
Good Morning

NANOTECHNOLOGY IN CONSERVATIVE DENTISTRY

DR. PARTHA SARATHI ADHYA

(WBUHS)

CONTENTS

INTRODUCTION

- Nanotechnology is receiving a lot of attention of late across the globe . The term nano originates from greek word meaning dwarf.
- The term indicates physical dimensions that are in the range of one billionth of a meter . This scale is called nanometer scale or nanoscale.

One nanometer is approximately the length of two hydrogen atoms.

- Nanotechnology relates to the design, creation and utilization of materials whose constituent structures exist at the nanoscale.These structures can, by convention be upto 100nm in size.
- Nanotechnology is a growing field that explores electrical, optical and magnetic activity as well as structural behavior at molecular and submolecular level.

Nanodentistry: A Hype or Hope
Ekta Ingle1, K. Saraswathi Gopal2
Journal of Oral Health Community Dentistry

- Despite better understanding of the materials and chemistry, and recent improvements in physical properties, no material has been found that is ideal for any dental application . Several techniques has been used to counter this shortcomings. Nanotechnology is one of them. There are plenty of hope surrounding nanomaterials in terms of either developing new materials or significant improvements in the properties of existing materials.

WHY NANOTECHNOLOGY??

Nature has arranged complex biominerals from the micro to the nano-scale and no one can yet combine biological and physical properties to get ideal structures. In addition, no synthetic material can be intelligent enough to respond to external stimuli and react like nature made tissues. There are a number of possible options to make smart materials which will mimic natural tissues.

Table 1. Options for the production of smart materials for dental applications.

Option	Description
Material Synthesis	Producing synthetic materials matching morphology and properties similar to natural dental tissues.
Biomimetic Approaches	To replace lost dental tissues follow the nature's principles and producing biomaterials resembling their properties very closely to the replacing tissues.
Tissue Engineering	Use of regenerative medicine and tissue engineering approaches for replacing the lost dental tissues by regenerations.

Mustafa Naseem 5,† and Ammar AbuReqaiba 6,† Materials 2015, 8

We classify the use of nanotechnology in two categories:

- 1)Nanorobots using nanotechnology
- 2)Nanotechnology in conventional materials to enhance their properties.

HISTORY

“History of Nanotechnology N.K.Tolochko Belarus State Agrarian University,Belarus

- Known to be Father of nanotechnology.
- The concept nanotechnology was set up by

physicist Dr Richard Feynman in 1959. The idea was entitled as “There’s Plenty of Room at the Bottom” and presented a talk at American Physical Society meeting at California Institute of Technology.

- The term nanotechnology was coined by Japanese scientist Dr. Nori Taniguchi in 1974 and was defined as “the processing of separation, consolidation, and deformation of materials by one atom or one molecule” .

- The idea of nanotechnology was further probed in depth and promoted by Dr. Drexler and published a book titled “Engines of Creation-The Coming Era of Nanotechnology” around late 1980s.

- In 1991, the publication by Dr Sumio Lijima “Helical microtubules of graphitic carbon” introduced the concept of nanotubes and boosted nanomaterials research .

- The term “Nano Dentistry” was used by

  DR R.A FREITAS in 2000.

DEFINITIONS

- **Nano-technology**' is the production technology to get the extra high accuracy and ultra fine dimensions, i.e. the preciseness and fineness on the order of

  1nm(10^{-8} m) to10^{-9}m in length.

  - Professor Norio Taniguchi

- **Nanotechnology** is science, engineering, and technology conducted at the nanoscale, which is about 1 to 100 nanometers.

  - **National Nanotechnology Initiative.(by Govt. of India)**

- **Nanotechnology** is the engineering of functional systems at the molecular scale. This covers both current work and concepts that are more advanced.

  - **Centre for Responsible Nanotechnology.(by Govt. Of USA)**

- **Nanodentistry** is defined as the science and technology of diagnosis treating and preventing oral and dental diseases, relieving pain , preserving and improving dental health using nanotechnology or nanostructured material.

APPLICATIONS

- On the basis of application, use and technology there are 4 approaches of nanotechnology in dentistry.

