Lignin derived flexible polyurethane foams

The synthesis and characterization

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Introduction

Polyurethane (PU) is a polymer used for various purposes. With a demand of 3,9% in the plastic market, PU is a highly sought-after polymer ^[1]. With a total of 68%, the dominance products are PU foams used for packaging, insulation and comfort materials ^[2]. PU is formed through a polyaddition between a polyol and a diisocyanate. Polyol's and diisocyanates are obtained from fossil fuels. With the future in sight, there is an increasing focus on the sustainability of polymers. One solution is to replace fossil resources with biobased materials. An example of a natural polymer is lignin. Lignin is a heterogeneous polymer that has many hydroxyl groups. It is currently seen as a waste product in the paper industry. Because of the high hydroxyl content in lignin, it can be used as a natural polyol. the incorporation of lignin as a polyol would reduce the use of fossil fuels in the PU production and reduce the waste streams from the paper industry.

Results & discussion

The FT-IR shows an overlay with the isocyanate, the co-polyol, lignin and one of the produced foams. The spectrum shows the characteristic O-H peak from the starting materials. The foam does not consist of the NCO peak at 2256 cm⁻¹ from the isocyanate. The foam consists of an extra peak at 1515 cm⁻¹. This is the HNC=O peak, that shows a polyurethane linkages have been formed. This peak differs the foam from the polyol starting materials.



Gelling reaction polyurethane

Goal and hypothesis

The goal of the research is to develop a flexible lignin derived polyurethane foam suitable for packaging materials. Hereby the polyol amount will be partially replaced by lignin. The synthesis will be carried out without the use of a catalyst. This will be done by depolymerizing and modifying lignin beforehand.

It is expected that a lignin percentages of >30wt% (according to literature) will lead to brittle and unusable polyurethane foams. A percentages around 25wt% lignin will improve the tensile-, compression- and tear strengths, as well as the thermal stability ^[3,4]. The use of lining with a lower hydroxyl content will lead to the development of a flexible foam ^[5]. Because of the use of depolymerized lignin, a higher amount of lignin can be incorporated in the PU foams.



verlay isocyanate (red), co-polyol (green), lignin (blue) and lignin-based PU foam (pink)

The apparent density shows that when more isocyanate is added, the density increases (up to TT-LPUF-010). When more lignin is added, the density also increases (TT-LPUF-025 and TT-LPUF-027). A higher DEA amount does not add to the density (TT-LPUF-030 is higher than TT-LPUF-009). The figure shows that the results are not reproducible.





Blowing reaction polyurethane

Method



	10,986
TT-LPUF-027 + duplo	1,513
TT-LPUF-030 + duplo	0,617

Apparent density from the lignin-based PU foams and their duplo's

95% confidence interval from the apparent density measurements

Compression testing shows that more isocyanate makes the foams more compact. It also shows that the addition of lignin makes the foams more flexible, because less force is needed to compress them. The most flexible foams is TT-LPUF-003



Compression testing results force at 70% in N from the lignin-based PU foams

Conclusion

This research concludes that TT-LPUF-003 is the most flexible foam, but the foam may be too

Weighing component A + B Pre-heating and stirring component A + B	Placing component A + B together	Mixing	Time (sec) Foaming proces	
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Method scheme



Produced lignin based polyurethane foams

flexible for packaging materials. TT-LPUF-030 is also very flexible but can resist a bit more force during the compression testing. The foams all show in the FT-IR that the polyurethane linkages has been formed. The apparent density of the foams and the compression testing of the foams show that when more isocyanate is added, the foams are more compact and can handle more compression force. Although they are still flexible, they are very compact and not suitable for packaging materials.

References

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