(International Print/Online Journal)

SJIF IMPACT FACTOR: 5.565
PUBMED-National Library of Medicine ID-101739732

ISSN (Print): 2209-2870
ISSN (Online): 2209-2862

International Journal of Medical Science and Current Research (IJMSCR)
Available online at: www.ijmscr.com
Volume 5, Issue 2, Page No: 842-850
March-April 2022

IJMSCR

Utilization of Nanotechnology in Prosthodontics

Dr Mandira Ghosh, Dr. Baisakhi Mallick

Dr. RAhmed Dental College and Hospital instead of Surya Kiran, 16/H/4khanpur road

Type of Publication: Original Research Paper
Conflicts of Interest: Nil

Abstract:

Nano is derived from the Greek word for 'dwarf'. When it combines with a noun it form words such as nanometer, nanotechnology and nanorobot. Nanotechnology is the science of manipulating matter on atomic and molecular levels or of matter measured in the billionths of meters or nanometer, roughly the size of 2 or 3atoms. Nano technology consists mainly of the processing, separating, consolidating, and deforming of materials by one atom or molecule. Since its origin, the definition of nanotechnology has generally been extended to include features as large as 100 nm. Nanotechnology is extremely diverse and multidisciplinary field, ranging from novel extensions of conventional physics to completely new approaches based upon molecular self-assembly to developing new materials and machines with nanoscale dimensions. The growing interest leads to emergence of "Nanodentistry" which involves the maintenance of oral health by the use of nanomaterials, biotechnology and dental nanorobotics. The recent developments, particularly of nanoparticles and nanotubes, the materials developed from the such as hollow nanospheres, core shell structures, nanocomposites, nanoporous materials, and nanomembranes will play a growing role in materials development for the dental fraternity. This paper is on nanomaterials and nanotechnology and its applications in the field of Prosthodontics.

Keywords: Nanoscience, Nanodentistry; Nanomaterials; Prosthodontics.

Introduction:

Prosthodontics is mainly used for dental defects, treatment after tooth loss, such as dentures, onlays, crowns, also including the use of artificial prostheses for periodontal disease, temporomandibular joint disease, and maxillofacial tissue defects. The main purposes of dentures are to restore dental function and esthetics and maintain the wearer's health. Dental materials of dentures can be divided into mainly three categories: resin, ceramic, and metal. They are important to fabricate dental prosthesis, which directly contacts with the oral mucosa and is under long-term use in the oral environment, so the dental materials must have comprehensive properties and good biocompatibility to function properly.

Nanotechnology is the field of science and technology pertaining to the creation and use of materials or devices at nanometer scale.[1] Nanoscale is small in size, but its potential is vast. In 1986 the term nano technology was coined by professor Kerie E Drexler, [1,2] in his book named 'Engines of creation' who promoted the technical scale of phenomena Since 1990s, nanotechnology has been exploited for potential medical and dental applications. [3,4,5,6] Nanomaterials in dentistry can be metals, ceramics, polymers, implant modifications, and composite materials that demonstrate novel properties when compared to conventional materials due to their nanoscale features. [5,6,7,8] The basic idea of nanotechnology, used in the narrow sense of the world, is to employ individual atoms and molecules to construct functional structures.

Nanomaterials:

It can be divided into various categories like Nano powder, Nano fibre, Nano membrane, Nano blocks etc. Out of which development of nano powder is longest and its technology is most mature. Nano materials have small size, large surface area, high surface energy and a large proportion of atoms. It has four unique effects -quantum size effect, quantum tunnelling effect, surface effect and small size effect Nano probes are functionalised to achieve biocompatibility and cell engineering. The usual aspects of nano probes include nano tubes, nanorods, quantum dots, polymeric nano particles. [9,10] These molecules have better penetration to cells. Because of the growing interest in the future of dental applications of nano technology, a new field called Nano dentistry is emerging.

