Study of Pyclen Type Fe(III) Complexes as Catalase Mimics

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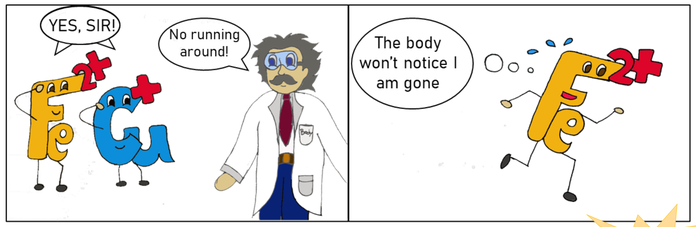
INTRODUCTION



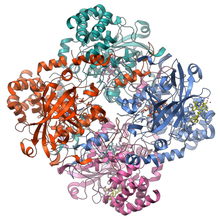
$H_2O_2 + Fe(II) \longrightarrow Fe(III) + HO^{\bullet} + HO^-$ ROS

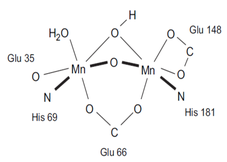
$2H_2O_2 \xrightarrow{\text{Catalase}} 2H_2O + O_2$

The desired antioxidant activity of catalase for medical and industrial applications has inspired the study of metal-based mimics hydrogen peroxide disproportionation.

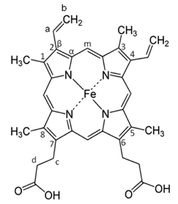
CATALASE

Structure



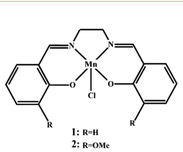


Mn-Based Catalases

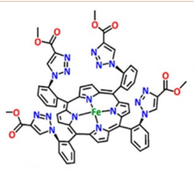


Fe-Based Catalases

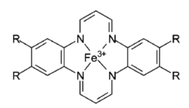
Mimics



Mn Based



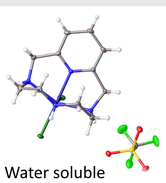
Heme based



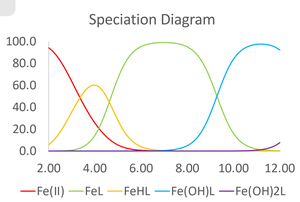
Non-heme based

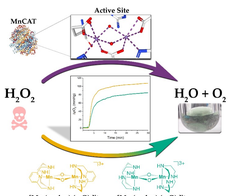
Targeted Mimics Properties
1. Water soluble
2. Formation of complex at biological pH
3. Active at micromolar concentration

Recent Results



Water soluble

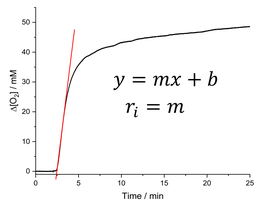




CATALASE ACTIVITY

Kinetics and TON

1. Kinetic Constant k ($M^{-1}\ s^{-1}$) determined via Initial Rates (r_i)



Unisense O_2 Microsensor

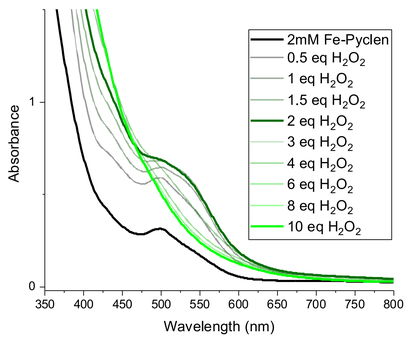
2. Activation Energy (E_a) determined via Arrhenius Equation

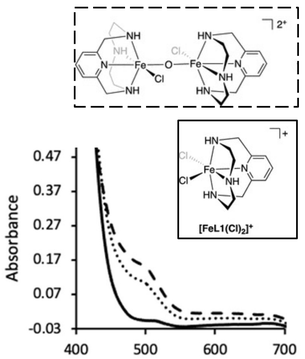
$$k = Ae^{-E_a/RT} \qquad ln\frac{k_2}{k_1} = -\frac{E_a}{R}\left(\frac{1}{T_2} - \frac{1}{T_1}\right)$$

