Industrial Feather Waste Valorisation for Sustainable KeRatin-based MAterials

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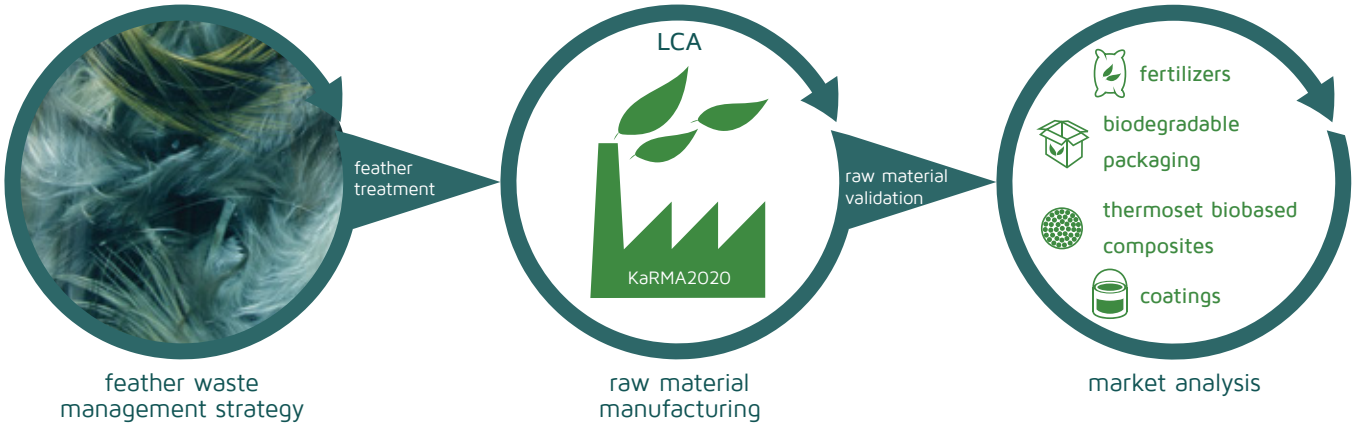
The project, funded in the frame of Horizon2020 TOPIC SPIRE-03-2016: Industrial technologies for the valorisation of European bio-resources into high added value process streams, aims to the industrial manufacture and exploitation of sustainable raw materials from feather waste to develop innovative green products for high impact cross-sectorial markets.

THE PROJECT

Poultry industry generates huge amounts of waste each year. Only in the European Union 13.1 million tons of poultry meat are produced for year, with an estimated generation of 3.1 million tons of feather waste. Due to the raise in poultry meat consumption in the EU countries, this amount is expected to increase in the following years.

In Europe, the majority of the poultry feather waste is disposed in landfills, incinerated, or a minor part converted into low nutritional value animal food, becoming a problematic for the future. At present, the conversion and the use of the feathers as raw material in industrial applications are still very limited. Therefore, the development of industrial conversion methods and exploitation strategies for poultry feathers will not only increase the value of feathers as raw material but also reduce environment impact and health hazards associated to landfill. In this context KaRMA2020 Project aims to the industrial manufacture and the exploitation of such underutilized feather waste for the production of valuable raw material that will be employed to develop products for cross-sectorial applications, such as hydrolysed keratin, bioplastics, flame retardant coatings, spun bonded non-wovens and thermoset biobased resins.



OBJECTIVES

The main objective of KaRMA2020 project is to develop new biobased products for high impact sectors from poultry feather waste.

This main objective will be reached through the following steps:

- Improving feather waste pre-treatment and conditioning processes
- Optimizing the isolation of keratin and other feather-based raw materials
- Validation of the feather-based raw materials for bio-based end products

BENEFITS

The valorization of the current waste, together with the technological breakthroughs proposed in KaRMA2020 guarantee significant benefits from both environmental and economical point of view. Due to the innovation potential of KaRMA2020, the project will have relevant impacts:

- **Technical impact**, by the optimization of feather processing methods from lab to industrial scale
- **Industrial impact**, by the manufacturing of bio-based raw materials and by the production and the validation of end products
- **Environmental impact**, by reducing the negative environmental effect due to the feather waste as well as by the replacement of non-renewable primary raw material with renewable raw materials for the industrial production
- **Economic impact**, by the promotion of innovative applications and products with higher value from the current waste

WHICH ARE THE INVOLVED COMPANIES AND ASSOCIATIONS AND WHAT THEY WILL DO?

