Ozone Treatment of Acid Yellow 17 Dye

Laura W. Lackey, Ph.D., P.E.
Richard O. Mines, Jr., Ph.D., P.E.
Mercer University
Macon, GA 31207

Why Perform Study?

- Textile plants consume large quantities of water and conventional treatment methods result in high effluent COD and color

- Industrial effluent standards continually becoming more stringent

Objectives

- Evaluate the effect of ozone on the removal of acid yellow 17 dye

- Evaluate the effect of pH on ozonation of acid yellow 17 dye

Background

- Liakou et al. ozonated Orange II azo dye at initial concentrations of 100, 250, 500, and 1000 mg/L at a rate of 8.8 mg/L of O_3 per minute.

- The 100 mg/L dye concentration was reduced to 0 mg/L in 12. 5 minutes whereas the 1000 mg/L was reduced to 0 mg/L in 180 minutes.

Background

- Marmagne and Coste achieved COD removals ranging from 5.2 to 50% at an O_3 dosage of 50 mg/L

- They also reported color removals ranging from 11 to 96% at an O_3 dosage of 50 mg/L

Materials & Methods

- A clear, 7.62-cm(3-inch) schedule 40 PVC pipe, 2.44-m(8 ft) in height was used in the batch bubble column experiments.
- Ozone feed was sparged through 3 SS disposable solvent inlet filters with 10 μm porosity.
- Ozone generated with the Ozotech, Inc. OZ2BTUSL
- The carrier gas was maintained at a constant 3.78 L/min (8scfm) resulting in a uniform O_3 introduction into the system of 79.2 mg O_3/min.

