Seed Grant Application Cover Page

PRINCIPAL INVESTIGATOR:

Name:	Mark F. Roll	Title:	Assistant Professor
Department:	Chemical & Materials Eng.	Email:	mroll@uidaho.edu

ADDITIONAL INVESTIGATORS:

Name:		Title:	
Department:		Email:	

Name:		Title:	
Department:		Email:	

Amount Requested: $ 12,000

Proposal Title: Thermal Depolymerization of Tires and Synthetic Rubber Wastes

PROPOSAL CHECKLIST:

- [x] Abstract
- [x] Narrative (2 single-spaced pages)
- [x] Budget Page
- [x] Biographical Data
- [x] Publications/Exhibits/Performances (5 years)
- [x] Proposals Submitted/Funded (5 years)
- [ ] Summary of Previous Seed Grant(s)
- [ ] Applicable animal/human requests for approval are attached

ELIGIBILITY:

- [x] Early career faculty establishing scholarly program (5 years or less employment at UI)
- [ ] Established faculty transitioning into a new scholarly area

Has seed grant previously been awarded? ☐ Yes ☒ No

Thermal Depolymerization of Synthetic Rubber Wastes

The proliferation of non-biodegradable, synthetic polymers and plastics has raised thorny questions about their accumulation as waste. As plastics are often the basis for low-cost, disposable products, their accumulation becomes even more problematic. In recent decades, plastics have undergone great scrutiny for recycling and reuse. Two examples of rapidly accumulating synthetic polymer wastes are vehicle tires and disposable safety gloves at hospitals and research facilities, where currently our only recourse for disposal is interment in a landfill.

We will be investigating "depolymerization", where with the careful heating of a polymer above 400˚C in an inert atmosphere, the chemical backbone begins to break-up or "depolymerize". **The goal of this project is the construction a proof-of-concept implementation for the thermal depolymerization of two high-value synthetic polymers: vehicle tires and nitrile gloves.**

This research project will support development of grant applications for NASA and the Department of Energy in the areas of carbon fiber production and biomass-or-waste-to-energy conversion. It will also serve as the basis for a senior design project within the Department of Chemical & Materials Engineering, in the College of Engineering, integration with the MSE434 "Fundamentals of Polymeric Materials", and student-led Sustainability Design Center projects.

Thermal Depolymerization of Tires and Synthetic Rubber Wastes

Energy and Materials efficiency is my research focus as a new faculty member in the Department of Chemical & Materials Engineering here at the University of Idaho. The long-term goals are the development of advanced battery and fuel-cell membranes, as well as the development of advanced polymers for carbon fiber composites and photolithography. One step towards these long-term goals is the investigation of ways to recycle polymer materials into chemical precursors suitable for producing our more advanced materials. **Specifically, we will construct a proof-of-concept chemical reactor for the thermal depolymerization synthetic rubber wastes, specifically vehicle tires and nitrile gloves.** The Seed Grant will fund the installation of a new chemical fumehood in the PI's lab to provide a safe working environment.

The proliferation of non-biodegradable, synthetic polymers and plastics has raised thorny questions about their accumulation over time. As plastics are often the basis for low-cost, disposable products, their accumulation becomes even more problematic. Given the effort, time and money used to produce these materials, it seems to make sense to reuse or recycle them instead of simply relegating them to a landfill after their useful lifespan.

In recent decades, plastics have undergone great scrutiny for recycling and reuse. Unfortunately, the availability of low-cost, oil-based feedstocks has removed almost all financial incentive to recycle these materials. Two examples of rapidly accumulating synthetic polymer wastes are vehicle tires and disposable safety gloves at hospitals and research facilities, where currently our only recourse for disposal is interment in a landfill.

Contribution to the Field and the PI's Professional Development

There have been recent commercial attempts at industrial-scale thermal depolymerization, converting polymeric materials into their chemical precursors for use as fuels or new chemical feedstocks. In this process, upon careful heating of a polymer above 400˚C in an inert atmosphere, the chemical backbone begins to break-up or "depolymerize".[1] **The goal of this project is the construction a proof-of-concept implementation for the thermal depolymerization of two high-value synthetic polymers: vehicle tires and nitrile gloves.** Whereas the recycling of tires in this context has seen some exploration,[2] the thermal depolymerization of nitrile gloves has yet to receive much attention, so the project will break new ground in this area. The mechanical resilience of elastomeric materials is useful for the thin-film battery materials, and their precursor chemicals can be of use in the production of carbon fibers. Each of these is of interest for the PI's long-term goals. We will answer the question: can we *efficiently* turn these landfill-bound materials into the chemicals we need to make *new* materials for carbon fibers or batteries?

