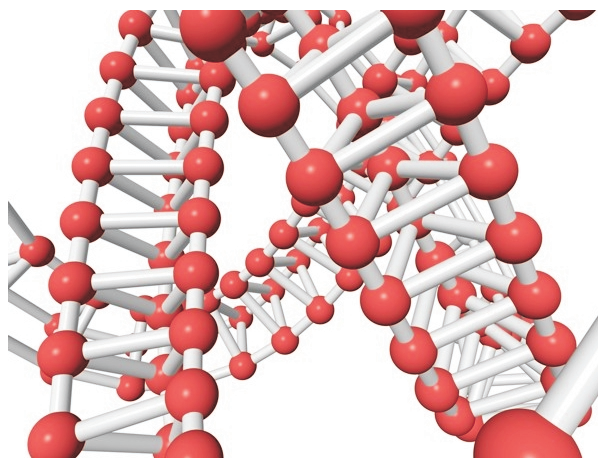


Applications and Uses of Nanotechnology

NANOTECHNOLOGY is rapidly developing and changing the way we manufacture and perceive materials and products. This technology allows us to reorganize particles on a molecular level. It gives us the ability to change and alter material characteristics. Particles can be designed to react in certain ways in the presence of other particles or materials. This technology can also allow us to design molecular structures that perform tasks, such as filtering and catalyzing.



Objective:



Describe applications and uses of nanotechnology.

Key Terms:



bioprocess

catalysts

magnetoresistance

nanomedicine

nanoparticles

nanotubes

tissue engineering

Nanotechnology Applications

MEDICINE

Nanomedicine is the hybrid field of medicine and nanotechnology. **Nanoparticles** are customized particles created on the molecular level. They can be designed to directly deliver drugs to specific diseased cells. This can be particularly helpful for cancer patients.

Drug delivery systems of nanotechnology can improve the pharmacological and therapeutic properties of the individual drug. The nanoparticle can be developed to penetrate through the cell's membrane to more efficiently deliver medication or therapy.

Nanoparticles have been used as contrasting agents to improve MRI and ultrasound. They can be designed to attach themselves to certain cells or infected cells and deliver a higher intensity when scanned with the device. Through the same processes as contrasting agents, they can be developed to alter their appearance when in contact with different agents in the body, resulting in improved diagnostics. Another medical application is **tissue engineering**, which is the process of growing cells artificially. Nanotechnology has the ability to repair or replace damaged tissue.

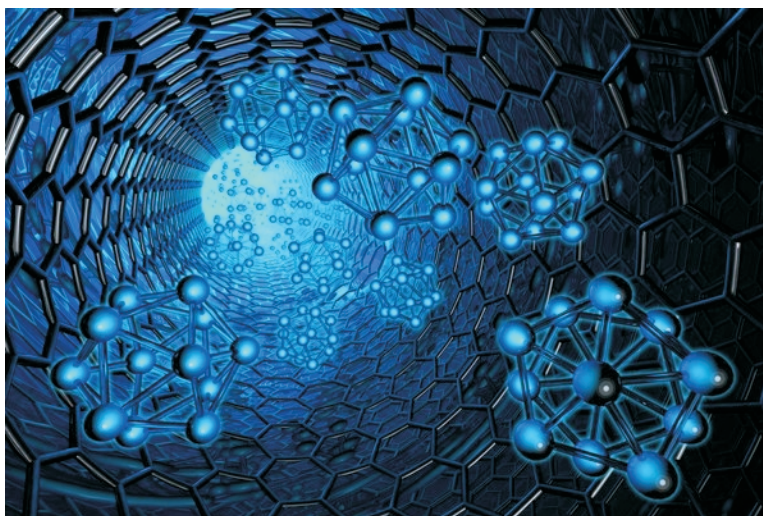


FIGURE 1. Nanotechnology can construct particles on the molecular level that have specific shapes. These shapes can be used for specific functions as seen here where only certain sized smaller molecules are allowed to pass through.

CHEMICAL SENSORS

Nanotechnology is able to create chemical sensors that can detect microscopic amounts of chemicals, even in air vapors. This technology uses nanotubes, nanowires, and nanoparticles that have been developed to change their properties in the presence of specified chemicals. **Nanotubes** are customized particles created on the molecular level in the form of tubes. Their application can have a broad range of usefulness, from searching and warning of dangerous chemicals to adjusting chemical mixtures and processing.