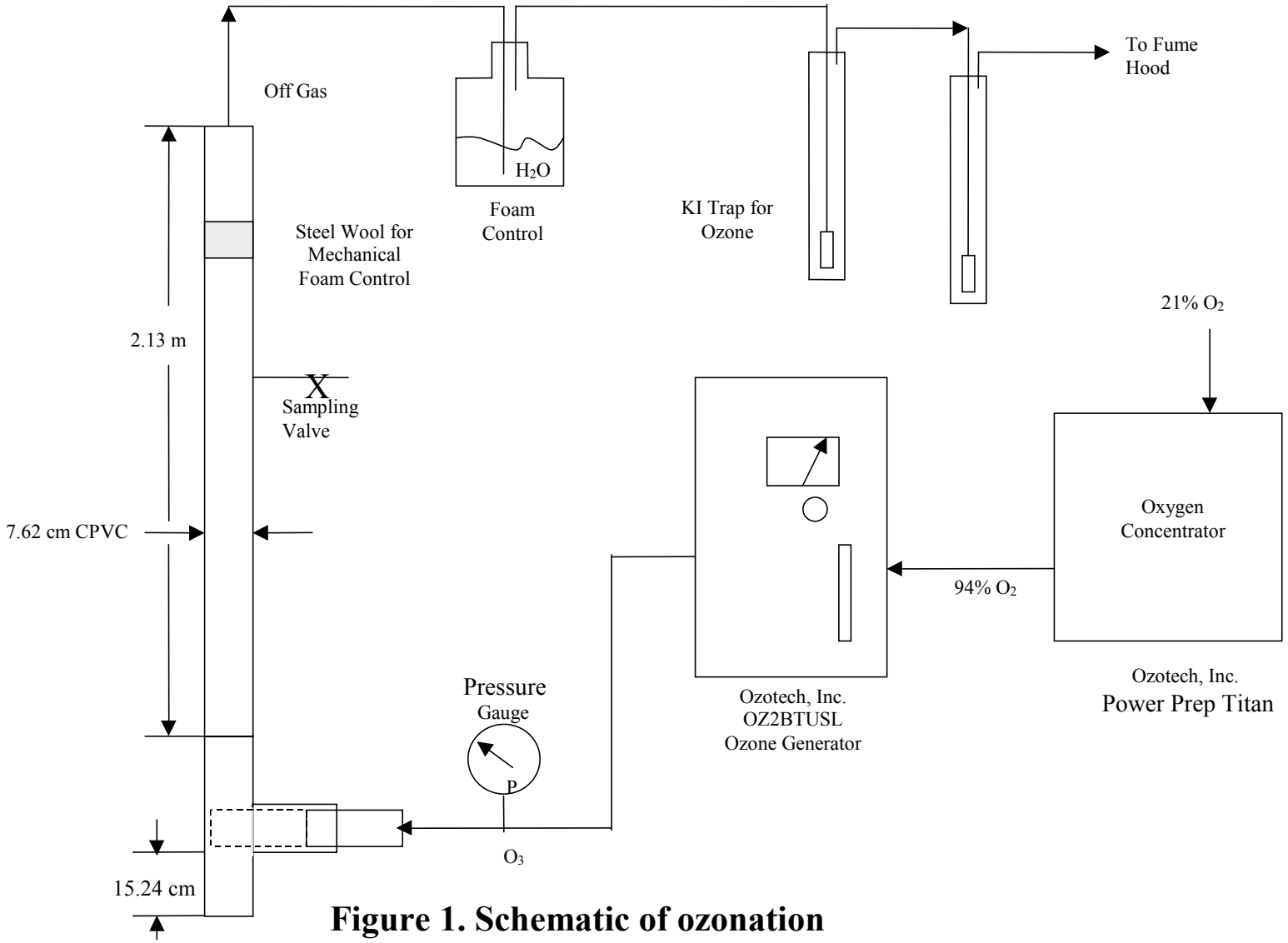


Figure 1. Schematic of ozonation

Materials & Methods Continued

- O_3 exiting the column was trapped in a KI solution and quantified by titrating with 0.005 N sodium thiosulfate solution.
- COD was measured by HACH method 8000 using the HACH DR/2000 spectrophotometer
- pH was measured with an Accument pH meter and probe.
- Acid yellow dye concentration was measured spectrophotometrically using a Spectronic 20D+ at a wavelength of 400 nm.

