Fermentation of glucose using yeast

This resource accompanies the article **Is fermented food and drink good for us?** in *Education in Chemistry* which you can view at: rsc.li/3PPCdm8. The article explores fermented food and drink from around the world, how they work and whether they make us healthier.

The experiment is part of the **Nuffield practical collection**, developed by the Nuffield Foundation and the Royal Society of Chemistry. Delve into a wide range of chemical concepts and processes with this collection of over 200 step-by-step practicals: rsc.li/3PzyCZn.

Learning objectives

1 Carry out and observe a fermentation reaction.

2 Test the products of a fermentation reaction.

3 Explain the conditions needed for a fermentation reaction.

The experiment allows learners to cover the first two learning objectives. Use the questions to test their results and observations. Questions 4–6 cover the third learning objective and ask learners to explain the conditions required. Use question 7 to see if learners can connect this experiment to rates of reaction. To stretch learners, expand this question and ask them to write a full plan.

How to use this resource

Part 1

Set learners the first part of the experiment. It usually yields results within a lesson if the water is at the correct temperature and the reaction mixture is well mixed to begin with. It also depends on the freshness of the yeast. Dried yeast does work. If fermentation is not rapid because of the yeast used, then carry the whole experiment over to the next lesson.

For an alternative practical arrangement to part 1, use a bung and delivery tube to bubble the carbon dioxide through limewater. Or watch the **Identifying ions** practical video from 08:20 to see how to use a pipette to collect the gas when testing for carbonate ions.

Part 2

In the second part of the experiment, you can demonstrate distilling the reaction mixture. Watch the **Fractional distillation** (rsc.li/43g548C) and **Simple distillation** (rsc.li/3IznSWP) videos and download the accompanying resources for setup, methods and more learner-facing activities on simple distillation.

If you demonstrate distillation, pool the class results and filter the groups' solutions into your distillation flask. Significant quantities of yeast will produce foaming and you can carry this over into the product if you do not filter the reaction mixture. Collect the fraction between 77–82°C. Ethanol boils at 78°C. This fraction should burn easily compared with the non-flammable original solution. Pour the ethanol away immediately and do not keep or reuse it.

Alternatively, set the distillation practical as a learner activity. Individuals or pairs may not produce enough ethanol to complete the distillation so learners may need to combine their solutions and work in groups.

Technician notes

Equipment (per group)

- 100 cm^3 conical flask
- 50 cm^3 measuring cylinder
- Boiling tube
- Boiling tube rack
- Access to a mass balance, correct to 1 decimal place
- Cotton wool – enough to plug the conical flask
- Safety glasses

Chemicals (per group)

- Glucose, 5 g. Not currently classed as hazardous. See CLEAPSS Hazcard HC040c at bit.ly/4a6ix58 for more information.
- Yeast, as fast acting as possible, 1 g.
- Limewater 5 cm^3 – 0.02 M aqueous solution of calcium hydroxide. Not currently classed as hazardous but best to treat as a skin and eye irritant. See CLEAPSS Hazcard HC018 at bit.ly/48Vykmp and recipe book RC020, available from bit.ly/4atWuWv and below.

  1. Wear eye protection and measure 5 g of calcium hydroxide.
  2. Add, while stirring, to 300 cm^3 of water in a large beaker.
  3. Continue to stir the suspension, then pour it into a clean, labelled 2.5 dm^3 screw-top bottle using a funnel.
  4. Fill the bottle with distilled water and tightly close the lid. Invert it to mix.
  5. Leave the bottle overnight to allow the suspension to settle.
  6. When required, slowly pour the limewater into small, labelled bottles.
  7. Add more distilled water and/or calcium hydroxide to the stock bottle as required.

- 50 cm^3 of warm water 30–40°C

Safety and hazards

Read our **Standard health and safety guidance**, available from rsc.li/3PinAYs, and carry out a risk assessment before running any live practical.

Ensure learners wear safety glasses.

Be aware that if the fermentation is fast, the mixture may overflow from the flask.

Answers

1. The reaction mixture will be cloudy and frothy due to the gas given off. The smell of the mixture is a yeast smell.
2. The limewater turns cloudy/milky.
3. Carbon dioxide.
4. The reaction will be too slow because the lower temperature slows down the rate of reaction.
5. The reaction will slow down because the higher temperatures can kill the yeast and denature the enzymes.
6. $C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$
7. You could attach the conical flask to a gas syringe or upside-down measuring cylinder in water. You could the measure the volume of gas produced at fixed time intervals. A more basic suggestion might be to count bubbles produced in a fixed time interval, or to measure the height the froth reaches in a set time.