offer complete, holistic services via a single contractor - the Single Entry Point (SEP)
2. They are comprised of a multitude of expert scientists from all over Europe, offering their expertise and infrastructure at competitive prices
3. They have integrated business and marketing services, which can help with access to financing opportunities and reaching out to new markets
4. They allow substantially reduced time and cost to progress from an idea to a successful product.

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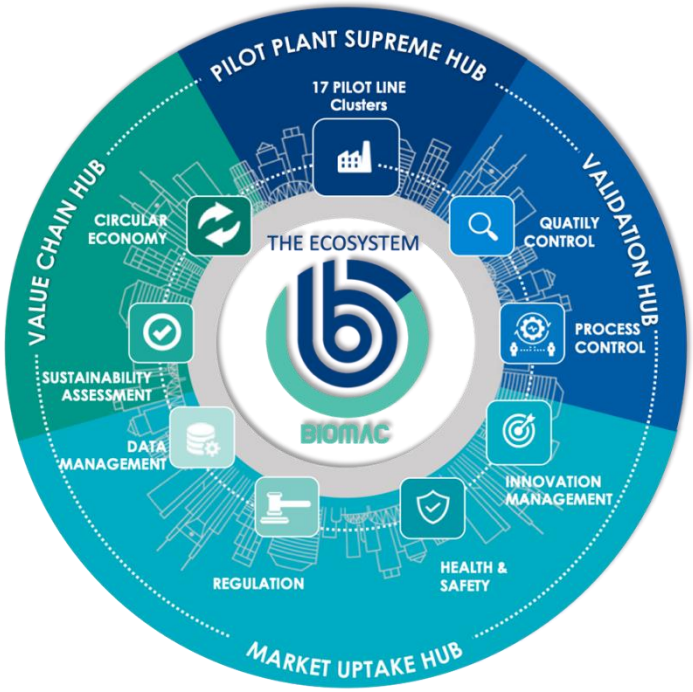
The BIOMAC OITB in a nutshell

BIOMAC (European Sustainable BIO-based nanoMAterials Community) is a Horizon 2020 project started in 2021, which has established its Open Innovation Test Bed (OITB), a true collaborative ecosystem where technologies and solutions utilising nano-enabled bio-based materials (NBMs) can be upscaled and prepared for market applications.

The overall ambition of BIOMAC is to boost and sustain innovation in the field of European bio-economy industries by reducing the time-to-market of novel nanotechnologies, thus reducing costs and risks.



The BIOMAC ecosystem services

BIOMAC offers a wide range of services, distributed in 4 hubs, including access to its 17 Pilot Lines that cover the whole value chain, starting from the biomass treatment and ending in the final plastic-based products. Everything is supported by and complementary services such as quality control, characterization, standardization, modeling, innovation management, health and safety, regulation, data management, sustainability assessment, supply management and circularity checks.
BIOMAC is coordinated by Aristotle University of Thessaloniki (Greece) and its management team (AUTH, STAM, UNIPD, EXELISIS, EUBIA) consists of experts in the fields of biobased

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polymers and additives, technology transfer projects, business management and exploitation strategies.

The service providers of the BIOMAC Ecosystem are all highly skilled experts in the field and they are geographically distributed across Europe.

The pilot lines and complementary services of BIOMAC are constantly being validated towards the objectives of 5 Test Cases (TeCs), and the actual realization of products and components, using bio-based materials (See page 48).

The BIOMAC partners

Useful links

BIOMAC website [link] BIOMAC team [link]	BIOMAC pilot lines overview [link] BIOMAC test cases [link]	BIOMAC publications [link] BIOMAC blog [link]

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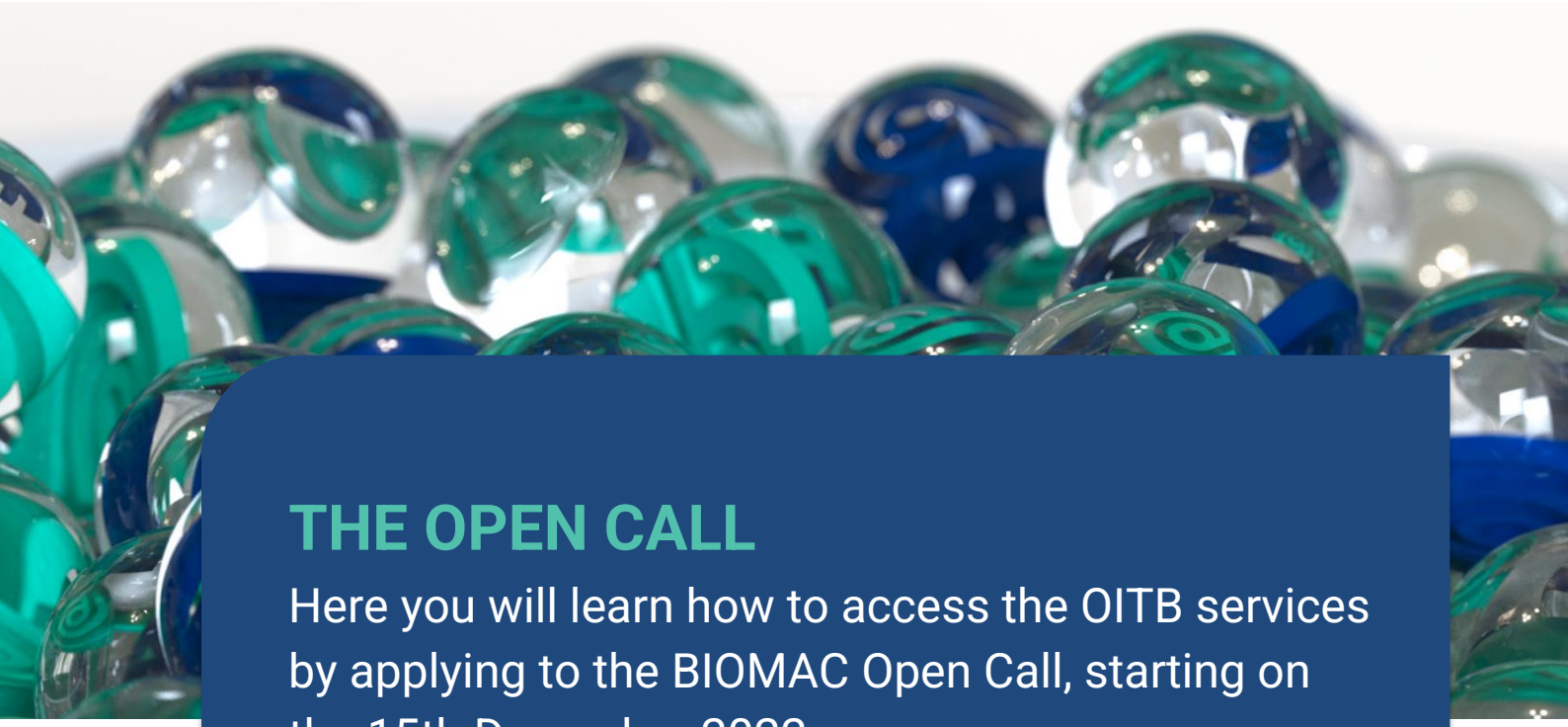

THE OPEN CALL

Here you will learn how to access the OITB services by applying to the BIOMAC Open Call, starting on the 15th December 2022

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Apply to our Open Call!

After the validation of the BIOMAC TeCs has been completed, SMEs and Research Centers can access the services and facilities of the BIOMAC ecosystem *free of charge*, via the Open Call.

The Open Call has the aim of selecting 5 additional Test Cases (for example in the field of textiles, medical-biomedical, tissue engineering, single used items, packaging, etc.) that utilize biobased nanomaterials.

What are the stages of the Open call?

- **15th December 2022**: Open Call starting date, applications can be
- **30th April 2023**: First cut-off date: Final submission of test case proposals for preliminary evaluation. Inadequate or incomplete proposals may submit corrections until the final cut-off.
- **15th June 2023**: Final cut-off date: Last day for submission of test case proposals. No corrections or amendments possible after this date.

The selected test cases will be implemented by the BIOMAC consortium from September 2023 to December 2024.

Applicants will liaise with BIOMAC's single entry point (SEP) constituted by the Industrielle Biotechnologie Bayern Netzwerk GmbH (BBI). A call for Innovation Concepts will be designed based on questionnaires filled in by the applicants. All the members of the OITB will participate to cover all aspects of innovation.

The main selection criteria will be the proof of TRL 4-5 of the applicants' cases, the feasibility study and the complexity of the test cases which will enable the utilization of all relevant BIOMAC's Pilot Lines and services.

Application procedure

Proposals must be submitted online using the application form available on the BIOMAC Open Call dedicated page.

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Proposals submitted by any other means will not be considered eligible for financial support. Each applicant may only fill out and submit one application form

Steps:

1. Registration in the platform
2. Fill in the online application form
3. Download and fill the proposal template
4. Submit before the deadline

Eligibility Criteria

Entities that can participate:

- SMEs (Small and medium-sized enterprises) as defined in the EU recommendation 2003/361
- Large enterprises
- Research and Development organizations

Eligible countries:

- Check if your country is eligible here.

Conflict of interest:

- By submitting a proposal to the BIOMAC Open Call platform you declare that, to the best of your knowledge, there are no conflicts of interest which might affect the objectivity of your proposal's evaluation. The list of BIOMAC partners can be found here.

Each applicant must confirm that:

- They are neither under liquidation nor an enterprise under difficulty according to the Commission Regulation No 651/2014, art. 2.18.
- The project is based on original works and any foreseen future developments are either free from third party rights, or they are clearly stated.
- All statements embodied in the Information and Consent Forms, included as annexes, apply, also considering the ethical issues that might arise concerning the gathering of personal data, during the application process.
- The Project is not excluded under the provisions of article 19 of Regulation (EU) No 1291/2013 of the European Parliament and of the Council of 11 December 2013 (ethics).

