Nanoparticles in sunscreen challenge

Download the teacher notes, student workbook and technician notes that accompany this resource at rsc.li/3cd4lcy.

ROYAL SOCIETY OF CHEMISTRY

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.

What are nanoparticles?

- A nanometre (nm) is one billionth of a metre, or 1×10^{-9} m, in size.
- Nanoparticles are particles that are 1 nm to 100 nm in size.
- Nanoparticles have a very high surface area to volume ratio, which means that nanoparticles of any substances have properties that are different to those of larger, more bulky particles of the same substance.
- For example, silver is known to have anti-bacterial and anti-fungal properties. In bulk, silver is a shiny, silver metal but a very thin coating of silver nanoparticles can be used in wound dressings, plasters and socks to prevent bacterial and fungal growth.

What are nanoparticles?

Smallest particle you can see with the naked eye is approximately 50 microns = 0.00005 metres = 5×10^{-5} metres

This is still large compared to the nanoscale.

What are nanoparticles?

If Mount Everest were **50 microns** high …

the climber would be **10 nanometres** high.

What are nanoparticles?

If the Eiffel Tower were **50 microns** high …

a tennis ball would be **10 nanometres** high.

Nano news

Mail Online

Toxic 'needle-like' nanoparticles similar to ASBESTOS are 'found in baby formula' - but regulators refuse to issue an urgent recall

Revealed: The toxic nanoparticles with asbestos-like properties found in everyday goods

theguardian

Toxic air pollution particles found in human brains

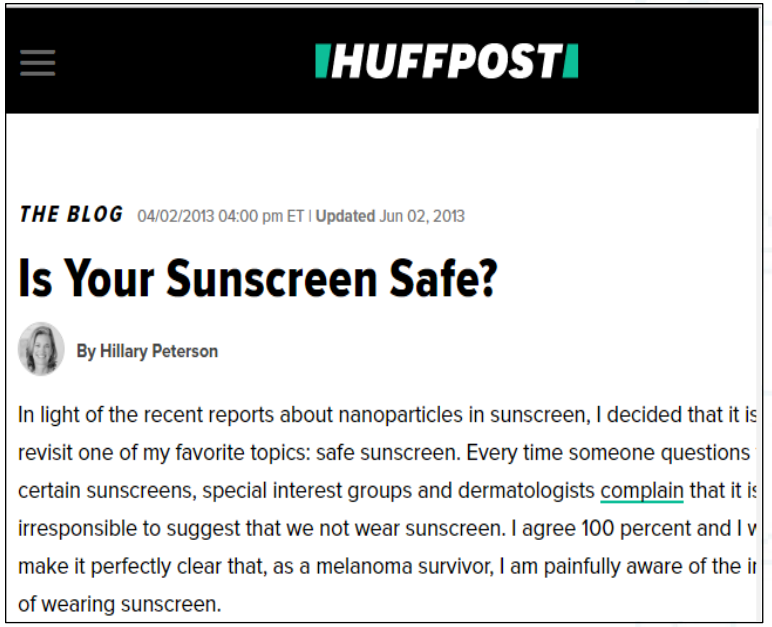
EXPRESS

Alzheimer's disease: Condition linked to exposure to air pollution and lack of Vitamin D

Career link

Nanotoxicologist

Meet Vicki, a nanotoxicologist, who examines how the nanoparticles present in sunscreens and other everyday products interact with our body to make sure they are safe to use.

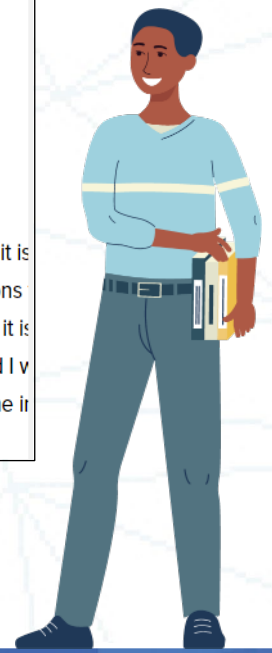

HUFFPOST

THE BLOG 04/02/2013 04:00 pm ET | Updated Jun 02, 2013

Is Your Sunscreen Safe?

