Advancing Bio-Based Chemicals and Next-Generation Fuels from Montana's Agricultural Crops

Challenges

The aviation industry does not have alternative technologies in minimizing emissions, improving fuel economy, and eliminating toxic components in the fuel unlike ground transportation.

- Oxygenated fuels (biodiesel and ethanol) are incompatible with most aviation engines.
- It is impractical at the moment to explore on how hybrid engines work in extreme flight conditions.

Advancing Bio-Based Chemicals and Next-Generation Fuels from Montana's Agricultural Crops

Research Progress

This grant funding allowed the center to formulate mechanisms of producing viable fuels from Montana-grown crops.

- Created new methods to make high-octane chemicals from Camelina
- Demonstrated that the technology can be scaled and products can be refined using existing technologies found in most refineries.
- Revealed that preliminary LCA modeling results into a promising greenhouse gas reduction for camelina-based biofuels.

MONTANA UNIVERSITY SYSTEM RESEARCH INITIATIVE

Recovery of Metal Contaminants from Industrial Wastewaters with Magnetic NanoComposites in a Novel Continuous Flow Process System

Jerome Downey, Professor, Montana Tech Department of Metallurgical and Materials Engineering

Edward Rosenberg, Professor, The University of Montana Department of Chemistry & Biochemistry

Hsin Huang, Professor, Montana Tech Department of Metallurgical and Materials Engineering

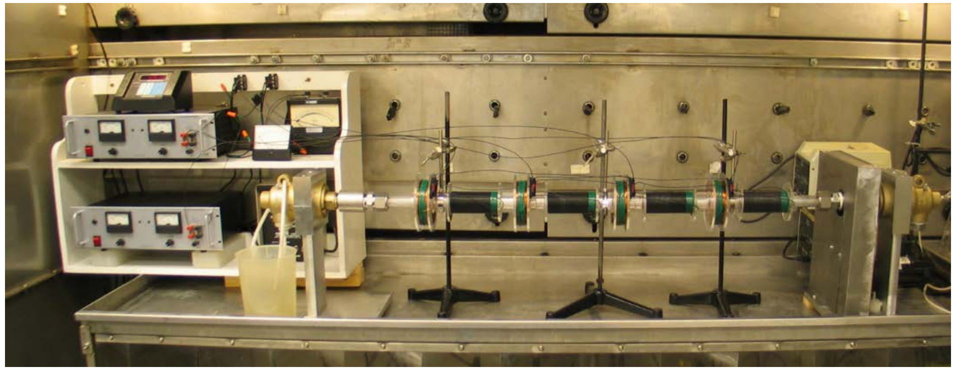
Alysia Cox, Assistant Professor, Montana Tech Department of Chemistry and Geochemistry

Continuous Flow Reactor

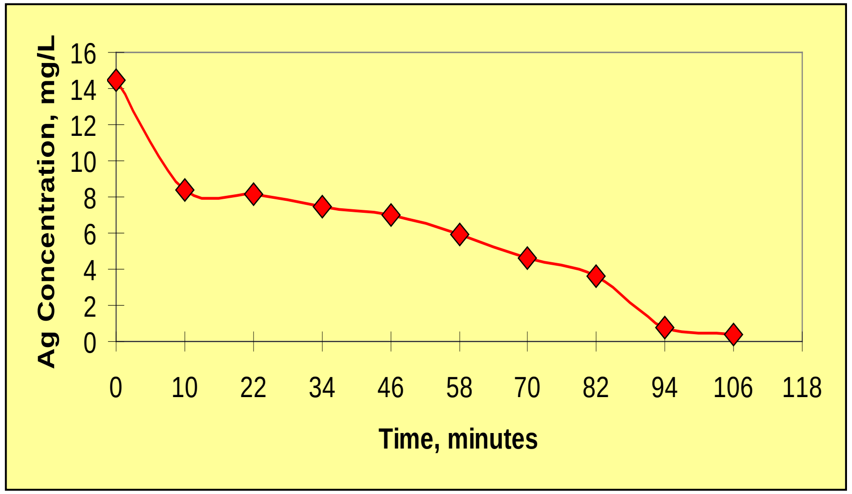
Ion exchange resin is impregnated on fine magnetic particles.

