Bionanopolys

HIGHLIGHTS NO. 3

WELCOME

to the third 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.

CONTENT

BRINGING TOGETHER THE BIONANOPOLYS COMMUNITY

AN INTERIM STATUS FROM OUR NATIONAL STAKEHOLDER EVENTS

The consortium of the Bionanopolys network counts 27 partners from 12 countries all over Europe. This is huge, but the network attached to this group is even bigger.
Who are the main players that are interested in developing nano-enabled bio-based materials? To find out, the Bionanopolys team held national stakeholder events in recent months. Most were held online, some were hybrid, and some were held as a side event of a larger congress. What they all had in common, however, was to give potential stakeholders an overview of what the Bionanopolys Open Innovation Test-Bed (OITB) has to offer and what specific role their own country plays in it.

Bionanopolys is developing a comprehensive service portfolio with 14 different pilot plants and transversal services that will support the development of bio-based nanomaterials in a most efficient way. The aim is to manufacture innovative bionanocomposites from sustainably sourced feedstocks in Europe as well as products for packaging, textile, agriculture, cosmetics, pharma or food.
As soon as these pilot plants and services are ready to be offered by a Single Entry Point (SEP) for users, an open call will kick off the open innovation procedure of Bionanopolys. The timeline of the open call and the objectives of the Bionanopolys SEP have been one of the central topics of each national event.

Some events also involved invited guest speakers who could bring an interesting aspect as external experts in the field. For example, in Austria an expert in biorefineries (Dr. Hedda Weber) was invited, and Prof. Stefan Spirk from TU Graz and start-up founder of the company ecolyte reported on different application areas of nanocellulose. The team of Croatia, who opened the national event series, did a joint event with another OITB project on the same field: representatives from BIOMAC, such as the University of Thessaloniki or the organization Miscanthus d.o.o. presented their views.
Romania focused a lot on the special services that are provided by IMT Bucharest. At the Spanish stakeholder event, the scenarios and business opportunities in the use of bio-based nanomaterials for various sectors were highlighted.
By beginning of June (editorial deadline of the newsletter), seven events had already been completed, generating a total of around 350 participants.

Thanks for joining us!

YOU HAVE MISSED IT?

GET ACCESS TO THE SLIDES ABOUT BIONANOPOLYS IN GENERAL AND THE OPEN CALL THAT HAVE BEEN PRESENTED AT ALL EVENTS.

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

BIOMASS

ENZYMATIC BIO-SYNTHESIS OF METALLIC

Written by Zygmunt Sadowski
(Wroclaw University of Science and Technology)

Two decades of experience with synthesis of metallic nanoparticles have shown that the green synthesis approach is an optimal method of metal nanoparticles preparation. The application of nontoxic reducing and stabilizing reagent causes that this method is environmentally friendly. This method fits perfectly into the area of so-called biological synthesis of nanomaterials. Microbial flora is the main source of reagents needed for metal nanoparticles fabrication. Of this group of reagents, enzymes are the most important. Enzymes can be produced by bacteria, viruses, fungi, yeasts, algae, and protozoa [1,2]. The site of nanoparticles formation can be outside or inside the cell, therefore intracellular and extracellular methods can be distinguished respectively.

The site of synthesis is decided by the characteristics of the cell. For example, *Lactobacillus* A09 cell has anionic groups on the cell surface that adsorb Ag+ cations [3,4]. The conversion of surface alcohol groups to aldehyde groups releases electrons that reduce silver ions to elemental Ag0. The cells of *Streptomyces sp.* and *Bacillus licheniformis* show a higher affinity for $AgNO_3$, which results in the migration of these ions (Ag+ and NO_3-) into the cell interior[5]. The intracellular enzyme nitrate reductase is responsible for the reduction of the NO_3- ions and the formation of electrons that reduce the silver ions to elemental Ag0.