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Evaluation Criteria & Process

1. Fit of the concepts to the Ecosystem capacities (e.g biomass to be processed, platform chemicals and polymers, biobased nanomaterials to be processed and evaluated etc.).
2. TRL of the proposed test cases. The Ecosystem entry level is TRL4-5.
3. Feasibility of the proposal.
4. Preliminary freedom to operate search.
5. Geographical distribution of new test cases (a maximum of one test case per country will be selected)

Applicant Support

For more information about the BIOMAC Open Call, please check the Frequently Asked Questions (FAQs) section, which can be found in the internal area of the submission platform. The applicants may find the FAQs section after signing up on the platform. Additionally, in case of technical support needed regarding the submission platform or the Open Calls in general, the applicants may also contact the BIOMAC Helpdesk through the following e-mail address: support@biomac-oitb.eu
When contacting the BIOMAC Technical Helpdesk, please include the following information in your email message: your username, telephone number and your email address; details of the specific problem (error messages you encountered, bugs descriptions, i.e. if a dropdown list is not working, etc.); and a screenshot of the problem.

After the selection

The selected new test cases will be informed by September 2023 about the next steps and the project will be implemented from September 2023 to December 2024.

All parties (including the BIOMAC OITB partners and the Open Call applicants) will exhaustively identify their background knowledge assets that they will bring to the project and will provide access rights to background for the cooperative implementation of the project. Ownership of project results (including joint results generated by two or more partners) will belong to the parties having generated them.

The successful applicants will sign an NDA with the BIOMAC OITB partners covering all aspects of confidentiality. All personal data and information included in the application submitted via the online submission system will be processed by the Selection Board on behalf of the BIOMAC project, with the purpose of participation in the BIOMAC Open Call and achievement of BIOMAC objectives. All critical data and content of the application will be kept confidential and will be shared internally with BIOMAC partners, evaluators and the European

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Commission. General data (e.g. type of company or country of origin) will be used to create statistics and reports, which will be exploited through the project in terms of communication activities. In addition, the names of the selected organizations and their countries of origin will be published on BIOMAC website as part of public evaluation reports.

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Why choose the BIOMAC OITB for your bio-based material development needs?

Complementarity of services:

1. BIOMAC offers technological services covering the complete value chain, including
   a. pre-treatment and conversion of biomass
   b. bio-based polymer and composites production pilot lines
   c. process monitoring and
   d. scale up industrialization services.
2. BIOMAC offers ecosystem services with strong cooperation between research and industry and good connections between users and suppliers of innovations across the bio-based value chain.
3. BIOMAC offers business-oriented services, supporting clients to commercially apply their innovations and transform their business, including access to financing and investors.

Open and fair access:

1. BIOMAC is an open innovation ecosystem that will reach out to new users/"clients" across different regions of the EU, sharing best practices and experiences.
2. BIOMAC creates only minimal administrative burden for the customers as they will only be in contact with the Single Entry Point

Expertise:

1. BIOMAC consists of a network of experts with yearlong knowledge in the fields of biomass pre-treatment, value platform chemicals extraction, processing and manufacturing, monitoring, testing, characterization, modeling, environmental assessment, standardization, nanosafety, innovation management and training.

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Who can access the services of BIOMAC and how?

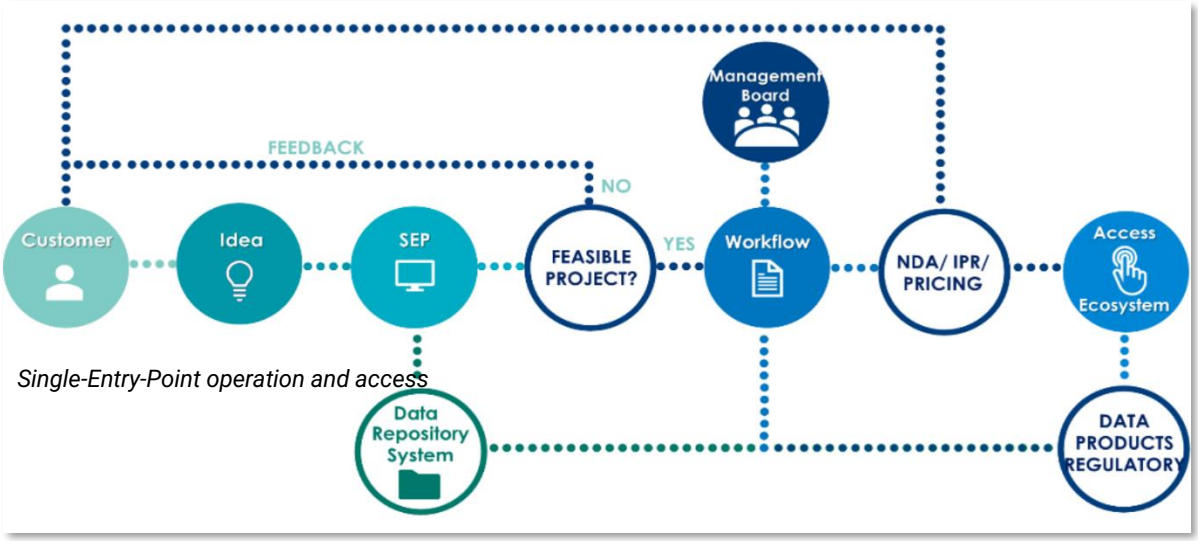
Who?

- SMEs, Industry, Start-ups, Universities, Research Institutes and other stakeholders from Europe and beyond have non-discriminative, open access to the OITB's facilities, capabilities and services, under fair conditions and prices and with transparent and mutual obligation with regards to, for instance, security and safety of IPRs.
- Any client operating in the field of nano-structured bio-based materials (NBM), aiming to upgrade existing or develop new concepts within the lignocellulosic value chains of nanomaterials and polymers, starting from Technical Readiness Level (TRL) 4-5.

How?

BIOMAC is a one-stop-shop, accessible at fair conditions and costs through a single entry point, represented by the IBB Netzwerk in Munich, Germany.

BIOMAC will offer its services free of charge to 5 parties, which will be chosen via the Open Call. Proposals can be submitted online using the application form available on the BIOMAC Open Call platform.



Single-Entry-Point operation and access

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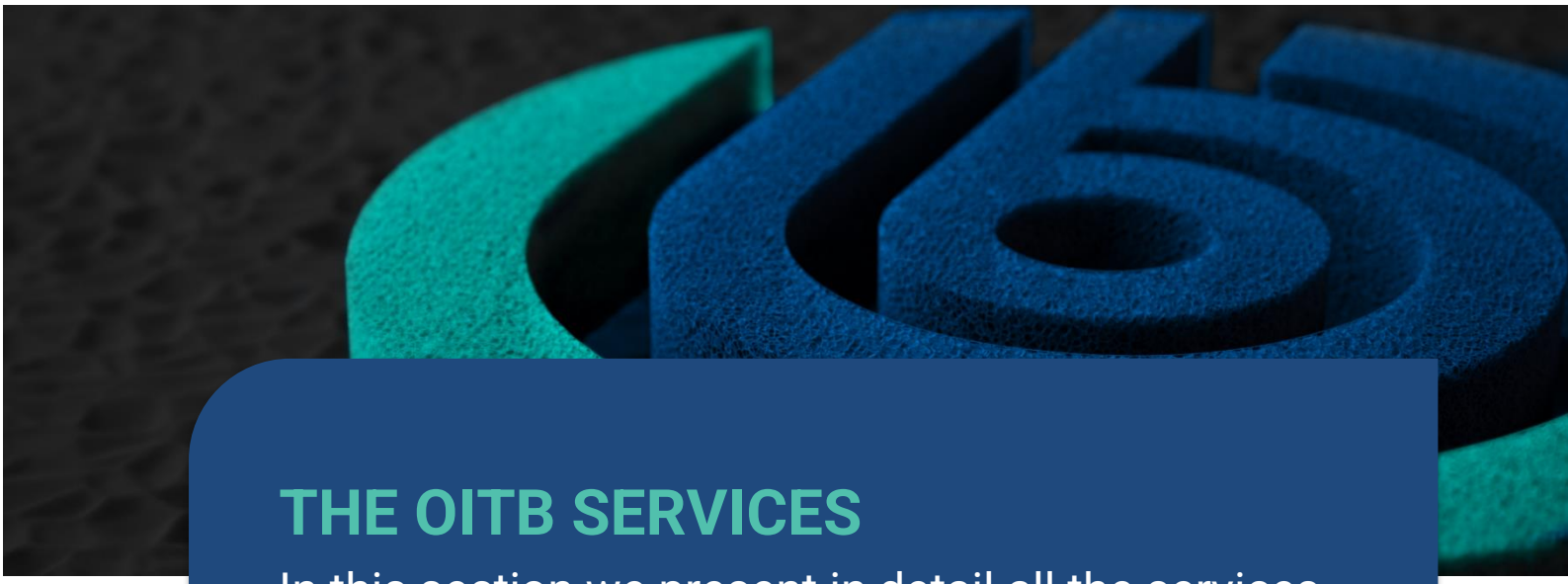

THE OITB SERVICES

In this section we present in detail all the services offered by the BIOMAC OITB. From the 17 Pilot Lines to the validation, value chain and market uptake hub.

