

A Clock Reaction

Summary

Two solutions (A and B) are mixed by pouring from one beaker into the other. After many seconds, the mixed solution turns dark blue, the color of the starch-iodine complex. Changing the concentration (or the temperature) of the solutions changes the time required for the blue color to be produced.

Materials

(wear safety equipment such as safety goggles)

Solution A: 4.3 g of KIO_3 (potassium iodate) per liter of water.

Solution B: make a paste of 4 g of soluble starch in a small amount of warm water.

Slowly add 800 mL of boiling water. Boil for a few minutes, and then cool the solution.

Add 0.2 g of $\text{Na}_2\text{S}_2\text{O}_5$ (sodium metabisulphite). Add 5 mL of 1.0 M sulphuric acid (see tip 1). Dilute to 1 L.

Procedure

1. Place 50 mL of solution A in a 250 mL beaker.
2. Place the same volume of solution B in a second beaker.
3. Mix the two solutions by pouring from one beaker into the other twice; hold the filled beaker in your hands to better see the reaction.
4. Note the time required for an observable reaction (blue color appearance) to occur after the solutions are mixed.
5. The reaction time can be varied by diluting solution A or by operating at other temperatures until a maximum of 35°C (see tip 2).

Tips

1. After sulphuric acid is added, solution B is usable for the next 10-12 hours. If you need to keep the solution longer, add the acid just before using the solution.
2. The starch-iodine complex becomes unstable above 50°C . Also, best results are obtained when the solutions are allowed to stabilize at room temperature for a minimum of a few hours prior to mixing.
3. This experiment is a good example to illustrate the dependence of reaction rates on concentration and temperature. At room temperature, the reaction time ideally is 10-15 s. If the reaction is too slow, add more sodium metabisulphite or more acid to solution B. If the reaction is too fast, dilute solution A.
4. The reaction mechanism can be summarized as follows:
 - Iodate reacts with bisulphite to form iodide (I^-)
 - Iodide reacts with iodate to form iodine (I_2)
 - Iodine is immediately consumed by reaction with bisulphite, giving back iodide.
 - When all bisulphite has been used up, iodine interacts with starch to form a blue complex
5. Species such as I_5^- (equivalent to two iodines plus one iodide) and I_3^- (equivalent to one iodine plus one iodide) fitted inside the coiled amylose structure are responsible for the blue starch-iodine complex. Metabisulphite hydrolyzes to bisulphite (HSO_3^-) in water solution.

Reference

L.R. Summerlin and J.L. Ealy, Jr., Chemical Demonstrations, *A Sourcebook for Teachers*, Vol.1, 2nd Edition, American Chemical Society, Washington (1988).