NANOTECHNOLOGY FOR MEDICAL AND OTHER APPLICATIONS

From diamonds to buckyballs, carbon comes in a wide variety of shapes, colors and textures. Thanks to its uncanny ability to bind to itself and other elements, it can be found in roughly 10 million compounds. Present throughout our bodies, not to mention virtually every mineral, fossil fuel or foodstuff we consume, it is the basic ingredient of all life.

CARBON

A nanometer is one-billionth of a meter. That's like comparing the size of a marble

to the size of Earth.



Welcome to the world of nanotechnology.

Nanotechnology refers to materials, applications and processes designed to work on extremely tiny scales, usually for things between 1 and 100 nanometers long.

A nanometer is one-billionth of a meter. A sheet of paper is about 100,000 nanometers thick, while a single gold atom is about one-third of a nanometer in diameter.

Many unique properties and uses can be derived from structures built at the nanoscale, giving nanotechnology enormous potential for future²development.²



Units in nanometers (μm) a billionth of a meter !

How small is Nano?

https://www.youtube.com/watch?v=5AAR7bNSM s go to 55 sec



A comparison of a nanotube to the size of a human hair !!

5<u>00n</u>m

POTENTIAL IMPACTS OF NANOTECHNOLOGY

Materials

Stain-resistant clothes

Health Care

 Chemical and biological sensors, drugs and delivery devices

Technology

 Better data storage and computation

Environment

- Clean energy, clean air



Thin layers of gold are used in tiny medical devices

Carbon nanotubes can be used for Hydrogen fuel storage



Possible entry point for nanomedical device

Commercial Products Containing Nanomaterials



cosmetics



toothpaste



supplements



beer bottles



drugs



sunscreen



coatings



wound dressings 3



3/2/2020

Nanomaterials in Consumer Products

The Future is Now



NANOMATERIALS IN CONSUMER PRODUCTS: THE PERSONAL CARE INDUSTRY IS LEADING THE WAY



BIONOVA



It all started with **sunscreens**.

Zinc oxide and <u>titanium</u> <u>dioxide</u> have been used in sunscreens because of their powerful UV blocking properties.

However, the conventional forms, leave a white coating on the skin, which most people find unpleasant.

Here is why the ultra-tiny versions of these ingredients were invented to make the sunscreen transparent.

Ever since then, nanoparticles are being incorporated in other personal care products, such as: deodorants, perfumes, moisturizers, anti-aging creams, toothpastes, soaps, lip balms, and lipsticks, shampoos, etc



Current Reported Uses of Nanotechnology in Cosmetics

- Excellent dispersability
- Alter optical properties
- Deliver water or lipid soluble ingredients
- Protect light or oxygen sensitive ingredients
- Improve stability of chemically unstable ingredients
- Controlled release of ingredients
- Improve skin hydration
- Transparent on skin
- Increase protection against both UVA and UVB rays

The most common types of nanomaterials that are used in personal care products are:

Liposomes (for their enhanced absorption by skin)

Nano-emulsions (for their ability to prolong the shelf life of personal care products)

Nanocapsules (for their controlled release)

Solid lipid nanoparticles (for their enhanced UV blocking)

Nanocrystals (for more effective passage through skin)

Nanosilver and nanogold (for their enhanced antibacterial properties)

Hydrogels (for their prolonged effect on the place of application)

Buckminster fullerene, or buckyballs (for its potential to scavenge free radicals and slow down the aging process).

Cancer treatment

Medical Applications

- Bone treatment
- •Drug delivery
- •Appetite control
- Drug development
- Medical tools
- Diagnostic tests
- •Imaging













https://www.youtube.com/watch?time_continue=3&v=2VcNpl8-PRI&feature=emb_logo







https://www.youtube.com/watch?v=cDUv3hUQ2C8

Candies, sweets and chewing gum have been found to contain the highest levels of titanium dioxide.

Powdered doughnuts, candies and gums with hard shells, products with white icing and even bread, mayonnaise, yogurt and other dairy products may also contain titanium dioxide.

According to research published in Environmental Science and Technology, up to 36 percent of the titanium dioxide found in nearly 90 food products was in the nanoparticle sizes.



Titanium (µgTi / mg food)





DRJOCKERS.com

Titanium Dioxide Levels in Popular Doughnuts

Product	TiO ₂ Listed as Ingredient	Total Ti PPM
Conchitas - Fine Pastry		Not Detected
Dolly Madison - Donut Gems	•	58
Dunkin' Donuts - Powdered Cake Donut	•	19
Entenmann's - Pop'ems Donuts		73
Hostess Brand - Donettes	•	75
Kroger - Sugared Cake Donut Holes	•	43
Little Debbie - Mini Powdered Donuts	•	43
Walmart The Bakery - Powdered Mini Donuts		63
Van de Kamp's - Donuts	•	43
Sunnyside Farms - Mini Powdered Donuts	•	71



Infrormation obtained from MLi, Xiangqian, et al. "Biosynthesis of nanoparticles by microorganisms and their applications." Journal of Nanomaterials 2011 (2011): 8.