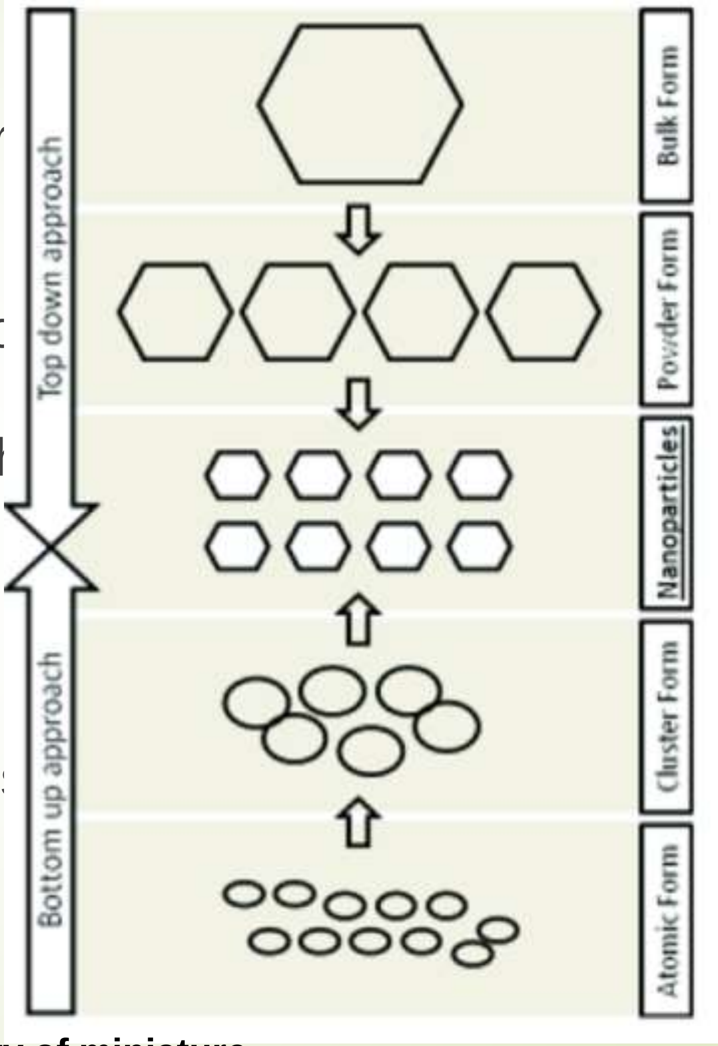
1. Top down approach
2. Bottom up approach
3. Functional approach
4. Biomimetic approach

APPROACHES

Review article -Nanodentistry,Sneha Sundarrajan,Sashi Rashmi Acharya,Vidya Saraswati
Indian J.Sci.Res.4(2):233-38,2013

- **The Top Down Approach:** Seeks to produce smaller devices by using larger ones in achieving precision in structure and assembly. (Das et al.,2007) These solid state materials can also be used to create devices known as N E M S (Nanoelectromechanical systems) which are used in cancer treatment .

