



**DELIVERABLE D.T1.1.7 “REVIEW OF ACTIONS ON SUSTAINABLE MATERIALS AND PACKAGING AND OTHER RELEVANT TOPICS”**

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## FOREWORD

The environmental, social and economic challenges are the main focus for a sustainability transition towards a bio-based circular economy. Conventional plastic packaging, non-biodegradable, non-renewable, poorly recyclable causes extensive accumulation in the environment endangering complete ecosystems. The urgency of the problem asks for viable alternatives to address this global challenge and to satisfy the needs of consumers, retailers and brand owners for sustainable packaging solutions.

In this review the most relevant past/ongoing actions on project-related topics are identified in order to obtain information on best practices, outputs, strategies to explore future potential synergies with ongoing projects. Project activities were categorised by major topics and short summary is provided for each of them. Furthermore, some of the main focus raised by project activities are pointed out both for research and innovation and policies under development.

## PROJECTS ACTIVITIES IDENTIFIED AS RELEVANT

### POLICIES FOR ENVIRONMENTAL SOCIAL AND ECONOMIC CHALLENGES / NETWORKING / CLUSTERING.

#### **STAR-ProBio**

##### **Sustainability Transition Assessment and Research of Bio-based Products**

Horizon 2020, from 2017-05-01 to 2020-04-30. University of Rome Unitelma Sapienza (Italy).

STAR-ProBio constitutes a multidisciplinary and multi-actor collaborative project that will meet environmental, social and economic challenges, paving the way for a much-needed sustainability transition towards a bio-based economy. The overall objective of the project is to promote a more efficient and harmonized policy regulation framework, needed to promote the market-pull of bio-based products. This will be achieved by developing a fit-for-purpose sustainability scheme, including standards, labels and certifications for bio-based products. Hence, STAR-ProBio will integrate scientific and engineering approaches with social sciences and humanities-based approaches in order to formulate guidelines for a common framework promoting the development of regulations and standards to support the adoption of business innovation models in the bio-based products sector.

#### **InnProBio. Forum for Bio-Based Innovation in Public Procurement.**

H2020. 2015-2018. Agency of Renewable Resources (Germany).

Aimed to develop a community of public procurement practitioners interested in innovative bio-based products and services. By harnessing the potential of public procurement to foster innovation, InnProBio aimed to work with the public sector to develop tools for purchasers, facilitate the creation of buyers groups, and increase awareness and incentives in order to lower the barriers to purchasing, thus leading to the opening of new markets of bio-based products in Europe.

#### **NEW InnoNet. The Near-zero European Waste Innovation Network.**

Horizon 2020. 2015-2017. PNO Consultants PV (Netherlands).

Main objective of this project is to mobilise stakeholders towards building a circular economy by developing and reinforcing solid foundations for building the European Near-Zero Waste Platform through: 1. Set-up and maintain near zero waste stakeholder platform, 2. Analyse selected waste streams and develop innovation roadmaps per waste stream, 3. Develop an integrated near zero waste strategic research and innovation agenda, 4. Stakeholder mobilisation and interaction.

#### **OpenAIRE - CONNECTING scientific results in support of Open Science**

Horizon 2020, ongoing project, from 2017-01-01 to 2019-06-30

OpenAIRE-Connect aims to provide technological and social bridges, and deliver services enabling uniform exchange of research artefacts (literature, data, and methods), with semantic links between them, across research communities and content providers in scientific communication.

## **ACTTiVate PAn-European Clusters for Technology Transfer and new VALUE chains**

*Fundacja Partnerstwa Technologicznego Technology Partners*

The overall concept of the project consist of supporting innovation in SMEs and fostering the smart reindustrialization of Europe by enabling the emergence of new cross-border and cross-sectoral value chains resulting from the translation of advanced technologies among selected sectors. ACTTiVate will focus its effort in setting up strategies that allow clusters to lead the engagement of SMEs in activities intended to create new services and products and therefore the generation of new value chains and emerging industries across Europe.

## **BIOPEN**

*Horizon 2020, Bio Based Industries Funding scheme. Coordination and Support Action 2017-2019. CIAOTECH Srl- Rome-Italy.*

BIOPEN ambition is to become a single voice for the bio-based industries in Europe, gathering expertise and promoting engagement and involvement of industry, researchers and academia at European and national level, by setting up an Open-innovation platform addressing strategic cross-cutting challenges such as 1.clustering and networking to develop new value chains and favour the emergence of co-innovation partnerships across the value chains; 2. Stakeholders engagement and support with regards to setting-up at least 20 co-innovation partnerships alongside existing and new value chains; 3. creation of a knowledge centre collecting the prospective and insight of the community, and providing access to relevant information for markets and products innovations in the bio-based ecosystem.

## **INNOLABS**

INNObative LABS for leveraging cross capacity building between ICT, Health, BIO and Medicine sectors for new emerging industries in personalized health.

*Horizon 2020, from 2017-01-01 to 2019-06-30. Norway Health Tech (Norway)*

The INNOLABS project is cluster/network driven and grounded in the conviction that cluster organizations guarantee a better understanding of what kind of services and added value can be provide to their "clients". Its specific focus is on unlocking the cross-sectoral collaborative potential of SMEs in combining ICT with the BIO, Health and Medicine sectors representing an emerging but still under-utilised market, and applying such results to personalized health for elderly populations in both rural and urban areas.

