

# 1. FORBIOPLAST Publishable summary

## Project context and Objectives:

The EC project FORBIOPLAST, grant agreement no. 212239, started on the 1<sup>st</sup> July 2008. The research activity in FORBIOPLAST is focused on the use of by-products from wood production and paper mill as raw materials for the production of composites with biodegradable and recycled polymers as well as for the production of hard and soft polyurethane foams by innovative sustainable synthetic processes with reduced energy consumption. The materials produced in the project are devoted to applications in automotive interior parts and in the packaging and agriculture fields.



The main objectives of FORBIOPLAST were:

- valorisation of forest resources for bio-based products production;
- identification of the best ways for industrial exploitation of forest biomass at European scale;
- production of polyurethanes from materials based on renewable resources;
- development of improved technologies with regard to the present industrial synthesis of polyurethane and target of an industrial scale up of the process;
- replacement of glass fibres and mineral fillers with wood derived fibres in automotive interior and exterior parts;
- development of biodegradable polymer/wood derived fibre composites for application in the packaging, cosmetic and agriculture fields;
- bio-valorization of FORBIOPLAST products after their use
- eco-sustainability evaluated by LCA studies in the production chain of FORBIOPLAST products

The consortium coordinated by Prof. A Lazzeri of the University of Pisa has a very positive interaction among the members as attested by the regular reaching of the scheduled deadlines. The researchers: University of Pisa (UNIPi-Italy-RTD), University of Budapest (LPRT-Hungary-RTD), the Latvian State Institute of Wood Chemistry (IWC-Latvia-RTD), University of Almeria (UAL-RTD) and Fundacion CARTIF (CARTIF-RTD) (Spain), University of Bucharest (UASVM-Romania-RTD), Organic Waste Systems (OWS-Belgium-SME), Norconserv A.S. (NORC-Norway-SME) constantly cooperated with the producer PEMU Plastic Processing Co. (PEMU-Hungary-IND), RODAX (RODAX-SME) and Incerplast (INCP-SME) (Romania), Ritols Ltd. (RIT-Latvia-SME) and end users FIAT Research Centre (CRF-Italy-IND), Neochimiki (NEOC-IND) and Cosmetic (COS-SME) (Greece) with the inputs of Wiedeman (WIED-Germany) a market expert in the exploitation of environmentally friendly materials.

The final meeting was held in Siofok, Lake Balaton, Hungary, at the end of the BiPoCo International Conference on Bio-based Polymers and Composites. The conference was organised by Partner LPRT and joined the participation of members of FORBIOPLAST consortium and advisory board as well as of the projects WOODY and BIOSTRUCT.

The Conference has a large attendance and was very positive. Partner LPRT will organise a second edition in 2014.

The FORBIOPLAST website is on line with the following address: <http://www.forbioplast.eu> and has been regularly updated. The website is divided into a public area for all the users and into a restricted area for beneficiaries and selected members of the Industrial Advisory Board.

The "publishable summaries" and the news letter were translated in the languages present in the consortium (Italian, Spanish, German, French-Flemish, Hungarian, Romanian, Latvian, Norwegian, and Greek) and load in the public area.

### **Description of work performed since the beginning of the project and main results achieved**

The cooperation of researchers with industries lead to the production of prototypes of soft and hard foam and to the introduction of wood fibres in the foams. Prototypes were obtained with polyurethane produced by substances derived by forest resources. Rigid polyurethane foams were used to produce a T-node (40x40 cm) part and a spoiler (1.4 m) for automotive applications. Soft polyurethane foams produced by lignin were proposed for applications in packaging and insulation.



Examples of prototypes based on hard and soft PU foams

Large amounts of granules were produced from the most promising recipes selected, based on recycled polypropylene and wood fibres. The pellets were sent to the industrial partner (FIAT) that performed injection moulding trials. They were produced car seat prototypes. The prototypes passed the test from FIAT and resulted suitable for production and marketing.