IK4-CIDETEC, is a Technology Centre created in 1997 as a non-profit foundation specialized in generating and transferring knowledge/ technology in the areas of Materials, Surfaces and Energy. IK4-CIDETEC has an annual turnover of 12 M€ in 2016 and a workforce of 160 people; 95% of them hold university degrees and 50%, a PhD. Since 2001 up to now, IK4-CIDETEC has developed R & D projects with 450 companies of the most varied sorts working in different productive sectors. At the same time, in collaboration with other industrial partners, CIDETEC has set up 4 new companies that industrialize a number of developments and complement the centre's activity. IK4-CIDETEC's work has been particularly strong in the European Union, which has resulted in the participation in 34 projects of the 7th Framework Program, leading 8 of them. This activity is followed up in the current European program, Horizon 2020, within which IK4-CIDETEC participates in 16 projects, leading 3 of them. The Polymers & Composites Unit is specialized in the synthesis and functionalization of polymers as well as in the compounding of thermoplastics and rubber and in the preparation of thermoset composites. The team is composed by 12 researchers and includes 2 engineers and 8 PhD polymer and organic chemists. It is worth to mention the experience of IK4-CIDETEC in the valorisation of biomass from different wastes. In this sense, IK4-CIDETEC has recently coordinated a European Project (Eclipse) in the FP7 programme for the valorisation of algae and other waste from lignocellulose biomass.

Role in the project

IK4-CIDETEC has the leading role as Coordinator of KaRMA2020 project. IK4-CIDETEC will be involved in the pre-treatment of poultry feathers and in the developping of technologies for the preparation of keratin based materials, specifically in the development of biobased plastic formulations for biodegradable packaging and in the development of bio-based and flame retardant composites.

Grupo Sada pa., S.A poultry division in Spain, focuses its activities on the complete management of the entire meat chicken production cycle, from grandparent stock, hatcheries, broiler farms and processing plants, to the distribution and marketing of the final product. Products: Poultry products (Carcass, cut up parts, Poultry further processing products and Services). GrupoSada p.a S.A., is headquartered in Madrid, and it forms an independent Business Unit. It is made up of 9 production plants, equipped with the latest technology, and its commercial network covers the whole of the Spanish territory. It was one of the first European companies to implement a quality assurance system in all of its processing plants and currently all of them are certified with the BRC by the certifying company SGS. In addition, it was pioneer in the implementation of a management system of Safety and Health, certified by SGS, according to the OHSAS 18001. In 2007, GrupoSada was certified with the ISO 14001 Environmental Management Standard, thus increasing its commitment to the sustainable development of its businesses and in 2011 obtained the ISO 14064 of carbon footprint reduction.

Role in the project

As feathers producer, Grupo SADA p.a S.A will be involved in the feathers pre-treatment phases and feathers cleaning tests.

VTT is the largest internationally networked R&D centre for applied research in Northern Europe, harnessing high technology to develop scientific solutions for sustainable development and creating new business opportunities. VTT's mission is to produce research and innovation services that enhance the international competitiveness of companies, society and other customers, as well as to create the prerequisites for society's sustainable development, employment and well-being. Solutions for natural resources and environment (SONE) business areas aim to be global key players in the fields of bioeconomy and cleantech through networking with the best international partners. The main target is to develop innovations for industry to support the utilisation of natural resources. The research is supported by unique laboratory and pilot infrastructures in chemical processing, industrial biotechnology, food and beverage processing, biofuel production, as well as fibre and composite technologies. In the past 20 years, VTT has participated in more than 1000 European R&D Framework Programme projects, within various thematic programmes.