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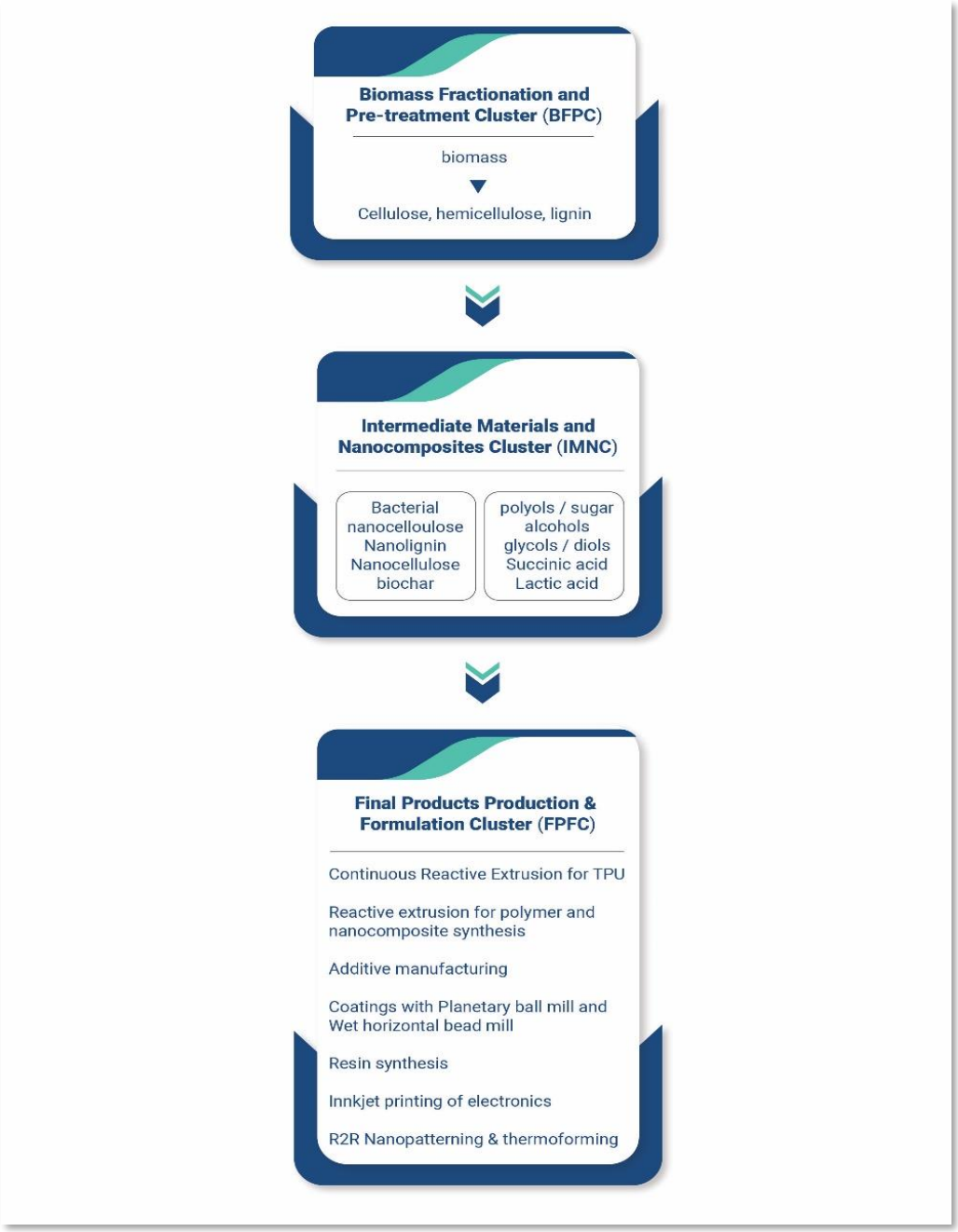
BIOMAC's services: The Pilot Plant Supreme Hub

Three clusters of PLs exist for the upscaling of multifunctional nanostructured materials and are available for open access by the clients of the ecosystem:

- Biomass Fractionation and Pre-treatment Cluster (BFPC)
- Intermediate Materials and Nanocomposites Cluster (IMNC)
- Final Products Production & Formulation Cluster (FPFC)



The three main clusters of the Pilot Lines

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Biomass Fractionation and Pre-treatment Cluster (BFPC)

PL1: Semi-continuous organosolv-steam explosion pre-treatment
Lulea University of Technology, Sweden

Facilities of the organosolv Pilot Line

Capabilities:

- Fractionating lignocellulosic biomass (e.g. agricultural and forest residues) to its three main polymer components, i.e. cellulose, hemicellulose and lignin.
- Combining the effects of steam explosion with that of hemicellulose and lignin solubilization (organosolv) in ethanol/water mixtures under pressure and temperatures up to 200 ^{o}C
- Continuous biomass feed with a capacity of 1-3 kg/h of biomass and solvent
- Feed of biomass from room temperature and pressure to the main reactor while in operation (50-60% w/w ethanol/water as solvent, up to 200°C and up to 30 bar)

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PL5: Hydrothermal pre-treatment of biomass
Bio Base Europe Pilot Plant, Belgium

Working on the biomass pre-treatment Pilot Line

Capabilities:

- Pre-treatment of biomass to obtain fractions of lignin, hemicellulose, cellulose
- Parameter optimization to achieve the desired monomeric characteristics while limiting the formation of unwanted byproducts (inhibitors)
- 50 L working volume
- Automated acid conditions on bioprocess tanks that improve safety

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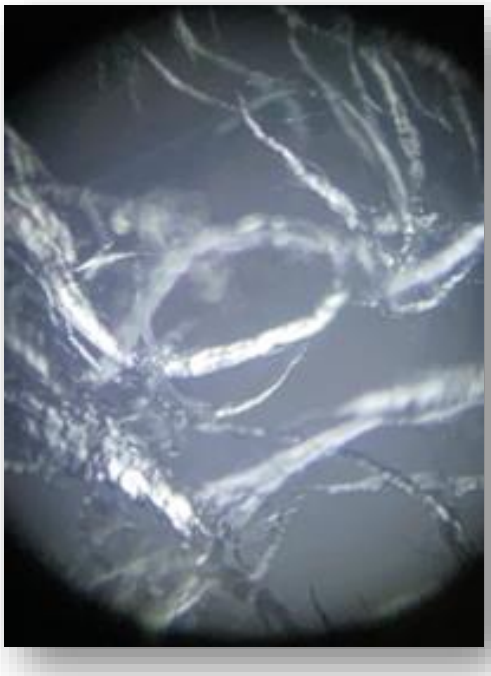
Intermediate Materials and Nanocomposites Cluster (IMNC)

PL2: Hydrolysis of fibre sludge and bacterial nanocellulose production
RISE Processum, Sweden.

The fermentation reactor of Pilot Line 2



TEM image of lignin nanoparticles produced at CNANO

Capabilities:

- Fiber sludge hydrolysis reactor of size 600 L.
- Bacterial nanocellulose fermentation reactor of size 600 L.
- Continuous mode operation.

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PL3: Sugar derived polyols and diols by catalytic hydrogenation/hydrogenolysis
Aristotele University of Thessaloniki, Greece.

The reactor of Pilot Line 3 in AUTH

Capabilities:

- Selective production of polyols/sugar alcohols (sorbitol, xylitol) and the controlled downstream hydrogenolysis to (glycerol, EG, 1,2-PDO)
- Two high-pressure reactors that can operate in separate (simultaneously) or in cascade mode.
- The second reactor offers better control of the residence/contact time, which is necessary to tune conversion and selectivity
- This configuration offers the flexibility to simultaneously operate the two main processes/steps, i.e. hydrogenation or hydrogenolysis, which require different temperature & pressure conditions
- Flexibility to simultaneously process different feeds, i.e. either sugars or acids or polyols

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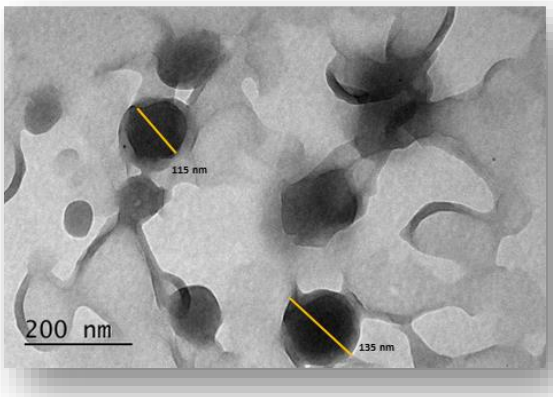
PL4: Ultrasonic assisted nanolignin production
CreativeNano, Greece

Ultrasonication equipment of Pilot Line 4



TEM image of lignin nanoparticles produced at CNANO

Capabilities:

- Formation of stable colloidal suspensions of lignin nanoparticles (NL) in the range of 10 to 500 nm
- Production of 200 g of nanolignin/week
- Operation within a flowing material stream (up to 4L/min)

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PL6: Purification of liquid fractions received from PL5 and PL3
Bio Base Europe Pilot Plant, Belgium

PL6 located at the Bio Base Europe Pilot Plant

Capabilities:

- Purification of the liquid fractions
- Available technologies: microfiltration, ultrafiltration, nanofiltration and reversed osmosis, ion exchange equipment, solvent extraction and crystallization to obtain monomeric fractions

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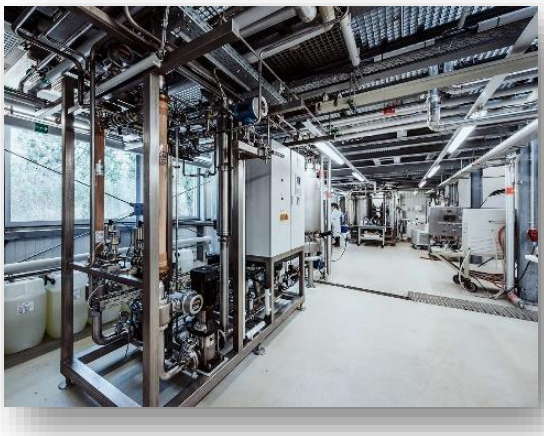
PL7: Enzymatic Hydrolysis & Microbial Fermentation for succinic acid and lactic acid
Leibniz Institute for Agricultural Engineering and Bioeconomy, Germany



Facilities of Pilot Line 7

Bio-based chemicals developed in PL7

Capabilities:

- Enzymatic hydrolysis depolymerizing biopolymers like starch or cellulose to fermentative sugar glucose (C6) and xylose (C5), by means of hydrolytic enzymes
- Fermentation metabolizing sugars to LA and SA
- Separation and purification of lactic/succinic acid purification to meet the standards of commercial applications
- Up-scaling of the entire process chain including downstream processing for the provision of product samples in kg-scale and high quality.