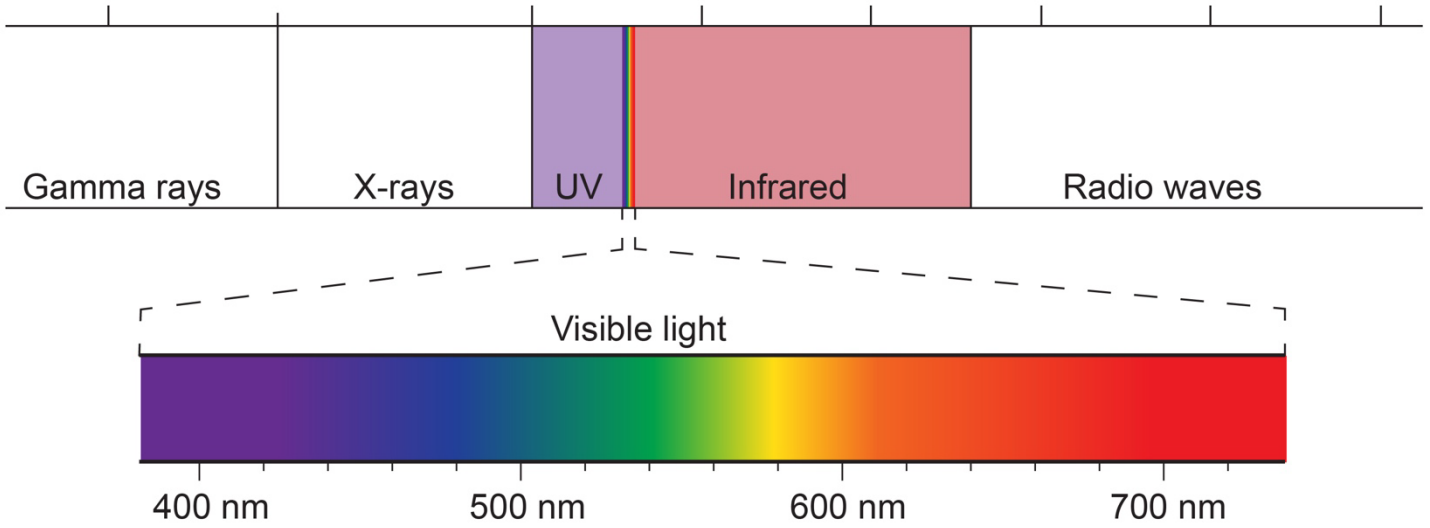
By Hillary Peterson

In light of the recent reports about nanoparticles in sunscreen, I decided that it is revisit one of my favorite topics: safe sunscreen. Every time someone questions certain sunscreens, special interest groups and dermatologists complain that it is irresponsible to suggest that we not wear sunscreen. I agree 100 percent and I v make it perfectly clear that, as a melanoma survivor, I am painfully aware of the ir of wearing sunscreen.

