Bionanopolys

HIGHLIGHTS NO. 2

WELCOME

to the second newsletter issue of the Bionanopolys Open Innovation Test Bed (OITB) project!

Every six months we would like to keep you posted about our project activities, about previous and upcoming events, where to meet our consortium members and we invite you to gain insights into specific aspects of Bionanopolys implementation.

Enjoy reading, feel free to share this issue with your colleagues and don't hesitate to drop us a line in case you have any question or cooperation request.

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BIONANOPOLYS AND ITS ROLE IN THE LANDSCAPE OF OITBS

OPEN INNOVATION TEST BEDS FOR NANO-ENABLED BIO-BASED MATERIALS

BIOMAC
European sustainable bio-based nanomaterials community

BIOMAT
OITB for nano-enabled bio-based PUR foams and composites

INN-PRESSME
Open innovation ecosystem for sustainable plant-based nano-enabled biomaterials deployment for packaging, transport and consumer goods

BIONANOPOLYS
OITB for developing safe nano-enabled bio-based materials and polymer bionanocomposites for multifunctional and new advanced applications

For the sake of our planet we urgently need appropriate alternatives to replace fossil-based materials. It's not a matter of a lack of ideas but the challenge to meet the product requirements is immense. Novel biomaterials from non-fossil-based resources must offer functional properties for large scale applications and need to perform even better than their fossil-based counterparts to drive their adoption by industry and end users. Apart from that, there is also the question mark of price. At the moment, nothing can beat the price of fossil-based materials.

How to make a change and where to set the right cornerstones for a visible impact in this matter?

BIO-BASED MATERIAL INNOVATIONS WANTED!

With the call for "Open Innovation Test Beds for nano-enabled bio-based materials" the European Commission has set a significant sign to drive forward the development in this field. Four OITB projects are currently working on this topic now: BIOMAC, BIOMAT, INN-PRESSME and Bionanopolys (see info box).

All of these OITBs have in common that they are establishing a network of pilot plants with additional technical and economical services, where industrial partners (eg SMEs) can validate their own ideas holistically. The OITB environments will help to accelerate the introduction of novel bio-based materials into the market by providing single entry points where users can take advantage of.

Lots of options, but which one will be the right choice? All OITBs are dedicated to the development of nano-enabled biomaterials and their service portfolios include a holistic set of supportive services, such as business and innovation management, validation services, legal consultancy, etc. to speed up the introduction of novel materials into the market. But despite the obvious overlaps, there are also some differences. OITBs under this call use different raw materials from biomass, which are used for nano-composites and end up in various end products for different industry sectors.

FEATURES WHEN CHOOSING BIONANOPOLYS

In the case of Bionanopolys the pilot plant network for raw materials is exploring biomass for the production of

- cellulose nanofibers, cellulose nanocrystals, nanolignins,
- block copolymers
- metallic nanoparticles (enzymatically obtained) and
- functional nanocapsules

that can be further processed to bionanocomposites (pilot plant network 2). In particular, the modification and functionalization of nanomaterials is an important topic here, that leads to the development of thermoplastics or biobased nanodispersions.
The bionanoproducts at the end of the value chain (pilot plant network 3) serve different industry sectors like for example, packaging, textile, construction, or cosmetics industries. The pilot plants of Bionanopolys in this network explores the production of rigid and flexible packaging, textiles and non-woven fabrics, foam applications, cellulosic products, 3D printing or coating applications.

Like all OITBs the services are not only limited to technical ones. A clear benefit of making use of a single entry point such as Bionanopolys is the availability of additional "out of the box" services that help to make ideas well-rounded. At Bionanopolys users will be advised in terms of legal aspects (patenting, IPR management), safety assessment, economic assessment, sustainability assessment, fund raising, business modelling and standardization.

The project Bionanopolys is developing all of these technical & business services in the frame of a funded EU project and will validate its service portfolio in the frame of an open call (2023) where interested users can submit their ideas.

Stay tuned and take part!

