NANOWARE Educators Guide

MODULE 6: APPLICATIONS OF NANOTECHNOLOGY

DELIVERABLE: R1/T1.3

NANOWARE

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HESO

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Contents

1. Introduction Part

Grade Level: 9-12

Subject Area: Applications of Nanotechnology

Time required: 120 minutes (3 lessons in total - 2 lessons for theory and video watching, 1 lesson for desktop research activity, each lesson is 40 minutes)

Learning Objectives (LO): Students will be able to:

- Understand how nanotechnology is applied in Electronics Engineering (LO1)
- Understand how nanotechnology is applied in Environmental Science (LO2)
- Understand how nanotechnology is applied in Medicine (LO3)
- Understand how nanotechnology is applied in Consumer Products (LO4)
- Understand the benefits of manipulating matter in the nanoscale for the advancement of various fields (LO5).

Summary: NANOWARE has developed an information package for teachers that includes background information and the documents about applications of nanotechnology. This information package is referred to as the NANOWARE Educators Guide. Below is an overview of its content.

2. Lesson Background Information

Nanoparticles and nanomaterials have unique physical, chemical, and electronic properties, depending on the number and kind of atoms that compose their structure. These properties allow them to have vast potential for applications in various fields; manipulating matter at the nanoscale can produce a new class of atomically engineered materials, thus revolutionizing research, and applications (Poole & Owens, 2003).

Nanotechnology in Electronics Engineering

In electronic engineering, nanotechnology is used to create improved systems and devices with more functions, higher performance results, etc. Precision engineering and the wider micro-electronics industry can now benefit from nanostructures' unique properties and develop faster and portable systems and devices that manage, process and store larger amounts of data while consuming lower quantities of power (Bayda et al., 2019). This is feasible thanks to nanomanufacturing.

Nanotechnology in Environmental Science

Researchers and scientists are experimenting with various nanotechnology applications for environmental purposes and energy-saving solutions. With efficiency and affordability in mind, high technology at the nanoscale is used to create new structures and devices that consume less energy, are lighter, produce less or zero emissions, are easy to install, and so on.

Nanotechnology is especially popular in the research and experimentation for alternative energy source applications. For example, scientists are testing the potential of printable solar panels as a more efficient alternative that will also be easier to install and cheaper (NGS, 2022).

In water quality research, nanomaterials are used to reduce toxicity by eliminating toxic metals and organic molecules like dangerous chemicals, virus cells, etc. An example of this approach is the use of bacteriophages as "nanoengineering tools" to monitor the quality of water and wastewater and detect pathogens (Bayat et al., 2020).

Similarly, magnetic nanomaterials are used to remove oil spill pollution particles (Singh et al., 2020).

Nanotechnology in Medicine

Researching and manipulating matter at the nanometer scale has given scientists and researchers a better understanding of molecular behaviour and function, as well as the origin of disruptions like diseases. Subsequently, the following are some subject areas where nanotechnology can be applied in medicine: Drug design and targeting,

- Analytical and instrumental applications, including tissue engineering and imaging,
- improvement 8of procedures, disease treatments and drug delivery, medical devices, medical tools,
- Diagnosis (including molecular imaging) and therapy/drug delivery of various diseases,
- Drug delivery and regenerative medicine,
- Nanopharmaceuticals,
- Nanobiotechnology,
- Nano-oncology,
- DNA nanotechnology.

Nanotechnology in Consumer Products

At the nanoscale, matter behaves very differently than at other scales: the physical and chemical properties of nanoparticles are significantly different than the properties of materials at larger scales. Depending on the shape, size, surface characteristics and inner structure, nanoparticles can change properties when met with certain chemicals and can have attractive or repulsive interactions between them that will either group or separate them (EC, 2006).

Many consumer products already contain nanoparticles. Nanotechnology seeks to improve their properties and resilience, thus making them indispensable to consumers.

Examples of nanotechnology in consumer products are:

- Clothing,
- Surface protection materials,
- Car safety,
- Cosmetics,
- Sports materials,
- Food safety and Packaging,
- Food enhancers.