The particles are mixed with the wastewater, which is pumped through the reactor.

Magnets extend the particle residence time as the solution flows through the reactor.



Proof of Concept



More than 93% of the silver was recovered after a 15 ppm (initial) silver solution was continuously circulated through the prototype reactor.

Advantages

Dissolved metals are efficiently captured from dilute solutions; the reactor can also be used to strip metals from the magnetic nanoparticles.

The process is mechanically simple and not labor intensive; energy requirements are low since pumping requirements are not severe.

Silica Polyamine Composites SPC: a proven technology for recovery of valuable metals from mining and industrial waste developed at UM

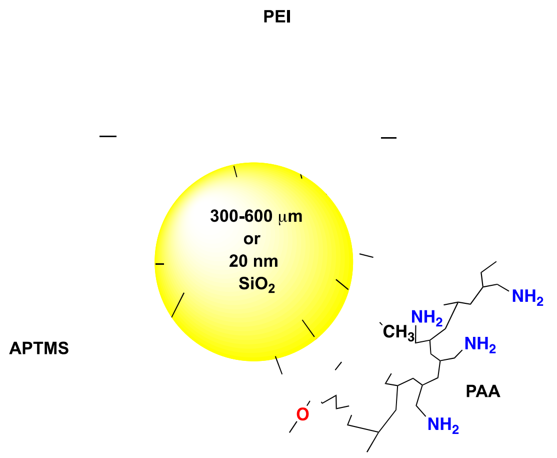
Commercial Projects

Red Banks Mine, Western Australia: flow Open pit mine drainage.

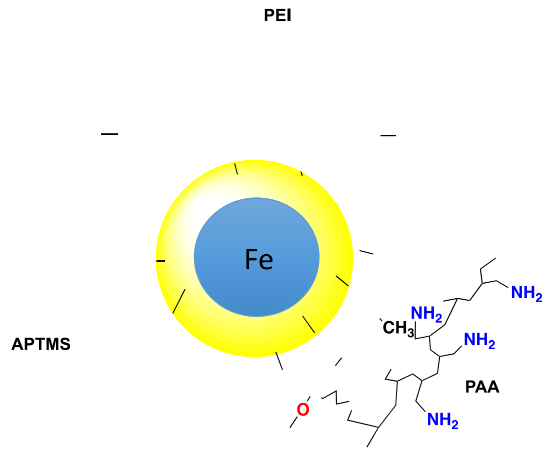
Adelaide Aqua in Western Australia: removal of all transition metals from desalinization plant water.

Envirite, St. Louis, MO: Ni recovery and electro-winning from industrial waste.

Yuan Jiang Refinery, China: Ni removal of Ni from mine waste to <5 ppm.



Current SPC: polymer further modified with metal selective ligand



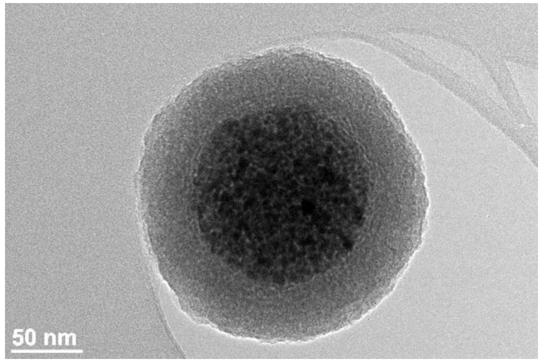
Magnetic core-shell nanoparticle with Fe_2O_3 nanoparticle core

Successful AMD Studies

Berkley Pit: recovery of 97 % pure copper directly from pit; recovery of 100% pure zinc 83% pure manganese.

Colorado/Wickes Mining District, Helena, MT. Removal of As, Pb, Cd and Zn to BDL from AMD creek.

Selective removal of As in AMD from high sulfate stream.



TEM image of a silica coated Fe nanoparticle

First Quarter Progress

- **Objective 1: Wastewater Characterization** -- **Dr. Alysia Cox and the EDGE Laboratory** have begun to compile local surface water data and samples to provide chemical targets and mixtures for the continuous flow reactor system

- **Objective 2: Magnetic Nanocomposite Synthesis – Dr. Ed Rosenberg's UM team** has identified three methods of modifying iron magnetic nanoparticles with ligands capable of capturing metal ions of interest.

