DELIVERABLE D.T2.1.2 REPORT BASED ON THE OUTCOMES OF THE BUSINESS SUPPORT SERVICE

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1. TRENDS IN EUROPE

1.1. BIOPLASTICS

Polymeric materials are the youngest in the comparison with other packaging materials. More than 90 % of flexible packaging is made of polymers. In past thirty years, the world production and use of polymers have been enormously increased, worsening the problem of waste disposal and significant leakage of plastic in the environment, especially in the sea. It is estimated that at least 8 million tons of plastic end up in the ocean and EU countries are responsible for 150 – 500 k tons. Plastic packaging represents the major share of this pollution.

The growing interest about the impact of discarded polymeric packaging on the environment has stimulated the development of polymers degradable more rapidly in the environment, leading to a complete mineralization or bioassimilation. Biodegradable polymers should be used in those application where biodegradability and/or derivation of natural resources gives added value, particularly, when conventional polymeric materials are used for applications of short lifetime.

The idea of replacing conventional non-biodegradable with biodegradable polymers is not new. It takes large proportions of interest from manufacturer's side but also public side encourage with higher ecological awareness. At the same time it is also necessary to emphasize to manufacturers and to end users the difference between **biopolymers** and **biodegradable polymers** and to point out what is biodegradation and composting. It is quite often mistake to use some term but without knowledge what is hidden behind that word.

1.2. PACKAGING MARKET

Majority of actors in the value chain exist in Croatian market of paper and plastic/bioplastic. However, due to the obviously rising market, the data are not available in official statistics. The most significant companies in packaging production in Croatia are listed below and their geographical position is shown in Figure 2.

Practically, there is no production of biodegradable i.e. compostable polymer materials in Croatia. Only few companies import these materials and process them into film and foils. Also, use of compostable packaging in Croatia and Split-Dalmatian County is on low level.

Nowadays, use of packaging is monitored from more points of view, especially regarding the circular economy and the sustainable waste management. Circular economy is based on the closed loop in industrial systems, aimed to reduce waste, raw materials and energy consumption. Practical solutions for this approach involve eco-design, waste prevention programs and extending the life time of products.

1.3. REGULATORY ENVIRONMENT

The best way is to use the European standards to clear all misconceptions. First, it is necessary to define what is meant by the term of biodegradation. According to the European Standard

EN13432, biodegradable means that materials are degraded after use into low molecular weight substances by combined action of physico-chemical agents (e.g. sunlight) and microorganisms (e.g. composting), ultimately degrading into carbon dioxide, water and biomass. A material is **compostable** when it is biodegradable under composting conditions.

2. COUNTRY SPECIFIC DATA – CROATIA

2.1. CROATIAN MARKET

Croatian plastic packaging manufacturers are gathered in the *Association of Plastics and Rubber Industry (UIPG)* of the Croatian Chamber of Economy (HGK).

Plastic industry is one of the few domestic economic activities that are continuously growing in the Republic of Croatia. Manufacturing of semi-finished and finished plastic and rubber products in 2014 amounted to 158,577 tons, while in 2006 it amounted to 96,790 tons, which is a 39% increase. In 2016, the plastics industry recorded a production of 198,000 tons.

Since the Croatian market is small, companies in this industry earn the highest revenue by exporting their products to foreign markets, and in 2017 the export of this sector was worth EUR 707 million.

The plastic and rubber sector in the Croatian industry today does not have a large share in domestic gross domestic product and exports, but it shows very high vitality. About 700 companies with more than 8,500 workers are registered in plastic and rubber processing industries in Croatia. Plastic production is performed by 615 companies, accounting for about 5.6% of total registered companies in the manufacturing industry.

Constant rise of plastic and rubber production and application put in the focus the plastic and rubber waste management. In the European households and the sectors of all producing industries was estimated more than 80 million tons of packaging waste evolved per year. Regarding the circular economy, proper manipulation with packaging waste is the challenge for packaging producers, customers and scientific society as well.

2.2. BIOPLASTICS AND BIOCOMPOSITES MARKET IN CROATIA

Field of bioplastic materials in the Republic of Croatia is at a very early stage. Croatia's innovation performance over the last decade has fallen short of expectations. Based on information from HGK (Croatian Chamber of Commerce), there is no possibility at this moment to identify bioplastics manufacturers through existing official bases. Namely, producers and production of semi-finished and finished products are monitored by the National Classification of Economic Activity (NKD) for all polymers. The production of the polymer is monitored according to the type of material but unfortunately the production of biopolymers in the Republic of Croatia for now does not exist according to official data and statistics. However, there is a production of biopolymer bags produced by companies Weltplast, EcoCortec and Mi-plast in Croatia.

