Degradation of Acetaminophen in Water with Bleach

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Background

- Acetaminophen is a common antipyretic commonly found in Tylenol.
- Acetaminophen metabolizes in the body once taken, but up to 9% can be excreted through urine. This will enter the water system, and into the environment.
- Small concentrations of acetaminophen can interfere with embryonic development, growth, behavior and more in fish populations.
- Bleach will be used to eliminate acetaminophen from water samples, acting like bleach tablets in toilet bowls.
- HPLC was utilized to measure acetaminophen concentrations in known samples.
- Kinetics experiments will be performed to find degradation over time.

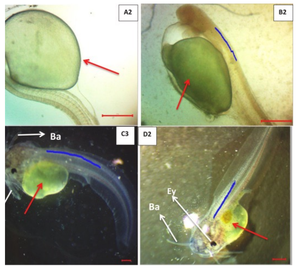

Figure 1: Pharmaceutical induced masses on fish.[4]

Objectives

- Due to the commonness of acetaminophen, the need to eliminate it before it reaches wastewater is important.
- The goal of this research is to degrade acetaminophen in a water sample using bleach tablets and asses using HPLC.

Figure 2: Tylenol sales are more than $300 million a year.

Methods

- UV-Vis Spectroscopy: An acetaminophen solution of 10 ppm was made, and a UV-Vis spectrum was created.
- The λ_{max} of this solution was 242.5 nm.
- This was used in the UV detector for HPLC.

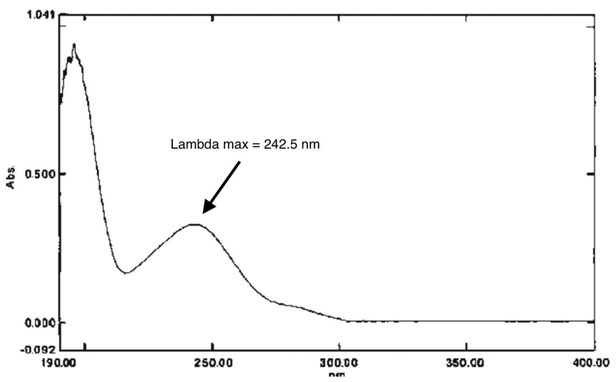

Figure 3: UV-Vis spectrum of 10 ppm acetaminophen. The λ_{max} is 242.5 nm.

HPLC Method Development

- Standards from 5-10 ppm were measured.
- Initially a mobile phase of 94.5:5.5 water:acetonitrile composition was used with a flow rate of 1.5 mL/min in HPLC.
- No clear peaks produced, therefore glacial acetic acid and triethylamine was added to the HPLC grade water. The mobile phase was 94.1:5.5:0.2:0.2 water:acetonitrile:glacial acetic acid:triethylamine. Differences in viscosity required the water, glacial acetic acid, and triethylamine to be combined in the same container.
- The mobile phase was finalized by adding more water to decrease the retention time. The final mobile phase was 97.6:2:0.2:0.2 water:acetonitrile:glacial acetic acid:triethylamine. The new retention time was ~ 4.175 minutes.
- Standard solutions of 1, 2, 3, and 4 ppm were made from the 10 and 5 ppm solutions to create a calibration curve to track acetaminophen concentration.

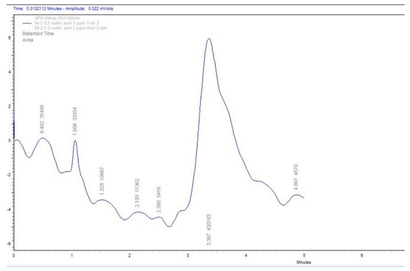

Figure 4: HPLC Chromatogram of 2 ppm Acetaminophen Solution. 94.5:5.5 water:acetonitrile in Separate Containers.

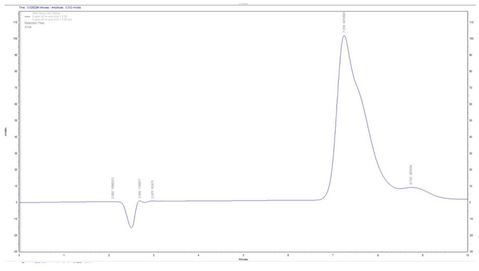

Figure 5: HPLC chromatogram of 5 ppm acetaminophen solution. 94.1:5.5:0.2:0.2 water:acetonitrile:glacial acetic acid:triethylamine in one container. Retention time of acetaminophen is 7.250 minutes.