**SUPERBIO** - SUpport and PartnERship for the development of multiple sustainable and market ready value chains in the BIObased economy

*Horizon 2020, ongoing project from 2016-06-01 to 2018-11-30. Politechnika Łódzka i Polska Platforma Technologiczna Biogospodarki*

SUPERBIO focuses on the biobased economy. This emerging economy relies on the use of biomass (e.g. plants, waste) as renewable raw material for the production of new or existing products. The technologies used are a combination of biochemistry, biotechnology, chemistry and processing technology. The project aims to provide comprehensive support for small and medium-sized enterprises operating in the bioeconomy area that want to establish cooperation with enterprises from various European countries through the creation of so-called value chain.

## **PLASTiCE**

**Innovative value chain development for sustainable plastics in Central Europe**

*Central Europe, project completed, 2014. National Institute of Chemistry (Slovenia)*

The main focus of PLASTiCE was to promote development and use of environmentally friendly and sustainable solutions in the packaging and end-user industries, particularly by use of biodegradable plastics. The project focused on identification and removal of barriers to the faster and more widespread use of sustainable types of plastics, particularly biodegradable plastics and plastics based on renewable resources, in Central Europe.

### **EcoPaperLoop Enhancing the quality of paper for recycling**

*Central Europe Project completed 2014. Innovhub SSI (Italy)*

The main goal was optimising paper products, packaging and collection systems.

Ecopaperloop created new knowledge and awareness on paper based products recyclability in the CE region; established new capabilities for the diffusion and application of paper recyclability assessment in the CE area; fosters innovation in the environmental sector through the adoption of better solutions for the recyclability of paper products; strengthens the territorial cohesion between lead knowledge providers and decision makers in the regions; increases the awareness of stakeholders and decision makers of the private and public sectors to extend product life cycle thinking thus contributing to a durable change towards more environmentally sound production processes and consumer behaviour.

### **COST Action FP1003 - Impact of renewable materials in packaging for sustainability - development of renewable fibre and bio-based materials for new packaging applications**

*Project completed, 2014*

Paper and board are made from renewable resources and are low carbon footprint materials, therefore giving them an environmental advantage compared to other materials. However, in packaging applications, paper and board are nearly always used in combination with non renewable materials; e.g. barrier materials derived from oil based plastics or aluminium. To give the forest industry a competitive edge this Action will focus on packaging solutions based entirely on renewable resources in order to remove the serious disadvantages associated with future paper and board packaging solutions that continue to rely on non renewable materials. [http://www.cost.eu/COST\\_Actions/fps/FP1003](http://www.cost.eu/COST_Actions/fps/FP1003)

### **MOVECO**

#### **Mobilising Institutional Learning for Better Exploitation of Research and Innovation for the Circular Economy**

*DTP, ongoing project from 2016-12-08 to 2019-05-31. Chamber of Commerce and Industry Slovenia (Slovenia).*

Partners included are promoting transitional cooperation to accelerate the transition to the circular economy. MOVECO project relates to a transition from a linear to a circular economy, aiming at manufacturing products, which, after their use phase, can be easily recycled or reused, which is achievable through intelligent product design and innovative business models. MOVECO responds to a challenge of The Circular Economy Strategy – “closing the loop” of product life cycles and sets its objective to improve the framework conditions and policy instruments for eco innovation and the transition to a circular economy, fostering smart and sustainable growth and reducing disparities among the regions in the Danube region.

<http://www.interreg-danube.eu/approved-projects/moveco>

### **DANUBIOVALNET**

#### **Cross-clustering partnership for boosting eco-innovation by developing a joint bio-based value-added network for the Danube Region**

*DTP, ongoing project from 2017-01-01 to 2019-06-30. BIOPRO Baden-Wurtemberg GmbH (Germany).*

The aim of this project is to develop new methods and tools to connect enterprises transnationally. One of the planned outputs of this project will be the development of a Joint Bio-based Industry Cluster Policy Strategy (JBICS). Furthermore a bundle of new methods and tools to support clusters for transnational working will be developed. They will be tested in three pilot actions where it is planned to create new bio-based value chains in the Danube region. The main target groups are on one hand the policy - four Ministries are involved-, on the other hand clusters and their SMEs - nine cluster organisations involved. The policy level will benefit from the JBICS which can be used as a political framework.

<http://www.interreg-danube.eu/approved-projects/danubiovalnet>

## **BIOECO-R.D.I.**

### **BIO-ECONomy Research Driven Innovation**

*Adriatic, ongoing project from 2018-01 to 2019-12. Regional agency for the Economic Development of Umbria (SVIL) (Italy).*

BIOECO-RDI aims at developing a Regional Innovation System for the Adriatic-Ionian area based on a structured bio-economy sector through the development of Research Driven Innovation (R.D.I.) strategy at regional and transnational level. Project main outputs are BIOECO-RDI regional and international strategies supporting regions in increasing bioeconomy RDI level and cluster maturity.

<http://cci.al/bioeco-r-d-i/?lang=en>

## **BioApp**

### **Transregional technological platform for transfer of advanced bio-polymers from lab to market**

*Interreg V-A Italy-Slovenia, ongoing project from 2017-01-10 to 2020-03-31. National Institute of Chemistry (Slovenia).*

The BioApp project will present a new strategic collaboration with a cooperative action of the complementary and interdisciplinary partners from neighboring regions, which will be reflected in a joint development of high added value products and services. The project is focused on the development of application of market-relevant highly innovative biopolymers.

<http://www.biopolife.com/the-company/bioapp-project-eu-interreg.html>

## **CelCycle**

### **Potential of biomass for development of advanced materials and bio-based products**

*EU - European regional development fund, ongoing project. Pulp and Paper Institute (Slovenia).*

Strategic direction of the programme is to exploit the potential of biomass for development of advanced materials and bio-based products, by creating new value chains for cascading utilisation of biomass. The programme is placed within priority area S4 (Slovenia's Smart Specialisation Strategy) - The natural and traditional resources for the future, Networks for the transition to the circular economy, and is co-financed by EU Structural Funds in Slovenia. It comprises all of the identified focus areas and technologies: technologies for development of new bio-based materials, technologies for utilisation of secondary raw materials, and technologies for reuse of waste and production of energy from alternative sources.