FOOD

Nanotechnology can impact how we eat and how food is grown. This includes smart packaging. Nanomaterials and composites can act as biosensors, monitoring bacteria content in food. These technologies will make a difference in food safety, its taste, and health benefits.

The efficient manufacturing of high-quality food through sustainable means can be enhanced in the bioprocessing industry with nanotechnology. **Bioprocess** is a technique that produces genetically engineered biological materials or matter. This can include the process of manufacturing items such as food, fuel, feed, and pharmaceuticals.

CLEAN WATER

Nanotechnology is currently being used and studied in several ways to improve water quality. One example is the removal of waste contaminants in ground water through a chemical reaction. In this case, chemicals (e.g., those from cleaning solvents) can be rendered harmless



FURTHER EXPLORATION...

ONLINE CONNECTION: Nanotechnology

Nanotechnology will dramatically change how we design and use materials. This technology may be difficult to understand, especially how it works and its applications. To learn more about what nanotechnology is and how it works, including some of its current applications, visit the following Web site:

http://www.youtube.com/watch?v=4_AFzKlAXsg&feature=related

as they react with nanoparticles. This also can be done at the underground source, thereby saving time and money by not having to pump out the water to clean it.

Another process for cleaning water is with membranes created with nanotubes. These nanoporous membranes are created with very specific hole sizes in the tubes that allow only H₂O (water) to pass through.

Nanoparticles can also be magnetized. This allows them to attach to heavy metals in water, increasing their ability to be absorbed. Magnetic separation processes can be used to remove the particles.

AIR QUALITY

Nanoparticles are being developed in such a way that they have very high surface-to-area ratios. This can be useful in increasing the effectiveness of catalysts. **Catalysts** are processes that use chemical substances to increase or decrease changes in chemical reactions. The larger surface area from the nanoparticles increases the reaction amount and time. They can be used to transform harmful exhaust from automobiles and industrial plants.

ELECTRONICS

Our ability to create smaller and more efficient devices has improved all elements of electronics. Nanotechnology is increasing this ability. Electronics rely on resistors and transistors. The ability to work at a nanoscale in their creation allows for more information and control on a molecular level.

One field is ultra high-density memory in which a carbon nanotube can be used as a switch to reconfigure connections in storing electrons. This can replace how transistors were previously used. By controlling the magnetoresistance of a material at this scale, there can

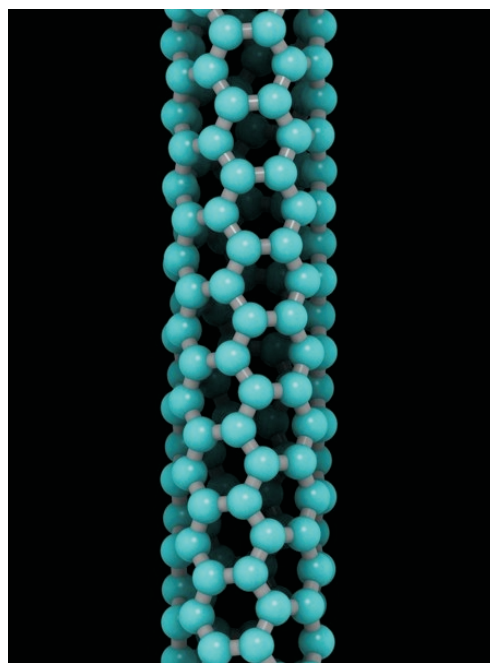


FIGURE 2. The nanotubes, as seen here, have great potential for their function and use in a wide range of applications from cleaning water to electronics.

be a significant increase in the density of data storage on hard disk. **Magnetoresistance** is the ability of a material to change its electrical resistance when an external magnetic field is applied. In addition, electrically conductive carbon nanotubes can be used to emit fields of light. Their nano size makes them efficient for displays.

SOLAR CELLS

Some companies have manufactured nanotech solar cells that cost much less than those currently on the market. The solar cells on the market use layers of semiconductors that roughly gather about 40 percent of the sun's energy. Nanotechnology can develop catalysts that utilize a maximum surface-to-area ratio. This greatly improves the efficiency of cells. Scientists have developed a spray-on substance that uses nanoparticles to instantly transform a surface into a solar collector.

