



## **REPROCESSABLE COMPOSITES VIA TRANSESTERIFICATION REACTION, CURED BY A SELF-CATALYTIC REACTION CALLED FRONTAL POLYMERIZATION**

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Efficient strategies for reusing thermoset materials hold significant potential to reduce material waste and promote sustainability. Developing novel thermoset polymers and composites through energy-efficient and environmentally friendly polymerization methods is a critical step in this direction. Key to this effort are advancements in the reprocessability, reshaping capability, and recyclability of these materials. This study focuses on the development of innovative photo-curable composites with controllable compliance and shape. The resin system is based on a reactive acrylate vitrimer system, capable of initiating a self-sustaining reaction triggered by light—known as photo-frontal polymerization [1]. This reaction is driven by the exothermic heat released during the polymerization, which activates the monomers ahead of it, initiating further polymerization. This approach allows for the curing of thicker and larger composite samples using minimal energy input. When using this method to cure composites, several difficulties arise, such as heat loss to the reinforcement phase, which reduces the reaction kinetics. Achieving strong interfacial bonding between the matrix and reinforcement can be challenging, potentially resulting in poor matrix-reinforcement interaction and reduced mechanical performance. Additionally, the high temperatures generated during frontal polymerization can degrade temperature-sensitive components in the resin.

In addition to energy efficiency, the material offers the ability to be reprocessed. These properties stem from the reversible nature of covalently exchangeable ester bonds [2], categorizing the material as part of the vitrimer family. Vitrimers are a class of polymers that bridge the gap between thermosets and thermoplastics by combining the structural rigidity of thermosets with the reprocessability of thermoplastics. Like thermosets, vitrimers possess a network of covalent crosslinks, providing high mechanical strength and thermal stability. However, unlike traditional thermosets, these crosslinks are dynamic and reversible under specific conditions, such as heat or the presence of a catalyst. To integrate the reactive precursors effectively into the reinforcement phase, a vacuum-assisted liquid impregnation process is employed, resulting in the production of a vitrimer composite [3].

In conclusion, the effective integration of reactive precursors into the reinforcement phase will be achieved through a vacuum-assisted liquid impregnation process, enabling the production of vitrimer composites [3]. This study will focus on evaluating high-quality composites developed using a photo-frontally polymerizable system. The investigation will assess the mechanical properties of these composites and their potential for reprocessability. A key focus will be understanding how the presence of the reinforcement and the matrix/reinforcement interface affect the curing process and the dynamics of disulfide bond rearrangement. Lastly, strategies will be implemented to enhance interfacial bonding between the two phases, leading to improved mechanical properties and more efficient reprocessability.

**Papers related to the research:**

- [1] C. Schmidleitner, M. U. Kriehuber, S. Schlögl, and E. Rossegger, "Frontal Polymerization of Covalent Adaptable Networks," Sep. 10, 2024, *ChemRxiv*. doi: 10.26434/chemrxiv-2024-k4vjd.
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- [3] J. Staal, E. Smit, B. Caglar, and V. Michaud, "Thermal management in radical induced cationic frontal polymerisation for optimised processing of fibre reinforced polymers," *Compos. Sci. Technol.*, vol. 237, p. 110009, May 2023, doi: 10.1016/j.compscitech.2023.110009.

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