Biofuel Enzyme and Surfactant Interactions

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Introduction/Background

Enzymes

Enzymes are a type of protein that act as catalysts, which help to accelerate chemical reactions in cells.

Surfactants

Surfactants (surface active agents) help to reduce the surface tension of liquids at the air-liquid interface.

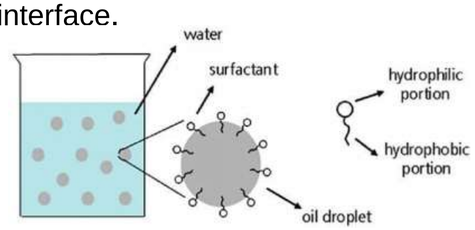


Figure 1. Surfactant molecules have hydrophilic heads and hydrophobic tails. Adapted from [1].

Stimulant-responsive surfactants

- Stimulant responsive surfactants change their properties based on environmental stimuli
  - Ex: heat, pH, light, magnetic fields, CO_2 levels, electrical potential
- Alters properties such as: lengths of hydrophobic tails, types of hydrophilic heads

Light-responsive surfactants

- Different wavelengths of light (ex: blue or UV) can be used to control properties of surfactants
  - Ex: interfacial tension, self-assembly
- Photorheological fluids can turn from highly viscous to a Newtonian fluid under UV light

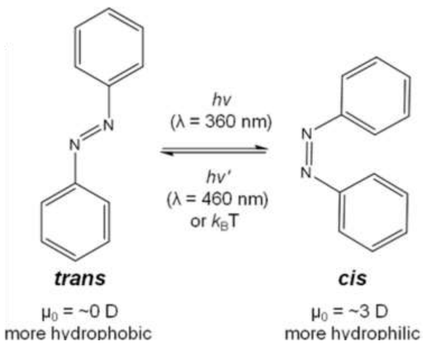


Figure 2. Photoisomerization of the azobenzene group leads to a change in the shape and polarity of the unit. Adapted from [2].

Method

Nelson-Somogyi Method

The Nelson-Somogyi method uses Nelson's arsenomolybdate reagent to determine the molar concentration of glucose solutions. A spectrophotometer is used to measure the absorbance of the solutions, which can then be plugged into the Beer's Law equation, $A=\varepsilon bc$, as A. Using known values for ε, the molar absorptivity constant, and b, the optical path length (1cm), then c, the molar concentration, can be found.

Figure 3. Test tubes containing increasing concentrations of glucose after Nelson's reagent is added. PC: The BU Biochemistry Laboratory Manual

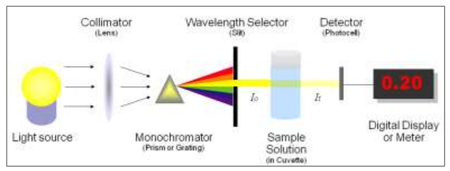
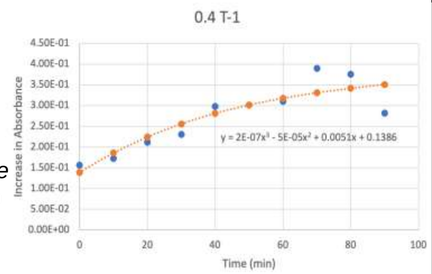


Figure 4. Spectrometry measures a substance's absorbance by passing a certain wavelength of light through it. PC: Chemistry LibreTexts

Assay

This assay uses solid cellulose crystalline substrate and an endocellulase enzyme, β-glucosidase. 16 different concentrations of the azoTAB surfactant, ranging from 0.25-4mM, are added into solutions to test its effect on β-glucosidase. The solutions are shone under visible and UV light for 10-minute increasing time intervals, ranging from 0-90 min. Then, their reaction rates are compared with that of pure solutions.

Figure 5. This trial tests the absorbance of a 0.4mM surfactant solution under visible light. The line of best fit is used to calculate the reaction rate. PC: Yolanda Zhu



Results

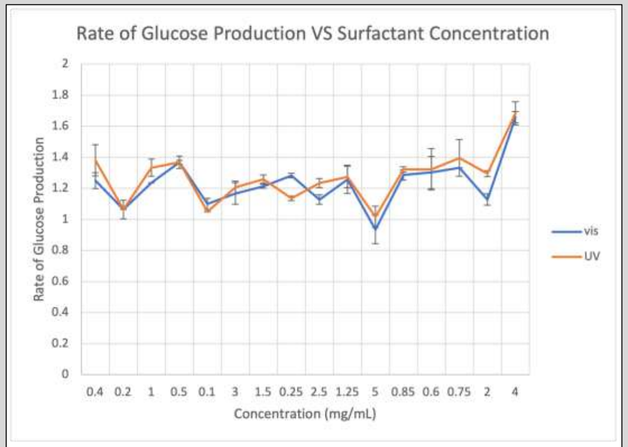


Figure 6. The rate of glucose production was calculated and plotted against the various concentrations of azoTAB surfactant tested. PC: Yolanda Zhu

- Overall, the rate of glucose production remained constant despite an increasing surfactant concentration.
- UV light produces slightly faster rate of glucose production than visible light.

My STEM Coursework

AP Chemistry

I was able to apply my knowledge from AP Chemistry into understanding the mechanism behind the surfactants.

Biomedical/Bio- Engineering

My previous experience with performing labs in biomedical and bioengineering courses and research allowed me to apply these skills towards understanding the assay-based experiments in this project.

Next Steps

I hope that my knowledge of enzymes and proteins can be applied towards taking AP Biology next year. In college, I am looking to major in chemical engineering with an emphasis in biology or medicine, and I hope to continue conducting research in related disciplines.

Conclusion & Impact

Conclusion

In conclusion, surfactants do not have a significant impact on glucose production. This could be due to the concentration of enzymes being a limiting reactant, leaving the surfactant in excess. Further studies should be done to investigate this hypothesis.

Impact

Surfactants such as azoTAB can be used to control enzymatic activity, such as that of β-glucosidase. This control is helpful in the production of biofuels, a process in which β-glucosidase is used to hydrolyze glucose. By adding surfactants to this procedure, biofuel production can become more efficient.

References

[1] "Review of Phase change emulsions (PCMEs) and their applications in HVAC systems. " by Jingjing Shao et al., May 2015, Energy and Buildings 94.
[2] "A Single-Component Photorheological Fluid with Light-Responsive Viscosity. " by Elaine A. Kelly et al., Nanoscale, 2020,12, 6300-6306.

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