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Nanotechnology: "Advancing Material Science and Medicine"

Jagessar RC

Department of Chemistry, Faculty of Natural Sciences, University of Guyana, South America

ABSTRACT

Nanotechnology has been a rapidly growing field of advanced science at the inception of this century. Nanotechnology of advanced materials, polymers, principally revolves around endeavours to plan materials at a sub-atomic level to accomplish alluring properties and applications at a naturally visible level. Nanotechnology can be used for the advancement of technologies, ranging from communication and information, health and medicine, future energy, environment and climate change to transport and cultural heritage, personal protective equipment (PPE), fuels, fuel cells, biosensors, disease sensors etc. Nanomaterials will lead to a new approach to manufacturing materials and devices. Faster computers, advanced pharmaceuticals, controlled drug delivery, biocompatible materials, nerve and tissue repair, crackproof surface coatings, better skin care and protection, more efficient catalysts, better and smaller sensors, even more efficient telecommunication. For example, a low risk solution using antibody modified bismuth nanoparticle, in combination with an X-ray dose equivalent to a chest X-ray specifically, has been shown to kill the common bacterium Pseudomonas aeruginosa in a set up designed to resemble a deep wound in human tissue. Nanosized gold particle could catalyse the oxidation of carbon monoxide better than anything previously known. Heparin functionalized nanoparticles have been use for targeted delivery of anti-malarial drugs. Heparin is abundant and cheap, compared to treatments that involve antibodies, an important consideration, since malaria is most common in developing countries. A bone repairing nano-particle paste has been developed that promises faster repair of fractures and breakages. DNA containing two growth genes is encapsulated inside synthetic calcium phosphate nanoparticles. In a remarkable demonstration of the extreme limits of nanoscale engineering, researchers have used the tip of a scanning tunnelling microscope to cleave and form selected chemical bonds in a complex molecule. Many medicinal and industrial endeavours have seen the use of Nanotechnology. Nanoparticles can attach to SARS COV-2 viruses, disrupting their structure and so kill the virus. These and other more recent advances in nanotechnology will be presented at this conference.

Corresponding author
Jagessar RC, Department of Chemistry, Faculty of Natural Sciences, University of Guyana, South America.

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Introduction
Nanotechnology, a relatively new area of study and research, is the "design, production, characterization, and application of structures, devices and systems, by controlling shape and size at the nanometer scale [1-4]. The particle matter usually range from 1 to 100 nm in size. Within this range, materials may have properties considerably different from those expected when they have larger dimensions. Nanoscience depends on the fundamental properties of nano size objects [5,6]. Figure 1 shows how useful is nanotechnology in the construction of a fullfurene nonogears.

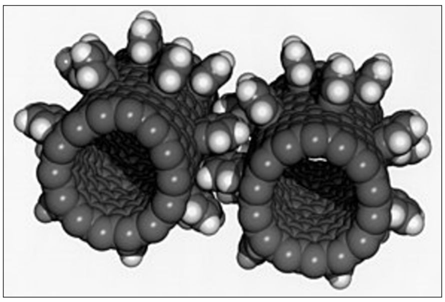


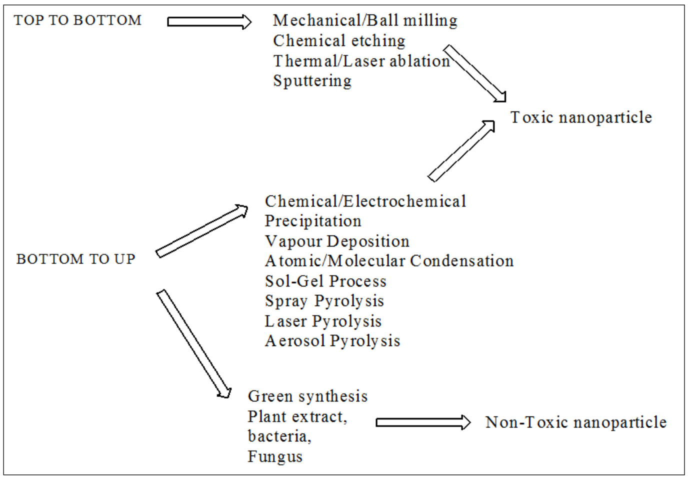
Figure 1: Fullerene Nanogears

Classification
Nanoparticles can be broadly divided into various categories, depending on their morphology, size and chemical properties. Based on their physical and chemical characteristics, some of the well known classes of NPs are as follows: Carbon based nanoparticles, ceramic nanoparticles, semiconductor nanoparticles, polymeric nanoparticles, lipid based nanoparticles, metallic and plant based nanoparticles.