Materials & Methods Continued

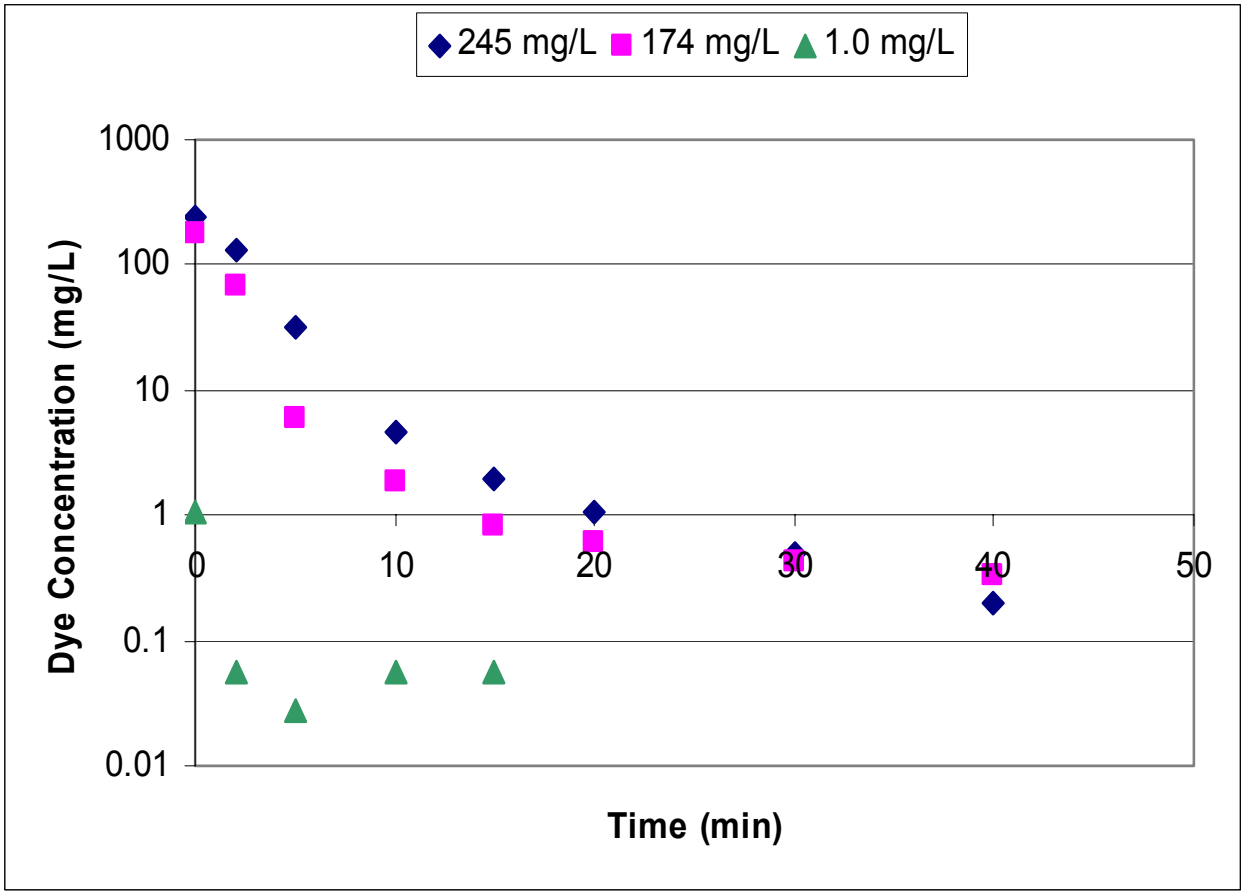
- Initial experiments conducted at pH 7 at dye concentrations ranging from 1 to 250 mg/L.
- Additional experiments performed at pH 7 to investigate the effect of glucose concentrations of 0.5, 1.0, and 2.0 mM were evaluated.
- Finally, the initial dye concentration was held constant at 200 mg/L and the pH varied from 2, 7, and 10 by buffering solutions.
- BOD analyses were also performed for correlation with COD.

Results

- pH was observed to drop significantly during ozonation in the unbuffered systems
  - @ 245 mg/L dye, pH dropped from 7.5 to 9.0
  - @ 174 mg/L dye, pH dropped from 7.2 to 3.3
  - @ 1 mg/L dye, pH dropped from 2.7 to 2.6

- Dye concentration decreased exponentially with respect to time in all cases.

