Layman´s Report

Life COMPOlive

New generation of bioCOMPosites based on OLIVE fibers for industrial application

The LIFE COMP0LIVE project has received funding from the LIFE programme of the European Union

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LIFE-COMP0LIVE PROJECT (LIFE18-ENV/ES/000309)

“NEW GENERATION OF BIOCOMPOSITES BASED ON OLIVE FIBER FOR INDUSTRIAL APPLICATIONS”

Duration: 4 years
Total costs: 1.818.362 €
LIFE programme contribution: 946.826 €

LEADER: andaltec CENTRO TECNOLÓGICO DEL PLÁSTICO

PARTNERS: CITOLIVA, Universidad de Jaén, Ford, MATRICERÍA PEÑA, caliplast OUVRONS NOS HORIZONS, Plasturgia

Introduction

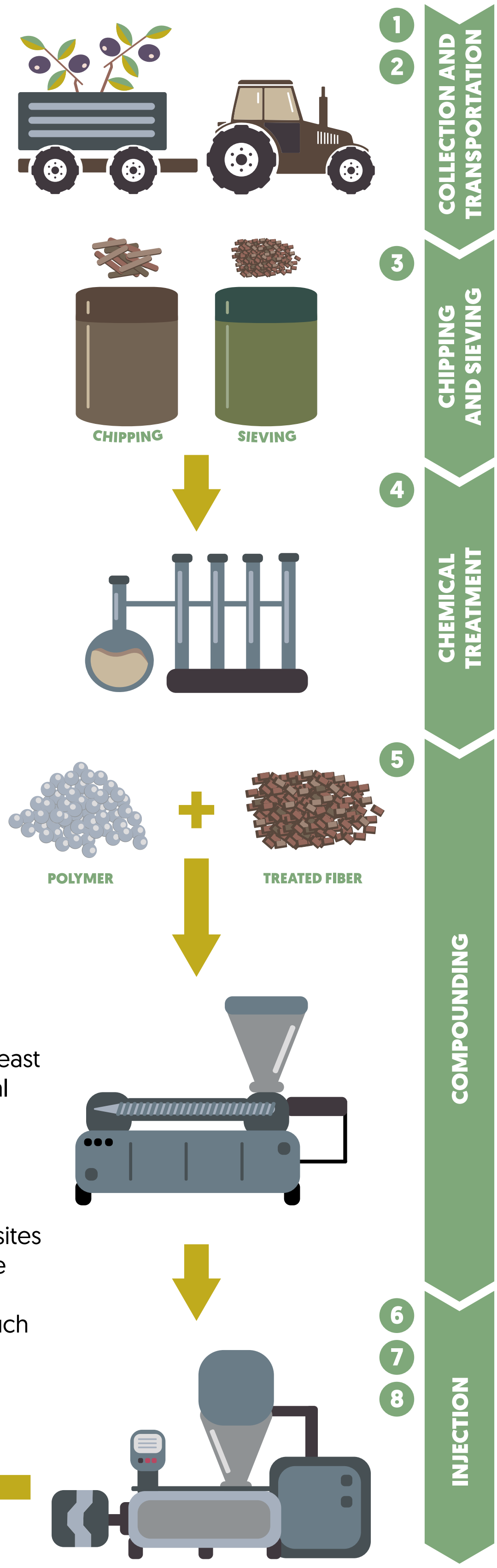
The **LIFE-COMP0LIVE project** aims to capitalize on natural fibers as reinforcement for polymeric matrices, forming biocomposites and offering a compelling alternative to synthetic fibers due to lower density, cost, and intrinsic biodegradability. Focusing on utilizing wood from olive tree pruning (OTP), a byproduct of olive cultivation, the project addresses significant waste generation issues (2,000-3,000 kg biomass ha^{-1}) and proposes OTP as a viable source for reinforcing polymeric materials. Unlike other natural fibers, OTP abundance ensures a stable industrial supply without competing with alternative uses and, in addition, it is a byproduct that does not need to be planted.

The project's motivations span legislative, environmental, technical, economic, and social aspects, including the promotion of legislation to support material use from olive grove waste, producing more sustainable polymer-based composites, and contributing to the circular economy. The endeavor aligns with European regulations promoting recycled materials in industries like automotive manufacturing (Directive 2000/53/EC). The economic and social benefits involve the development of customized materials from OTP, enhancing business opportunities in olive-producing regions and fostering a positive impact on local economies.

