Teacher's Preparatory Guide

The Surface Area-to-Volume Ratio of Nanoparticles: Part II

Purpose This inquiry-based lab should be used immediately after doing the *Surface Area-to-Volume Ratio of Nanoparticles* lab, using the same clay sample as before.

Level High school

Time required One 50-minute class periods or one 90-minute block day

Safety Information None

Advance Preparation To assist students with calculating their design, print and distribute surface area and volume formulas from the link below (non-calculus): http://www.math.com/tables/geometry/index.htm Alternatively, if the student has had calculus, you can use formulas from this link: http://mathworld.wolfram.com/SurfaceArea.html

Materials (the same as in part I of this lab)

- 8.5 inch × 11 inch sheet of waxed paper
- modeling clay, the size of a walnut
- metric ruler
- calipers, with metric markings
- pencil
- calculator

National Science Content Standards Addressed

Content Standard A

- Abilities necessary to do scientific inquiry

Content Standard B

- Structure and properties of matter
- Chemical reactions

Teaching Strategies This activity works well in groups of 2–3 students. Read the articles below to help engage students in *why* this topic is so important today. Students should have their answers to the Part I version of this lab for reference.

Background information Follow the link below for an easy-to-read article about how surface-to-volume ratio and nanoparticle catalysts may help fuel automobiles. http://www.memagazine.org/nanoapr05/spheres/spheres.html
This link is a short, sweet article explaning the introduction in the student worksheet: http://www.guardian.co.uk/uk_news/story/0,3604,1291039,00.html

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Enhancing Understanding Cover this section with students *after* they have completed their design. Challenge the student's understanding by asking: What would happen to the volume of the modeling clay if you made a million spheres all of the same diameter? *The volume will remain the same because you would still have the same amount of clay.* What would happen to the surface area of the clay if you made two identical spheres? *The surface area of the clay would decrease.* Remind students that *catalysts* accelerate a chemical reaction without interfering with the finished product by helping the reactants to meet much more quickly.

Nanotechnology can enhance the understanding of the mechanisms involved in catalysis but its application helps to improve strategic and invaluable industrial processes, necessary to maintain our standard of living. Catalysts are playing an important role in the petroleum industry, as well in the development of hydrogen from organic matter such as corn stalks and sugar cane pulp.

Nanoscience involves the study and development of materials and structures within the range of 1 nanometer (10^{-9} m) to 100 nanometers (10^{-7} m). At these dimensions the properties of materials are unique and different providing potential development different than those which are seen at the micro scale or larger. At the nanoscale the materials being observed or handled are so small that special instruments had to be developed to make the studies. Special electron microscopes, such as the Scanning Tunneling microscope (STM) and the Atomic Force microscope (AFM) are two of the type of instruments which have lead to the study of nanoscale materials and particcles. With such instruments research scientists have been able to determine the shape of the nanoparticles and their surface area, allowing for research to continue in the development of catalysts, with a more desireable surface to volume ratio, to accelerate the reaction rate.

Going further: Research Project & Presentation Have students write a 1-page paper and make a 5-minute presentation to the class on one of the following topics:

- other uses for nanoparticle catalysts
- tools used to see nanoparticles and how they work
- pick a nanoparticle shape (nanorod, for example) and list advantages/disadvantages of each

After the presentation, engage the students in a discussion of nanoparticles. Here are some possible questions to guide the discussion. For example you might ask: When might an industry want to use spherical (ball-shaped) nanoparticles? *A ball has some significant advantages because they are normally easier to make and to control the size and the ball is usually stronger and more abrasion resistant.*

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The Surface Area-to-Volume Ratio of Nanoparticles: Part II

Student Worksheet with Answer Key

May 1, 2007

Dear Team:

Thank you for your recommendation on what shape might work best for our nanoparticle catalyst. Trouble is, the nickel isn't reacting as much as we would like.

Please design a prototype for a new shape of particle that would get the greatest surface area-to-volume ratio. Show us, through calculations, why your shape is better than the ones we gave you.

Just so you know, you are in competition with other teams working on the same project. The best design will get a percentage from our profits!

Sincerely,

John Turner, CEO
Hydrogen Fuel, Inc.

Question Which shape would be the most reactive?

Make a Prediction *Example prediction: I think that a tortilla rolled into a cylinder would be more reactive, because it will have a larger surface area-to-volume ratio.*

Procedure

Using the same clay as you used in Part I of this lab, your team's goals are:

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Materials

- waxed paper sheet
- modeling clay, the size of a walnut
- metric ruler
- calipers, with metric markings
- pencil
- calculator

1. Design a new shape with the clay that would be even more reactive than your recommendation in Part I.

Data

2. Draw your shape on the back of this page.
3. Measure any factors (radius, height, width, etc.) that would contribute to surface area and record your measurements (make your own data table) on the back of this page.
4. Label all parts of your drawing that you measured.

Analysis

5. Calculate the surface area of your shape.
6. Calculate the volume of your shape.
7. Calculate the surface area-to-volume ratio of your shape .
8. Be sure to show all of the formulas you used and the calculations you made.

Example answer: a rolled-up tortilla (a hollow cylinder)

Shape	Diameter (cm)	Length (cm)	Width (cm)	Height (cm)
Tortilla	*14.7*			*0.2*

Shape	Surface area (cm^2)	Volume (cm^3)	Ratio $\frac{\text{Surface Area}}{\text{Volume}}$
Tortilla	*348.47 cm^2*	*33.49 cm^3*	*10.40*

Conclusion

9. Explain why your shape is more reactive than the shapes in Part I.

Students should demonstrate through their calculations that their surface area-to-volume ratio is higher than those in Part I of this lab.