- **Objective 3: Secure Fundamental Aqueous Processing Data and Generate Process Models** – using MBMG data, **Dr. H.H. Huang (MTech)** prepared a preliminary wastewater database that will be used to generate aqueous processing models.

- **Objective 4: Continuous Flow Reactor Design, Construction, Commissioning, and Operation –** construction of the bench-scale continuous flow reactor system is underway. The cross-sectional area has been scaled up by a factor of 4.

- **Objective 5: Data Consolidation and Reporting --** Documentation protocols, metadata accumulation, consolidation, and security measures have been established and are in effect

Continuous Flow Reactor

Economic Impacts of the Proposed Particle Technology

- **<u>Address Montana Needs</u>:** hundreds of abandoned mine sites throughout Montana require attention, but the technology is not restricted to ARD treatment. The technology represents a cost effective means of remediating these sites and for recovering metals from effluents at existing operations.

- **<u>New Entrepreneurial Venture</u>:** a Montana-based manufacturing and technical services company will be created to produce magnetic nanoparticles and to manufacture the continuous flow reactors for site-specific applications.

- **<u>Job creation</u>:** the company will need chemists, materials scientists, design engineers and process engineers. Personnel demands will be satisfied by hiring science and engineering graduates from Montana colleges and universities as well as the collaborative Materials Science Ph.D. program. Each resource recovery/remediation project site will require well-educated technicians for operation and maintenance.

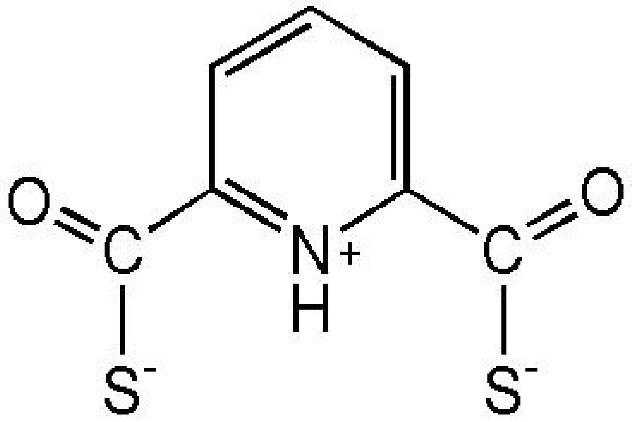
- **<u>Spin-off industries</u>:** Clean water is a global concern and successful demonstration in Montana is expected to lead to the development of national and global markets thus increasing the ROI to Montana.

New Project Team Members

- David Hutchins, Materials Science Ph.D. student at Montana Tech
- Renee Schmidt, Geochemistry MS student at Montana Tech
- Ryan Letterman, Post-Doctoral Research Associate,
- Emil DeLuca, Research Associate
- Jared Geer, Bachelor of Science in Metallurgical and Materials Engineering at Montana Tech.

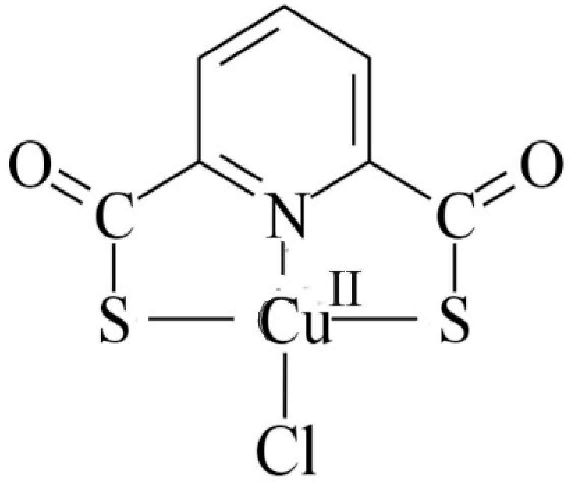
Remediation Technology for Chlorinated Pollutants Based on a Natural Product from Soil Bacteria