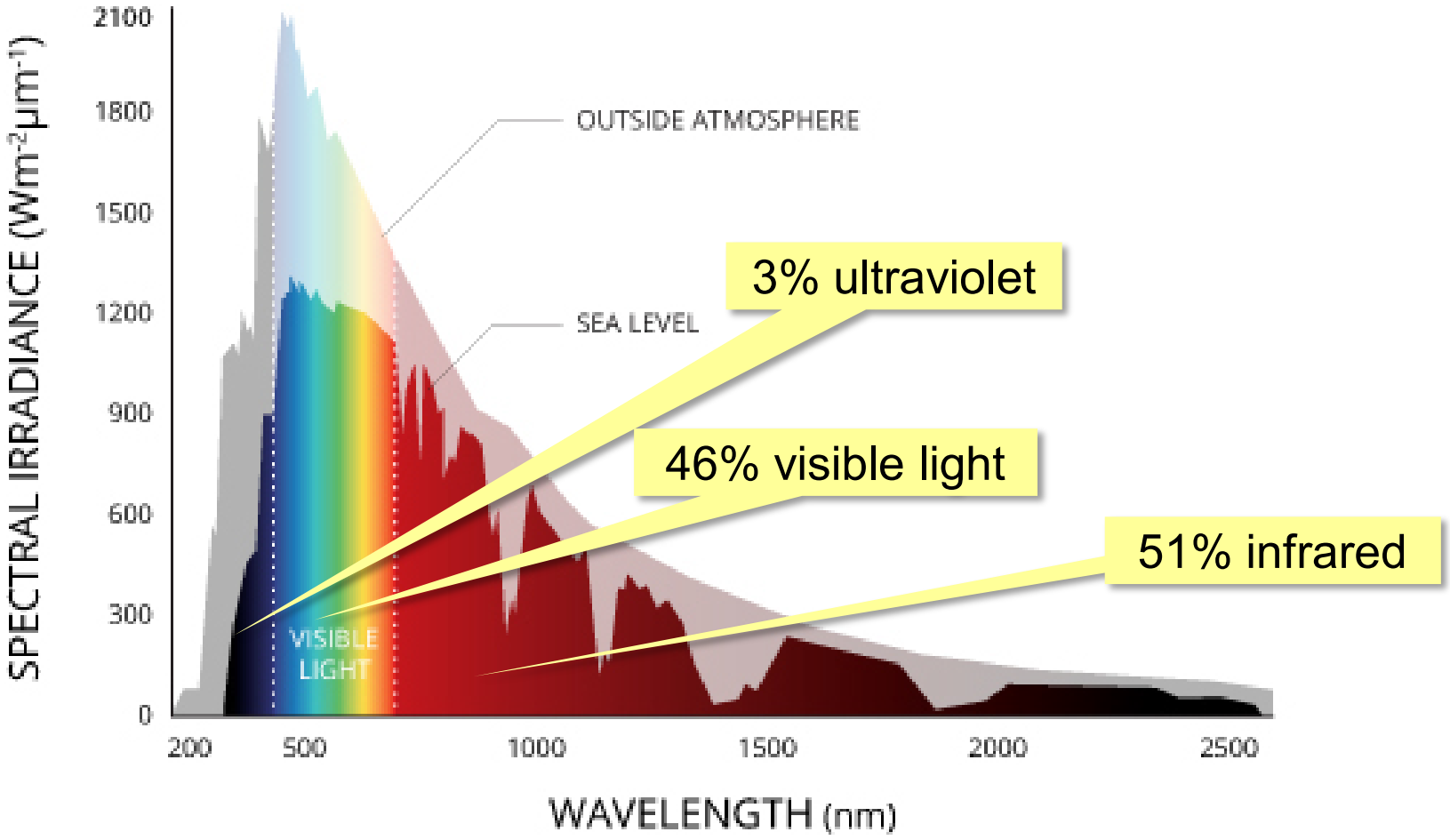


The electromagnetic spectrum

Visible light is just a small part of the **electromagnetic radiation (EMR)** spectrum.

