BBC Bitesize – Chemistry

Episode 8 – Nanoparticles

SUNAYANA: I'm Dr Sunayana Bhargava, a scientist and poet.

TULELA: And I'm Tulela Pea, a science communicator and podcaster.

SUNAYANA: And this is Bitesize Chemistry.

TULELA: This is the final episode in an eight-part series on bonding, structure and properties.

SUNAYANA: We're going to be shrinking down to look at some cutting edge science on a really tiny scale. We'll be looking at the wonderful and maybe not so wonderful world of nano particles.

TULELA: What they are, how and where we can use them as well as areas of concern over their use.

SUNAYANA: As always, it might be handy to write some notes or diagrams along the way.

For most exam boards nanoparticles is only for those doing GCSE chemistry single science so check with your teacher. However, even if this doesn't apply to you, relax , sit back and enjoy the tiny world of nano particles with us.

TULELA: Before we get down to the nano level, let's get some low-down on these nanoparticles with our AI chatbot… NNICK. Can you give us a summary of nano-particles?

NNICK: Nanoparticles are between 1 and 100 nanometres in size, which is of the order of a few hundred atoms. Although small, nanoparticles have a high surface area to volume ratio and so may be effective in smaller quantities than materials with larger particle sizes. They also have very big egos because of how useful they are in medicine, electronics, cosmetics and GCSE chemistry.

In conclusion:

SONG

Has anybody seen my nanoparticle?
It's very very very very small
It's smaller than the wavelength of visible light
So optically it can't be seen at all

Has anybody seen my nanoparticle?
A hundred nanometres or below

Has anybody seen my nanoparticle?
The answer is of course not, no.

SUNAYANA: Thanks NNICK! So, a couple of definitions to start with. A nanometre is one one-billionth of a metre. Or 10 to the minus 9 of a metre. And particles on the scale of one to one hundred nanometres are called nanoparticles.

TULELA: Nanoparticles are larger than atoms and molecules which are around 0.1 nanometres,

SUNAYANA: So a nanoparticle might contain only a few hundred atoms.

TULELA: If we were the size of a nanoparticle then the thickness of one sheet of paper, around 100 thousand nanometres would look like a mountain!

SUNAYANA: So I think we get the idea that nanoparticles are really really really tiny! So why do we care about them Tulela since they are so small?

TULELA: The properties of nanoparticles are different to the ones the same material would have if it was in bulk. And this is because nanoparticles are so small that they have a much higher surface area to volume ratio compared to the same material made of much larger particles. That means that the surface area of a nanoparticle is large compared to the space it takes up.

SUNAYANA: So as the size of the particle decreases, the size of the surface area increases in relation to the volume.

TULELA: A good way to think about this is that cup of tea you have there, Sunayana.

SUNAYANA: Still nice and warm. But could do with some sugar to sweeten it.

TULELA: So let's give you one cube-shaped sugar lump.

SUNAYANA: Thanks. Takes a bit of time to dissolve and make the tea nice and sweet.

TULELA: But how about if we split the sugar lump into mini-cubes, and then split those into even smaller cubes and then split those….

SUNAYANA: Might be easier to get a spoonful from the sugar bowl Tulela…

TULELA: probably right – and in this case all the grains of sugar put together have a higher surface area to volume ratio than the large single sugar cube.

SUNAYANA: Wow that's dissolved much faster.

TULELA: Correct – that's because that higher surface area to volume ratio of the smaller grains means that a greater proportion of the sugar can interact faster to sweeten the tea.

SUNAYANA: Because as we decrease the lengths of each side of a sugar cube by a factor of 10, the surface area to volume ratio increases by a factor of 10. And that means the tea is in contact with more of the sugar in a shorter time.

TULELA: Correct. In the same way, the higher surface area to volume ratio of nanoparticles means that more of the atoms are available to interact with any other substances they come into contact with and so they have different properties to a larger bulk of the same substance.

SUNAYANA: And one of the amazing things about the fact that they have different properties to the same material in bulk is that this means less of it is needed when it is in nanoparticle form to get the same effect as with it in bulk.

TULELA: In one of the previous episodes we looked at the different structures of carbon…

SUNAYANA: Allotropes of carbon

TULELA: And saw that one such allotrope are a group of nanoparticles called fullerenes.

SUNAYANA: And my favourite – buckminsterfullerene!

TULELA: These have some really useful properties to make materials that are much lighter and stronger than previously possible and shows demonstrates the exciting recent advancement in the science of nanoparticles.

SUNAYANA: In nano-medicine for example nanoparticles are absorbed more easily than most larger particles to deliver drugs targeted to the right cells or wherever needed.

TULELA: In cosmetics, we have new sunscreens made from nanoparticles which have the advantage that they don't leave that annoying streaky white mark on your skin. And other nanoparticles are used in deodorants.

SUNAYANA: Nanoparticles also make really good catalysts because of that high surface area to volume ratio. The larger the surface area, the more atoms available to interact and so the faster the rate of reaction.

TULELA: Nanoparticles has lots of wide applications in research and again shows that studying chemistry is not just about learning the periodic table but about how we can advance and improve our world today and into the future.

SUNAYANA: Absolutely. But as with all new technology we should also be aware of some of the areas of concern, especially as the nano world is a pretty recent area of study.

TULELA: Sure – we need to know more about the way that these particles affect the human body, whether for example they disperse easily or clump together once inside a cell – and this is why lots and lots of research and testing is being done in nanoscience.

SUNAYANA: As with all science, the more we make predictions from our observations, conduct experiments and learn from those results, the more we enhance our knowledge and improve the world we live in.

TULELA: That's a nice way to end, Sunayana!

SUNAYANA: not before a quick nano-quiz Tulela.

TULELA: Go for it.

SUNAYANA: Three questions, five seconds to answer – unless you hit the pause button. Write your answers down.

TULELA: Question 1 – what is size of a nanoparticle?

SUNAYANA: Answer – around 1 to 100 nanometers.

TULELA: Question 2 – why do nanoparticles have different and more useful properties to the same material in bulk?

SUNAYANA: It's because of the higher surface areas to volume ratio – remember how that sugar lump compares to the many grains.

TULELA: And question 3 – if we reduce the length of the sides of a cube by a factor of ten, do we increase or decrease the surface area to volume ratio? And by how much?

SUNAYANA: We increase it by a factor of ten – and remember that in nanoparticles this means there are more atoms available to interact.

TULELA: Thanks for listening to this episode and this series. Remember you can revise this and many other topics by heading over to the Bitesize website.

SUNAYANA: Or by listening on BBC Sounds to the other episodes in this and other series of this podcast.

TULELA: In the next series we'll be looking at chemical changes, from acids and alkalis to reactions with oxygen and electrolysis.

SUNAYANA: Sounds exciting – better boil that kettle again for a really fresh cup of tea. Maybe not so sweet this time…

TULELA: Say bye Sunayana.

SUNAYANA: Bye Sunayana!

TOGETHER: Bye.