**MODULE:**

Chemistry in nanotechnology: Testing sunscreens and photocatalytic test

**DESCRIPTION OF FIELD:**

Nanoscience and nanotechnology have for a long time now been extremely interesting in terms of the development of new materials. Due to their small size (between 1 nm and 100 nm), materials in the so-called nanoform or nanosize have special physical and chemical properties and a large specific surface area (i.e. a large surface area in relation to volume). Nanomaterials are increasingly used in cosmetic, textile, food and construction industries as well as in medicine. This means that we are already seeing commercially available nanosize materials such as titanium dioxide, silver and silicon dioxide in our homes. Titanium dioxide is added to a broad range of products. It is very often found in cosmetic products such as powders and creams, particularly in sunscreens, which protect us from UV light. $TiO_2$ scatters and reflects unwanted UV rays. It is found in food in micro and nano sizes – as the additive called E171. It is also used as a bleaching agent in the coating of chewing gums and in sweets, dry foods, etc. Increasingly, it is gaining prominence as a self-cleaning coating for windows and facades. $TiO_2$ becomes hydrophilic under UV light and does not soak the surface, which prevents misting and simultaneously cleans the surface.
In medicine, nanomaterials are increasingly used as radiocontrast agents in nuclear magnetic resonance imaging and for delivery of active substances. The latter uses magnetic nanoparticles whose surface has been processed so as to bind the active substance to it. These magnetic particles can then be led to the affected area using an external magnet.
Besides the numerous positive properties of nanomaterials, we should, however, also take note of the negative aspects of these small particles. Nanotechnology is a very complex field, and we often encounter various nanomaterials unknowingly. Since they are present everywhere, we can ingest or inhale them, or they can enter our body through the pores of the skin. Due to the possibilities listed above, researchers are not only developing new nanomaterials but also studying the impact nanoparticles have on our body and health. Studying the toxicity of nanomaterials tells us what happens to them in our body and whether they can harm us.

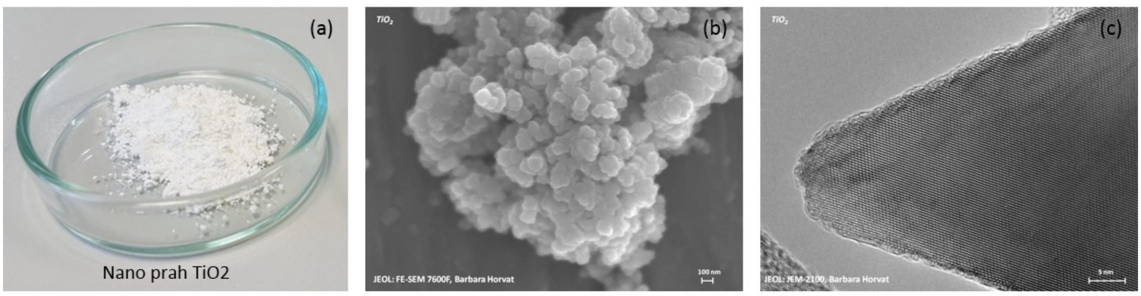


Figure 1: $TiO_2$ nanopowder. (a) $TiO_2$ as seen by the naked eye, (b) a cluster of $TiO_2$ particles and (c) a single $TiO_2$ particle as seen using electron microscopy.

These are just a few examples, but there is a lot more that we could write regarding nanomaterial types and uses. And now you can observe the behaviour of nano- and microsized particles by yourselves to check which example involves nanoparticles. We have prepared two simple experiments.

**MATERIAL:**

**First example:** two sunscreens. The first contains $TiO_2$ nanoparticles, the second $TiO_2$ microparticles. We can find a large number of sunscreens on store shelves. Reading the product labels, we can see that some contain nano $TiO_2$, while others contain $TiO_2$. Choose sunscreens with the higher SPF. (I'll add pictures).
**Second example:** $TiO_2$ nanopowder (Degussa P25), $TiO_2$ micropowder (pigment), Resazurin dye (10mg/l), distilled water, pipette, 2 spatulas, 4 beakers

**METHODS OF WORK:**

1. Testing two sunscreens. $TiO_2$ scatters UV rays, thereby protecting us from sunburn. Your assignment is to observe the difference between the two sunscreens and to understand why they are different.
   The first contains $TiO_2$ microparticles, while the second contains $TiO_2$ nanoparticles. Apply a thin line of the first and the second sunscreen to your arm. Do you notice any difference?
   **Explanation:** The sunscreen containing microparticles leaves a thick white cast on the surface of the skin, while the sunscreen with nanoparticles is nicely absorbed into the skin. Though both sunscreens use the same operating principle (reflection of UV rays), one of them is absorbed into the skin and the other is not – thanks to the size of the particles.
2. Photocatalytic test. Nanosized $TiO_2$ is a photocatalyst, which means that it can degrade organic molecules when illuminated with light of the appropriate wavelength. In this experiment, you will determine which particles are nanosized and which are microsized.
   Pour 5 ml of Resazurin dye solution into four 10 ml beakers. Add a spatula tip of $TiO_2$ nanopowder into the first beaker and a spatula tip of $TiO_2$ micropowder into the second beaker. Leave only the dye in the last beaker for a comparative test. Stir and watch as the dye solution changes colour. The change in colour will be even more pronounced if the nanopowder solution is placed in sunlight. After some time, the nanopowder solution will become colourless because the $TiO_2$ will degrade the dye. The micropowder solution on the other hand will remain unchanged because the $TiO_2$ micropowder is photocatalytically inactive.