LET'S SHED A LIGHT ON BIONANOPOLYS' PILOT PLANTS!

BIOMASS

BLOCK COPOLYMERS PRODUCTION

Written by Alejandro Aragon, ITENE (Pilot Plant 3 Leader)

Pilot plant 3 focuses its services on the synthesis of novel block copolymers through polycondensation reactions. To accomplish the best strategy, ITENE has at its facilities polymerization reactors of different capacities. A 3 L reactor will be initially used to perform proof of concept experiments and then, a 15 L stainless steel reactor will be employed to scale up the optimized polymerization reactions in a relevant environment, enabling to obtain 10-12 kg per day of block copolymer-based additives.

CHALLENGES FOR THE PILOT PLANT

The production of certain block copolymers includes a polycondensation reaction step in which a small molecule such as water or methanol is produced as a by-product. For example, poly(butylene succinate) (PBS), is one of the most important biodegradable polyesters synthesized by polycondensation reaction between succinic acid and 1,4-butanediol. The reaction proceeds in two steps. First esterification occurs between the diacid and the diol, and then polycondensation takes place under high temperature to form high-molecular-weight PBS. During this step, water is formed and should be removed so that the reaction can proceed.

OUR SOLUTIONS

ITENE has upgraded its polymerization reactors by installing a distillation column, enabling to perform polymerization reactions in the different reactors. In addition, an inline viscosimeter is going to be installed with the aim of monitoring the polymerization process, allowing the optimization of the reaction parameters (i.e., time, temperature, catalyst concentration, etc.).

BIONANOCOMPOSITES

NANOCOMPOSITE COMPOUNDING – THERMOPLASTICS

Written by Elena Torres, AITEX & Amparo Verdu Solis, ITENE (Pilot Plant 7 Leader)

Pilot Plant 7 focuses its services on engineering thermoplastic bionanocomposites through compounding and reactive extrusion (REX) technologies. To accomplish the best strategy, the pilot plant comprises a laboratory extruder at CeNTI facilities to drive proof of concept experiments, and a Reactive Extrusion pilot plant available at AITEX facilities to scale up the process in a relevant environment.

CeNTI - Centre for Nanotechnology and Smart Materials is a R&D technological centre located in Portugal, explores advanced technologies enabling the development, testing, prototyping, and scaling-up of nanotechnology solutions for the market.

AITEX - The Textile Industry Research Association located in Spain, promotes the modernisation and introduction of emerging and new technologies via R&D actions and projects that contribute to the industrial progress of the textile sector.

Furthermore, ITENE is equipped with two different compounding lines composed by twin-screw extruder (40 L/D COPERION, and 44 to 60 L/D LEISTRITZ extrusion lines) and different feeding systems that allow to work with broad spectrum of materials (in pellet, powder, and liquid form), in addition of a MiniTwin gravimetric feeder specially focused in low feeding range capacities.

CHALLENGES OF THE PILOT PLANT

Polymer properties must be constantly improved to meet the ever-increasing demands of plastic applications. As the development of new polymers is decreasing, the deliberate modification of the properties of a base polymer by using inorganic fillers and/or blending with other polymers is becoming more and more important. This is the main goal of compounding operations and special attention needs to be paid in control and achieve an adequate dispersion grade of this reinforcements/additives.

Polymer functionalization with additives by compounding technology is a common approach to obtain added value thermoplastic bionanocomposites. This process is based on a physical mixture of polymer and bioadditive in the molten state. Nevertheless, in many cases, the final product eventually loses the added functionality since the additives migrate to the surface and are released to the environment.

OUR SOLUTION

Reactive extrusion is being used to overcome the aforementioned drawback, considering that functional molecules are anchored into the polymeric matrix. REX technology provides stable and irreversible covalent bonds, achieving a uniform distribution of functional moieties into the polymer matrix and avoiding particle aggregation, migration, and leaching. Furthermore, reactive extrusion offers a one-step solvent-free route to produce novel and high-performance materials with new functionalities. Therefore, the REX process allows the incorporation of additives into the polymer matrix through covalent bonds under milder and environment-friendly conditions.