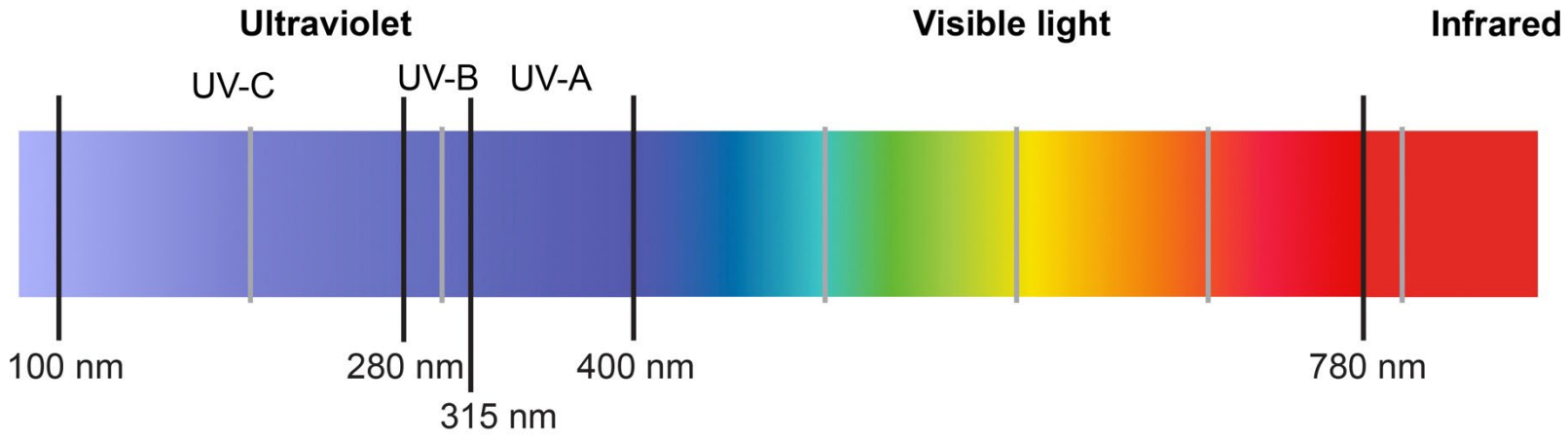


Radiation from the Sun



Sunlight and ultraviolet (UV) radiation

The UV region of the spectrum can be divided into three types:



UVC has the shortest wavelengths, the highest frequencies and the greatest energy, so does the greatest damage.

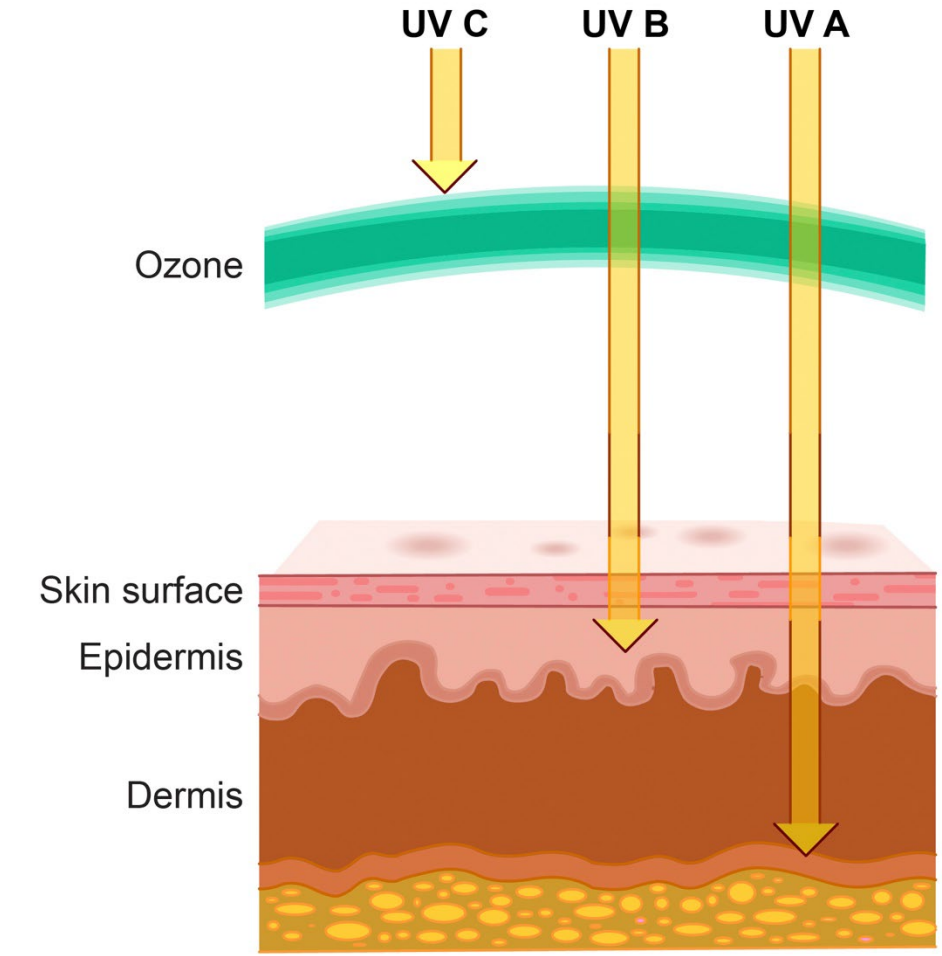
Risks of UV

Very high energy radiation (**UVC**) is absorbed by the ozone layer.

High energy radiation (**UVB**) causes tanning and sunburns.

Lower energy radiation (**UVA**) penetrates deep into the skin, leading to long-term damage with wrinkles, freckles and skin cancer.

99% of the UV reaching the Earth is UVA.



