Biodegradable water bottles from brown seaweed Years 6/7 – TEACHER VERSION

What is green chemistry?

Green Chemistry aims to change the mindset and practices associated with everyday chemistry, to be safe, sustainable, environmentally friendly, re-used and non-toxic.

Seaweed for the future

Seaweed is a great source of material that chemists, biologists, engineers, and medical industries are trying to use to improve our future. Brown seaweed (Figure 1) contains a substance called alginate that turns into a gel when mixed with water. Solutions with calcium can be added to create a functional material which can then be turned into biodegradable water bottles (Figures 2 and 3).

Did you know?

Alginate can be eaten, its not harmful to our body, but some do have allergies to seaweed, so please DO NOT EAT OR HANDLE if you have a known seafood allergy.

Figure 1. Brown seaweed from South Australia

Encapsulation is the word we use to describe when a liquid is enclosed (held together) like water in a bottle.

Figure 2. Alginate gels holding different liquids together.

Figure 3. Blue water encapsulated with alginate

In this experiment, you will mix alginate with a calcium solution to encapsulate a liquid. See if you can change the shape of the alginate, or even try different liquids to encapsulate, like orange juice or milk. Think about how you can use this for different applications and what could be changed to improve the process.

Each kit contains resources for 32 students working in groups of 4.

Each kit contains:
32 clear cups
8 plastic pipettes
24 small cups
24 wooden stirrers
8 spoons

15 g $CaCl_2$. The SDS is on our website https://tcgcm.com.au/outreach. Note: $CaCl_2$ is an eye irritant (H319) and so precautions such as wearing safety glasses during solution preparation and taking care not to touch the eye area before removing gloves and washing hands should be taken.
12 g sodium alginate from brown seaweed. The SDS is on our website https://tcgcm.com.au/outreach
5 pH testing strips

Not included in the kit - orange juice, milk and food dye.

Pre-class preparation

1. Prepare a 1.5% solution of $CaCl_2$ by dissolving the 15g $CaCl_2$ provided in 1000 mL water.
2. Prepare a 4% solution of alginate by adding the 12 g of alginate supplied to 300 mL of water and stirring. It may take some time to dissolve the alginate. This process can be sped up by using a blender.

Each group should be given the following

- 4 clear cups with a different liquid in each. One containing orange juice, one containing dilute food colour, one containing milk and one containing $CaCl_2$. Approximately 10 mL of each liquid is required. Exact volumes are not essential.
- 1 plastic pipette
- 1 spoon – to scoop the biodegradable water bottles from the calcium chloride solution
- 3 wooden stirrers
- 3 x 10mL of alginate solution. The small paper cups can be used for this.

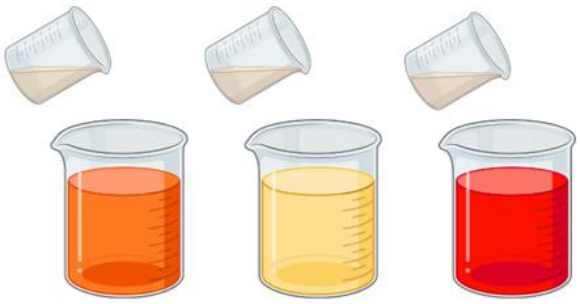
The pH of each liquid can be tested as a class. The pH indicator chart is on our website https://tcgcm.com.au/outreach.

Method

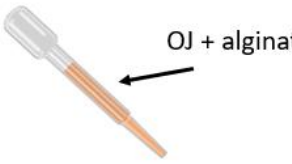
STEP 1:
Collect your liquids.

Orange juice | Milk | Water + food colouring (few drops)

STEP 2:
Mix 10ml of alginate with 10ml of your liquid. Stir to combine.
Test the pH of your solutions.



STEP 3:
Pipette drop your alginate liquids into the calcium chloride.
Observe what happens ☺



Calcium chloride

Observe what happens and have a look at the questions on your table ☺

Results

Group members: _____

Solution name	Write observations	Stick photo or draw diagram here
Orange juice	Does not hold its shape very well.	
Food dye (1 -2 drops) mixed with water	Form small gel beads	
Milk	Form small milk balls. Will hold its shape really well due to the added calcium in solution. Students can squeeze this between their fingers to pop.	

Discussion questions – possible student answers and actual answers.

a. Observe the reaction. What happened? Can this be used for a water bottle? Why/why not?

Students should observe small gel-like balls being created once being pipetted into the calcium chloride solution. Neutral mixes will work effectively. Orange juice should work less effectively, due to the pH, unless more alginate has been added at a larger ratio than 1:1 (e.g. 1 part orange juice: 2, 3, 4…parts alginate). It decreases the acidity and improves encapsulation.

Students' responses to this question will also vary. Some may contest that it is not sustainable and usable. Some students may support alginate as water bottles.

They may question: how can we drink from it? How will it stay in school bags? etc.

b. What liquid was better at being encapsulated? Write in order of the best to the worst.

Milk, water + food dye, orange juice

c. Explain why using seaweed is a sustainable source of material?

Seaweed is an abundant resource in Australia. So much of it exists that we can use the washed-up seaweed from the beach and process it for medical applications and replacing plastic. It can also be farmed without too much impact on the environment unlike farming cows (methane emissions).

d. How could you improve this experiment? What was its limitations?

Improve: If low viscosity is being used then it's harder for the calcium to interact with the alginate. Using a higher viscosity improves the experiment.

Limitations: Materials available.

Extension questions

e. What was the solvent? What was the solute?

Solute is the substance being dissolved (e.g. Calcium chloride, sodium alginate)

Solvent is what the solute is being dissolved in (e.g. Water)

f. Was this a chemical reaction? Why/why not?

Yes. It is a replacement reaction, where calcium replaces sodium in the alginate to form a gel.

g. How else could you use the properties of alginate to help the environment?

Subject to student creativity.