Durr Group Research Summary

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Bio

I received my bachelor's degree in chemistry from Kent State University where I worked for nearly three years in undergraduate research, including two summer NSF-REUs. My thesis, advised by Prof. Scott Bunge, was focused on the synthesis of air and moisture sensitive transition metal complexes for use as catalysts and nanoparticle precursors.

After graduation, I moved down the road to The Ohio State University where I received my PhD under the direction of Prof. Malcolm Chisholm, FRS. There, I worked with a dynamic team of colleagues studying how light interacted with dimolybdenum and ditungsten paddlewheel complexes and how we can harness their properties in photovoltaic applications.

After a year teaching as a Visiting Assistant Professor at The College of Wooster, I moved to the University of Oxford where I was a Fulford Junior Research Fellow at Somerville College. My research with Prof. Charlotte Williams focused on the synthesis of new group IV catalysts for the ring-opening polymerization of cyclic esters and the formation of poly(olefins).

Research

Research in the Durr group is centered around developing and understanding next generation polymeric materials. This includes discovering new inorganic catalysts, as well as new techniques. One of the advantages of this research is that there is something to be found in it for every type of chemist. Whether you are interested in inorganic, organic, physical, analytical, and biological chemistry you will be able to contribute to these projects and learn something new along the way.

Photoswitchable Catalysts

How do we match nature's accuracy and precision in polymer synthesis? Nature routinely makes perfectly sequenced polymers which act as the basis for life. DNA, which is a polymer made up of four repeating monomers, encodes vast amounts of data while proteins, which are polymers made up of ~20 different monomers, are applied in numerous roles throughout living systems. *Synthetic* polymer chemistry is always striving for, but has thus far failed to achieve, such accuracy.

Our group hopes to achieve accurate polymer sequencing through the development of switchable catalysts. A switchable catalyst is one which polymerizes a particular monomer, A, until a stimulus is applied (oftentimes this is a redox reagent or a temperature change) and then it prefers to polymerize a different molecule, B. If we can oscillate the stimulus back and forth we can achieve sequence control of the final polymer which allows us to tune how the final material melts, moves, assembles, and physically behaves. The current challenge in this field is based around efficiently adding and removing the stimulus. Our group aims to tackle this problem by using *light* to switch between monomers, where the catalyst polymerizes A in the dark, and B in the light (Figure 1).

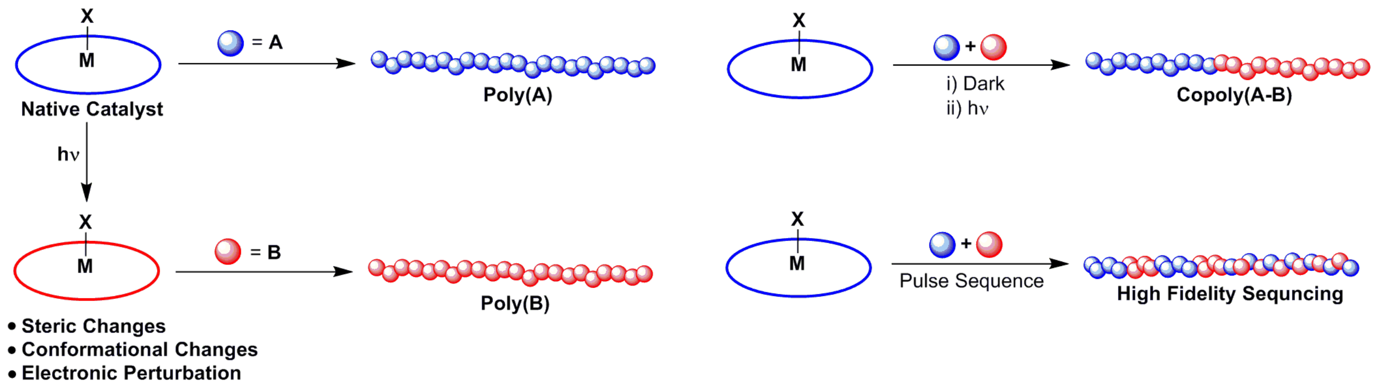

Figure 1.

What will it take to accomplish this task? Well, in short, it will take you, the student. Photoswitchable polymerization catalysts will have wide ranging implication on the fields or inorganic and materials chemistry. While challenging, their benefits could be extraordinary. To design and understand them we need to assemble a team that is interested in inorganic, organic and physical chemistry.