The nature of the project dovetails with the growing public interest in "green" materials, with minimized impact on the environment throughout its life-cycle. The "real world" applicability of this research adds to the science and engineering merit of investigating and disseminating valuable information regarding thermal depolymerization. The acquisition of the fumehood with the Seed Grant will provide a safe, workspace for the PI or other collaborators working with chemical reactions and enable a very broad range of additional research projects in the PI's area of expertise: Materials Chemistry.

Objectives

Our formal project objectives are the following:

1. Construct an operational thermal depolymerization reactor
2. Evaluate the synthetic feasibility of synthetic rubber depolymerization
3. Gather processing data to determine large-scale economic feasibility

Methods and Timeline

Based on previous work, thermal-breakdown of these materials should be achievable above 400˚C.[1,2] A recently donated tube furnace will be used as the heat source, and our initial work can be conducted with laboratory glassware we already possess. At these higher temperatures, reaction rates will be significantly elevated, and may provide the efficiency boost needed for allow more significant explorations. As we move to investigate higher temperatures, pure quartz silica glassware will be procured, allowing us to investigate reaction temperatures up to 1000˚C. This Seed Grant will enable the installation of the necessary fumehood for operations.

We specify three terms in the funding cycle: Fall, Spring and Summer. Objective 1 will be accomplished by fumehood acquisition and installation along with prototype development during the Fall 2012 term. The nature of the process and the potential products, including volatile organic compounds, will require a large fumehood space. The existing fumehood space in the PI's laboratory is too small for the prototype and is currently oversubscribed. Therefore, a new 8 foot wide fumehood will be installed in the PI's laboratory for the proposed project. This will include purchasing the required equipment and working with Facilities to ensure a timely installation. With fumehood installation completed in the Fall, the finalized depolymerization reactor will be constructed and put into operation during the Spring 2013. This will entail the assembly of the required glassware, heating and cooling elements, and implementing the nitrogen gas flow required to give an inert atmosphere.

Objective 2 will consist of running many sets of reactions with variations in time and temperature to gain a solid understanding of the reaction dependencies and rates. Through these experiments we will ascertain a set of optimized conditions for each of the materials of interest: tires and nitrile gloves. The tasks will be accomplished through investigations occurring throughout the funding cycle, beginning with the prototype development in the Fall, and concluding during final summer term. The greater portion of this objective will be accomplished after the reactor is operational.

Objective 3 will be accomplished towards the end of the final Summer term (2013), when the depolymerization processes have been optimized. Once we have an understanding of the reaction rates, required temperatures, energy input requirements, and reaction products; we can begin to make quantitative judgments about the economic value of the process and its outputs. Critical questions will be asked regarding the purity and value of the chemical products in comparison to the reaction input energy required.

Expected Outcomes and Deliverables

This research project will support development of grant applications for NASA and the Department of Energy in the areas of carbon fiber production and biomass-or-waste-to-energy conversion. It will also serve as the basis for a senior design project within the Department of Chemical & Materials Engineering, in the College of Engineering, integration with the MSE434 "Fundamentals of Polymeric Materials", and student-led Sustainability Design Center projects. In order to supplement published reports on related projects in the scientific literature, we intend to compile the general and outstanding observations of the research as a peer-reviewed report for other researchers in the area of polymer science and green chemistry. Two journals, which may be a good fit for the different aspects of this project, include *Macromolecules* and the *Journal of Chemical Education*. The optimized processes may be patentable.

Works Cited:

1. Cowie, J.M.G.; Arrighi, V. Polymers: Chemistry and Physics of Modern Materials. 3rd edition, CRC Press: Boca Raton (2008).
2. Lopez, G.; Olazar, M.; Aguado, R. Elordi, G.; Amutio, M.; Artetxe, M.; Bilbao, J. "Vacuum Pyrolysis of Waste Tires by Continously Feeding into a Conical Spouted Bed Reactor," *Industrial & Engineering Chemistry Research* **49**, 8990-8997 (2010).