Landolt Iodine Clock

**Description:** Two clear colorless solutions are mixed and after a short period of time turn dark blue. Kinetic measurements can be made by varying the concentrations of the stock solutions or the temperature of the reaction.

**Materials:**

- 0.10 M KIO$_3$
- 1% starch solution
- 0.25 M NaHSO$_3$
- Deionized Water
- Ice bath
- 100 mL graduated cylinder
- 400 mL beakers
- 600 mL beakers
- Timer
- Hot plate / thermometer

**Procedure:**

1. Mix a KIO$_3$/starch solution in several 400 mL beakers by adding the following to each: 100 mL of 0.10 M KIO$_3$, 50 mL of 1% starch solution, and 100 mL of deionized water. Prepare the same number of 600 mL beakers with 20 mL of 0.25 M NaHSO$_3$ and 130 mL of water.

2. To perform the demonstration, add the KIO$_3$/starch solution to the 600 mL beaker and record the time required to observe a change in color to dark blue. Do this for each set of KIO$_3$/starch solutions prepared. The length of time should be the same for each reaction. Upon mixing, the concentration of [KIO$_3$] = 0.025 M and [NaHSO$_3$] = 0.013 M.

3. The effect of concentration on the rate of the reaction can be measured by varying the concentrations of the starting solutions. It is suggested to decrease the concentration of KIO$_3$ for this demonstration (0.04 M and 0.02 M KIO$_3$ are used in Shakhashiri reference).

4. The effect of temperature on the rate of the reaction can also be determined by performing the reaction as described in steps 1-2 in an ice bath or by warming the starting solutions to ~ 60 °C. Do not keep the solutions warm for more than 5 minutes as the concentrations will change as water evaporates. Also, do not warm the bisulfite solution in the 600 mL beaker as SO$_2$ may be driven off. SO$_2$ is a respiratory irritant. For a more accurate analysis, be sure to monitor the temperature upon mixing with the thermometer.
Discussion: The clock period in this reaction refers to the amount of time the mixture remains colorless until the change to dark blue. Shakhashiri has noted this period is equal to $0.003 \text{ sM}^2 / [\text{IO}_3^{1-}]_0 [\text{HSO}_3^{1-}]_0$. Therefore, the given procedure should result in a clock period close to 9 seconds. The limitation to this setup is that if $[\text{HSO}_3^{1-}]_0$ is three times greater than $[\text{IO}_3^{1-}]_0$ then the reaction will not change color. This reaction can be described by the following series of reactions (Shakhashiri):

Step 1 $\text{IO}_3^{1-} + 3 \text{HSO}_3^{1-} \rightarrow \text{I}^{1-} + 3 \text{SO}_4^{2-} + 3 \text{H}^1^+$
Step 2 $\text{IO}_3^{1-} + 8 \text{I}^{1-} + 6 \text{H}^1^+ \rightarrow 3 \text{I}_3^{1-} + 3 \text{H}_2\text{O}$
Step 3 $\text{I}_3^{1-} + \text{HSO}_3^{1-} + \text{H}_2\text{O} \rightarrow 3 \text{I}^{1-} + \text{SO}_4^{2-} + 3 \text{H}^1^+$
Step 4 $2 \text{I}_3^{1-} + \text{starch} \rightarrow \text{starch-I}_5^{1-} \text{complex (blue)} + \text{I}^{1-}$

Normally, the generation of $\text{I}_3^{1-}$ in the presence of starch will generate the blue starch complex; however the triiodide ion is consumed by any remaining bisulfite ion, preventing starch complexation. In this reaction, the color change occurs when the bisulfite has been consumed.

Safety: Wear proper protective equipment including gloves and safety glasses when preparing and performing this demonstration. KIO$_3$ is a strong oxidizing agent. NaHSO$_3$ is a strong reducing agent and therefore solid or concentrated solutions should not be mixed with oxidizing agents.

Disposal: Combine all solutions and slowly add solid sodium thiosulfate until the mixture is no longer blue. At this point, the resulting solution is suitable to flush down the drain with plenty of water.

Reference:


Summerlin, L. R.; Ealy, J. L. In Chemical Demonstrations: A Sourcebook for Teachers; American Chemical Society: 1985; Vol. 1, p 75-76.


Video:

http://www.youtube.com/watch?v=E0T45zK5eTs