Review Article

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Nanotechnology

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ABSTRACT

Background: The emerging science of nanotechnology, especially within the dental and medical fields, sparked a research interest in their potential applications and benefits in comparison to conventional materials used. Therefore, a better understanding of the science behind nanotechnology is essential to how these materials can be utilised in our daily practice.

Keywords: Nanotechnology nano dentistry and nanomaterials.

INTRODUCTION

The era of nanotechnology is fast approaching. Virtually unheard of two decades, all disciplines will be impacted by advances in nanotechnology in the near future. The growing interest in the future medical applications of nanotechnology is leading to the emergence of a new field called nanomedicine – the science and technology of diagnosing, treating, and preventing disease and traumatic injury, of relieving pain, and of preserving and improving human health, using nanoscale-structured materials, biotechnology and genetic engineering, and eventually complex molecular machine systems and nanorobots. Similarly, development of "nano dentistry" will make possible the maintenance of near-perfect oral health through the use of nanomaterials[1], biotechnology including tissue engineering, and nanorobotics. Dental nanorobots are the most exciting and challenging approach to nano dentistry.

HISTORY

1959 – Richard P. Feynman proposed *using machine tools to make smaller machine tools, which, in turn, would be used to make still smaller tools, and so on all the way down to the molecular level.* He suggested that such small nanomachines, nanorobots and nanodevices ultimately could be used to develop a wide range of atomically precise microscopic instrumentation and manufacturing tools[2]. Feynman argued that these tools could be applied to produce vast quantities of ultra-small computers and various microscale and nanoscale robots. He concluded that this is "*a development which I think cannot be avoided*." The vision of nanotechnology was born. With the dawn of microcomputers, there was a significant increase in the speed & power of computers. Similar progress is underway in the related field of robotic miniaturisation.

The 1980s & early 1990s – the microelectromechanical system was made possible the fabrication of the first **micromotors. 1986 – K. Eric Drexler** coined the term "**Nanotechnology**". **1994 – "*Working Electric Car*"** smaller than a grain of rice by engineers at Nippondense Ltd. 1,000 times smaller of 1939 Model AA Toyota sedan (incorporated 24 parts, including a motor, wheels, body, spare tire, bumpers & 10 μm-thick license plate

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1997 – Researchers at Cornell's nanofabrication facility produced **Silicon Guitar** that was 10 mm in length & 2 mm in wide, with six individual strings that were only 50 nanometers thick.

DEFINITION

"Nano" in Greek prefix - signifies a "billionth" (one billionth of a meter is the unit of measure in the field of nanotechnology). Not to be confused with the term Nanoscience", which does not describe a practical application but rather the scientific study of the properties of the nanometric world.

TYPES OF NANOTECHNOLOGIES[2]:

A) Top-Down: From top (larger) to bottom (smaller).

Mechanisms and structures are miniaturised to a nanometric scale.

Most frequent application of nanotechnology

B) Bottom-Up: From bottom (smaller) to top (larger).

Begin with a nanometric structure (molecule) and creating a mechanism larger than the original structure.

Broadly it consists of 3 mutually overlapping & progressively more powerful molecular technologies,

A. Nanoscale- structured materials & devices that can be fabricated advanced diagnostics & biosensors, targeted drug delivery & smart drugs.

B. Molecular medicine via genomics, proteomics & artificial biobotics (microbial

C. Molecular machine systems & medical nanorobots allow instant pathogen diagnosis & extermination, & efficient augmentation & improvement of natural physiological function.

NOVEL NANOTECHNOLOGY PRODUCTS[2]

A. Nano Aluminium Oxide Fibers (Nanoceram)

- Major break through in ceramic fibers.
- Ultrasmall 2 nm diameter with a high surface area of 300 – 600 m2/g
- Fibres made up of principally Boehmite (AIOOH) with minor phases of gamma-alumina & AI(OH)3
- The large no. of hydroxyl groups available on the nanofibers generates a positive change in water solution such that it will attract & retain –ve charged particles, (bacteria, viruses, organic & inorganic colloids)

SUGGESTED APPLICATIONS

- Nanofiltratiuon.
- Purification of water for medical &dental purposes.
- Filter sterilisation of medical serum, biological fluids and other pharmaceutical products.
- Separation of macromolecules like proteins & DNA.
- Electrical & thermal insulation.
- Sintering acid for ceramics & Fibre-reinforced plastics.
- Clean up of plating water & trace dissolved radioisotopes.
- Tissue engineering compacts of nanoceram attract & retain osteoblasts and allow their proliferation at higher rates than hydroxy apatite.