Role in the project

In KaRMA2020, VTT will participate in the mechanical, thermochemical, biochemical and chemical processing of feathers as well as convert them into films and slow release fertilizers. VTT will analyse the characteristics of these fractions, based on their chemical and physical properties.

SP SVERIGES TEKNISKA FORSKNINGSINSTITUT AB (SP) is a state owned company under the Ministry of Industry. SP is the national institute for technical evaluation, research, testing, certification, metrology and calibration. It works closely with large and small companies, universities, institutes of technology and other organisations, linking fundamental research with particular industrial needs. SP's activities cover a wide technical range organised in 17 inter-working technical departments, covering 15

broad technology areas, or, alternatively, 6 main business areas. SP also hosts several knowledge centres and research platforms, including Waste Refinery, SP Biofuels, and SP SME. SP provides advisory services to the Swedish government, to government authorities and to national and international standardisation organisations. Cutting edge expertise in a multitude of R&D areas, including Building technology and building physics, Wood technology, Fibre technology, Energy Technology, Environmental technology, Biorefinery, Industrial Process Development, Food and Biotechnology, Fire and Safety, Materials and Polymer technology, Electronics and ICT, and Measurement technology. SP is a notified body for certification, testing and inspection of construction products, and is also accredited for certification of quality and management systems. Most topical for this particular project is the strong interlinked expertise and experience in the areas of biorefinery, waste refinery, wood and fibre technology, and process development.

Role in the project

SP will lead the work on sustainability assessments, as well as the development of business plans through analyses of market opportunities, raw material availability, logistics, costs, and more. Furthermore, SP will contribute to the selection of value-added chemical intermediates, development of novel biobased monomeric and polymeric products and biocomposite products made thereof.

CTB is the Belgian Textile and Plastics Competence Centre. Their activities comprise four main pillars: (i) performing research, development and innovation activities; (ii) giving (technical) consultancy and organising trainings; (iii) offering a complete range of standardised testing; (iv) certification: CTB is a notified body for CE marking and testing. The R&D is focussed on applied research, aiming at involving companies as much as possible. CTB has an annual turnover of ca. 13 M€ and employs 165 people. CTB activities include the coating and finishing of textiles. This comprises the use of novel deposition techniques on textile materials but also the try out of novel chemistries and novel materials on textiles. For KaRMA2020, it is of importance that within CTB knowledge on the use of biobased materials has been built up via some (European) projects, including the use of keratin.

Role in the project

CTB will mainly work on the processing of the pre-treated feathers into a form enabling the use of keratin in industrial processing. CTB will also work on the addition of keratin into PU coatings and their characterisation. CTB will also contribute to the LCA analysis and to the project dissemination activities.

AIMPLAS, Technological Institute of Plastics located in Valencia, is a private, non-profit Association with more than 500 associated companies created in 1990. AIMPLAS is formed by +105 highly skilled professional, more than 65% with a Masters, Engineering or equivalent degree in Chemistry, polymer engineering, materials engineering or equivalent, including 15 PhD. AIMPLAS' fields of work are related to technological research and development on thermoplastic and thermosetting plastic materials & products, its transformation processes and their recyclability and sustainability. AIMPLAS generates new knowledge and technologies that can be transferred to companies in order to help them to increase their effectiveness and competitiveness. AIMPLAS, as research center is focused to help companies in the plastic sector to develop new products and increase their competitiveness through innovation, has more than 20 pilot plants representing the most relevant polymer/plastics/composites production technologies present in the industry nowadays and has state-of-the art test facilities for chemical, optical, morphological, mechanical and physical characterization. These pilot lines and laboratories are used by many customer's every year allowing them to test new materials, optimize production processes and launch new products to the market, supported by AIMPLAS technical staff, resulting in more than 5000 assays, 170 technical assessments and 120 skills training actions to more than 1500 clients per year. AIMPLAS has state-of-the-art 8500 m2 facilities, including

thermoplastics and thermoset pilot plants, analysis and testing laboratories (physical-mechanical, chemical, packaging, automotive and construction) and training areas. Our main research lines include the production of bioplastics from organic by-products, nanotechnology, coatings and plastic processing.

