OPTINANOPRO

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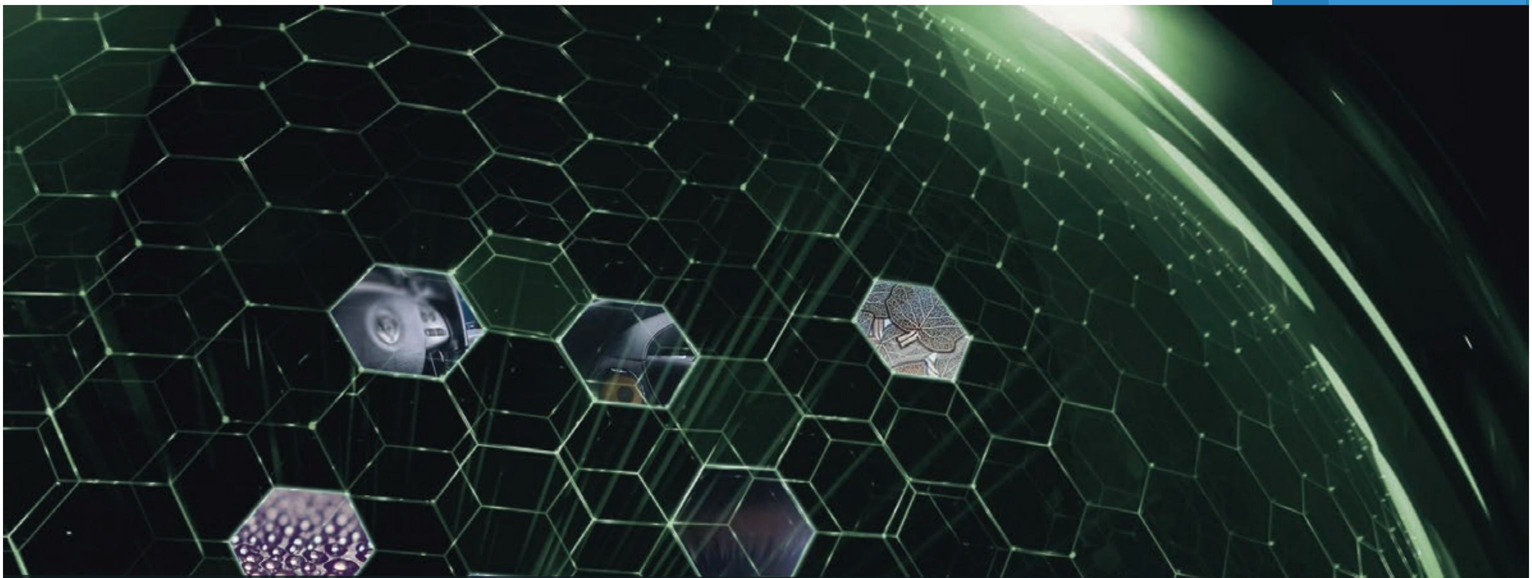

Processing and control of novel nanomaterials in packaging, automotive and solar panel processing lines

Content

THE RESEARCH PROJECT RECEIVES FUNDING FROM THE EUROPEAN COMMUNITY'S FRAMEWORK PROGRAMME FOR RESEARCH AND INNOVATION HORIZON 2020 (2014-2020) UNDER GRANT AGREEMENT NUMBER **686116**

Newsletter edited by **IRIS**

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Editorial

The OptiNanoPro project is evaluating a variety of approaches for introducing nanotechnology into production lines in the packaging, automotive and solar energy sectors. The project will focus on the development and industrial integration of customized dispersion and monitoring systems for ensuring constant material quality.

In the packaging industry, nanomaterials are able to improve the barrier properties and modify surfaces such that food residues are "repelled", so allowing the complete emptying of packaging. The surfaces of solar modules can be afforded with self-cleaning properties due to the use of nanotechnology and also protection against UV radiation. In the automotive industry the weight of chassis elements can be reduced by using nanocomposites, resulting in a lowered fuel consumption and thus improving the CO2-Footprint.

15 partners from European industries and R&D organisations collaborate in the OptiNanoPro project covering the full supply and value chains allowing nano-enabled innovations to reach the three target industries.

We have just reached one year in our journey and excited to present some of our key technologies and initial results in this first issue of project newsletter.