Process

Obtaining a product made with biocomposite is carried out in the LIFE-COMPOLIVE project through the following stages:

1. Collection and pre-chipping of olive tree pruning residues in the cultivation area itself.
2. Transportation of the biomass from the field to the processing facilities to obtain the olive fiber.
3. Chipping and sieving of biomass to obtain olive fiber with selected granulometry.
4. Chemical treatment of olive fiber.
5. Insertion of the olive fiber in the polymeric matrix by means of compounding technology to obtain the polymeric biocomposite.
6. Characterization of biocomposites and optimization of their properties to adapt them to the requirements of end users.
7. Scaling of the biocomposite manufacturing process.
8. Manufacture of prototype parts by injection and extrusion technologies using the developed biocomposites.



What is a BIOCOMPOSITE?

It is a composite material formed by two or more different constituent materials, where at least one of them comes from natural sources. One of the most ancient examples is the adobe. **Polymeric biocomposites** are those biocomposites whose matrix is made up of a material of a polymeric nature, such as polypropylene.

FIGURE 1. Detailed scheme of the process of transforming olive pruning fiber into new biocomposite type materials.

Objectives

The **LIFE-COMP0LIVE project** outlines specific objectives rooted in Circular Economy principles to optimize the valorization of agricultural waste from olive grove pruning. These objectives span various domains, including environmental protection, legislative advancements and public awareness. The defined goals are as follows:

- Efficiently utilize 30-40% by weight of the gathered olive pruning waste, transforming it into valuable resources.
- Decrease the reliance on fossil-based plastics by incorporating 10-40 wt.% natural fiber from OTP into polymer matrices.
- Minimize carbon dioxide emissions associated with traditional plastic manufacturing processes through the adoption of sustainable materials.
- Innovate waste management practices by establishing three novel business models within the emerging value chain of the olive sector.
- Promote ecological economy principles and responsible management of olive grove waste to increase awareness and sensitivity in the primary sector.
- Pave the way for sustainable material development by creating new materials and showcasing manufacturing demonstrators for final products derived from these materials.

These objectives collectively align with the overarching aim of fostering a circular economy, emphasizing resource efficiency, waste reduction, and the creation of innovative models that benefit both the environment and the olive sector.

1. Logistic of olive pruning

The initial phase confirmed the potential of olive tree pruning (OTP) waste in the European Mediterranean regions as a renewable resource for polymer-based composite materials. Economic analysis of waste logistics, exemplified around a region in the South of Spain, was conducted. To replicate the supply chain at a pilot scale, operations included pre-selection and pre-shredding in the olive grove, followed by shredding to produce wood particles suitable for integration into polymer matrices using melt compounding technology.

FIGURE 2. Olive tree pruning in the growing area.

2. Material selection and biocomposite development

The fibers obtained from the previous stage underwent comprehensive characterization, including morphological, chemical, thermal, and physical properties. Techniques such as SEM, FT-IR, and DSC were employed for analysis.

Following this, optimization of fiber format was conducted to ensure optimal coupling with the polymer matrix. Polymer matrices, selected based on recycled or renewable sources (e.g., polypropylene -PP-, recycled polypropylene -rPP-, recycled polyethylene -rPE-, polylactic acid -PLA-...etc.), met industrial requirements for final products. Chemical treatments on fibers were defined to eliminate unnecessary components from OTP, optimize chemical behavior, and enhance stress transmission from the polymer matrix, optimizing mechanical properties of the final biocomposite material.

FIGURE 3. Shredded and sieved wood fiber from OTP waste (left), reaction configuration necessary to carry out chemical treatment of the fiber on a laboratory scale (center) and chemically treated OTP fiber (right).

Mathematical models and response surfaces guided the identification of the most optimal biocomposite solutions for each application. Subsequently, up to 8 different biocomposites were manufactured on a laboratory scale to meet mechanical requirements specified by end users. Their properties were determined from specimens obtained through injection molding technology. Characterization involved tensile, flexural, and impact strength, as well as thermal and structural properties, comparing results with predefined requirements. Finally, those with superior properties were selected for large-scale production.

