

ORGANIC DYES

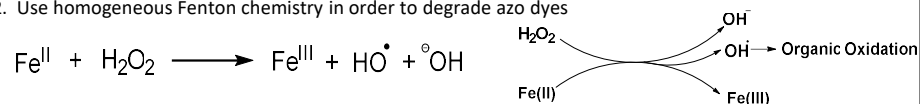
Dyes found in wastewater from textile or food industries damage ecosystems via discoloring water and filtering sunlight. These dyes are often designed to resist photodegradation, resulting in incredibly persistent compounds. This currently removal is performed through bioremediation, or energy-intensive physical techniques. Some research has been performed towards chemical degradation, often resulting in a secondary pollutant. Advanced oxidative processes, such as Fenton Chemistry, have shown promising results for the complete degradation of various dyes.

FENTON CHEMISTRY

Fenton Chemistry is the iron mediated production of a hydroxyl radical from hydrogen peroxide. This technique is desirable for the study of the breakdown of dyes, as a hydroxyl radical can quickly breakdown chemicals into multiple byproducts. These byproducts can then continue to be mineralized into carbon dioxide and water. This oxidative process is an incredibly efficient technique, and one of few shown to effectively break down dyes.

GOALS:

1. Confirm Fenton chemistry as a valid technique for the degradation of organic compounds
2. Use homogeneous Fenton chemistry in order to degrade azo dyes



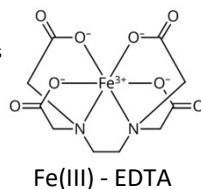
LIGAND DESIGN

Iron ligands can vary in denticity, from mono to hexadentate. An antioxidant ligand would fully bind Fe(II), such that it would be unable to be oxidized to Fe(III) for the Fenton reaction. Conversely, oxidation promoting ligands do not fully chelate iron, and therefore an Fe(II) oxidation proceeds unimpeded. Ligand addition allows iron to stay in solution in a larger range of pH values, increasing versatility.

EDTA is the standardized divalent metal ligand due to its availability, and used in the hydroxyl radical assay. However, EDTA is persistent in the environment, and mobilizes heavy metals or other undesirable compounds through their dissolution.

4 Common Ligand Types: polycarboxylates, aminocarboxylates, phosphates, and N₄ donor-based

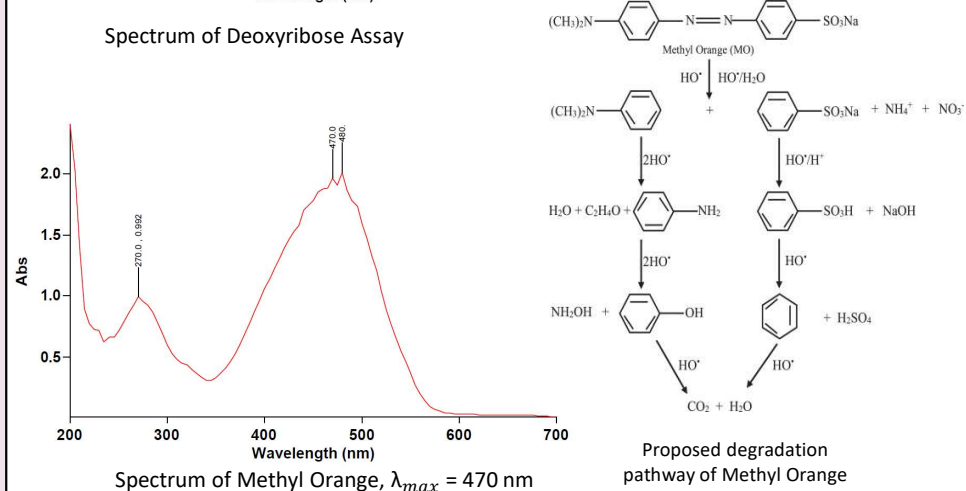
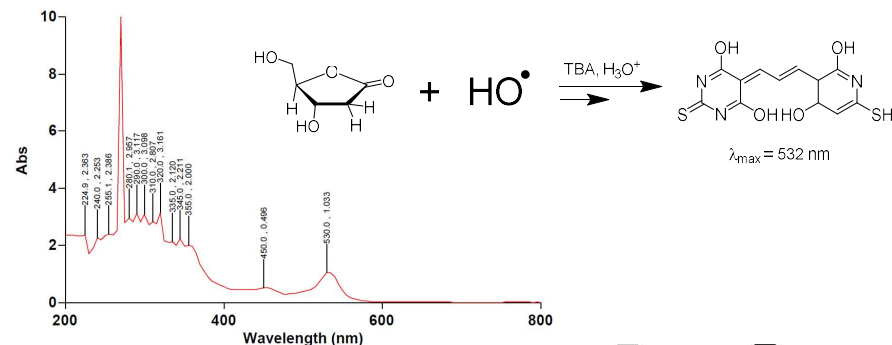
GOAL: 3. Design an Iron chelator(s) that is prooxidant, recyclable, & biodegradable



NEXT STEPS

- Synthesize biodegradable, nontoxic, and prooxidant ligand(s) to replace EDTA as the iron chelator.
- Develop Fenton assay and confirm degradation of azo dye (Methyl Orange) with environmentally-preferred ligand.
- Confirm biocompatibility and investigate breakdown products and environmental persistence using UV-VIS.
- Confirm route of dye degradation through computational analysis for methyl orange and other azo dyes.

ANALYTICAL ANALYSIS: UV-VIS Spectroscopy



FURTHER FIELD QUESTIONS

How effective is degradation when the catalyst is changed (other transition metal, bimetallic system, solid support)? Can changing catalyst types still be chelated with positive effects?

To what degree is mineralization occurring? How can this progress be monitored through LCMS?

How does the wastewater matrix effect degradation? Can Fenton reactions be self-mediated?

LITERATURE

- Oviedo, C.; Rodriguez, J. EDTA: The Chelating Agent under Environmental Scrutiny. *Quimica Nova* **2003**, *26* (6), 901–905.
- Abdeslem Omri, Wiem Hamza, Mourad Benzina, Photo-Fenton oxidation and mineralization of methyl orange using Fe-sand as effective heterogeneous catalyst, *Journal of Photochemistry and Photobiology A: Chemistry*, Volume 393, 2020, 112444
- Shao, B.; Dong, H.; Zhou, G.; Ma, J.; Sharma, V. K.; Guan, X., Degradation of Organic Contaminants by Reactive Iron/Manganese Species: Progress and Challenges. *Water Research* **2022** *221*, 118765