Dr. Elodie Bugnicourt, Project Coordinator

Development of Electrospray solutions for tailored surface properties

Nanocomposites have special physical and chemical properties and an array of potential applications, in particular they can be used to adapt surface properties and introduce additional functionalities such as antimicrobial properties, UV radiation filtering and hydrophobicity. Nano-enhanced coating can be applied by Electrospinning, a phenomenon that occurs when an appropriate electric field is applied to a conductive solution. This solution is usually injected through a capillary tube. The semispherical meniscus of liquid anchored at the end of the tube takes the shape of a cone, so-called Taylor cone. This cone breaks into a jet at its apex (Fig. 1) that can generates a fiber or atomised particles after solvent evaporation. This electro-hydrodynamic-based technique is capable of depositing nanoparticles dispersions as well as generating controlled fibers with diameters well below the micron.

Solutions must be tuned in order to generate fibers or droplets; for example, high viscosity solutions are necessary in order to generate fibers. Other properties like the electrical conductivity of the solution, surface tension or polarity of the solvent or mixture of solvents used must be adapted to the specific material to be deposited. Among the many applications found for electrospray/electrospinning, coating of surfaces is one of them with great interest to the materials science community that will be tackled in OptiNanoPro. Fig. 2. shows a droplet of water deposited on a hydrophobic SiO2 nanoparticles-coated surface fabricated using this technique.

The low typical throughput of a single Taylor cone demands the use multi-cone sources for industrial applications. Although multi-jet electrospinning has been demonstrated to be a better approach to enhance electrospinning productivity rather than substantially increasing the throughput of a single spinneret, this technology is a more complex process than the single-jet. The company Bioinicia S.L., Spain (www.bioinicia.com), through

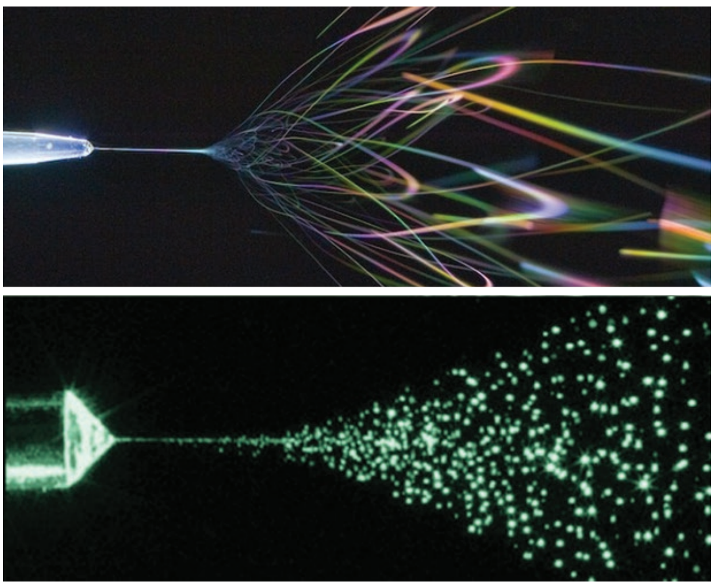

Fig.:1 electro-hydrodynamic-based technique generating nanofibers (electrospinning) and nanodroplets (electrospray)

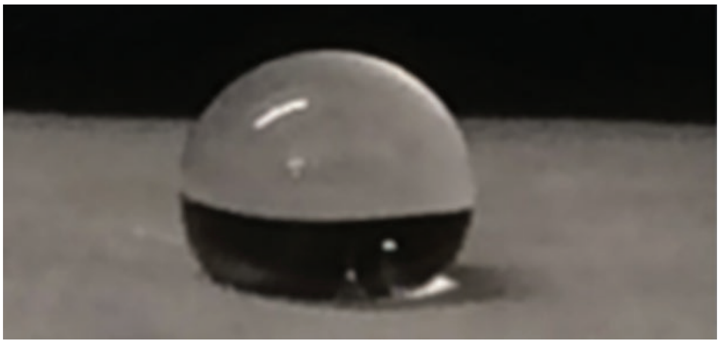

Fig. 2. First hydrophobic surfaces from OptiNanoPro

their engineering division Fluidnatek® has optimized and launched since 2012 a range of high throughput multi-nozzle equipment for pilot plant and manufacturing purposes, called LE-500 and LE-1000, respectively. These tools, that come with climate control, e.g. temperature and %RH control, are designed to, for instance, meet the existing stringent legislation criteria in the bio space and to provide complete flexibility for the manufacturing of electrospun/electrosprayed products. The equipment was designed to be integrated in industrial production lines that involve roll-to-roll collection or any other type of collection, pre or post-processing steps.

