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Kinetics of photochemical reactions

Studying the kinetics of a photochemical reaction using UV-Vis absorption spectroscopy

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I. Introduction

In the following lab report, we will study the kinetics of the photochemical reaction between ammonium oxalate and iodine. We have used an LED torch as a light source, which is responsible for increasing the reaction rate. No significant reaction occurs between the two chemicals when left in the dark. The solution is initially brownish in colour due to the presence of iodine. When placed under the LED light, the initial brown colour of iodine fades and slowly becomes colourless, indicating the formation of ammonium and iodine ions. The growth of this reaction is monitored by uv-vis absorption spectroscopy. According to Beer-Lambert's law:

$$\text{Absorbance} = \epsilon \times c \times l \tag{1}$$

where ϵ is the molar extinction coefficient, which is the property of the molecule under observation, c is the concentration, and l is the path length. For a given setup, ϵ and l are constants. Thus, the absorbance is directly proportional to concentration. Therefore we analyse the nature of the graphs for Absorbance vs Time will be the same as that for Concentration vs Time. Which helps us determine the kinematics of the reaction.

II. Materials

A. Chemicals

1) Ammonium Oxalate
2) Iodine Solution
3) Distilled Water

B. Apparatus

1) Two test tubes
2) Aluminum Foil
3) UV-Vis Absorption Spectrophotometer
4) Cuvette
5) LED Torch

III. Safety Measures

1) It is essential to wear gloves and safety glasses while in the laboratory.
2) Try to avoid any contact with the chemicals.

IV. Procedure

1) Make a solution of ammonium oxalate that's fully saturated.
2) Put 4 mL of this solution into two labelled test tubes.
3) Cover test tube 1 with aluminium foil to keep it dark.
4) Add some drops of iodine (say x) to both test tubes and mix well.
5) Check the absorbance of the solution in test tube 2 to find the starting concentrations.
6) Put test tube 2 under LED light and measure the absorbance every 10 minutes.
7) Plot absorbance against time and discuss how the reaction happens over time.
8) After the experiment, check the absorbance of the solution in test tube 1.
9) Every 10 minutes, take some solution from test tube 2 and put it in a special container called a cuvette. Use a UV-Vis absorption spectrophotometer to check the colour until the solution in test tube 2 becomes clear.
10) Next, remove the aluminium foil covering test tube 1.
11) Take a sample from test tube 1 and use the UV-Vis absorption spectrophotometer to measure the absorbance.
12) Study the data to figure out how the reaction progresses over time and determine its order.

V. Graphs

Now we plot the graph for absorbance vs wavelength for all the samples taken at the interval of 10 minutes.