Degradable Polymers

Many of the plastics we use every day are not biodegradable – once they are used and disposed of, they will persist in our environment long after we're gone. There are polymers that can degrade over time, but there are relatively few commercial examples compared to traditional, non-degradable, plastics. Our goal is to discover new families of polymers that will be both environmentally friendly *and* useful to our society. (Figure 2) This means finding new routes of degradation as well as new monomers that are capable of this chemistry. In all cases we will be searching for catalysts that can efficiently produce such materials.

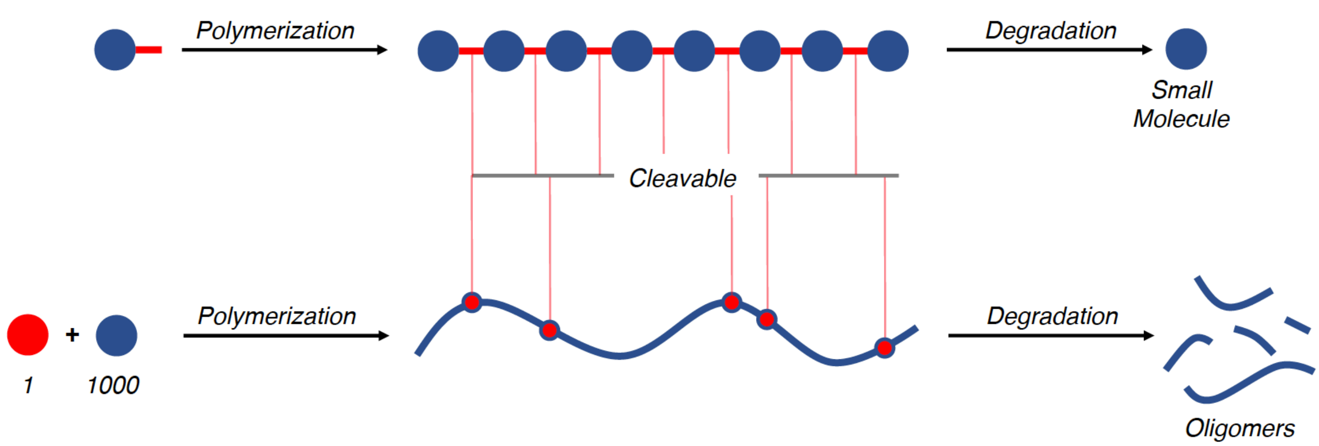

Figure 2.

Bio-medical Materials
We will be looking to utilize the catalysts we make in the production of polymers that are capable of drug delivery, medical imaging and tissue scaffolding. By controlling the composition and architecture of the polymers we produce we can influence their material properties such as crystallinity, degradation rate, strength etc. (Figure 3)

