Student workbook

Nanoparticles in sunscreen challenge

Contents

Acknowledgements

This resource was originally developed by Nottingham Trent University to support outreach work delivered as part of the Chemistry for All project.

To find out more about the project, and get more resources to help widen participation, visit our Outreach resources hub: rsc.li/3CJX7M3.

Learning objectives

By the end of this session, you will be able to:

- Describe the use of nanoparticles for a specified purpose.
- Evaluate methods for testing the effectiveness of sunscreens.

Nanoparticles in sunscreen

In this challenge, you will work in pairs and follow a simple recipe to make sunscreen containing clusters of large zinc oxide particles.

To estimate the sun protection factor (SPF) for your sunscreen you will test how your homemade sunscreen compares with commercial sunscreens under ultraviolet (UV) light. The commercial sunscreens contain the same material as your homemade sunscreen but in the form of much smaller nanoparticles.

You should record any observations or measurements made during the activities in your notes, which will be useful for the poster presentation at the end of this challenge.

Career links

Nanotoxicologist

Watch the video job profile on **slide 8** (also available at rsc.li/3Z6btiW) to learn about Vicki's role as a nanotoxicologist. She examines how the nanoparticles present in sunscreens and other everyday products interact with our body to make sure they are safe to use.

Development chemist

Meet Mariam, a development chemist, who makes custom inks used to print labels for food, medicines and household goods, including sunscreens. Watch her video job profile at: rsc.li/3ls8V13 or on **slide 18**.

Activity 1: preparing your sunscreen

Equipment

Per pair of learners:

- Eye protection
- 10 cm^3 measuring cylinder
- 1 × boiling tube
- 1 × 250 cm^3 beaker
- 1 × boiling tube rack
- Glass stirrer
- Glass marker pen

Chemicals/materials

Per pair of learners:

- 6 cm^3 vegetable oil
- Around 40 yellow beeswax beads (approximately 1.5 g)
- Access to freshly-boiled water
- 5 g zinc oxide powder in a small tube

Safety and hazards

Wear safety glasses throughout all stages of this activity.

To do

1. Use a glass marker pen to label your boiling tube as ‘sunscreen unknown SPF value’ and place the boiling tube into the boiling tube rack.
2. Measure out 6 cm^3 of vegetable oil into a clean measuring cylinder.
3. Pour this into your labelled boiling tube and add 1.5 g of beeswax (approximately 40 yellow beeswax beads). Beeswax will help thicken the sunscreen.
4. Pour approximately 150 cm^3 of freshly boiled water into a clean, dry 250 cm^3 glass beaker. Place this on the hot plate using heatproof gloves to prevent burns.
5. Place the boiling tube containing the vegetable oil into the beaker of freshly boiled water and carefully stir the oil/wax mixture until it forms a consistent cream paste.
6. You have been provided with 5 g of zinc oxide powder in a tube. Do not use all the powder. Instead add a quarter to a half of the tube’s contents to the paste while stirring gently.
7. Once you have a consistently smooth mixture, carefully lift the boiling tube out of the water bath using tongs and rest it back in the boiling tube rack to cool down.
8. After cooling, the mixture in the boiling tube (your homemade sunscreen) should have the same consistency as commercial sunscreens. If the mixture seems too runny, reheat it in the water bath and add more beeswax beads. If the mixture seems too thick, reheat it in the water bath and add a little more vegetable oil.
9. Once you are happy with the consistency of your homemade sunscreen, you can move on to the next activity.

Career link

Pharmaceutical associate researcher

Watch the video job profile on **slide 27** (also available from rsc.li/3LIA7TR) to learn about pharmaceutical associate researcher roles. Can you think of other careers that may involve the skills you have been using to prepare your sunscreen?

Activity 2: estimating an SPF value for your sunscreen

Equipment

Per pair of learners:

- Disposable nitrile gloves (one pair for each learner)
- 6 × pieces of transparent plastic (35 mm × 35 mm)
- 6 × disposable micropipettes
- Glass marker pen
- Film holder
- Sheet of light sensitive paper
- Spectrometer (UV light meter)
- Graph paper
- UV light source

Chemicals/materials

Per pair of learners:

- 1 × UV sensitive dye in beaker (eg UV Condensate Drain Dye)
- 4 × samples of sunscreens with known SPF values
- 6 × small beakers of tonic water

Safety and hazards

Wear safety glasses and disposable nitrile gloves, if instructed, throughout this activity.