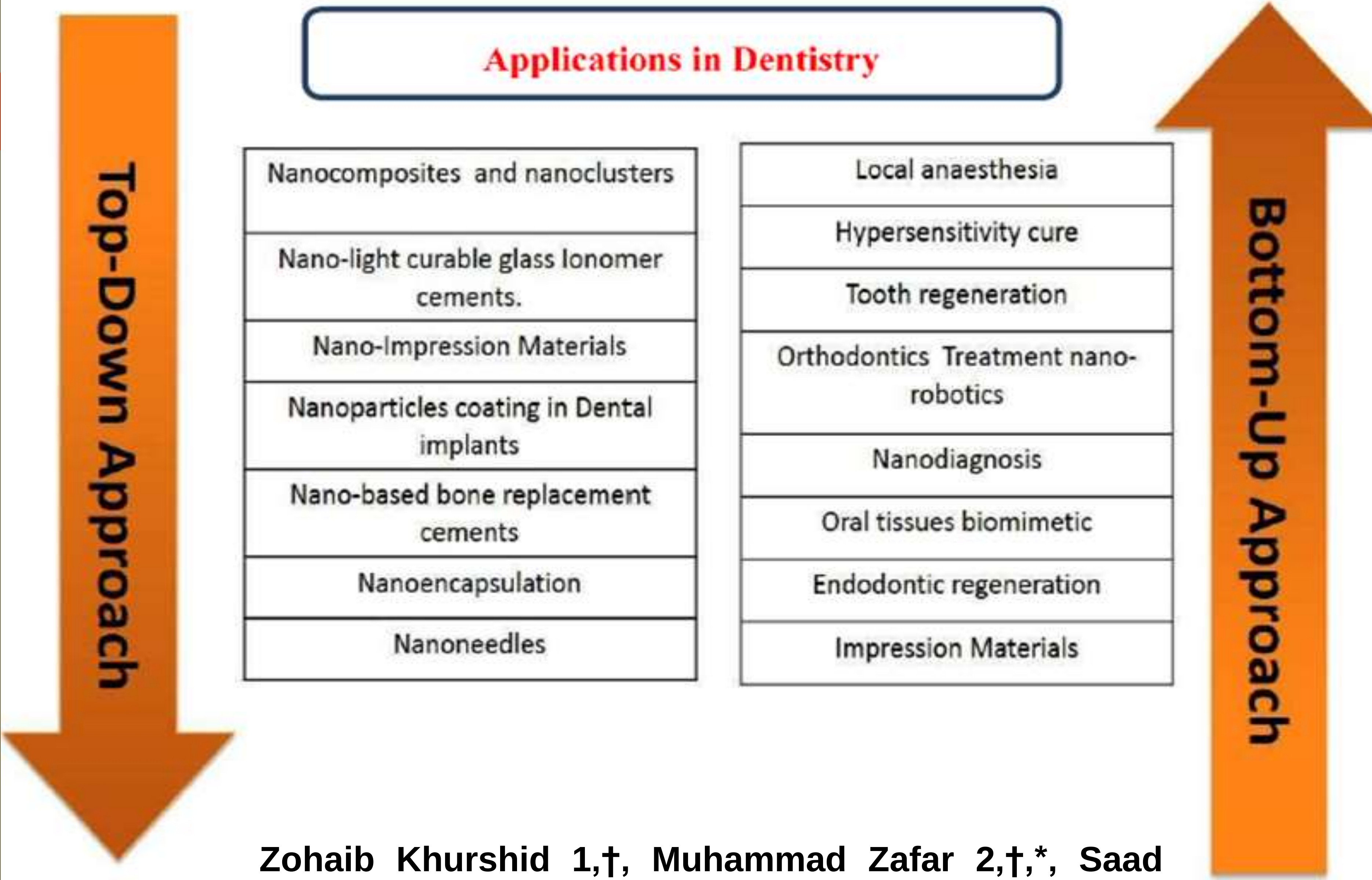
- **The Bottom Up Approach:** Seeks to arrange smaller components into more complex assemblies, the covalent bonds of which are extremely strong. (Das et al.,2007)



Review article'NANODENTISTRY': Exploring the beauty of miniature.
Rita Chandki 1, M. Kala 2, Kiran Kumar N. 3 , Biji Brigit 4, Priyank Banthia 5, Ruchi Banthia 6
J Clin Exp Dent. 2012;4(2):e119-24

1. **The Functional Approach**: Seeks to develop components of a desired functionality without regard to how they might be assembled.
2. **The Biomimetic Approaches:** Seeks to apply biomolecules for applications in nanotechnology.(Ghalanbor et al., 2005)

Among all these 4 approaches last two are in still experimental level.



Zohaib Khurshid 1,†, Muhammad Zafar 2,†,*, Saad Qasim 3,†, Sana Shahab 4,†, Mustafa Naseem 5,† and Ammar AbuReqaiba 6,† Materials 2015, 8

The Bottom Up Approach

- **This comprises of-----**

1. **Inducing anesthesia**
2. **Major tooth repair**
3. **Dentin Hypersensitivity**
4. **Dental Durability and Cosmetics**
5. **Nanorobotic Dentifrice (dentirobots)**
6. **Tooth repositioning**
7. **Local drug delivery**
8. **Nanodiagnostics**
9. **Therapeutic aid in oral diseases**

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1.Inducing anesthesia

Review article -Nanodentistry,Sneha Sundarrajan,Sashi Rashmi Acharya,Vidya Saraswati
Indian J.Sci.Res.4(2):233-38,2013

- Nanotechnology uses millions of active analgesic nanometer sized dental nanorobots in a colloidal suspension for local anaesthesia.

- On reaching the dentin nanorobots, within 100 secs, are said to enter dentinal tubules(1 to 4 μm) in diameter ,
- proceed toward the pulp, guided by a combination of chemical gradients, temperature differentials and even position of navigation all under the control of the onboard nanocomputer as directed by the dentist. (Freitas Robert, 2000)

- Once installed in the pulp, the analgesic dental robots may be commanded by the dentist to shut down all sensitivity in any particular tooth that requires treatment.