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PL8: Pyrolysis and carbonisation of biomass
University of Edinburgh, United Kingdom

PL8 in Edinburgh

Different biomass samples before and after

Capabilities:

- Production of porous solid carbons, liquids rich in phenolic compounds and organic acids, and combustible gases.
- Solid carbons (biochar) with high porosity and tunable surface functionality, and controllable electrical conductivity, suitable for additives
- Process biomass and biomass fractions at rate between 0.5 up to 50 kg/h of input material
- Temperatures up to 850°C

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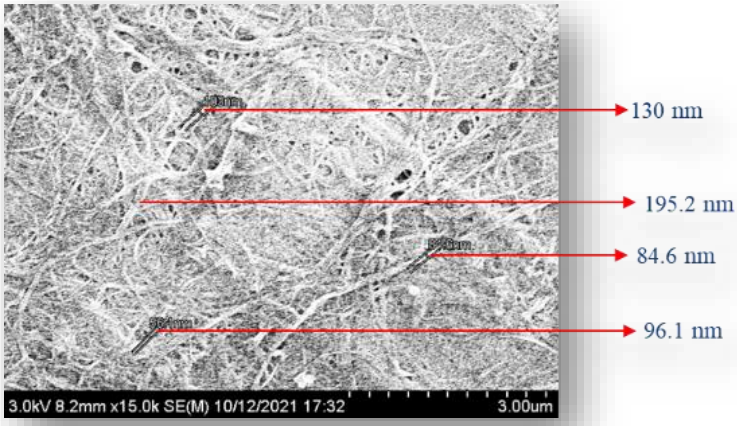
PL10: Mechanical milling and Production of different grades of nanofibrillated cellulose
Luxembourg Institute of Science & Technology

Grinder of Pilot Line 10



SEM image of nanocellulose produced at LIST

Capabilities:

- Standard capacity: 80~2000 kg/h
- Feed ~1-5 wt% solids in water
- Size reduction of a range of different cellulose fibers (short and long) without the clogging issues

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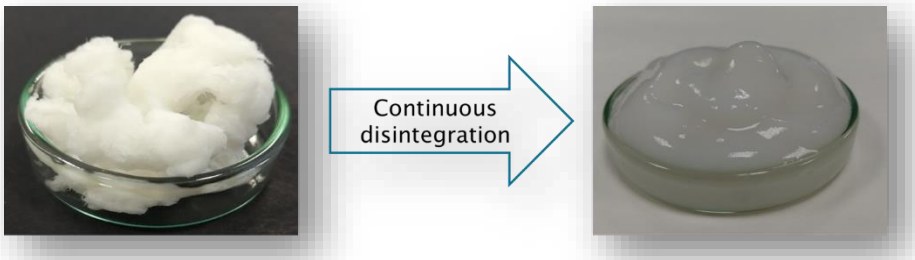
PL13: Mechanical treatment to produce nanofibrillated cellulose and / or crystalline nanocellulose

Instituto Tecnologico del Embalaje, Transporte y Logistica, Spain

Grinder of Pilot Line 13



Commercial eucalyptus pulp processed to obtain nano-cellulose

Capabilities:

- Cellulose nanocrystals production by acid hydrolysis
- Nanofibrillated cellulose production with mechanical treatment
- Continuous viscosity measurement to assess the quality of the nanocellulose obtained.

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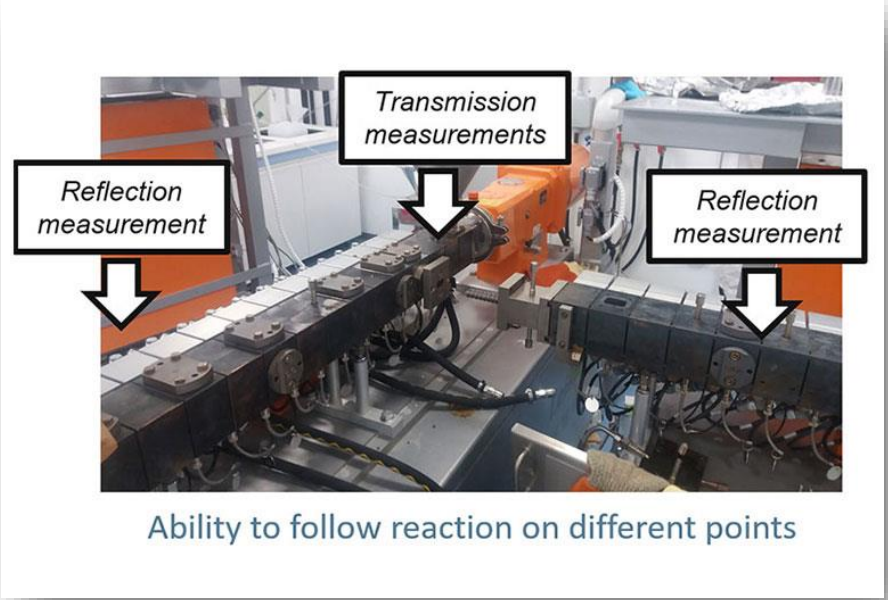
Final Products & Formulation Cluster (FPFC)

PL9: Continuous Reactive Extrusion for thermoplastic polyurethanes
Luxembourg Institute of Science & Technology



The extruder of Pilot Line 9

Capabilities:

- Reactive extrusion (REx) tandem set-up for longer residence time polymer synthesis
- Continuous and solvent-free process, ability to work with highly viscous materials
- Output : 1 - 10 kg/h
- Temperature 90 - 220 oC, N2 flow
- Online monitoring with Near-Infrared

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PL11: Reactive extrusion (REX) for PLA and PLA copolymer based nanocomposites
Asociacion De Investigacion De Materiales Plasticos Y Conexas, AIMPLAS

The extruder of Pilot Line 11

Capabilities:

- Co-rotating Twin Screw Extruder
- Continuous reactor for polymerization of PLA and its copolymers by ROP of lactide
- Possibility of PLA polymerization in presence of nanoparticles “in-situ polymerization” or incorporation in a compounding step after polymerization.
- Online monitoring with Near-Infrared

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PL12: Resins Pilot Line
Fraunhofer Institute for Wood Research – Wilhelm-Klauditz-Institut, Germany

3D-printed biobased resin developed at PL12

The reactor of Pilot Line 12

Capabilities:

- Synthesis of resins with azeotropic polycondensation or polyaddition
- Resins suitable for additive manufacturing (UV-curable) and printing inks
- Use of biobased monomers (e.g. succinic acid, glycerol, EG, 1,2-PDO and sugar alcohols)
- Reactor size 25 kg

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PL14: Coating formulation PL
Instituto Tecnologico del Embalaje, Transporte y Logistica, Spain

Coating machine from PL14

Capabilities:

- Formulation of inks with nanocellulose
- Formulation of biobased coatings for barrier properties and mechanical reinforcement
- Equipment for dissolving, dispersing and milling with capacities up to 15 L

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PL15: Additive manufacturing
Asociacion De Investigacion Metalurgica Del Noroeste, Spain

Robotic arm for large format 3D printing, UV-printer, FDM printer

Capabilities:

- Large Format Additive Manufacturing of thermoplastic polymers and composites for creating complex geometries, with a thermal camera for monitoring.
- Photopolymerization 3D-printing for resins with an inverted microscope setup, a large resin tank, a femtosecond pulse laser, a camera with imaging optics and a very fast piezoelectric microscope objective mount.

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PL16: Printed Electronics
Danish Teknologisk Institut, Denmark

Screen printing facilities of Pilot Line 16

Capabilities:

- Screen print line (INO Print VS6 500) and tunnel dryer (INO Dryer HA1 500)
- Allows to align, control many parameters and to carry out pilot production of large volumes.
- Complementary stretch test, wash test
- Pick and place machine for attachment of electronic components to printed circuits (video)

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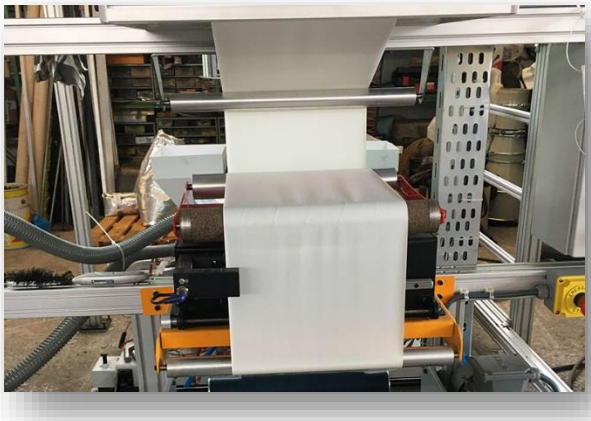
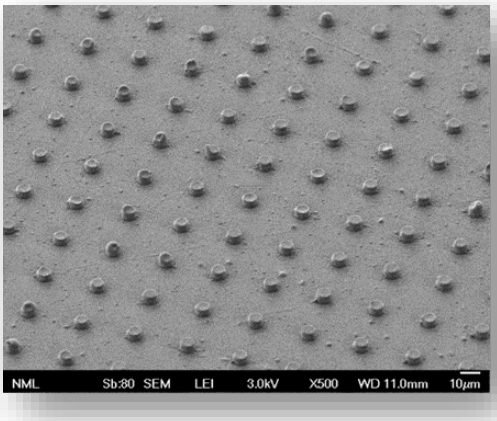
PL17: R2R Nanopatterning & thermoforming
Nanotypos, Greece



Roll-to-Roll instrumentation of Pilot Line 17



SEM image of micropillars on PLA film, created in PL17

Capabilities:

- Complete manufacturing value chain for the production of large area micro/nano structures surfaces
- Master preparation with electroforming and silvering, Roll-2-Roll extrusion embossing and thermoforming.
- R2R extrusion embossing specifications: 3 layer extruder, input film width 350 mm, output film width 100-350 mm, output film approx. 30kg/h - 40kg/h, film thickness min-max 50-500µm

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BIOMAC's services: Validation Hub

Group of services that examines the feedstock, the technologies and the products from a chemical, environmental, and economical perspective.

