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Turning Heme Proteins Green: A Study of the Degradation of Anthraquinone Textile Dyes using Mammalian Hemoglobin and Myoglobin and H_2O_2

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The textile industry is one of the world's largest industries, consuming nearly 1 million tonnes of dye per year (Zollinger, 1987). The very properties that make certain molecules desirable as textile colorants, such as light-, water-, and chemical-resistance, are problematic when the dye effluent is discharged into the environment. Dye concentrations as high as 1,500 mg/L have been reported, which is a concern given the mutagenic, carcinogenic, teratogenic, and acute and chronic toxic properties associated with textile dyes.

Anthraquinone dyes, the second largest group of industrial dyes, have a fused aromatic ring structure that makes this group of dyes more resistant to common physical and chemical degradation methods. This study focuses on the anthraquinone dye Remazol Blue 19 (RB-19), a toxic and common textile dye known to have a long half-life under ambient pH and temperature conditions (Hao et al., 2000). We compared the ability of equine heart myoglobin and equine hemoglobin to degrade RB-19 with hydrogen peroxide using UV-vis spectroscopy. We used Michaelis-Menten kinetics to determine that the k_{cat} for myoglobin degradation of RB-19 with H_2O_2 is ~10-fold greater than with hemoglobin which means that myoglobin is significantly faster at degrading the anthraquinone dye RB-19. In addition, the apparent dissociation constant for RB-19, the K_M, is greater for myoglobin (204 ± 8 μM) than with hemoglobin (105 ± 6 μM); thus, the catalytic efficiency (k_{cat}/K_M) of myoglobin for degrading anthraquinone is 5-fold greater than with myoglobin. This work shows that while both mammalian myoglobin and hemoglobin have potential as bioremediation catalysts of anthraquinone dyes. horse heart myoglobin is the more promising catalyst. We also studied the dye degradation products of RB-19 using gas-chromatography-mass spectrometry (GC-MS) and liquid chromatography-mass spectrometry (LC-MS) to help design better degradation catalysts for use in bioremediation efforts.

Zollinger, H. Synthesis, Properties of Organic Dyes and Pigments. In: Color Chemistry. New York, USA: VCH Publishers; 1987. p. 92-102.