<http://celkrog.si/>

## **BIOPLASTICTRAIN**

*Ongoing project from 2016-11-01 to 2018-10-31. AITIIP Technology Center (Spain).*

Project will develop innovative e-learning training contents for plastic transformation technicians on the use of bioplastic and biopolymers. These training contents will be newly produced products based on the results of recently closed European research and development funded project results and lessons learnt. The project plan will include a very intensive dissemination and exploitation strategy.

<https://bioplastictrain.eu/>

## **Ceplafib**

### **Implementation of a new Circular Economy through the valorisation of postconsumer PLastic waste and reclaimed pulp FIBer**

*LIFE 2017, ongoing project from 2018-07 to 2021-06. TECOS (Slovenia).*

CEPLAFIB aims to design a new circular economy in which recycled plastic and waste newsprint paper will be reused and transformed into elements for the automotive industry, packaging and construction.

<https://www.tecos.si/index.php/sl/o-podjetju/novice/item/630-life-ceplafib-predelava-odpadne-plasticne-embalaze-in-casopisneqa-papirja-v-nove-kompozitne-materiale>

**NEWEX- Politechnika Lubelska.** The main research goal of the NEWEX Project is the construction and testing of the new innovative extruder. It will ensure manufacturing the products of improved properties and will enable processing materials that couldn't be processed so far, as well as food materials, cosmetic and pharmaceutical. <https://depot.ceon.pl/handle/123456789/12555>

#### **Deeply eutectic mixtures as new "green" plasticizers and starch solvents**

*Narodowe Centrum Nauki, SONATA 9. Project ongoing from 2016-02-24 to 2019-01-2019.*

*Zachodniopomorski Uniwersytet Technologiczny w Szczecinie; Wydział Technologii i Inżynierii Chemicznej*

Research on the properties of plasticizing starch, and its biocomposites. The research can contribute to the development of so-called green chemistry (biodegradable, environmentally friendly materials, obtained from renewable raw materials, green solvents).

<https://projekty.ncn.gov.pl/index.php?s=10198>

#### **The influence of ionizing radiation on copolymers**

*Narodowe Centrum Nauki, PRELUDIUM 5. Project completed 2016-02-27.*

Research of the influence of ionizing radiation on copolymers composed of mimes of trimethylene and lactic carbonate, PTMC-co-PLA, important from the point of view of the possibility of future application of radiation technology to modify the properties and sterilization of biomaterials made of these copolymers.

<https://projekty.ncn.gov.pl/index.php?s=1038>

#### **Comprehensive studies of (bio) degradation of composites of selected biodegradable polymers with natural fillers and bacteriocins**

*Narodowe Centrum Nauki, Sonata 11,*

*Project ongoing from 2017-01-13 to 2020-01-12*

*Centrum Materiałów Polimerowych i Węglowych Polskiej Akademii Nauk*

Determination of the influence of the content and type of natural fillers and bacteriocins on the (bio) degradation process in the laboratory conditions and industrial composting of selected composites, in which the matrix is biodegradable polymers.

<https://projekty.ncn.gov.pl/index.php?s=12453>

#### **Natural anti-aging compounds of biodegradable polymers**

*Narodowe Centrum Nauki, SONATA 9,*

*Project ongoing from 2016-02-08 to 2019-02-07*

*Uniwersytet Kazimierza Wielkiego w Bydgoszczy; Wydział Matematyki, Fizyki i Techniki*

Determination of the possibility of using natural substances of plant origin (coffee, cocoa, cinnamon) as compounds delaying the aging of biodegradable polymers. The use of these compounds will improve the resistance of biodegradable polymers to external factors, without negatively affecting the possibility of their decomposition in the conditions of industrial composting.

<https://projekty.ncn.gov.pl/index.php?s=2533>

#### **New packaging using renewable raw materials and innovative paraffin impregnants**

*Narodowe Centrum Badań i Rozwoju, BIOSTRATEG 2, project ongoing from 2016-01-01 to 2018-12-31*

The development of safe, modern barrier-based products for coating paper packaging on the basis of safe and environmentally friendly raw materials (paraffins) and the methodology of recycling the obtained packaging.

<http://www.icso.com.pl/projekty/krajowe/nowe-opakowania-z-wykorzystaniem-surowcow-odnawialnych-i-innowacyjnych-impregnatow-parafinowych.html>

#### **Biodegradable nonwovens with a spatial network of multi-wall carbon nanotubes, multifunctional modification possibilities**

*Narodowe Centrum Nauki, SONATA 11, project ongoing 2017-02-21 to 2020-02-20*

*Centrum Badań Molekularnych i Makromolekularnych Polskiej Akademii Nauk*

The aim of the project is to produce conductive hybrid materials based on non-woven fabrics made of polylactide (PLA), a biodegradable, compostable polymer, produced from agricultural raw materials. Its results will in the future be able to form the basis for the production of a new class of materials - multifunctional non-wovens, on an industrial scale.

<https://projekty.ncn.gov.pl/index.php?s=12783>

#### **Biodegradable polylactide based composites with the enhanced antibacterial properties**

*Narodowe Centrum Nauki, PRELUDIUM 12, project ongoing from 2017-07-20 to 2019-07-19*

*Politechnika Poznańska; Wydział Budowy Maszyn i Zarządzania*

The aim of the project's research is to determine the effect of the addition of aromatic oils on the thermal, structural, mechanical and antibacterial properties of polylactide-based compositions.