ITENE is working on an upgraded nanocomposite compounding pilot plant: a simulation software will be used to design preliminary screw profile, combining different types of elements (i.e., conveying elements, kneading blocks, gear mixing and high-performance elements) to obtain an ad-hoc screw design in order to maximize dispersion and avoid possible thermal degradation of material during processing. The different screw profiles will be applied to optimise the incorporation of the nanoparticles and the optimization of the extrusion parameters (i.e., residential time, Specific Mechanical Energy, throughput, etc.). In addition, the correct dispersion will be monitored by rheological and infrared in-line measurements enabling to obtain nanocomposites with high performance properties optimizing amount of nanoparticles used and also minimizing off-line characterization times.

Figure 1: Extruder for thermoplastic compounding Pilot Line available at CeNTI facilities

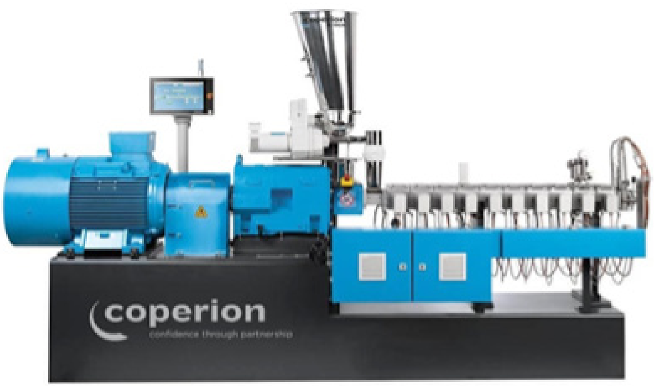


Figure 2: Reactive extrusion Pilot Line available at AITEX facilities

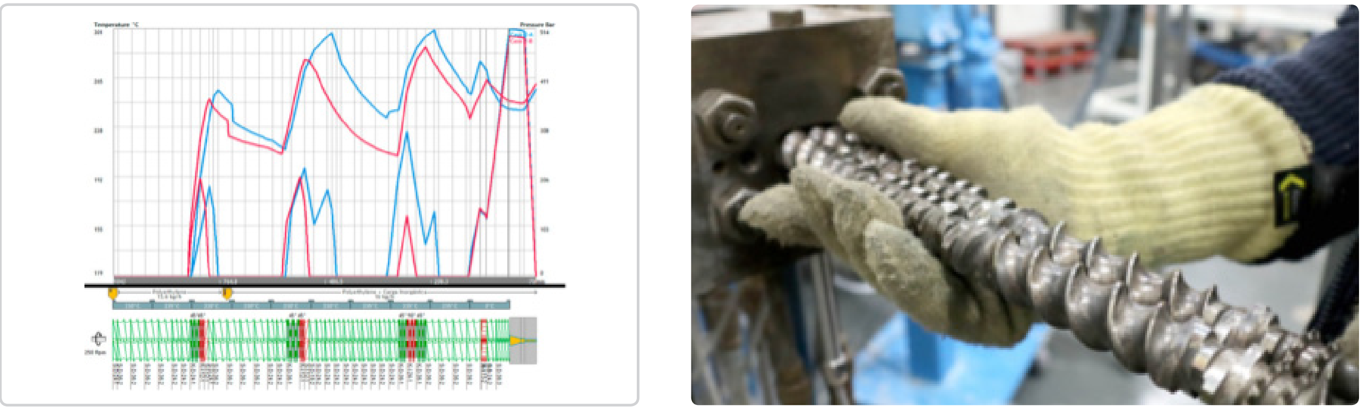


Figure 3: Simulation software & ad-hoc screw design.

Figure 4. Leistritz ZSE 27MAXX compounding line.