  After completion of the treatment procedure, the dentist orders the nanorobots to restore all sensation, to relinquish control of nerve traffic and to egress from the tooth by similar pathways used for ingress.

2. Major Tooth Repair

- Nanodental techniques for major tooth repair may evolve through several stages of technological development, first using genetic engineering, tissue engineering and tissue regeneration, and later involving the growth of whole new teeth in vitro and their installation.
- There are many substances which help in teeth repair and regeneration process. These are

I. Hydroxyapatite as a Biomaterial for Dental Restoration

- Hydroxyapatite particle (HAp) is a naturally occurring mineral form of calcium apatite, which is predominately obtained in mineralized tissue. It is also one of the major components of dentin.
- Uses- HAp is used in various forms, such as powders , coatings in implants ,and composites for dental restoration.

(Anil Kishen Nanotechnology in Endodontics Current and Potential Clinical Applications)

- Hap is highly biocompatible and can rapidly osteointegrate with bone tissue.
- Despite various advantages, hydroxyapatite has poor mechanical properties (highly brittle) and hence cannot be used for load-bearing applications
- range of techniques have been developed to improve the mechanical toughness of this Hap
- Uezono et al. showed that nanoHAps have signifi cantly higher bio- activity when compared to microHAps, as determined by an enhanced bone-bonding ability.
- the addition of hydroxyapatite nanoparticles to a polymer matrix result in enhanced mechanical strength.

- Liu et al. showed that the addition of nHAp to chitosan scaffolds enhances the proliferation of bone marrow stem cells and an upregulation of several genes, together with myosins.

- nHAp significantly enhances pSmad1/5/8 in BMP pathways and showed nuclear localization along with enhanced osteocalcin production.

- These bioactive nanomaterials can be used as an injectable matrix for periodontal regeneration and bone regrowth.
- Overall, nHAp-reinforced nanocomposites or surface coating improves mechanical stiffness and bioactivity of implants and can be used for dental restoration.

II.**Dental Regeneration(Remineralization) Using Bioactive Glass**

- It is composed of silicon dioxide (SiO_2), sodium oxide (Na_2O), calcium oxide (CaO), and phosphorous pentoxide (P_2O_5) in specific proportions.
- Formation of hydroxycarbonate apatite/hydroxyapatite layers on the surface. It has also bone bonding ability .
- But BAG is bioglass is brittle and has a low wear resistance.
- Ananth et al. reinforced bioglass with yttria-stabilized zirconia nanoparticles.
- The yttria-stabilized zirconia bioglass (1YSZ-2BG) coating showed significantly higher bonding strength compare to conventional one.

III. **Bioinert Zirconia Nanoparticles**

Zirconia (or zirconium dioxide) is a polycrystalline biocompatible ceramic with low reactivity, high wear resistance, and good optical properties.

- the properties of zirconia particles can be improved by—

1. By reducing the grain size of zirconia to nano scale**(20-50nm)**
2. Incorporation of nano sized yttria stabilized tetragonal zirconia (Y-TZP).
3. Incorporate various nanoparticles such as carbon nanotubes and silica nanoparticles.

- Guo et al. fabricated Y-TZP nanocomposite by reinforcing with silica nanofiber. The reinforced nanocomposite showed significant increase in the flexural modulus (FM), fracture toughness, flexural strength, and energy at break (EAB) compared to Y-TZP.

(Anil Kishen Nanotechnology in Endodontics Current and Potential Clinical Applications)

- This nano filled zirconia particles promote bone bonding , mineralization, dental tissue repair .