<https://projekty.ncn.gov.pl/index.php?s=13578>

#### **Preparation of biodegradable polymers and polymer blends as well as assessment of their suitability for applications in controlled release systems in agrochemistry**

*Narodowe Centrum Nauki, PRELUDIUM, project ongoing from 2018-01-12 to 2021-01-11*

*Akademia im. Jana Długosza w Częstochowie; Wydział Matematyczno-Przyrodniczy*

The aim of the project is to develop innovative immobilized formulations of plant protection products that will be formed using environmentally friendly, fully biodegradable polymers.

<http://www.wmp.ajd.czest.pl/428,Nauka>

#### **Multiphase polymer systems: structure and physical properties**

*Ministerstwo Nauki i Szkolnictwa Wyższego, project completed 2017-12-31*

*Zachodniopomorski Uniwersytet Technologiczny w Szczecinie; Wydział Inżynierii Mechanicznej i Mechatroniki*

The aim of the project is work on the preparation and characterization of widely understood multiphase materials. The scope of tests includes: •block copolymers with elastomeric properties based on thermoplastic polyesters •urethane elastomers •composites based on biodegradable polyesters reinforced with natural fibers (biocomposites) •composites based on thermoplastic polyesters and their copolymers reinforced with nanoparticles •recyclate based on polyolefin waste.

<https://innowacje.zut.edu.pl/projekty/struktura-nadczasteczkowa-i-wlasciwosci-fizyczne-furano-estrowych-wielofazowych-ukladow-polimerowych-na-bazie-substratow-pochodzenia-roślinnego>

#### **Design, preparation and testing of properties of materials based on natural polymers with the addition of glycosaminoglycans isolated from food industry waste**

*Narodowe Centrum Nauki, PRELUDIUM 10, project ongoing from 2016-08-08 to 2018-08-08*

*Uniwersytet Mikołaja Kopernika w Toruniu; Wydział Chemii*

The main aim of the research is to design, obtain and characterize materials based on natural polymers (collagen and chitosan) with the addition of glycosaminoglycans isolated from food industry waste.

<https://projekty.ncn.gov.pl/index.php?s=4811>

#### **PLA biocomposites with hybrid cellulose reinforcement**

*Ministerstwo Nauki i szkolnictwa Wyższego. Project completed 2015-12-31*

*Zachodniopomorski Uniwersytet Technologiczny w Szczecinie; Wydział Inżynierii Mechanicznej i Mechatroniki*

Obtaining the desired properties of hybrid biocomposites and determining the content of particular types of fibers ensuring obtaining the best properties of the material being developed, limiting or eliminating at the same time undesirable features of other components of biocomposites. Composites were prepared with optimal amounts of particular types of reinforcement, mechanical properties of materials were examined and optimal processing conditions were determined.

<https://innowacje.zut.edu.pl/projekty/realizowane>

**SKROBIOMAT - Modification and functionalization of biopolymer raw materials derived from cereal and milling processing for the development of new generation biomaterials**

*Centrum Badań i Rozwoju, project completed, 2015*

[http://www.ibwch.lodz.pl/pl171,projekty\\_w\\_ramach\\_programu\\_badan\\_stosowanych.html](http://www.ibwch.lodz.pl/pl171,projekty_w_ramach_programu_badan_stosowanych.html)

**Biotrem-novum - Innovative group of compostable packages for food "Biotrem-novum" produced from renewable raw materials and the technology of their manufacturing.**

*Narodowe Centrum Badań i Rozwoju, Demonstrator+, project completed, 2014*

The aim of the project was to modify the wheat bran packaging.

<http://biotrem.at/pl/aktualnosci/>

**SoLaPack**

**Preventing of migration of critical substances through the application of a sorption layer on packaging material of cellulose origin.**

*Narodowe Centrum Badań i Rozwoju, project completed, 2014*

The goal of the project SoLaPack was development of a sorption layer between packaging and food product.

<http://www.pio.org.pl/index.php/pl/solapack-2/solapack/78-pio/234-czym-jest-projekt-solapack>

**SelectPerm**

**Food packaging materials with O<sub>2</sub>/CO<sub>2</sub> selective permeability.**

*Narodowe Centrum Badań i Rozwoju, project completed, 2016*

The main outcome of the project is a concept for innovative paper- and plastic-based packaging materials which can be used for example as substitutes for perforated packaging films. These materials with tailored permselectivity to oxygen and carbon dioxide will improve the shelf life of fresh, respiring food.

<http://www.cornet-selectperm.eu/>

**BIOCOMPLACK – Ecofriendly food packaging with enhanced barrier properties** – Horizon 2020 Fast Track to Innovation. 2016-2018. Sapici (Italian Company). University Milan – Defens.

BIOCOMPLACK is a food biopackaging with three main points of innovation: the use of cellulose nanocrystals (CNCs), the multilayer structure and the PLA biopolymer reinforced with organoclays which contain natural food preservatives. These three innovations will enhance the barrier properties to oxygen (more than 100 times compared with common biopackaging) and water vapour as well as will improve the shelf-life of food. BIOCOMPLACK is an alternative to common bio-packaging products that enhances 300% the shelf-life of food.

This international project is born in a consortium integrated by two large enterprises (Sapici and Goglio), two small-medium enterprises (SMEs) (NaturePlast and Tecnopackaging) and a research institution (Packlab, University of Milan) from four different countries which together cover the supply chain of the food packaging industry.

**BIOBOARD Novel Coating System technology for eco-friendly food and beverage packaging.** FP7-SME – Spain (and Lucense Italy) 2012-2015.

The overall goal of the project is to replace existing plastic coatings in multilayer paper and board-based packaging and enhance their recyclability. A coating system based on renewable raw materials derived from agrofood waste (based on whey proteins from cheese production and potato pulp from starch production) and its technological application by extrusion and lamination with paper or board to produce packaging materials for both solid and liquid food products were developed.