Quality Control & Characterization

Provided by:
Politecnico Di Milano (Italy)
Universidad De Burgos (Spain)

- Quality assurance of the feedstock, technology, and products.
- Comprehensive description of characterization facilities available in the BIOMAC consortium.

The quality control and characterization service is responsible for characterization of materials and products through suitable characterization techniques in order to ensure the achievement of the desired properties.

In particular, the characterization service offers a dual support: validation of materials and products (e.g., consolidation and repeatability of the analysis performed) and provision of the BIOMAC Characterization Catalogue, containing a full description of all the characterization techniques available within the BIOMAC consortium that can be exploited by the OITB users.

The quality assurance will involve different levels of investigation: fundamental analytical approaches (e.g., molecular, chemical-physical, thermal, structural and morphological characterization); technological approaches focused on materials processability and exploitability (e.g., mechanical and thermo-physical approaches); and characterization approaches directly associated with specific final products (e.g., antioxidant properties, barrier properties, biodegradability).

To this end, the characterization catalogue will provide detailed information concerning the characterization facilities of the Consortium, that can be employed by the OITB users. This catalogue includes the characterization method name, manufacturer/model, main functions, technological features, and location. In the short term, an online tool for the visualization, search, and selection of characterization facilities on the BIOMAC platform will also be available.

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Standardization

Provided by:
European Bioplastics (Germany)

Facilities for mechanical testing of materials

Compliance with the relevant standards is key for the development of new technologies and processes. Understanding, monitoring and contributing to the activities of relevant standardization committees and regulatory bodies is necessary to integrate existing rules with new standards or provide suggestions for amendments on current standards and regulations.

Standardisation

- Compilation of all relevant information on standards in the field of nano-enabled biomaterials.
- Verification and enabling of compliance with standards of all project results.
- Development of specific actions to guide the project and partners´ activities toward the standards.
- Contribution to standardisation committees regarding new technologies, such as integrating existing rules with new standards based on the results of the project.

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- Organisation of international fora and network activities to promote discussions and provide suggestions for amendments on current standards or development of new ones.

Process Validation - Modelling

Provided by:
Idener Research & Development Agrupacion De Interes Economico, Spain
Instituto De Soldadura E Qualidade (Portugal)
IRIS Technology Solutions SL, Spain
Abis Spolka Z Ograniczona Odpowiedzialnoscia Spk, Poland
Stam S.r.l. (Italy)

- Optimization of reliability of complex systems in the micro/nano range and their performance in real conditions.
- Simulation and modelling providing suitable failure criteria and models for the evaluation of the reliability of real components
- Validation of simulations with characterization.

Techno-economic modelling (IDENER)

The development of mathematical models of the systems will provide a feasible prediction of process performance in a range of conditions. Such models also include the associated economic parameters (investment, fixed and variable operational costs, revenues and basic economic indicators). Thus, they allow the optimisation of operational parameters on the basis of economic criteria, among others, skipping the need of experimental workload and, consequently, saving time and money. The provided results will be the starting point for the optimal design and engineering of processes. Moreover, the results of simulations with models will provide an excellent and accurate basis for the construction of extended techno-economic analysis and new business cases while reducing drastically the associated evaluation costs.

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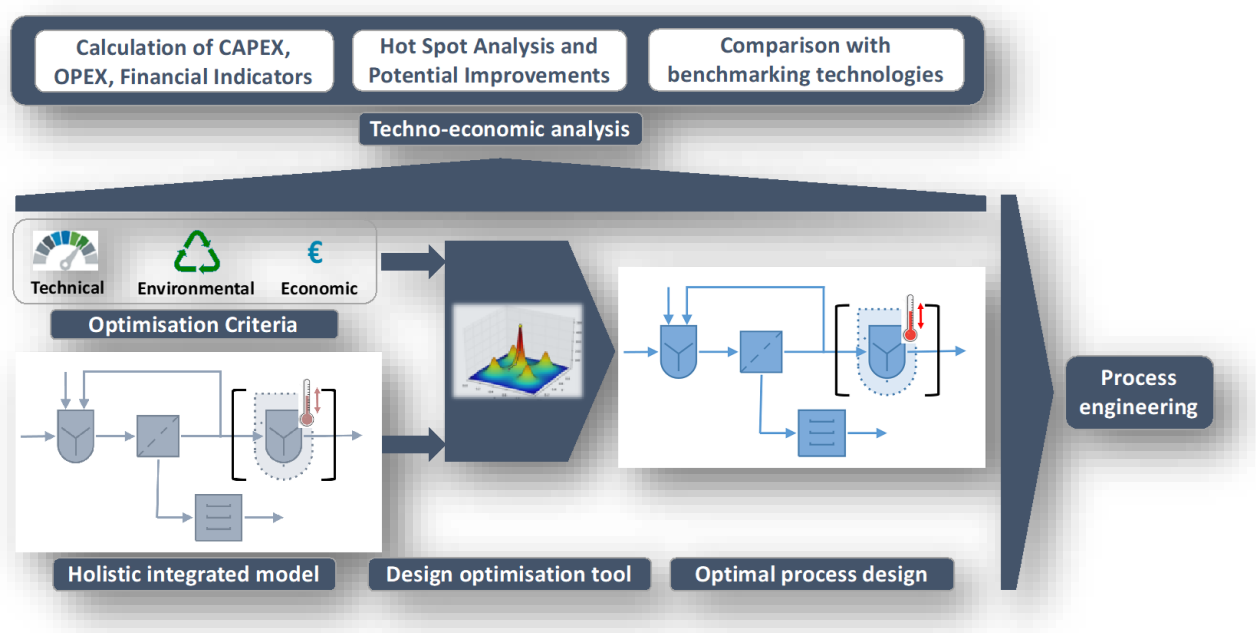

Mathematical models for techno-economic analysis

Development of sensor-based setups to monitor and evaluate the state of a system (ISQ)

The development of sensor-based setups that monitor and evaluate the state of a given system, capable of triggers and warnings relevant to a case-to-case study. As a complement to this system, and given a significant amount of data, predictive modelling and optimization can be developed to find the best configuration of parameters to produce the best outcome, whether it be quality, quantity, time consumption, etc. This approach provides the consumer with a better knowledge of the system as well as a monitoring platform that can improve the overall workflow and cost-objective relation.

Real time monitoring solutions (IRIS TECHNOLOGY SOLUTIONS)

- High quality solutions for off-line and in-line real-time monitoring of parameters of interest in a fast and reliable way regarding different chemical processes. This becomes crucial to characterise the behaviour of the production systems.
- Find new ways of optimisation and identify certain malfunctions in a process.
- Ensure the quality of feedstock, intermediate materials in a process or final products
- Development of chemometric models in order to have information on materials in the process and iterations for improving the models according to the samples that should be analysed.

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- Provide photonic sensors coupled to artificial intelligence algorithms for the control of industrial and production processes in real time, including NIR handheld and in-line sensors.

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BIOMAC's services: Value Chain Hub

Services around the environmental monitoring, resource efficiency, logistics and cost analysis of the introduction of the developed biomaterials and processes

Sustainability Assessment

Provided by:
Universidad De Burgos (Spain)
Instituto De Soldadura E Qualidade (Portugal)

- Life Cycle Assessment (LCA) service (ISQ) allows for estimating the environmental impacts of a product throughout its life cycle. It can be used to inform stakeholders, and support decision-making toward the improvement of a product's sustainability. LCA measures the environmental impact of a product or service, from raw material extraction to end-of-life (cradle-to-grave) or over a subset of the life cycle (eg. cradle-to-gate). Based on normalised standards (ISO 14040 and ISO 14044) LCA takes into consideration several impact categories, being the base for Environmental Product Declarations (EPDs) and/or EU recommended Product Environmental Footprint (PEF). In addition, LCA can be used to avoid problem-shifting, since it identifies the environmental life cycle hot-spots and allows to compare alternative production routes or functionally equivalent products. Further to this, LCA can be a valuable tool to stimulate innovation by supporting sustainable choices in product design, development, and manufacture. With the arrival of net-zero targets, new ideas, designs, products, and processes will be required to facilitate the transition to a low-carbon economy, and LCA can be a vital first step in this process. Streamlined or comprehensive LCA studies can be tailored to the client's needs.

- Life Cycle Costing (LCC) will help to identify the economic hotspots during the life cycle of the innovative products, in order to determine the actions needed to make them economically feasible when bringing them to the market. This will include the assessment of all the costs incurred during the life cycle, the monetization of the environmental impacts, and the financial analysis to evaluate the viability of the innovations, considering the risks and uncertainties in a sustainability approach.

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Value chain assessment

Provided by:
RDC Informatics (Greece)
AXIA Innovation (Germany)

- Decision Support to simultaneously assess the products against environmental and economic criteria
- Access via an online, user-friendly platform to secure the use from non-optimization experts

Decision Support Tool towards Value Chain Analysis and Assessment (AXIA)

Biobased industries are characterized by different alternatives in each of the steps of the value chain. To deal with the plethora of options, map over the possibilities and deal with the uncertainties, a pack of skills and data is required simultaneously (modeling, optimization, sustainability analysis, economic analysis, pricing policies, supply chain management etc.). That process is time consuming and demands highly qualified personnel.

