Synthesis and characterization of novel levoglucosenone-based polymers

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Introduction:

Levoglucosenone (LGO) is a promising bio-sourced platform molecule derived from the pyrolysis of cellulose and produced on an industrial scale as part of the Furacell process [1]. LGO possesses a rigid skeleton which enables reactions with high regio- and stereoselectivity. Its conjugation grants susceptibility to Michael-type reactions, while 1,2-condensation leads to imine products. Among other uses, LGO has been extensively investigated for polymer synthesis due to its multiple reaction sites uniquely positioning it for the creation of network structures [2, 3]. Bio-based polymers offer a promising alternative to traditional petroleum-based plastics with their superior renewability, biodegradability, and carbon footprint, which has led to work in the use of LGO in polymer synthesis.

Objectives:

This work reports the development of novel materials using LGO as the co-monomer, with potentially reduced costs and a lower environmental impact compared to existing methodologies. These materials were characterized using a variety of analytical techniques to gather information about their physical and chemical properties and investigate the suitability of the novel materials herein.

Methods:

Synthesis proceeded with LGO as the co-monomer, with a facile polymerization observed under mild and sustainable conditions. Various conditions were iterated through, including the use of toxic solvents and external energy inputs. Synthesized polymers were characterized through diverse techniques that are standard in polymer chemistry [4]. These include thermogravimetric analysis (TGA) to determine thermal stability, differential scanning calorimetry (DSC) to determine glass transition temperature, infrared spectroscopy (FTIR) and nuclear magnetic resonance spectroscopy (NMR) to elucidate molecular structure, swelling and solubility assays to evaluate solvent stability and the presence of a network (thermoset) structure, heat-pressing to evaluate vitrimeric properties, and gel-permeation chromatography (GPC) to determine dispersity and molecular weights.

Results:

DSC and TGA analysis revealed varied glass transition temperatures and thermal stabilities for the materials synthesized. Some of the analytical techniques used can be seen in Fig. 1.

Figure 1. ^{1}H NMR analysis of synthesized materials, GPC, TGA (L to R)

Conclusions and Recommendations:

As this work aimed to conform to green chemistry principles, the reactions and conditions used were deemed favorable. The thermal stability and glass transition temperatures observed were interesting and warrant further study of these novel materials. Overall, these findings demonstrate that LGO can serve as a cost-effective, sustainable monomer platform, broadening the design space for renewable polymers.

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