A PLASTIC FUTURE FOR SHELL WASTE

ChiBio investigates sustainable solutions for residues produced by the seafood industry

The project: Cracking the chitin

Global shell waste is estimated at 6 million tonnes per year, and growing fast. In Europe alone estimations are as high as 750 000 tonnes per year. Shrimp and lobster are among consumers' most popular fisheries products, made widely available by global aquaculture breeding. However, the waste produced by the seafood industry has significant issues beyond contributing to landfills or maritime dumps. Due to flesh or speck residues left in the shells, seafood waste is also a breeding ground for pathogens. Archaic and environmentally dangerous methods of waste treatment are consequently used; shell waste has to be burnt and the ashes dumped at sea or on land.

In many Asian countries, shrimp waste is already converted to chitosan, a commercially valuable compound with myriad applications ranging from use as a biopesticide to biomedical solutions in tissue engineering, non-viral gene delivery and enzyme immobilisation. The problem is that European crustacean shells harbour higher levels of calcium carbonate, thus making the Asian approach unviable.

This is where ChiBio comes in. The project seeks to establish a biorefinery process which breaks down the chitin present in shells into basic components and tries to convert them into precursor compounds for the plastic industry. These components could be used as building blocks in the synthesis of polymers such as nylon or polyester. Whereas current industrial shell processing focuses on the extraction of the chitin from the shells, ChiBio is the first to take the process a step further and tries to integrate the biowaste stream into biorefinery processing using its cascade of potentials.

The product: Novel biobased compounds, process innovation, demonstrators

ChiBio's goal is to gain an array of biobased polymers as precursor plastics for the chemical industry. This could lead to new fibres and fabrics, made from nylons and polyesters.

The protocol used in the project should also lead to other novel biogenic materials - such as insect carapaces, fungi and other chitin-rich derivatives - to be considered for application in pharmaceutical and chemical products.

Another gain of the project is the discovery of new methodologies and processing steps. ChiBio works with white biotechnology along the entire process- and value-chain of waste treatment and waste conversion. New pretreatments with respect to eco-efficiency and sustainabilitiy for European, African and Asian fisheries industries are tested. Novel enzymes for depolymerisation are evolved, and cheap separation processes for proteinogenic and lipoid by-products are developed.

A novel chemo-enzymatic/microbial route to synthesize N-containing bifunctional monomers starting from glucosamine will be established, and the fermentative production route for bifunctional olefins starting from glucosamine and/or N-acetylglucosamine will be developed. The new polymers emerging from this process will have potential for new applications in the marketplace.

The study of the technical feasability of new biotech methods and prototypes of novel polymers will also be used for further demonstration acitivites.

Moreover the potential of energy-rich by-products as feed for anaerobic biogas production will be evaluated. A lifecycle analysis of the entire process chain will supplement the products gained from the project.

The end users: Producers of chemicals, enzymes, pharmaceuticals, neutraceuticals, recyclers

Chemical industry, pharma, food and packaging industry. Bifunctional fatty acids and n-containing heterocycles generated from purified chitin/chitosan display potential building blocks for novel bioplastics and consumables. New polymer characteristics will lead to new fields of application to be evaluated by the chemical industry.

Recycling and biomass-based energy suppliers.

At present, the fishing industry has disposal costs of about 7500 €/t for chitin-rich fishery wastes. The fishing industry pays also for the transport of waste. By directing the waste stream into the production process, cost savings are evident in the first step of the ChiBio biorefinery process.

The inventors: Research and technology organisations, academia and industry

The project consists of five academic partners, four SME partners, and two large industry partners. ChiBio is led by Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V. (research organisation, Germany). Participating institutes: Fraunhofer IGB and Fraunhofer ICT.

Special contributions:

- Letterkenny Institute of Technology (Ireland): Novel (more sustainable) pre-treatment methods for crab shells;
- UMB (Norway): Novel enzymes and enzyme cocktails for the depolymerisation of chitin/chitosan;
- UMB: Novel oil yeasts to produce high amounts of lipids
- Fraunhofer IGB – Project group BioCat: Novel multi-enzymatic process to produce N-containing heterocycles for polymeric application;
- Fraunhofer ICT – Novel purification methods for bifunctional monomers;
- Apronex (Czech Republic): Optimised expression protocols to upscale enzyme production;
- TUM (Germany): Life cycle analysis;
- Energieinstitut an der Johannes Kepler Universitat Linz GmbH (Austria): Process-Analysis;
- Clariant: optimisation of downstream processing ;
- Evonik: characterisation of polymers;
- Earagail Eisc Teoranta Ltd. (Ireland), Institut National des Sciences et Technologies de la Mer (Tunisia) and PT. Biotech Surindo (Indonesia) : technology transfer options to alternative substrates.

Development stage: Proof of principle, upscaling, piloting

One of the final project goals is the upscaling of the full process chain to make needed enzymes/microbial strains available in kg-scale. Currently the aim is to develop a 1kg demonstrator of a biobased polyamide – current status is at 5-10g dummies for initial testing.

One of ChiBio's current research aims is to find ways of enzymatic depolymerisation of chitin/chitosan as well as the successful separation of new monomers to polymer grade (minimum of 10g for initial testing).

Policy impact: Competitive with petrochemical based products

Enhanced capacity of sustainable processes to compete with petrochemical-based processes is one of the major goals of ChiBio. This will lead to new standards and regulation.

ChiBio contributes to environmental policy action plans, energy policy and eco-technological road maps.

Next Steps: Process optimisation and dissemination

- Characterisation of new polymers and their properties (such as stability, consistency, thermo-mechanical behavior) will be provided by partners from the chemical industry;
- Implementation of large scale processes for the whole production chain is needed for reliable evaluation of lifecycle and process analysis;
- Optimisation of process for different substrates, meaning the processing of chitin containing fishing wastes from different origin. This would be accomplished by ChiBio contributors in Tunisia and Indonesia (Pacific Ocean fishing wastes). Furthermore the technology platform will be evaluated for possible use of different chitin-containing natural recources;
- For a more profitable export, inventions will be included in further publications and secured in patents;
- The new ChiBio technology platform will strengthen the European biotechnology sector on the global market.

ChiBio

Project coordinator: Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB
Contact: Prof. Dr. Volker Sieber
Email: volker.sieber@igb.fraunhofer.de
Website: www.chibiofp7.fraunhofer.de