Approaches To Nanotechnolgy:

Current research is directed towards the production of a wide array of different nanoscale structures. The fabrication techniques of these structures can be divided into two approaches: Top-down approach and Bottom down approach [10,11,12,13]

Top-down approach: Top-down fabrication reduces large pieces of materials all the way down to the nanoscale. This approach requires a large amount of materials and can lead to waste, if excess material is discarded. The 'top-down' techniques that are used to manufacture nanoscale structures are mostly extensions of methods already employed in small-scale assembly at the micron scale. By further miniaturization, the nano dimension is entered. Nano dentistry as top-down approach: used in nanocomposites, nano light-curing glass ionomer restorative materials, nano impression materials, nanocomposite denture teeth, nano solutions, nanoencapsulation, plasma laser application, prosthetic implants, nanoneedles, bone replacement materials.

Bottom-up approach: The bottom-up approach to nanomanufacturing creates products by building them up from atomic and molecular scale components, which can be time consuming. Scientist are exploring the concept of placing certain molecular scale components together that will spontaneously "self-assemble" from the bottom up into ordered structures.

Nano dentistry as bottom-up approach is Nanorobotic dentifrice, Dental cosmetics, Hypersensitivity cure, Photosensitizers and carriers. [11,12]

Nanomaterials Applied In Prosthodontics: [13,14]

Research in nano technology of dental materials is mainly focused on two ways: Preparation of new inorganic nano particles and modifying the surface with inorganic nano fillers. These materials are widely used in ceramics, metals, resins and composites. [1,13]

Nanoceramics:

Nanoceramics refer to the ceramic material with nanoscale dimensions in the microstructures phase. Compared with the conventional ceramics, nano ceramics have unique properties like good toughness and ductility.[10] Secondly, compared to the conventional ceramics, nanoceramic has the superior mechanical properties, such as strength and hardness. Most importantly toughness of nanoceramics is much higher than that of traditional ceramics. Carbon nanotubes (CNTs) have attracted remarkable attention as reinforcements of materials because of their exceptional mechanical and electronic properties.[15]

Nano Resin Based Materials:

Nano hybrid and nano filled are generally the two types of composite restorative materials characterized by filler-particle sizes of ≤100 nm referred to under the term **"**nanocomposite"**.** Nanomers and nanoclusters are the two types of monodispersed non agglomerated discrete nanoparticles that are homogeneously distributed in resins or coatings to produce nano composites. Nanomaterials available as titanium dioxide, aluminium oxide and silica oxide are used in small amounts (1%–5%) to improve powder flow of composites.

Nano-structural aluminium oxide fibres provide added strength and improved performance to metals, plastics, polymers and composite materials. Nano porous silica filled composite is a fairly new material still in experimental form, proven to increase wear resistance in posterior applications**.** Organo silanes such as allyltriethoxysilane have demonstrated good compatibility with nanoparticle fillers such as TiO_2. In addition, 3ethacryloxypropyltrimethoxysilane has also been demonstrated to enhance dispersion of

Volume 5, Issue 2; March-April 2022; Page No 842-850

silica nano particles (5–25 nm) within the restorative resin matrix.

Nano Filled Composites:

Nano fillers of 1-100nm have been incorporated into the resin matrix to produce nanocomposites. The two types of nanoparticles that have been used are nanomers and nanoclusters.

Nanomers:

They are mono dispersed, non-aggregated and non-agglomerated particles of silica treated with 3methacryloxy-propyltrimethoxysilane (MPTS). MPTS has helped in chemical bonding of the nanomer filler to the resin whilst curing. They have advantage like *g*ood optical properties, good dispersion rate, high polish and polish retention, superior hardness, flexural strength and good esthetics. But they have disadvantages like poor rheological and handling properties. [10,13]

Nanoclusters:

Nanocluster fillers range from 2-20 nm. They have been formed by lightly sintering nanomeric oxides to form clusters of a controlled particle size distribution. Nanoclusters of silica sol exclusively and mixed oxides of silica and zirconia have been synthesized. They have shown the same advantages as nanomers with better rheological properties but the disadvantage of poor handling has still persisted.