Role in the project

AIMPLAS will take part on technical steps: AIMPLAS will work in the production of fireproof additives from modified keratins, will develop polyurethane based coating with green fireproof properties and will contribute to the characterization of final products.

The Institute of Biopolymers and Chemical Fibres (IBWCh) founded in 1952, specializes in R&D aimed at biopolymers, functional thermoplastics including biodegradable, bioprocesses, biocatalysis in polymers and fibres, biomaterials, nanotechnology, pulp& paper and environmental protection.

Role in the project

IBWCh will developed spun-bonded technology for composite non-wovens for the preparation a new assortment of hydrophobic textiles. Composite non-woven will be produced by spun-bonded technique from fibres directly extruded from the spinneret. This method already patented by IBWCh, allows the production of biobased fibers by the incorporation of feathers into a polymeric matrix during the well-known spun-bond process.

Sioen Industries is market leader in coated technical textiles. With 4300 people worldwide, an extensive portfolio of coated fabrics is offered to the market. Among the applications we can mention PU coated fabrics for garments, mattress covers, wound care patches, upholstery, automotive coatings. Further to PU coatings, textiles coated with PVC or silicon rubber also make part of the portfolio (tensile architecture, truck covers, publicity banners,...). Sioen Industries is vertically integrated: from the spinning of the yarns, over the weaving and coating to the finishing/confectioning of the coated fabric to semi-finished or finished goods, all within one and the same company.

Role in the project

Being the largest coated textile producer in the world, Sioen Industries will apply the keratin-based raw material streams into their PU-coatings.

The LPMC (http://lpmc.unice.fr/) is a joint laboratory between CNRS and University of Nice Sophia Antipolis (UNS). It was founded in 1973 and gathers 52 permanent professors, associated professors and researchers specialized in materials science and peculiar behaviours of condensed matter and over than 50 PhD student and postdoctoral fellows. LPMC has an internationally recognized expertise in several fields including biomass derived materials and valorisation of monomer/polymer from biomass into new commodity materials; kinetics of polymerization/phase transitions, thermo-mechanical and surface characterization, synthesis of conducting and superhydrophobic polymers, complex fluids rheology, interfacial dynamics, plant biomechanics, quantum information, optical fibres. LPMC is turned to international since more than 20% of its staff comes from abroad.

Role in the project

CNRS will play a role during the feather processing technologies phases. CNRS will work on feather valorization focusing on the study of the compatibility between the polymeric chain and the feather fibers. With the aim to develop new biomaterials, CNRS studies will also focus on the combination between keratin and humins. CNRS will conduct investigations on the potential to combine, by copolymerization, these kinds of biopolymers. This activity includes reactivity study, synthesis, characterization of chemical structures, analysis of chemo-rheology during polymerization, optimization of chemical reactions, thermo-mechanical performances of final biomaterial.

AVT is a worldwide recognized leader (Cleantech Top 100 Company) in catalytic biomass conversion into furanic building blocks and high throughput technology. It has created an impressive patent portfolio in this area and is a proven adept of the open innovation model. From 2011 to 2015, these novel concepts will be demonstrated in a first of a kind pilot facility. AVT has over 145 employees and employs a team of 65+ highly educated professionals (more than 40 PhD's) who are experts in biomass pre-treatment and conversion, humins, methyllevulinate, syngas chemistry, organic chemistry, catalysis, engineering of robotic systems, process engineering, statistics, analytics, chemo informatics and software development. AVT's employees are dynamic and enthusiastic people, open-minded, ambitious and professional. The company fosters creativity as well as a result-oriented, customeroriented attitude.

Role in the project

In KaRMA2020 project, Avantium will supply humins, the carbohydrate derived by hydrophilic resin to assembly composites together with the poultry feathers. Avantium will also test feather/resins processing technologies for the preparation of humins/keratin based materials and composites targeting innovative applications.

