One piece of the puzzle :Chemistry

Synthesizing Biobased Polyesters

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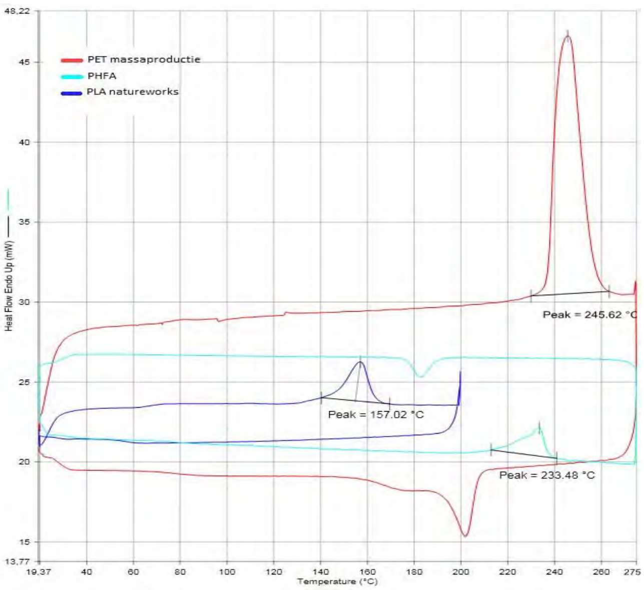
Introduction

Aromatic polyesters, which are of great technical relevance because of their excellent material properties undergo no noticeable hydrolysis in contrast to aliphatic polyesters e.g. polylactic acid. Only limited knowledge about the de-polymerization of aromatic polyesters is currently available. By introducing changes in the aliphatic part of some aromatic biobased polyesters, effects on the degradability will be studied.

Aromatic and aliphatic monomers derived from biomass and used to synthesize polyesters, already make a favorable carbon footprint. However, recovering these monomers from the polymer based material at the end of the technical or economical lifetime, reinforces this impact enormously.

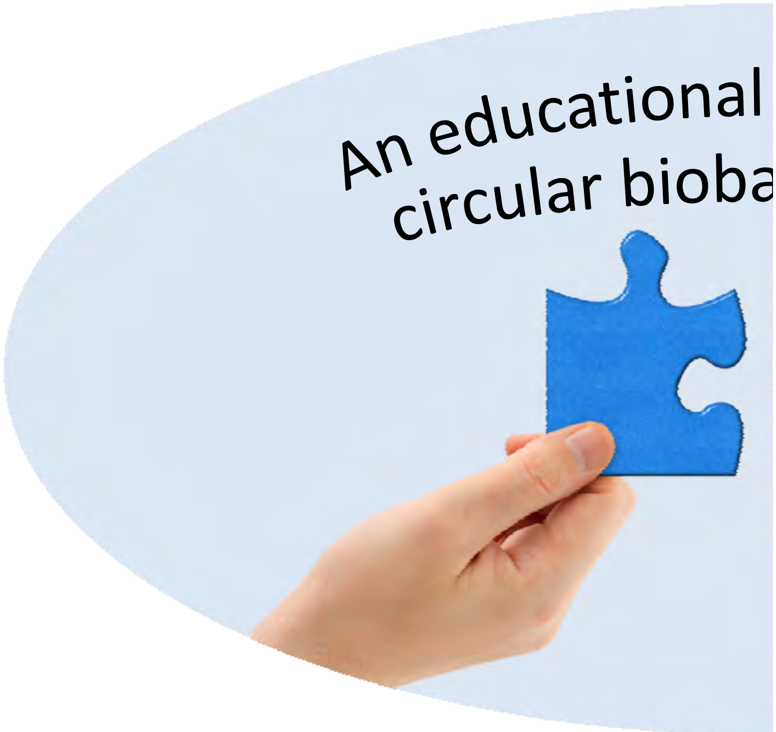
Methods and Results

Both aliphatic polylactic acid (PLA) as the aromatic PET analog polydihydroferulic acid (PHFA) have been synthesized and analyzed for purity, chain length, and thermal properties by our students .
The results correspond to data reported in the literature.



Conclusion

We are capable to synthesize polylactic acid (PLA) and polydihydroferulic acid (PHFA) with an acceptable Mn to study the de-polymerization.
The formed PHFA is the first wholly biorenewable polymer that successfully mimics the thermal properties of polyethylene terephthalate (PET). Future studies will determine the important material properties and degradation characteristics of PHFA and target copolymers with tunable thermal properties.