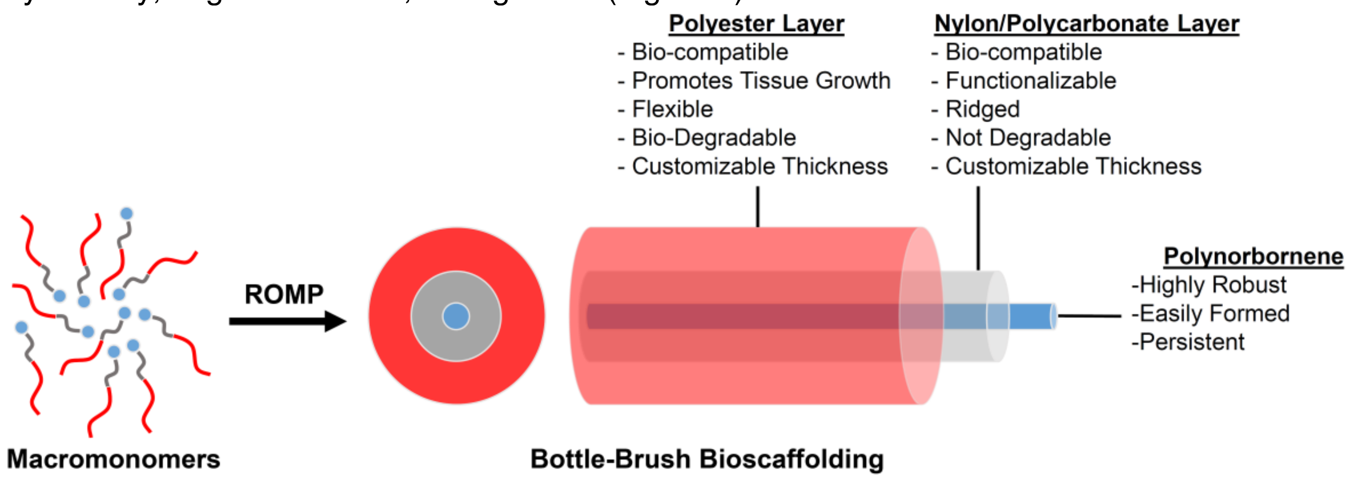

Figure 3.

FAQ

What would research in your group look like?
The Apollo Program, the Human Genome Project, splitting the atom; the thread that runs through all of these human advances is *teamwork*. Even discoveries made by individual labs are almost always reliant on a team of researchers. That's because science done right is science done as a community. Research in our lab embraces this idea: many projects, many voices, many ideas – one team.

You'll be given a project based on your experience and, when possible, your chemical interests. We will work together to assemble a plan for your project with tangible goals. You will take ownership over the project, designing experiments you think will prove your hypothesis, reading scientific literature to support your findings, and collaborating with students inside and outside of the lab. You'll have the opportunity to report your findings, where appropriate, at scientific meetings and through publications.

Along with learning how to do cutting edge research you'll also be learning something equally important: safety. There is *zero* difference between good chemistry and safe chemistry – they're one and the same. Our lab will *always* put safety first, so you feel confident in the work you're doing.

How would I fit in?
Great question. I truly believe there is a place for everyone our lab. You may come in with your mind made up that you are a chemist who loves X and find out that you also love Y. That's what undergraduate research is about. While our main focus is on inorganic chemistry, the applications of that chemistry can go in any number of directions.

I'm interested in inorganic chemistry.
Well, then you are in the right place as we are first-and-foremost an inorganic chemistry lab. Most of our synthesis will be focused on making metal-containing catalyst from around the periodic table. We're keeping our options open which means the potential to work with main group metals, transition metals, and lanthanides. You'll learn how to handle air and moisture sensitive chemicals in an inert environment, typically in a glovebox, and then apply the molecules you make in catalysis.

I'm interested in organic chemistry.
For every piece of inorganic chemistry that happens there is usually an equal amount of organic chemistry that has to happen. New catalytic systems *demand* new organic ligands. That means you'll have the chance to be creative. You can use your passion for organic chemistry to design a framework no one has ever seen before and thus a brand-new catalyst with new and exciting properties.

I'm interested in physical chemistry.
A crucial part of understanding the catalysts and polymers we make hinges on physical chemistry. One of our major focuses is on photoactive catalysts. This means we will have to investigate how they interact with light and how this in turn influences catalysis. Once the polymers are made we will have brand-new state-of-the art instrumentation for analyzing how they crystalize and melt.

I'm interested in biochemistry.
Our team touches on biochemistry in several ways. We are interested in making new polymers that are capable of drug delivery, tissue scaffolding, and antimicrobial activity. This will require chemists who are interested in how polymers interact with biological systems and how we may apply our materials in new ways.

I'm interested in analytical chemistry.
Analytical chemistry is vital to characterizing both the progress of our catalysts and the properties of the final polymer. We intend on purchasing three pieces of instrumentation rarely seen at a liberal arts college. The first is a special form of liquid chromatography called gel permeation chromatography (GPC) which allows us to characterize the molecular weight of our polymers. The second is a differential scanning calorimeter (DSC) which can provide a full thermal analysis of our materials from crystallization temperatures to glass transitions. The third is an *in situ* reactIR which is capable of monitoring reaction kinetics *in real time*. You'll be able to learn how to use all of this instrumentation and apply them towards solving chemical problems.

I'm interested in everything.
Perfect. The projects in our lab are highly interdisciplinary and being interested in a little bit of everything is crucial to their success.

What experience do I need?
At least one semester of Organic Chemistry + Lab is desirable though highly motivated students below this experience level will be welcome.

How do I get involved?
If you're interested in research in the Durr group feel free to email cdurr@amherst.edu anytime so we can discuss a project.