Nanohorizons, a company in Pennsylvania, has started producing a silver nanoparticle material as both a dye and use in polyester and nylon.

The silver nanoparticles are toxic to microbes, and so colonies will never form, and clothes using this material will not have odors.





Mines and other enclosed environments could use fiber optic sensors to detect pollutants.

An ultrathin layer of metal (typically a coinage metal) will allow specific pollutants to adhere to the surface, but light could still see through to detect them.

This would allow real-time, onperson environmental monitoring.

NANOMEDICINE

- •It is the medical application of nanotechnology.
- •It`s defined as the repair, construction and control of human biological systems using devices built upon nanotechnology standards.
- The Nanotechnology market was forecast to grow to \$44.5 billion in **2019**



MICROSCOPES



Smartphone Microscopes

A new smartphone app can detect nanoscale particles of norovirus in water



Samples are placed on a

paper chip containing

beads of fluorescent

polystyrene



clumps around the

beads, increasing their

fluorescence



Smartphone microscope analyzes the light emitted to count the virus particles

Nanopatch Vaccines

Patches made from thousands of silicon microneedles could offer more convenient and effective vaccines





Offer similar immune response with a smaller dose of vaccine

Eliminates the need for refrigeration, bulky equipment, and scary needles



MEDICAL USES OF NANO TECHNOLOGY



HEALTH CARE: NERVE TISSUE TALKING TO COMPUTERS

- Neuro-electronic networks interface nerve cells with semiconductors
 - Possible applications in brain research, neuro-computation, prosthetics, and biosensors



Snail neuron grown on a chip that records the neuron's activity

Health Care: Preventing Viruses from Infecting Us

- Nano-coatings over proteins on viruses
 - Could stop viruses from binding to cells
 - Never get another cold or flu?



Gold tethered to the protein shell of a virus



Influenza virus: Note proteins on outside that bind to cells

HEALTH CARE: MAKING REPAIRS TO THE BODY

- Nanorobots are imaginary, but nano-sized delivery systems could...
 - Break apart kidney stones, clear plaque from blood vessels, and ferry drugs to tumor cells





SCHEMATIC ILLUSTRATION OF DIFFERENT ARCHITECTURES OF ENGINEERED NANOMATERIALS.

Micelles are a group of molecules in a solution, such as those formed by detergents.

A **Liposome** is a minute spherical sac of molecules enclosing a water droplet, especially as formed artificially to carry drugs or other substances into the tissues. 3/2/2020

VARIOUS TYPES OF NANO MEDICINES



Cancer is a leading cause of death worldwide.

Currently available therapies are inadequate and spur demand for improved technologies.

Rapid growth in nanotechnology towards the development of nanomedicine products holds great promise to improve therapeutic strategies against cancer.



SOME NANOTECHNOLOGY-BASED DRUGS THAT ARE COMMERCIALLY AVAILABLE OR IN HUMAN CLINICAL TRIALS

Abraxane, approved by the U.S. Food and Drug Administration (FDA) is used to treat breast cancer, non-small-cell lung cancer, and pancreatic cancer.

Doxil was originally approved by the FDA for the use on HIV-related Kaposi's sarcoma. It is now being used to also treat ovarian cancer and multiple myeloma.

Onivyde, liposome encapsulated irinotecan to treat metastatic pancreatic cancer, was approved by FDA in October 2015.

Rapamune is a nanocrystal-based drug that was approved by the FDA in 2000 to prevent organ rejection after transplantation.







Background

Nanowires are just like normal electrical wires other than the fact that they are extremely small. Like conventional wires, nanowires can be made from a variety of conducting and semiconducting materials like copper, silver, gold, iron, silicon, zinc oxide and germanium.

Nanowires can also be made from carbon nanotubes.

Nanowire Size

Nanowires are less than 100 nanometers in diameter and can be as small as 3 nanometers. Typically nanowires are more than 1000 times longer than their diameter.

NANOWIRES



Researchers from North Carolina State University have developed a wearable, wireless sensor that can monitor a person's skin hydration for use in applications that need to detect dehydration before it poses a health problem.

It is made of made of conductive silver nanowires inlaid in a silicone matrix.

The device is lightweight, flexible and stretchable and has already been incorporated into prototype devices that can be worn on the wrist or as a chest patch.



Sensor test chips containing thousands of nanowires, able to detect proteins and other biomarkers left behind by cancer cells, could enable the detection and diagnosis of cancer in the early stages from a few drops of a patient's blood.



Researchers at the Emory/Georgia Tech Center of Cancer Nanotechnology Excellence synthesize, by vapor-solid process, aligned Zinc Oxide nanowire arrays as shown in the scanning electron microscopy (SEM) image.