Dye Concentration vs Time



Ozonation of acid yellow dye Modeled as 2nd Order Reaction

$$\frac{d[dye]}{dt} = k_d [O_3][dye]$$

$$k_d [O_3] = const. = k$$

$$\frac{d[dye]}{dt} = k[dye]$$

First Order Removal Rate Constants

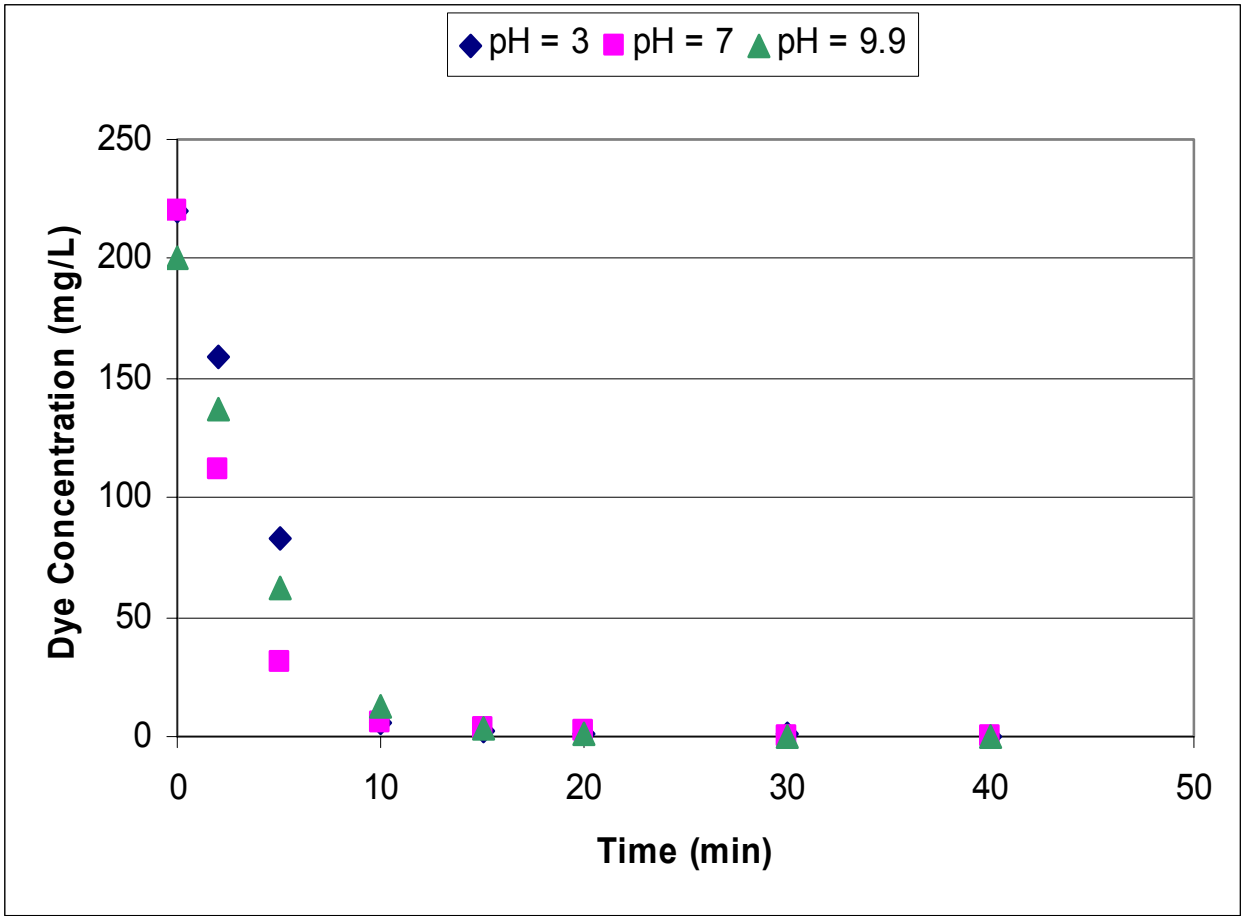
- 0.174 min^{-1} @ 245 mg/L dye concentration
- 0.142 min^{-1} @ 174 mg/L dye concentration
- 0.120 min^{-1} @ 1 mg/L dye concentration

