Industrial Feather Waste Valorisation for Sustainable KeRatin-based MAterials

Enjoy reading the KaRMA2020 newsletter!

KaRMA2020 Pilot scale facilities up and running!

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 KaRMA2020 project is growing up, moving forward from laboratory to pilot scale! That is why, within this 3rd newsletter, we want to show you the pilot scale facilities we are using to scale up the interesting lab results.

STEAM EXPLOSION PROCESS

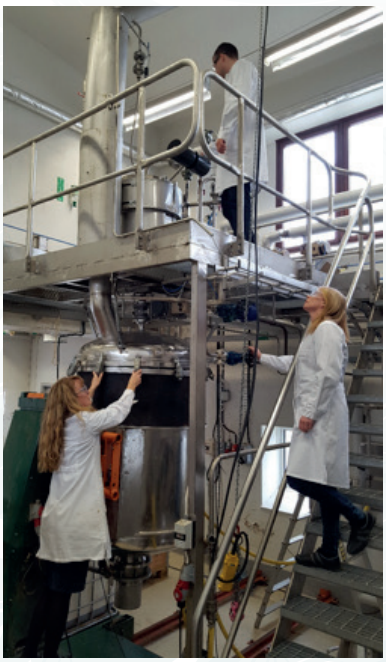

Figure 1. RISE Processum steam explosion device. From left to right: Julia Forsberg, Roger Molinder and Karin Johnson. The equipment upside is a 40 L reactor above a 1000 L explosion vessel.

This is one of the most original processes available to break protein structures and reduce particle size without excessive chemical degradation. It can be used as a pre-treatment substituting mechanical methods to reduce feather size such as grinding or milling. In the process, steam cooking is followed by explosive decompression achieving a disruption of keratin structure and reduction of disulphide bonds. Steam explosion increases keratins solubility in water and other polar solvents, and accessibility to enzymes. The only problem? Breaking disulphide bonds means you better cover your nose unless you want to smell rotten eggs!

The Finnish Research Centre VTT researched the process at lab scale, and now our colleagues from RISE Processum are researching the use of this process with feathers feedstock at pilot scale since up to now it was mainly used for wood and agro processing. The treated feathers will be used to feed further chemical/biological processes or directly as slow release fertilisers.

DEEP EUTECTIC SOLVENT FRACTIONATION

It has been the first time that DES treatment is applied for feathers. The solvent is able to manipulate the properties of feathers, such as hydrophilicity, by conserving/destroying the tertiary structure of the protein. The main motivation to use this method instead of other similar processes such as ionic liquids is that DES are cheaper, less toxic and even biodegradable compounds.

The main challenges faced in the lab scale experiments are referred to find the adequate process conditions and solvent composition in order to obtain an acceptable degree of keratin solubilisation. Now that the critical bottlenecks and optimal process conditions are identified, RISE Processum is scaling up the process.

Figure 2. RISE Processums pilot scale facility for Deep Eutectic Solvent.

BIOPROCESSING OF FEATHERS

The objective in this treatment is to use enzymes to attack the tightly packed and insoluble keratin, destroying hydrogen bonds and hydrophobic interactions. This process is done in mild conditions allowing to have a less intensive process. There are two main shortcomings when thinking about upscaling this process: the cost of commercial enzymes (which can be overcome using microorganisms instead of enzymes) and the degree of keratin solubilisation achieved.

The pilot scale research at RISE Processum will tune the raw material properties to be suitable for technical final products, biocomposites, films and fertilizers. Enzymatically-treated feathers will be implemented in technical products to improve the compatibility of feathers in the matrix or bring functionality (e.g. flame-retardancy) to the products. For this purpose, a 50L and 600L bio-reactor for enzymatic hydrolysis and fermentation are available.

Figure 3.RISE Processums 600L pilot line for biotechnical treatment.

HOT MELT EXTRUSION

This process consists in applying heat and pressure to melt a polymer in a continuous process where mixing and formulations compounding can be achieved. The process is widely used in the polymer industry to produce plastic products such as bags, films, tubes, etc. and lately in the health care industry to mix active pharmaceutical ingredients with polymeric matrixes.

In KaRMA2020, CID is researching at lab scale the most promising formulations which integrates the pretreated feathers into polymeric matrixes in order to obtain pellets, later on used for food packaging. The pilot scale facilities used by FKuR are allowing to optimise the processing conditions and upstream/downstream processes set up (such as feeding, cooling, cutting, etc.). In example, the feathers feeding operation is becoming one of our colleagues' headaches.

