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Synthesis and Characterizations of Isosorbide Based Thermoplastic Polyurethanes : Biodegradable Biomass Material with Different Polyol and Hard Segment Ratios for Water-barrier Film

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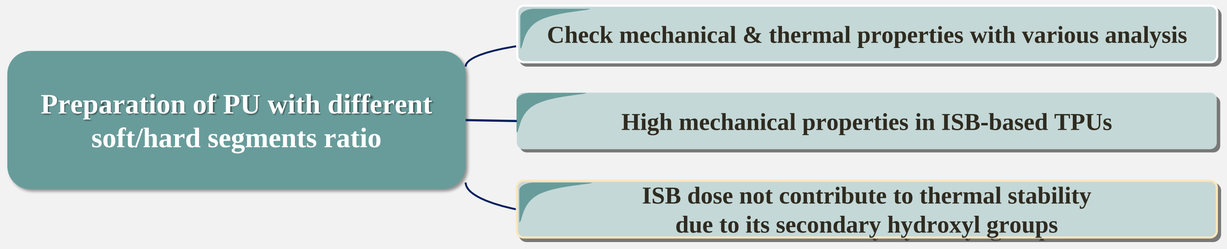
Abstract

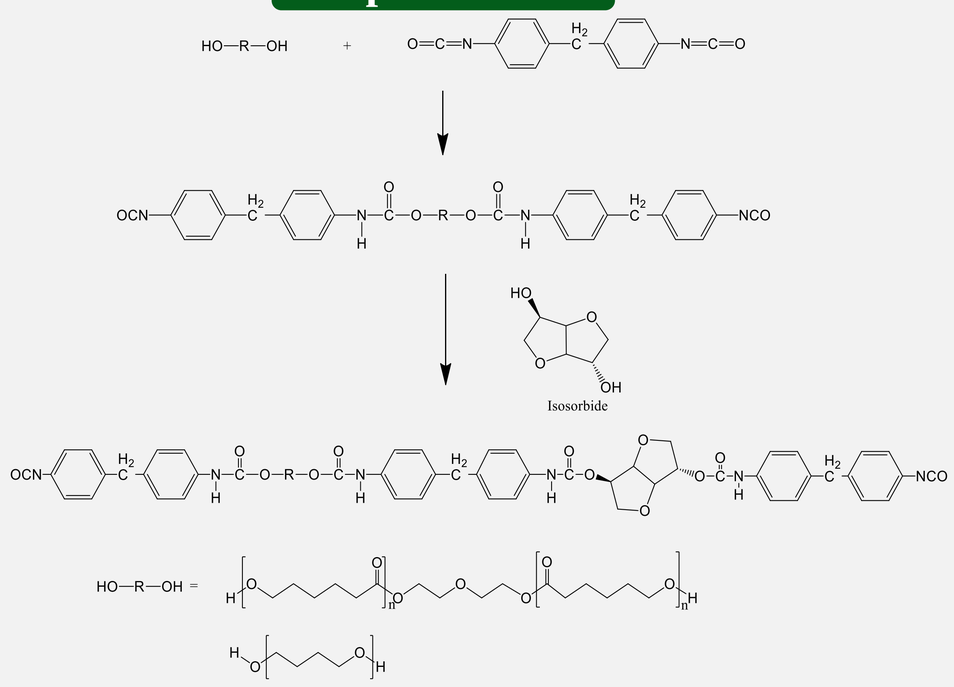
A series of isosorbide-based thermoplastic polyurethanes (TPUs) with different soft/hard ratios but the similar molecular weight were successfully synthesized by step-polymerization using two types of polyols. polycaprolactone diol (PCL) or poly tetra methylene glycol (PTMG), and methylene diphenyl diisocyanate (MDI) as the soft segment, and bio-based & bio-degradable material isosorbide (ISB) for chain extender and MDI as hard segments. The ratio of soft/hard segments consisted of weight fractions of 6/4 and 9/1, respectively. The structure of the polyurethane series was analyzed by fourier transform infrared spectroscopy (FT-IR) and gel permeation chromatography (GPC). The thermal properties were analyzed by thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC). TPUs films with high hard segment ratios indicated lower water vapor permeability. Although hydrophilic isosorbide was used in polyurethane, water vapor permeability could be adjusted by structural differences. In addition, in order to confirm the biodegradability of isosorbide, a biodegradation test was performed according to the international standard OECD 301F. The microorganisms used in the test were collected from a nearby sewage treatment plant. The pass levels for ready biodegradability is exceed 60% of ThOD in 10-d window. The 10-d window begins when the degree of biodegradation has reached 10% ThOD.