**BioBarr New bio-based food packaging materials with enhanced barrier properties.** H 2020 Bio Based Industries Funding scheme. Research and Innovation Action 2017-2021. Tecnoalimenti (Italy).

BioBarr will develop new bio-based and biodegradable food packaging materials by improving the barrier function of the biopolymer PHAs (poly-hydroxyalkanoates). These have the potential to replace conventional polymers, possessing similar properties with higher biodegradability and better functional properties and mechanical strength. Currently, using PHAs for food packaging has some limitations, particularly in transmitting oxygen and water. This makes them less than ideal for dry products as bakeries, where loss of crispiness and oxidation of fats can be a problem. BioBarr aims to overcome this by improving vapour and gas barrier properties through material functionalisation. This involves compounding biodegradable materials in multi-layer structures specific for the food product category to be packed. It will also look at surface treatments as a further step. The BioBarr project should create a new bio-based value chain, from bioplastic producer to food industry end-user.

**BIOSMART. Bio-based smart packaging for enhanced preservation of food quality.**

H2020 Bio Based Industries Funding scheme. Research and Innovation Action 2017-2021. IK4 Teckniker (Spain).

The BIOSMART project proposal will develop active and smart bio-based and compostable packages to meet the needs of both fresh and pre-treated food applications. In addition, the novel packaging system will form the basis for tailoring performance and functionality to specific flexible and rigid food packages in diverse market segments.

Improve mechanical properties of the Polylactide (PLA) film by developing nanoclay composites and copolymers. Implement a single or multiple active and smart at acceptable costs. Reduce the overall environmental impact of the value chain through novel material selection, package designs, recycling methodologies, extended shelf life and controlled product quality. Introduce novel bio-based lipopeptide and peptide additives with anti-microbial, anti-fungal and/or anti-oxidant properties to increment food shelf life, new coatings with enhanced O<sub>2</sub>, CO<sub>2</sub>, water and UV barrier properties.

**FRESH - Fully bio based and bio degradable ready meal packaging.** H2020 Bio Based Industries Funding scheme. Innovation Action - Demonstration 2016-2020. Huhtamaki Molded Fiber Technology BV (Netherlands).

Ready meal consumption continues to grow throughout Europe – 6.5 billion and growing. The trays they come in are creating vast quantities of waste, many of which go for landfill.

The FRESH project will demonstrate an innovative, cellulose-based alternative to existing fossil-based plastic trays, which is a fully bio-based and biodegradable composite material.

The project will deliver a full value chain that will demonstrate the techno-economic viability (including customer satisfaction) of a 100% bio-based and 100% biodegradable alternative made from an innovative cellulose-based composite, using a new lamination technology.

**PULPACKTION Optimised moulded pulp for renewable packaging solutions.** H2020 Bio Based Industries Funding scheme. Innovation Action - Demonstration 2016-2020. Rottneros Packaging AB, (Sweden).

The aim of PULPACKTION project is to develop cellulose-based tailored-to-purpose packaging solutions for specific food and electronic packaging applications which needs medium and high barrier requirements and that nowadays are packing in polymer fossil based solutions. This innovation will take advantage of the flexibility in the wet-moulding production of wood pulp based materials. Different types of wood pulp will be combined to prepare slurries for wet-moulding applications. These slurries will be additivated with biopolymers and other bio-based compounds in order to tailor the final properties of the resulting wet-moulded materials. By tailoring the composition of the wet mouldable slurry, a wide range of final properties in the resulting dry material will be achieved. This flexible packaging manufacturing system will be combined with 100% bio-based coatings and films on the cellulose-based substrate. To fulfil the properties required for PULPACKTION's specific packaging applications using a fully bio-based approach, additional barriers will be implemented onto the wet moulded substrate. For this purpose, new bio-based polymer blends will be optimized. These new blends, containing biopolymers such as thermoplastic starch (TPS), poly (lactic acid) (PLA), other bio-additives, and reinforcements such as microfibrillated cellulose (MFC), will be processed into multilayer films, composites and coatings. In this manner, not only coatings

for improved barrier properties, but also 100% bio-based films for packages' top lids will be produced. Therefore, a final 100% bio-biobased integral packaging solution with similar properties to existing fossil-based packaging solutions will be achieved.

**RefuCoat. Full recyclable food package with enhanced gas barrier properties and new functionalities by the use of high performance coatings.** H2020 Bio Based Industries Funding scheme. Research and Innovation Action 2017-2020. AIMPLAS – Asociacion de investigacion de materiales plasticos y conexas (Spain).

RefuCoat project aims to develop hybrid bio-based high oxygen/water barrier and active coatings to be used in a monolayer bio-based food packages (films and trays) as alternative to current metallised and modified atmosphere (MAP) packages to avoid the use of non-renewable materials in multilayer structures that currently lead to complex and expensive recycling steps.

Hybrid coating formulations will combine cost-efficiently produced polyglycolic acid (PGA) and modified silica oxide. Fully biodegradable packages for fresh food products will be obtained with middle chain modified PHAs. PGA and PHA based hybrid coatings with high gas barrier properties will be further improved with active substances for improved shelf-life. Furthermore, new packages based on bio-PET and bio-PE combined with hybrid and active coatings will be developed. The generated products will be validated and compared to current metallised, non bio-based alternatives in industrial products, in performance, shelf-life and biodegradability. Safety and regulatory compliance, environmental and economic sustainability will be specifically addressed. Refucoat main impacts are expected in the improved performance of food packages, reduction of landfilling waste, cost-and environmental effectiveness in processing by Life Cycle and Techno-Economic Assessment, improved preservation of food products, new markets and contribution to KPI of BBI-JI.