Matt Queen and Tom Lewis

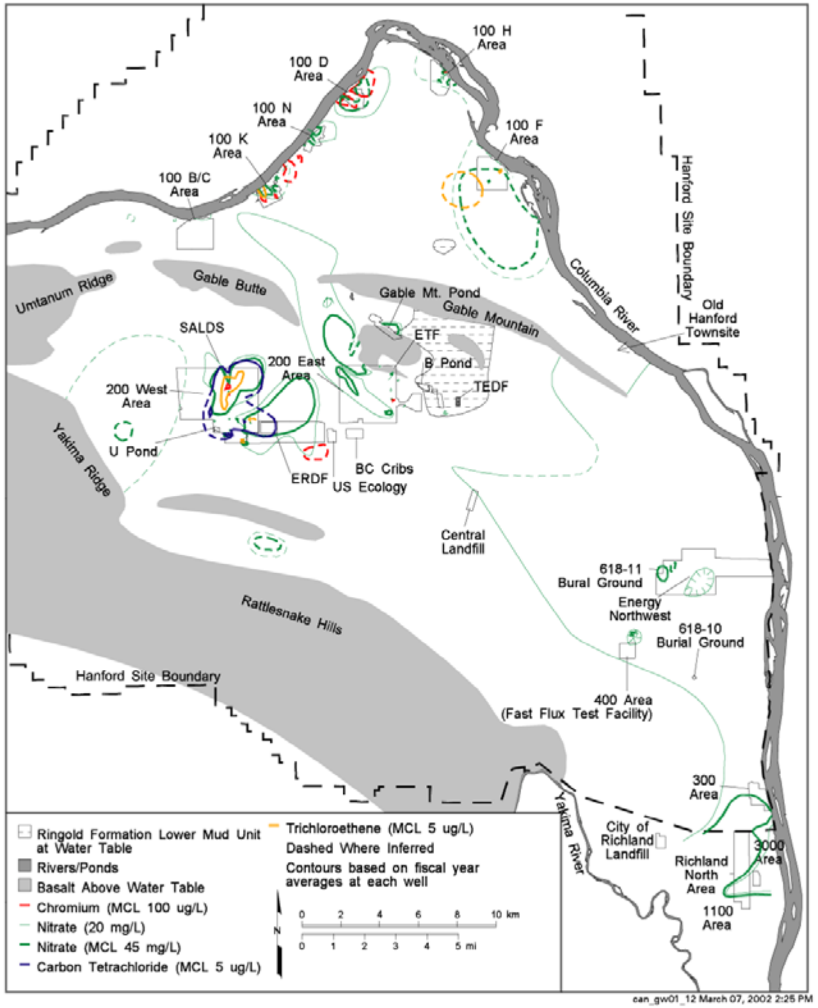


- **Background:** CCl_4 destruction via PDTC

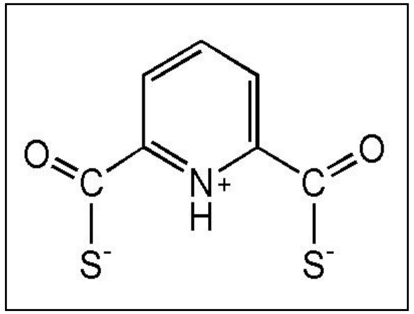
- **Objectives:** New derivatives of PDTC for effective remediation technology



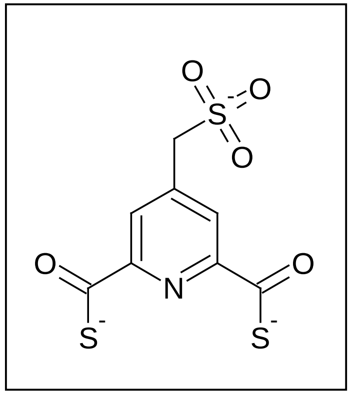
Rationale for Developing Remediation Technology for Carbon Tetrachloride: the Hanford Example

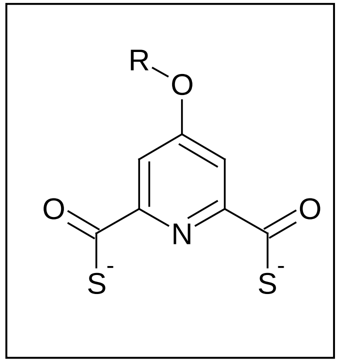


Synthetic PDTC Derivatives for Remediation Applications



PDTC





- **Improved water solubility**
- **Improved CCl4 solubility**
- **Also: Modified density, Flow-through Cartridge Development**