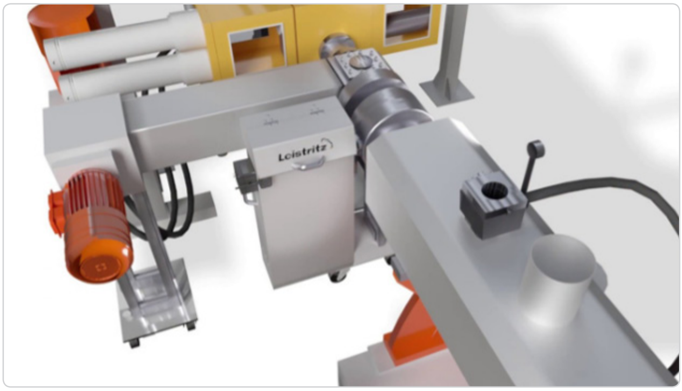


Figure 5. In line rheometer.

BIONANOPRODUCTS

RIGID AND FLEXIBLE PACKAGING

Written by José Alonso, ITENE
(Pilot Plant 9 Leader)

There is a trend in finding sustainable solutions in the packaging industry to change towards a circular economy by 2030. Nanocomposites offer an interesting approach since they can offer the required functionalities, these are mechanical, thermal and barrier properties, while at the same time reducing material consumption. Additionally, they can be used as a replacement for multilayered structures and thus enhance the recycling efficiency of the packaging. However, there is still some challenges that face these materials to become an alternative to traditional packaging materials.
Pilot plant 9 aims to convert bionanocomposites into rigid and flexible products for packaging applications to evaluate the performance of nanofillers within the polymeric matrix. Both cast film extrusion and thermoforming will be used to obtain the aforementioned products.

However, there exist some challenges that need to be addressed for the successful transformation of bionanocomposites into flexible and rigid packaging. Dispersion is the main limiting factor when processing bionanocomposites to obtain its optimum properties. Furthermore, dispersion plays an important role in the thermoforming process since melt strength and rheology properties are in direct dependence of polymer microstructure.

To overcome these challenges, processing of films with different single screw configurations will be carried out and its performance is evaluated.
For the production of films, a Dr Collin co-extrusion line will be used. This co-extrusion line is based on three single screw extruders connected to a feedblock and a variab-