**SHERPACK. Innovative structured polysaccharides-based materials for recyclable and biodegradable flexible packaging.** H2020 Bio Based Industries Funding scheme. Research and Innovation Action. 2017-2020. Centre Technique de l'Industrie des Papiers, Cartons et Celluloses (France).

The objective is to develop a renewable, biodegradable and recyclable flexible paper-based packaging material, that can be easily converted by heat-sealing and folding, with improved stiffness and grip, in order to replace materials such as plastics or aluminium foil currently used on the market by an advanced biomaterial.

Nowadays, food packaging needs to be both functional and innovative, and to offer good end-of-life alternatives. Sherpack aims at developing 2 proofs-of-concept for such packaging materials, through 3 major innovations that will be brought together to offer new functionalities: wet-lamination of a thin layer of fibre specialty on the cellulosic substrate, formulation and coating of a biodegradable polymer waterborne emulsion, and specific design, formulation and printing of a polysaccharides grid to improve the grip and stiffness.

Sherpack's cellulosic materials will be brand new and inventive, and integrate concepts that will enhance food conservation, guarantee customers' safety, and improve mechanical properties and converting while remaining recyclable in the paper process, biodegradable, and compostable. The materials developed in Sherpack will be assessed in terms of economic and environmental impacts to ensure they are consistent with the market requirements.

**HYPERBIOCOAT. High performance biomass extracted functional hybrid polymer coatings for food, cosmetic and medical device packaging.**

H2020 Bio Based Industries Funding scheme. Research and Innovation Action. 2016-2019. Fraunhofer Gesellschaft e.V. (Germany).

Improve barrier properties of bio-based packaging by a new class of biodegradable coatings, such as new functional hybrid (inorganic-organic) coatings for applications for food. The new coatings are based on functionalised biopolymers extracted from lignocellulosic biomass sources using the bioORMOCER® synthesis approach.

The new functional bioORMOCER®s will be coated on flexible and rigid biopolymer substrates and tested for packaging applications for food, cosmetic and medical devices.

**COMPAC. Plasticized lignocellulose composites for packaging materials.** Vinnova and EU within the program of WoodWisdom ERA-Net +. 2014-2016.

Aims to integrate production of composite material into a conventional reel to reel paper and board making processes with minor changes. The innovativeness is in the pre-modified fibre material, which can be produced as a sheet-like material offering very large variety of applications to be used. COMPAC has the goal to manufacture plasticized cellulosic materials in pilot scale and identify possible applications of it. Plasticized cellulose is recyclable and can be used in packaging in order to replace some of the packages made from fossil based sources. Plasticized cellulose might be designed into curved shapes and it provides barrier resistance towards water vapour, oxygen and fat. It is the high strain at break, toughness and density of plasticized cellulose compared to normal paper that gives the material its unique properties. Traditionally, cellulose has been plasticized using zinc chloride but has the drawback of being toxic for life in water environments. With green chemistry there are possibilities to partly dissolve cellulose and a few of those systems might give similar plasticization effects as zinc chloride.

PCF can offer the packaging products more stability, strength and barrier properties without high investments in process equipment. Barrier properties are usually made through metal or plastic layers which can be replaced using the PFC packaging materials. PCF offers totally recyclable and biodegradable alternative for the traditional industry.

**PAPTIC. The good conscience alternative.** H2020 SME Instrument. 2016-2019. Paptic OY (Finland- Tuomas Mustonen).

Paptic has developed the novel wood fibre based material PAPTIC® that combines the renewability of paper with the resource efficiency and functionality of plastics. Once fully developed, PAPTIC bags will be 100% biodegradable and recyclable, with at least 85% renewable content.

The patented PAPTIC® bags are the World's first economically sound and environment-friendly alternative to plastics bags. Although market entry is achieved through carrier bags, PAPTIC® will revolutionise the whole flexible packaging market expected to be worth > €200 billion by 2018. The production logistics of Paptic is based on utilising existing paper mills, enabling rapid scale-up with low CAPEX investments.

## **DIBBIOPACK**

### **A new range of smart and multifunctional packages**

*Seventh Framework Programme for Research and Technological Development, completed 2016. AITIIP Technology Center (Spain).*

Project is going to develop packaging that will be used in the near future by food, pharmaceutical and cosmetic industries. In particular, it will develop multifunctional packages in a wide range of processes which improve the structural and barrier properties, introduce smart features and increase sustainability using nanotechnology.

The project includes the design, development, optimisation and manufacturing of multifunctional smart packages, assuring compliance of environmental requirements through LCA and LCC analysis, managing nanotechnology risk through the whole packaging value chain end user evaluation in the cosmetic, pharmaceutical and food industry sectors. The project results and the high impact reached through a wide range of technologies utilised will boost the European Packaging Industry to a higher level.

<http://www.dibbiopack.eu/>

## **Citruspack**

### **Revalorization strategies within the circular economy for the use of citrus waste in green packaging and cosmetics.**

*LIFE 2016, ongoing project from 2017-07 to 2020-06. AITIIP Technology Center (Spain).*

The project aims to demonstrate that **sustainability and efficiency** can be applied to agricultural and industrial practices by researching and boosting the potential of byproducts through their valorisation in a

number of new value chains. At the end of the project researchers and participating companies will offer three solutions with high added value into the packaging and cosmetic sector. The juice bottles will be the first demonstrator.