Preparing slides

You have been provided with six pieces of transparent plastic. (Glass is not suitable as it absorbs UV light.) You will use one slide with no sunscreen applied as a control. You will coat four of these slides with different sunscreens of known SPF values and one with a sample of your homemade sunscreen.

It is essential that you use the same amount of sunscreen each time and to spread it as evenly as possible.

To do

1. Collect a clean disposable micropipette. Make sure that you know which pipette is used with which sunscreen. Label the pipette with the sunscreen's SPF value using a marker pen.
2. Draw up a sample of sunscreen into the bulb of the pipette – sunscreen is thick and will take time to fill most of the pipette. Gently squeeze out a single drop onto the middle of a slide – you decide the size of the drop to use but make sure you are consistent each time.
3. Put on the plastic gloves. Using a clean, gloved finger spread the sunscreen evenly over the whole slide.
4. Place the slide into the film holder (or other support provided).
5. Use the marker pen to label the back of the slide (at one end) with the known SPF value.
6. Repeat steps 1–5 for three other sunscreens with known SPF values.
7. Repeat steps 1–5 to produce a slide of your homemade sunscreen from Activity 1. Label this slide as 'Homemade sunscreen'.
8. Finally prepare a sixth slide with only the plastic slide (no cream at all). Label this slide as 'Control'.

Career link

Senior scientist

Slide 30 highlights the chemistry career of a senior scientist for household goods. Phillip leads a small team of researchers testing household goods such as toothpaste, shampoo and sunscreen. They look for new ways to improve their performance. Find out more at: rsc.li/3kfmiRF.

Measuring SPF values

There are four methods you could use to estimate the SPF factor of your homemade sunscreen. Each method involves comparing the slides of the commercial samples with your sunscreen.

Carry out all four methods to compare the sunscreens' effectiveness in blocking UV light.

A. In the dark, place all six slides on top of sheet of light sensitive paper. Keep the paper and slides covered until you are ready to expose them to direct sunlight. Remove the cover and expose the paper and slides to direct sunlight for 30–45 seconds. Immediately wash the sheet with water to 'fix' the colour of the paper. Compare the colour of the paper to the original colour. The darker the colour, the higher the amount of UV light the paper was exposed to.

B. Place each slide (including the control) between a UV light source and a spectrometer (UV light meter). For sunscreens that block less of the UV light, more UV light passes (is transmitted) through the slide and the meter will record a higher value. Draw a graph, plotting the intensity of the light reaching the meter (% transmission) against the SPF value for your commercial sunscreens with known SPF values. Use this chart to find the SPF for your homemade sunscreen.

C. If you hold a UV torch directly over a beaker containing tonic water (UV-sensitive material), the contents of the beaker will glow. The higher the amount of UV light reaching the tonic water, the brighter it will glow.

   Collect six small beakers of tonic water. Place each of the six slides on top of each beaker. Hold the UV light source over each and observe the glow from the contents of the beaker. Judge the intensity of glow and place the slides in ranked order of their ability to block UV light. (The brighter the beakers contents glow, the lower the ability of the sunscreen to block the UV light.)

D. Taking one slide at a time, place each of the six slides on top of a beaker containing a solution of UV-sensitive dye. Position this directly under a UV light source. Any UV light that passes through the slide will cause the solution to glow. The intensity of this glow can be recorded with a light meter placed next to the beaker – the better the sunscreen, the weaker the glow. Draw a graph, plotting the intensity of the light reaching the meter (% transmission) against the SPF value for the four commercial sunscreens with a known SPF value. Use this chart to find the SPF for your sunscreen.

Activity 3: presenting your findings

Use your notes from the sunscreen testing activities to prepare a poster summarising the use of nanoparticles in sunscreens.

The questions below provide some guidance about what you should include in your poster. You will be judged on whether your poster answers these questions.

Questions

1. What are nanoparticles?

2. What are the nanoparticles present in some sunscreens?

3. What is the relationship between the SPF value of a sunscreen and the amount of UV light that it allows through?

4. How do the nanoparticles prevent UV light getting to your skin?

5. Which of the methods for finding the SPF value of your homemade sunscreen was 'the best', in your view? Explain your reasoning.