한국접착및계면학회
The Society of Adhesion & Interface,Korea

2022 한국접착 및 계면학회 추계심포지움
November 16 - 18, 2022 | Hanyang University ERICA Convention Center, Korea

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Improving the adhesion properties of structural epoxy adhesives : Using bio-based polyurethane and core-shell rubber

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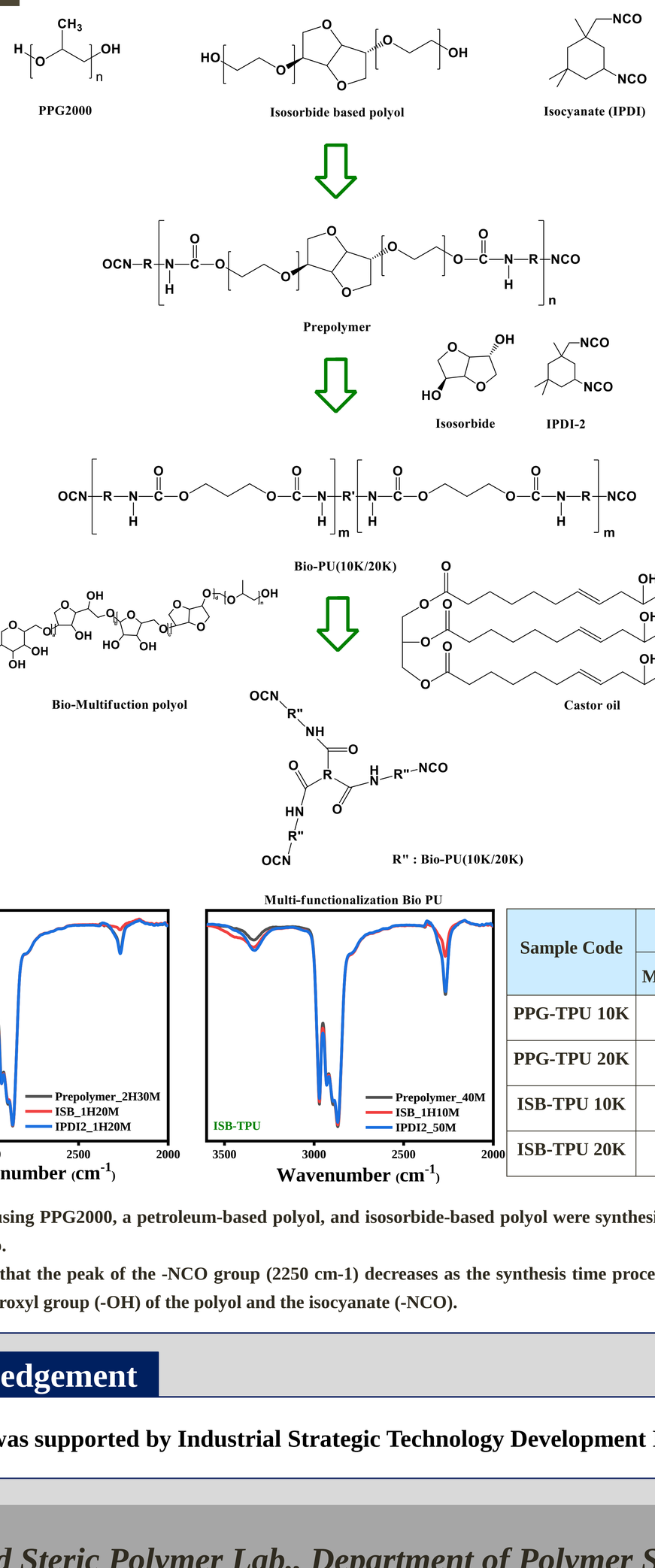
Abstract

To improve the properties of structural epoxy adhesives, a series of thermoplastic polyurethanes (TPUs) with similar hard/soft segment ratio were successfully synthesized by step-polymerization using two types of polyols, isosorbide-based polyol and poly(propylene glycol) (PPG). TPUs were synthesized by polyols as the soft segment, and isosorbide (ISB) and isophorone diisocyanate (IPDI) as hard segment. The molecular weights were 10000 (10K) / 20000 (20K), respectively. Multi-functional polyol was added to the synthesized ISB-TPU to increase molecular weight and significantly affected mechanical properties. The structure of TPUs series were 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), and the shear strength was measured using a universal testing machine (UTM). In addition, hydroxyl-terminated polybutadiene (HTPB) was used for the core, which is to improve impact strength, and polyurethane acrylate (PUA) was used for the shell, successfully synthesized polyurethane-based core-shell rubber (CSR).

