

Degradation of the Synthetic Food Dye Red 40 Through Ozone Treatment

Sunhye Choi, Elisha Kim, Sean Lee, Kelly Kim, Kathryn Tam, Hoseong Lee

ABSTRACT

Red 40 is a synthetic dye that is now present almost everywhere in the man-made world. Synthetic dyes—in our furniture, snacks, drinks, cosmetics—are cheap and easily available, providing vibrant colors. However, this increased use of dyes heightened the amount seeping into bodies of water, contaminating natural systems through the wastewater produced through industrial methods. In order to solve this problem, this paper utilizes the purification property of O₃, or also known as ozone, to break the azo bond (R-N=N-R), causing the dye to completely lose its color. We hypothesized that the ozone will oxidize the nitrogen bonds, breaking the bonds, making the solution turn from a vibrant red color to a transparent solution to the naked eye. Red 40 solutes were bought and made into a solution, where an ozone tube and stone filter were inserted. The data demonstrates that the Red 40 solution, after around sixty minutes of ozone treatment and exposure, the solution became clear and transparent. We concluded that this will not aid in the contamination aspect, as that will most likely call for a more intensive treatment, but would aid the inhabiting species of the contaminated water bodies and balancing the relationship in the biome.

Introduction

Red 40, a widely used synthetic food dye, can enter wastewater and aquatic environments through industrial and domestic discharge. Its strong coloration can reduce light penetration in water and may pose environmental concerns (1,2,3,4).

Ozonation is an oxidation process that breaks down compounds by adding an oxygen molecule to make separate products (5,6). The effectiveness of ozone treatment depends on exposure time and concentration.

This study investigates the effectiveness of ozone in degrading Red 40 in water.

Methods

- 1.0g Red 40 power was dissolved in 150mL of water
- The solution was diluted to approximately 0.03 M and ozone reacted with the azo bonds
- Ozone was generated using an A2Z Aqua-6 Ozone Generator

Procedure

- The diluted Red 40 was in a beaker
- The solution was exposed to ozone treatment
- Photographs of the solution were taken at every 5 minute intervals using a fixed camera
- The treatment continued till visibly clear
- The experiment was repeated for 5 trials.

Data Collection

- Independent variable: ozone exposure time
- Dependent variable: Red 40 color intensity/degradation
- A Vernier Go Direct SpectroVis Plus Spectrophotometer was used to get quantitative data for the 5 trial comparisons (**Figure 1**).

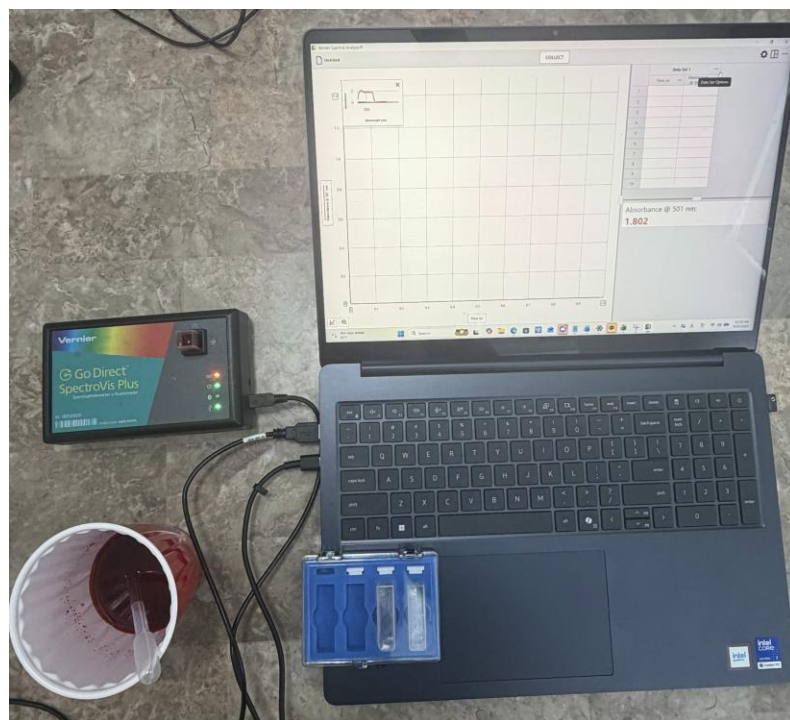


Figure 1. Setup of the Spectrophotometer

Results

The results show a continuous reduction in visual color intensity was observed over time (**Figure 2**)(**Figure 3**). Considering the variability across replicates, mean visual color intensity percentages and standard deviations for each 10-minute interval were calculated (**Figure 4**). The linear regression in Figure 3 indicate a constant decolonization rate of ~ -1.75% per minute ($R^2 = 0.982$).

With the data gained from the Spectrometer, ozone exposure resulted in a progressive decrease in Red 40. The wavelength used to measure the solution was 504 nm. The solution's absorbance decreased from **1.62 to 0.05 over 60 min**, corresponding to a **96.9% overall decrease in absorbance**.