<https://citruspack.eu/>

#### **LIFE BAQUA**

##### **Solutions through the new use for a waste of banana crop to develop products in aquaculture and plastics sector**

*Environment and Climate Action LIFE Programme, ongoing project from 2016-07-10 to 2019-06-30. University of Las Palmas de Gran Canaria (Spain).*

The main objective of the project is to establish a new circular economy approach to take advantage of wastes from banana plantation (pseudo stem of the plant). From this pseudo stem, and using mechanical processing, two different raw materials are obtained: high quality natural fibres from one side and the residual pulp on the other side. Treated fibre is going to be used to obtain natural reinforced composites, which, as such, may be applied to the automotive sector, as well as bio-based films, which can be employed, among other applications, in the plantation for agricultural use and in the packaging of fish feed. With the residual pulp, as a great technological innovation, it will be held the development of antioxidant additives which serve as a supplement in the production of fish diets for aquaculture.

<http://lifebaqua.eu/index.php/es/>

#### **WHEYLAYER**

##### **Why protein-coated plastic films to replace expensive polymers and increase cyclability**

*CORDIS, completed 201. LAJOVIC TUBA EMBALAZA DOO (Slovenia).*

Project is included in a context whereby packaging market is demanding innovative and green technologies. Project developed a biopolymer-coating based on pure whey protein isolates (WPI) for plastic films able to replace currently used expensive synthetic oxygen barrier layers used in food packaging such as ethylene vinyl alcohol copolymers (EVOH).

[https://cordis.europa.eu/result/rcn/58176\\_en.html](https://cordis.europa.eu/result/rcn/58176_en.html)

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#### **BIOWASTE VALORIZATION**

##### **KARMA 2020 Industrial Feather Waste Valorisation for Sustainable Keratin based Materials**

*Horizon 2020, from 2017.01.01-2019.12.31. Fundation Cidetec (Spain).*

The overall objective of KARMA2020 is the industrial exploitation of underutilized feather waste to obtain added value raw materials for the chemical sector: keratin, bioplastics, flame retardant coatings, non-woven and thermoset biobased resins. The obtained raw materials will be manufactured at industrial scale and further used for the production of novel bio-based products such as: slow release fertilizers, biodegradable food packaging plastics, flame retardant coated textiles and flame retardant thermoset biobased composites.

##### **Development of a method for the production of biocomposites based on waste native starch and sewage sludge**

*Ministerstwo Nauki i Szkolnictwa Wyższego, project completed 2017-12-31. Główny Instytut Górnictwa*  
Development of a method for the production of biocomposites for agrotechnical applications made on the basis of waste native starch (not suitable for food purposes) and sewage sludge.

[https://www.gig.eu/pl/projekty-zakonczone?type\\_1=projekt\\_krajowy](https://www.gig.eu/pl/projekty-zakonczone?type_1=projekt_krajowy)

##### **Development of a method for producing biocomposites based on waste from the film recycling process**

*Ministerstwo Nauki i Szkolnictwa Wyższego, project completed 2016-12-31*

Development of an environmentally effective method of processing heavily polluted polymer waste from the recycling line of the film, that it can be re-used as a raw material in the processing of polymer materials and produce, for example, biocomposites.

[https://www.gig.eu/pl/projekty-zakonczone?type\\_1=projekt\\_krajowy](https://www.gig.eu/pl/projekty-zakonczone?type_1=projekt_krajowy)

**BioRECO2VER - Biological routes for CO2 conversion into chemical building blocks**

*Horizon 2020, project ongoing from 2018-01-01 to 2021-12-31. PKN Orlen (Poland)*

The goal of the project is to demonstrate the technical feasibility of more energy efficient and sustainable non-photosynthetic anaerobic and micro-aerobic biotechnological processes for the capture and conversion of CO<sub>2</sub> from industrial point sources into 2 valuable platform chemicals, i.e. isobutene and lactate.

**Development of a method biodegradable nanocomposite preparation based on nanocellulose derived from fruit and vegetable waste**

*Narodowe Centrum Badań i Rozwoju, Program LIDER, project ongoing 2016.08.01-2019.07.31.*

Opracowanie technologii optymalizacji wytwarzania nanocelulozy oraz opracowanie technologii otrzymywania nanocelulozy z odpadów owocowych i warzywnych.

<http://www.ipan.lublin.pl/badania/projekty/narodowe-centrum-badan-i-rozwoju/>

**Res Urbis. RESources from URban Bio-waSte** Horizon 2020 January 2017-December 2019. Università la Sapienza Roma (Italy).

The overall objective of the project is to integrate into a single facility and to use one main technology chain for the conversion of several types of urban bio-wastes into valuable bio-based products, while also minimizing any residual or consequent waste to be disposed of. Bio-based products include polyhydroxyalkanoate (PHA) and related PHA-based bioplastics.

Urban bio-waste include the organic fraction of municipal solid waste (from households, restaurants, caterers and retail premises), excess sludge from urban wastewater treatment, garden and parks waste, selected waste from food-processing (if better recycling options in the food chain are not available), other selected waste streams, i.e. baby nappies.

**Biocosi.** Italian research funding programme Puglia Region: Programma Operativo Regionale POR-FESR. 2018-2019. ENEA (Italy).

Biocosi project objective is the transformation of dairy waste waters to obtain biodegradable and compostable bioplastics for the production of food packaging. PHA (poly hydroxyalcanoates) are produced by fermentation reducing the dairy companies waste production (zero waste).

**ECO-PULPLAST** . Local circular economy by an innovative approach for recycling paper industry pulper waste into new plastic pallets. Programme LIFE+ Environment and Resource Efficiency. 2015-2018. Selene SpA (Italy).

The LIFE ECO-PULPLAST project aims at demonstrating the possibility to recycle pulper waste – the industrial waste of paper mills that use recovered paper – in the manufacturing of eco-sustainable plastic pallets. The main idea behind this project is to realize plastic euro-pallets to be reused by the same paper district that generates the material waste in the first place and creating local Circular Economy, which is one main goals of the European environmental strategy for the next decades.

