Enhancing Non-isocyanate Polyurethanes: Hybridization with Cellulose and Sodium Lignosulfonate for Improved Properties

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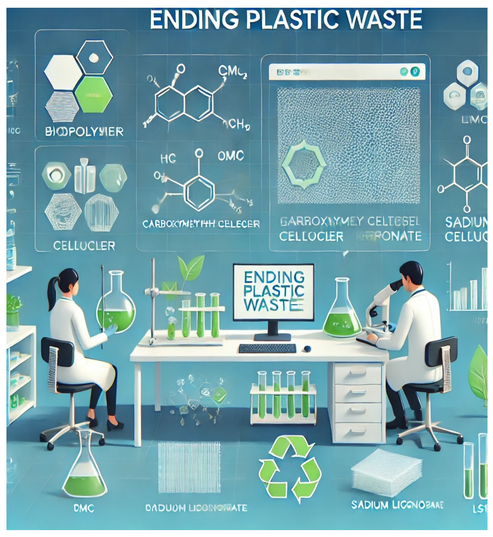
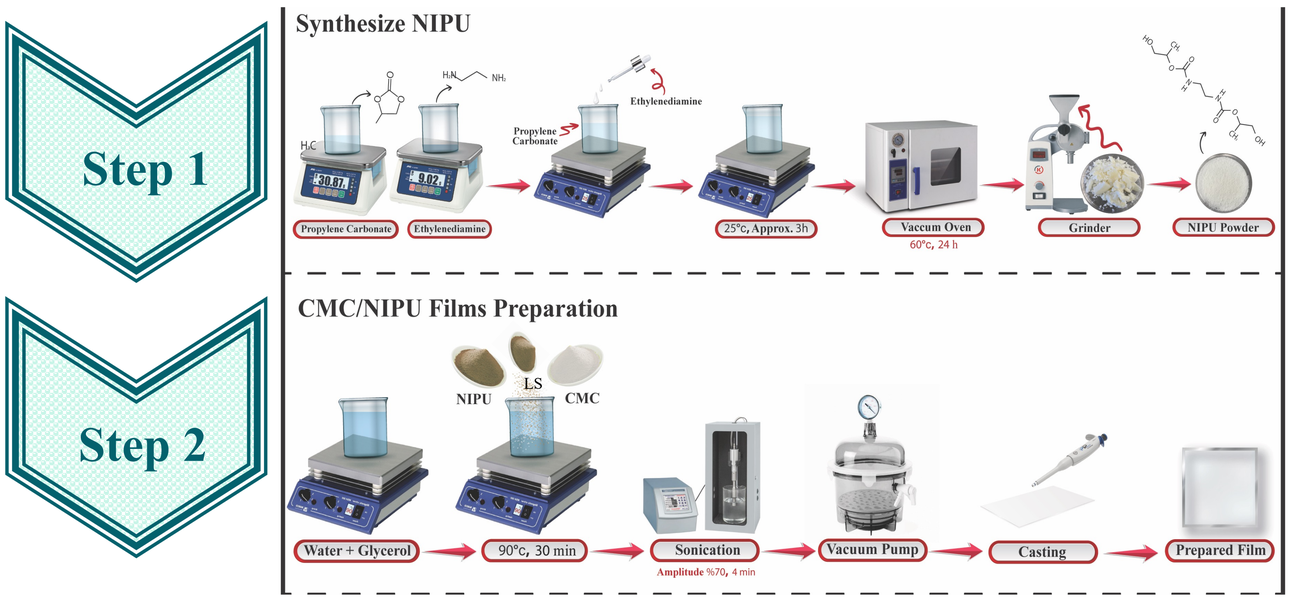
1 Introduction

The increasing environmental concerns over conventional polyurethanes, derived from harmful isocyanates, drive the need for sustainable alternatives. This study presents the synthesis of non-isocyanate polyurethanes (NIPUs) via a green chemistry method, hybridized with biodegradable Carboxymethyl Cellulose (CMC) and enhanced with sodium lingosulfonate (LS). The resulting material exhibits improved mechanical properties, antioxidant activity, and UV barrier capabilities, making it a promising candidate for eco-friendly active food packaging solutions.



2 Methodology



- **Step 1:** NIPU Green Synthesis
- **Step 2:** Hybrid Preparation of CMC/NIPU (80:20) with LS in different ratios.

3 Results

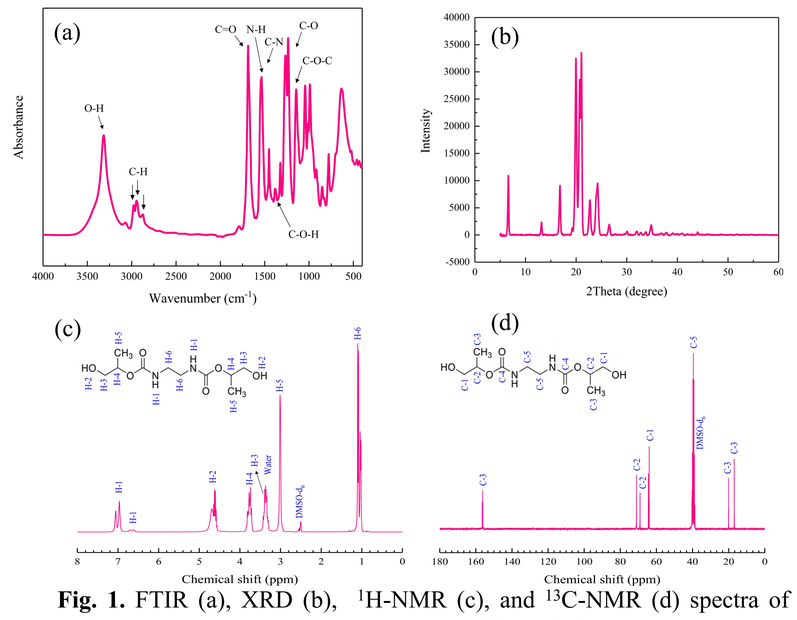


Fig. 1. FTIR (a), XRD (b), ^{1}H-NMR (c), and ^{13}C-NMR (d) spectra of NIPU obtained from the reaction between PC and EDA.