Synthesis of Nanomaterials
There are three ways of synthesizing metal nanoparticles: Physical, chemical and green synthesis.

Chemical and physical methods are quite expensive and potentially hazardous to the environment and involve the use of toxic and perilious chemicals that are responsible for the various biological and environmental risks. Physical synthetic method include: inert gas condensation, severe plastic deformation, high energy ball milling and ultrasonic shot peeling [7]. Scheme 1 shows the synthesis of nanoparticles via the "top to bottom" and "bottom to up" approach.

Scheme 1: The Synthesis of Nanoparticles Via the "Top to Bottom" and "Bottom to Up" Approach



Characterisation of Nanoparticles
Nanoparticles, once synthesized is characterized by the following means: UV-visible spectrophotometry, Powder X-ray diffraction (XRD), dynamic light scattering (DLS), Fourier transform infrared spectroscopy (FTIR), Scanning Electron Microscopy (SEM), Transmission electron microscopy (TEM), and energy dispersive spectroscopy (EDS), Scanning Tuneling Microscopes (STM), SEM and STM are both used to image and manipulate materials at the nanoscale. STM can also be used to move individual atoms [8-11].

Applications of Nanotechnology in Materials Science
Nanotechnology has found applications in many realms. These are discussed below.

Fabrics: Nanoscale additives applied to or surface treatments of fabrics provide lightweight ballistic energy deflection in personal body armor, or can help them resist wrinkling, staining, and bacterial growth.

Nanoscale Films: Clear nanoscale films on eyeglasses, computer and camera displays, windows, and other surfaces can make them water and residue-repellent, antireflective, self-cleaning, resistant to ultraviolet or infrared light, antifog, antimicrobial, scratch-resistant or electrically conductive.

Automobiles: Nanoengineering has led to lightweighting of cars, trucks, airplanes, boats, and space craft which would lead to significant fuel savings.

Automotive Products: These include high-power rechargeable battery systems, thermoelectric materials for temperature control, tires with lower rolling resistance, high-efficiency/low-cost sensors and electronics, thin-film smart solar panels and fuel additives for cleaner fuels.

Nanotechnology-enabled lubricants and engine oils also significantly reduce wear and tear, which can significantly extend the lifetimes of moving parts in everything from power tools to industrial machinery.

House Hold Products: Nano-engineered materials make superior household products such as degreasers and stain removers; environmental sensors, air purifiers, and filters; antibacterial cleansers; and specialized paints and sealing products, such a self-cleaning house paints that resist dirt and marks.
Personal Care Products: Nanoscale materials are also being incorporated into a variety of personal care products to improve performance. Nanoscale titanium dioxide and zinc oxide have been used for years in sunscreen to provide protection from the sun while appearing invisible on the skin.

Computing: Nanotechnology has led to major advances in computing and electronics, leading to faster, smaller, and more portable systems that can manage and store larger and larger amounts of information. These continuously evolving applications include:

Transistors: The basic switches that enable all modern computing, have gotten smaller and smaller through nanotechnology. Table 1 shows transitors efficiency with year of manufacture

Table 1: Transistors Efficiency and Year of Manufacture

Year	Size of transitor (nanometres)	Comments
2001	130-250	
2014	14	
2015	7	Created by IBM
2016	1	Smaller, faster and better transistors

Smaller, faster, and better transistors may mean that soon your computer's entire memory may be stored on a single tiny chip.

Carbon nanotube sheets are now being produced for use in next-generation air vehicles. For example, the combination of light weight and conductivity makes them ideal for applications such as electromagnetic shielding and thermal management.

High-resolution image of a polymer-silicate nanocomposite has improved thermal, mechanical, and barrier properties and can be used in food and beverage containers, fuel storage tanks for aircraft and automobiles, and in aerospace components.

Nano-bioengineering of enzymes is used to enable conversion of cellulose from wood chips, corn stalks, unfertilized perennial grasses, etc., into ethanol for fuel.

Cellulosic nanomaterials have demonstrated potential applications in a wide array of industrial sectors, including electronics, construction, packaging, food, energy, health care, automotive, and defense. Cellulosic nanomaterials are projected to be less expensive than many other nanomaterials and, among other characteristics, tout an impressive strength-to-weight ratio.

Applications of Nanotechnology in Medicine
In pursuit of a cure, the used of plant extracts or parts to make plant based nanoparticles, may be one area to target. These are environmentally safe, economically and are in sustainable abundance. The SARS-COV-2 virus consists of a structure of a similar scale or dimension as plant based nanoparticles, Figure 2.