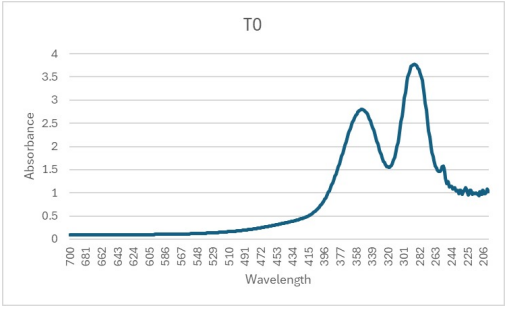


Fig. 1: Absorbance vs Wavelength for t=0 min

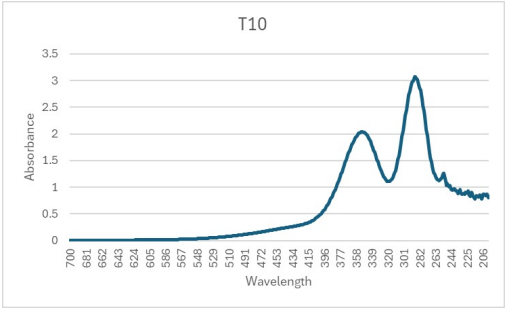


Fig. 2: Absorbance vs Wavelength for t=10 min

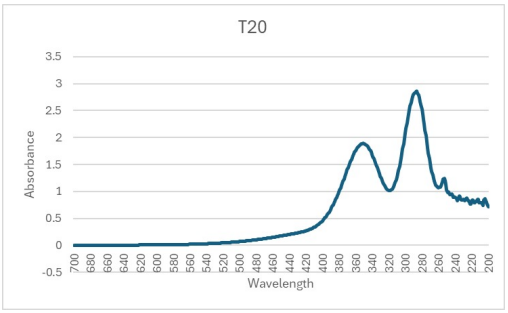


Fig. 3: Absorbance vs Wavelength for t=20 min

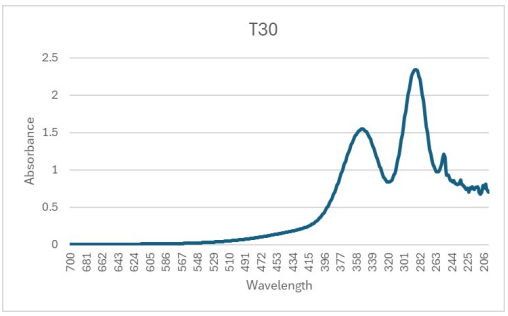


Fig. 4: Absorbance vs Wavelength for t=30 min

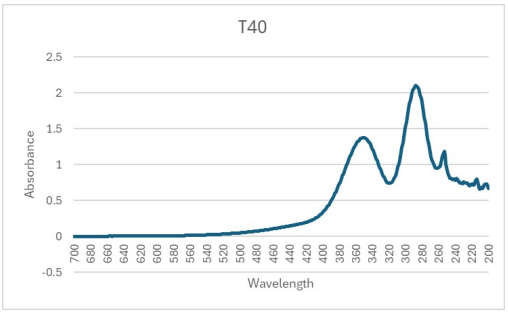


Fig. 5: Absorbance vs Wavelength for t=40 min

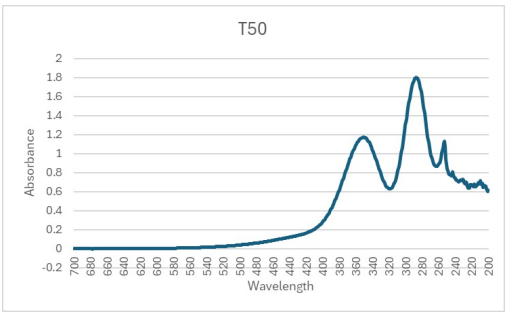


Fig. 6: Absorbance vs Wavelength for t=50 min

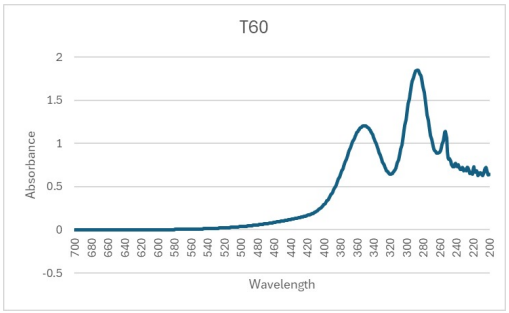


Fig. 7: Absorbance vs Wavelength for t=60 min

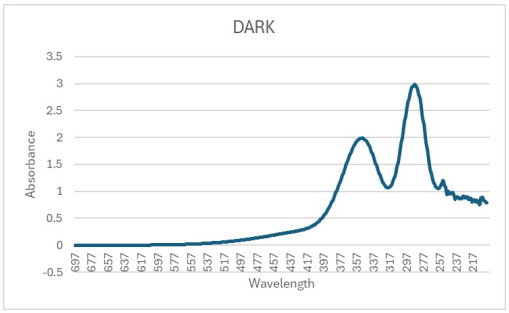


Fig. 8: Absorbance vs Wavelength for the test tube kept in the dark

In order to compare the peaks at a constant time we plot all these graph on a single plot

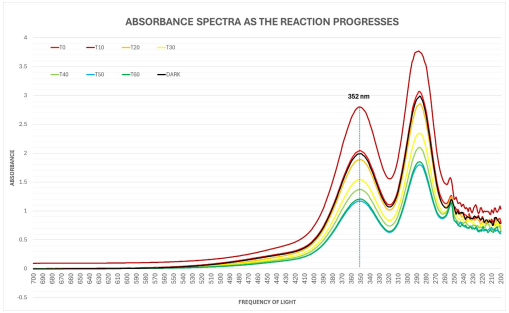


Fig. 9: Absorbance vs Wavelength for all t

Now we plot a graph for Absorbance at 351 nm vs time to analyze the cahnge in absorbance with respect to time.

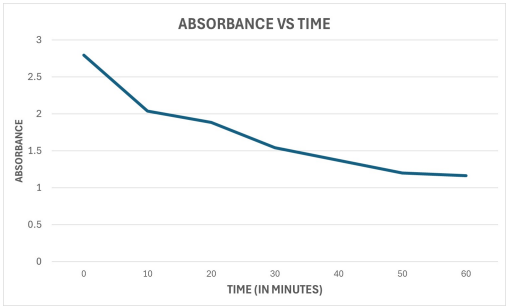


Fig. 10: Graph for Absorbance vs time

VI. Observations and Results

It can be observed from the graphs that the absorbance decreases as time increases. Now by Beer-Lambert's law absorbance is directly proportional to concentration. Thus, the same can be said for the concentration of the reactants. However, the absorbance for the test tube kept in the dark remains almost constant, and so does the concentration. Thus, these results prove that the reaction is driven by light. As time passes, the solution kept in light becomes colourless, whereas for the solution kept in the dark, not much change is observed, which shows that no reaction has taken place in the test tube kept in the dark.

The absorbance vs time plot clearly shows that the reaction follows first-order kinetics.

VII. Conclusion

The experiment shows that light significantly impacts the reaction between iodine and ammonium oxalate. Under LED light exposure, iodine gradually changes from yellow-brown to colourless, which depicts the conversion of Iodine to Iodide. This was verified by UV-vis absorption spectroscopy, which, over time, showed a decrease in iodine concentration. Thus, light is key in initiating and driving the reaction forward. No significant change was noticed in the container kept in the dark (absence of light), demonstrating the importance of light for the reaction to occur efficiently. This indicates that the reaction is a photochemical process initiated by light. From the absorption spectra graph, it was concluded that the above reaction was a first-order reaction.

VIII. Author Contributions

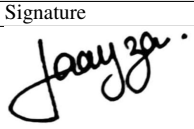
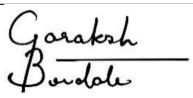
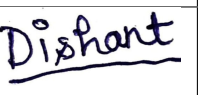
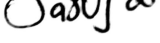
Name	Roll number	Contribution	Signature
Faayza Vora	23110109	Introduction, Observation and the results, compiling of the report, Handeled the solution and the timer in the lab.	
Goraksh Bendale	23110118	plotting of graphs for all the values of t and the graph of absorbance vs time, handeled the measurement of teh absorbance spectra of all samples.	
Dishant Tanmay	23110100	Proceedure, Handeled the solution and the timer in the lab	
Hriday Pandya	23110136	Safety measure, Materials, Apparatus, handeled the measurement of teh absorbance spectra of all samples	
Haravath Saroja	23110127	Conclusion	

TABLE I: Author's Contribution