Protecting against UV

Sunscreens, suncreams or sunblocks block UV radiation by either **scattering** or **absorption**.

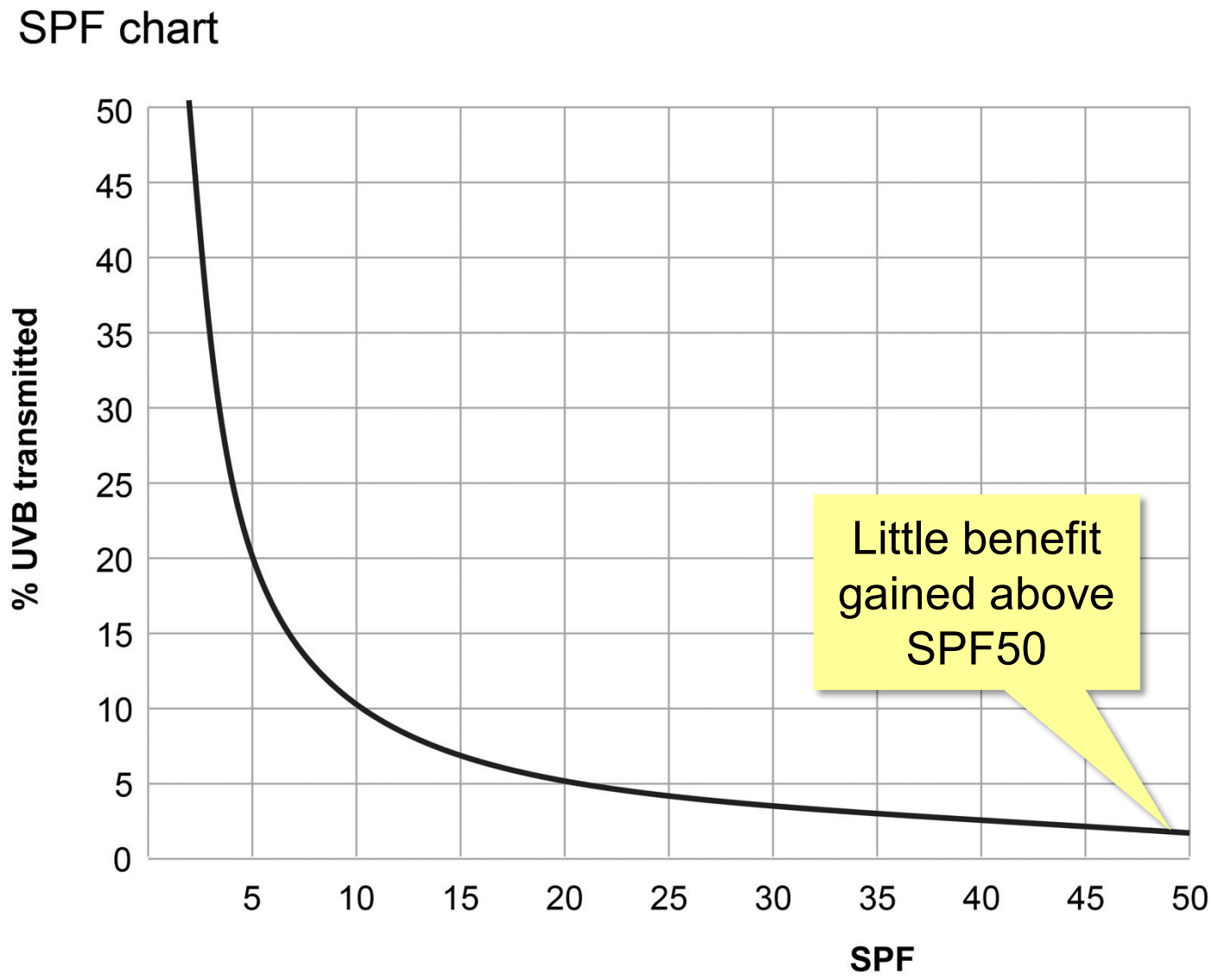
Bottles display a sun protection factor (SPF), which is a measurement of protection against **UVB** rays, which cause tanning and sunburn.

What do SPF values mean?

SPF values can be used to calculate the amount of UVB that is either blocked or passes through to the skin.