An extension of extracellular synthesis are methods using culture supernatant and cell-free extract for nanoparticle synthesis. The supernatant after 12 or 48 hours of bacteria culture is rich in organic compounds produced by the bacteria, which are ideal for the reduction of Ag+ ions. To avoid the need to detach the nanoparticles from the surface of the biomass, an extraction method can be used [6]. In this method the reducing substances (enzymes) are extracted from the biomass and extract is combined with a metal ion solution.

Fungi possess a wide range of enzymes and are therefore suitable materials for the synthesis of metal nanoparticles. It is estimated that the total number of reagents produced by fungi is 6,400 [7,8]. Similarly to bacteria, fungi biosynthesize metal nanoparticles by intra- or extracellular method. One of the most commonly used fungi for the synthesis of metal nanoparticles is *Aspergillus funigatus* [9]. In the synthesis carried out by the extracellular method silver nanoparticles with size range of 5 – 25 nm are obtained. The aqueous extract of *Penicillium sp.* and *Aspergillus niger* fungus biomass was used by Sadowski and co-workers to synthesise AgNPs [10,11]. Among the fungi used in the synthesis of metal nanoparticles *Fusarium spp.* plays a particularly important role [13]. Fungi in this group produce enzymes that can effectively replace chemical reagents in industrial processes such as the textile, leather and paper industries. In addition, the extracellular production of enzymes, makes it common for these fungi to be used for the fabrication of nanoparticles.

The mechanism of nanoparticles synthesis by *Fusarium* is similar to that proposed for bacteria. The enzyme nitrate reductase secreted by the fungus *Fusarium oxysporum* is responsible for the reduction of silver ions. *Fusarium oxysporum* fungi are able to synthesize gold nanoparticles in a simple way by contacting the fungal biomass with AuCl4- ions [13]. After contact for 72 hours the UV-vis spectrum of the supernatant showed a peak at 545 nm which clearly indicates the presence of gold nanoparticles.

The alkali-tolerant fungi of the genus *Trichothecium* can produce AuNPs both intra- and extracellularly [14]. The


PICTURE: SHUTTERSTOCK

biosynthesis of nanoparticles inside a fungal cell is called mycosynthesis and consists of two steps. In the first step, attraction of metal ion to the cell wall occurs due to the attraction between lysine residues and metal ions. In the second step, enzymatic reduction of the metal ion occurs and the nanoparticle is formed. Electron microscopy studies have shown that AgNPs form at the cell wall surface as a results of enzymatic reduction. Lactobacillus isolates have the ability for production of nitrate reductase NR [2,15]. Bioreduction of metal ions is initiated via the secretion of NADH and NADPH-dependent reductase NR. The enzyme reduced nitrate into nitrite during dissimilatory nitrification and the electron is released. These released electrons are used for ions reduction according to the reaction:

$$Au^{3+} + 3e^{-} = Au^{0}$$
$$Ag^{+} + e^{-} = Ag^{0}$$

Another group of microorganisms with great potential in the biosynthesis of metal nanoparticles are algae. All algae are broadly classified into two types microalgae and microalgae. Most synthesis of metal nanoparticles have been performed using microalgae. There are two major technique use for nanoparticles synthesis using algae. Direct extraction of living algae for biosynthesis of nanoparticles or lysis of algae cell and extraction of enzymes. Subsequently, fabrication of nanoparticles using the obtained extract with enzymes. Undoubtedly, marine algae can be a cheap source of biomass. One example is the *Gracilaria parvispora* algae collected from shallow waters (0.2-2.5 m) on the Red Sea coast [16]. An aqueous extract of dried algae was used as a solution to reduction silver ions. The silver nanoparticles obtained were spherical in shape and had dimensions in the range of 12-30nm.

A full understanding of the biosynthesis processes of metal nanoparticles will allow better control of quality of the resulting product. It will become possible to bio-fabricate products of a given shape and specific dimension. Taking into account that the biomass necessary for the synthesis is cheap, we can expect rapid development of this bionanotechnology.

