



# Newsletter Elasto-Plast

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## Thermoplastic Elastomer Demonstrators

In the Interreg France-Wallonië-Vlaanderen Elasto-Plast project, the project team set out to familiarize companies with the potential thermoplastic elastomers (TPE) offer terms of performance and processing advantages. We also set out to investigate limitations of current commercial TPE and to develop new materials that can address these limitations.

To highlight developments and make them more tangible to a wider audience, we took it upon ourselves to develop a series of demonstrators that could highlight the potential of TPE, raise awareness of their behaviour and potential, and showcase interesting new developments.

## Foamed Thermoplastic Elastomers

The addition of blowing agents not only leads to a reduction in



**Fig 1: 1-6: POE + microspheres (0 to 5 % in 1 % intervals), 7-8: POE + 5% exotherm foaming agent/ microspheres (different ratios).**

density of the final product, it can also result in unique product properties, such as sound or temperature damping. In the pictures shown, you can see some examples of foamed polyolefin elastomers (POE) by adding different blowing agents (endothermic, exothermic or microspheres) at different concentrations (0 to 5%). More information about the influence of the different blowing agents on the extrusion process, the density, and the compression set can be found in Newsletter 2.

The POEs used to prepare these samples had a hardness of 61 Shore A and Figure 1 shows the effect of an increasing concentration of microsphere blowing agent (1-6). The concentration of the blowing agent in the last 2 bars (7-8) is also 5%, but this is a combination of an exothermic blowing agent and microspheres in different ratios, which led to an even more pronounced expansion compared to the bar with only a single blowing agent (5 % microspheres) (sample 6).



**Fig 2: POE + endothermic foaming agent (0 tot 5 % in 1 % intervals)**

The use of endothermic blowing agents was hindered by coagulation of the foam bubbles at concentrations as low as 2%. This gave rise to surfaces with a high surface roughness, which could be problematic for some applications.

## Damping Properties of Thermoplastic Elastomers

There is a constantly increasing demand for vibration and sound damping materials. These materials can be used to make buildings vibration-free, to reduce disturbing ambient noise, to reduce the transmission of vibrations from hand tools, etc. When using them to reduce vibration transmission for handheld power tools, they also have to be soft enough for comfort and ergonomics. Vulcanized rubbers were and are still often used for these applications. However, the rubbers used tend to have a performance that is too high for what is desired. Moreover, they cannot be recycled.

TPEs can be used as alternative materials. They are naturally quite soft, flexible, and elastic plastics, but which show little or no attenuation. Depending on the type of "damping" (sound damping or vibration damping), different strategies can be used, such as chemical modification of the soft phase of the TPE, adding specific fillers or cross-linking of the TPE matrix. In the INTERREG Elasto-Plast project, the Elasto-Plast team has mainly investigated the addition of fillers to TPE for this application. Different fillers with different grain size and shape were analysed. The results of this will be discussed during the webinar of 16/03/21 and a demonstrator was built to visualize the effect of fillers on the damping behavior. A movie of the demonstrator will be added to the Elasto-Plast project website and it can be used to test and compare a wide variety of

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different TPEs.

## A Partially Bio-sourced Thermoplastic Elastomers

An important part of the Elasto-Plast project is devoted to the design and synthesis of second generation TPE, i.e. TPE with a new molecular structure. They are carried out by means of new catalytic systems, or by considering new combinations of monomers and polymers. This notably includes biobased polar TPE. The use of biomass as an alternative raw material is interesting for the replacement of fossil resources whose stock is decreasing, but also for the development of new innovative and more efficient products.



**Fig 3: Patch produced from a partially bio-sourced TPE**

We have developed two types of second-generation TPE in which the soft block is biobased, derived from plant oil, and the hard block is based on PMMA (poly(methyl methacrylate)). Figure 3 shows a patch obtained from this material. A second TPE developed has a polyester-type soft block. More information on the chemistry of these materials can be found in Newsletter 5.

## 3D Printing of Thermoplastic Elastomers on Various Substrates

TPE have been tested in 3D printing processes to validate their printability, as well as to study the impact of process parameters on the thermal and mechanical properties of the printed TPE. Depending on the print settings, the elastomers will stick more or less to the printing platform of the 3D printer.

As part of this work, flexible polymer filaments were tested in the 3D printing process to validate the bonding and adhesion between the polymer and various substrates. After our preliminary work we chose the TPE IstroFlex from the company Nanovia to produce our demonstrators. This TPE is a fully biodegradable thermoplastic material, with a hardness of 44 Shore D, intended for the

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manufacture of parts requiring low elasticity and high flexibility. The polymer was printed using a Raise 3D N1 printer and this on different substrates: Textile, ceramic and wood. To quantify the strength of adhesion between the polymer and the substrate, tensile tests were performed with a pulling speed of 5 mm / min and using a force transducer <100 N.



