Rate of permeation of aspirin through cellulose tubing

Student worksheet

Health and safety note

Wear eye protection. 0.1 mol dm^{-3} sodium hydroxide solution is irritant.

Principle

The ease with which a drug can move through a cell membrane is measured by the drug's permeability. Two main techniques are used by pharmacologists to determine permeability: parallel artificial membrane permeability assay (PAMPA) and Caco-2 assay.

Both are used routinely in drug development and pre-clinical development. However, neither is readily available for use in a school or college. Therefore, in this experiment cellulose tubing is used as the membrane. Cellulose tubing is a partially permeable membrane. It may be used to model passive transport through cell membranes. Passive diffusion through membranes is driven by concentration differences and does not require an input of energy.

Equipment and materials

For the permeation

- 15 cm length of cellulose tubing knotted at one end
- Sawn-off plastic syringe barrel to support the cellulose tubing (Figure 1)
- Elastic band
- 400 cm^3 beaker
- 5 cm^3 pipette (or plastic syringe)
- Paddle stirrer
- 0.05 mol dm^{-3} aspirin in buffer solution

For the colorimetric analysis

- Calibration graph for the colorimetric determination of aspirin (see *Colorimetric analysis of aspirin*)
- Colorimeter and suitable filter
- Boiling tubes (at least 6) and rack
- 0.1 mol dm^{-3} sodium hydroxide solution – Irritant
- Dropper pipette
- 0.02 mol dm^{-3} iron(III) chloride solution
- Bunsen burner and test-tube tongs
- 50 cm^3 volumetric flask (or a 50 cm^3 measuring cylinder)

Method

1. Measure 350 cm^3 of buffer solution into a 400 cm^3 beaker. Place a paddle stirrer in the beaker. Tie a knot in the end of the cellulose tubing. Soak the tubing in water and use an elastic band to fasten it to the sawn-off syringe barrel (figure 1).
2. Measure 5 cm^3 of 0.05 mol dm^{-3} aspirin in buffer solution into the tubing.
3. Clamp the sawn-off end of the plastic syringe so that the level of the aspirin solution in the cellulose tubing is level with the buffer solution in the beaker (figure 2). Start the paddle stirrer.

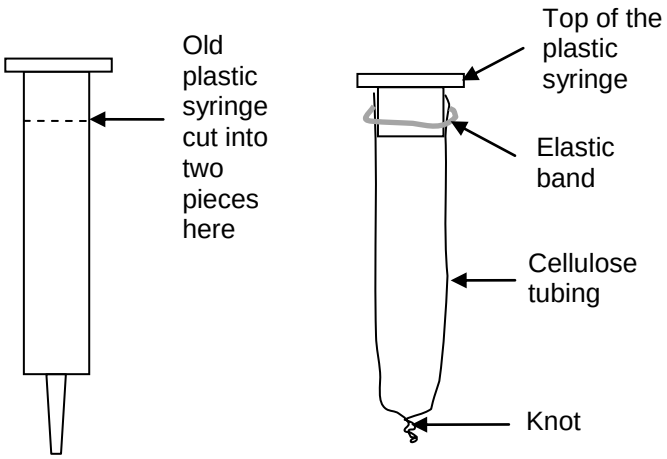

Figure 1 Preparing the cellulose tubing for permeability experiments.

4. Choose a spot about 4 cm below the water surface and about 2 cm from the side of the beaker from which to withdraw samples.
5. Start the stopwatch and immediately withdraw a 1 cm^3 sample and put into a boiling tube labelled 'zero time'.
6. Withdraw further 1 cm^3 samples every 5 minutes for 30 minutes labelled '5 min', '10 min', '15 min', '20 min', '25 min' and '30 min'.

