



## Unbridle Treasure of Nanotechnology in Dentistry- A Review

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[Review Article](#)

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**Crossref doi:** <https://doi.org/10.36437/ijdrd.2020.2.4.H>

### ABSTRACT

A nanometer is a unit of length in the metric system, equal to one billionth of metre  $10^{-9}$ . Nanotechnology is the study of manipulating matter on an atomic scale. The first-ever concept was presented in 1959 by famous professor of Physics Dr. Richard P. Feynman. Invention of the Scanning Tunnelling microscope and the discovery of fullerene ( $C_{60}$ ) lead to the emergence of nanotechnology.

Three approaches used in nanotechnology, bottom-up approach, top-down approach, and functional approach, and there are various field of application of nanotechnology for e.g in the field of medicine and drugs, nanodevices, therapeutics, Diagnostics, Surgery, Medical nanorobots, Cancer treatment some other field like nanoelectronics, Texttile, cosmetics, national safety, space, and energy application, etc.

Nanotechnology is part of a predicted future in which dentistry may become more advance and brings enormous changes in the field of medicine and dentistry.

**Keywords:** Nano, Nanotechnology, Nanoparticles, Dentifrobots.

### Introduction

Science has gone into a new era and the name of the era is nanotechnology. This change is very essential to help mankind. Nanotechnology is an end result of our scientific development and gives the ability to understand and operate the matter at a smaller and smaller level. The general conference on weights and



measures (CGPM) usage of nano as standard prefix in 1960. In nanotechnology, the prefix word originated from the Latin word which means “DWARF” or on the scale it means “NANOMETERS”. Symbol “n” meaning 1 billionth. In the metric system, this denotes 10<sup>-9</sup>.<sup>1</sup>

A nanoparticles can be defined as a particle of matter that ranges between 1 to 100nm in diameter and the diameter of an atom is 0.15 to 0.6 nm. Nanoparticles have very different physical, chemical properties like colloidal properties, optical or electrical properties, and these are highly specific for nanoparticles. They are easily distinguishable from microparticles (1~100µm) fine particles (100-2500nm) and coarse particles (2500-10000nm). Nanoparticles show Brownian motion and being much smaller than the wavelength of visible light (400-700nm). Nanoparticles can not be seen on an optical microscope, require an electron microscope. The production of Nanoparticles with characteristic properties is an important branch of Nanotechnology. Anisotropy in nanoparticles brings lots of changes in their properties and cause an impact in the field of application.<sup>2</sup>

Nanotechnology has enormous application in dentistry including complete orthodontic realignment in a single visit, dentition renaturalisation, enhance the properties of root canal sealers, oral health maintenance used in mechanical dentifrobots, covalently bonded diamondized enamel, nanomaterials e.g composite, bioglass, zirconia, titanium hydroxy appetite, nanorobotics in nanomedicines and controlled oral analgesia, etc.<sup>3</sup>

## History

The first-ever concept was presented in 1959 by the famous professor of physics Dr. Richard fenyman. He is also known as the father of Nanotechnology, his speech he told there is “plenty of room at the bottom”. Fenyman words were received as science fiction. Today we have instruments like electron microscope that allow what fenyman had predicted.<sup>4,5</sup> Invention of scanning the tunneling microscope in 1981 and the discovery of fullerene C60 in 1985 lead to the emergence of nanotechnology and another one is atomic force microscope. Both STM and ATM are capable of imaging with atomic resolution. The principle for working these tools (STM, ATM) is imaging the surfaces of nanoscale. STM and ATM were invented by BINNING and his co-workers from IBM zurick. The term of nanotechnology was coined by Nori Taniguchi in1974.<sup>6</sup>

## Definition of Nanotechnology

1. “Nanotechnology is the understanding and control of matter at dimensions between approximately 1 to 100 nm, where unique phenomenon enables the novel application.” According to the National Nanotechnology initiative 2007 The European commission.
2. Merriam websters collegiate dictionary defines it as “the act of manipulating on an atomic or molecular scale especially to build microscopic devices/robots”.
3. Webpedia define-Nanotechnology as “A field of science whose goal is to control individual atoms and molecules to create computer chips and other devices that are thousand times smaller than current technologies permit”

**Nanotechnology Principle:** Nanotechnology function on following three principles.

1. Quantum physics
2. Surface area phenomenon
3. Cation exchange phenomenon



## Properties

At the nanoscale strange things happen to materials, they change their properties eg reactivity, size, magnetism, thermal properties like melting temperature, mechanical properties like adhesion, optical properties like prisms, etc.