FOCUS ON RESEARCH – INNOVATION – DEMONSTRATION -

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**PERFORMANCES/PROPERTIES OF BIO-BASED MATERIALS.**

Biodegradable packaging materials have been on the market for many decades. However, severe restrictions are still present preventing their broad application in packaging and food contact packaging. In fact, these materials often do not provide the requested properties, such as for example a sufficient barrier against water vapour, oxygen or flavours. Nowadays, several research efforts are engaged to improve the

mechanical and/or functional properties of the bio-based packaging products against the current state-of-the-art in the field. Here following the main focused targets.

- The development of renewable raw materials: green plasticizers, inorganic fillers, bio-based additives of natural origins: anti-aging compounds, antibacterial additives (i.e. aromatic oils) and innovative coatings surface treatments.
- Tailor performances and functionalities to specific food packages applied in different market segments. Active and smart bio based packaging antimicrobial, barrier properties improving food preservation/shelf life .
- Improving barrier function of bioplastics such as PHAs developing specific multilayer structures, or active coatings.
- Improve structure and physical properties of innovative multiphase polymer systems;
- PLA multilayer packaging reinforced by nanocellulose and organoclays, or cellulose fibres.
- Improving performances by.
- New environmentally friendly coatings for paper packaging with innovative barrier properties to substitute traditional plastic coatings.
- Innovative design for paper and plastic based food packaging with selective permeability to gas or presence of sorption layers preventing migration of critical substances.
- New cellulose based food trays by innovative lamination technology. Addressing full value chain demonstrating techno-economic viability including customer satisfaction.
- Wet moulded pulp packaging by addition of innovative biobased polymer blends and bio-based coating; tailoring specific food packaging applications.
- Paper-based food packaging design and formulation addressing market requirements and guaranteeing biodegradability and recyclability by innovative lamination and bio-based coatings.
- Innovative plasticized cellulose obtained by green chemistry to produce totally bio-based composites for packaging materials. Integrate production of composite materials into conventional industrial paper and board processes by minor changes.
- Improve availability of raw materials i.e. bioplastics/biopolymers.
- Innovation in production processes (innovative extruders for plastics, adaptation of existing production process)

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#### SUSTAINABILITY RESEARCH.

- Ensuring sustainable end of life waste management: food packaging that should be biodegradable or compostable and processed food packages that should be recyclable, in line with the EU's objective of reducing the recyclable content in landfilled waste.
- Spread the adoption of life-cycle methodologies LCA, LCC, S-LCA and enhance the confidence in their results
- Develop a sound and harmonised approach for environmental LCA, Social-LCA and techno-economic LCC assessment of bio-based products;
- Enhance the reliability of sustainability certifications and standards.
- Acceptable "costs" and sustainable solutions: Life Cycle Analysis and/or Life Cycle and Techno – Economic Assessment

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#### MARKET RESEARCH

- Reduce costs of packing compared to current materials by measuring costs on a life cycle basis.
- Open new markets for new applications for biodegradable materials.

- Public procurements regulations: harnessing the potential of public procurement to foster innovation, developing tools for purchasers, facilitate the creation of buyers groups, and increase awareness and incentives in order to lower the barriers to purchasing. Thus leading to the opening of new markets of bio-based products in Europe.
- Encourage market pull for bio-based products through the assessment of consumers' preferences and acceptance;
- Spread awareness about sustainable production of bio-based products among farmers associations, industries, EU bodies, entrepreneurs and stakeholders from the civil society.
- Encourage exploitation and re-utilization of organic waste within biobased industries clusters (i.e. building blocks for bioplastics): focus and address zero waste target.

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#### ENTERPRISE RESPONSIBILITY.

Enterprise responsibility is a defined set of PROJECTS, PRODUCTS and VALUES, (assessed by GRI Standard approaches -Global Standard for Sustainability Report): favouring the transition from product economy to system economy, addressing, social environmental and economic sustainability. The entire society is involved by collaboration among all stakeholders in the involved territory to demonstrate the company's positive contribution to the world.

#### FOCUS ON CREATING POLICIES AND SUSTAINABILITY SUPPORTING NETWORKS

- Develop a fit-for-purpose sustainability scheme, including standards, labels and certifications for bio-based products.
- A proactive regulatory approach is an important driver in developing emerging industries and attracting investment.
- Similarly, a proactive approach to standardisation can help harmonise supply chains and create an environment that stimulates investment by reducing risks and offering a better potential return on investment.
- Develop and perform policy analysis (scenario analysis) in order to support the European Commission in developing a common framework (level playing field and harmonized policy regulation).
- Create a new cross-sectorial interconnection in bio-based economy clusters linking to the complete value chain, from bio-based raw material to end-users.
- Integrate scientific and engineering approaches with social sciences and humanities-based approaches in order to formulate guidelines for a common framework promoting the development of regulations and standards to support the adoption of business innovation models in the bio-based products sector.
- Supporting innovation in SMEs intended to create new services and products and therefore the generation of new value chains and emerging industries across Europe.
- New companies accompanying converters to develop and integrate products of packaging into bioplastics/biomaterials. A case: *Natureplast*.
- Public procurements regulations: harnessing the potential of public procurement to foster innovation for bio-based products.
- Initiatives of Biobased industries (Biopen project) clustering and networking to develop new value chains and favour the emergence of co-innovation partnerships across the value chains; stakeholders engagement and support with regards to setting-up co-innovation partnerships alongside existing and new value chains; creation of knowledge centre collecting the prospective and insight of the community, and providing access to relevant information for markets and products innovations in the bio-based ecosystem.