

Synthesis and Potential of Bio-Based Polyurethane and Core-Shell Rubber for Enhancing Structural Epoxy Adhesives

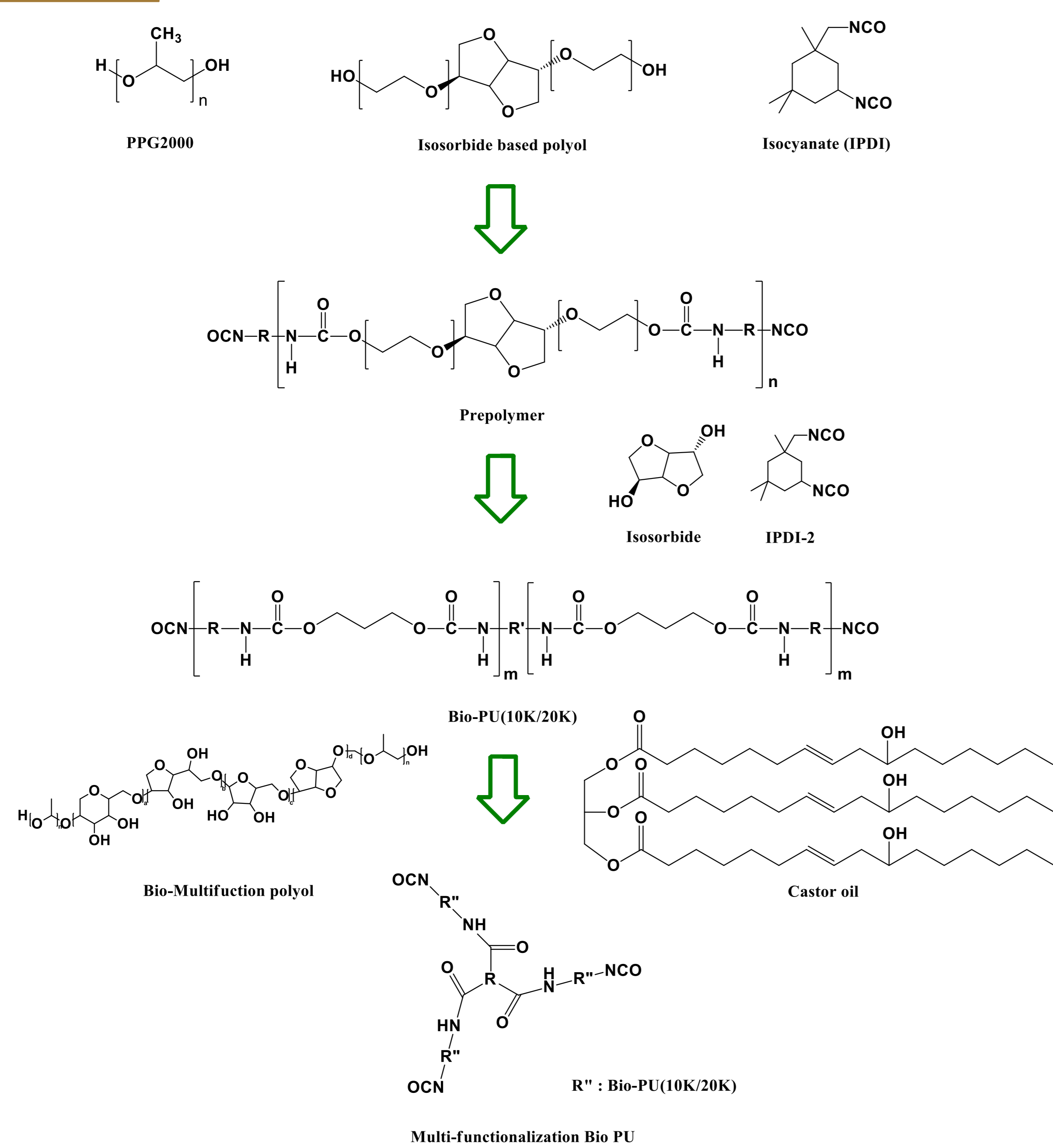
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Abstract