Time (min)	Absorbance (504 nm)
0.0	1.62
10.0	1.35
20.0	1.09
30.0	0.69
40.0	0.32
50.0	0.12
60.0	0.05

Table 1. Red 40 ozonation measured with a 504nm wavelength

Red 40 degradation increased rapidly with ozone exposure. The greatest decrease occurred during the first 40 min, with absorbance falling to 0.32, then plateauing to 0.05 at 60 min mark (**Table 1**). These results indicate substantial degradation of the Red 40 solution absorbance.

Discussion

The resulting data reveals a negative correlation between time and color intensity, supporting our hypothesis: the ozone will oxidize the azo bond, making the solution transparent. Our team connected that if ozone can treat a red 40 sample, then it has the potential to treat other pollutant dyes within water sources. This research constructs the foundation for further research into whether ozone can effectively treat wastewater containing organic pollutants.

However, wastewater containing organic compounds is composed of a variety of organic pollutants. As a result, further investigation is necessary before placing wastewater under ozone treatment.

References

- Lellis, Bruno, Cintia Zani Fávaro-Polonio, João Alencar Pamphile, and Julio Cesar Polonio. "Effects of Textile Dyes on Health and the Environment and Bioremediation Potential of Living Organisms." *Biotechnology Research and Innovation*, vol. 3, no. 2, 2019, pp. 275–290. <https://doi.org/10.1016/j.biori.2019.09.001>. "A Review of Bioremediation of Textile Dye Containing Wastewater." *Cleaner Water*, vol. 4, 2025, article 100092. <https://doi.org/10.1016/j.clwat.2025.100092>.
- The Green America. "Toxic Textiles Report." *Green America*, 2019, <https://greenamerica.org/green-americas-2019-toxic-textile-report>. Accessed 22 September 2026.
- Leong, Chin, and Rashmila Maiti. "Fast Fashion and Its Environmental Impact in 2026." *Earth.org*, 3 February 2026, <https://earth.org/fast-fashions-detrimental-effect-on-the-environment/>. Accessed 22 September 2026.
- Han, Dong. "Do or dye: Synthetic colors in wastewater pose a threat to food chains worldwide." *EurekAlert!*, 2023, <https://www.eurekalert.org/news-releases/1006009>. Accessed 22 September 2026.
- Reusch, William. "Supplemental Topics." *MSU chemistry*, 05 5 2013, <https://www2.chemistry.msu.edu/faculty/reusch/virttxtjml/suppmnt0.htm>. Accessed 4 October 2026.
- Allura Red in Aquatic Systems: Treatment Technologies, Process Intensification Strategies, and Future Perspectives for Sustainable Water Management - Sciencedirect, www.sciencedirect.com/science/article/abs/pii/S0169772226001191. Accessed 29 Sept. 2026.
- U.S. Environmental Protection Agency. "What is Ozone? | US EPA." *EPA*, 13 May 2026, <https://www.epa.gov/ozone-pollution-and-your-patients-health/what-ozone>. Accessed 22 September 2026.
- U.S. Environmental Protection Agency. "Ozone Generators that are Sold as Air Cleaners | US EPA." *EPA*, 19 February 2026, <https://www.epa.gov/indoor-air-quality-iaq/ozone-generators-are-sold-air-cleaners>. Accessed 22 September 2026.

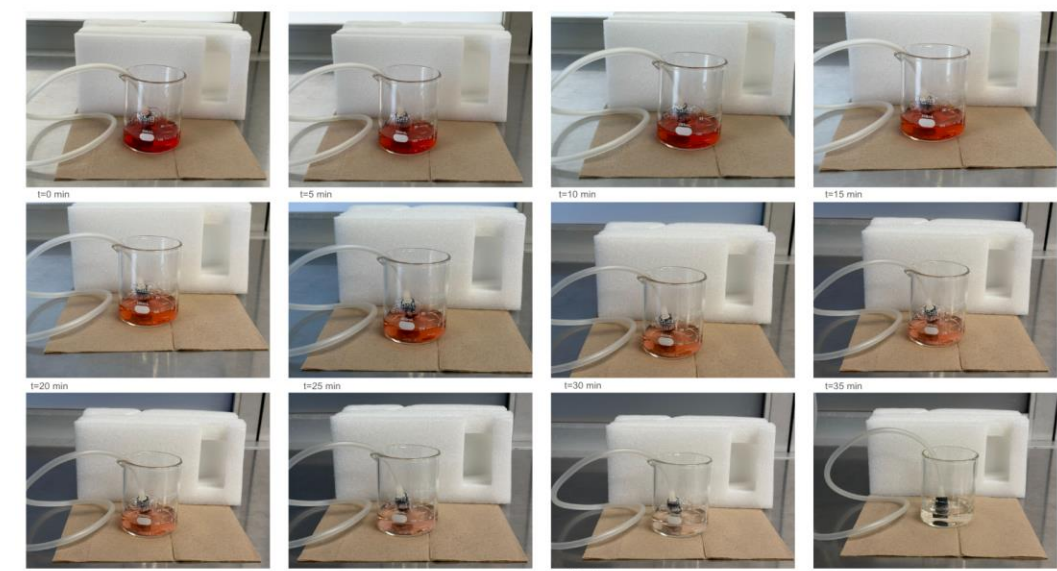


Figure 2. Trial one of a 0.003M Red 40 solution's color intensity decreased over the 55 minute time span, ending in a visible clearer solution.