Best Practices of Applications of Nanotechnology

Below are some of the best practices for nanotechnology applications:

- The “smart bandage” detects and can prevent infections,
- The “double-core tennis ball”, the inner core of which is coated with clay nanoparticles. Acting as a sealant, this makes it far more difficult for air to escape and the ball retains its pressure and bounces for twice as long as ordinary balls.
- A hydrophobic and oleophobic coating technique for products using nanotechnology. Due to the high contact angle, the coating provides easy-to-clean properties, extreme abrasion resistance and durability towards stains and markers among others. Some application areas of this coating are plastic covers, protection films, advertising panels, in-car infotainment etc.

Sources:

- Bayat, F., Didar, T. F., & Hosseinidoust, Z. (2020, December 8). Emerging investigator series: Bacteriophages as Nano Engineering tools for quality monitoring and pathogen detection in water and wastewater. Environmental Science: Nano. Retrieved October 10, 2022, from https://pubs.rsc.org/en/content/articlelanding/2021/en/d0en00962h/unauth
- Bayda, S., Adeel, M., Tuccinardi, T., Cordani, M., & Rizzolio, F. (2019, December 27). The history of nanoscience and nanotechnology: From chemical-physical applications to nanomedicine. Molecules (Basel, Switzerland). Retrieved October 5, 2022, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6982820/#B16-molecules-25-00112
- EC. (2006). Nanotechnologies. Public Health. Retrieved October 10, 2022, from https://ec.europa.eu/health/scientific_committees/opinions_layman/en/nanotechnologies/index.htm#il1
- Jain, K. K. (2017). Nanopharmaceuticals. SpringerLink. Retrieved October 10, 2022, from https://link.springer.com/chapter/10.1007/978-1-4939-6966-1_5
- Marr, B. (2022, October 12). 7 amazing everyday examples of nanotechnology in action. Forbes. Retrieved October 12, 2022, from https://www.forbes.com/sites/bernardmarr/2020/07/03/7-amazing-everyday-examples-of-nanotechnology-in-action/?sh=1561e0843e82
- Oakes, K. (2020, September 24). Nanotechnology: How it's used in food and packaging. FoodUnfolded. Retrieved October 10, 2022, from https://www.foodunfolded.com/article/nanotechnology-how-its-used-in-food-and-packaging

- Otto, D. P., & de Villiers, M. M. (2013). Why is the nanoscale special (or not)? fundamental properties and how it relates to the design of Nano-Enabled Drug Delivery Systems. Nanotechnology Reviews, 2(2), 171–199. https://doi.org/10.1515/ntrev-2012-0051
- Paramasivam, G., Palem, V. V., Sundaram, T., Sundaram, V., Kishore, S. C., & Bellucci, S. (2021). Nanomaterials: Synthesis and applications in Theranostics. Nanomaterials, 11(12), 3228. https://doi.org/10.3390/nano11123228
- Poole, C. P., & Owens, F. J. (2003). Introduction to nanotechnology. Wiley-InterScience.
- Seeman, N. C., & Sleiman, H. F. (2017). DNA nanotechnology. Nature Reviews Materials, 3(1). https://doi.org/10.1038/natrevmats.2017.68
- Singh, H., Bhardwaj, N., Arya, S. K., & Khatri, M. (2020). Environmental impacts of oil spills and their remediation by magnetic nanomaterials. Environmental Nanotechnology, Monitoring & Management, 14, 100305. https://doi.org/10.1016/j.enmm.2020.100305

Materials:

- Computer and Internet Access
- YouTube access

3. Suggested Teaching Strategies

The teacher can perform the following activities.

Activity 1: "What Exactly is Nanotechnology" Video

In Activity 1, "What Exactly is Nanotechnology" video, students will watch a video explaining why nanotechnology is part of our daily lives.

