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Synthesis of high-performance plastics from renewable bioresources

In this work, monomers based on lignin containing the highly polar nitrile group have been prepared with the ambition to develop biobased polymers with high glass transition temperatures (T_gs). The synthesized polymers appeared to be crosslinked, which means that the polymer chains formed a big network. These crosslinks, in combination with increased intermolecular interactions imposed by the nitrile group, will strongly reduce the flexibility of the polymers, and therefore increase the T_g significantly. Depending on the application, cross-linking can be highly advantageous as it can provide enhanced mechanical properties and improved solvent resistance. In order to prepare non-crosslinked polymers, the reactivity of the monomers needs to be regulated.

Plastics are some of the most popular materials that have ever been developed, which most people come in contact with in their everyday life since it is so versatile and inexpensive. Today, almost all plastics are produced from fossil-based resources such as natural gas and oil. Therefore, the development of plastics based on renewable bioresources is important to combat the ongoing emissions of greenhouse gases, and to become less dependent on fossil fuels as part of the green transition.

Polymers are basically chains of repeating units, formed by monomers. Polymers can be based on of the same monomer throughout the entire structure, but they can also be made from different types of monomers depending on the desired properties of the synthesized polymer. T_g is the temperature where the polymer goes from a hard glassy state to a soft rubbery state. This is an important property to consider, especially for amorphous polymers, since it determines which temperatures the polymer can operate at for certain applications.

Today, there is a general lack of biobased polymers which exhibit T_gs above 100 °C. The molecular flexibility of the repeating units in the polymer chains and the intermolecular interactions are some factors that affect the T_g. The flexibility can be controlled by incorporating segments with varying mobility. For instance aromatics, being cyclic compounds, which are less flexible will lead to a higher T_g. By having polar groups present in the polymer chain, the intermolecular interactions will increase, also resulting in a higher T_g.

A renewable bioresource which has gained a lot of interest is lignin. It is one of the most abundant naturally occurring polymers, which can be found in trees and plants. Lignin has shown great potential as a resource for the synthesis of polymers with high T_gs. This is because of its readily availability since it is a by-product from the pulp and paper industry, as well as containing high contents of aromatics that can be isolated and used as building blocks to synthesize biobased polymers with improved thermal properties.