**Striking Properties:** The properties of Nanoparticles are dependent upon their size.

ON Nano Scale	On Bulk Scale
Cu stiff	Malleable and ductile
Si conductive	Insulator
Au chemically active	Chemically inert
Tio <sub>2</sub> colorless	White colour

1. Highly reactive
2. Surface resonance
3. Quantization of electronic energy
4. Superparamagnetism
5. Semiconduction
6. Driving force for effusion

## Methods for Nanoparticles Production

1. **Physical Method:** Like physical vapour deposition, laser pyrolysis, electrospraying techniques and inert gas conduction.
2. **Chemical Method:** Like microemulsion techniques, hydrothermal synthesis.
3. **Biological Method:** Like certain unicellular or multicellular organisms are able to synthesize extra and intracellular inorganic nanoparticles.

## Basic Approaches to Prepare Nanomaterials

1. **Bottom-Up Approach:** In this approach chemical or physical forces which are operating at the nanoscale are used to assemble the basic unit into larger structures for the nanofabrication. eg. nanoparticles used this approach are nanopores, nanotubes, quantum dots, nanoshells, dendrimers, liposomes, nanocapsules, nanorings, fullerenes, etc.<sup>7</sup>
2. **Top-Down Approach:** Nanostructure synthesized by removing the crystal planes or etching out the crystal plane.<sup>7</sup>
3. **Functional Approach:** In this approach components of desired functionality are developed.

## Application of Nanotechnology in Dentistry

Nanotechnology has various field of application in dentistry:

1. **Nanotechnology in the Field of Medicine:** we can use nanotechnology in the field of medicine for diagnosis, drug delivery, and tissue engineering field and advances in biotechnology and biomaterials resulted in the formation of this field. Three types of nanotechnologies used in the field of medicine



are nanoscale materials and devices which are used for advanced diagnosis, second one is the molecular medicine in which we used microbial robots, genomics, and proteomics. the last one is the molecular machines and medical nanorobots in the diagnosis and treatment.<sup>5,7</sup>

2. **Nanotechnology in the Field of Dentistry:** A new field i.e nano dentistry is an emerging field because of growing interest in the future of dental application in nanotechnology. By the use of nanomaterials, biotechnologies including tissue engineering and nanorobotics in developing dentistry will provide nearly perfect oral health. Some important procedures like local anesthesia, dentition, renaturalization, covalently bonded diamondized enamel, oral health maintenance using nanorobotics dentifrice, orthodontic realignment procedures.<sup>7</sup>
3. **Nanotechnology in the Field of Diagnostics (Nanodiagnosics):** Nanodiagnosics used for the early detection of disease at the molecular and cellular level. Nanodevices are used for the detection of the diseases and quantify the presence of toxic molecules and tumor cells.<sup>8</sup>
4. **Nanodiagnosics in the Diagnosis and Treatment of Oral Cancer:** In malignancy certain marker level is seen elevated. These markers are exosomes which are membrane-bound secretory vesicles containing certain proteomic and genomic marker has been studied by using atomic force microscopy. Some other aids are oral fluid nanosensor test, optical biosensor, nanoelectromechanical system, using for the diagnosis of oral cancer.
5. **Nanoelectromechanical systems (NEMS)** are the devices that are used to integrate electrical and mechanical functions at nanoscale. NEMS consist of miniaturized electrical and mechanical apparatus such as ACTUATORS, BEAMS, SENSORS, PUMPS, MOTORS, RESONATORS.<sup>9</sup>
6. **Nanotechnology in the Therapeutics of Oral Cancer:** Nanotechnology is considered as a boon in the treatment of oral cancer. Oral cancer is the 3rd leading cause of death in the world after the stroke and heart disease. Cancer is a highly complex disease and the treatment modality available to date is radiotherapy, chemotherapy, and surgery. Nanoparticles have 2 most important characteristic one is its unique size of 1-100 nm and large surface volume size, these properties offer the solutions to overcome the obstacles in oral cancer therapies. Some Nanoparticles eg. Quantum dots (QDs), liposomes, gold nanoparticles, carbon nanotubes, paramagnetic nanoparticles.<sup>9</sup>
  - Nanoparticles can be used for brachytherapy.
  - In the treatment of Alzheimer's, Parkinson.
  - Nanovector for gene therapy
7. **Bone Replacement Materials:** Bone defect can be treated by Hydroxyapatite nanoparticles, which are:
  - Nan OSSTM (Angstrom Medica, USA) HA
  - VITOSSO (orthovita, Inc, USA,) HA+TCP<sup>10</sup>
8. **Nanoanesthesia:** To give local anesthesia is one of the most common procedure in dentistry. Which can require a long wait for effective analgesia, patient discomfort, and various degree of efficacy. Lots of alternatives were used to overcome these effects such as cell demodulated electronic targeted anesthesia, transmucosal, intraosseous or topical techniques, transcutaneous electric nerve stimulation. Nanoanesthesia of the patient is introduced with a colloidal suspension which containing the millions of acting analgesic properties. These micron-sized nanorobots reach the pulp, dentinal tubules, lamina propria under the control of specific temperature and chemical gradient. Once introduced into the pulp the analgesic dental robots gives the command to shut down all the sensitivity in any particular tooth that requires treatment after the procedure is completed, the dentist can restore the sensation to renounce the control of nerve impulse with anxiety-free and needleless comfort.<sup>13</sup>