FIGURE 4. Manufacture of biocomposite at laboratory scale.

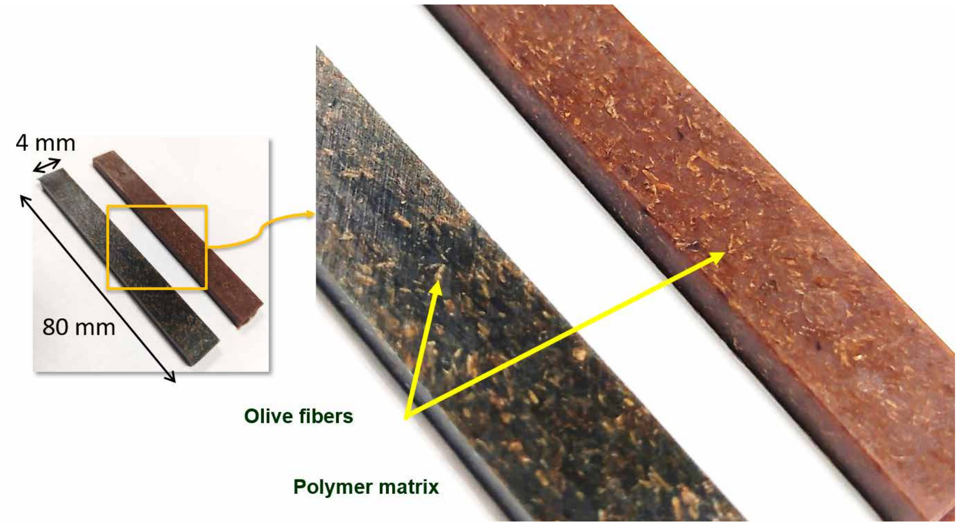


FIGURE 5. Biocomposite samples manufactured using injection molding technology and detail of the fiber within the polymer matrix.

The characterizations revealed that the selected biocomposites exhibited improved mechanical properties compared to the unreinforced polymer matrix, meeting specific mechanical requirements for various industrial applications as defined by end users.

3. Scaling up the biocomposites manufacturing process

The initial laboratory-level material development phases successfully met end-user requirements for mechanical, thermal, and appearance aspects. In the subsequent scaling stage, up to 5 biocomposite materials with pellet format, containing up to 40 wt.% OTP fiber, were produced in significant quantities (over 800 kg total). This material was utilized to manufacture prototypes for various applications, demonstrating the feasibility of industrializing the solution. The large-scale production aimed at conducting industrial tests for suitable demonstrators, necessitating a substantial material quantity.

Fiber preconditioning scaling, involving chopping and sieving, was successfully achieved using industrial means. Pilot-scale chemical treatment of the fiber in a 50 L reactor resulted in approximately 300 kg of treated fiber, sufficient for producing over 800 kg of biocomposite.

Following the successful fiber preparation, industrial-scale manufacturing of polymer biocomposites in pellet format occurred using an extrusion-pelletizing line. Materials produced with industrial methods were also characterized to obtain the properties of the materials with which the final demonstrators were manufactured. Additionally, two biocomposite materials underwent specific characterization for rheological injection model simulations using engineering software.

FIGURE 6. Scaling up of the chemical treatment of OTP fiber.

FIGURE 7. Extrusion process to manufacture biocomposite materials on an industrial scale (left), and pellets of biocomposite material resulting from the manufacturing process (right)

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A comprehensive cost analysis across production phases determined the cost-effectiveness of the industrial-scale biocomposite materials compared to conventional polymeric materials like raw PP and rPP. The results indicated a highly competitive cost for the biocomposites manufactured on an industrial scale.

4. Manufacture of industrial demonstrations

At this project stage, a significant amount of biocomposite material was utilized to refine manufacturing processes for end-user demonstrators. Mandatory tasks included optimizing part and mold designs, manufacturing molds and tooling, and simulating processes with engineering software. Demonstrators for Ford-Werke GmbH, like the footrest for the Ford Focus and trunk trims for the Ford Mondeo, were produced via injection molding, emphasizing the visibility of olive pruning fibers in the final product.