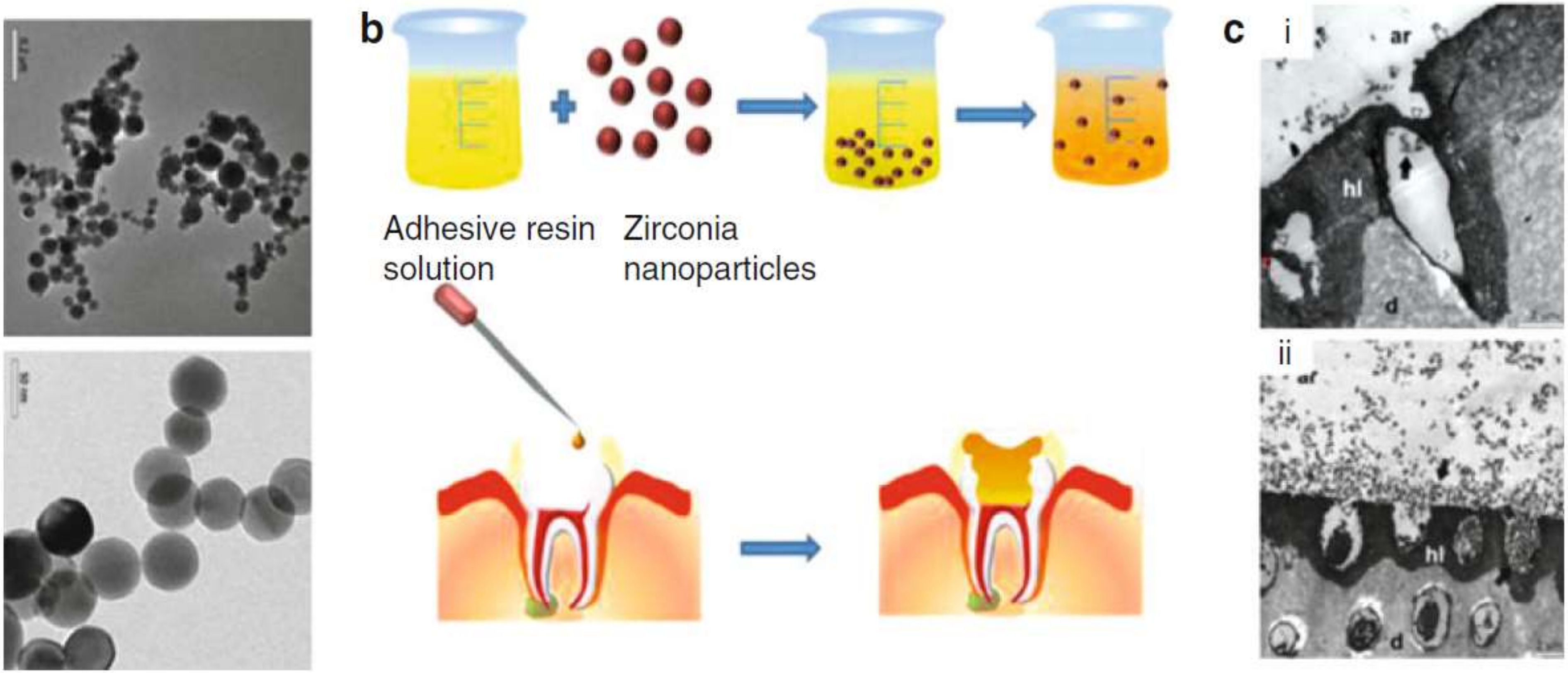


Fig. 2.6 (**a**) TEM images of zirconia nanoparticles prepared by laser vaporization. (**b**) Resin solution acting as adhesive is combined with zirconia nanoparticles. The composite resin loaded with zirconia nanoparticle showed uniform dispersion after ultrasonication. The adhesive dental resin loaded with nanoparticles are incorporated within to etched dentin with the implant. (**c**) TEM photographs showing dental resin composite with (**i**) 5 % wt and (**ii**) 20 % wt zirconia nanoparticles. The nanocomposite loaded with zirconia nanoparticles showed formation of submicron crystal enhancing remineralization and bioactivity at the implant-dentin interface. Adhesive resin (*ar*), hybrid layer (*hl*), demineralized dentin (*d*) are represented in image. Black arrow represents nanoparticles and open arrow represent formation of hybrid layer. (Adapted from Lohbauer et al. [77]. With permission from Elsevier)

Future Outlook

- In future major tooth repair by manufacturing the nanorobots and installation of a biologically autologous whole-replacement tooth that includes both mineral and cellular components. Several tooth structures have been regenerated in animal models using stem cell approaches. epithelial cell rests of Malassez (ERM) are used to regenerate enamel.
- In future stem cells will be injected in the congenitally deformed teeth surface or in the carious lesion using nanotechnology . This stem cells would help eliminate those defected tooth structure and regenerate dental tissues.