To support the holistic screening of alternative production routes towards bio-based products enhanced with nanoparticles an **assessment tool** is proposed as a mean to support decisions. The **Decision Support Tool** is an optimization model that performs a holistic value chain analysis involving a systematic integration of different types of biomass fractions, intermediate monomers and polymers taking into consideration simultaneously all the available finite uses. The different paths are undergoing an optimization with the goal to minimize and/or maximize a value of interest (e.g., cost, biomass availability, energy consumption, green gas house emissions etc.).

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Simultaneous consideration of more than one criteria is also available to support what if studies and propose optimal paths in the area of interest.

To serve the clients AXIA Innovation, can undertake different studies based on the pilot ecosystem of BIOMAC, offering consultancy services in value chain analysis and assessment, providing report and analysis customized to the need of the analysis each time (e.g., include parameters in the analysis). As an extra feature of the DST, the analysis can be expanded including similar processes* (available in the market or owned by the client), of interest to the customer, customizing the optimization model and the analysis and the assessment according to the needs of the clients each time.

Decision Support Online Platform (RDC, AXIA)

As a step further, AXIA together with RDC supports the development of an online tool based on the Decision Support tool. The online platform, Decision Support Platform, being an online assessment tool includes all the above-mentioned functions of the tool and gives the possibility of non-optimization experts to run on their own the different studies, including the data of their preference. For the online platform, RDC will design a User-Friendly Interface which will include graphical representations of the value chain under consideration and the different solutions of the optimization studies depictured on tables and figures. The serve of the potential customers will be done with the provision of specific cloud-based software as a service (SaaS) license model, for the use of the software and the technical support from both AXIA and RDC. Extra features will be also available such as including extra processes in the automated optimization tool with additional charge.

*This aspect can also provide further Clients to the LCA and LCC partners of the project.

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Circular Economy

Provided by:
Politecnico Di Milano (Italy)
AXIA Innovation (Germany)
University of Padova (Italy)

- Evaluation of sustainability and economy feasibility
- Development of efficient networks identifying opportunities to foster the transition from linear to circular model
- Identification of future commercial viability and improvement conveying environmental and circular sourcing in consistency with the Green EU Policy.

This service is related to the definition of sustainable recycling and end-of-life (EoL) management strategies for biobased (nano)materials and products developed within the BIOMAC Consortium in a Circular Economy perspective. The activities are organized following a stepwise approach focused on three main successive actions, namely:

(1) Evaluation of reference EoL management strategies for target biobased (nano)material wastes within a European framework.
(2) Evaluation of current practices for EoL management of target biobased (nano)materials in reference to benchmark BIOMAC practices.
(3) Definition of end-of-life management guidelines to be provided to OITB users.

In particular, the following main aspects will be considered in the analysis: (a) technical characteristics (including product durability) and quality requirements downstream the target value chain; (b) raw/semi-processed material selection in view of its recycling/reuse potential and end-of-life fate; (c) sustainability of current end-of-life treatment strategies; (d) barriers and risks associated with the reuse and/or recycling of BIOMAC products.

UNIPD will value the economic benefits and impact of the circularity and end of life strategies associated with the products in the definition of the business plans (see Market Uptake Hub section for further details about the services).

With the view of including all the potential aspects that impact a technology and its interaction within the network of a value chain, AXIA will incorporate potential scenarios of circular economy models within the service of Value Chain assessment. The study will assess how different types of circular strategies with a holistic analysis of the overall value chain identifying the best practices to be followed.

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BIOMAC's services: Market Uptake Hub

Services to support business, regulatory compliance, and data handling issues.

Innovation Management

Provided by:
Exelisis (Greece)
University of Padova (Italy)

- Identification of innovation margins of each result in market terms.
- Use of innovation management tools to reinforce the exploitation strategy.
- Identification of customer segments and value propositions they require.

Division of Innovation Management Services offered by the BIOMAC OITB in connection with the responsible organization:

1. **Business plan environment**: these are a range of services that UNIPD (with the support of UNISMART) will provide to the end users with the aim to define the business environment for the specific company and product involved in BIOMAC. The main goal of these services is the development of business plans to assess the innovation potential of the test case involved in the project. These services will allow the end users to better develop and position its product in the bioplastic and specific industry market, understanding potential opportunities, and to define a clear value proposition and business plan for the implementation of the product. The services include a range of analyses and assessments to choose from based on each particular case: Focused market analysis, competition analysis, business model canvas, value proposition analysis, SWOT and PESTLE analysis.
2. **Exploitation risk assessment:** All potential exploitation risks associated with the clients' projects will be analyzed, including significant barriers, evaluating risk probability of occurrence and potential impact as per different risk types, as well as establishing a risk management plan that includes predefined monitoring and re-assessment plans, mitigation actions foreseen and other previsions (*EXELISIS*).
3. **Intellectual Property Rights management and patent mapping analysis**. Concerning Intellectual Property, UNIPD (with the support of UNISMART) is able to provide descriptive analytics of patents, focusing on different technological classes and assignees, in different years and countries and with multiple combinations of keywords. In this way we can operate a market discovery analysis, identifying also key players. We can offer landscape mapping based on knowledge channeling between assignees and potential areas of collaboration in terms of shared technologies

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4. **Investment need assessment**: Evaluating the financial sustainability of the clients, conducting a financial valuation and forecasting scenarios to assess the client's investment need, conducting identification and offering consultancy for the appropriate funding instruments to cover those investment needs, optionally also offering assistance in the engagement of various funding sources (instruments) (*EXELISIS*).

Health and Safety

Provided by:
Universidad De Burgos (Spain)
Instituto De Soldadura E Qualidade (Portugal)

Health & Safety is an essential aspect to demonstrate the safety nature and the associated hazards of the product's fabrication and use. For that, it is taken into consideration the following points:

- Reduction of potential health and safety risks via a Safe-by-Design approach across the value chains.
- Identification and management of uncertainties and potential risks.
- Nanosafety guidelines in terms of handling nanomaterials and their release from polymeric matrices.
- A multi-tiered exposure assessment approach to airborne nanomaterials.
- Monitoring activities: workplace airborne (nano)particles monitoring with portable real-time reading equipment capable of measuring particle concentration, particle size, surface area and size distribution of airborne (nano)particles.
- Identify the dose-response assessed through the physicochemical properties of the materials studies.
- Perform assays with the identified most relevant models (human cells, yeast, bacteria) to evaluate the ecotoxicity of the nanoparticles.

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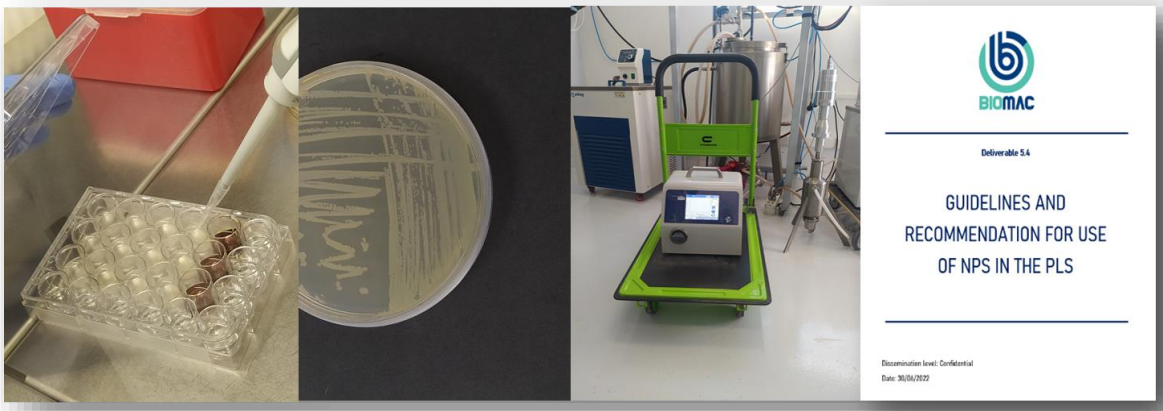

Nanoparticle toxicity testing for BIOMAC

The guidelines regarding Safe by Design provides the ISQ and UBU Team a baseline to grant a reliable assessment of human and environmental safety aligned with the EU standards.

These services connect with others along the BIOMAC partnership, providing meaningful results to the nanomaterials-related industries.

Standardisation and Regulation

Provided by:
European Bioplastics (Germany)

Compliance with the relevant standards and regulations is key for the development of new technologies and processes. Understanding, monitoring and contributing to the activities of relevant standardization committees and regulatory bodies is necessary to integrate existing rules with new standards or provide suggestions for amendments on current standards and regulations.

Standardization

- Compilation of all relevant information on standards in the field of nano-enabled biomaterials.
- Verification and enabling of compliance with standards of all project results.

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- Development of specific actions to guide the project and partners´ activities toward the standards.
- Contribution to standardisation committees regarding new technologies, such as integrating existing rules with new standards based on the results of the project.
- Organisation of international fora and network activities to promote discussions and provide suggestions for amendments on current standards or development of new ones.

Regulation

- Assessment of existing rules in the field of nano-enabled biomaterials to ensure partnering in the commercialisation phase of a technology, securing compatibility, and reducing market uncertainties.
- Definition of specific actions to direct the project and partners´ activities toward regulatory frameworks affecting the new technologies under development.
- Close collaboration with key regulatory bodies and provision of technical input based on project results.
- Organisation of international fora and network activities to promote discussions and provide suggestions for amendments on current regulatory frameworks.

Data management

Provided by:
RDC Informatics (Greece)
Idener Research & Development Agrupacion De Interes Economico (Spain)

- Data governance, Analysis and Design, Database Management, Security, and quality assurance.