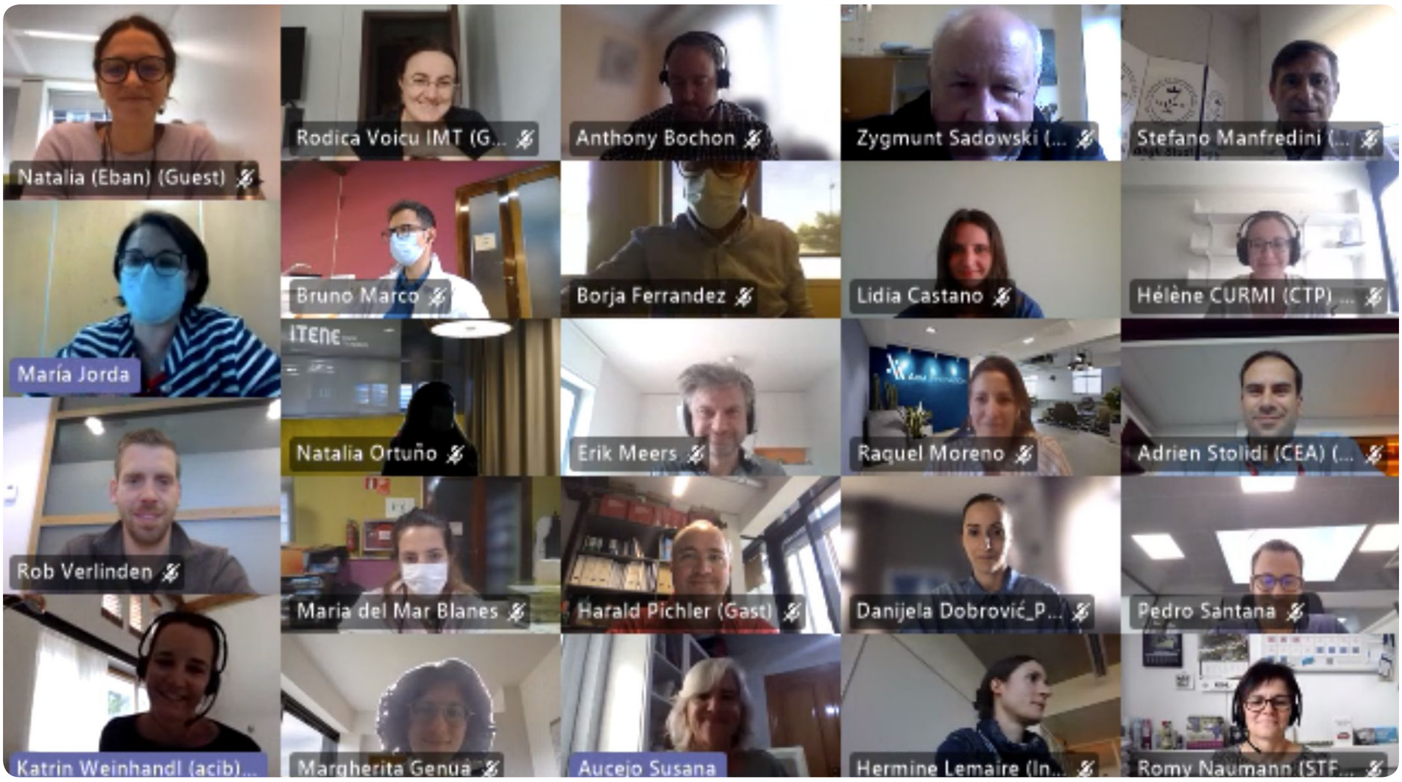
le thickness flexible lip die. The unit has a feed-block that can provide up to five layers (ABCBA), as well as different multilayer rearrangements (ABC, BCB, ACA), bilayer (AC, BC), or monolayer structures. The flat sheet die has 500 mm width, and a variable thickness from 0.3-0.9 mm. The line can work as well as lamination unit or extrusion coating, based on project requirements.

To gain insight into the thermoforming process when using bionanocomposites, formability will be evaluated through small moulds with increasing height and pattern deformation. In a further step, thickness distribution along the moulded shape will be determined by optical microscopy. These tasks will be aimed to develop and design a mould suitable for the specific properties of the bionanocomposites within the project.

These tasks will be carried out in a FORMECH HD 686 semiautomatic vacuum assisted thermoforming machine. This machine consists of a maximum workspace of 260x360 mm and it's operated pneumatically at 6 Bar. Both upwards and downwards movements of the plug and mould respectively can be speed and delay controlled. To prevent sagging of the thermoforming sheet an additional blowing step can be performed. Different moulds are available, and additionally design of specific moulds is available through 3D SLA printing.

Knowledge gained in the processing of bionanocomposites along with the expertise in the packaging field will provide ITENE the capability of developing specific solutions for the packaging industry, aimed to be more sustainable while improving their functionalities.

HIGHLIGHTS FROM THE FIRST 6 MONTHS



Bionanopolys met for the **first General Assembly meeting** on 21st and 22nd September 2021 and discussed early project outcomes and further strategies. Due to the ongoing pandemic, the meeting was held online again.

Together with the Bionanopolys sister projects from the same H2020 call, BIOMAC, BIOMAT and INN-PRESSME, we had an inspiring on-line workshop **Empowering SMEs to accelerate market access of nano-enabled biomaterials** on 20th October 2021, hosted by INN-PRESSME coordinator Ulla Forsström, VTT Finland.

The presentations and the recording of the workshop are available here.

UPCOMING EVENTS

OITB Clustering event in SEP business model and legal structure organized by INNPRESS-ME

13TH DECEMBER 2021

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