Poison Study of Polylactic Acid Polymerisation from Biogenous Feedstock

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Introduction

The rapid growth in plastics production is extraordinary and was increasing from about 2 Mt in 1950 to 380 Mt in 2015. The vast majority of monomers used to produce this huge amount of material is derived from fossil sources.

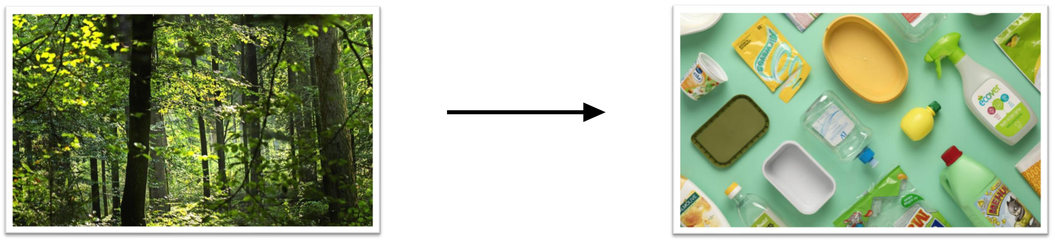

Figure 1: Possible resource of Polylactic acid and resulting products.

To overcome the persistent usage of fossil resources so called “green” polymers are targeted to be the future perspective. Polylactic acid (PLA) is one of these promising materials, which in fact is not only biocompatible and biodegradable but also can be produced from biogenous remnant. The aim is now to evaluate the polymerisation process of lactic acid originating from bacteria and to visualise the effect of the different impurities in the system.

Methods

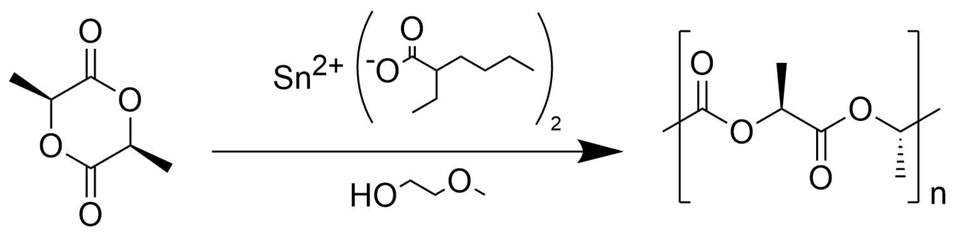

Figure 2: Ring opening polymerisation of lactide using Tin(II)-2-ethylhexanoate and 2-Methoxyethanol.

At first the educt is polymerised by means of a ring opening polymerisation (ROP) with Tin(II)-2-ethylhexanoate as the catalyst and 2-Methoxyethanol as the initiator. The purified lactide is polymerised for 1 h at 180 °C in a Schlenk apparatus representing the standard experiment. In order to reveal the poisoning effects of different polymerisation inhibitors on the process, the educt was additionally doped with 0.1 w% of possible included impurities.

Figure 3: Schlenk apparatus used for unimpeded polymerization tests.

Results and Discussion

Figure 4 shows the influence of different impurities on the melting point of PLA in comparison to the standard experiment (dashed line). It has become apparent that there is no significant influence on the T_m for most of the poisoning substances. Only L(+)-Aspartic acid, D(+)-glucose, D(+)-saccharose, and $CaSO_4$ cause a deviation of T_m larger than the standard deviation (dotted line).

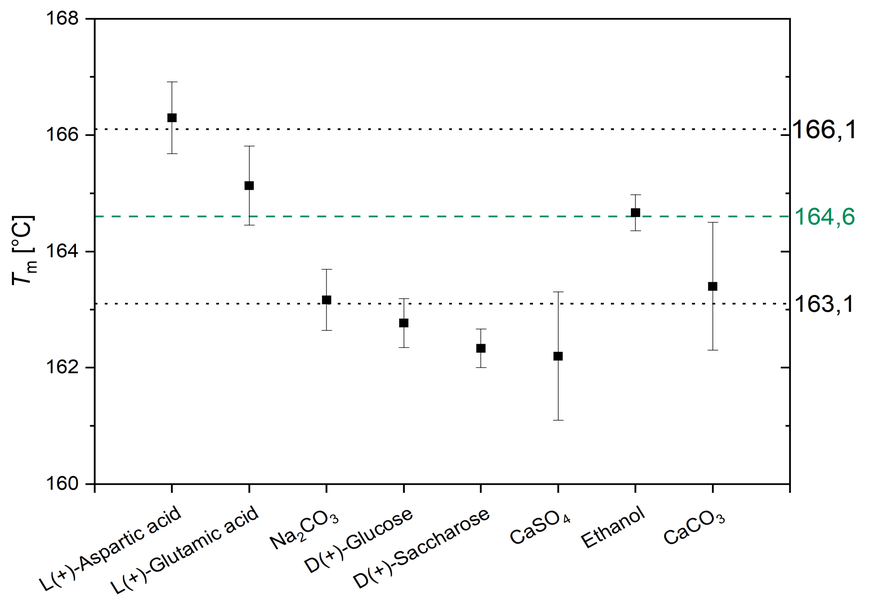

Figure 4: Melting points of doped samples measured by Differential Scanning Calorimetry given in the range of standard experiment.

In Table 1 the PLA properties of the doped polymers measured are listed. It can be seen that the influence of poisoning is only of a little value.

Table 1: Values measured (melting point T_m, number average molecular weight M_n, weight average molecular weight M_w, polydispersity index *PDI*) of doped PLA samples.

	T_m / °C	M_n / g mol^{-1}	M_w / g mol^{-1}	*PDI* -
L(+)-Aspartic acid	166.3	26 708	46 957	1.76
L(+)-Glutamic acid	165.1	25 371	41 004	1.62
Na_2CO_3	163.2	23 917	41 857	1.75
D(+)-Glucose	162.8	23 050	42 788	1.86
D(+)-Saccharose	162.3	21 924	37 954	1.73
$CaSO_4$	162.2	24 374	42 701	1.75
Ethanol	164.7	*	*	*
$CaCO_3$	163.4	23 316	45 281	1.94
Ø Std-Experiment	**164.6**	**24 062**	**42 722**	**1,78**

* Gel Permeation Chromatography not evaluable.

Conclusion

The effects on the properties of polylactic acid caused by impurities of educts originating from a fermentation process are negligible. Neither Tm, Mn, Mw nor PDI show significant changes at the used concentration of impurities. This implies that the ROP process of lactic acid is a robust reaction and constant polymer grades can be produced.

About the author

Regina Itzinger is currently working on her PhD thesis in the field of lactic acid polymerisation. The focus lies on the investigation of impurity influences.

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