Materials & Chemicals

Compostable Thermoset Polymers

WiSys: T120033US02

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WiSys Technology Foundation is seeking a strategic partner to further develop and commercialize a series of cross-linkable, biodegradable thermoset polymers for a broad range of applications including health care, durable goods and packaging.

Overview

Thermoset materials, such as cured rubber and phenolics, offer enhanced properties over traditional thermoplastics (such as Poly(lactic acid) or PLA, polystyrene, PET, etc.). This is due to their ability to crosslink making them better suited for high-temperature applications. However, they are generally more brittle, are insoluble and non-reformable and therefore are among the most difficult polymeric materials to recycle and reuse. As a result there is a clear and unmet need for the development of polymer materials with improved properties over thermoplastics such as PLA, while also being capable of readily degrading and being reused.

The Invention

Research from the University of Wisconsin-Stevens Point has resulted in the development of a series of crosslinkable, degradable thermoset polymers with reversible crosslinking from mercaptosuccinic acid and diols. This novel series of polymers have utility for a broad range of applications including health care, durable goods and packaging. Monomeric base materials are polymerized in a facile synthesis and crosslinked (cured) with methods compatible with current industry methods, allowing for the creation of resins with a wide variety of properties. The crosslinking reactions offer the unique feature of being readily reversible allowing for depolymerization to monomers, thereby providing for recyclability for use in sustainable commodity applications, aka “sustainable thermosets”. The polymers are degradable under commercial compost conditions comparable to current bio-derived compostable polymers such as PLA and polycaprolactone. Properties such as duration of degradation in a compost setting, material pliability, toughness and optical clarity are controllable via the degree of polymer crosslinking. In addition, copolymers with PLA, such as poly(lactic acid-copentylenemercaptocuccinate) have been developed in an effort to improve the physical characteristics of PLA.

Applications

- Bioresorbable materials for healthcare applications
- Biodegradable films and plastics
- Durable goods made from bio-derived polymers

Key Benefits

- • Processing times and conditions are similar to available thermoset resins
- Low odor
- Curing (cross-linking) of the polymer series has produced polymers with high thermal stability at elevated temperatures greatly exceeding that of PLA
- Polymers have been shown to degrade to a similar extent and timeframe as PLA and degradation time of cured samples can be controlled by adjusting the crosslink density of the polymers
- Cured crosslinked films are insoluble in organic solvents and infusible, but degrade readily under aqueous conditions when heated following parameters similar to those employed to reclaim PLA

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- Post-curing enhances the mechanical strength and glass transition temperature (Tg) with some-fully cured members of the series possessing a Tg at or above that of PLA. Uncured materials have shelf lives at room temparature greater than one year. Cured materials are stable under ambient use conditions for long periods
- Cured films have readily undergone hydrolysis at elevated temperatures to produce clear aqueous solutions
- Some members of the series exhibit excellent optical transparency after curing with a refractive index near that of ordinary glass (~1.5)
- The adhesive properties of the materials can be controlled with many possessing strong adhesive properties on a variety of surfaces and materials
- Select materials show elastomeric properties similar to rubber, including foams, while others are rigid. Both types can be readily degraded at the end-of-life for reuse

Stage of Development

Batch-quantity synthesis of the materials under both catalyzed and self-catalyzed conditions have been realized. Laboratory-level processing as well as preliminary engineering-level testing has been completed demonstrating that these novel polymers can be processed to form crosslinked thermosetting resins. Following processing, and depending on the desired properties, these materials range from highly transparent to opaque, showing excellent engineering properties. Industry-standard material data sheets have been prepared for two of the resins, including characterization of tensile strength, tensile modulus, elongation, hardness, scratch resistance, glass transition temperature, demold temperatures, and molecular weight, viscosity, and "pot life" characterization of uncured resins. These data sheets are available upon request.

Tech Fields

- Materials & Chemicals : Polymers

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