Since 2003 FKuR Kunststoff GmbH located in Willich, Germany, is concentrating its business activities on the development and sales of biobased and/or bio-degradable plastics. FKuR cooperates closely with the Fraunhofer UMSICHT Institute located in Oberhausen, Germany. FKuR supplies tailor-made compounds for nearly all plastics processing processes including film extrusion, injection molding and blow molding. Generally, raw bioplastics (starch, PLA, PHA, PBS and others) are not ready-to-use, but need to be blended and compounded to tailor-made functional materials for particular applications. This processing of raw bioplastics requires special knowledge in the field of additives and a smooth compounding process. FKuR's compounds are being used successfully within the consumer, packaging and even the automotive sector to produce goods on an industrial scale. The compounds are being sold under the well-known and established brands Biograde®, Bio-Flex® und Fibrolon®. FKuR belongs to the biggest players worldwide within the niche of bioplastics having international subsidiaries and sales representatives. Today FKuR's staff counts more than 40 highly educated specialists both in technical support and R&D as well as sales & operations that are mainly employed within the German headquarters. FKuR is always keen to further improve their own products or to develop completely new compounds for technically challenging applications. This is one strategic measure to maintain and strengthen the leading position as producer of first class bioplastic compounds for challenging applications.

Role in the project

FKuR's task in KaRMA2020 project is the compounding of treated modified feathers into bioplastics. FKuR will focus on the properties of the new materials and will provide the knowledge about filler-matrix-interaction. Furthermore, FKuR will analyse the high dispersion of feathers and additives in combination with a high volume throughput, and will investigate thr feeding to the compounding process.

Fertiberia, S.A. is the second largest Spanish capital company in the chemical sector, has a highly sound balance structure, upon which Grupo Fertiberia's expansion is based. Fertiberia produces the most comprehensive range of intermediate and finished products. It produces solid and liquid simple and complex fertilizers, thus covering all the needs of today's farmers, providing them with fertilizers for large-scale unirrigated crops and crops using traditional and drip irrigation methods, regardless of their weather and soil conditions. The diversification policy fostered in recent years has allowed for strong growth and an increasingly relevant presence in other chemical sectors not related to agriculture. Industrial products currently represent 38% of Fertiberia's revenue and 44% of the Group's revenue. Thus, Fertiberia's presence in other industrial sectors as a supplier of raw materials to other large companies in diverse industries

grows every day. The activities in the ammonia and derivatives industry, in which the Group is one of the main operators around the world, must be noted. Furthermore, Fertiberia is the only primary manufacturer of the AdBlue solution in Spain and one of the main manufacturers in the European Union.

Role in the project

Fertiberia will test some polymers from queratine as coating for fertilizers granules. The objective is to analyse if these coatings can give to a controlled release of nutrients in the soil when applied to the fertilizers granules as a coating. Furthermore, resulting materials from feather treatments will be also evaluated as a raw material (N and/or organic matter source). Lab and camera test will be made, such as dissolution test and drainage columns, and trials with plants will be developed. Finally, Fertiberia will validate the technology for the application of the new additives to the fertilizer.

VTG is a French research intensive SME that focuses its business on providing advance environmental and sustainable solutions for different sectors such as sustainable revalorization of agricultural and urban residues. Vertech Group is specialized in sustainability and risks assessments of novel technologies and modelling of industrial and chemical processes. VTG is member of the French Life Cycle Assessment Platform AVNIR, The Forum for Sustainability through Life Cycle Innovation, the Indian LCA Alliance and the Ibero American Life Cycle network. The staff of VTG has over 10 years of experience on international cooperation, performing the referred activities. The company is based in Nice, in the French EcoValley, that is the first example of a real sustainable urban environment in France. Vertech is also present in Spain and has expansion plans to other markets besides Europe (e.g SouthAmerica). VTG is member of the French Life Cycle Network-AVNIR, The Forum for Sustainability through life cycle innovation, the Indian LCA Alliance and the Iberoamerican Life Cycle Network. Vertech Group contributes with the UNEP/SETAC Life Cycle initiative and the DR-JRC from the EC. Vertech has organized the Second European Workshop in LCA in 2015 and is organizing the third one to be held in 2016 www.vertechgroup.com/lifecycleassessmentworkshop/speakers.php

Role in the project

VTG will lead the activities concerning the Risk Assessments of the proposed feather valorization to fertilizers, packaging applications, etc., the implementation of specific risk assessment methodology, in order to reduce risks to a minimum level and to assure the highest possible safety and reliability. Vertech will also perform the Modeling and simulation of the feather processing, manufacturing of keratin-based products and the scaling up.

