Toward Sustainable Flexible Materials: Biodegradable Thermoplastic Elastomers Based on PBAT/P(3HB-co-4HB) Dynamic Covalent Networks via Reactive Melt Processing

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Abstract

This study develops fully biodegradable thermoplastic elastomers (BTEs) based on poly(butylene adipate-co-terephthalate) (PBAT) and poly(3-hydroxybutyrate-co-4-hydroxybutyrate) [P(3HB-co-4HB)] blends through reactive melt processing with a dynamic covalent network strategy. Epoxidized soybean oil (ESO) was employed as a reactive compatibilizer and plasticizer, Peroxide initiated radical-mediated chain coupling, and boronic ester (BE) served as a dynamic crosslinker conferring vitrimer-like behavior. Peroxide progressively enhanced melt viscosity, storage modulus, and relaxation time; however, beyond an optimal concentration, competing chain scission limited further improvement. The synergistic combination of BE and DCP induced a morphological transition from dispersed-phase to co-continuous structure, sustaining elastic behavior in the molten state. The optimized formulation achieved a maximum elastic recovery of 76.01 ± 4.05% and elongation at break exceeding 1303%. Arrhenius analysis confirmed that increasing BE content reduced network rearrangement activation energy, enhancing dynamic bond exchange kinetics and melt reprocessability. For pilot scale study, one-step reactive extrusion outperformed two-step processing in morphology and mechanical properties, highlighting the importance of mixing sequence and residence time. Biodegradation testing per ISO 20200 over 268 days confirmed retained biodegradability through surface cracking, weight loss, and microbial colonization. This work establishes PBAT/P(3HB-co-4HB)/ESO/DCP/BE as a scalable platform for flexible, reprocessable, and environmentally friendly elastomers for industrial applications.

Biography (For Plenary, Keynote, and Invited Speakers)

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Personal History:
Supakij Suttiruengwong serves as an Associate Professor in the Department of Materials Science and Engineering at Silpakorn University, where he specializes in teaching and research related to polymer engineering and characterizations. His career is grounded in a solid educational background, including a Bachelor's in Chemistry from Silpakorn University, a Master's from Swansea University, UK, and a Doctorate in Chemical Engineering from Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany. Professionally, he balances his teaching duties with his role as the head of the Sustainable Materials lab, focusing on practical advancements in bioplastics compounding and materials circularity. His work is characterized by a strong emphasis on addressing environmental challenges through the development of biobased and degradable materials or low-carbon materials, such as those derived from agricultural waste like rice straw and algaes, and he actively collaborates with international research partners e.g. Japan, Germany, Spain and China and industrial stakeholders to implement sustainable engineering solutions. He also serves as various working group committees such as working group in costal and ocean pollution, both government and professional associations like MRS.

Research Keyword (3-5 keywords use commas to separate each word):
Bioplastics, Circular economy, Carbon-neutral materials, Biobased polymers