Chemistry Research Projects at WKU.

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This presentation will begin with an introduction to WKU chemistry master's program, some thoughts for students about planning for graduate school or other endeavors after graduation, and an overview of several research projects being conducted at WKU. The remainder of the talk will focus on three materials chemistry research projects being conducted in my lab, which are described below. I hope that there will be something of interest for everyone!

Degradable vinyl polymers with antioxidant pendent groups (ascorbic acid monomers)
We recently synthesized a polymerization initiator with a boronic ester linkage and showed that polymers grown from this initiator are degradable in the presence of hydrogen peroxide. Our current goal is to create polymers that incorporate antioxidant groups with these degradable linkages, and we are working to synthesize polymerizable ascorbic acid derivatives for this purpose. These antioxidant groups are expected to afford some protection to the degradable linkage, and adjusting the feed ratio of antioxidant monomer to filler monomer will then allow us to tune the rate at which polymer molecular weight decreases in the presence of hydrogen peroxide. These materials with tunable lifetimes and compositions are envisioned as antioxidant additives, degradable packaging, and containers for drug delivery simply by changing the filler monomer to suit the application needs.

Synthesis of nanoparticle photocatalysts (metal/semiconductor hybrids)
Hydrogen obtained from water-splitting is one route being pursued as a renewable energy system. Water-splitting involves reduction of protons at one electrode to produce hydrogen, oxidation of water at an electrode to produce oxygen, and an energy source to drive the reaction away from water and towards the more reactive H_2 and O_2. The hydrogen can then be used as a fuel to generate energy at a later time without producing CO_2. Platinum is known to be highly efficient for the hydrogen evolution reaction, and it is commonly used as an electrode material for these devices, but recently nanostructured electrode materials based on more abundant metals (e.g., iron and nickel) have been shown to have performances comparable to that of platinum. These studies consist of coating an electrode in the material being studied and then measuring the overpotential required for the reactions of interest. We are interested in applying these materials that have been used on electrodes to metal/semiconductor hybrid nanoparticles that can harvest light directly. Our research is focused on deposition of these new iron/nickel electrode materials onto semiconductor nanoparticles to create photocatalysts capable of splitting water using sunlight, and challenges associated with characterizing these materials.

Waste-free approach for CO_2 hydrogenation catalysts (metal nanoparticles in ionic liquids)
Catalytic conversion of carbon dioxide to valuable materials uses an abundant, inexpensive waste product as a feedstock to prepare other materials. Hydrogenation of CO_2 is widely investigated as the starting point in CO_2 modification, and catalyst materials include noble metals, organocatalysts, metal organic frameworks, and others. These materials are studied by synthesizing catalyst materials with well-defined structures and correlating structure with performance to aid further catalyst development. However, existing synthesis approaches for well-defined catalysts often involve multiple purification steps before the catalyst is coated, dispersed, or otherwise made ready for use. This means that further development will be required to reduce the cost and waste associated with preparing functional catalysts. Our idea is to develop a holistic approach to synthesizing catalysts to reduce waste and cost by generating well-defined nanoparticle catalysts directly in the medium that will be used for the catalytic hydrogenation reactions. We are currently investigating platinum/cobalt alloy nanoparticles in ionic liquids that are designed as solvents/ligands for nanoparticle shape control and solvents and organocatalysts for CO_2 hydrogenation. Results from ionic liquid synthesis, nanoparticle shape control, and the methods used to measure catalyst performance will be discussed.