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BIONANOCOMPOSITES

CHARACTERIZATION, PROCESS MONITORING AND MODELLING ACTIVITIES

Written by Hermine Lemaire (CEA)

Several partners of Bionanopolys joined the project to bundle expertises on all important aspects about the develeopment of bio-based nanomaterials. Technical support activities will allow to improve the production processes of the pilot lines. Characterization and monitoring actions all along the production chain are key elements in new developments and different technologies were evaluated and proposed for primary, intermediate and final materials and products. In parallel, modelling physical processes through advanced simulation tools will provide valuable insight to the physical properties of new materials and on the predicted behaviour of nanocomposite based products. Let's have a short look on these supportive services:

INNOVATIVE METHODS FOR THIN LAYERS MEASUREMENTS AND HOMOGENEITY ASSESSMENT

The proposed characterization actions aim to cover areas of measurements which are not readily available to the pilot lines through commercial products. CEA (France) works into extending the capacities and the performance of Energy Dispersive X-ray Fluorescence (EDXRF) techniques applied to inspection and monitoring new materials or coatings. The homogeneity of non-transparent or opaque materials or coating layers will be measured using a specially designed prototype device. Homogeneity and other characteristics such as fibre orientation or porosity analysis, at micron and sub-micron scale, will also be evaluated by using phase contrast techniques on an adapted laboratory bench, well suited to low absorption materials.

MATHEMATICAL & PHYSICAL MODELLING

Technical support activities also benefit from IMT (Romania) expertise, particularly in terms of mathematical modelling at micro and nanoscale, and analysis of material properties by analytical and hybrid models. The industrial users of the OITB will be able to benefit from IMT technical services for example for predicting effective properties from microstructure (replacing some costly experiments with numerical predictions), or for on-line monitoring (obtaining 2D or 3D images of the microstructure) to predict on the fly the influence of process variations on effective properties. A tool will be offered for end users, based on models for optimization of composites formulation and of some processing parameters, on methodologies for nanocomposites virtual characterization, and on a neural network able to predict directly the properties of nanocomposites from their constituents. The type of materials suitable for applying this tool are composites, fibres, coatings, foams and fluidic. The tool will provide valuable aid in the optimization of product formulations, in order to improve functionalities and performances of bionanocomposite materials for packaging, textile and nonwovens, agriculture, cosmetics, medicine, pharma or food applications.

RAPID PROTOTYPING

Technical support activities carried out by CIDAUT (Spain) aim at providing a predictive performance modelling of 3D printed parts by FDM (Fused Deposition Modelling) or similar additive manufacturing technologies employing bionanocomposites or polymers with any reinforcements. A characterization study is being performed on test samples, printed in three different orientations (flat, on-edge and upright) and in some cases, taking into account the influence of the strain rate, in order to consider the materials performance related with each building orientation. Material models are created by means of the proper management of the data obtained from the characterization tests campaign on printed specimens. The final objective of CIDAUT will be to provide material cards in accordance with the software used by potential stakeholders, as well as to propose and implement mechanical and thermal performance simulations.

BIONANOPRODUCTS

FOAM APPLICATIONS

Written by Victoria Bernardo
(Cellmat Technologies, pilot plant 13 leader)

This pilot plant offers services for the production and characterization of foamed prototypes. The pilot plant is divided into two main technologies:

- **EXTRUSION FOAMING**
- **BEAD FOAMING**

Each line is devoted to a specific type of foam. Extrusion foaming is mostly used for the production of continuous foamed parts, either with high density (weight reduction applications) or low-density (insulation, packaging or impact protection applications, among others). Bead foaming consists of the foaming of small beads that are later molded together to get rise to a 3D part.
This technology is used to produce low-density foams with complex shapes thanks to the versatility of the small expanded beads. Both pilot lines are fully equipped to monitor the process during the fabrication of the prototypes. CellMat Technologies offers to its partners the opportunity to produce foamed prototypes at small scale with small material cost in these two pilot lines that allow reproducing the results obtained in industrial facilities. Besides the fabrication facilities, CellMat Technologies provides its wide experience in the foam industry to help in the design of formulations suitable for foaming applications. In addition, CellMat Technologies supports with complete characterization services to characterize the prototypes, both at the microscopic level (cellular structure) and at macroscopic scale (mechanical properties, acoustic absorption, thermal conductivity, etc.)