Objective

1. To synthesize ISB-TPU series composed of PTMG or PCL as the polyol and MDI as the isocyanate and ISB as the chain extender
2. Comparison of characteristics according to polyol and soft/hard segment ratio
3. To evaluate the mechanical properties and thermal properties of ISB-TPUs
4. Certification of biodegradability of ISB through OECD 301F

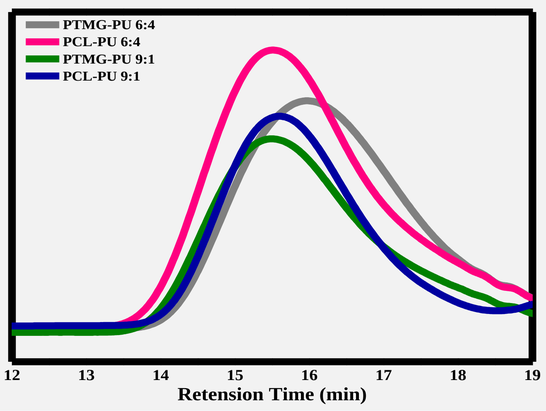


Experimental



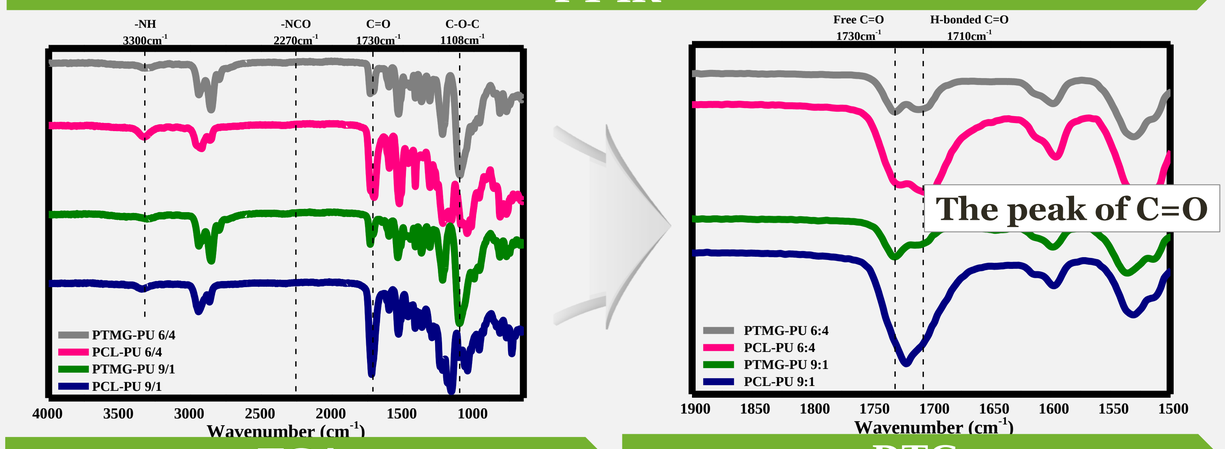
Results

GPC

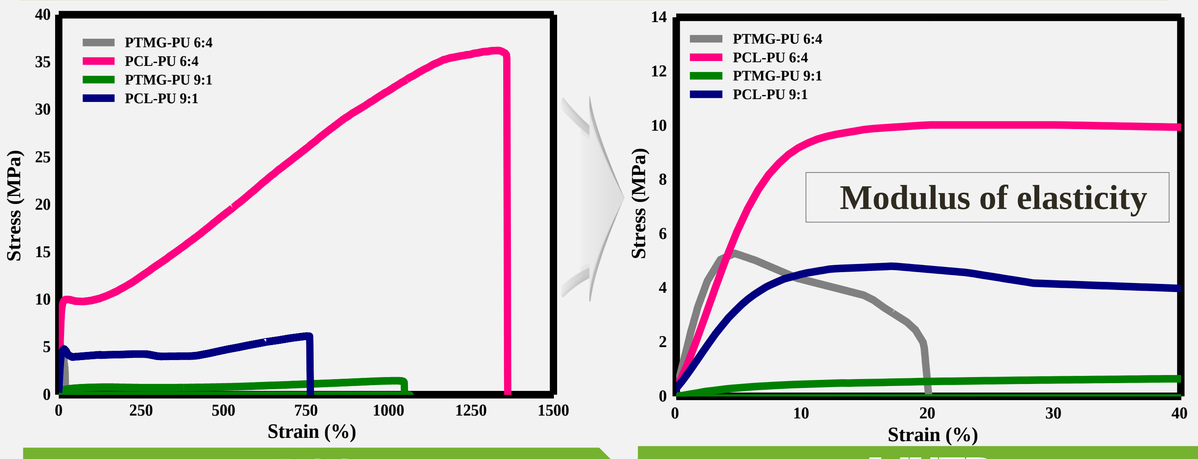


Sample Code	Average Molecular Weight	
	Mn (g/mol)	PDI
PTMG-PU 6/4 (PU-1)	15,821	1.97
PCL-PU 6/4 (PU-2)	17,860	2.35
PTMG-PU 9/1 (PU-3)	20,695	2.06
PCL-PU 9/1 (PU-4)	20,692	1.87

