SYSTEMIC APPROACH TO REDUCE ENERGY DEMAND AND CO2 EMISSIONS OF PROCESSES THAT TRANSFORM AGROFORESTRY WASTE INTO HIGH ADDED VALUE PRODUCTS (REHAP)

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Abstract

REHAP's 15 partners aim at revalorizing agricultural (wheat straw) and forestry (bark) waste through its recovery, and primary (sugars, lignin, tannins) and secondary (sugar acids, carboxylic acids, aromatics and resins) processing to turn them into novel materials, and considering Green Building as business case. The project will provide reductions in utilization of fossil resources of 80-100%, and energy utilization and CO2 emissions above 30%.

Keywords:

lignocellulose waste, lignin, tannins, sugars, building blocks, up-scaling, process engineering, construction sector, bioresins, bioadhesives, bio-insulation foam, biosuperplastificant, revalorization

1 INTRODUCTION

REHAP is an ongoing European H2020 project for circular bio-economy that started October 2016.

Agricultural and forestry residues are being used in many new innovative ways. This bio-based chemical industry is now showing greater growth than the petrochemical industry. The development of chemicals and materials from lignocellulosic biomass (plant dry matter) is a particularly important area in terms of research, thanks to the abundance of these resources and because they do not compete with the food chain. However, the conversion of lignocellulosic biomass is not easy and still has little commercial viability.

Specifically, building blocks (1,4 and 2,3-Butanediol, esterpolyols), materials (polyurethanes, phenolic resins, modified hydrolysis lignin) and products (wooden boards, insulation foams, cement, adhesive) will be obtained:

- Isolation of tannins and carbohydrates from forestry waste to turn them into bio-phenolic resins for wooden panels and isocyanate-free polyurethanes (PU) for insulating foams, respectively.
- Isolation of lignin and carbohydrates from agricultural waste to turn them into bio-phenolic resins for wooden panels and biosuperplasticizers for cement, and esterpolyol PU for adhesives, respectively.
- Fire retardant lignin and sugar-based additives will be also developed.

Developed processing technologies (chemo/thermo/enzymatic and fermentation) will be optimized at pilot scale (TRL6-7) for further exploitation and replication of results. All products will be integrated in a prototype to demonstrate industrial applicability into the Green Construction sector. Throughout the project, Life Cycle and Cost Assessment, market analysis, business plan, waste management strategy and measures for future standardization will be implemented using a systemic perspective approach.

2 PROJECT NOVELTIES AND PARTNER IMPLICATIONS

- **Processing of lignocellulosic waste, optimization of the obtaining of building blocks and scaling-up of the processes.** Current processes demonstrated at R&D level by REHAP partners will be transferred to the industrial environment. Starting from fractionation and purification processes developed by VTT, new chemical routes will be developed by innovative companies such as BIOSYNCAUCHO, NOVAMONT and TECNALIA and VTT as singular building blocks developers.
- **Conversion, optimization and scaling-up of new building blocks as well as bioresins and products developed therefrom** (biophenolics, bioesterpolyols, biosuperplasticizers and non-isocyanate polyurethanes/NIPUs). These new molecules coming from agroforestry wastes are not yet available in Europe. Companies engaged with these new routes are FORESA, CUSA and RAMPF.
- **Demonstration of the technical-environmental-economic feasibility of the product use in the construction sector, with important mass consumption prospective by the companies.** FORESA, COLLANTI, LAFARGEHOLCIM and

RAMPF, all of them responsible for creating different industrial solutions. Finally, FORESA will design and make a prototype system based on all the particular developments, capable of reaching the market, as a solution for Green Buildings as a case study, in order to ensure its use in large quantities.

3 AIM AND TECHNICAL OBJECTIVES

The overall aim of the project is to develop bio-residue based materials to achieve low embodied energy, and energy- and cost-efficient building solutions. For this purpose, chemical and enzymatic processes will be developed and optimized to convert agroforestry wastes (bark and wheat straw) into sustainable polymer precursors and resins with low carbon footprint and additionally reduced cost, using industrially feasible and up-scalable processes. The developed technologies will support the valorisation of waste materials in new high added-value products to substitute traditional solutions in massive consumption fields:

Technical Objectives

1. Development of novel and feasible chemical routes to convert natural wastes into sustainable polyurethanes. Sugars from wheat straw and forestry waste will be the base to develop polyols for polyurethanes (PU) and Non Isocyanate Polyurethanes (NIPUs). These bioresins will be used to develop insulation foams and to provide interlayer adhesives for the construction solution. Additionally, fire retardant molecules will be also developed by modification of these sugars.

2. Development of new high performance bioresins to substitute non-renewable solutions in panels for building applications. Tannins and lignin from forestry waste and wheat straw, respectively, will be used as precursors of biophenolic resins to produce ecofriendly wooden panels.

3. Production of eco-friendly sustainable cement with improved properties. Superplasticizers will be obtained from wheat straw hydrolysis lignin and added to improve mortar rheology and enhance the mechanical properties of cementitious materials.

4. Design and assembly of an environmentally sustainable and fire resistant constructive solution. Design and assembly of a constructive system based on the developed sustainable products from Objectives 1, 2 and 3.

5. Demonstration of the development of eco-friendly products and their integration on a sustainable construction solution. LCA (environmental and social), LCC, market assessments, a business plan and a demonstrator will be developed to prove the sustainability and business potential compared to existing solutions. Key Performance Indicators (KPI) will be also set up for environmental, social and economic impacts and they will be compared with benchmark calculations. Moreover, an integrated waste management strategy will be assessed and measures and guidelines for future standardisation of the new products will be provided to assure commercial potential of the new materials and products.

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Fig. 1: REHAP project scheme