Ciaotech srl is the Italian branch of PNO Innovation B.V.. PNO is Europe's largest independent public funding and innovation consultancy firm with 30 years of hands-on expertise and more than 500 funding programmes in most EU countries, annually raising approximately 1 Billion Euro for its clients. Created in 1985, PNO is a high-growth knowledge-intensive company, supporting over 2000 clients throughout Europe, annually developing over 250 European consortia. PNO has presence in 6 + 6 European countries, employing in around 250 people in Western Europe alone. Ciaotech-PNO's "Innovation Management" services delivers high quality support to large sized companies, SMEs, Universities, Research Institutes, Associations and clusters in the full cycle of the innovation process, including:

- Analysing, defining and planning innovation processes;
- Building innovation networks, partnerships and projects;
- Managing Projects and driving innovation.

Role in the project

Ciaotech will lead all partners within the Dissemination, Communication & Exploitation activities as well as the IPR issues. In addition Ciaotech will be strongly involved in the development and delivery of the Market Analysis & Business plan.

Daren labs is a chemical research & consulting company, founded by Dr. Steve Daren. Daren Labs has wide ranging experience and capabilities aimed at solving problems in plastics, polymers, materials, bio, agro – and organic chemistry world wide. Daren labs expertise is in polymerizations, polymer-inorganic nanocomposites, catalysis, and optical properties of plastics, flame-retardants and hydro gels. During its 20 years of existence the company has solved hundreds of problems ranging from traditional industry such as concrete additives to hightech including nanotechnology and biotech such as artificial insemination. In addition Dlabs provides laboratory space and facilities for many start-up clients. The combination of Dlabs experience with energetic new comers has proven to be highly synergistic.

Role in the project

In KaRMA2020 the main task for Daren lab will be the Synthesis of polymers and oligomers which will contain flame retardant components derived from renewable resources (Non-halogen).

Processum is part of RISE, Research Institutes of Sweden, and has a strong research based on lignocellulosic raw material within the fields of general biorefinery development, biotechnology and organic chemistry. Processum offers research and development support in the areas of biotechnology and organic chemistry. The core competence of Processum is in the field of bio refinery with specialist competences within organic synthesis, flow chemistry and biotechnology in lab and pilot scale. Processum has during the last 5 years invested in pilot units with the purpose to strengthen the development of new products and bio refinery processes. The equipment is suitable for scaling up laboratory results, evaluating and improving new processes and preparation of larger quantities of material. The equipment is built to handle flammable materials and is capable to utilize high pressures and temperatures. The ATEX classified equipment and the processes are designed with a high degree of safety awareness and risk mitigation. Processum is also part owner and coordinator of the Biorefinery Demoplant (BDP) and the new crystalline nanocellulose (CNC) pilot installed 2017 located on the same site.

Role in the project

Processum will scale up the steam explosion process as well as the enzymatic and the DES processing of feather material, extraction/ isolation of material up to pilot scale.

KaRMA2020 PARTNERS

CIDETEC
www.cidetec.es

SADA
www.sadagrupo.com

VTT
www.vttresearch.com

SP
www.sp.se

CTB
www.centexbel.eu

AIM
www.aimplas.net

IBWCh
www.ibwch.lodz.pl

SIOEN
sioen.com

CNRS
www.unice.fr

AVT
www.avantium.com

FKuR
fkur.com

FTIB
www.fertiberia.com

VTG
www.vertech-group.com

CIAOTECH – PNO
www.pnoconsultants.it

DLABS
www.darenlabs.com

PROCESSUM
www.processum.se

For more info about the project visit the KaRMA2020 website at www.karma2020.eu or contact us: Project Coordinator Sarah Montes, smontes@cidetec.es

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