pH Change in Buffered Systems

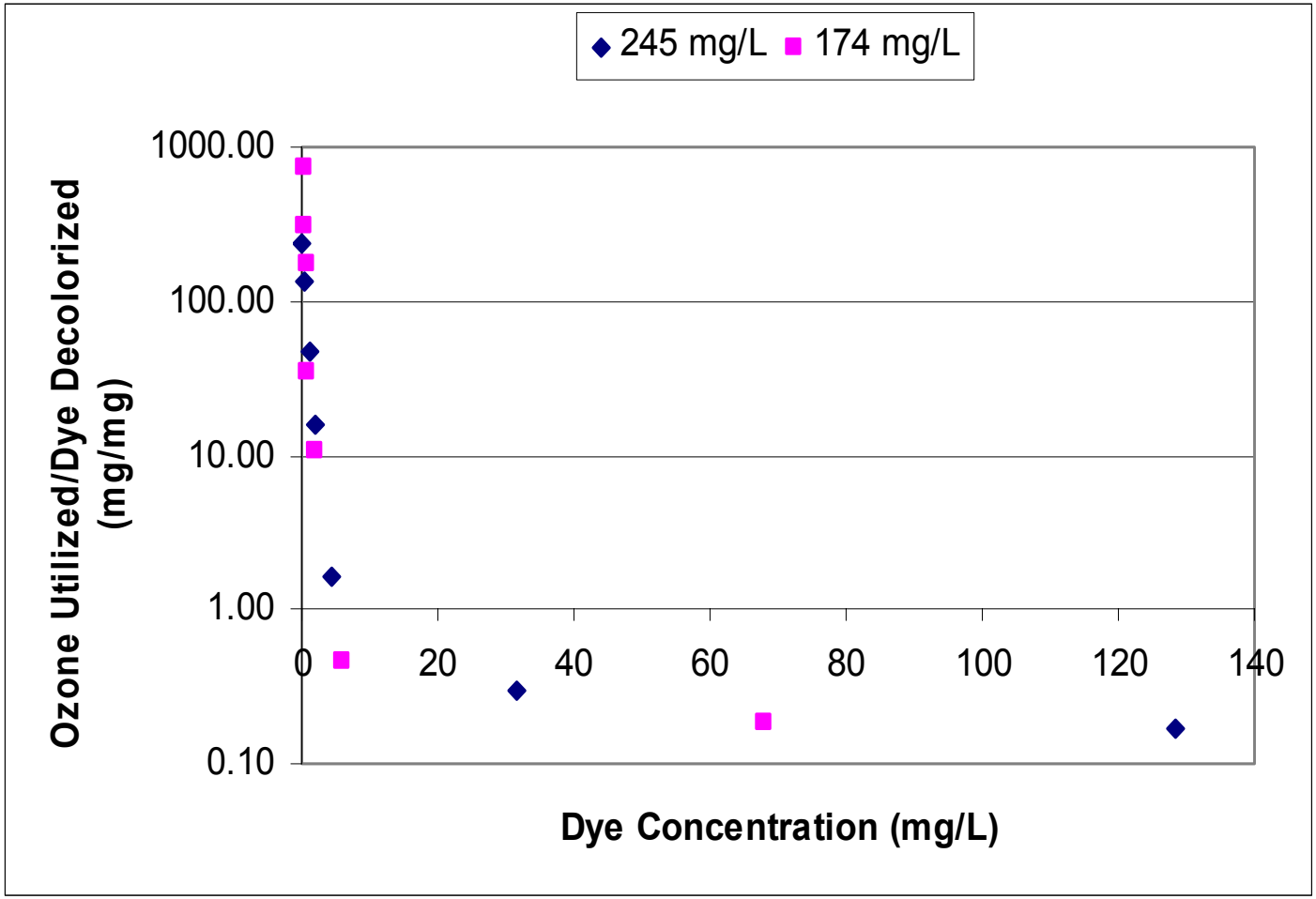
- pH was observed to change but not significantly during ozonation in the buffered systems
  - @ 200 mg/L dye, pH dropped from 9.9 to 9.2
  - @ 220 mg/L dye, pH dropped from 7.0 to 6.7
  - @ 220 mg/L dye, pH dropped from 2.7 to 2.6

- Pseudo first order removal rate constants were 0.2184, 0.186, and 0.175 min^{-1}, respectively.