Objective 1: Have verified, chemically pure PDTC sulfonate, polymer-linked PDTC, and their copper complexes

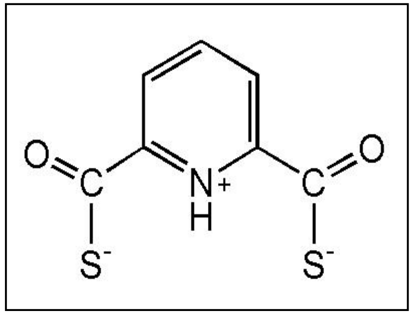
Hiring:

- Permission was sought and granted from MUS to contract the work at MSU and hire a laboratory research technician at MSUB.
    - Synthetic work will be done in the laboratory of Dr. Tom Livinghouse, MSU Dept. of Chemistry and Biochemistry.
    - A contract has been drafted to support a graduate student and supplies at MSU and is pending administrative approval.

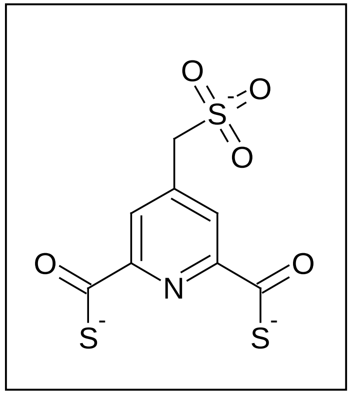
Progress Towards Objective:

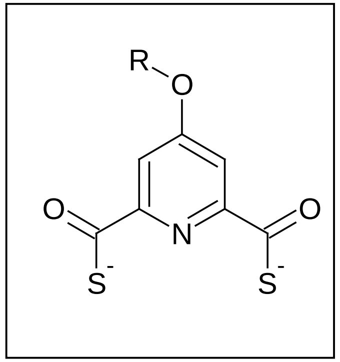
- Dr. Livinghouse has devised synthetic routes for molecules specified under this objective.

Synthetic PDTC Derivatives for Remediation Applications

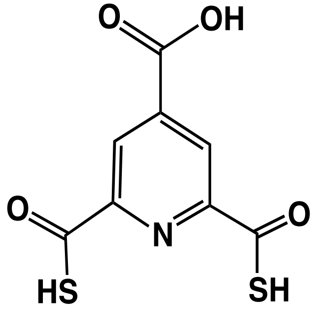


PDTC





Livinghouse:



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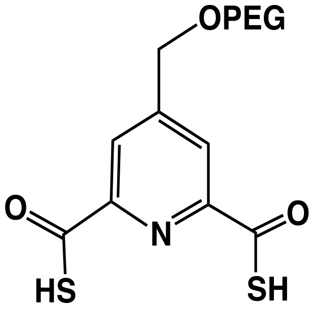

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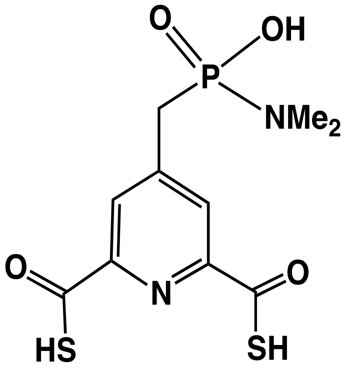

2c

- **Improved water solubility**
- **Improved CCl4 solubility**
- **Also: Modified density, Flow-through Cartridge Development**

Objective 2: Have data regarding solubility and dechlorination rates for new derivatives of PDTC

Hiring:

- A search for a laboratory research technician is pending administrative approval.

Equipment:

- An Agilent 7697A headspace autosampler with associated controlling software has been purchased and will be installed in February 2016

Progress Towards Objective:

- Tests of the natural dechlorination agent, PDTC, will begin when the new equipment is installed (February 2016) and a technician is hired.
    - Generation of comparable data using synthetic derivatives of PDTC will commence upon receipt of deliverables of Objective 1 above.

Objective 3: Have initial toxicology assessment of simulated remediation mixtures, refined dechlorination data to include other solvents, effects of aquifer solids.

Progress Towards Objective:

- We have made initial contacts with contract toxicology providers
    - No formal quotes at this time.
    - Other components will await deliverables of Objective 1.