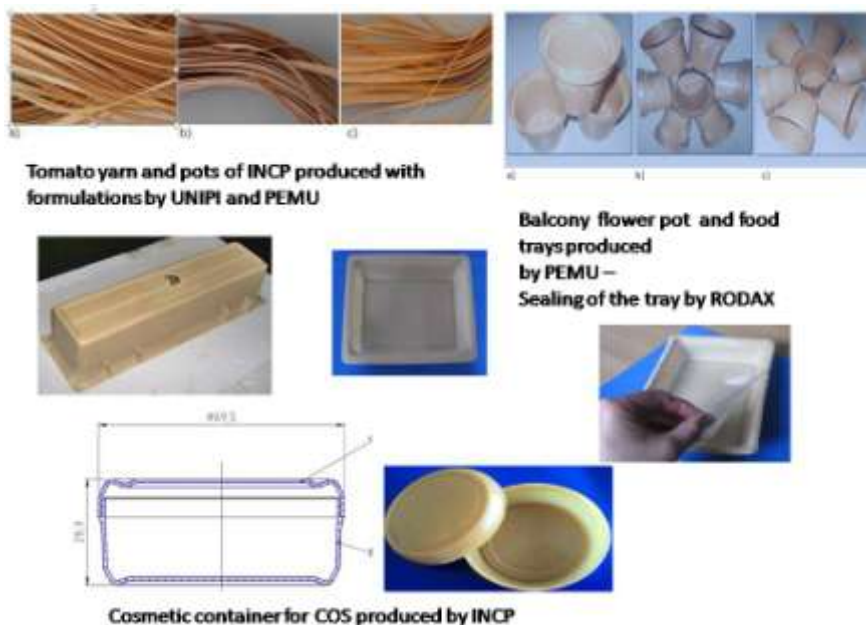
Car seat

They were produced items for agriculture and packaging applications based on the formulations selected by the researchers. The formulations were based on biodegradable polymeric matrices and wood fibres. Materials were also prepared with wood fibres pre-treated by the addition of waxes and with wood fibres modified by enzymes.

Tomato yarns were tested in trials set in green houses and in open fields. Some of the prototypes prepared fulfilled the requirements of the cultivar cycle. These tomato yarns can be collected with the organic remaining of the tomato harvest and sent to a compost plant. Tests were also organised to the transplanting pots and in packaging for the trays, and egg containers.

Some slow release fertilizers were prepared as sticks based on starch and wood fibres enriched with Nitrogen-Phosphorus-Potassium (NPK) components.

The materials produced for packaging applications were tested for properties relevant to packaging (sealing ability, permeation to gas and water, toxicity etc). The end users producers of cosmetics products and of chemicals performed tests on the containers produced for packaging on their products which allowed to identify the best formulation for each single applications.



Materials based biodegradable polymers and wood for applications in packaging and agriculture

They were evaluated also the degradability and the anaerobic digestion of the most representative of the materials prepared. The materials based on biodegradable polymers and wood fibres resulted compostable. It was extremely interesting to find out that the use of fibres modified by enzymes improves the biogas production in anaerobic digestion than what observed for samples prepared with the raw wood fibres. Thus the treatment with enzymes modifies the fibres making them more prompt to degradation in anaerobic conditions.

The data for the Life Cycle Assessment (LCA) analysis on materials based on biodegradable polymer and wood fibres and automotive components, were collected and they were performed the LCA studies. The benefit in the use of FORBIOPLAST materials are mainly connected with the use of materials from renewable resources and the opportunity to send to compost plan the materials after use versus landfill or incineration options for not degradable materials.

The FORBIOPLAST website is successfully online with full access for FORBIOPLAST beneficiaries and restricted for guests. Beneficiaries communicate regularly with good attendance at the project meetings, dissemination in workshops and meeting participations.

### **Expected final results and their potential impact and use**

The results and the prototypes produced in FORBIOPLAST attest for the possible valorisation of forest biomass for the production of environmentally compatible materials to be applied in packaging, agriculture and automotives. These materials include composites based on biodegradable polymeric matrices, or recycled polypropylene with lignin or wood fibres and hard and soft polyurethane, eventually loaded with wood fibres produced by green synthesis from tall oils or lignin.

The research activity performed in the project had a significant impact on the RTDs performers in terms of increased knowledge, new contact, positive cooperation and experience acquired in working with industries. Problems from the perspectives of the industrial users and producers were evaluated, and with these impressions the RTDs were able to attend the necessities required by the local industries.

With regard to the FORBIOPLAST materials devoted to agricultural market segment, questionnaires have been prepared and evaluated striving for the best opportunities of market entrance for the agriculture product portfolio.

From this portfolio, tomato yarn, plant pots and encapsulated fertilizer, which have been developed at pilot scale, were treated within market analysis.

Within FORBIOPLAST, bio-based and biodegradable yarn for trellising tomatoes has been evolved at pilot scale. After potato, tomato is the second most important vegetable plant in the world. With a total amount of 17.9 million t harvested on 314209 ha in 2009, around 12% of global tomato production occurred in EU-27.

Since requested amount of yarn is approximately 350 kg per ha, the amount of string for that purpose which could be substituted in EU-27 would exceed 100.000 tonnes. Materials currently under use are polypropylene, polyethylene, raffia and other natural fibres like jute. Applications beyond tomato could be for other crops like cucumber and paprika, flowers and ornamental plants, trees grafting, tying of grapes and straw bales.

