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Nanotechnology: The future Dentistry

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Abstract

Nanotechnology uses material in the atomic, molecular, and supramolecular levels. It is one of the most popular areas of current research and has developed in multiple disciplines .Nanotechnology has been used in the development of restorative materials with significant success. This comprehensive review article highlights the importance of Nanotechnology in dentistry
Key words : Nanotechnology , Nanomer, Nanocluster and Nanocomposite.

Introduction

The art and science of material engineering at the nanoscale, or 1-100 nm, is known as nanotechnology. The name "Nano" is derived from the Greek word for dwarf[1]. The process of separating, consolidating, and deforming materials by one atom or one molecule is known as nanotechnology. It has been applied to the creation of restorative materials with an impressive rate of effectiveness.(**Figure 1**)

Figure 1 Nanotechnology

Dr. Richard Feynman, a well-known American physicist, first proposed the idea of nanotechnology in 1959. Bio-nanorobots can use the properties of biological materials and their designs[2]. Nanotechnology is built on the concept of individually manipulating atoms and molecules to produce functional structures[3].To effectively and completely control the structure of matter, it arranges atoms.[4,5]The characteristics of nanoparticles are notably different from those of ordinary materials due to two main factors: In comparison to bigger particles, nanoparticles have a significantly higher surface area per unit mass. Particularly as the structure or particle size near the smaller end of the nanoscale, quantum effects can have an impact on the optical, electrical, and magnetic behavior of materials. A new field called "nanomedicine" has emerged as a result of improved nanotechnology applications in medicine [6]. Applications for nanomedicine range from tissue scaffolds to medication release nanospheres[7].

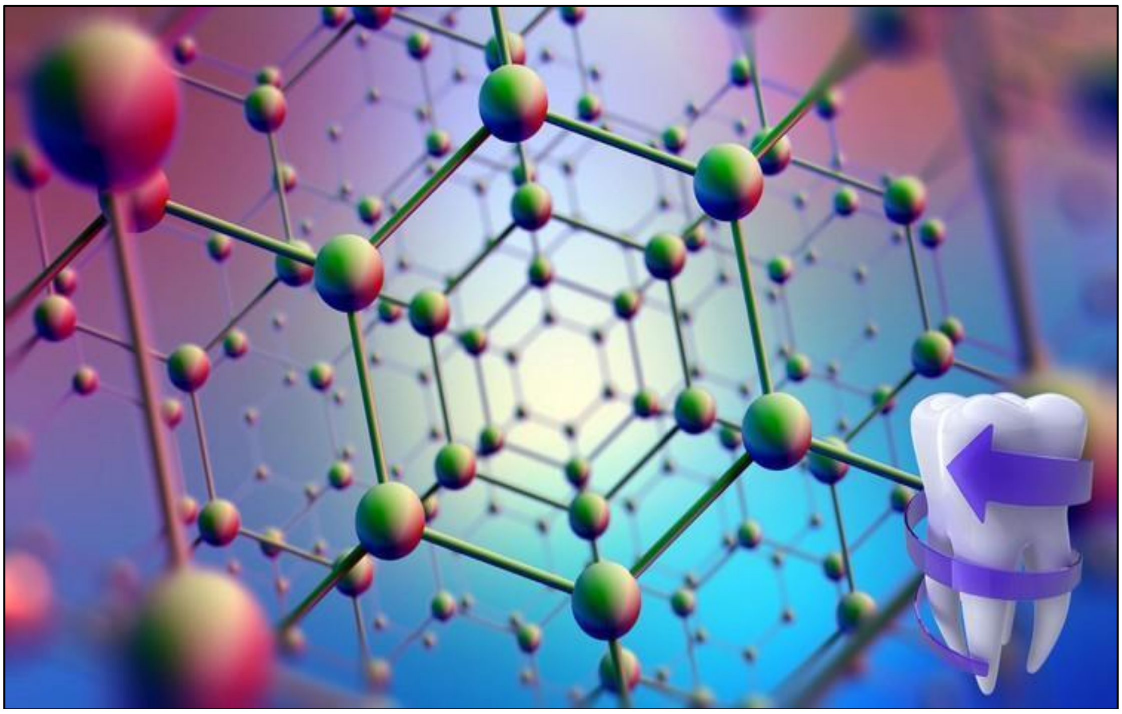

Figure 2 Need For Nanotechnology

Applications of Nanotechnology (Figure 2)

Producing synthetic materials with qualities similar to those of real dental issues is known as material synthesis.

Biomimetic strategies: To replace missing dental tissues, mimic nature by creating biomaterials with characteristics that are highly similar to the missing tissues.

Tissue engineering: Regenerating missing dental tissues using techniques from regenerative medicine and tissue engineering.

Enamel, dentin, and cementum are three dental hard tissues that are made up of nanoscale structural units.

Approaches in nanotechnology

Top-down approach - To assemble tiny gadgets by utilizing larger ones as a guide.

Bottom up approach -To combine smaller parts into more intricate structures.

Functional approach- The creation of a nanoparticle with a particular functioning is the functional goal.

- Nanotubes
- Quantum Dots
- Nanoshells
- Dendrimers
- Nanospheres
- Nanowires
- Nanobelts
- Nanorings
- Fullerene

Applications of Nanotechnology In Prosthodontics

In prosthodontics, metals, ceramics, acrylic resins, composites, dental adhesives, dental cements, implants, and maxillo-facial prostheses are all given nanoparticle additions.
Since these materials' efficacy and durability were increased by modifying them to nanosize.