Nanohybrid Composites:

Pre-polymerized organic fillers have been incorporated in nanomers to improve the desirable rheological properties of composites. Improved esthetics and rheological properties are its advantages. Disadvantages of this material are decreased polish retention and loss of surface gloss. [12,16]

Tio_2 Reinforced Resin Based Composite: Titanium dioxide nanoparticles treated with organosilaneallytriethoxysilane have been used to improve microhardness and flexural strength of composites.[17]

Nanocomposites With Alumina Nano Particles: Alumina nanoparticles have shown increased hardness, strength and modulus of elasticity of the nano composites. [12]

Calcium Phosphate And Calcium Fluoride Nanoparticles Based Composites:

Materials that release Calcium phosphate and calcium fluoride have shown remineralization of tooth structure and hence have been incorporated in composites. They have also maintained the level of Calcium (Ca) and Phosphate (P) ion release through recharge and release and hence has been called a "smart" material and it has also inhibited secondary caries. Nanohydroxyapatites (HAP) of 20 nm size has mimicked natural building blocks of human enamel and shown anti caries repair effect.

Ormocers (Organically Modified Ceramics): These nanoparticles consist of a polysiloxane backbone used for glass and ceramics. Iron oxide, titanium oxide and aluminium sulfo silicate pigments have been added for shade. These nanoceramic particles have prevented the micro crack propagation. [13]

Light Cure Nanocomposites:

The nano fillers are incorporated into the resin matrix to develop newer light cure nano composites with numerous advantages as highest mechanical strength, low polymerization shrinkage, reliability, durability, low thermal expansion coefficient, low water sorption, excellent marginal integrity and excellent handling characteristics.

Nanofilled Resin-Modified Glass Ionomer:

A new nano filled RMGI restorative material has been introduced. The major innovation of this material involves the incorporation of nanotechnology, which allows a highly packed filler composition (69%), of which approximately two-thirds are nanofillers. Good lustre and enhanced mechanical properties are the two advantages of this material.[10]

Impression Materials:

Nanofillers are integrated in vinyl polysiloxanes, producing a unique addition of siloxane impression materials (Fig 1). The material has better flow, improved hydrophilic properties hence fewer voids at margin and better model pouring. Advantages of this material are increased fluidity**,** high tear resistance, hydrophilic properties**,** resistance to distortion and heat resistance**,** snap set that consequently reduces errors caused by micro movements.[13]

Volume 5, Issue 2; March-April 2022; Page No 842-850

Nano Composite Teeth:

Nanocomposite denture teeth are made of Polymethylmethacrylate (PMMA) and homogeneously distributed nanofillers. The three-layered nanocomposite teeth consist of microfilled hybrid composite, reinforced with layered glass. They have excellent polishing ability and stain-resistant**,** good aesthetics, lively surface structure and enhanced wear resistance and surface hardness.

Nanoparticles In Polymethylmethacrylate Resin: Nanoparticles are added to polymethylmethacrylate as antimicrobial agents to increase the viscoelastic property of resins. Incorporation of nanoparticles into the denture base materials is mainly in the form of silver and platinum nanoparticles as an effective antimicrobial agent. Some researchers showed that the addition of metal nanoparticles such as TiO_2, Fe_2O_3 and silver to PMMA materials could increase the surface hydrophobicity to reduce bimolecular adherence. The silver nanoparticles incorporation within the acrylic denture base material can improve its viscoelastic properties. Other nanoparticles such as ZrO_2, TiO_2, and carbon nanotubes (CNT) have been used to improve the performance of PMMA, and the results showed that desired mechanical property enhancement can be achieved in those composites with small amounts of nanoparticles. [13,18]

Removable Prosthodontics:

The incorporation of carbon nanotubes into heat cure monomer has reduced the polymerization shrinkage and improved the mechanical properties. Incorporation of metal oxide nanoparticles into conventional polymethyl methacrylate has improved the flexural strength, antimicrobial property and reduced porosity.

