Introduction to Nanotechnology

Nanotechnology is defined as the study and use of structures between 1 nanometer and 100 nanometers in size. To give you an idea of how small that is, it would take eight hundred ,100 nanometer particles side by side to match the width of a human hair.

Looking At Nanoparticles

Scientists have been studying and working with nanoparticles for centuries, but the effectiveness of their work has been hampered by their inability to see the structure of nanoparticles. In recent decades the development of microscopes capable of displaying particles as small as atoms has allowed scientists to see what they are working with.

Now that you have an idea of how small a scale nanotechnologists work with, consider the challenge they face. Think about how difficult it is for many of us to insert thread through the eye of a needle. Such an image helps you imagine the problem scientists have working with nanoparticles that can be as much as one millionth the size of the thread. Only through the use of powerful microscopes can they hope to 'see' and manipulate these nano-sized particles.

Nanotechnology Applications

The ability to see nano-sized materials has opened up a world of possibilities in a variety of industries and scientific endeavors. Because nanotechnology is essentially a set of techniques that allow manipulation of properties at a very small scale, it can have many applications, such as:

1- Nanotechnology in Medicine (Nanomedicine)

Nanomedicine is the medical use of molecular-sized particles to deliver drugs, heat, light or other substances to specific cells in the human body. Engineering particles to be used in this way allows detection and/or treatment of diseases or injuries within the targeted cells, thereby minimizing the damage to healthy cells in the body.

Drug delivery. Today, most harmful side effects of treatments such as chemotherapy are a result of drug delivery methods that don't pinpoint their intended target cells accurately. **Researchers at Harvard and MIT** have been able to attach special RNA strands, measuring about 10 nm in diameter, to nanoparticles and fill the nanoparticles with a chemotherapy drug. These RNA strands are attracted to cancer cells. When the nanoparticle encounters a cancer cell it adheres to it and releases the drug into the cancer cell. This directed method of drug delivery has great potential for treating cancer patients while producing less side harmful affects than those produced by conventional chemotherapy.

2-Fabric and Nanotechnology

Making composite fabric with nano-sized particles or fibers allows improvement of fabric properties without a significant increase in weight, thickness, or stiffness as might have been the case with previously-used techniques.

Fabrics. The properties of familiar materials are being changed by manufacturers who are adding nano-sized components to conventional materials to improve performance. For example, some clothing manufacturers are making water and stain repellent clothing using **nano-sized whiskers** in the fabric that cause water to bead up on the surface.

Silver **nanoparticles** in fabric that kills bacteria making clothing odor- resistant.

Nanopores providing superior insulation for shoe inserts in cold weather

Clothing protective against hazardous chemicals using an **honeycomb of polyurethane nanofibers**

3-Air Pollution and Nanotechnology

There are two major ways in which nanotechnology is being used to reduce air pollution: catalysts, which are currently in use and constantly being improved upon; and nano-structured membranes, which are under development.

Catalysts can be used to enable a chemical reaction (which changes one type of molecule to another) at lower temperatures or make the reaction more effective. Nanotechnology can improve the performance and cost of catalysts used to transform vapors escaping from cars or industrial plants into harmless gasses. That's because catalysts made from nanoparticles have a greater surface area to interact with the reacting chemicals than catalysts made from larger particles. The larger surface area allows more chemicals to interact with the catalyst simultaneously, which makes the catalyst more effective.

Nanostructured membranes, on the other hand, are being developed to separate carbon dioxide from industrial plant exhaust streams. The plan is to create a method that can be implemented in any power plant without expensive retrofitting.

Reactivity of Materials. The properties of many conventional materials change when formed as nano-sized particles (nanoparticles). This is generally because nanoparticles have a greater surface area per weight than larger particles; they are therefore more reactive to some other molecules. For example studies have show that **nanoparticles of iron can be effective in the cleanup of chemicals in groundwater** because they react more efficiently to those chemicals than larger iron particles.

4-Nanotechnology and Water Pollution

Nanotechnology is being used to develop solutions to three very different problems in water quality.

One challenge is the removal of industrial wastes, such as a cleaning solvent called TCE, from groundwater. Nanoparticles can be used to convert the contaminating chemical through a chemical reaction to make it harmless. Studies have shown that this method can be used successfully to reach contaminates dispersed in underground ponds and at much lower cost than methods which require pumping the water out of the ground for treatment.

The challenge is the removal of salt or metals from water. A deionization method using electrodes composed of nano-sized fibers shows promise for reducing the cost and energy requirements of turning salt water into drinking water.

The third problem concerns the fact that standard filters do not work on virus cells. A filter only a few nanometers in diameter is currently being developed that should be capable of removing virus cells from water.

5-How can nanotechnology improve sporting goods?

If you're a tennis or golf fan, you'll be glad to hear that even sporting goods has wandered into the nano realm. Current nanotechnology applications in the sports arena include:

- Increasing the strength of tennis racquets by adding nanotubes to the frames which increases control and power when you hit the ball.
- Filling any imperfections in club shaft materials with nanoparticles; this improves the uniformity of the material that makes up the shaft and thereby improving your swing.
- Reducing the rate at which air leaks from tennis balls so they keep their bounce longer.

6-Strength of Materials.