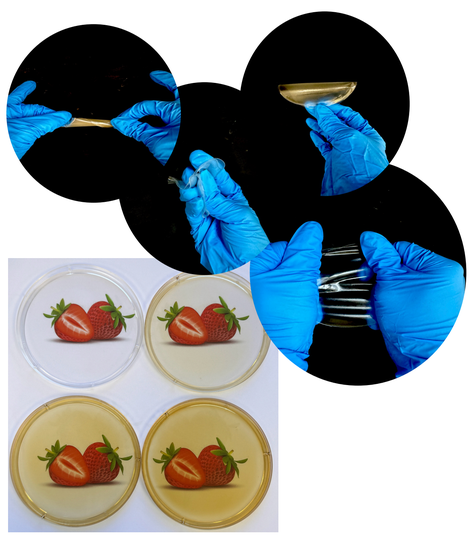


Fig. 2. The deformation of hybrid film samples and transparency of CMC/NIPU/LS to qualitatively assess their flexibility.

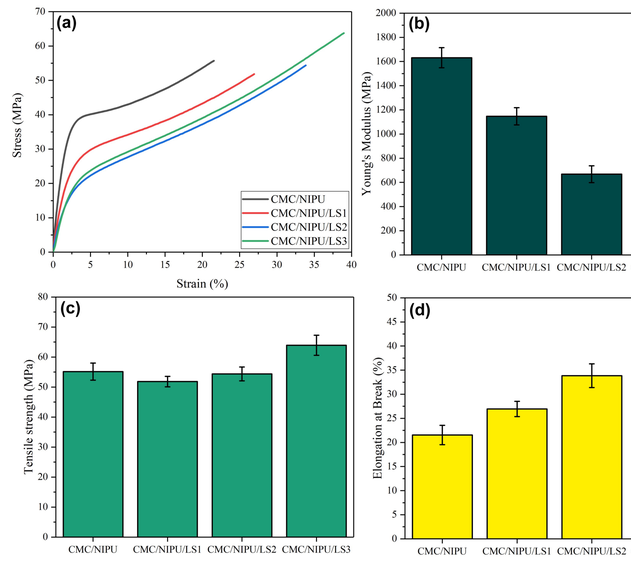


Fig. 3. Mechanical properties of CMC/NIPU/LS hybrid materials. Representative stress-strain curves (a) Young's modulus (b), tensile strength (c), and elongation at break (d) of synthesized CMC/NIPU/LS hybrid materials.

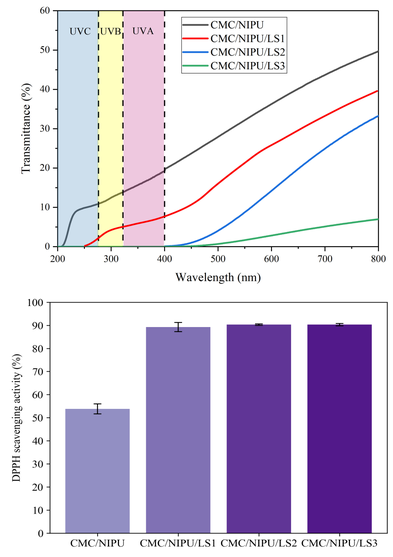


Fig. 4. UV-Blocking and antioxidant activity of CMC/NIPU/LS hybrid films.

4 Discussions

- **Structural Characterization:** FTIR, NMR, and XRD analyses confirmed the successful synthesis of NIPUs.
- **Enhanced Mechanical Properties:** The hybrid films exhibited a significant reduction in Young's modulus and an increase in elongation at break, indicating a balanced improvement in strength and flexibility. This suggests that the addition of LS contributes to the mechanical robustness of the material, making it suitable for diverse packaging applications.
- **Antioxidant Activity:** The introduction of LS significantly enhanced the antioxidant properties of up to 90% of the CMC/NIPU films. This improvement is crucial for active food packaging as it helps in extending the shelf life of food products by protecting them from oxidative damage.
- **UV Barrier Properties:** The UV-blocking capability of the hybrid films was markedly improved with the addition of LS up to 99.99%. Enhanced UV barrier properties are essential for protecting food products from UV radiation, which can cause deterioration in quality.
- **Biodegradability:** The use of biodegradable CMC in hybrid films addresses environmental concerns associated with conventional polyurethanes. The enhanced properties achieved through green synthesis and the incorporation of LS highlight the potential of these materials in reducing plastic waste.

5 Conclusions

- The successful synthesis of NIPU using green chemistry.
- Effective hybridization of NIPU with CMC and LS.
- Significant improvement in mechanical properties with the addition of LS.
- Enhanced antioxidant activity and UV barrier capabilities.
- Promising potential for active food packaging applications.
- Potential for development into commercial packaging solutions.
- Recommendation for further research on scalability and long-term performance

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