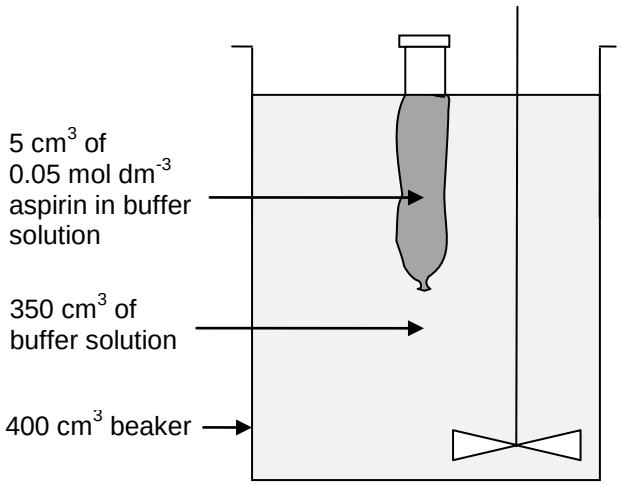

Figure 2 Experimental set up for permeation study.

For 'zero time' and the other six diluted samples:

7. Add 2 drops of 0.1 mol dm^{-3} sodium hydroxide solution each sample and warm the mixture for a few minutes over a small flame.
8. Allow to cool and add 10 cm^3 0.02 mol dm^{-3} iron(III) chloride solution.
9. Measure the absorbance of the solution and use it to calculate the concentration of aspirin.
10. Now calculate the concentration of aspirin in the solution from which the sample was taken.

Processing the data

If the experiment was left long enough and samples taken, the graph would be similar to that shown in figure 3.

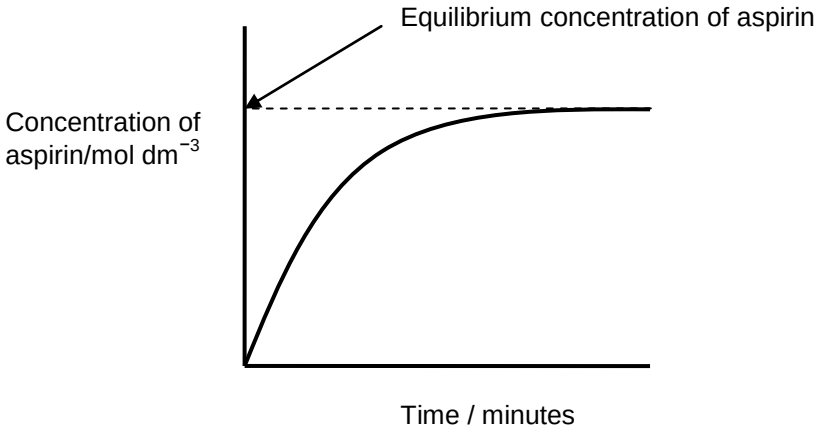

Figure 3 Equilibrium is reached when the concentration of aspirin is the same inside the cellulose tubing as it is outside the tubing.

However, permeation is quite slow and it is likely that you will obtain a straight line graph (possibly a slight curve). This is can be used to measure the initial rate of permeation, when the concentration of aspirin is 0.05 mol dm^{-3}.

Therefore,

1. plot a graph of concentration of aspirin against time; and
2. calculate the gradient of the straight line or the gradient (figure 4).

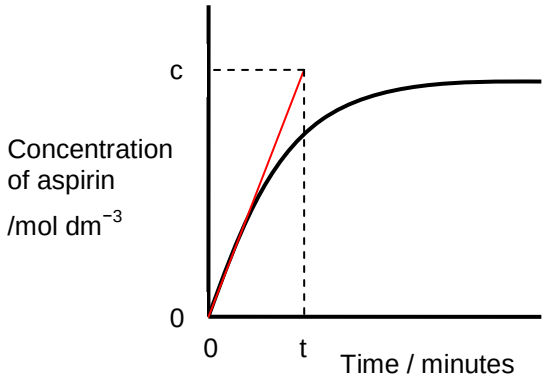

Figure 4

$\text{Initial rate of permeation} = \frac{c}{t} \text{mol dm}^{-3} \text{ min}^{-1}$

Possible extension ideas

The experiment could be repeated using different initial concentrations of aspirin in the same buffer and, in each case, determining the initial rate of permeation. Plot a graph of initial rate of permeation against initial concentration of aspirin. From this decide whether the permeation process is:

- zero order;
- first order;
- second order.

Further extension ideas are:
Investigate the effect of pH on permeation rate by using a number of buffer solutions.
Investigate the effect of temperature on rate of permeation could be investigated.
Compare the rate of permeation of aspirin with that of paracetamol and other compounds.