SPF value	% of UVB blocked	% of UVB that passes through
10	90.0	10.0
15	93.3	6.7
30	96.7	3.3

SPF chart


SPF chart
% UVB transmitted
50
45
40
35
30
25
20
15
10
5
0
5
10
15
20
25
30
35
40
45
50
SPF
Little benefit gained above SPF50

Measuring SPF for UVB

The SPF of a sunscreen is tested in the laboratory by smearing a standard amount over a given area of skin ($2\ \mathrm{mg\ cm^{-2}}$)

Studies suggest that people only apply 0.5 $\mathrm{mg\ cm^{-2}}$ or less; this represents 20–25% of the amount used to determine the SPF value written on the label.

More than just UVB

In 2015, results from a survey of 2000 UK adults showed that one in five adults were unaware that the SPF rating does not refer to the protection against all sun damage – only the protection from UVB rays.

Protection against UVA rays has its own separate rating system.

Career link

Development chemist

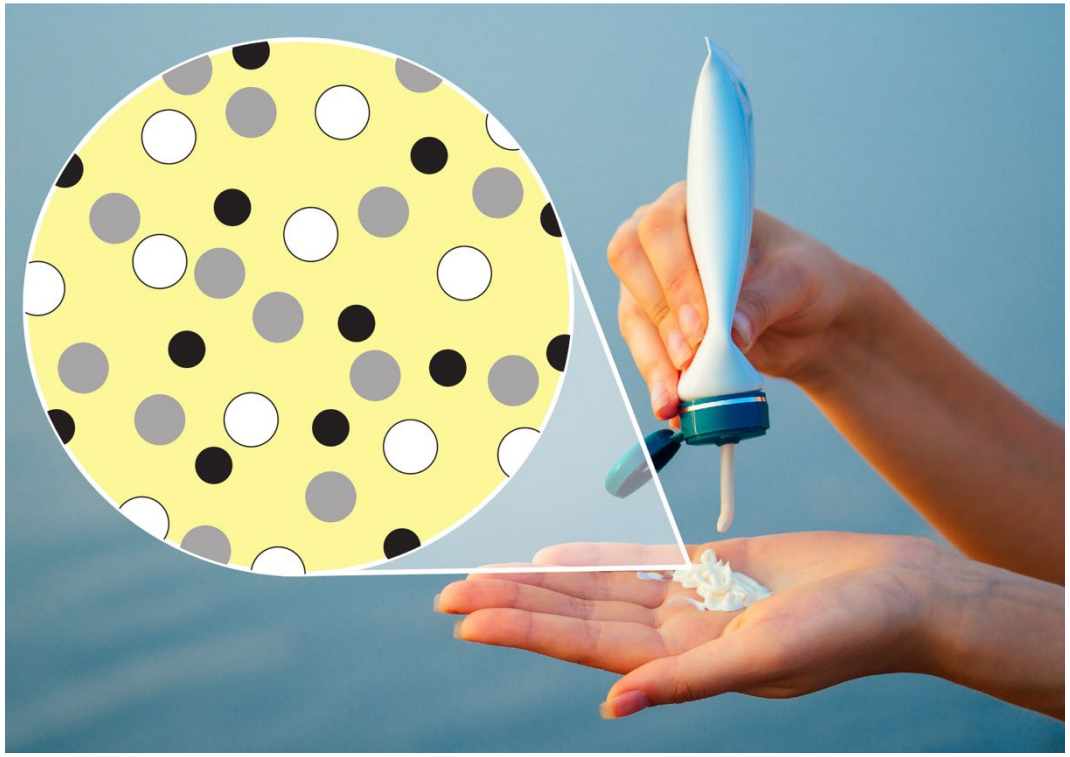
Meet Mariam, a development chemist, who makes custom inks used to print labels for food, medicines and household goods, including sunscreens.

Sunscreen composition

Most of a bottle of sunscreen is made of inactive ingredients that have little effect on UVA or UVB. These form the lotion part of the sunscreen and are commonly made up of natural oils and butters.

The active UV blocking agents are suspended in the lotion (colloidal suspension).