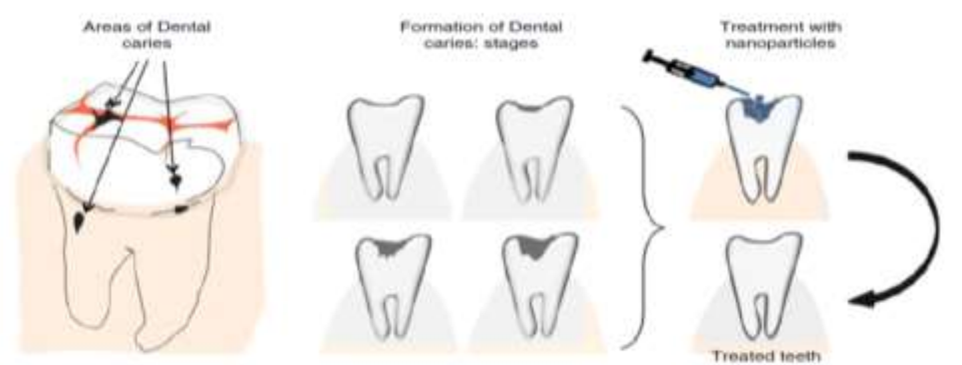


Fig. 2.10 Nanomaterials in the treatment of dental caries. Various stages of caries formation. These caries can be treated by injecting nanoparticles for localized release of drug in the affected area

(Anil Kishen Nanotechnology in Endodontics Current and Potential Clinical Applications)

3. Dentin Hypersensitivity

- Dentine hypersensitivity (DH) is characterized by ‘pain derived from exposed dentine in response to chemical, thermal, tactile or osmotic stimuli which cannot be explained as arising from any other dental defect or pathology.’ Dentin hypersensitivity, one of the most commonly encountered dental problems.
- **There are substances which are being used to treat hypersensitivity –**

I. **BIOACTIVE GLASS (S53P4)**

- Bioactive glass was developed by Hench et al. in 1960 with a primary composition of silicon dioxide (SiO_2), sodium oxide (Na_2O), calcium oxide (CaO), and phosphorous pentoxide (P_2O_5).

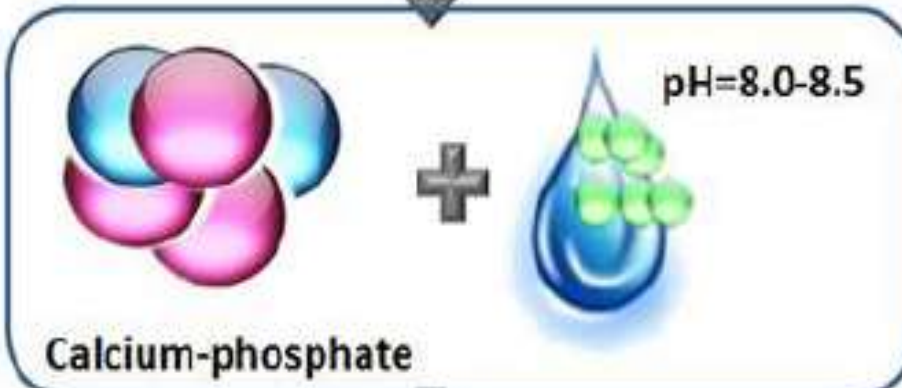
- For the treatment of hypersensitivity nano particles of BAG is used. This technology is known as NovaMin® . NovaMin® ,technically described as an inorganic amorphous calcium sodium phosphosilicate (CSPS) material that was designed based on a class of materials known as bioactive glasses. It comprises 45% SiO_2, 24.5% Na_2O, 24.5% CaO and 6% P_2O_5.

Remineralization of dentin induced by treatment with bioactive glass S53P4 in vitro A.P Frosback,S Arifa,J I Salonen
Acta odontol stand 2004;62:14-20

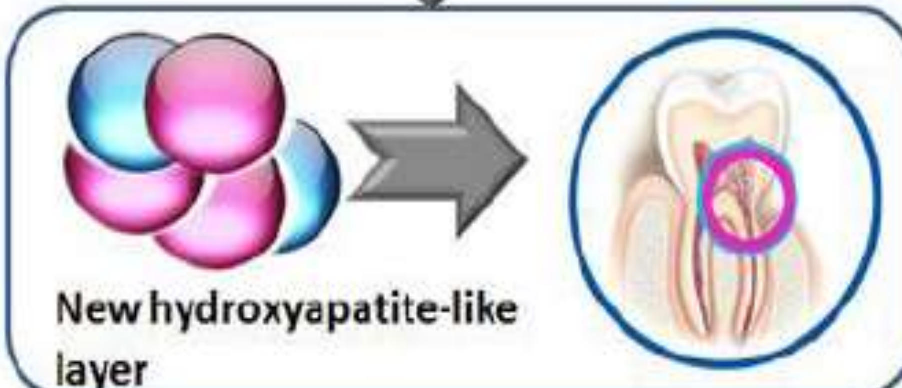
NovaMin® comes into contact with saliva and releases Ca^{2+} and PO_4^{2-}