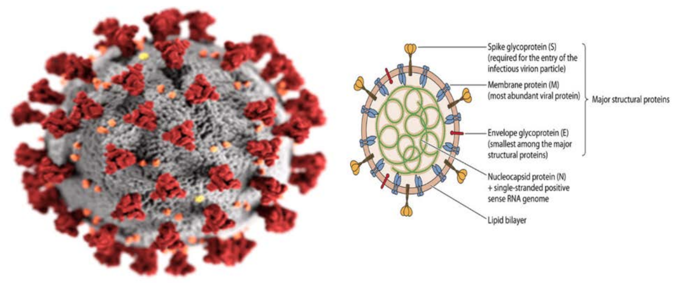


Figure 2: (A) Generalised Structure of SARS-COV-2 Virus (B) Detailed Structure of SARS-COV-2

Its anticipated that the proposed plant based nanoparticles can attach to SARS COV-2 viruses effectively, disrupting their structure and so kill the virus, under infrared light treatment [12]. Plant based nanomaterials could be used to deliver drugs to the pulmonary system to inhibit interaction between angiotensin-converting enzyme 2 (ACE2) receptors and viral S protein.

"Nanoimmunity by design" can help us to design materials for immune modulation, either stimulating or suppressing the immune response, which would find applications in the context of vaccine development for SARS-COV-2 or in counteracting the cytokine storm, respectively.

Nanotechnology has important roles in diagnostics, with potential to support the development of simple, fast, and cost-effective nanotechnology-based assays to monitor the presence of SARS-COV-2 and related biomarkers, Figure 3 Nanotechnology is critical in counteracting COVID-19 and will be vital when preparing for future pandemics [12].

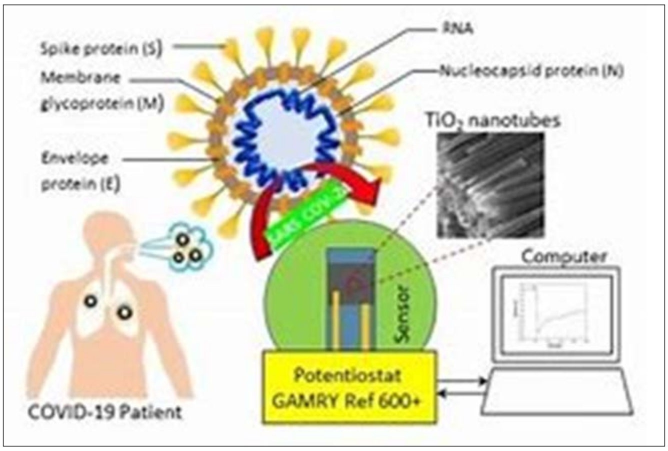


Figure 3: Nanotechnology Been Used as A Diagnostic Tool to Detect the SARS-COV-2 Viruses

The possible use of how polymer nanoparticles (nanosponges) could slow the spread of COVID-19 has been reported [13]. The cellular nanosponges consist of two types of cores: human lung epithelial type II cell and human macrophage, made from poly (lactic-co-glycolic acid, PLGA) sonicated to form Epithelial-NS and M-NS, respectively. It must be noted that SARS-COV-2 is believed to enter the body through the nose, mouth or eyes. It attaches to the protein called ACE2 enzyme found in the epithelial cells of lungs, heart, blood vessels, kidneys, liver and gastrointestinal tract [13].

Covering the polymer-nanoparticles core with the outer membranes of lung epithelial cells, allow viruses to be trap into it and preventing from entering the human epithelial cells. Thus, the polymer, neutralizing the virus [13,14]. This is shown in Figure 4.

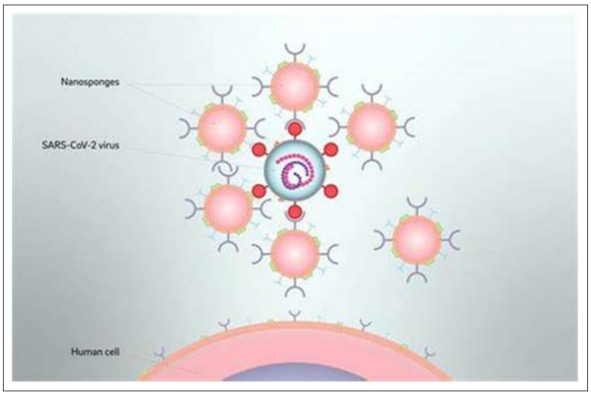


Figure 4: Shows How Nano-Sponges Can Mop Up SARS-COV-2 Viruses

Nanomaterials, both synthetic and plant based, incorporated with copper and copper alloys, are currently being explored for their activity against coronavirus, SARS-COV-2. Copper was shown to be effective against polio virus in the late 1970s, and recently against another coronavirus, HuCOV-229E. It was found that the virus, which lives typically for around six days on a surface became inactive in sixty minutes on surfaces coated with copper alloys [15].