In OptiNanoPro, the application of nanocoating by electrospray will be used to obtain surfaces with tailored repellence to selected liquids (fig. 3). In case of OPV surfaces, hydrophobicity will allow the panels to self clean from dirty rain, whereas the same effect will allow facilitating the emptying and therefore reduced leftover at end of life in case of polar liquids/pastes being packed (eg. oil in water emulsions for cosmetic). Likewise for content of different polarities, amphiphobicity or lipophobicity will be sought.

Figure 3: Ketchup residues in a conventional bottle (left) and in a bottle with a nanocoating (right) [1]

One important task within the OptiNanoPro Project includes further development of wet chemical coating processes for packaging films to enable successful application of coatings containing dispersed nanoparticles. The aim is to reduce the permeability of the films via the incorporation of nanoparticles.

Indeed, in prior research efforts, Wheylayer® whey-protein based coatings were developed achieving far superior barrier properties compared to other bioplastics (fig. 4) and were found suitable to substitute other synthetic barrier layers, such as EVOH, while providing recyclability to multilayer films.

On the other hand, the use of nanoparticles presents potential for resource optimization while providing similar barrier with lower thickness and therefore improve the cost effectiveness of the developed bio-coating.

It is well known that for the packaging application the barrier improvements provided by nanocomposites depend on a so-called tortuosity effect, where the nanofillers increase the gas diffusion pathway (fig. 5). Other effects, like the selective adsorption of gas molecules on the particles of a high specific surface area, are also involved. Nanoplatelets composed of clays or other silicate materials are the most studied for this application, as is the case in OptiNanoPro. The platelets have a thickness in the nanometre range, lateral dimensions from tens of nanometres up to several microns, surface areas above 750 m2/g and an aspect ratio in the range of 100–500.

Promising initial project results at FRAUNHOFER disclose the ability to improve the coating barrier properties by a factor 2 in optimized conditions. Further work will deal with the transfer of the results to the industry as the nanoparticles affect the processability of the coating and its drying, as is currently being simulated.

The extrusion compounding is an other important polymer processing techniques to develop a new nanocomposites. The main function of the process is mixing the polymeric matrix with the filler and dispersing it to achieve a good homogeneity in the final compound. The polymer nanocomposites are promising for multifunctional materials in many industrial fields such as aerospace, automobile, and electronic packaging device

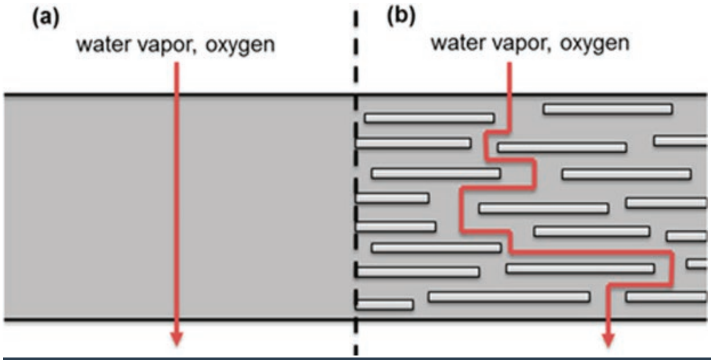

Fig. 5. Illustration of the “tortuous pathway” created by the incorporation of exfoliated nanoplatelets into a polymer matrix film. [2]

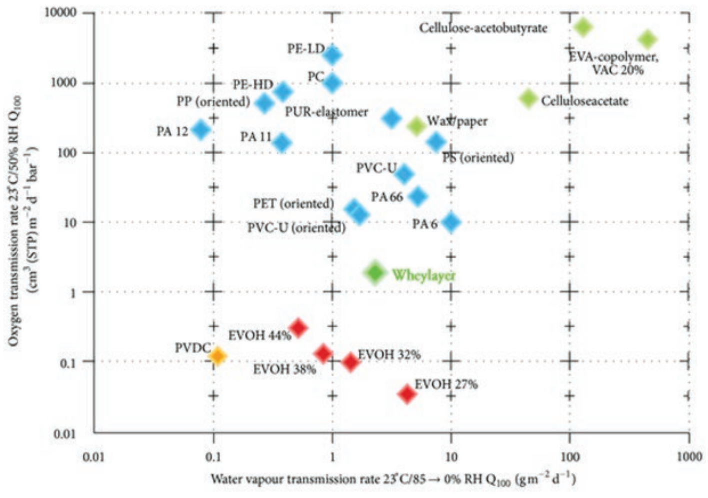

Fig. 4: Barrier properties of whey-based layer versus other plastics commonly used in the packaging industry (all normalized to 100 m) [2]

systems. Depending of the final application, the strategy is adding appropriate nanoparticle to a polymer matrix to enhance its performance and achieve the target properties.