Unfortunately, there is no manufacturer in the Republic of Croatia that produces biodegradable polymers from any of the biodegradable polymer groups, just companies that deals with processing of purchased material made of biodegradable polymers, as already said. Republic of Croatia has huge agriculture potential, but the land is not cultivated and can be used to harvest wheat, potatoes and corn, as a renewable source for some biodegradable polymers. These sources can be also used to produce other materials or additives that have to be mixed with biodegradable polymers to obtain adequate processing options and final product properties. Obtained material is called biodegradable polymeric material or biodegradable plastic. Those additives or materials include stabilization additives, lubricants, pigments, different fillers, and others. For biodegradable plastics it is very important that all components of polymeric material are biodegradable.

The innovation system is operating below its potential, whether measured by the system's inputs, outputs or by the contribution of innovation to economic growth. Croatia is significantly below EU-average in innovation and belongs to a group of countries considered as moderate innovators. There are two major companies at the market that produce biodegradable films and foils, EcoCortec in Beli Manastir and Weltplast in Odra, Zagreb. In its production program, Eco Cortec offers products based on three types of biodegradable polymers – PLA, PHA and fossil-based biodegradable polymer, while Weltplast works with BASF biodegradable polymers.

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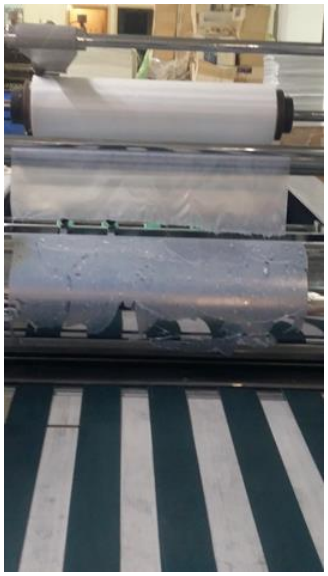
3. ECONOMIC FEASIBILITY STUDY ON SOLUTION AND CONCLUSION

The attempt to laminate the printed paper for folders with PLA based film was not successful. Due to the fact that the PLA film is formulated for bags, it is obvious that for lamination another formulation is needed.

Also, the fact is that the use of biodegradable material for this purpose is not reasonable. The laminate is impossible to delaminate and the material is not suitable for composting.
Final recommendation is that for the biodegradable materials and the biocomposites specific niche is recommended. It means that simple replacement of non-biodegradable material with biodegradable/ compostable material is meaningless. The first step should be the life cycle assessment of the potential product.



ANALYSIS OF MATERIALS AT THE FACULTY OF CHEMISTRY AND TECHNOLOGY

EcoWorks films, non-sticked and sticked on the roll during the experiment of paper lamination, were analyzed using differential scanning calorimetry (DSC) and infrared spectroscopy (FT-IR) in order to establish the potential thermal changes of material. According to the Figures 1-4 there are no changes of materials chemical or thermal properties during heating in the range 70-90 °C.

Also, the conventional lamination film used in Jafra was identified using FT-IR. It is commercial film composed of polypropilene (glossy side) and hot melt adhesive ethylene-vinyl acetate (opaque side), as shown on Figure 5 and Figure 6, respectively. Identification was made comparing with spectrum of known material from database. Characteristic IR bands for polypropylene are 1456, 1375, 1167, 988, 972, and 840 cm^{-1}.
Ethylene-vinyl acetate were recognized due to the bands at 1737 cm^{-1} (C=O bond) and 1464 cm^{-1} (C-H bond).

Conclusion: Due to the high melting point EcoWorks film cannot adhere to the paper at the working temperature. At higher temperatures it adheres to the rolls.

DSC measurements: samples are cooled from room temperature to 0 °C, then heated to 200°C, maintained 5 minutes at 200°C and then cooled to 0 °C (cooling and heating rates were 20°C/min). All measurements were performed in nitrogen atmosphere with flow rate of 50 mL/min.

FT-IR measurements: identification of samples, as received, was performed using HATR method, with ZnSe crystal. Each spectrum is the result of 10 scans and resolution of 4 cm^{-1}.