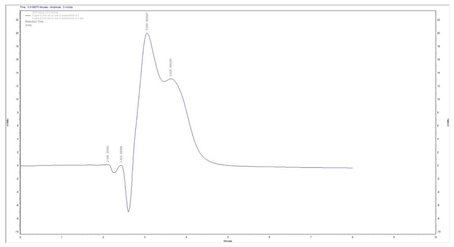

Figure 6: HPLC chromatogram of 5 ppm acetaminophen solution. Mobile phase is 97.6:2:0.2:0.2 water:acetonitrile:glacial acetic acid:triethylamine in one container. Retention time of acetaminophen is 3.058 minutes.

Results

- The method was modified by combining solvents in one container to stop pulsing effects from viscosity differences in solvents shown in Figure 4.
- The retention time was too long, therefore a more polar mobile phase was made by adding more water, decreasing the retention time from 7.250 minutes to 4.175 minutes. Increased polarity decreased retention time necessary for kinetic studies.
- The final method included a 1.5 mL/min flow rate, and a mobile phase of 97.6:2:0.2:0.2 water:acetonitrile:glacial acetic acid:triethylamine.

Results Continued

- A calibration curve of concentration and retention time was made with the 1, 2, 3, 4, 5 and 10 ppm solutions.

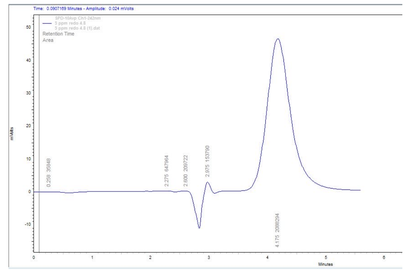

Figure 7: HPLC chromatogram of 5 ppm acetaminophen solution. 97.6:2:0.2:0.2 water:acetonitrile:glacial acetic acid:triethylamine in one container. Ideal chromatogram.

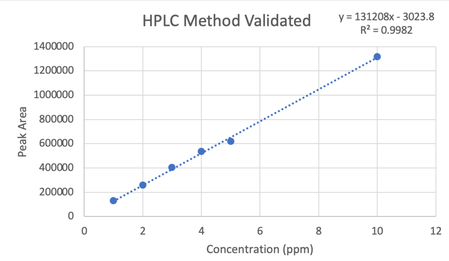

Figure 8: Calibration curve with a linear equation of y=131208x-3020.8 and an R^2 of 0.9982.

Next Steps

- More research is needed in the kinetics of bleach degradation.
- A bleach tablet will be added to a known acetaminophen solution, and the concentration of acetaminophen will be monitored over time with validated HPLC method.

References

(1) Medical Definition of Antipyretic https://www.rxlist.com/antipyretic/definition.htm (accessed 2022 -04 -10).

(2) Acetaminophen in Drinking Water. Minnesota Health Department, Environmental Health Division. **August 2014,** 2**.** https://www.health.state.mn.us/communities/environment/risk/docs/guidance/dwec/acetaminfo.pdf

(3) Ferguson, G. K. Quantitative HPLC Analysis of an Analgesic/Caffeine Formulation: Determination of Caffeine. *J. Chem. Educ.* **1998**, *75* (4), 467. https://doi.org/10.1021/ed075p467.

(4) Erhunmwunse, N. O.; Tongo, I.; Ezemonye, L. I. Acute Effects of Acetaminophen on the Developmental, Swimming Performance and Cardiovascular Activities of the African Catfish Embryos/Larvae (Clarias Gariepinus). *Ecotoxicol. Environ. Saf.* **2021**, *208*, 111482. https://doi.org/10.1016/j.ecoenv.2020.111482.

(5) McGorry, A.; News, F. Study Finds That Tylenol May Make You Take More Risks. *New York Post*, 2020.

(6) Behera, S. UV-Visible Spectrophotometric Method Development and Validation of Assay of Paracetamol Tablet Formulation. *J. Anal. Bioanal. Tech.* **2012**, *03* (06). https://doi.org/10.4172/2155-9872.1000151.

(7) Clorox Automatic Toilet Bowl Cleaner Bleach 2 - 3.5 oz (100 g) Tablets https://www.kmart.com/clorox-automatic-toilet-bowl-cleaner-bleach/p-03212677000P (accessed 2022 -04 -11).

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