This research investigates synthesizing bio-based polyurethane and core-shell rubber (CSR) to enhance structural epoxy adhesives. We created thermoplastic polyurethanes (TPUs) through step-polymerization, targeting molecular weights of 10K and 20K using isosorbide-based polyol and poly(propylene glycol). Adding a multi-functional polyol to ISB-TPU markedly improved mechanical properties. Our methods included Fourier Transform Infrared Spectroscopy (FT-IR), Gel Permeation Chromatography (GPC), and Thermogravimetric Analysis (TGA) and Differential Scanning Calorimetry (DSC), with shear strength assessments confirming enhanced performance. We also synthesized a polyurethane-based CSR with hydroxyl-terminated polybutadiene (HTPB) for impact strength and polyurethane acrylate (PUA) for the shell. This work highlights the potential of bio-based materials in improving structural epoxy adhesives, paving the way for sustainable, high-performance material solutions.

Experimental

Scheme



- Successfully synthesized using PPG2000, Isosorbide based polyol, and types of isocyanates including IPDI and H12MDI.
- Increased molecular weight using Bio-Multifunctional polyol and Castor oil.

Conclusion

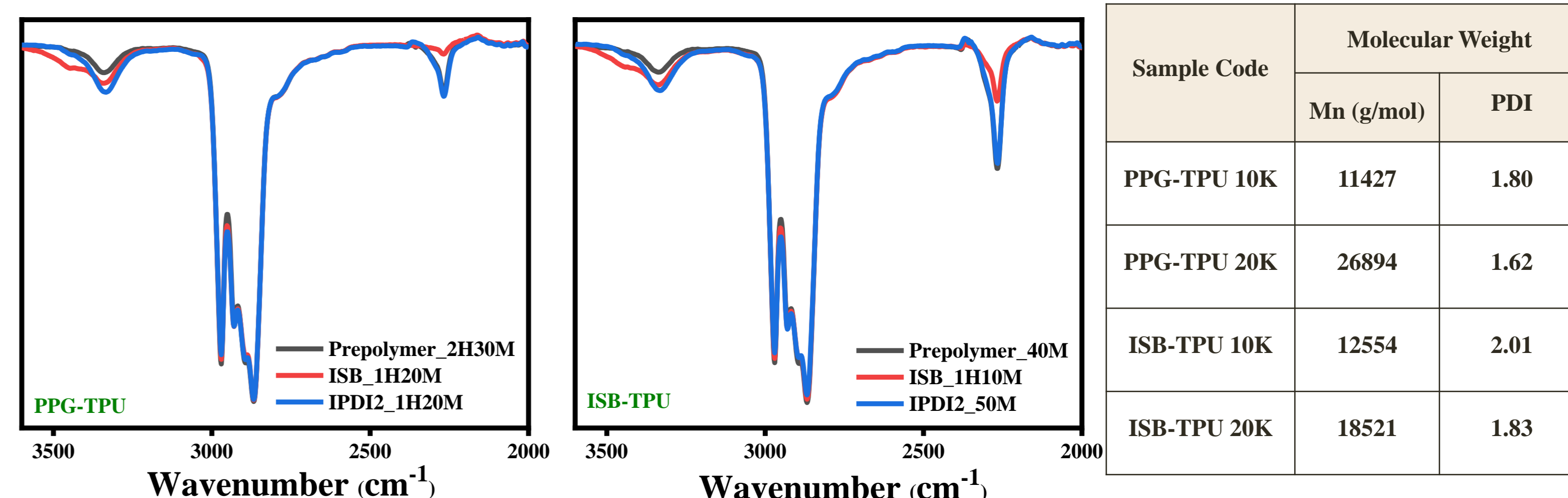
- ① Bio-based TPUs enhance adhesive properties, indicating potential for stronger, sustainable adhesives.
- ② Adding CSR maintains physical properties despite slightly lower shear strength, enabling balanced adhesive performance.
- ③ This study supports sustainable materials as viable for high-performance adhesives, promoting environmental friendliness.