NovaMin® reacts with saliva allowing sodium ions to exchange with hydrogen ions, raising pH

At this elevated pH, calcium and phosphate precipitate as calcium-phosphate



Calcium phosphate crystallizes to build a new hydroxyapatite-like layer over exposed dentine and within the dentine tubules



II **. Calcium Fluoride Nanoparticles**

- Calcium fluoride is a well known agent for the treatment of hypersensitivity.
- The CaF2 nanoparticle (nano-CaF2) has a 20-fold higher surface area compared with traditional CaF2.

III**. Beta Tricalcium Phosphate**

- β-TCP serves as a bioactive source of mineralizing components.The functional form of these particles are known as *f* β- TCP.
- It has been reported that the combination of fluoride and *f* β- TCP produces stronger, more acid-resistant minerals relative to fluoride, native β-TCP, or *f*β-TCP alone. nanomaterials of β-TCP may achieve more effective remineralizing results. [ex-**CLINPRO TOOTH CRÈME**]

(Anil Kishen Nanotechnology in Endodontics Current and Potential Clinical Applications)

IV. **Hydroxyapatite (HAP) Nanoparticles**

- nano-sized HAP (n-HAP) is similar to the apatite crystal of tooth enamel in morphology and crystal structure. Therefore, it is logical to consider n-HAP as compound substitute for the natural mineral constituent of enamel.
- It is shown that the basic building blocks of enamel are 20–40 nm size HAP nanoparticles.
- *In vitro* data indicate that n-HAP with a size of 20 nm fits well with the dimensions of the nanodefects on the enamel surface caused by acidic erosion.

- Under *in vitro* conditions, these n-HAP particles can strongly attach to the demineralized enamel surface and inhibit further acidic attack.
- Nanoparticles of HAP have been incorporated into toothpastes or mouth-rinsing solutions to facilitate the remineralization of demineralized enamel or dentin by depositing HAP nanoparticles in the lesions.
- Recently, some studies indicated that biomimetic synthesis of hierarchically organized enamel-like structures composed of n-HAP would be an ideal approach to repair enamel microcavities.

(Anil Kishen Nanotechnology in Endodontics Current and Potential Clinical Applications)

V. **Nanocomplexes of Casein Phosphopeptides Amorphous CalciumPhosphate**

- It is proposed that the CPP binds to the spontaneously forming ACP nanoclusters under alkaline conditions**.**

IT produces a metastable colloid of nanocomplexes of CPP-ACP. From the stoichiometric and cross-linking analyses, the stabilized nanocoplexes of CPP-ACP complex have unit formula of $[\alpha_{S1}(59\text{–}79)(ACP)_7]_6$ and $[\beta(1\text{–}25)(ACP)_8]_6$.

Ex-GC Tooth Mouse Plus

(Anil Kishen Nanotechnology in Endodontics Current and Potential Clinical Applications)

- Nanocomplexes of CPP-ACP(**Enamelon™**, **GC Tooth Mousse**) provide a new effective remineralization method thus helps in the treatment of hypersensitivity .
- The mechanism of CPP-stabilized ACP is transforming itself into HAP crystal in the process of biomineralization of dental hard tissues.

4. **Dental Durability and Cosmetics**

Durability and appearance of tooth may be improved by

- replacing upper enamel layers with covalently bonded artificial materials for aesthetic purposes.(Freitas,2000)
- They have 20 to 100 times the hardness and failure strength of natural enamel or contemporary ceramic veneers
- good biocompatibility.
- Pure sapphire and diamond which are brittle and prone to fracture, can be made more fracture resistant by incorporating part of a nanostructured composite material that possibly includes embedded carbon nanotubes (Jayraman et al., 2004).

Review article -Nanodentistry,Sneha Sundarrajan,Sashi Rashmi Acharya,Vidya Saraswati Indian J.Sci.Res.4(2):233-38,2013

Future of dentistry, nanodentistry, ozone therapy and tissue engineering
Maryam Moezizadeh
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Accepted 14 December, 2012

5. **<u>Nanorobotic Dentifrice (dentirobots)</u>**

- Nanorobotic dentifrice (dentirobots) delivered by mouthwash or toothpaste could patrol all supragingival and subgingival surfaces at least once a day metabolizing trapped organic matter into harmless and odourless vapours and performing continuous calculus debridement.
- Properly configured dentirobots 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.