Nano Adhesives In Prosthodontics:

The new bonding agents (Fig2) manufactured from nano solutions contain stable nano particles homogeneously dispersed throughout the solution. The silica nano filler technology contributes to higher bond strength performance.

Nano Adhesive Poss:

Polyhedral Oligomeric Silse Squiox (Poss) enables the design of additives that make plastics that are unusually lightweight, durable, heat-tolerant and environment friendly. Poss combines organic & inorganic materials in molecules with an average diameter of 1.5 nanometers. They can be used as either additives or replacements for traditional plastics. Current applications of Poss include dental adhesives in which resin provides a strong interface between the teeth and the restorative material. In addition, tests have shown that Poss materials are much more resistant to radiation damage and erosion than conventional polymers.

Tissue Conditioner:

Tissue conditioners have been commonly used to enhance the recovery of denture bearing tissues from trauma, damage or residual ridge resorption usually caused by ill-fitting dentures. However, these materials are degenerated with time and are susceptible to colonization by microorganisms. To overcome this problem silver nanoparticles are added in tissue conditioners because of their smaller size they provide large surface area. According to study conducted by Ki-Young Nam the modified tissue conditioner combined with silver nanoparticles displayed antimicrobial properties against S. aureus, S. mutans at 0.1% and C. albicans at 0.5% after a 24 hrs and 72 hrs incubation period.[13]

Coating Agents In Prosthodontics:

This light cured agents contain nanosized fillers and are used as a final coating over composite restorations, glass ionomer restorations, jacket crowns, veneers and provisional. These coating agents have higher wear resistance, preventing abrasion and discolouration. Recently, a nanotechnology liquid polish system was designed to overcome the limitations of liquid polishers. The addition of nanofillers provides excellent results such as a glossy surface for direct or indirect resin composite restorations.

Nanocare Gold:

The use of nanocare gold before embedding composite/ ceramic restorations enhanced adhesive and antibacterial properties. [11,19]

Nanosolutions:

Nano solutions produce unique and dispersible nanoparticles, which can be employed in bonding agents. The adhesive is fast, easy, and convenient nano-based bonding agent offering exceptional bond

Volume 5, Issue 2; March-April 2022; Page No 842-850

strength. The adhesive has been recognized as a new option in total-etch visible light activated dental adhesives. It contains Bis GMA, HEMA, dimethacrylates, ethanol, water, a novel photo initiator system acid, and methacrylate functional copolymer of polyacrylic and polyitaconic acids. It incorporates 10% by weight of 5-nm-diameter spherical silane-treated silica particles through a process that prevents agglomeration. As discrete particles, their extremely small size keeps them in colloidal suspension. The use of silica nanofiller nanotechnology contributes to higher bond strength performance and provides a stable, filled adhesive. meant for multiple uses.

Nano Technology In Implants:

The application of nano technology in dental implants can be made by coating of nano particles over the dental implants. (Fig 3) It has been demonstrated that different cell types respond positively to nano topography Nano structured materials contain a large volume fraction of defects such as grain boundaries, inter phase boundaries and dislocations and this strongly influences their chemical and physical properties. [7,13]

Biomimetic implant may be the next development in the field. Coating implants with nano textured titanium, hydroxyapatite and pharmacological agents such as bisphosphonates may induce cell differentiation and proliferation, and promote greater vascularity in cortical bone thereby improving conditions for early and long-term bone remodelling.

Surface Modifications:

It is a powerful way of altering protein interactions with the surface. There is an increase vitronectin adsorption on nano structured surfaces when compared to conventional surfaces. This led to increased osteoblast adhesion when compared to other cell types such as fibroblast on the nano surfaces. Varieties of techniques are used to create nano features on dental implant surfaces. These can be divided into physical and chemical process.