LAB-ON-SKIN

Stretchable and flexible electronic devices as biosensors for measuring (clockwise from top right)

skin modulus stiffness)

Electro-cardiology

Hydration

Blood oxygen

Wound-healing rate

Sweat content

Skin surface temperature

Blood pressure,

Electromyography

Electroencephalography. (© ACS)



Nanotechnology materials are going to open new realms of possibility for flexible and stretchable monitoring gadgets that are wearable directly on the skin

Graphene-based Sensors in Health Monitoring



These sensing systems are able to detect a wide variety of clinically relevant molecules, like nucleic acids, viruses, bacteria, cancer antigens, pharmaceuticals and narcotic drugs, toxins, contaminants, as well as entire cells in various sensing media, ranging from buffers to more complex environments such as urine, blood or sputum



Chitosan is a sugar that is obtained from the hard, outer skeleton of shellfish, including crab, lobster, and shrimp, called Chitin.

It is used for medicine to help with obesity, high cholesterol, high blood pressure, and Crohn's disease.



NEW BIOSENSOR WITH CARBON NANOTUBES COULD MONITOR GLUCOSE LEVELS IN TEARS AND SWEAT



Nanotechnology in 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.
 - In manufacturing bullet proof jackets.
 - Making spill & dirt resistant, antimicrobial, antibacterial fabrics.









• Untreated and Nano-treated

Engineering Bionic Skin

WITHIN 20 YEARS, ARTIFICIAL LIMBS COULD HAVE SKIN THAT SENSES TEMPERATURE AND TOUCH.

1 CARBON NANOTUBES are dispersed in a flexible polymer composite skin.

2 SENSORS distinguish between temperature and pressure.

3 SENSATIONS are picked up by the active endings of living nerves.



- Carbon nanotubes— 1/10,000 as thick as a human hair—are the most efficient thermal and electrical conductors known.
- Nanotechnology will be used to create the water-resistant skin composite, shaped by lasers to be lifelike.
- FILMskin, a joint project of Oak Ridge National Laboratory and NASA, may also benefit burn victims.

ART BY BRYAN CHRISTIE SOURCES: OAK RIDGE NATIONAL LABORATORY; NASA

NANORODS

Nanorods are one form of nanoscale objects.

Dimensions range from 1–100 nm.

A combination of ligands act as shape control agents and bond to different facets of the nanorod with different strengths.

This allows different faces of the nanorod to grow at different rates, producing an elongated object.

USES:

In display technologies, because the reflectivity of the rods can be changed by changing their orientation with an applied electric field.

In micro-electro-mechanical systems (MEMS).

In cancer therapeutics.



NANO BORANES FOR CANCER AND OTHER DISEASE TREATMENT

Polyhedral Boranes, or clusters of boron atoms bound to hydrogen atoms, are transforming the biomedical industry.

These man-made materials have become the basis for the creation of cancer therapies, enhanced drug delivery and new contrast agents needed for radio-imaging and diagnosis.

They also can be improved diagnostic tools for cancer and other diseases as well as low-cost solar energy cells



Bee Venom Kills HIV: Nanoparticles Carrying Toxin Shown To Destroy Human Immunodeficiency Virus

Nanoparticles (purple) carrying melittin (green) fuse with HIV (small circles with spiked outer ring), destroying the virus's protective envelope.

Molecular bumpers (small red ovals) prevent the nanoparticles from harming the body's normal cells, which are much larger in size.



The finding is an important step toward developing a vaginal gel that may prevent the spread of HIV, the virus that causes AIDS.

GRAPHENE – HEXAGON-SHAPED PLANE OF CARBON ATOMS IN SHEET FORM



Graphene and fullerenes are <u>nanoscale</u> <u>allotropes</u> of carbon.

Graphene is a flat sheet of carbon atoms arranged in hexagons.

Fullerenes are molecules of carbon in the shape of spheres, ellipses and tubes.

C₆₀ is known as buckminsterfullerene, or a buckyball, and is a spherical fullerene with 60 Carbon atoms.

Carbon nanotubes, also known as buckytubes, are fullerenes in the shape of a tube.



BUCKYBALLS WITH 540 CARBON ATOMS





BUCKYBALL WITH 60 CARBON ATOMS

NANOTUBES ARE FLAT AREAS OF GRAPHENE THAT IS ROLLED UP INTO A TUBE



PROPERTIES OF CARBON NANOTUBES

- Tensile strength can be 400 times that of steel
- Very light-weight their density is one sixth of that of steel
- Their thermal conductivity is better than that of diamond
- They are highly chemically stable and resist virtually any chemical impact unless they are simultaneously exposed to high temperatures and oxygen - a property that makes them extremely resistant to corrosion
- Their hollow interior can be filled with various nanomaterials, a property that is extremely useful for nanomedicine applications like drug delivery.



Consumer Products Inventory An inventory of nanotechnology-based consumer products introduced on the market.

After more than twenty years of basic and applied research, nanotechnologies are gaining in commercial use.

But it has been difficult to find out how many "nano" consumer products are on the market and which merchandise could be called "nano."

While fairly comprehensive, this inventory gives the public the best available look at the 1,800+ manufacturer-identified nanotechnology-based consumer products introduced to the market.

This "living" inventory is a resource for consumers, citizens, policymakers, and others who are interested in learning about how nanotechnology is entering the marketplace.



https://www.youtube.com/watch?v=acudS85okxw 8.3 minutes