

CHEMISTRY

The Fermentation of Sugar to produce Ethanol

❖ Aim

To ferment a glucose solution in order to produce ethanol and to monitor the mass changes involved.

❖ Hypothesis

Ethanol will be a product of the fermentation procedure, the limewater solution will become clouded, or milky, and the mass of the glucose solution will decrease.

❖ Method

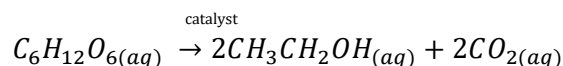
- 1) Yeast was added to a glucose solution and the solution was poured into a conical flask.
- 2) The opening was sealed at the top of the flask with a stopper that has glass tubing passing through its centre.
- 3) These materials were weighed on accurate scales, and the weight recorded.
- 4) A rubber hose was added to the open end of the glass tubing. The open end of the rubber hose was inserted in a medium-sized beaker filled to an approximate half-way point with limewater, and the equipment was assembled
- 5) The solution was hence left to ferment for 30 minutes. During this time, the limewater was observed for a change in colour or appearance.
- 6) The solution, whilst inside the conical flask still attached to the stopper and glass tubing, was reweighed.

❖ Results

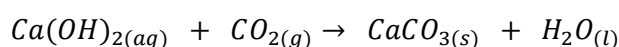
	<i>Initial</i>	<i>After 30 minutes</i>
Combined mass of conical flask, solution, cork and rubber tubing (g)	259.6	258.5
Observation of lime water	Clear, colourless	Clouded, milky

❖ Discussion

The solution's mass loss of 1.4g and the qualitative observation of the limewater changing from clear to milky both serve to indicate that the process of fermentation occurred. Fermentation is the biochemical reaction in which sugars are converted into ethanol and carbon dioxide. The process depends on microorganisms, such as yeasts, producing enzymes which act as catalysts in the reaction. This is represented by the equation:



As the carbon dioxide was produced the gas evaporated out of the solution, resulting in mass loss. The carbon dioxide then passed through the tubing and bubbled through the limewater solution, where it reacted with the calcium hydroxide to produce a solid precipitate of calcium carbonate, represented by the equation below:



The precipitate is easily observed as it is chalk, or limestone, which makes the previously clear limewater appear milky, or cloudy.

The fermentation of glucose can be promoted under particular, optimum conditions. Firstly, alcohol-tolerant yeast and a substrate such as a simple sugar or starch must be used. The solution needs to have a slightly acidic pH, ideally between 3.5-5.5, as this prevents pathogens from growing. A temperature which lies within the range of 20 - 35°C is also required as enzymes are highly pH and temperature sensitive and thus will denature if heated above 40°C. Moisture is important as are anaerobic conditions. This is because yeast is an aerobic organism which, when deprived of oxygen, is forced to respire sugars anaerobically to obtain energy. Therefore, if oxygen or air are present the yeast would use the sugars and oxidise them to carbon dioxide and water. Lastly, a series of days are necessary for the full process to complete itself.

This experiment was successful in meeting these conditions in several ways. The yeast utilized was brewer's yeast (*saccharomyces cerevisiae*) which is, as the name suggests, alcohol-tolerant. Glucose is further an ideal simple sugar for fermentation, while the solution lies within the specified pH range. On the particular date when the experiment was performed, room temperature also lied within the necessary temperature range, and the stopper sealing the conical flask was an effective means of limiting the air and oxygen present.

However, this student-designed experiment could be improved in many ways. Conditions on the experiment date were quite dry, and the 30 minute interval left for the process to occur is quite insufficient for complete fermentation. Experimental design also would have failed in maintaining complete anaerobic conditions, as air would have infiltrated the conical flask via the opening at the end of the tubing and during the time the equipment was being prepared. Further, had it been a cold day, a warm water bath in which to place the conical flask would

have been necessary, as well as a thermometer to ensure the temperature remains with the specified temperature range. Safety glasses should also have been worn as a precaution.

The creation of ethanol as a result of the fermentation holds much significance in society. Alcoholic beverages such as beer, wine and spirits have been prepared for thousands of years using this process.

❖ *Conclusion*

Ethanol was produced as a result of fermentation, as observed by the limewater solution becoming clouded, and the mass of the glucose solution decreased.