Bone Replacement Materials:

Bone is comprised of natural nano composite made up of nanohydroxyapatite, [7,12,13,20] which is reinforced by collagen fibrils and this interaction is known to significantly dictate its strength and toughness. The fibrous collagen matrix transfer load to apatite crystals and provide resistance to fracture (i.e., high toughness), whereas the apatite deposit between fibrils can mechanically stabilize the collagenous fibres.

Maxillofacial Prosthodontics:

Various types of materials have been used for the fabrication of maxillofacial prosthesis. Nano-oxides when incorporated into polymers provided materials with better strength and flexibility. The nanosized material particle results in the optimization of characteristics and controls the biological, mechanical, electrical, magnetic, and optical characteristics as well.[21] Nano sized rutile TiO_2 and ZnO have a high ultraviolet (UV) absorbing and scattering effect that results in UV protection. Nano sized SiO_2, TiO_2, and ZnO are characterized by their small size, large specific area, active function, and strong interfacial interaction with organic polymer. Therefore, they can improve the physical properties and optical properties of the organic polymer, as well as provide resistance to environmental stress related aging. Silver nano particles (AgNPs) are used as antimicrobial agents in many medical fields. They reduce or prevent the biofilm layer formation. In fact, this metal has a broad antimicrobial activity spectrum against both Gram-positive and Gram-negative bacteria.[22] The biosafety of silver nanoparicles have been of concern. Studies associated with the toxicity of these silver nanoparticles in the biological and ecological systems are yet to be reported.

Surface Disinfectants In Sterilization:

A new sterilizing solution following nano emulsion concept has been developed. Nanosized oil droplets attack and destroy the pathogens. Eco-True is a surface disinfectant that safely kills 100% of HIV and other particles. It has been used to sterilize tools and incisions to prevent postoperative infections.[23]

Dental Nanorobot:

Carbon will likely be the principal element comprising the bulk of a medical nanorobot, probably in the form of diamond or diamondoid or fullerence nanocomposites. Many other light elements such as hydrogen, sulphur, oxygen, nitrogen, fluorine, silicon etc. will be used for special purposes in nanoscale gears and other components. The dental nanorobot(Fig 4) have a nano computer which will

Volume 5, Issue 2; March-April 2022; Page No 842-850

execute planned missions, receive and process signals, communicate with other nano computers and it respond to external control and monitoring devices and also possess the knowledge to ensure the correct functioning of nanomechanical devices.[24] Dental nanorobots have a spider like body as they need to be quick in fulfilling their tasks. These nanorobots are manufactured out of diamondoid structures. Diamondoids have unique properties due to the exceptional atomic structure. They are chemically and thermally stable, can self assembly, more resistant, but lighter than steel. Disadvantages of nanorobots are clusters of different nanorobots are harmful, installation cost is high, maintenance is difficult.

Challenges Faced By Nanodentistry :

Biocompatibility:

It is essential to develop biofriendly nanomaterial and ensure compatibility with all intricate of human body. Smaller particles are more bioactive and toxic. Their ability to interact with other living system increases because they can easily cross the skin, lung and in some cases the blood brain barriers. Once inside the body there may be further many biochemical reactions like the creation of free radicals that damage cells.[13,25]

Cost factor:

Nanotechnology will dramatically reduce the cost and increase the capabilities. New application expected to emerge in next decade will range from very low cost, long life and high efficiency devices. Nanomedicine will revolutionize the way we diagnose and treat the disease with substantially lower cost.

Social issues of public acceptance:

Continued advancement of nanotechnology research, and eventual integration of nanotechnology into consumer products and useful applications, will depend heavily on the public acceptance of nanotechnology. Governments around the world must take a proactive stance to ensure that environmental, health and safety concerns are addressed as nanotechnology research and development moves forward in order to assure the public that nanotechnology products will be safe.

