Rate of hydrolysis of aspirin

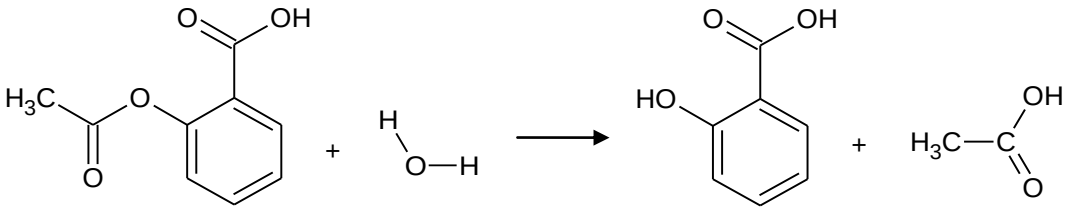
Student worksheet

Health and safety note

Wear eye protection.

Hydrolysis of aspirin

Aspirin (2-ethanoyloxybenzoic acid or acetylsalicylic acid) hydrolyses to produce 2-hydroxybenzoic acid and ethanoic acid. Here is the equation for the reaction:



The rate at which this reaction happens is important for two reasons. When administered, aspirin hydrolyses in the body. Also, if aspirin tablets are stored in a humid environment, such as a bathroom, they hydrolyse.

The amount of 2-hydroxybenzoic acid produced can be determined form the intensity of the violet-blue complex it forms with iron(III) ions.

Equipment and materials

- Colorimeter and suitable filter (green/yellow); a solution of the complex displays maximum absorption at 530 nm.
- Thermometer
- Colorimeter cuvette/tube, able to hold 6 cm^3
- 5 cm^3 and 1 cm^3 graduated pipettes or syringes
- 100 cm^3 conical flask
- Powdered aspirin − Harmful
- 0.025 mol dm^{-3} iron(III) nitrate solution
- pH 7.5 buffer solution
- Magnetic stirrer-hotplate and flea

Method

1. Measure out 100 cm^3 of the pH 7.5 buffer solution into a conical flask. Put this on a magnetic stirrer/electric hotplate and bring the temperature up to 70 °C.
2. Add 0.10 g of powdered aspirin to the buffer solution and stir the mixture gently until the aspirin is completely dissolved. No measurements should be made until all the solid has dissolved.
3. Pipette 5 cm^3 of iron(III) nitrate reagent directly into a colorimeter tube. Pipette 1 cm^3 from the reaction mixture and empty it into the colorimeter tube. Mix well and measure the absorbance. The intensity of the colour and, therefore, the absorbance value depends on the concentration of the hydrolysis product 2-hydroxybenzoic acid.

   Note: The first reading represents "time 0" although it is likely that some decomposition will have already occurred.

4. Take 1 cm^3 samples every 15 minutes for at least 2 hours and treat them as in step 4.
5. Use the calibration graph produced in *Determination of 2-hydroxybenzoic acid* to calculate the concentration of 2-hydroxybenzoic acid in solution at each time interval.

Processing results

The rate equation for the hydrolysis of aspirin is complex, but at a given pH in dilute aqueous solution the equation reduces to the first-order equation:

$$\text{Rate} = k[\text{A}]$$

where,

[A] is the concentration of aspirin

k is the rate constant (its value depends on temperature and pH).

1. From the concentration of aspirin, calculate the concentration of aspirin remaining in solution.
2. Plot a graph of aspirin concentration, [A], against time.
3. Measure the tangent at various point on the [A] vs time graph. These give the rate of reaction at various aspirin concentrations.
4. Plot a graph of rate of reaction against aspirin concentration. The slope of this graph gives the value of the rate constant, *k*, under the reaction conditions used.
5. The half-life of a reaction is the time it takes for the concentration of a reactant to halve or the concentration of a product to double. For a first order reaction the half-life is a constant value. No matter what the starting concentration of a reactant it takes the same time for this concentration to halve. From your results, work out the half-life for the hydrolysis of aspirin.

Possible extension ideas

The effects of pH and temperature on the rate of hydrolysis could be investigated.