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Name:

Class:

STEM Project

Chapter 4 – Chemical reactions

Pages 89–110

Slime optimisation

Engineers are often asked to design things to a high quality but at a minimum cost. The process of finding a compromise between competing factors, such as quality and cost, is called optimisation.

Chemical engineers carry out this process of optimisation using chemistry. They are often employed to find the best quality and lowest cost formula for products such as food, drugs and fuel.

In this task, you will use the concept of optimisation in a chemical manufacturing process to create optimised slime.

The chemistry of slime

The basic slime formula you will be using requires only three ingredients: sodium borate (or borax), PVA glue and water.

PVA glue is named for the chemical 'polyvinyl acetate' that it contains. Polyvinyl acetate is an example of a polymer – a chain of identical repeating molecules. When sodium borate (borax) is mixed with polyvinyl acetate, special links are created between the chains of molecules in a process called cross-linking.

This cross-linking makes the mixture thicker and more 'gluggy'. We use the word **viscosity** to describe the 'glugginess' of a substance. The more **viscous** your mixture, the thicker and more 'slime-like' it will be.

How to make slime

Slime is very easy to make. There are only three steps as follows:

Dissolve sodium borate (borax) into water in a beaker. Stir to combine.

Dissolve PVA glue into water in another beaker. Stir to combine.

Add the borax mixture to the PVA mixture. Stir to combine until slime-like.

The cost of slime

For the purpose of this activity the cost of your slime ingredients are as follows:

Borax: $2.50 per gram

PVA glue: $1 per gram

Water: $0.50 per mL   (Note: 1 mL of water is equal to 1 g of water)

Your total costs for a batch of slime will therefore depend on the proportions of each ingredient you use.

Your optimisation goal

Your optimisation goal is: to produce the most viscous slime possible at the lowest possible cost.

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Constraints of the task

1   The combined amount of borax and PVA glue in a batch must equal 30 g.
    For example, if you use 20 g of borax you must use only 10 g of PVA glue.

2   You may use as much or as little water as you wish.

Time to optimise!

It is time to do some chemical engineering. Use the five steps of the engineering design process to guide you through the task of optimising your slime formula to the meet the goal and constraints described above.

Step 1: Think

Consider the chemistry of your slime. How will you determine the proportions for a viscous but inexpensive slime?

•   How will you determine the ratio of borax to PVA?

•   How will you determine how much water will be required?

Write down some ideas about how to decide on the proportions of each ingredient in your initial batch.

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Step 2: Design

Decide on a test batch formula (a prototype formula). How much of each of the three ingredients will you try first? Calculate the cost of this batch.

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Step 3: Create

Make your test batch of slime.

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Step 4: Test

Make observations about your batch of slime in the Data and Results section. Describe the viscosity as best as you can. Keep your slime batch in a plastic zip-lock bag and label it 'Batch 1'. You will use it for comparison with subsequent batches.

Step 5: Improve

Based on the results of your test batch, change the proportions of borax, PVA glue and water to improve your formula. Calculate the cost of the improved formula.

Repeat steps 3–5 as many times as possible to optimise your formula for maximum viscosity and minimum cost. Keep each batch in a labelled zip-lock bag for comparison.

Data and results

Note down the cost of your slime batches below. Describe the viscosity of each batch in comparison to previous batches.

Slime Batches	Cost	Observations of viscosity
Batch 1		
Borax (g):		
PVA glue (g):		
Water (mL):		
Batch 2		
Borax (g):		
PVA glue (g):		
Water (mL):		
Batch 3		
Borax (g):		
PVA glue (g):		
Water (mL):		
Batch 4		
Borax (g):		
PVA glue (g):		
Water (mL):		
Batch 5		
Borax (g):		
PVA glue (g):		
Water (mL):		

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Discussion and reflection

What are the proportions of borax, PVA glue and water in your best (most optimised) batch of slime and how much did the batch cost?

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Compare your batches to others in the class. Which slime formula had the highest viscosity?
Which formula had the lowest cost? Which formula was the best compromise between viscosity and cost?

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How would you optimise your slime further if you could continue making batches?

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In what other activities is the idea of repeated (or 'iterative') attempts at something used to work towards a goal?

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