Ethics:

The dominance of the drastic opposition in the debate on the future perspective of nanotechnology holds the risk of undesirable conflicts and unnecessary black lashes. Hence more balanced ethical views are required in the field of nanotechnology.[25]

Human safety:

Nanotoxicity is still a new field but there is possibility that some nanomaterials may present health risk. The properties that allow nanomaterials to penetrate the body in new ways are not necessarily bad, but in fact may be beneficial, such as in the development of targeted cancer therapies. It is also crucial to bear in mind that not all nanomaterials are created equal toxicity will likely vary depending not only on the material, but also vary based on the particle size.[13,26,27]

Summary:

Nanomaterials have been playing a significant role in basic scientific innovation and clinical technological change of Prosthodontics. It shows that many properties such as modulus of elasticity, surface hardness, polymerization shrinkage, and filler loading, of materials used in prosthodontics can be significantly improved after their scales were reduced from micron-size into nano size by nanotechnology. The performances of composites can also be enhanced by adding appropriate nanomaterials Presently, although the vast customization of nanoparticles in prosthodontics is increasing progressively, there is a lack of studies addressing the safety and optimal concentrations of different nanoparticles in dental materials. Further efforts are needed to extend the arms of research where release of particles from present and future dental materials could be scrutinized. Use of nanomaerials judiciously in prosthodontics can only make nanodentistry acceptable to human civilization.

References:

1. Patel R.M, Dahane T.M, Godbole S, et al. Applications of nanotechnology in prosthodontics. J Evolution Med Dent Sci 2020;9(47):3566-3571

Volume 5, Issue 2; March-April 2022; Page No 842-850

2. Apaza-Bedoya K, Bijukumar D, Benfatti CAM, et al. Adverse local and systemic effect of nanoparticles released from oral and cranio-maxillofacial implants. Chap- 4. In: Souza J, Hotza D, Henriques B, et al, eds. Nanostructured biomaterials for cranio-maxillofacial and oral applications. Elsevier 2018:63-79.
3. Fahy GM. Short-term and long-term possibilities for interventive gerontology. Mt Sinai J Med 1991;58(4):328- 40.
4. Fahy GM. Molecular nanotechnology and its possible pharmaceutical implications. In: Bezold C, Halperin JA, Eng JL, eds. 2020 visions: health care information standards and technologies. Rockville, Md.: U.S. Pharmacopeial Convention 1993:152-9.
5. Shakir DA, Abdul-Ameer FM. Effect of nano-titanium oxide addition on some mechanical properties of silicone elastomers for maxillofacial prostheses. J Taibah Univ Med Sc 2018;13(3):281-90.
6. Asiri A, Inamuddin, Mohammad A, eds. Applications of nanocomposite materials in dentistry. Elsevier 2019:191- 203.
7. Pai UY, Mundathaje M, Mallya L. Applications of nanotechnology in dentistry. J Int Med Dent 2015;2(3):186-203
8. Panchbhai A. Nanocomposites: past, present, and future of dentistry. In: Asiri A, Inamuddin, Mohammad A, eds. Applications of nanocomposite materials in dentistry. Elsevier 2019:181-90.
9. I.Roy,M.K.Stachowiak,E.J.Bergey,"Nonviral ge transfection nanoparticles: function and applications in the brain," Nanomedicine: Nanotechnology, Biology, and Medicine, vol. 4, no. 2, pp. 89–97, 2008.
10. Wang W, Liao S, Zhu Y, Liu M, Zhao Q, Fu Y. Recent Applications of Nanomaterials in Prosthodontics. J Nanomater 2015, article ID 408643,11 pgs. http://dx.doi.org/10.1155/2015/408643
11. Gopinadh A, Prakash M, Lohitha K, Kishore KK, Chowdary AS, Dev JR. The changing phase of prosthodontics: Nanotechnology. J Dent Allied Sci 2015;4:78-83.
12. Sree K S, Abhishek V, S Sidhartha, Srikanth L, Ramakrishna M, Lakshmi K. Nanotechnology in prosthodontics. IP Annals of Prosthodontics and Restorative Dentistry 2021;7(1):22–28
13. Coutinho IF, Aras MA, D'souza KM. Nanomaterials and their application in prosthodontics: a review. Journal of Research in Dentistry 2018, 6(6):124-131
14. Karni PA, Patil P, Acharya A, Shankargouda S and. Doddamani MH. "Nanotechnology" - The new era of prosthodontics. Innternational Journal of Current Research 2017;9(5):50006-50009.
15. W An, DH You, DS Lim. Tribological properties of hot pressed alumina-CNT composites. Wear 2003; 255(1-6):677-681
16. CRA Foundation Newsletter. Clinicians' guide to dental products and techniques, understanding current resin-based composites relative to filler. 2007;31(10):12.
17. Yang X, Feimin Z, Haifeng X, Ning G. Nanoparticle – Reinforced resin based dental composites. J Dent 2008; 36;450-55
18. Pai UY, Mundathaje M, Mallya L,Kanchana. Applications of Nanotechnology in Dentistry. Journal of International Medicine and Dentistry 2015; 2(3): 186-203
19. Robert A, Freitas RA Jr. Nanodentistry. Cover story. J Am Dent Assoc 2010;131:1559-65
20. Kanaparthy R, Kanaparthy A. The changing face of dentistry: nanotechnology . Int J Nanomedicine 2011;6:2799-804
21. Shakir DA, Abdul-Ameer FM. Effect of nano-titaniumoxide addition on some mechanical properties of silicone elastomers for maxillofacial prostheses. J Taibah Univ Med Sc 2018;13(3):281-90.
22. Zhala M, Alexandros B, Tracy De P, Richard D H. Antifungal properties and biocompatibilty of silver nanoparticles coatings on silicone maxillofacial prostheses.