RAW MATERIALS & EXPECTED PRODUCTS

Our lines are prepared to work with any type of polymer or polymer additive. Bio-based and bio-degradable polymers have been tested successfully. All types of additives can be used to reinforce the properties of the material or add an extra functionality to the foamed prototype. They can work with a wide range of blowing agents, both chemical and physical, and even combinations.

CHALLENGES THAT WE MEET

Current regulations are being more and more demanding about the reduction in polymer consumption. The use of foaming technologies to reduce weight is a green and sustainable approach to fabricate plastic parts with lower quantity of raw materials, saving money and reducing the carbon footprint of the product. In addition, already existing low-density foamed products are mostly produced from fossil-based polymers. The foaming pilot plants in our facilities are equipped to test formulations based on bio-composites, which may partly or totally replace traditional polymers in foamed products. Testing formulations using large industrial equipment is often expensive and time consuming. Our pilot plants offer the possibility of testing several bio formulations at a more affordable cost and using less time.

INDUSTRIAL SECTOR THAT WE ADDRESS

Regarding applications, foamed goods are found in almost every industrial sector, from leisure, packaging, and sports to construction and automotive. For these reasons there is a growing interest in this type of materials. Companies producing foams in these sectors can use our foaming facilities to test new formulations, which will speed up the development process and the time to reach the market.

COATING APPLICATIONS

Written by Sara Fernandes
(CENTI, pilot plant 14 leader)

The application of coatings with functional nanoadditives by different coating methods and on different type of substrates is an excellent approach to obtain added-value products through the improvement of properties such as barrier, optical, mechanical, antimicrobial, water repellency, among others. PP 14 includes several coating technologies, such as flexure and gravure coating, roll-to-roll spray- and slot-die coating, electrospraying coating, and spray-coating for 3D objects, that are accessible for studies and developments on the improvement of textile, polymer or paper based substrates or objects through the application of functional coatings.

HIGHLIGHTS FROM THE FIRST 6 MONTHS

AT THE BEGINNING OF THIS YEAR, BIONANOPOLYS HAD ITS FIRST ANNIVERSARY!

Time flies and we are eager to develop a Single Entry Point for our customers to ensure an efficient use of the Bionanopolys service portfolio. Raquel Moreno from AXIA Innovations has summarized, what the Bionanopolys SEP has to offer.

Upgrading of pilot lines for nano-additives and raw materials extraction

Upgrading of pilot lines for the production of bionanoproducts

PICTURE: ITENE

PICTURE: ITENE

FIRST & SECOND LEGAL WORKSHOPS

To bring our SEP into reality, the first and second legal workshops were held as hybrid meetings in Valencia. Most representatives of the core partners participated in the workshops that were organized by AXIA Innovation and G&S, and hosted by ITENE. The group discussed how to realize a sustainable Bionanopolys ecosystem and focused on the establishment of the legal entity supporting the SEP as a unique entrance for potential customers to the services of Bionanopolys OITB.

SECOND EXECUTIVE BOARD MEETING

In March, the second Executive Board Meeting took place and with a heavy heart we had to say “Good-Bye” to our coordinator from ITENE, Maria Jorda. We thank you again for a successful project start and wish you all the best for your new position! The coordination is taken over by Carmen Sanchez. A warm welcome to the team!