BATTERIES

Current market batteries require frequent replacement or recharging. Nanomaterials are being developed that increase the storage capacity of batteries. These batteries have much longer shelf lives and can be recharged quicker and over a longer period of time. They will become super capacitors with much higher energy content and longer operating times. This technology creates batteries that are more recyclable and are safer for the environment, addressing current disposal problems.

FUEL CELLS

Catalysts are used in fuel cells to produce ions from methanol and other fuels. These more efficient catalysts developed from nanotechnology enhance the membranes used to separate hydrogen ions from oxygen. Hydrogen fuel cells are very environmentally friendly and renewable.

Nano structured materials (e.g., carbon metal particles) can store large amounts of hydrogen. This can reduce the use of combustion engines. The very porous nanomaterial can be used as a filter cleaning the exhaust from engines as catalytic converters or used in the fuel as a catalytic mixture.



FIGURE 3. Nanomaterials have a wide range of possible applications, including the advancement of membranes used to separate hydrogen ions from oxygen in fuel cells.

FUELS

With a finite supply of fossil fuels, our need to find new energy sources and more efficient means of using current fuels is increasingly important. Nanotechnology can address these issues on several levels, such as solar and fuels cells, and in designing processes that are much more efficient in their use and production of raw materials. Lower grade materials can be converted into fuel at a cheaper cost with higher yields.

Fuel consumption by engines will also decrease as new nanomaterials are developed that specifically utilize their molecular structure in converting fuel into energy. These materials can be used in engine production as well as in the car's frame, creating stronger and lighter structures that lower consumption.

SPACE

Materials that are stronger and lighter will reduce the amount of rocket fuel necessary to reach orbit. They can be used in the production of alternate ways to produce energy in space, such as solar sails. This technology will provide aircraft with better designed navigation systems that will increase performance.

SPORTING GOODS

Nanotechnology is already being commercially used in sporting goods. This includes harder and lighter metal alloys used in golf clubs and nanomaterial used in the production of golf balls. Tennis racquets now have increased strength. New materials are used to make the shaft more rigid, and nanotechnology has increased the retention of air in tennis balls.



FIGURE 4. Nanomaterials are being used in tennis racquets to make them stronger and lighter.

FABRIC

Nanotechnology has been responsible for a range of composite fabrics and fibers. They have improved the durability and function through designed properties, such as wrinkle-resistant and stain-repellent clothes. Nanothreads can be programmed into “smart” clothing. These clothes can have woven in electronics and communicate whether the clothes require cleaning.

Summary:



Nanoparticles are customized particles created on the molecular level. They can be used in tissue engineering and can be designed to directly deliver medicine to specific diseased cells. Nanotechnology is able to create chemical sensors that can detect microscopic amounts of chemicals.

This technology is impacting how we eat and how food is grown, including the enhancement of bioprocesses. It is currently being used and studied in several ways to improve air and water quality, creating filters and catalysts. It is increasing our ability to develop smaller and more efficient devices that will improve elements of electronics today and in the future.

Companies have manufactured nanotech solar cells that cost much less than those currently on the market. Nanomaterials are being used to increase a battery's storage capacity. Nanomaterials can be designed to increase material strength with a decrease in weight, which is very beneficial for the aerospace and sporting goods industries. The fabrics and fiber industry already has clothes on the market that utilize nanotechnology in creating stain- and wrinkle-resistant cloths.

Checking Your Knowledge:



1. What is the term used for customized particles created on the molecular level?
2. What is the process of growing cells artificially?
3. What are nanotubes?
4. What is the term for the technique that produces genetically engineered biological materials or matter?
5. Name one field in electronics that is using nanotechnology.

Expanding Your Knowledge:



Many books have been published recently on nanotechnology. They range from the basics of what it is and its uses to the complex ways molecular alteration is performed. Take a trip to your local library and check out several books on areas of nanotechnology that may be of interest to you. Create a PowerPoint presentation of your findings, and share it with your class.

Web Links:



Applications of Nanotechnology

http://www.discovernano.northwestern.edu/affect/applications_content

Nanotechnology

<http://www.iscid.org/encyclopedia/Nanotechnology>

Applications of Nanotechnology in Textiles

<http://www.educationmaster.org/news/application-nanotechnology-textiles.html>