**Fig 4: IstroFlex printed on textile**



**Fig 5: IstroFlex printed on a ceramic substrate**



**Fig 6: IstroFlex printed on wood**

**3D printing on textile (Figure 4)** The textile substrate is characterized by its elasticity and by its porous surface allowing the creation of bonding links between the substrate and the polymer. It is also known for its absorbency making it possible to create bonds with the molten polymer. The bond strength between the two materials was more than sufficient to validate the quality of the demonstrator.

**3D printing on ceramics (Figure 5)** The same TPE filament was printed on a smooth sintered ceramic surface. Printing went well with good adhesion of the polymer to the substrate surface. The adhesion force exceeded 100 N without any sign of detachment, showing that TPEs can be reliably printed onto ceramics.

**3D printing on wood (Figure 6)** The IstroFlex filament was then also tested for printing on a wooden substrate. Again, the print went well with good adhesion between the polymer and the substrate. Good adhesion was achieved due to the roughness of the surface and the absorbency of the wood. The determined bond strength also exceeded 100 N without the polymer detaching from the surface of the wood substrate.

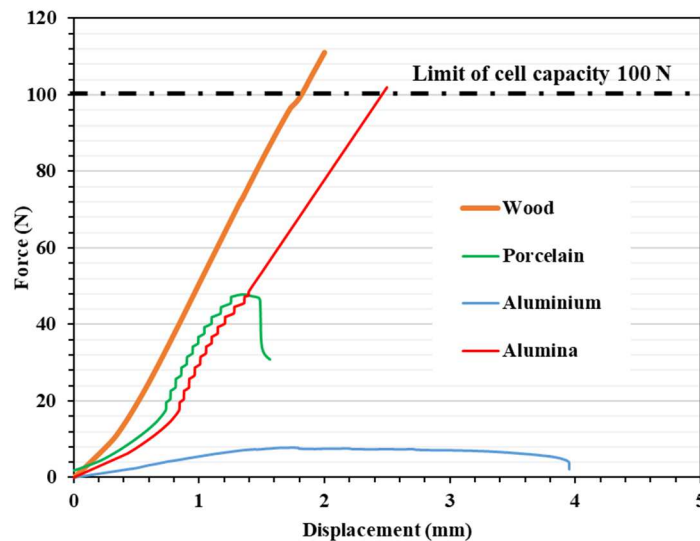
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Determination of the bond strength between the IstroFlex polymer and the various substrates by tensile testing is shown in Figure 7. The 3D printed TPE bonds well to wood and alumina substrates (Bond strength exceeds limit 100 N load cell). The same polymer



**Fig 7: Adhesion strength for printing of IstroFlex on different substrates as measured by tensile tests (Force transducer < 100 N).**

was also printed on porcelain and on an aluminium surface. These two substrates exhibited intermediate adhesion with a maximum adhesion force of 48 N and 8 N, respectively. To conclude, glass support, ceramic and wood

substrates can be used to prepare products with limited adhesion problems during the 3D printing process. With metallic and porcelain surfaces, one should be more careful, and applicability will depend on the final application demands.

## Improving the impact resistance of poly(lactic acid)

One of the goals of the Elasto-Plast project is to use TPE to modify standard thermoplastic polymers to give them more flexibility or a better impact resistance.

Hence, we carried out a study to improve the impact resistance of polylactic acid (PLA), a brittle biobased thermoplastic polymer.

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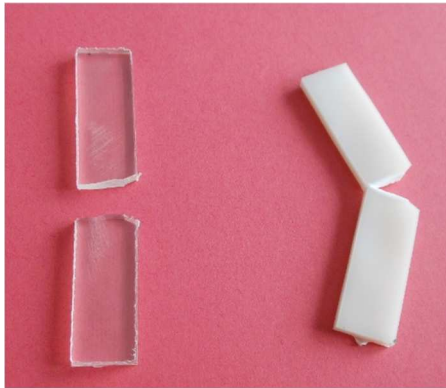


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A blend consisting of 90 wt% PLA and 10 wt% poly(ether-block-ester) (PEBE) was developed. PEBEs represent one of the main families of TPE. This formulation had a remarkable impact resistance ( $E = 56 \text{ kJ/m}^2$ ) after annealing. Annealing increases the crystallinity of the PLA in the mixture.



**Fig 8: PLA test bars after an impact test. On the left, PLA (absorbed energy  $3 \text{ kJ/m}^2$ ) ; on the right, a PLA/PEBE (90/10) blend, absorbed energy  $56 \text{ kJ/m}^2$ .**

Figure 8 shows, on the left, a PLA bar, and on the right, an annealed bar made of the PLA/PEBE mixture (90/10). The photos of the bars were taken after they were struck by the pendulum hammer during an impact test. It can be seen that the PLA bar is broken into two pieces. The energy absorbed by the bar during impact is very low ( $3 \text{ kJ/m}^2$ ). On the other hand, the bar made of the PLA/PEBE blend and annealed is only partially broken during the impact test. The absorbed energy was 56

$\text{kJ/m}^2$ .

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