Acknowledgement

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

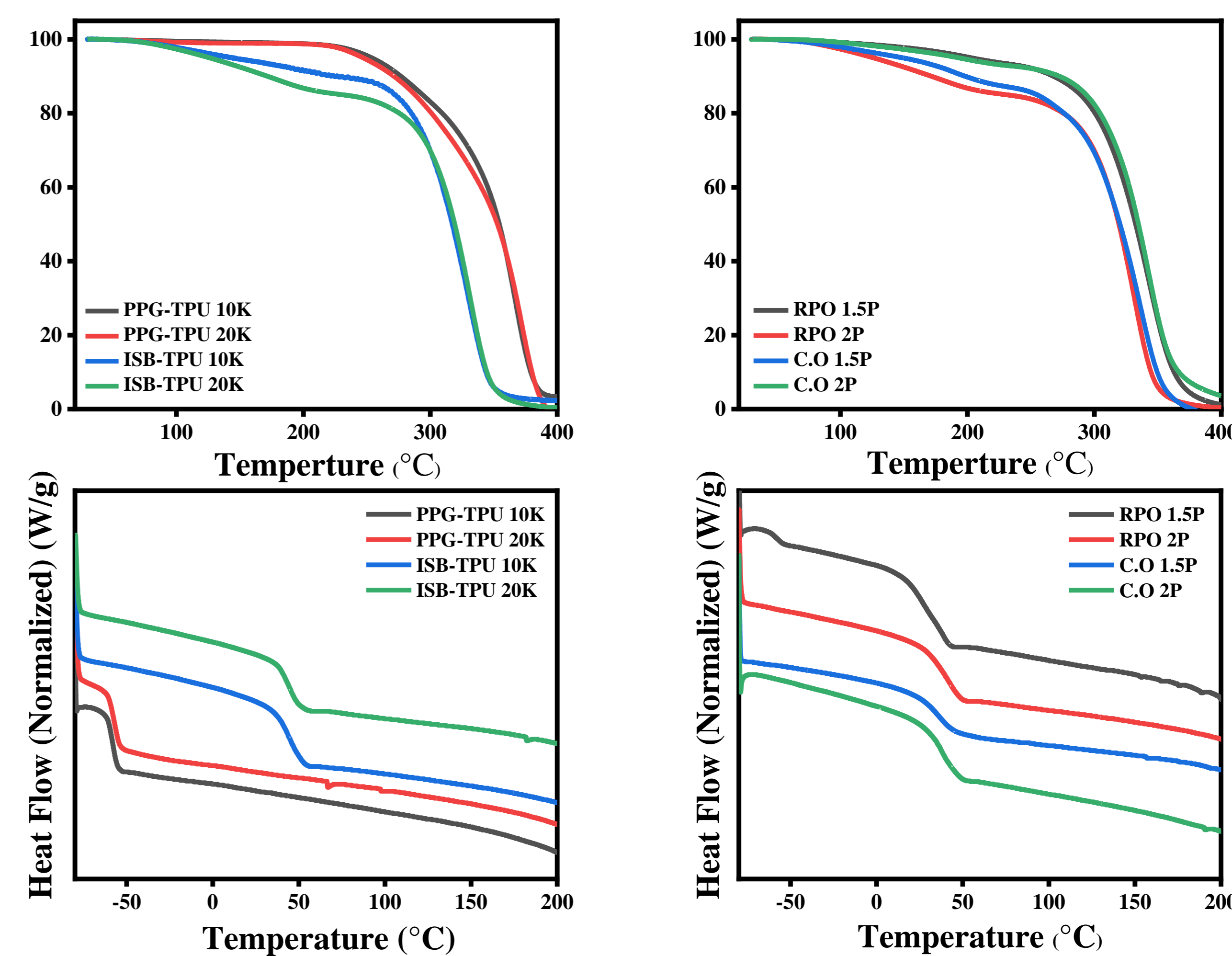
Results

GPC



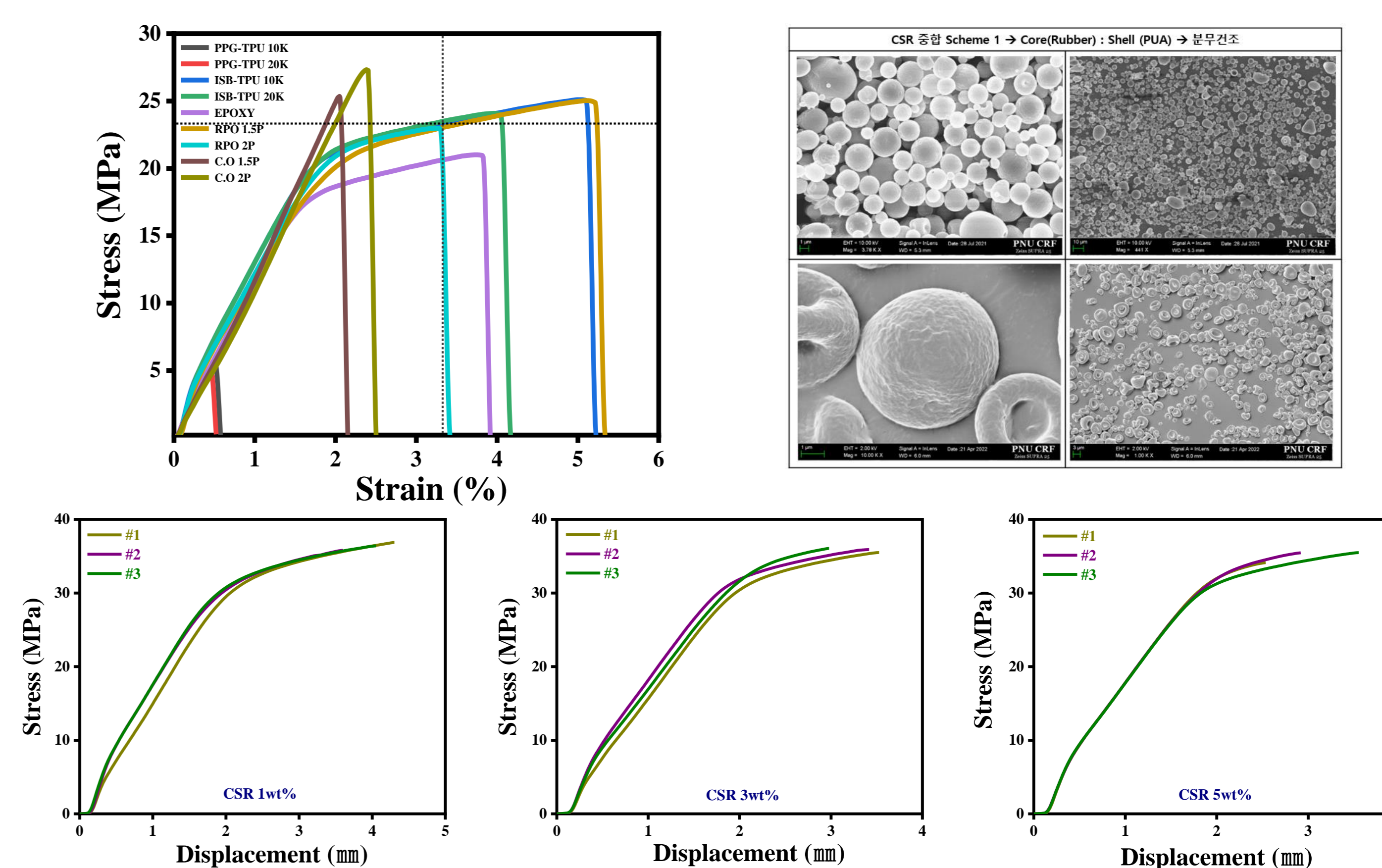
➢ It can be seen that the peak of the -NCO group (2250 cm⁻¹) decreases as the synthesis time proceed due to the reaction between the hydroxyl group (-OH) of the polyol and the isocyanate (-NCO).

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.