Novel Green Super Adhesives

Proposed Technical Approach

Our research team has devised a number of novel and useful approaches for the preparation of strong adhesives from renewable starting materials. These ideas are based upon nature in both design and precursors. Naturally derived, yet cost-effective monomers will be used as the building blocks for these adhesives. These green monomers will be polymerized to form highly functionalized hyperbranched or network polymers using two well-known techniques (cationic and condensation polymerization, respectively). Our team has both experience designing polymerization systems that operate by these mechanisms in addition to reducing them to practice in a laboratory setting. The following is a non-technical description of our approach that does not disclose any proprietary information.

Proposed Plan and Deliverables

Recently one of the members of our research team introduced the concept of using naturally derived terpenes as solvents for polymerization reactions.[1] Using this concept as a springboard another member of our team suggested using these natural compounds as a green replacement for isoprene in the production of commercial polymers.[2] Introductory experiments have shown this approach is viable and results in a number of cost benefits. Our team has devised a number of ideas that expand upon the approach of using naturally abundant compounds (green monomers); in this case, for the synthesis of adhesives.

In one approach (Figure 1) a commercially available natural compound of low cost will be chemically functionalized in a 1 step reaction to produce a hexafunctional monomer in high yield and in a cost-effective manner. This hexafunctional monomer will be a liquid of moderate viscosity that can be readily cured to form an adhesive with a flexibility that can be tailored during the functionalization stage. Due to its chemical microstructure this adhesive will posses good adhesion to various substrates (metals, glass, plastics, wood).

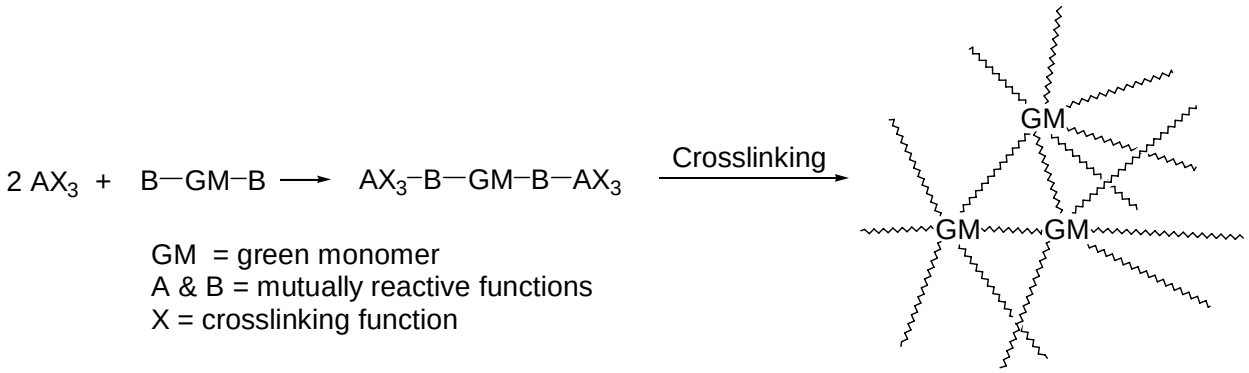

Figure 1

In a separate approach (Figure 2) another commercially available green monomer will be polymerized by a cationic mechanism to yield a highly, randomly branched polymer. This highly branched polymer will then be subjected to simple one-pot post-polymerization functionalization. The high density of functional groups will promote strong adhesion to metal substrates. The flexibility of these highly branched polymers can be readily controlled by technology currently under development by a member of our research group.

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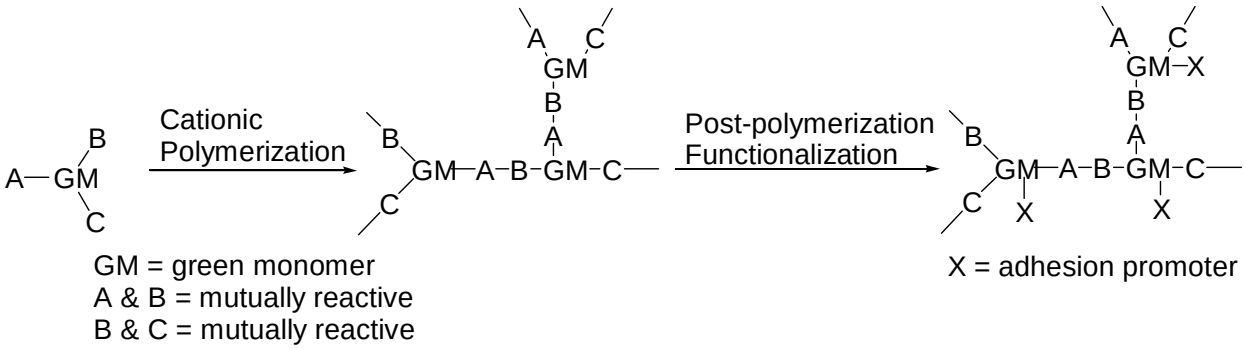

Figure 2

References

1. (a) Mathers, R. T. Damodaran, K. Renewable chain transfer agents for metallocene polymerizations: The effects of chiral monoterpenes on the polyolefin molecular weight and isotacticity. *J*. *Polym*. *Sci*., *Part A*: *Polym*. *Chem*. **2007**, *45*, 3150-3165.(b) Mathers, R. T.; McMahon, K. C.; Damodaran, K.; Retarides, C. J.; Kelley, D. J. Ring opening metathesis polymerizations in d-limonene: A renewable polymerization solvent and chain transfer agent for the synthesis of alkene macromonomers. *Macromolecules* **2006**, *39*, 8982 – 8986.
2. This work is being conducted under contract (Innovative Science, Inc.) and a provisional patent filing covering it is under preparation.

Proof of Concept-Stage 1

Both strategies (condensation and cationic polymerization) will be explored for a 1-1.5 month period. The condensation methodology will be studied by Dr. Robert T. Mathers (under contract) whereas the cationic polymerization approach will be explored by Innovative Science, Inc.; both under the direction of Dr. Stewart P. Lewis. Innovative Science, Inc. will provide research sized samples of each type of adhesive to the client under the protection of a nondisclosure type agreement for evaluation. The cost of conducting this phase of the research project will not exceed $ 10,000. A detailed budgetary breakdown is available upon request. If the client has interest in continuing the research effort then Innovative Science, Inc. will enter formal negations to this effect. Possible scenarios include a joint development arrangement or a contract research and development agreement.

Proposal Team Experience

Dr. Stewart P. Lewis (Innovative Science, Inc.), as director of this research effort has extensive experience in the cationic polymerization field. Dr. Lewis is the inventor of the only known aqueous polymerization systems for polyisobutylene and butyl rubber. This invention (US Patent 7,202,317 {2007}) allows for the production of these materials in a green manner. He also discovered that sterically hindered pyridines are capable of decomposing carbocations under special circumstances (*Macromolecules*, **2007**, *40*(21), 7421-7423.); this had been a topic of intense debate for almost 30 years. Recently Innovative Science, Inc. has developed a process for producing both PIB and butyl rubber in a more economical and environmentally friendly manner (provisional patent in progress).

Dr. Robert T. Mathers (Penn State New Kensington) is an innovator in the field of green polymerization processes. He introduced the concept of using natural materials as solvents in olefin polymerization.[1] Recently, Dr. Mathers has devised a new method that can be used for the polymerization of naturally occurring monomers. He has an extensive knowledge of naturally occurring compounds that are of value in the production of polymeric materials.

More detailed biographical information on the key members of the research team is available upon request.