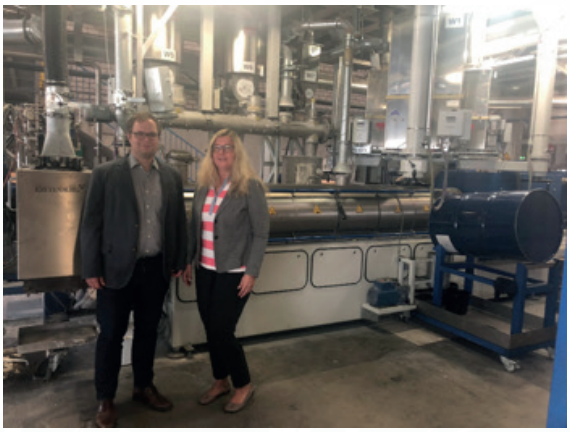

Figure 4. FKuR Hot Melt Extrusion equipment

FLAME RETARDANTS

Polyurethane materials are used in furniture construction, paint formulations and in civil engineering as acoustic insulation. To avoid flammability problems, additives are used as flame retardants. Since halogen-containing additives have been banned by EU regulations, there is a need in the market to find out novel environmentally friendly additives, such as the keratin-based ones developed by our partners DLABS and AIMPLAS.

The work carried out jointly by these two organisations is based on the chemical modification of keratin to increase their flame-retardant capacity. After performing lab-scale experiments, pilot scale reactor are being used to optimise the flame retardant production process.

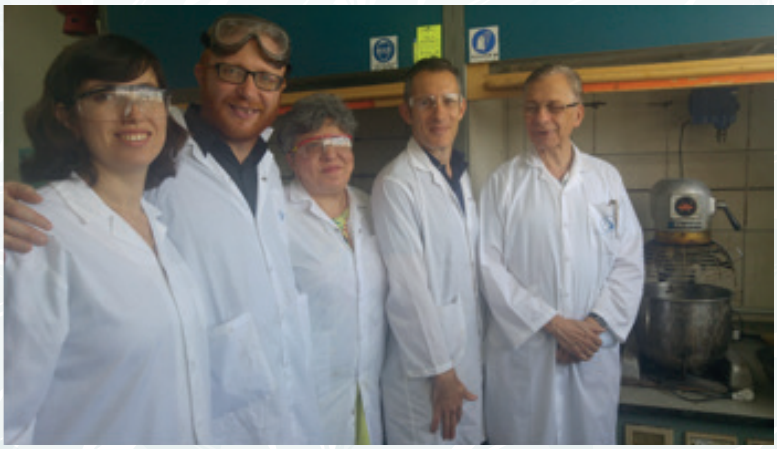

Figure 5. Daren Labs' team at the "kitchen"

FLAME RETARDANTS

Following the work of DLABS and AIMPLAS (keratin-based flame retardants production) and CTB (keratin integration into polyurethane matrixes), SIOEN pilot scale experiments aim at scale up the production of feather-based technical coatings.

SIOEN is using its coating facilities to further evaluate the most promising formulations. Later in the project, industrial trials will be undertaken to make prototypes.

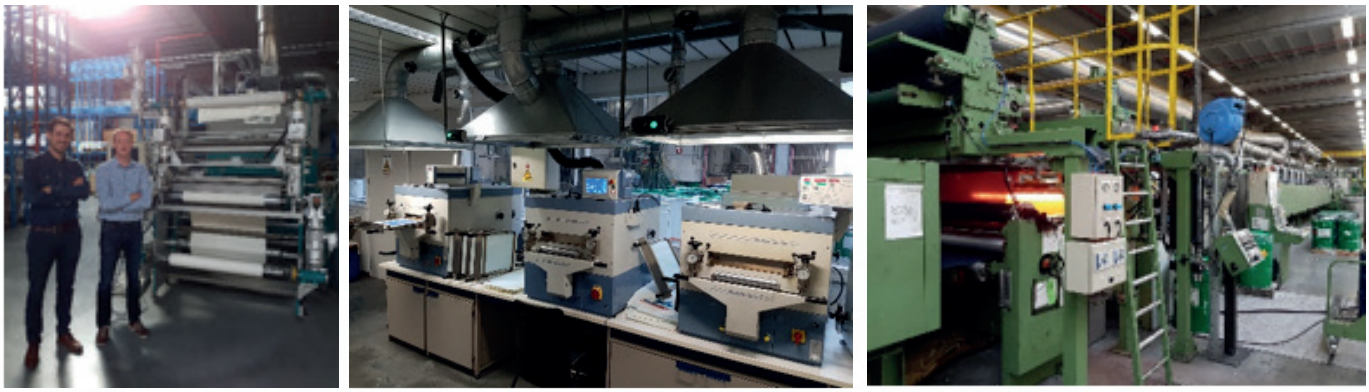

Figure 6. SIOEN facilities. Left side: the pilot coating machine, center: labdryers, right: industrial line

THERMOSET RESINS

A thermoset resin is a prepolymer in a soft solid or viscous state that changes irreversibly into an infusible, insoluble polymer network by curing. Humins, obtained as by-product during carbohydrate dehydration and feathers are components highly suitable to produce 100% bio-based thermoset resins.

In close collaboration with CNRS, Avantium is scaling up the copolymerisation process to combine the humins matrix with feathers in order to manufacture the thermoset resins. First, they are manufacturing feather/humins based composites starting from the most promising formulations identified at lab scale. Second, scaling up the polymerisation process with special attention to the chemical crosslinking of keratin with the humins matrix. Finally, the produced materials are extensively characterized.

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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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