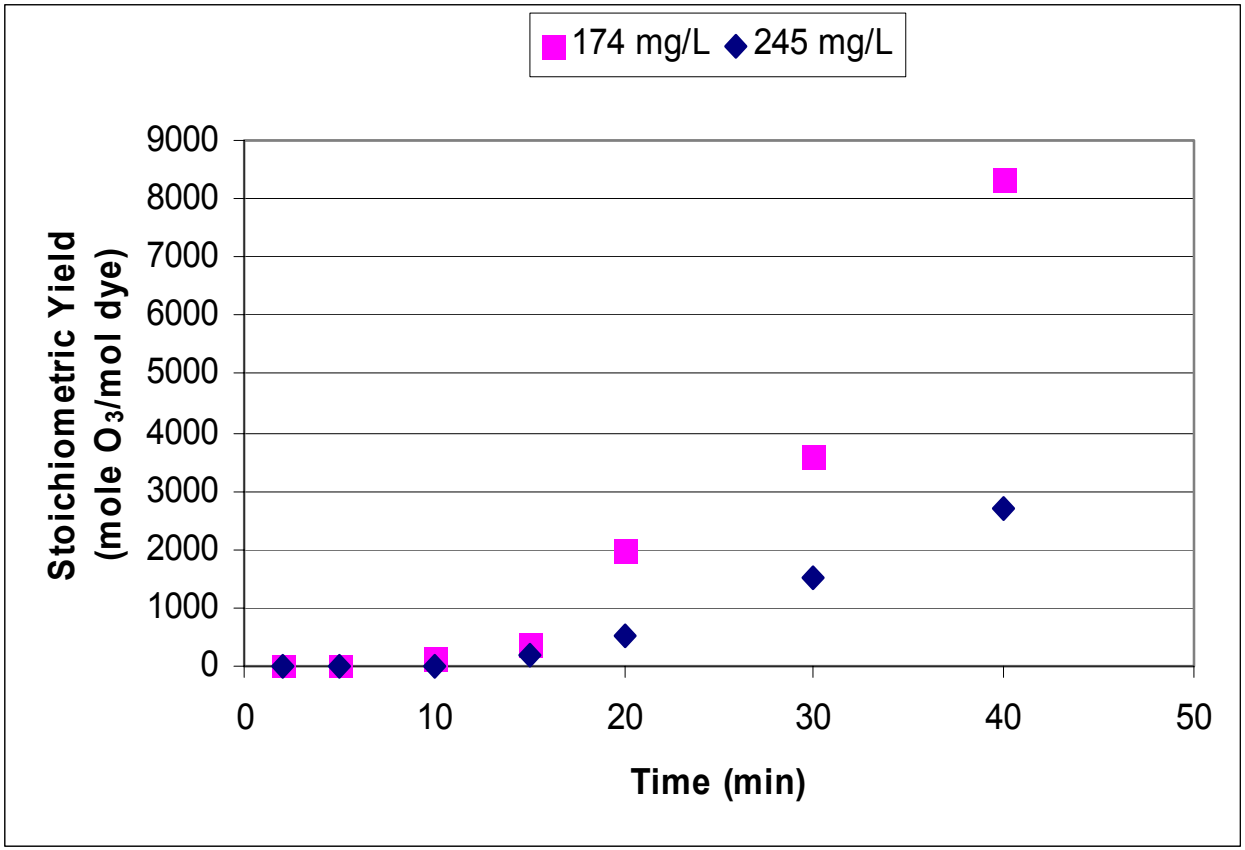
Effect of pH on Ozonation of Dye



O_3 Consumed per Dye Decolorized



Stoichiometric Ratio



Conclusions

1. Initial dye concentration effects pseudo-first order removal rate constants. The rate constant increases as dye concentration increases.

2. pH significantly effects the pseudo-first order removal rate constant. Rate constants increased with an increase in pH for the buffered systems.

Conclusions continued

3. Apparent dye concentration effects the ozone demand required to decolorize the dye. Ozone demand increased by 4 orders of magnitude when going from a dye concentration of 100 to 1 mg/L.

4. The stoichiometric ratio increases as the reaction time increases.