B. Nanoporous Silica Filed Composites

- New material, still in experimental form.
- Proves to increase water resistance in posterior application.
- Nanosized porous silica fillers allow the monomer to inter-penetrate it through a capillary force.
- The monomer is draw in & out of the filler, reinforcing the composites & increasing the durability of the bonding between the two phases robots)
- Light cure polymerisation results in solid organic / inorganic nanostructure.

C. Nanoadhesive – Poss

- *Polhydral Oligomeric Sil Sesquioxanes* enable the design of additives that make plastics that are unusually lightweight, durable, heat & environmentally friendly.
- POSS combines organic & in organic materials in molecules with an average diameter of 1.5 nm.

- Used as either additives in or replacement for traditional plastics.

***CURRENT APPLICATIONS*[2]**

- Dental adhesives in which a strengthened resin provides a strong interface between the teeth & restorative material.

- Much more resistant to radiation damage & erosive than conventional polymers.

NEW TREATMENT OPPORTUNITIES IN PERIODONTICS

- Tooth Repair
- Hypersensitivity Cure
- Nanorobotic Dentifrice (Dentifrobots)

Tooth Repair

Major tooth repair may evolve through several stages of technological development,

- First using genetic engineering,
- Tissue engineering and
- Later growing whole new teeth invitro & installing them.

Ultimately, the nanorobotic manufacture and installation of a biologically autologous whole replacement tooth including both mineral and cellular components (e.g., complete dentition replacement therapy) should become feasible to undertake within the time and economic constraints of an ordinary office visit, using an affordable desktop manufacturing facility in the dentist's office.

Hypersensitivity Cure

Reconstructive dental nanorobots would selectively and precisely occlude selected tubules in minutes, using native biological materials, offering patients a quick and permanent cure.

Nanorobotic Dentifrice (Dentifrobots)

- Subocclusal-dwelling nanorobotic dentifrice delivered by mouthwash or toothpaste could patrol all supragingival and subgingival surfaces at least once a day, metabolising trapped organic matter into harmless and odourless vapours and performing continuous calculus debridement.

- Invisibly small (1-10 micron) dentifrobots[3], 10^3 - 10^5 nanodevices / oral cavity and crawling at 1-10 microns/sec.

- Would be inexpensive purely mechanical devices safely deactivate themselves if swallowed and programmed with strict occlusal avoidance protocols. Diamondoid nanomachines can be crushed by dental grinding.

- Properly configured dentifrobots could identify and destroy pathogenic bacteria residing in the plaque and elsewhere while allowing the ~500 species of harmless oral microflora to flourish in a healthy ecosystem[4].

- Dentifrobots would also provide a continuous barrier to halitosis since bacterial putrefaction is the central metabolic process involved in oral malodor.

- With this kind of daily dental care available from an early age, conventional tooth decay and gum disease will disappear into the annals of medical history.

FACT[5]

a. A first series of commercially nanobioelectronic products are expected to 2007.
b. Next 5-10 years: First nanorobots to medicine and environmental applications
c. Company Display Search: Rapid market grow from US$ 84 million today to $ 1.6 Billion in 2007
d. Devices and systems based on Nanotechnology: US$ 1 trillion market for 2015

TODAY'S VISION TOMORROW'S REALITY

The visions of nanotechnology may sound unlikely[6], implausible, or even heretic. Yet, the theoretical and applied research to turn them into reality is progressing rapidly. Nanotechnological developments[7] are expected to accelerate significantly through governmental & private sector initiatives. It is unimportant which of these scenarios will actually come to pass. The important point is that advances in nanotechnological research and development have made such applications theoretically possible. Time, specific advances, resources, and needs will determine which ones will become reality.

CONCLUSION

Nanodentistry faces many significant challenges in bringing its promises to fruition. Basic engineering problems run the gamut from the precise positioning and assembly of molecular-scale parts, to economical nanorobot mass production techniques, to biocompatibility and the simultaneous coordination of the activities of large numbers of independent micron-scale robots. There are larger social issues of public acceptance, ethics, regulation and human safety that must be addressed before molecular nanotechnology can enter the modern medical armamentarium.

Nanotechnological[8] advances should be viewed in the context of other expected developments relevant to oral health in the coming decades. t is hoped that dental nanorobots in due time will make fast, painless & precision dentistry a reality. At the same time, continual refinement of traditional methods, development of advanced restorative materials, and new medications and pharmacologic approaches will continue to improve dental care.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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