Biodegradable plant pots have been manufactured and tested within the project. Crucial requirements for pots to be marketed in horticulture are no negative impact on plant growing, suitable for potting machines, no negative effect on workflow, stability, low weight, low costs, printable and bondable (EAN-Code). Apart from horticulture, possible applications could be ornamental and flower plants, breeding perennials, tree nursery and aquatic plants. A possible demand in Buzau/Romania exceeds 10.000 pieces p.a.

As a further product devoted to the agricultural market segment, an encapsulated fertilizer with a bio-based and biodegradable coating is created within the project.

The global market for coated fertilizers shows tremendous growing rates and this type of fertilizer is more and more applied in major agriculture crops like cereals and potatoes. Among the advantages of these fertilizers are a possible reduction of fertilizer application quantity and full nutrient supply for plants under plastic cover. Moreover, with the bio-based and biodegradable coating, the drawback of plastic residues (up to 50 kg/ha/year) can be avoided.

The FORBIOPLAST project has developed the process of a new generation of packaging solutions using renewable and fully recyclable materials that also respond to the growing packaging market. The future for fibre-based packaging will require the re-engineering of the packaging value chain to deliver increased, capital efficiency, product innovation and more competitive packaging materials.

In 2010, the production of eggs (eggs in shell) has reached a quantity of around 112 billion pieces in the European Union. An egg production of 14,5 billion pieces was documented in Italy, an amount of 13,5 billion pieces in France, 13,3 billion pieces in Spain and in Hungary an amount of 2,7 billion pieces.

Following these figures, FORBIOPLAST egg cartons could serve a large market in Europe. Cosmetic is a very important industry sector in Europe. Following a market study of Global Insight, the European market size of cosmetics and toiletries was 63,5 billion € in 2006. That means about the value of the combined market size of USA (38,2 billion €) and Japan (23,7 billion €). The Chinese market was valued with 8,2 billion € in 2006.

FORBIOPLAST research and development in the cosmetic packaging area and its outcomes offer bio-based and sustainable solutions for cosmetics industries.

Partner INCP has produced a prototype of a chemical container that was tested by Partner NEOC. The chemicals, plastics and rubber industries belong to the most dynamic and most relevant industrial areas in the European Union. In more than 60.000 companies are around 3,2 million persons employed, which have created a turnover of 537 billion € in 2007 (~30% of global chemical sales). Sustainable development is a topic which is set out in the Treaty on European Union and the chemicals industry will contribute to solve the problems like global warming and decline of natural resources with new materials and technologies towards increasing sustainability. Bio-based chemical containers as generated within FORBIOPLAST are tailor-made for offering sustainable solutions to chemical industries.

European strategy on clean and energy efficient vehicles has been set up in 2010.

"The strategy proposed the European action where it can have distinct, value-added and complement the actions by the industry, national and regional public authorities."

The main objectives of the European Commission concerning the automotive sector are: To strengthen the competitiveness of the Automotive Industry, To complete, adapt and simplify the Internal Market regulatory framework, To promote globalization of the technical regulatory framework through UNECE. In order to achieve these ambitious goals, legislation in the European Union is focussed From a total demand of 52,5 million tonnes of plastics, 18% of this request was polypropylene in 2007. Considering the environmental issues of plastics in Europe (EU27/NO/CH), it has been reported that 50% of the plastics have been recovered either for materials (20,4%) or for generating energy (29,4%). Recycled polypropylene plays a crucial role in development of ecological automotive parts (seat system) within the project.

Polyurethanes (PUR), often described as the most versatile plastics materials, are produced with remarkable share from bio-based feedstock (tall oil and lignin) within FORBIOPLAST research towards end uses in automotive acoustic insulation, spoilers and packaging such as fish transport boxes (Rigid PUR). Lignin-based Soft PUR can be applied e.g. in furniture industry as the biggest consumer of PUR in Europe (2005) as

well as in automotive sector. Opposed to bio-based polyols from vegetable oils already introduced onto the market, FORBIOPLAST polyols are generated from waste material of pulp industry and their raw materials are commonly not grown on agriculture crop areas.

New efficient methods of processing and new materials are generated as a result of the activities undertaken within the project. Saving raw materials and reducing costs for manufacturing and logistics will supply competitive products and secure employment. Energy consumption and effects of greenhouse gas emissions will be reduced by the exploitation of the new materials and commodities. Due to the new technologies customers benefits will be the availability of items with improved quality and lower prices related to environmentally friendly waste disposal. Renewable resources are continually renewed by the cycle of nature and are considered to be practically inexhaustible.