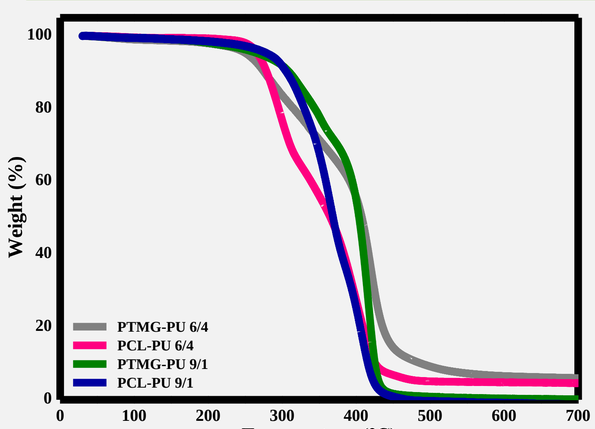
FT-IR



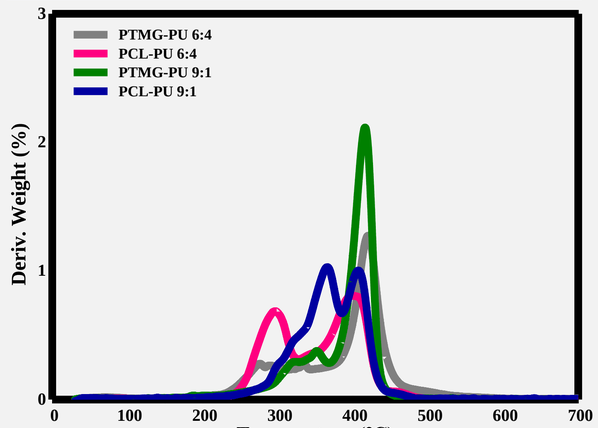
UTM



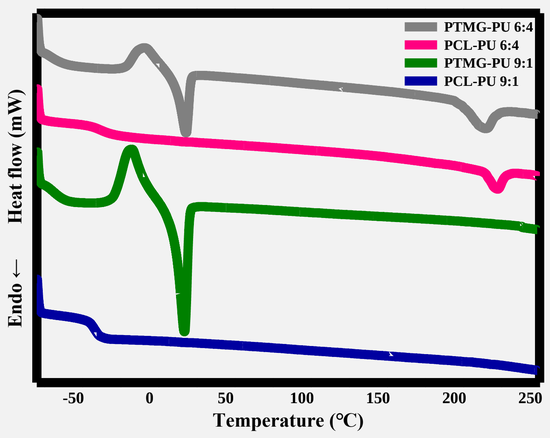
TGA



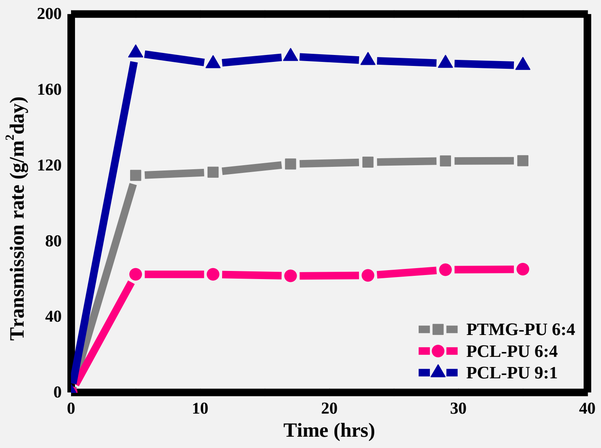
DTG



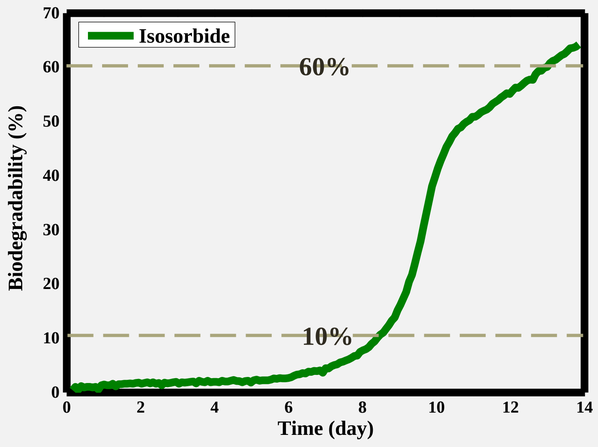
DSC



WVTR



Biodegradable test - ISB



Conclusion

- The successful synthesis ISB-TPUs
- ISB is confirmed to be a biodegradable monomer by biodegradability test
- ISB-TPUs improved mechanical properties
- ISB does not contribute to thermal stability due to its secondary hydroxyl groups

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