

STEM Project

Chapter 5: Physical and chemical change

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Engineering chemical reactions

Milk is made up of a mixture of particles including fats, water and different small proteins including casein. These particles can be separated in different ways to make cream, butter, ice-cream and polymer plastic. The first three you might have known, but making polymer plastic from milk is rare today. Before World War II, buttons and simple jewellery were made from the casein in milk.

When you heat milk, it allows the casein to change its shape. By adding vinegar (an acid) it makes the casein arrange itself into a shape a bit like building blocks. These blocks can then join together to make long strands called polymers. These long strands can slide past each other easily like strands of spaghetti.

In this task, you will explore the chemical production of polymer plastic from milk. You will start with the following pre-experiment to test the process involved. This task is best done as a group.

Pre-experiment: Manufacturing plastic from milk

Aim: To create a polymer plastic from milk

Materials:

- 50 mL full cream milk
- Clean wash cloth
- Vinegar
- 1 beaker
- Funnel
- 1 measuring cylinder
- Scales
- Teaspoon
- 60°C water bath

Method:

- 1 Add the milk to a beaker.
- 2 Place the beaker of milk in the water bath for 10 minutes.
- 3 Add 2 teaspoons of vinegar into the warm milk and stir gently with the spoon.

- Observe the mixture as it starts to curdle. The liquid part is called whey. The solids are called curds - these are the molecules of casein forming a polymer.
- Place the clean cloth inside the funnel.
- Gently tip the curds and whey into the cloth, catching the casein curds in the cloth.
- Weigh your casein plastic on the scales and enter your data into the table in the 'Data and Results' section.
- Knead the casein plastic with your fingers. Describe the consistency of the material

Improving the manufacturing process

Chemical engineers are interested in the way materials can be changed into useful products. They research the properties of raw materials and design and evaluate the processes used to produce the products. Their role often involves improving the manufacturing process so that the amount of product is maximised, improving the quality of the product and ensuring that the manufacturing process is safe and cost effective.

Imagine your group has been employed by the casein plastic button company to improve their product at minimum cost. There are two ways you can improve your product:

- Maximise the amount of product (by weight) that can be produced from 50 mL of milk.
- Improve the consistency of the product so that no cracks appear in the final dried buttons.

Use the following steps to guide you through the improvement process.

Step 1: Review the cost of materials

The material available for you to use for manufacturing casein have the following costs:

| Material | Cost |
|-----------------|----------------------|
| Full cream milk | \$1.50 per litre |
| Low fat milk | \$2 per litre |
| Vinegar | 60 cents per litre |
| Cloth | \$4.50 for 10 cloths |
| Funnel | \$3 each |
| Beaker | \$2.85 each |

Step 2: Modify a variable

Consider the following questions: What variables could you change in your manufacturing process to either maximise the amount of product or improve the consistency? In what way could you modify these variables and how would this affect the cost?

You must now choose, as a group, how you will change variables to explore improvements in the manufacturing process.

In your group, decide which variable from the pre-experiment to modify first and write a description of this first ‘modification scenario’ in the table in the ‘Data and Results’ section. Calculate the cost of this first modification scenario and add it to the table.

Step 3: Investigate

Repeat the pre-experiment with the modification scenario you have decided on. Enter your results in the table.

Step 4: Clean and repeat

Having observed the results of your first modification scenario, decide what you will modify next and repeat steps 2 and 3. You will need to clean your equipment before repeating the experiment. Continue modifying your variables, one at a time, until you feel your manufacturing process has been considerably improved at a reasonable cost. Record your results for each modification in the table.

Data and results

Pre-experiment results

| Weight of casein plastic from 50 mL of milk | Observations of the consistency of the casein plastic |
|---|---|
| | |

Manufacturing improvement process results

| Modification scenario (Description of modified variable) | Cost of material | Weight of casein produced | Consistency observations |
|---|------------------|---------------------------|--------------------------|
| | | | |
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Discussion and reflection

- Describe your overall approach to the improvement of the plastic polymer manufacturing process.

2 Describe any improvements you achieved in the manufacturing process.

3 What effect did your improvements have on the cost of the process?

4 Do you think the cost impact of your improvement was worth it? What effect would your improvement have on the price of the plastic buttons?

5 What could you measure to understand if the improvement has been worthwhile?

6 How much milk and vinegar would be needed in your improved process to produce 100kg of casein plastic and what would be the total cost of manufacturing this amount?

7 What other chemical manufacturing processes can you think of? List as many as you can.

Extension activity

Commercial companies that make casein plastic wash the final product in a harsh chemical called formaldehyde. Research the Material Safety Data for formaldehyde and explain why you think this step was not included in the classroom.