1. **Implants (Figure 3)**

Figure 3: Nanotechnology in Implants

Dental implants have been extensively modified with the help of nanotechnology because it may change the surface of an implant at the atomic level, changing its chemical composition. This shift in the chemistry and the roughness has aided in successful osseointegration. Osteoblastic cells produced more alkaline phosphatase activity when coated with titanium dioxide nanotubes. A complex is produced by the addition of calcium phosphate and hydroxyapatite nanoscale deposits. Osteoblast development on implant surface [8,9]It has also been attempted to immobilize medications that promote osteogenesis, such as bisphosphonates and simvastatin, or that fight bacterial infection, such as silver and zinc oxide nanoparticles, onto the biofunctionalized implant surface. Dental implants have been treated using radio-frequency plasma, lithography, ionic implantation, anodization [10], and tubes [11], dots[12], and nodules [13] to create controlled nanosurface characteristics. In order to create a surface with antibiofilm properties on titanium alloy implants without sacrificing the biocompatible hydroxyapatite surface necessary for successful osseointegration and speedy bone repair, a dual-layered silver hydroxyapatite nanocoating has been employed.

2. Composites

Figure 4: Nanocomposites

The use of nanoparticles into restorative materials is the most recent development in composite resins [14]. The resin matrix has been combined with nano fillers ranging in size from 1 to 100 nm to create nanocomposites. These filler particles can neither scatter nor absorb visible light since their sizes are less than those of visible light. This phenomenon is crucial for obtaining outstanding cosmetic qualities and can be applied to the repair of anterior teeth. By combining the aesthetic qualities of microfill composites and the mechanical qualities of hybrid composites, nanofiller technology has made it possible to produce nanofill composites [15,16].Dental composites can be made with filler particles that are produced using nanotechnology. [17]The two types of nanoparticles that have been used are Nanomers and Nanoclusters

Nanomers:

They are silica particles that are monodispersed, unaggregated, and non agglomerated. These aided in the nanomer filler's chemical attachment to the resin during the curing process.

Advantages**:**

- High polish and polish retention,
- superior hardness,
- good dispersion rate,
- good optical characteristics,
- flexural strength,

Disadvantages**:**

poor handling and rheological characteristics.

Nanoclusters:

The size range of nanocluster fillers is 2–20 nm. They are composed of clusters with a predetermined particle size distribution that were created by gently sintering nanomeric oxides. It has proven possible to create both pure silica sol nanoclusters and mixtures of silica and zirconia. Nano-Hybrid Composites

Nanomers have been used with pre-polymerized organic fillers to enhance the ideal rheological characteristics of composites.

Advantages:

- enhanced aesthetics
- additional filler loading
- greater adaptability

Disadvantages:

- diminution of polish retention
- surface sheen

Nano-Composite Denture Teeth (Figure 5)

Figure 5 Nanocomposite Denture Teeth

Nanofillers and polymethyl methacrylate are uniformly dispersed in nanocomposite denture teeth. They have demonstrated excellent abrasion resistance, enhanced shear strength, good durability, and polishability. [18,19,20]

3. Dental Adhesives

Different adhesive resin systems are used to bond dental composite to tooth structure, resulting in a transitional zone known as a hybrid layer or inter-diffusion zone of collagen reinforced with adhesive resin. [21] Resin-dentine contact tensile strength may be compromised by-

Breakdown of the collagen matrix;

Hydrolysis of the resin monomer and incomplete penetration and polymerization of the resin monomer

4. Tissue Conditioners and Soft Liners

Including silver, after a 24-hour incubation period, nanoparticles in these materials demonstrated antibacterial activities against S. mutans, S. aureus, and C. albicans at 0.1 percent and 0.5 percent, respectively. The most efficient antifungal agent has been shown to be chlorhexidine solutions combined with sodium triphosphate, and chlorhexidine-HMP coating, which lengthens the life of the prosthesis. **(Figure 6)**

Figure 6: Tissue conditioner with silver nanoparticles

5. Maxillofacial Prosthesis

With no adverse effects on the human dermal fibroblast cells, the addition of silver nanoparticles to these materials has prevented candida albicans from adhering to the surface of these prostheses. Silicone elastomers have had titanium dioxide, zinc oxide, and cerium dioxide nanoparticles added as opacifiers, with titanium dioxide and cerium dioxide nanoparticles displaying the least amount of color instability.

Surface-treated Silicone dioxide nanoparticles added at a concentration of 3% have improved the mechanical characteristics, particularly the tear strength. **(Figure7)**

Figure 7 : Nanotechnology in maxillofacial prosthesis

6. Tissue Engineering (Figure 8)

Figure 8: Tissue engineering

The scaffolding materials can now be significantly improved thanks to nanotechnology in tissue engineering, which creates special 3D matrix conditions for cells and tissue[22]. As matrices for the regeneration of dental tissues, such as the dentin-pulp complex, enamel, PDL, cementum, alveolar bone, and temporomandibular joint, the nanofibrous scaffolds have been widely developed. Given that the majority of tissue proteins, including collagen and elastin, are nanofibrous, one important characteristic of nano fibrous structures is their morphological attribute of closely resembling the architecture of original tissue.

Nanofiber production is frequently accomplished using electrospinning. [23,24]

Concerns with Nanotechnology [25]

- An efficient mass production method for nanorobots that involves precise positioning and assembly of molecular scale component
- Coordination of multiple independent, large-scale microrobots operating simultaneously.
- Biocompatibility
- Funding
- a lack of adequate clinical research integration.
- public opinion, ethics, regulation, and human safety are all social issues.

Conclusion

It is fascinating to think about how nanotechnology will change dental care in the future. In prosthodontics, the advancement of material science will be crucial, opening up new paths for extensive and abundant research while taking into account the security, effectiveness, and adaptability of these new technologies.

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