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Another piece of the puzzle: Technology

Mechanical properties of Biobased Polyesters

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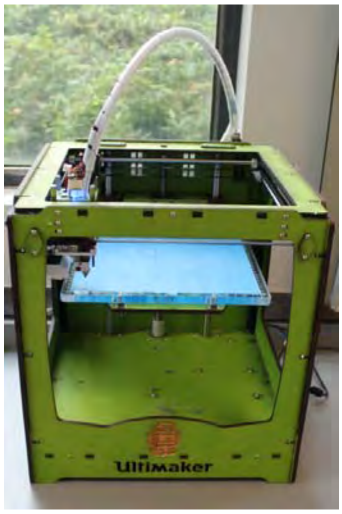
Introduction

Chemical recycling of polymers is a possible technique for recovering building blocks, according to the principles of "Sustainable Development". Therefore we design known and novel polymers and optimize their mechanical properties while maintaining their chemical recyclability. The chemical structure is the most important factor dictating these characteristics, but physical properties like molecular weight, porosity, elasticity and morphology (crystalline, amorphous) will also be taken into account.

Materials and Methods

Processing techniques (fiber drawing/annealing) and additives (plasticizers/nucleating agents) improve mechanical properties both the aliphatic PLA and aromatic PHFA polymers.
Our students use normal extrusion and injection molding machines but also the Ultimaker (3D printer) as a small injection molding machine.
The material properties were studied by differential scanning calorimetry (DSC), standard tests for measuring tensile modulus and percentage elongation at yield and break load.
To compare the degradability of the structurally different polymers, we are now working on a standard evaluation method. A pilot scale reactor will be designed for chemical recycling of our polymers.



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Conclusion

Both PLA and PHFA seems to be good examples for education in Circular biobased economy.

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Chemical Recycling of Aromatic Polyesters

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Introduction

A major portion of plastics is used for packaging or other disposable items. Because of the durability of these materials however, substantial quantities of discarded end-of-life plastics are accumulating worldwide as debris in landfills and in natural habitats. By taking the end-of-life phase of these materials into account during the design of novel plastics we hope to encourage future recycling.

Limits to recycling

At the moment most plastic winds up on landfills (see figure 1).

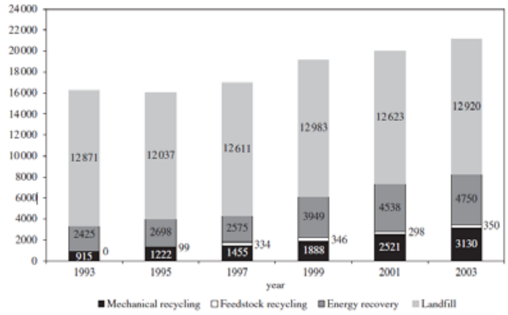


Figure 1: Volume of plastic waste disposed to landfills and recovered by various methods (in tons).

PET recycling is currently the most successful recycling program, but is very limited. PET can only be *recycled mechanically* where the material is melted and re-molded into new bottles. Purification of the recycle stream is very difficult so that only very well-defined sources can be used.

Integrating research into education

There is a growing social need to incorporate research programs into the curricula of Universities of Applied Sciences.

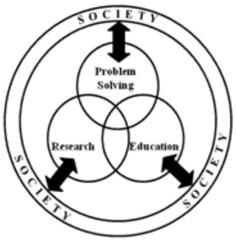
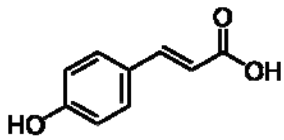


Figure 3: Universities of Applied Science as knowledge centre's within society.

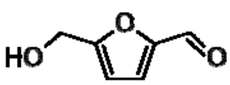
Research is a cyclic endeavour where problems, hypotheses, theories, methodologies, design and solutions keep succeeding each other. Traditional teaching is linear in nature however. Two-way information exchange between research and education can profit both by synergic co-regulation and co-amplification.

Back to the drawing board

Our research program focuses on the utilization of biomass such as lignin and cellulose for the production of novel aromatic polyesters (see figure 2).



Coumaric acid



Hydroxymethylfurfural

Figure 2: Structures of biobased monomers under investigation.

By varying the aliphatic part linking the aromatic monomers we hope to achieve less energy intensive de-polymerizations. This would open the way to *chemical recycling* where the petrochemical constituents of the polymer can be reclaimed and then used to re-manufacture plastics.

Conclusion

Chemical recycling would not only be part of a waste-management strategy, but could also be seen as an example of industrial ecology, where the waste of one process becomes the feedstock of another.

Students are taught green chemistry principles within this research program. These hands-on experiences prepare them before entering the professional world with the knowledge needed to effectively address the grand challenges of the 21st century.

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