9. **Impression Materials:** Nanofillers are amalgamated in vinyl polysiloxane, producing a unique addition of siloxane impression materials. The materials have better flow, improved hydrophilic properties, and enhanced detail precision.<sup>13</sup> Brand name- Filtek Osupremr universal restorative Nanotech Elite H\_D.
10. **Nanosolutions:** Nanosolutions provides a very unique and dispersible form of nanoparticles which can be used as a bonding agent. DENTIFLOW which is a new flowable composite has a excellent shear bond strength for bonding. The orthodontic brackets and it is used without liquid that reduces its bonding time and gives acceptable bond strength clinically.<sup>10</sup> **Trade name-** Adper, Adhesive single bond etc.
11. **Dentifrobots (Nanorobotics Dentrifices):** Nanorobotics is nanodevices that will be used for the purpose of maintaining and protecting the human body against a pathogen. These dentifrobots used in the form of mouth wash or toothpaste left on the occlusal surface of teeth can clean organic residue by petrolling throughout the supragingival and subgingival surfaces, metabolizing organic matter into harmless odorless vapors, and perform continuous debridement. These tiny nanorobots have a velocity of -10 micron/sec and deactivated when they swallowed.<sup>13</sup>
12. **To Cure Dentin Hypersensitivity:** It can be defined as short sharp pain arising from exposed dentin in response to stimuli, typically thermal, evaporative, osmotic, tactile, or chemical which can be described as any other dental defect. In hypersensitivity tooth, the diameter of the dentinal tubule is twice and 8 times the surface sensitivity of those in non-sensitive teeth. These tiny dentinal nanorobots could select tubules within a minute using native biological material and give the patient a quick and permanent cure.<sup>14</sup>
13. **Orthodontic Treatment:** It has been reported that the use of excessive orthodontic force might cause loss of anchorage and root resorption. Orthodontic robots allow directly operate the periodontal tissues, painless tooth uprighting, vertical repositioning, rotation of tooth. This procedure takes time within minutes to an hour.<sup>13</sup>
14. **Dental Nanomaterials**  
**Nano Composites (Nanotechnology as a Top-Down Approach):** Nanocomposites can be defined as filler particles having a size < 100nm. They can also be divided into nanohybrid and nano filled resin-based composite. They have excellent finishing, polishing, shade matching, flexural strength as compared to conventional ones. Nanofiller used in it is Aluminosilicate powder with a mean particle size of 80nm and 1:4 molar ratio of Alumina: silicate, having refractive index 1.508. Trade name- FILTEK SUPREME Universal restorative P lire Nano.<sup>13</sup>

#### **Advantages**

- Excellent hardness
  - Flexural strength is very high
  - Reduction in polymerization shrinkage up to 50%
  - Good hardening properties.
  - Excellent polish retention property.
15. **Nanoencapsulation:** Southwest research institute (SWRI) developed a specifically targeted release system, these systems include nanoencapsulation in vaccines, antibiotics, drug delivery with very less adverse effect. SWRI also develops other products such as nanocarriers having calcium phosphate which integrate with natural bone, Mask and protecting outfit having antipathogenic nanoemulsions and nanoparticles.<sup>14</sup>
  16. **Nanosterilising Solutions:** Gandy enterprises Inc Florida develop a new sterilizing solution using the concept of nanoemulsion.



### Advantage

- These sterilizing solution are broad spectrum.
- Very less allergic
- Non corroding properties
- Does not stain the fabric or other objects.
- Eco friendly
- Showing compatibility with various impression materials.

Trade name-Eco-Tru disinfectant<sup>12</sup>

### Conclusion

Nanotechnology is a part of a predicted future in which dentistry may become more high tech and more effective looking to manage individual dental health on a microscopic level by enabling us to battle decay where it begins with bacteria. Construction of a comprehensive research facility is crucial to meet the rigorous requirements for the development of Nanotechnology.

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**How to cite this Article:** **Nida Shreen, Upender Malik, M. K. Sunil, Nayira Johar, Aiman Mehfooz;** *Unbridle Treasure of Nanotechnology in Dentistry- A Review*; Int. J. Drug Res. Dental Sci., 2020; 2(4): 48-54, doi: <https://doi.org/10.36437/ijdrd.2020.2.4.H>  
**Source of Support:** Nil, **Conflict of Interest:** Nil.  
**Received:** 4-8-2020 **Revised:** 10-9-2020 **Accepted:** 15-10-2020