Nanofillers can significantly improve or adjust most of the different properties of the polymer base materials in which they are incorporated, sometimes also in synergy with conventional fillers and/or additives.

The nanocomposites have different advantages compared to conventional composites, such as a light weight or the surface finish. As the nanoparticle size decreases for a given volume fraction, the effect of the nano-reinforcement of the phase is exhibited more remarkably. Properties like Young’s moduli, thermal expansion coefficient, thermal conductivity or electrical conductivity are enhanced with nanoparticles, seeing the improvement decreasing the particle size.

An important aspect of the process is the dispersion of the nanoparticles within the polymeric matrix. To enhance the dispersion of the particles, a good design of the equipment and the screw’s configuration are vital, and results in improved properties of the material.

In order to enhance the dispersion of the nanoparticles, EURECAT is carrying out an optimization of an ultrasound system to be coupled in an extruder. The ultrasounds may assist in better filler dispersion, when is applied on the melt polymer, decreases the viscosity and the die pressure, thus affecting the final material behavior. In different cases (e.g. nanoclays) the ultrasounds are used to improve the degree of dispersion of the particles. Ultrasound helps in rapid intercalation and partial exfoliation of nanoclay in a polymer matrix. In this sense, this technology is developed studying the range of energy needed to apply in order to decrease the viscosity of the polymer and enhance the dispersion of the nanoparticles. With this technology, further dispersion of the filler and the homogenity of the final compound could be achieved.

The end users point of view

Expectations from the cosmetic sectors

Recently cosmetic products are more and more exposed to customers' expectations to follow increasing trends in ecological awareness. Packaging represents important part of cosmetic product and its composition plays essential role both for recycling and emptying ability. Especially viscous to high viscous products packed in tubes cause a lot of waste at the end of use. The cosmetic industry intends to contribute to the lower quantity of waste for example, as in OptiNanoPro, improving the emptying behavior of the tubes.

For the cosmetic industry, the costs that have to be paid for waste management are obviously also important. We expect to significantly decrease these costs due to usage of materials repellent towards the product allowing this new functionality. At the same time also the customer would benefit as he would get more product out of the packaging what would save his money.

Furthermore, in OptiNanoPro, bio-based (and optionally biodegradable) jars as well as barrier tubes will also be developed meeting the demand of the consumers for more sustainable materials.

Zdenka Koren, Ilirija

Expectations from the OPV sector

The consortium believes that nanotechnology could be key for the future of OPV. Indeed, typical fouling (dust, dirt, rain, etc.) that can lead to significant losses of energy harvesting efficiency in classical PV and requires frequent maintenance (which can be every few months in dusty areas) is supposed to have also a negative impact on new PV technologies. Multifunctionality of the encapsulating materials for OPV is another challenge that OPTINANOPRO is working on to improve the stability of the materials used as substrate for OPV with regard to UV light and weathering. Inorganic nanodeposits are well known to filter UV-light while being transparent in the visible range of the spectra. As such OptiNanoPro nanocoatings could increase the effectiveness of solar panels by a self-cleaning effect and extend the periods between maintenance, while also increasing the durability of their materials.

Pavel Schilinsky, Opvius GmbH (ex BELECTRIC).

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OptiNanoPro at Nanotec 2016

On 26th & 27th of September, the NANOTEC 2016 Conference took place in Valencia (Spain). The Conference was addressed to the main researchers and industries in the field of Nanotechnology focusing Pharma, Food, Packaging, Agriculture, Biomedical applications, Structural reinforcement, processing and characterisation. The Conference was attended by 130 participants and speakers of the different fields coming from 28 countries. Taking advantage of this event OptiNanoPro Consortium presented a poster and leaflets explaining the project objectives and expected results. The OptiNanoPro project was represented by several projects partners including Bioinicia, Fraunhofer-IVV and EURECAT.

Partners

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