

Abstract

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Number of Words: 350

The versatility of polyurethane (PU) flexible foam has made it an indispensable material in furnishing, transportation, and packaging. To make PU flexible foam, petroleum-derived reactants, polyol and isocyanate, are used. As the price of crude oil has escalated and the cost of PU reactants doubled, researchers have turned to renewable natural oils for polyols. Recent developments have successfully derived polyols from natural oils and synthesized a range of PU products from them. However, making flexible foam from natural oil polyols is still proving challenging. The goal of this thesis is to understand the potentials and the limitations of natural oil polyols as an alternative to petroleum polyols.

An initial attempt to understand natural oil polyols showed that flexible foams could be synthesized from castor oil, a naturally occurring polyol, but not from soybean oil-derived polyol (SBOP), which produced a rigid foam. Characterization results indicated that both foams were phase-mixed and the glass transition temperature (T_g) was the predominant factor that determines the

rigidity of the foam. The high T_g of SBOP foam was attributed to the low number of covalent bond between crosslinkers.

As neither castor oil nor SBOP was suited as sole polyol component for flexible foams, we partially substituted petroleum polyol with these natural oil polyols in a flexible foam formulation. A 30-wt% replacement with SBOP more than doubled the foam compressive modulus and this increase was achieved by changing the hard domain morphology as well as creating a SBOP-rich second soft phase. Although foaming natural oil polyol-containing samples showed no signs of kinetic issues, an infrared spectroscopy (IR) study demonstrated that not only was urethane formation rate reduced but phase separation in foams was delayed as well.

To further explore the potentials of natural oil polyols as sole polyol component in flexible foam, the relationship between the T_g and the number of covalent bonds between crosslinks was investigated. It was found that with increasing number of covalent bonds between crosslinks, the T_g of PU can be systematically lowered and that the dangling chains present in natural oil polyols act as a plasticizer to help lowering the T_g further.

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