AQA GCSE

Design and Technology 8552

Smart materials

Unit 2
Energy, materials, systems and devices

PG ONLINE

Objectives

- Be able to recognise a range of smart materials
- Understand how the functional properties of a range of smart materials can be changed by external stimuli

Starter

- Smart materials react to an external stimulus by changing their characteristics and/or properties
  - What stimulus is changing the colour of the mug?
  - Why does the handle stay black?

Smart materials

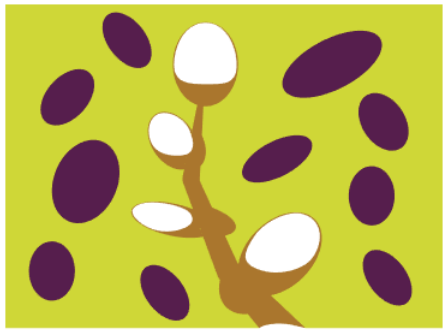
- What different stimuli can make changes occur in smart materials?

Self-healing polymer

- Self-healing polymers react to stress fractures by releasing a resin into the new crack
  - Microcapsules of liquid resin are ruptured to bond the polymer back together again
  - What triggers the resin to cure?

Microcapsules ruptured by fracture

Polymer resin is released into fracture



Resin hardens and heals damage

Self-healing concrete

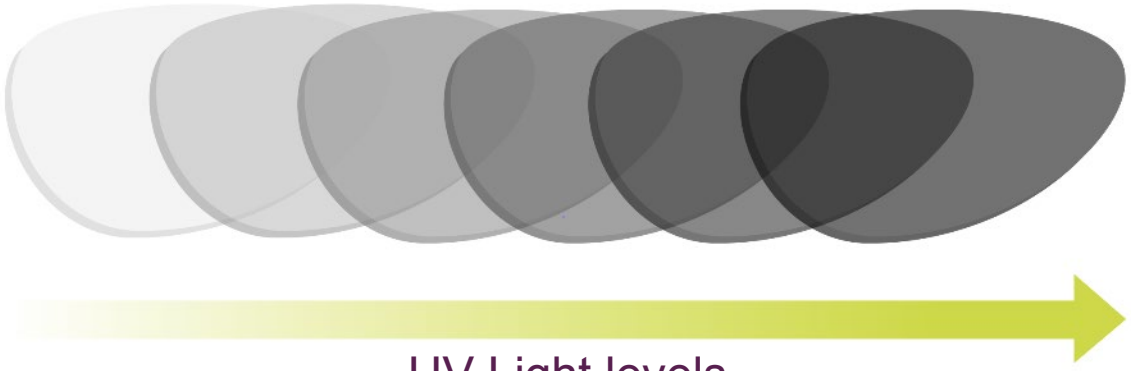
- Designed to avoid stress cracks filling with water
  - Cracks enlarge over time and water can cause the steel reinforcements to rust and weaken the structure
  - Self-healing concrete has spheres of bacteria added to the mixture which contain their own food
  - When a crack forms and water seeps in, the bacteria start to feed, producing calcium carbonate which fills the crack

Thermochromic pigments

- Hot and cold temperatures trigger a change of colour in special thermochromic dyes
- Applications include:
  - Fever scan strips used on infants
  - Room thermometers
  - Children's cutlery and crockery
  - Novelty goods and colour changing clothing
- Some pigments have a permanent change
  - How might these be useful in the medical or food industry?