Volume 5, Issue 2; March-April 2022; Page No 842-850

J Biomed Mater Res Part B; Appl Biomater, 106B:1038-51.

23. Jhaveri H M, Balaji P R. Nanotechnology: The future of dentistry. J Indian Prosthodont Soc 2005;5:15-7
24. Shetty NJ, Swati P, and David K. Nanorobots: Future in dentistry. Saudi Dent J. 2013 Apr; 25(2): 49–52.
25. R Kanaparthy, A Kanaparthy. The changing face of dentistry: Nanotechnology. Int J Nanomed 2011;6:2799-2804.
26. BDSD Mohammed, BDSM Mudhaffar. Effect of Zirconium oxide nanofiller addition on some properties of heat cure acrylic denture base materials. J Baghdad Coll Dent 2012 vol 24,(4) 1-7.
27. Warheit DB, Lawrence BR, Reed KR, Roach DH, Reynolds GA, Webb TR. Comparative pulmonary toxicology assessment of single wall carbon nanotubes in rats. Toxicol Sci 2004;77:117-125.

Fig 1: Addition siloxane impression material with incorporated nanofillers

Fig 2: Nano adhesives in prosthodontics

Fig 3: Nano implant

Volume 5, Issue 2; March-April 2022; Page No 842-850

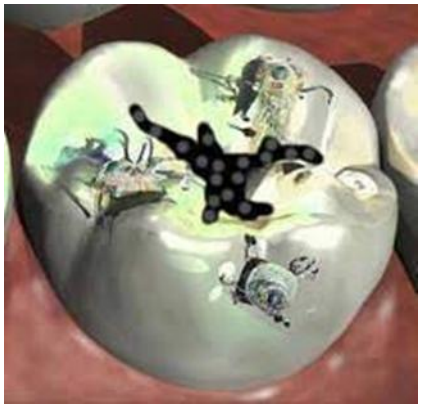

Fig 4: Nanorobots on tooth surface

Volume 5, Issue 2; March-April 2022; Page No 842-850