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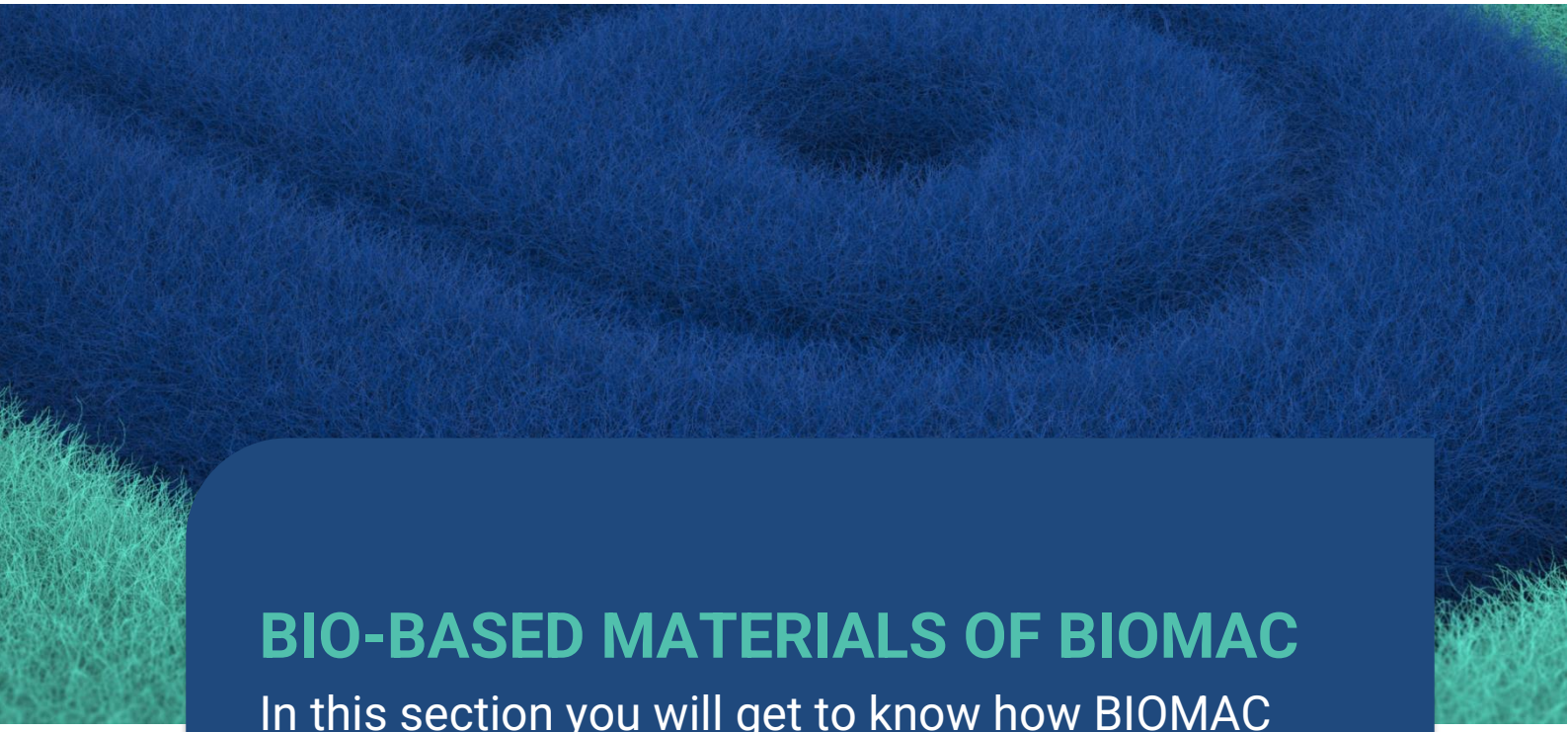

BIO-BASED MATERIALS OF BIOMAC

In this section you will get to know how BIOMAC partners have used the 17 Pilot Lines to realize five different nano-enabled Bio-based materials.

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Novel nano-enabled bio-based materials concepts developed in BIOMAC

The BIOMAC OITB is developing 5 test cases using nano-enabled bio-based material Value Chains.

With the help of the demonstrators, DIAD, Novamont, Eversia, Acciona and Precure, we are developing and upscaling innovative concepts in the fields of automotive, agriculture, food packaging, construction and printed electronics industries.

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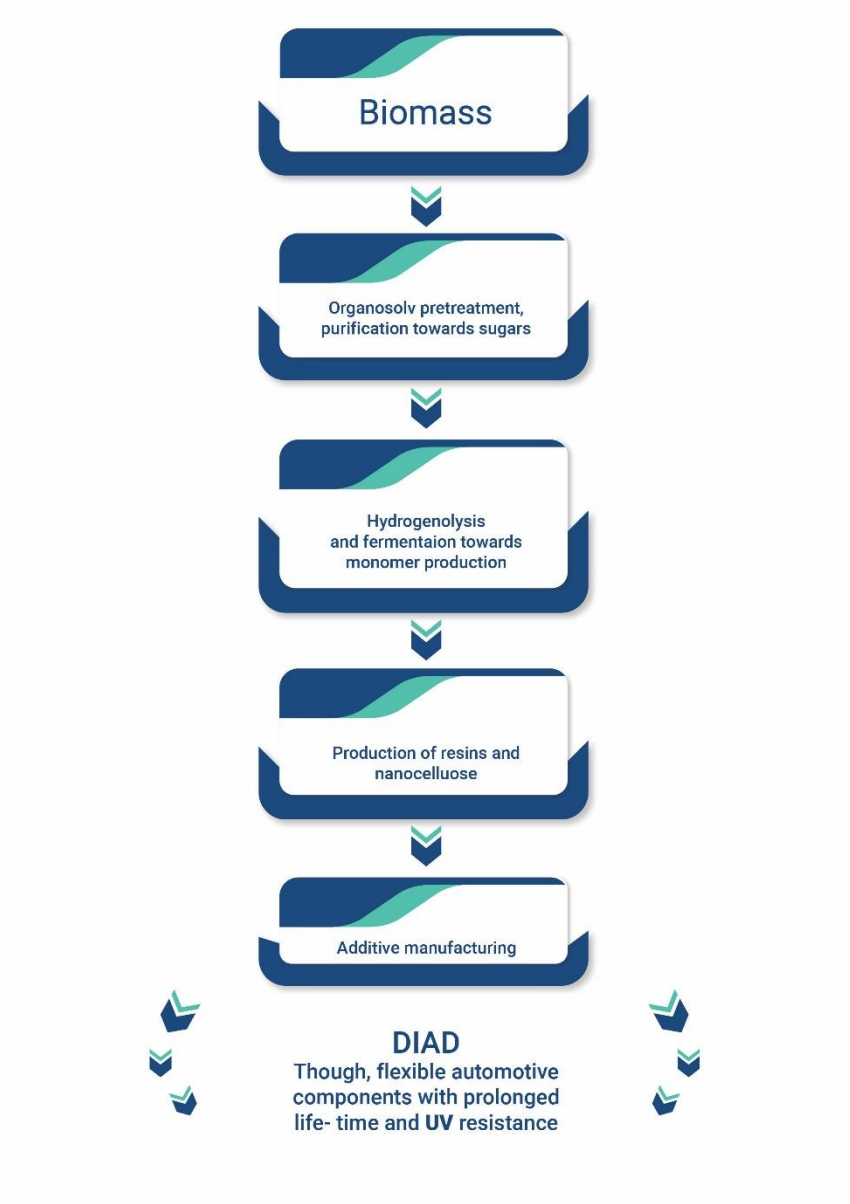
Test Case 1: Automotive

- Biobased resins reinforced with nanocellulose will be used in the fabrication of interior car parts and components for the automotive industry.
- These will be succinate-based polyesters and isocyanate-free polyurethane resins with exceptional physical properties including toughness, flexibility, and resistance to abrasion and temperature.



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Test Case 2: Agricultural applications

- Succinic acid derived from biomass will be used as a monomer in the development of biopolymers.
- Biochar will be used to nano-reinforce PLA and create a material with enhanced optical properties and UV/thermal resistance to be used in agriculture.
- Biopolymers and nano-additives will contribute to soil amendment and remediation after biodegradation of bioplastics in soil, thus increasing soil health and quality.

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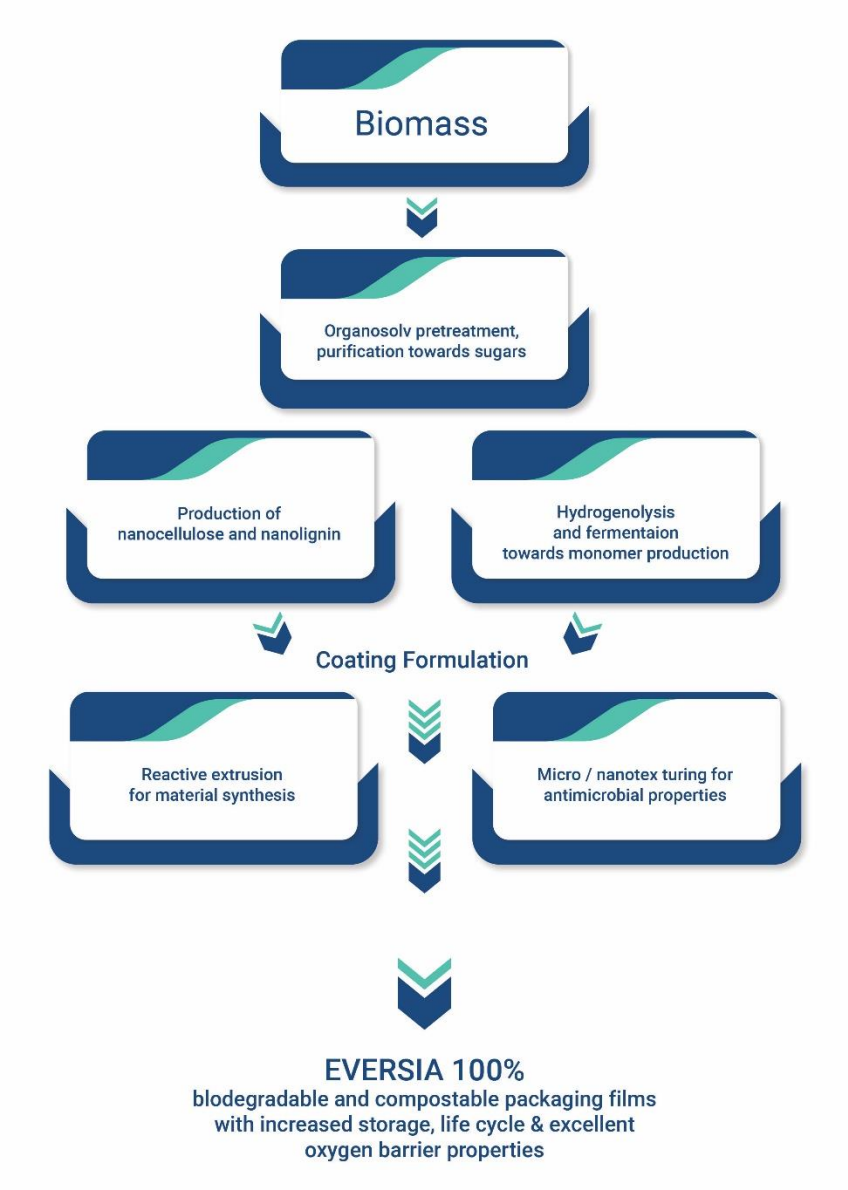
Test Case 3: Food packaging