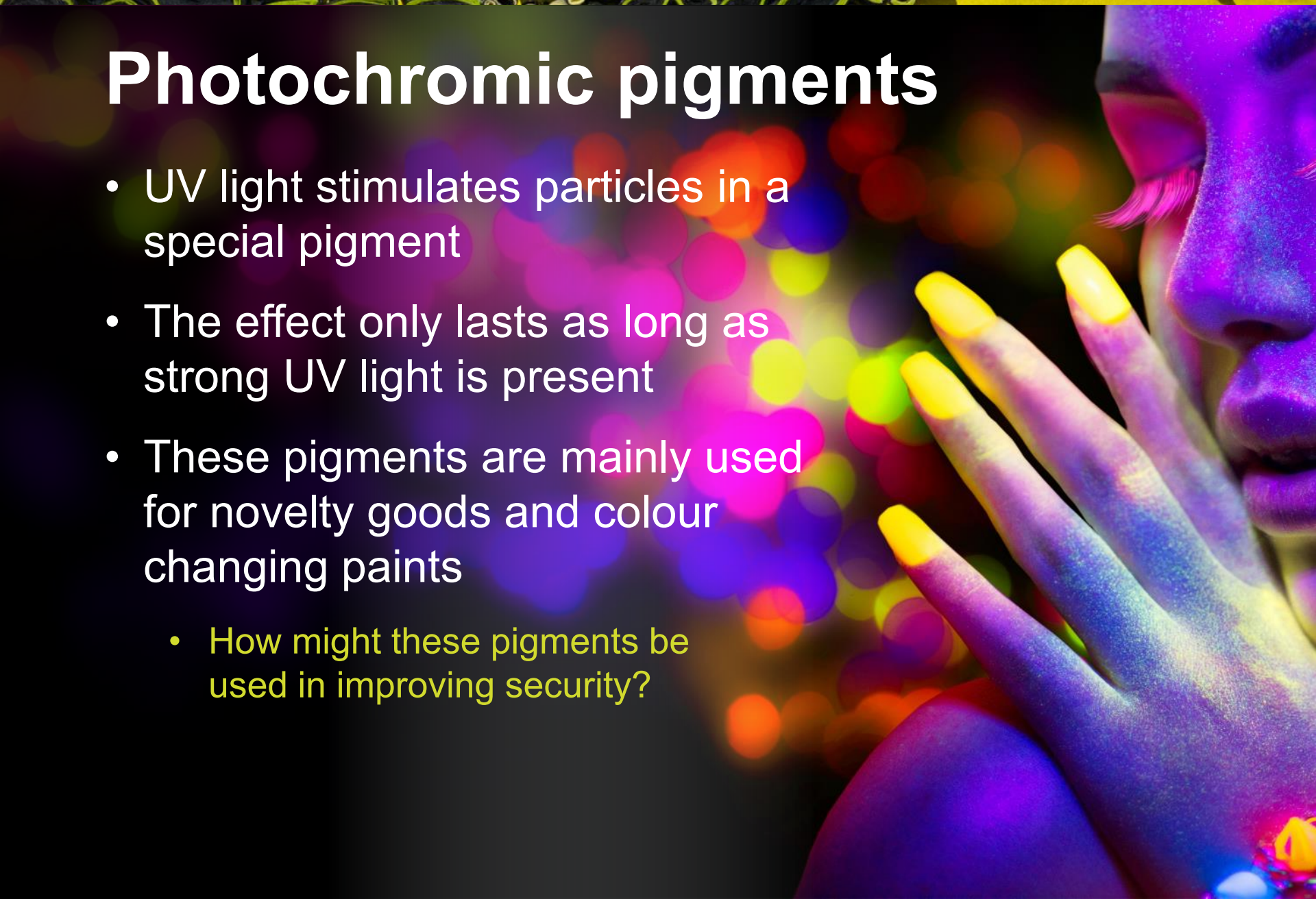
Photochromic particles

- Ultraviolet light reacts with photosensitive silver halide particles within the lenses
  - This reaction is commonly seen in prescription sunglass lenses that darken in bright sunlight and return to clear indoors
  - The reaction can take up to two minutes to complete
  - Over time the particles can lose their ability to revert to clear



Photochromic pigments

- UV light stimulates particles in a special pigment
- The effect only lasts as long as strong UV light is present
- These pigments are mainly used for novelty goods and colour changing paints
    - How might these pigments be used in improving security?

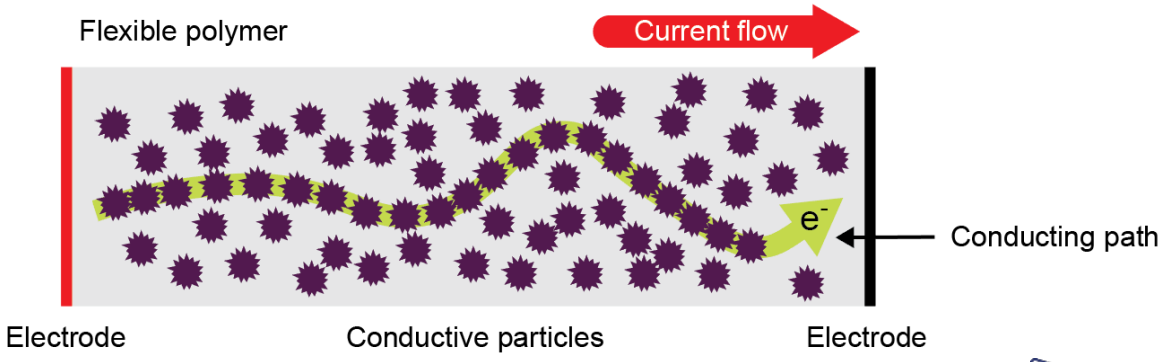


Shape memory alloy (SMA)

- Nitinol is an SMA of nickel and titanium
  - Nitinol needs to be ‘set’ into a shape which requires a high temperature of around 540°C
  - Once set, the alloy can be deformed into a different shape
  - Heat or electricity is used to trigger a response in its shape
  - When reheated to around 70°C it will go back to its pre-set shape
- How might nitinol be used in dentistry, eyewear or heart surgery?

Quantum Tunnelling Composite

- QTC is a polymer that contains billions of metal particles that don't actually touch each other
  - It is an unusual material being both an insulator and a semi-conductor
  - When pressure is applied the polymer becomes a conductor allowing an electrical signal to flow
  - Where might this material be useful?



Piezoelectric material

- Piezoelectric material works in two ways:
  - Subject it to movement or stress and it produces electricity
  - Attach an electrical signal to it and it moves
- How might it be used to detect vibrations?

Piezo transducer

- Using a thin layer of piezoelectric material, small transducers vibrate when an electrical signal is sent through the contacts
  - These are used in mobile phones and other small electronic devices and toys
  - When tapped or spoken into they produce a small electrical charge that can be amplified to create sound or trigger a response in a circuit

Acid or alkali?

- PH levels can be detected using litmus paper
  - It uses compounds found in different varieties of lichen
  - Different colours and shades appear depending on the PH
  - Common uses include: Garden soil testing / pool water testing / skincare products – (dermatological testing)

Worksheet 4

- Complete **Tasks 1** and **2** of the worksheet

Plenary

- Imagine you are a designer for a car manufacturer
  - You have been asked to create the best driving experience for their customers
- How could smart materials be used to help you design the ultimate car?
  - Consider all aspects of the passenger experience including safety, entertainment, comfort, easy of use of controls, reduced maintenance etc.

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