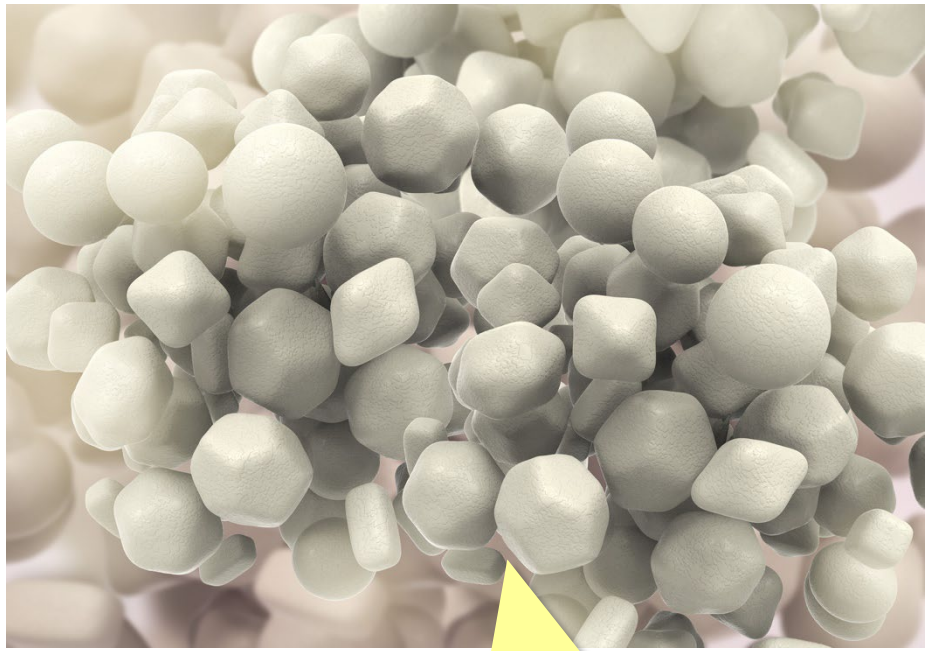
These are either classed as organic or inorganic chemicals.



Inorganic components

Many sunscreens involve white **ionic** compounds such as titanium oxide and zinc oxide.