In addition, nanomaterials, derived from plants or via synthesis can be employed in the production of vitally personal protective equipment (PPE) to help reduce the spread of COVID-19 to frontline medical and other workers. Nanomaterials can be incorporated in facemasks and other PPE to capture and immobilize viruses [15].

Nanotechnology has been used in the creation of artificial cells, tissues as well as organs. Artificial cells are actively investigated for the replacement of defective cells and organs especially those related to metabolic functions [16]. For example, a novel nanodimension red blood cell substitute based on ultrathin polyethylene glycolpolylactic acid (PEG-PLA) membrane nanocapsules (80-150 nm diameter) has been reported [16].

Conclusion

Nanotechnology is indeed a versatile field of research and has found applications in many realms. Many significant applications in materials sciences and medicine have been realised. These include the development of therapeutic agents to fight and prevent transmission of COVID-19, diagnosis agents and as nanosensors against COVID-19. Nanotechnology has also improved the efficiency of air filters against viruses. Targeted encapsulated drug delivery using nanoparticles is more effective than conventional method. Nanoparticles are effective against imaging, diagnosis and in anticancer therapy. Research in this field needs to further proliferate, because of the novel properties of nano-based materials. Research in this field should further intensify to even broaden the scope of this dynamic and rewarding field of contemporary science.

References

1. Clark W, Harley A (2020) Sustainability Science: Toward a Synthesis. Annual Review of Environment and Resources 45: 331-386.
2. United Nations General Assembly (1987) Report of the World Commission on Environment and Development:

Our Common Future. Transmitted to the General Assembly as an Annex to document A/42/427 – Development and International Co-operation: Environment.
3. United Nations General Assembly (1987) "Report of the World Commission on Environment and Development: Our Common Future; Transmitted to the General Assembly as an Annex to document A/42/427 – Development and International Co-operation: Environment; Our Common Future, Chapter 2: Towards Sustainable Development; Paragraph 1". United Nations General Assembly. Retrieved 1 March 2010.).
4. Nanoscience and Nanotechnologies (2004) Nanoscience and nanotechnologies: opportunities and uncertainties. The Royal Society & The Royal Academy of Engineering England https://royalsociety.org/-/media/policy/publications/2004/9693.pdf.
5. Abou El-Nour KMM, Eftaiha A, Al-Warthan A, Ammar RAA (2010) Synthesis and applications of silver nanoparticles. Arabian Journal of Chemistry 3: 135-140.
6. Mohanpuria, P, Rana NK, Yadav SK (2007). Biosynthesis of nanoparticles: technological concepts and future applications. Journal of Nanoparticle Research 10: 507-517.
7. Van Dijken A, Meulenkamp EA, Vanmaekelbergh D, Meijerink A (2000) Identification of the transition responsible for the visible emission in ZnO using quantum size effects. Journal of Luminescence 90: 123-128.
8. Dhanapal R (2012) Nanotechnology Engineering- A Review. Journal of Science 2: 13-25.
9. Heney P (2022) What is Nanoengineering?. R&D World https://www.rdworldonline.com/what-is-nanoengineering/.
10. Todescato F, Fortunati I, Minotto A, Signorini R, Jasieniak, et al. (2016) Engineering of semiconductor nanocrystals for light emitting applications. Materials 9: 672.
11. Holzinger M, LeGoff A, Cosnier S (2014) Nanomaterials for Biosensing Applications: A Review. Frontiers in Chemistry 2: 1-10.
12. Sebastian Kelly (2020) Express, Home of the Daily & Sunday's express.
13. Corum J, Zimmer C (2020) How Coronavirus Hijacks Your Cells. The New York Times https://www.nytimes.com/interactive/2020/03/11/science/how-coronavirus-hijacks-your-cells.html.
14. Chhantyal P (2020) Can nanoparticles Treat Covid-19 patients?. https://www.azonano.com/article.aspx?ArticleID=5537&azosrc=downloadpdfcopyemail
15. Lea R (2020) Nanotechnology and the Fight Against COVID-19. https://www.azonano.com/article.aspx?ArticleID=5540.
16. Azmal Moshed, Sarkar MKI, Khaleque MA (2017) The application of Nanotechnology in medical sciences: New horizon of treatment. American Journal of Biomedical Sciences 9: 1-14.