Nano-sized particles of carbon, (for example nanotubes and bucky balls) are extremely strong. Nanotubes and bucky balls are composed of only carbon and their strength comes from special characteristics of the bonds between carbon atoms. One proposed application that illustrates the strength of nanosized particles of carbon is the manufacture of t-shirt weight **bullet proof vests made out of carbon nanotubes**.

7-Nanotechnology in Batteries

Companies are currently developing batteries using nanomaterials. One such battery will be a good as new after sitting on the shelf for decades. Another battery can be recharged significantly faster than conventional batteries.

8-Nanotechnology in Fuels

Nanotechnology can address the shortage of fossil fuels such as diesel and gasoline by making the production of fuels from low grade raw materials economical, increasing the mileage of engines, and making the production of fuels from normal raw materials more efficient.

9-Nanotechnology in Solar Cells

Companies have developed nanotech solar cells that can be manufactured at significantly lower cost than conventional solar cells.

10-Nanotechnology in Fuel Cells

Nanotechnology is being used to reduce the cost of catalysts used in fuel cells to produce hydrogen ions from fuel such as methanol and to improve the efficiency of membranes used in fuel cells to separate hydrogen ions from other gases such as oxygen.

11-How Can Nanotechnology Improve Electronics?

Nanotechnology holds some answers for how we might increase the capabilities of electronics devices while we reduce their weight and power consumption. Some of the areas under development, which you can explore in more detail by following the links provided in the next section, include:

- Improving display screens on electronics devices. This involves reducing power consumption while decreasing the weight and thickness of the screens.
- Increasing the density of memory chips. Researchers are developing a type of memory chip with a projected density of one terabyte of memory per square inch or greater.
- Reducing the size of transistors used in integrated circuits. One researcher believes it may be possible to **"put the power of all of today's present computers in the palm of your hand"**.

12-Nanotechnology and Space

Nanotechnology may hold the key to making space-flight more practical. Advancements in nanomaterials make lightweight solar sails and a cable for the space elevator possible. By significantly reducing the amount of rocket fuel required, these advances could lower the cost of reaching orbit and traveling in space. In addition, new materials combined with nanosensors and nanorobots could improve the performance of spaceships, spacesuits, and the equipment used to explore planets and moons, making nanotechnology an important part of the 'final frontier.'

13-How is Nanotechnology being used in Food Science?

Nanotechnology is having an impact on several aspects of food science, from how food is grown to how it is packaged. Companies are developing nanomaterials that will make a difference not only in the taste of food, but also in food safety, and the health benefits that food delivers.

Clay nanocomposites are being used to provide an impermeable barrier to gasses such as oxygen or carbon dioxide in lightweight bottles, cartons and packaging films

Storage bins are being produced with **silver nanoparticles** embedded in the plastic. The silver nanoparticles kill bacteria from any material that was previously stored in the bins, minimizing health risks from harmful bacteria.

Nanoparticles are being developed that will deliver vitamins or other nutrients in food and beverages without affecting the taste or appearance. These nanoparticles actually encapsulate the nutrients and carry them through the stomach into the bloodstream.

Researchers are using **silicate nanoparticles to provide a barrier** to gasses (for example oxygen), or moisture in a plastic film used for packaging. This could reduce the possibly of food spoiling or drying out.

Zinc oxide nanoparticles can be incorporated into plastic packaging to block UV rays and provide anti bacterial protection, while improving the strength and stability of the plastic film.

It is possible to use nanosensors in plastic packaging to detect gases given off by food when it spoils. The **packaging itself changes color to** alert you.

14-Micro/Nano ElectroMechanical Systems.

The ability to create gears, mirrors, sensor elements, as well as electronic circuitry in silicon surfaces allows the manufacture of miniature sensors such as those used to **activate the airbags in your car**. This technique is called MEMS (Micro-ElectroMechanical Systems). The MEMS technique results in close integration of the mechanical mechanism with the

necessary electronic circuit on a single silicon chip, similar to the method used to produce computer chips. Using MEMS to produce a device reduces both the cost and size of the product, compared to similar devices made with conventional methods. MEMS is a stepping stone to NEMS or Nano-ElectroMechanical Systems. NEMS products are being made by a few companies, and will take over as the standard once manufacturers make the investment in the equipment needed to produce nano-sized features.

15-Cleaning and Nanotechnology

Nanotechnology companies are finding ways to make the world a cleaner place by exploring three methods for improving cleaning products. These methods are:

Producing films that can be applied to surfaces such as countertops or windows that make it much easier to keep those surfaces clean.

Using nanoparticles in soap that make it work better while producing less environmentally harmful byproducts.

Using materials in the cleaning process that are antibacterial, such as silver nanoparticles. Note that there is interest in regulating the use of silver nanoparticles because of concern that they may harm useful bacteria in groundwater, such as lakes, when released (see Nanotechnology news story below).

16 - Molecular Manufacturing.

If you're a Star Trek fan, you remember the replicator, a device that could produce anything from a space age guitar to a cup of Earl Grey tea. Your favorite character just programmed the replicator, and whatever he or she wanted appeared. Researchers are working on developing a method called **molecular manufacturing** that may someday make the Star Trek replicator a reality. The gadget these folks envision is called a molecular fabricator; this device would use tiny manipulators to position atoms and molecules to build an object as complex as a desktop computer. Researchers believe that raw materials can be used to reproduce almost any inanimate object using this method.

Reference: http://www.understandingnano.com/introduction.html