Activity 1 Name	**"What Exactly is Nanotechnology" video**	**Tool**
Short Description	Show students a video introducing nanotechnology to get their attention. Pause the video frequently to spark conversation.	https://www.youtube.com/watch?v=Mr7IEvlflnI
Objectives	The students will eventually realize that nanotechnology has far-reaching applications in various fields including food, health/medicine, energy, agriculture, electronics, and the environment.	
Keywords	Nanotechnology, Nanotechnology Applications	
Ages	14-17	

Activity 2: "How Nanotechnology Can Change Your Life" Video

In Activity 2, "How Nanotechnology Can Change Your Life" video, students will watch a video that will refresh their newly acquired knowledge about the basics of nanotechnology as well as show them numerous of its applications in modern life and science through relatable examples.

Activity 2 Name	"How Nanotechnology Can Change Your Life" video	Tool
Short Description	Show the video to students: Pause the video in each slide for "potential uses of graphene" (5:44' to 7:41') to discuss the wide variety of nanotechnology applications.	https://www.youtube.com/watch?v=IGjCOJqINPA
Objectives	To increase students' knowledge of the basics of nanotechnology as well as show them numerous of its applications in modern life and science.	
Keywords	Nanotechnology, Nanotechnology Applications	
Ages	14-17	

Activity 3: Find nanotechnology applications on the Web!

In Activity 3, “Find nanotechnology applications on the Web!”, students will perform desktop research to find nanotechnology applications and case studies or companies that use nanotechnology for their products.

Activity Name	Light and Electron Microscope	Tool
Short Description	Students will be divided into groups of 4 or 5 (depending on the classroom’s total number). They will be asked to find nanotechnology applications/case studies in the following fields: -Electronic Engineering (guide them towards nano-sized electronic devices, like microchips) -Environmental Science (guide them towards alternative energy sources and/or pollution) -Medicine (guide them towards therapy/drug delivery methods) -Consumer Products (discover nanomaterials’ properties and existing solutions for better clothing manufacturing, car safety, athletics, etc.) Discuss students’ findings and use, if necessary, the following case studies: 1.‘Smart bandage’ 2. Wilson’s ‘double-core’ tennis ball 3. Hydrophobic coating	https://www.uri.edu/news/2021/01/smart-bandage-detects-could-prevent-infections/ https://www.wilson.com/en-us/tennis https://kriya-materials.com https://www.bridgestone.com/technology_innovation/nanopro-tech/

	4. Bridgerstone's NanoPro-Tech for car tires	
Objectives	Students will learn to find nanotechnology applications/case studies in the fields of electronic engineering, environmental science, medicine, and consumer products.	
Keywords	Nanotechnology, nanotechnology in electronic engineering, nanotechnology in environmental science, nanotechnology in medicine, nanotechnology in consumer products	
Ages	14-17	

Pre-requisite Knowledge:

Students should have understood what nanotechnology is and how it is applied to simple everyday objects.

4. Assessment

Assessment: (Rubric for Assessment of Applications of Nanotechnology)

Learning Objectives	Exceptional 4	Satisfactory 3	Developing 2	Unsatisfactory 1	Total
Understand how nanotechnology is applied in Electronics Engineering (LO1).	Can clearly explain LO1.	Provides an explanation of LO1.	Provides some explanation but with details missing.	Does not explain LO1.	
Understand how nanotechnology is applied in Environmental Science (LO2).	Can clearly explain LO2.	Provides some explanation of LO2.	Provides less of an explanation but with details missing.	Does not explain LO2.	
Understand how nanotechnology is applied in Medicine (LO3).	Can clearly explain LO3.	Provides some explanation of LO3.	Provides less of an explanation but with details missing.	Does not explain LO3.	
Understand how nanotechnology is applied in Consumer Products (LO4).	Can clearly explain LO4.	Provides some explanation of LO4.	Provides less of an explanation but with details missing.	Does not explain LO4.	
Understand the benefits of manipulating matter in the nanoscale for the advancement of various fields (LO5).	Can clearly explain LO5.	Provides some explanation of LO5.	Provides less of an explanation but with details missing.	Does not explain LO5.	