Experimental

Scheme

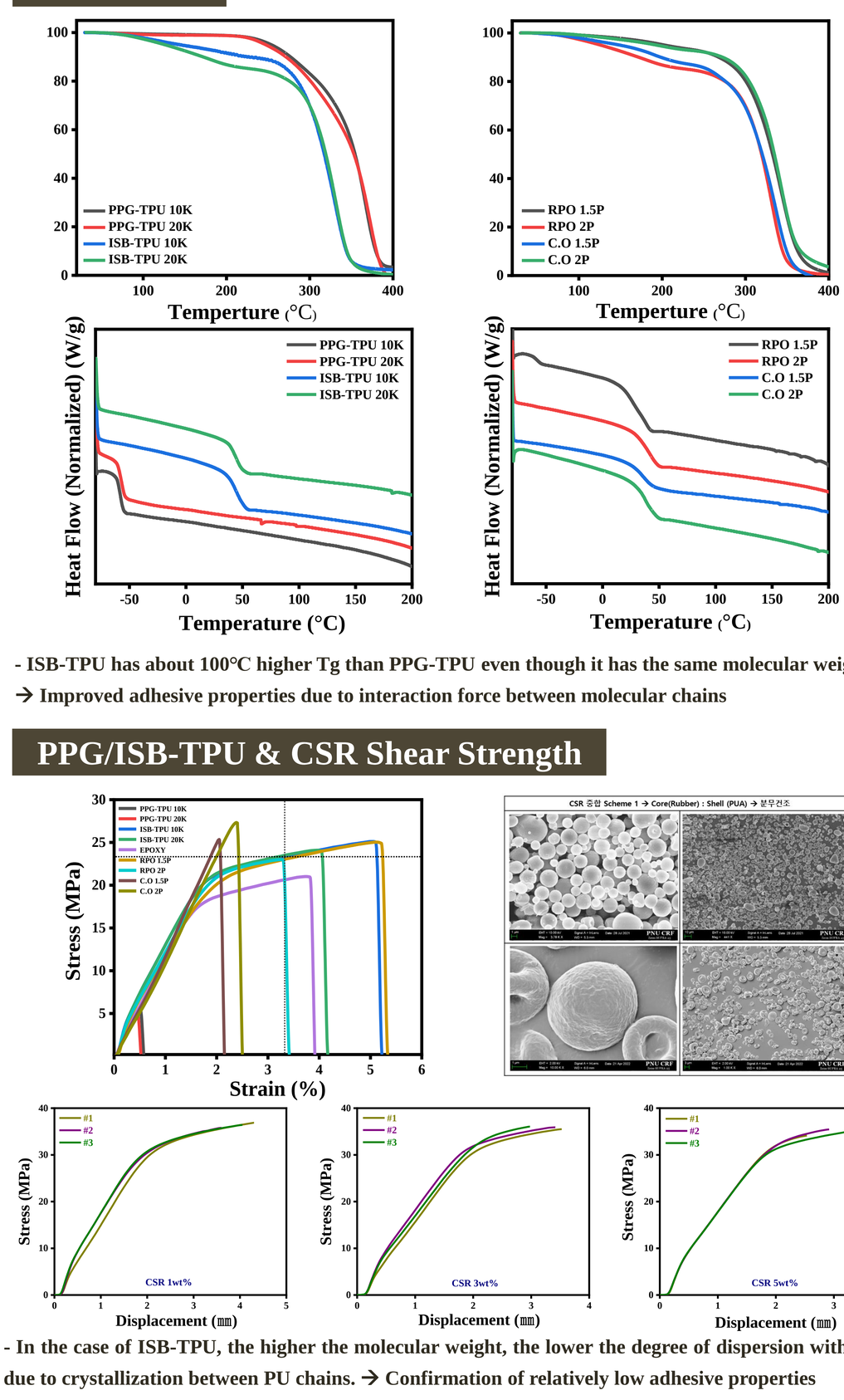


Sample Code	Molecular Weight	
	Mn (g/mol)	PDI
PPG-TPU 10K	11427	1.80
PPG-TPU 20K	26894	1.62
ISB-TPU 10K	12554	2.01
ISB-TPU 20K	18521	1.83

- Polyurethane using PPG2000, a petroleum-based polyol, and isosorbide-based polyol were synthesized using a bio multi-functional group.
- It can be seen that the peak of the -NCO group (2250 cm-1) decreases as the synthesis time proceed due to the reaction between the hydroxyl group (-OH) of the polyol and the isocyanate (-NCO).

Results

TGA & DSC



- ISB-TPU has about 100°C higher Tg than PPG-TPU even though it has the same molecular weight.

→ Improved adhesive properties due to interaction force between molecular chains

PPG/ISB-TPU & CSR Shear Strength

- In the case of ISB-TPU, the higher the molecular weight, the lower the degree of dispersion with epoxy due to crystallization between PU chains. → Confirmation of relatively low adhesive properties
- The shear strength of epoxy is 35.38Mpa / CSR 1wt%(36.35MPa), 3wt%(35.81MPa), 5wt%(35.02MPa)
- As the CSR wt% increases, the shear strength ↓ → but maintains the same physical properties as epoxy.

Acknowledgement

This work was supported by Industrial Strategic Technology Development Program (Bio tackifier adhesive material with a biomass content of 50% or more, 20010807)