Translating Dynamic Crosslink Chemistry into Self-Healing Rubber Technologies: From Fundamental Mechanisms to Engineering Applications

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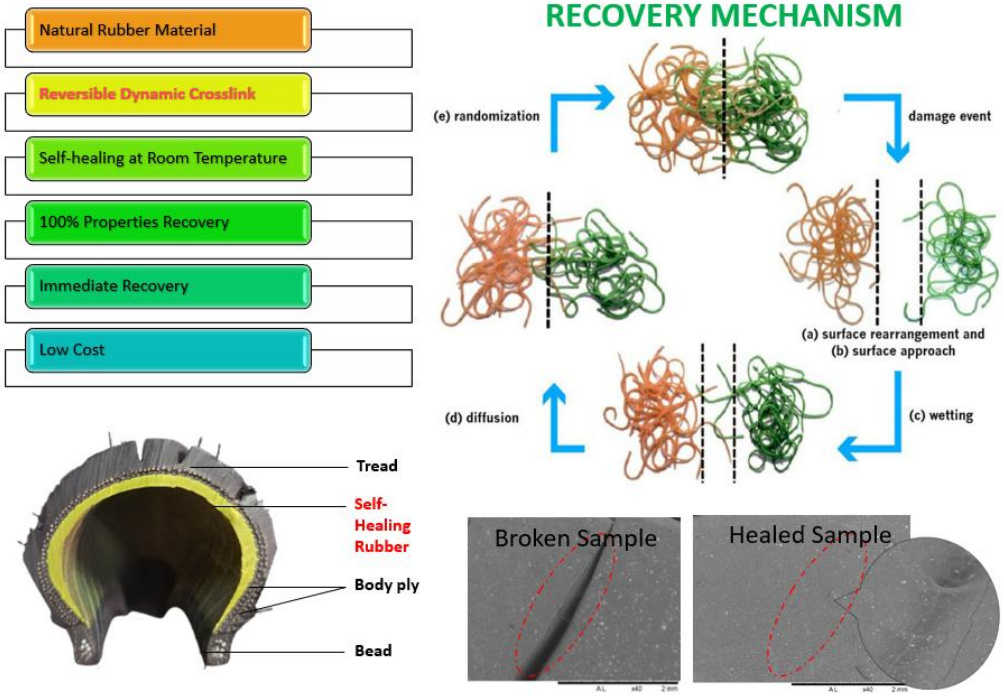
Abstract

The development of self-healing elastomers has emerged as a promising strategy to enhance durability, safety, and sustainability in rubber products. This research bridges fundamental polymer chemistry with practical engineering applications in elastomer technology. The work begins with the design of dynamic crosslink networks based on reversible metal–thiolate ionic interactions, which enable autonomous healing of rubber materials without external stimuli. Fundamental investigations were conducted to elucidate the formation of dynamic ionic networks, crosslink density, and molecular diffusion mechanisms responsible for healing behaviour. Building on this understanding, the research progressed toward engineering self-healing rubber systems through the incorporation of functional fillers, nanostructured reinforcements, and recycled rubber particles. These strategies were explored to optimize mechanical performance, healing efficiency, and structural stability in rubber composites. The concept was further extended to various elastomer architectures, including nanocomposites, foamed rubbers, and coated textile systems, demonstrating the versatility of dynamic crosslink chemistry in diverse material formats. Finally, the translational pathway culminates in the development of functional rubber technologies such as self-healing tapes and puncture-resistant tyre components. The findings highlight how fundamental insights into dynamic crosslink chemistry can be translated into innovative elastomer systems with real-world engineering impact, paving the way for next-generation durable and sustainable rubber products.



Biography (For Plenary, Keynote, and Invited Speakers)

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Personal History:
Dr. Raa Khimi received his Ph.D. from the University of Waikato, New Zealand, in 2015 and is currently an Associate Professor at the Polymer Engineering Department, Universiti Sains Malaysia (USM). His research expertise centers on functional and smart rubber materials, as well as the biodegradation of commodity plastics by bacteria isolated from natural rubber latex environments, contributing to advancing sustainable solutions for polymer waste. Over the years, Dr. Raa Khimi has secured more than RM 3.9 million in research funding through international, national, and industry grants. He is also the founder of RAA Technology Sdn. Bhd., a USM spin-off company that has successfully commercialized puncture-proof self-healing tyres. Dr. Raa Khimi continues to actively bridge academia and industry. His work reflects a strong commitment to impactful research, innovation, and technology transfer, particularly in developing sustainable polymer technologies and strengthening Malaysia's role in advanced materials innovation.

Research Keyword (3-5 keywords use commas to separate each word):
Rubber' Self Healing, Tyre, Foam, Coating