FIGURE 8. Ford Focus footrest prototype and Ford Mondeo trunk trim prototype.

Matricería Peña S.L. utilized extrusion technology to manufacture diverse profiles for street furniture applications, creating various bench models.

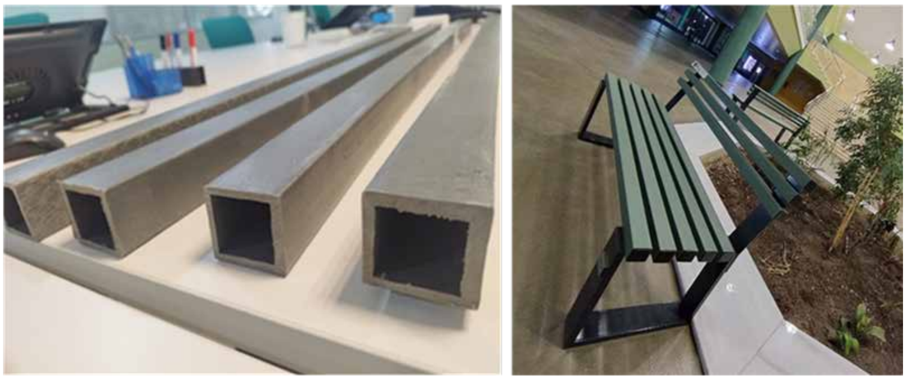

FIGURE 9. Some examples of the profiles manufactured by extrusion (left) and bench prototype manufactured from the profiles obtained (right).

Caliplast's home furniture pieces were also injection-molded.

FIGURE 10. Some examples of manufactured parts and prototype of the final product manufactured with said parts during their assembly.

Some demonstrators underwent validation tests defined by end-users to determine if they met requirements for commercialization. It was achieved a successful integration of olive pruning fibers in diverse applications, highlighting the versatility of the biocomposite material.

5. Life cycle assessment

The LIFE-COMP0LIVE project conducted a life cycle assessment (LCA) comparing the environmental impact of the developed biocomposite, rPP, with a conventional industrial composite made of PP and talc (5 wt.%). The "Comp0live biocomposite" underwent modeling through various manufacturing stages until obtaining pellet form, encompassing processes from olive pruning collection to compounding, including biomass size reduction and chemical treatment of olive fibers. This approach follows the "cradle to gate" concept, covering the entire lifecycle until the material reaches the pellet stage.

Applying the ReCiPe methodology in both Midpoint and Endpoint approaches, the LCA results revealed a 46% reduction in the carbon footprint when using the Comp0live biocomposite compared to a conventional PP-based industrial composite. This underscores the environmental advantage of the developed biocomposite material in terms of reduced carbon emissions.

Impact of the LIFE-COMP0LIVE project

The LIFE-COMP0LIVE project's results hold significant potential for a new business model centered on utilizing and valorizing OTP waste through polymer biocomposites in various industrial sectors like automotive and furniture. This innovation promises economic, environmental, and social benefits. The abundance, low cost, and localized availability of OTP, coupled with minimal modified preexisting machinery requirements for transforming the biocomposites, contribute to the competitiveness and customizability of the resulting material. The project not only demonstrates environmental and technical advantages but also economic and social merits.

Economically, the project's solution is promising, with sufficient annual OTP waste to meet industrial demands in sectors such as furniture and automotive. Market opportunities include the need for machinery for precise OTP fiber extraction and the adaptability of processing technology, allowing the use of existing extrusion and injection molding machines. Importantly, the production costs of these biocomposites are comparable to conventional polymers. The ability to tailor biocomposites to specific industrial requirements and the circular economy principles underlying the technical solution further enhance the project's economic potential.

Regarding the communication actions, the project has had a considerable impact. Below are some relevant data that help to get an idea of the scope achieved.

Life COMPOlive

8,600
PAGE VIEWS ON WEBSITE

234
PRESS IMPACTS

116,286
IMPRESSIONS ON SOCIAL NETWORKS

35
PRESENCE AT EVENTS/NETWORKING

3/155
WORKSHOPS / INTERESTED STACKEHOLDERS

2
INTERNATIONAL AWARDS: EL ARCO / IBEROLEUM

FIGURE 11. Awareness of the project by the targeted audiences.

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