3. TON via $[O_2]$/[Catalyst] (n=3)

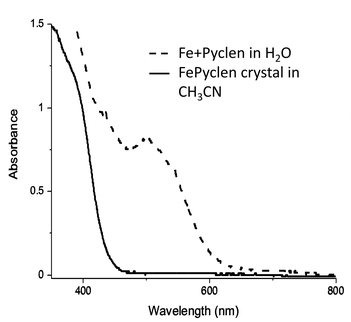
Ligand	k ($M^{-1}\ s^{-1}$)	E_a (kJ mol^{-1})	TON	Formation Constants (log K_{ML})
Fe-PyN_3	1.5(1)	34(1)	33(2)	14.02(5)
Mn-PyN_3	1.8(1)	20(2)	25 (1)	10.11(4)

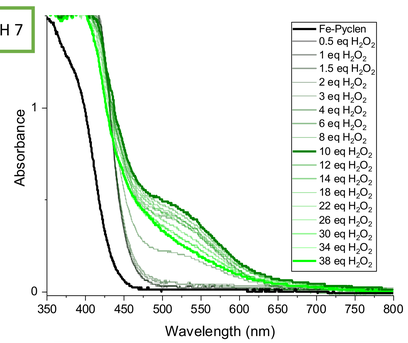
UV-visible





$FeCl_2$+Pyclen [2mM] in H_2O buffered at pH 7

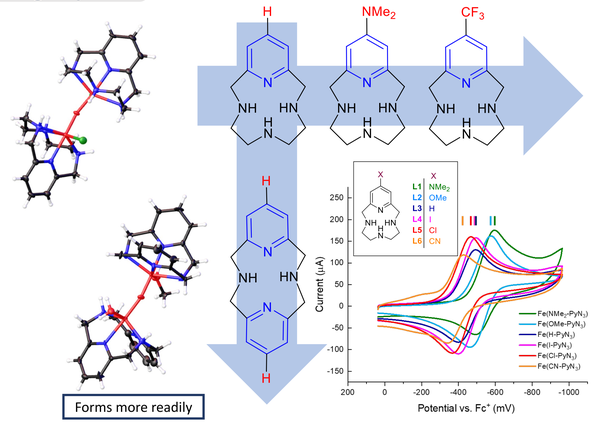




FePyclen [2mM] in CH_3CN

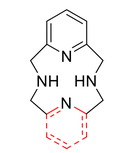
TUNING REACTIVITY

Electronics & Rigidity



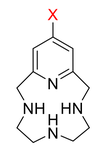
Forms more readily

Results



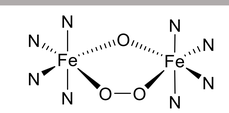
Ligand	k ($M^{-1}\ s^{-1}$)	E_a (kJ mol^{-1})	TON	Formation Constants for Fe(II) (log K_{ML})
PyN_3	1.5(1)	34	33(2)	14.02(5)
Py_2N_2	0.64(9)	22	19(3)	10.71(4)

Ligand	k ($M^{-1}\ s^{-1}$)	E_a (kJ mol^{-1})	TON	Formation Constants for Fe(II) (log K_{ML})
NMe_2-PyN_3	1.5(1)	38	25(1)	13.14(4)
PyN_3	1.5(1)	34	33(2)	14.02(5)
CF_3-PyN_3	0.89(8)	30	28(2)	13.11 (2)



CONCLUSIONS

$2Fe(III)L + H_2O_2 \longrightarrow LFe(III)\text{-}O\text{-}Fe(III)L \xrightarrow{H_2O_2}$



- The above mechanism is hypothesized, more studies will be conducted to support it
- Fe-oxo-dimer is an active species in the catalytic process
- Activation energy data supports the involvement of a dimer species in the activity
- TON and formation constants parallel each other

Acknowledgements:

Green Group

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1. Brewer, m. S.; Wilson, r. K.; Jones, G. D.; Reinheimer, W. E.; Archibald, J. S.; Prior, J. T.; Ayala, A. M.; Foster, L. A.; Hubin, J. T.; Green, K. N. *Inorg. Chem.* **2018,** *57*, 8890-8902
2. Freire, D. M.; Beeri, D.; Pota, K.; Johnston, H. M.; Palacios, P.; Pierce, B. S.; Sherman, B. D.; Green, K. N. *Inorg. Chem. Front.* **2020,** *7* (7), 1573-1582
3. Lakk-Bogáth, D.; Török, P.; Csendes, F. V.; Keszei, S.; Gantner, B.; Kaizer, J. *Molecules.* **2021**, *26*, 4501.
4. Mekhail, M. A.; Pota, K.; Schwartz, T. M.; Green, K. N. *RSC advances* **2020,** *10*, 31165-31170.