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Self-Healable and Reprocessable Thermoset Polymer Networks (2022-039)

Self-healing fluorinated acrylic polymers that enable re-processability and create durable materials with enhanced mechanical properties.

Market Overview

Thermosetting polymers are known for their excellent mechanical properties, thermal stability, and resistance to environmental stresses, making them ideal for numerous industrial applications. However, the irreversible nature of their cross-linking poses a challenge for reprocessing and repair. To address this, there has been an increased need for the development of re-processable and self-healing thermosets.

Technical Summary

Clemson researchers have developed fluorinated acrylic-based covalent adaptable networks (CANs) that combine re-processability and self-healing capabilities. These materials are synthesized by copolymerizing (2-acetoacetoxy)ethyl methacrylate (AAEMA), 2,2,2-trifluoroethyl methacrylate (TFEMA), and n-butyl acrylate (nBA), followed by cross-linking with tris(2-aminoethyl) amine (TREN). The resulting CANs exhibit a maximum stress at break of approximately 16 MPa and a storage modulus of around 2.6 GPa within the temperature range of -60 to 25°C. These materials can be fully reprocessed through compression molding at 120°C, maintaining their mechanical properties over multiple cycles. The self-healing mechanism is driven by dipolar interactions and conformational changes within the polymer structure, allowing the material to autonomously heal under ambient conditions. Furthermore, equipping fluorinated acrylic-based copolymers with dynamic crosslinks provides an opportunity for the development of a new class of thermoset networks with sustainable functions.

Applications

- Aerospace and defense: Fuel hoses, gaskets, seals, wiring insulation
- Medical Devices: Catheters, surgical instruments, implantable devices
- Chemical Processing: Linings, gaskets, seals, piping, valves
- Electronics and Semiconductor manufacturing: Wire insulation, circuit boards, equipment
- Automotive: Fuel systems, seals, gaskets for temperature resistance
- Energy sector: Photovoltaic panels, fuel cells

Development Stage

TRL 3/4

Advantages

- **Reprocessability**: Can be reprocessed multiple times without significant loss of mechanical properties, reducing waste.
- **Mechanical Performance**: Maintains high mechanical strength and modulus, even after multiple reprocessing cycles.
- **Self-Healing**: Capable of autonomously repairing damage at room temperature without external intervention.
- **Expanded Market**: Opportunity for the development of a new class of sustainable thermoset networks.

App Type	Country	Serial No.	CURF Ref. No.	Inventors
Provisional	United States	63/592,335	2022-039	Dr. Marek Urban Dr. Siyang Wang

About the Inventors

Dr. Marek W. Urban

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Dr. Marek Urban is the Sirrine Foundation Endowed Chair and Professor in the Department of Materials Science and Engineering. Dr. Urban has published over 500 research papers, is the author of four books, twelve patents, and editor of seven American Chemical Society, Oxford Academic Press, and Wiley books. He is the recipient of numerous prestigious awards and his research on self-healing and antimicrobial polymers has been featured by a variety of media channels, including NY Times, BBC, NBC, USA Today, Yahoo, NSF, and many others.

Dr. Siyang Wang

Postdoctoral Scholar at the University of Chicago

Dr. Siyang Wang worked with Dr. Marek Urban's group and received her Ph.D. in Materials Science and Engineering from Clemson University in 2022. During her time at Clemson, she was awarded the Kentwool Educational Fellow for Excellence in Graduate Research in 2019 and was invited to speak at the National American Society Meeting in 2021. She currently is a postdoctoral at the Pritzker School of Molecular Engineering at the University of Chicago.

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