PICTURES BY ITENE

UPCOMING EVENTS

TechTex 2022

STFI represents Bionanopolys at the Technical Textiles Fair

from 21st to 24th June 2022, Frankfurt / Germany

IndTech 2022

Bionanopolys will be part of the OITB village, represented by ITENE, AXIA and G&S

from 27th to 30th June 2022, Grenoble / France

First Review Meeting

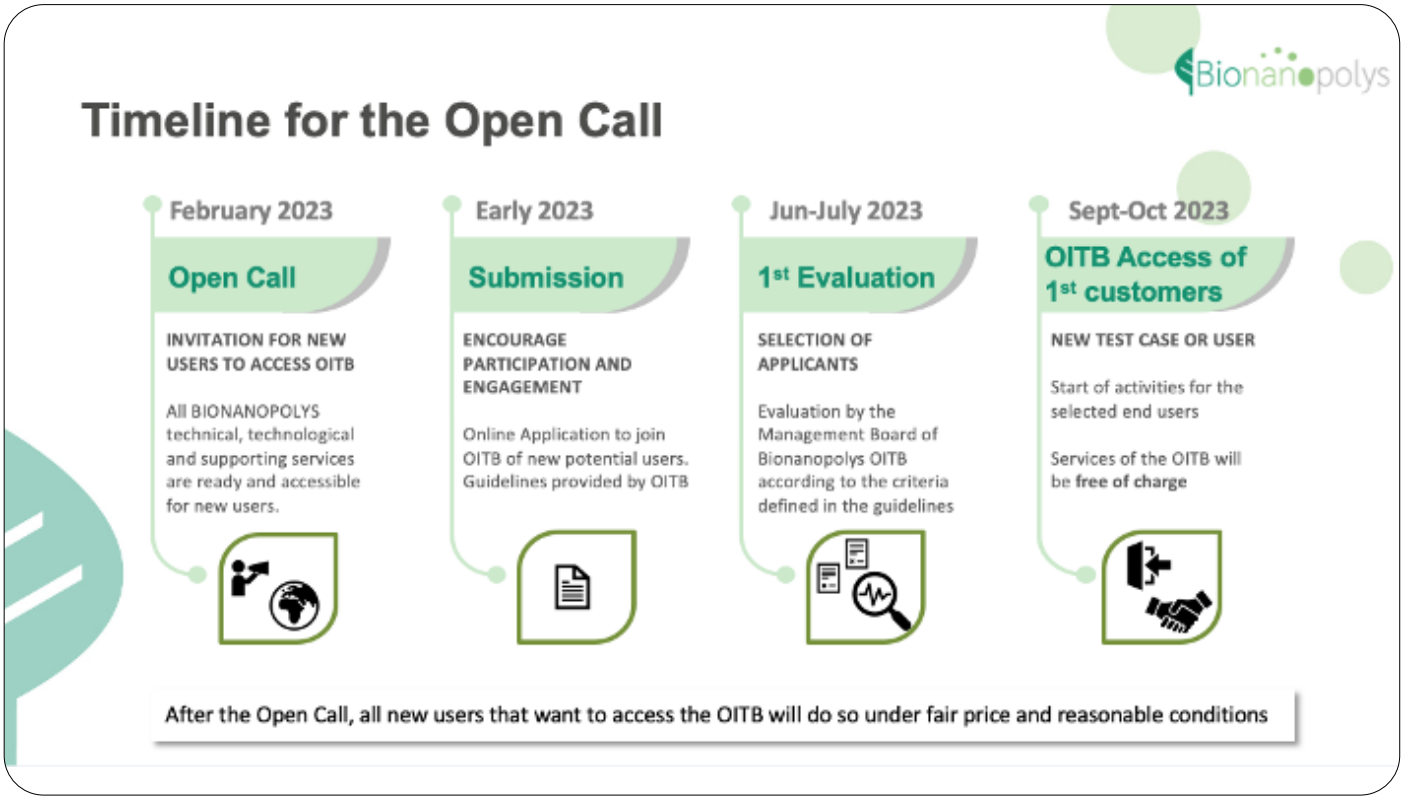
September 2022, virtual

ESIB 2022

Exhibition booth and partnering, organized by acib

14th to 16th November 2022, Graz, Austria

OPEN CALL SCHEDULE



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