- Test vacuum thermoforming will be further utilized to produce biocompostable and biodegradable food containers, using biobased PLA foils.
- These will be reinforced with nano-additives to enhance the mechanical and antibacterial properties of flexible packaging materials.
- By further improvements, the antimicrobial and antifungal properties of the film surface will be enhanced, leading to improved food maintenance/conservation and safety



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Test Case 4: Construction

- Bio-nanocomposites will be tested in the construction industry.
- A footbridge module made by biopolymers reinforced with nanolignin, biochar and nanofibrillated cellulose will be constructed using 3D printing technology.
- Fused filament fabrication (FFF) filaments prepared by melt extrusion will be used, and simple printing tests of the bio-filament will be performed using conventional fused deposition modelling equipment.
- The final product is expected to have high UV and fire resistance >80 °C, anti-fouling & easy-cleaning capability.

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Test Case 5: Printed Electronics

- Development of stretchable conductive layers embedded into textiles (sock with integrated conductors) using a biobased stretchable substrate, an ink and adhesives with printed electronic processes.
- To achieve this, nano-biochar will be modified by nano-copper and silver to enhance its electrical conductivity.
- TPU produced by reactive extrusion and biobased succinate polyesters will be used as flexible substrates, and nano-copper for stretchable electrical prints will be integrated directly into textiles as stretchable circuitry between sensors and electronics.

The electromyography (EMG) electrodes, currently used by PRECURE, are made of a silver textile. The aims of the project are to make products that are more durable, cheaper to manufacture, and with a lower environmental impact. Prototypes show promising durability and preliminary tests show sensing performance comparable to silver textile electrodes. In the end, this will create a better and more sustainable solution to the benefit of users, customers, and the environment.

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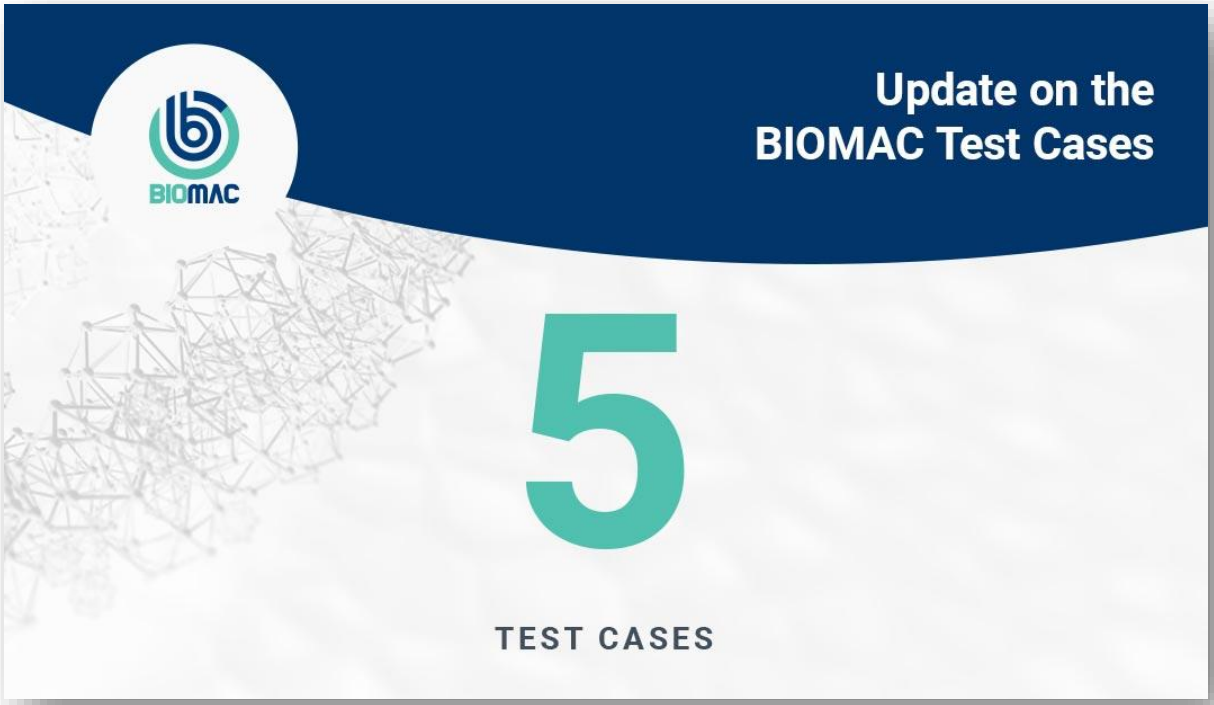

Read the latest updates on the BIOMAC Test Cases up to November 2022.

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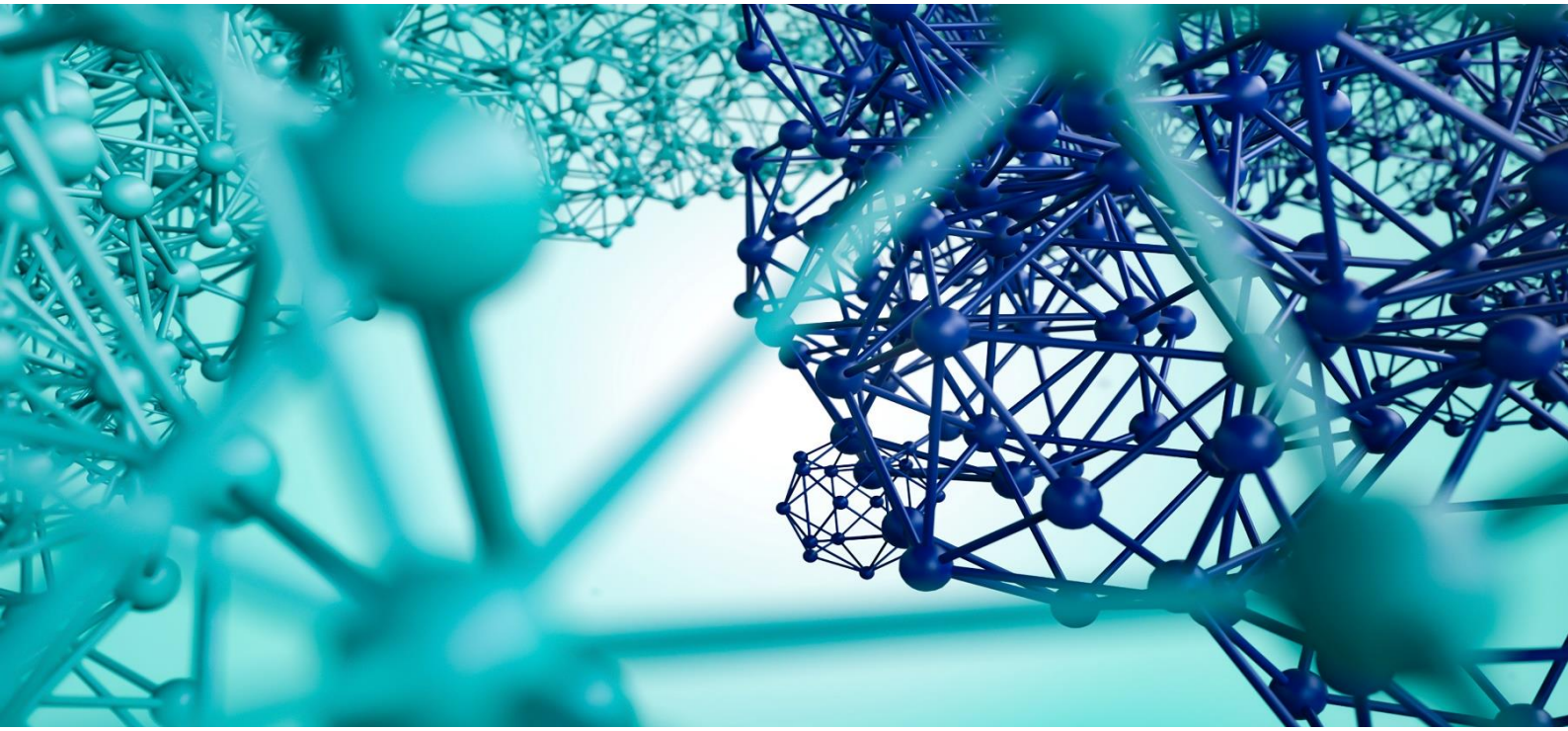

biomac@chem.auth.gr

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