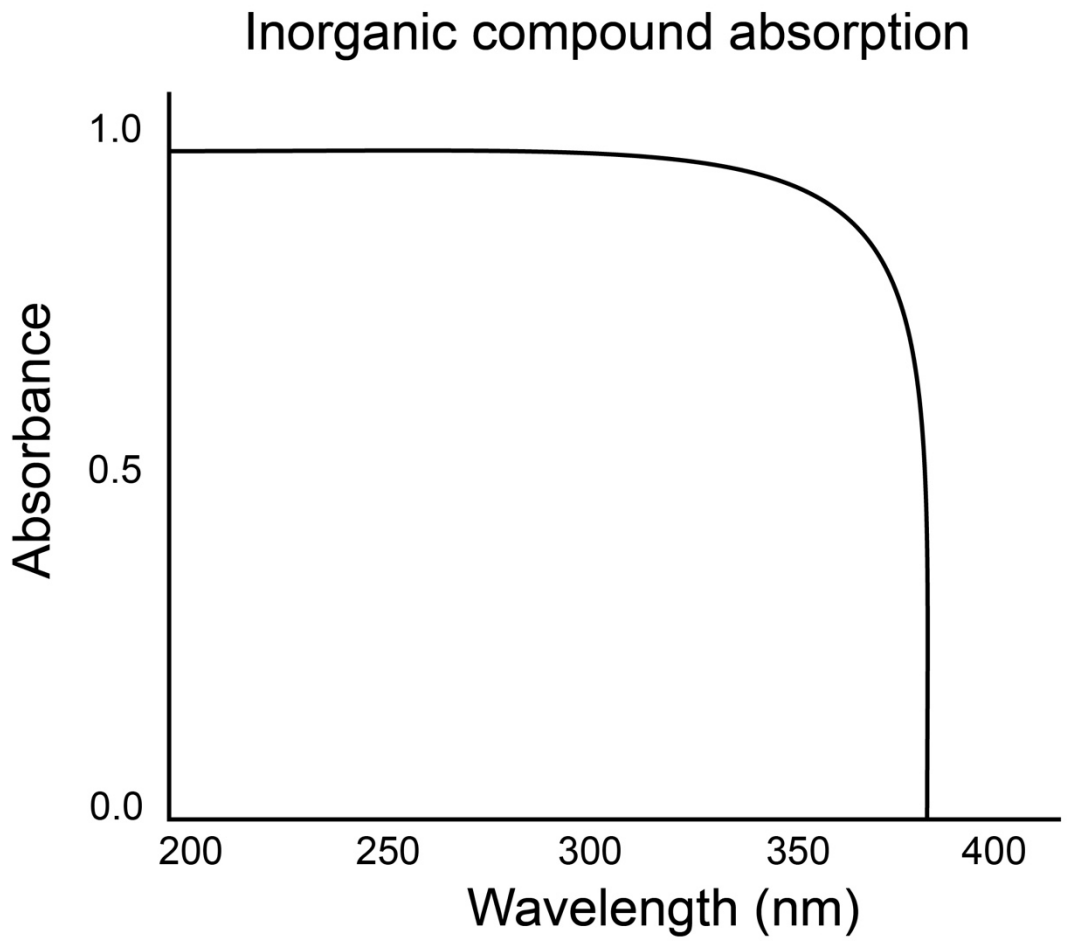
Fine white **powder** of zinc oxide



Zinc oxide **nanoparticles**

Inorganic components

These white powders are good at absorbing UVC, UVB and some of the UVA range up to ~380 nm.



Clear vs white sunscreens

Nano-sized ZnO particles

Large ZnO particles

Scattering visible light

- If visible light reaches the skin, some colours are absorbed (blue-green) while other wavelengths are reflected.
- Some sunscreens scatter visible light – it doesn't reach the skin and all colours are reflected.
- Visible light (~500 nm) is easily scattered by 250 nm clusters.
- 100 nm clusters are too small to scatter visible light, so the sunscreen appears transparent on the skin.

The challenge

- You will now complete a series of practical activities in which you will prepare your own sunscreen sample and estimate its SPF value.
- You will follow a simple recipe published on the internet for a ‘chemical–free’ sunscreen. You will be using zinc oxide in a heated mixture of natural oils. The zinc oxide will not be in the form of nanoparticle clusters.
- You will compare how well your sunscreen blocks UV light compared with other commercial brands.
- Finally, you will produce a poster to summarise your findings.

Activity 1

Preparing your sunscreen

See student workbook

Activity 1

Preparing your sunscreen

In this activity you will work in pairs to produce your own sunscreen.

The instructions are provided in your student workbook.

Remember to wear eye protection throughout the activity.

Career link

Associate researcher

Meet this associate researcher who uses similar skills to those you have used during this activity to produce a range of pharmaceutical products in his role with Pfizer.

Activity 2

Estimating an SPF value for your sunscreen

▶ See student workbook

Activity 2

Estimating an SPF value for your sunscreen

- Now you have prepared your own sunscreen, you will use four different methods to compare it against other sunscreens with known SPF values and determine its SPF value and efficiency.
- The instructions are provided in your student workbook.
- Remember to wear eye protection throughout the activity.

Career link

Senior scientist

Meet Phillip, a senior scientist for household goods. He leads a small team of researchers who test household goods such as toothpaste, shampoo and sunscreen and look for new ways to improve their performance.

Activity 3

Presenting your findings

See student workbook

Activity 3

Presenting your findings

Now that you have tested your homemade sunscreen you need to use your findings to prepare a poster summarising the use of nanoparticles in sunscreens.

You should include answers to the following questions in your poster.

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.

Suggested answers

Your answers to the questions may include:

1. Nanoparticles are particles that are 1–100 nm in size, of the order of a few hundred atoms.

2. The nanoparticles in some sunscreens are clusters of particles of white chemicals such as titanium oxide or zinc oxide.

3. The higher the SPF value, the less UV light it allows through. The relationship is not linear: higher SPF values have a decreasing effect as the SPF value increases.

Suggested answers (continued)

4. Nanoparticles prevent UV light getting to your skin by scattering or absorbing the light.

5. You may have drawn diagrams of your methods and annotated these. You may have compared the accuracy of judging ‘glow’ by eye with using a light meter. You may also have discussed the methods that measure the glow of a liquid compared with direct measurement of UV light passing from a source through the slide.

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.