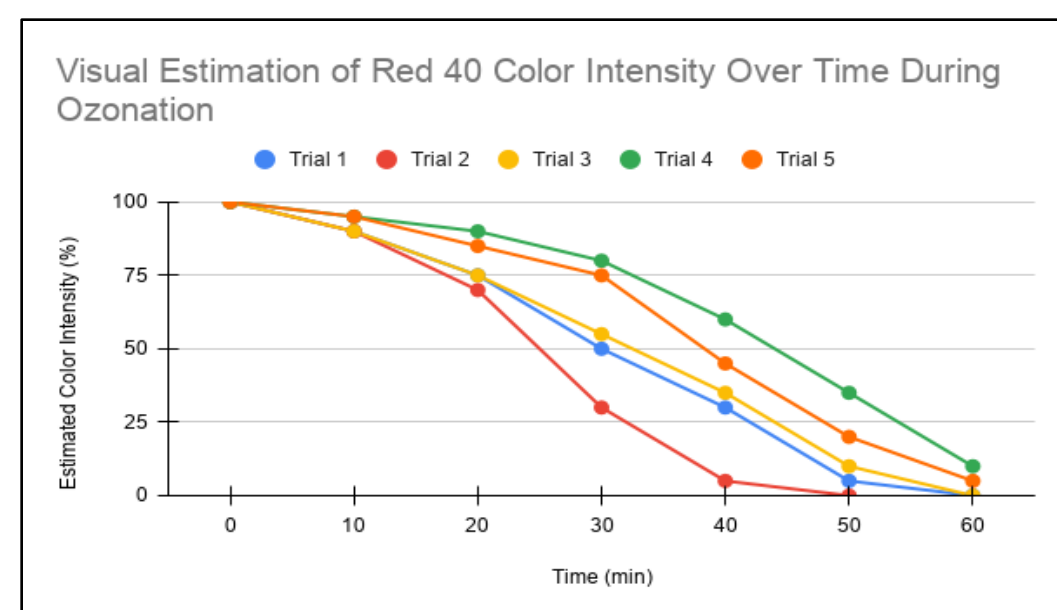


Figure 3. Visual graph of Red 40 Color Intensity Over Time across five independent trials of continuous ozone treatment.

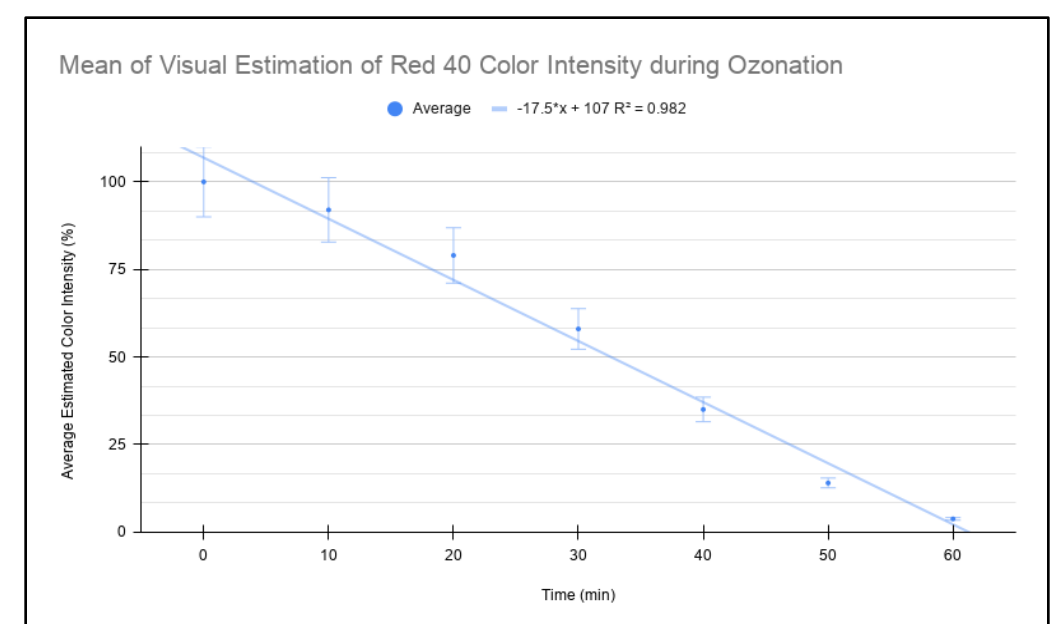


Figure 4. Mean visual estimation from the five trials. Data points represent the trial mean ± standard deviation.

Conclusion

All trials supported our hypothesis that ozone breaks down Red 40. However, our accuracy was limited: increased variability in the molarity throughout trials; small Red 40 concentrations; visual evaluation; byproducts negligence. Future research should use Standard Operation Procedures (SOP), and hydrogen peroxide alternative to test the possibility of different byproducts.

Overall, this research is a step forward in addressing water pollution from artificial solutions, specifically dyes.