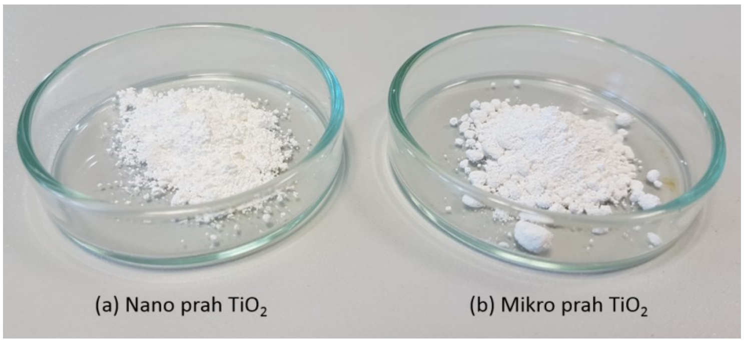


Figure 2: $TiO_2$ nanopowder and $TiO_2$ micropowder.

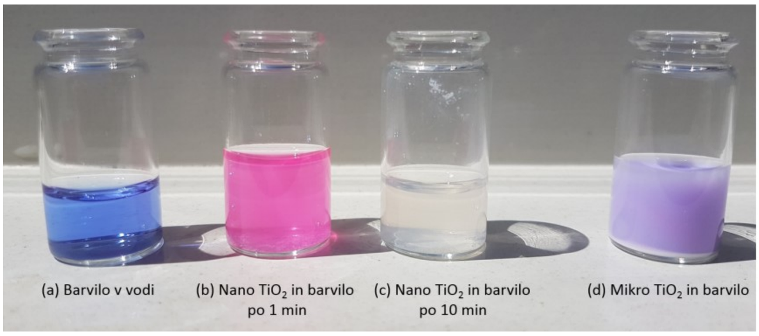


Figure 3: The reaction between the Resazurin dye and nano $TiO_2$.
(a) Dye in water (b) Nano $TiO_2$ and dye after 1 min (c) Nano $TiO_2$ and dye after 10 min (d) Micro $TiO_2$ and dye

**Explanation:** The photocatalytic reaction (the degradation of the dye in this case) takes place on the surface of the nanoparticles but not on the surface of the microparticles. The nanoparticles are small enough to discolour (degrade) the dye, which does not occur on the surface of the photocatalytically-inactive microparticles.

**Detailed explanation of photocatalysis (advanced level):**

Photocatalysis is a chemical reaction that occurs when a photocatalyst is illuminated with light of sufficient energy. The wavelength of light needed to excite the electrons in a given material depends on the properties of this material. As the best known photocatalyst, the semiconductor titanium dioxide needs to be illuminated by a wavelength of 390 nm or less. Light of this wavelength has sufficient energy to excite the electrons in the valence band of titanium dioxide. The electrons pass into the conduction band, leaving holes in the valence band. The electrons and the holes move to the surface of the material, where they react with molecules of water or hydroxide ions (holes), or with oxygen dissolved in water (electrons). These reactions form active components (the most important being hydroxyl radicals) that oxidise the organic molecules on the surface of the photocatalyst. Photocatalytic reactions can also take place in air and are used for the degradation of organic pollutants in water or air.

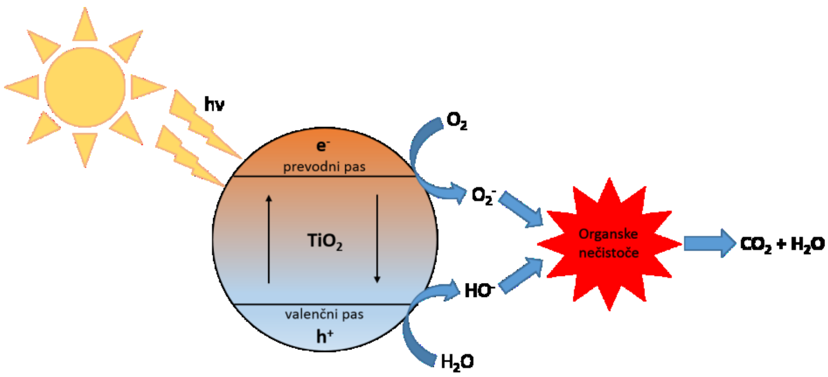


Figure 4: The mechanism of photocatalysis.

**RESULTS:**

Observe the experiments and describe what happens and why. Use the explanation given in each experiment for assistance.

**REPORT:**

You can record videos or take pictures in both experiments. The second experiment changes over time. What is going on and why? Please explain.
Why does the experiment run faster when the beakers are placed in sunlight? What is the wavelength of sunlight? What happens in the beaker containing the $TiO_2$ micropowder (pigment)?

**EXAMINATION OF ACQUIRED KNOWLEDGE:**

What is nanotechnology? What is nano?
Where can nanomaterials be found?
Give examples of the use of nanomaterials.
Are nanomaterials potentially toxic?
What experiments did you perform? Explain the first and the second experiment.
What is photocatalysis?

**EVALUATION OF THE PRACTICAL:**

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| Knowledge for practical: | | | |
| Experimental Exercise: | | | |
| Results and answers: | | | |
| Compliance with security rules: | | | |
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| Review date: | | Supervisor signature: | |