- Dentirobots also would provide continuous barriers to halitosis, since bacterial putrification 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 gingival diseases will disappear .

Nanodentistry-the future ahead S.Gorav,P Kamlesh,P Niddhi,BFUDJ Vol 1,july,2010

Review article'NANODENTISTRY': Exploring the beauty of miniature.
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The Top Down Approach

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Comprises of…

1. Nanotechnology for Glass Ionomer Cement
2. Nanotechnology for Composites
3. Improving Endodontics
4. Impression Materials
5. Nano-Composite Denture Teeth
6. Nanoneedles
7. Nanoencapsulations
8. Nanosolutions
9. Nanotechnology in implants

1.Nanotechnology for Glass Ionomer Cement

- Glass ionomer cements are water-based cements, also known as polyalkenoate cement. It is widely used in dentistry as a restorative material. Now scientists are using various methods to improve its physical, chemical mechanical properties. Nano technolgy is one of those methods.

I. **Hydroxy Appetite & Fluroapetite**

- the size of the nano hydroxy appetite and nano fluro appetie crystal is 100-200 nm.
- This particles when incorporated in GIC **(ex- 5 wt%, Fuji II, GC Corp)** shows-

1. improvement is setting reaction.
2. Improvement in poly salt bridge formation.
3. Better bonding with dentin..
4. More compressive strength.

- In another research, HA and FA nanoparticles (50–100 nm) were added to the powder and N-vinylpyrrolidone (NVP) to the liquid of a commercial **GIC (Fuji II, GC International, Japan).**
- Overall, the addition of nanoparticles (HA and FA) was more effective to improve properties such as biaxial flexural strength, diametral tensile and compressive strength than the modification of the polymeric chain.
- When compared to micro-HA modified GIC to nano-HA modified GIC, the latter shows higher bond strength to tooth structure as well as increased resistance to demineralization when observed under scanning electron microscopy (SEM).

(Anil Kishen Nanotechnology in Endodontics Current and Potential Clinical Applications)

(Anil Kishen Nanotechnology in Endodontics Current and Potential Clinical Applications)

- nHA modified GIC has got increased setting time. But this can be improved by addition of Yttria-stabilized zirconia (YSZ) (20 wt% nHA/80 wt% YSZ) in the powder composition.
- An alternative to HA is the calcium-deficient hydroxyapatite (CDHA).
- It is a variant of HA with a Ca/P ratio between 1.67 and 1.33. Its composition and structure are similar to those of HA.
- Nano-CDHA (n-CDHA average particle size 24 nm) added in different concentrations (5, 10 and 15 wt%) to the powder of Fuji II LC.
- Even though n-CDHA is a promising alternative to improve clinical performance of GIC, stability of the material, increased solubility in the mouth may be limiting factors.

(Anil Kishen Nanotechnology in Endodontics Current and Potential Clinical Applications)

II. Titanium dioxide (TiO_2)

- TiO_2 nanoparticles **(average size~21 nm)** added to the powder of a commercial GIC **(Kavitan, Spofa Dental, Czech Republic) in 3 wt%.**
- The smaller size of the TiO_2 particles allows for a wider range of particle size distribution, occupying empty spaces between the larger GIC particles, which results in better mechanical properties due to the additional bonding sites between the polyacrylic acid and the glass particles.

III. Chlorhexidine (Chx). Nanoparticles

- Nanoparticles of CHX hexametaphosphate (CHX-HMP) added to the powder of a commercial **GIC (Diamond Carve,Kemdent).**
- it is act as anti microbial agent.Though nano-chx modified GIC shows less fluoride release than conventional one.

Nanotechnology In Resin Modified GIC-

- **Ketac Nano (3M ESPE)** is a two-paste commercial resin-modified glass ionomer advertised as having aggregated 'nanoclusters'(1 µm size range) composed of 5–20 nm spherical particles as well as non-agglomerated silica fillers and acid-reactive glass fillers in its powder.
- The presence of the nanoclusters increase the resistance of the material to biomechanical degradation.
- The amount of F released by this material is almost same as that of conventional resin modified GIC.
- Surface roughness is more in nano incorporated resin modified GIC.

(Anil Kishen Nanotechnology in Endodontics Current and Potential Clinical Applications)

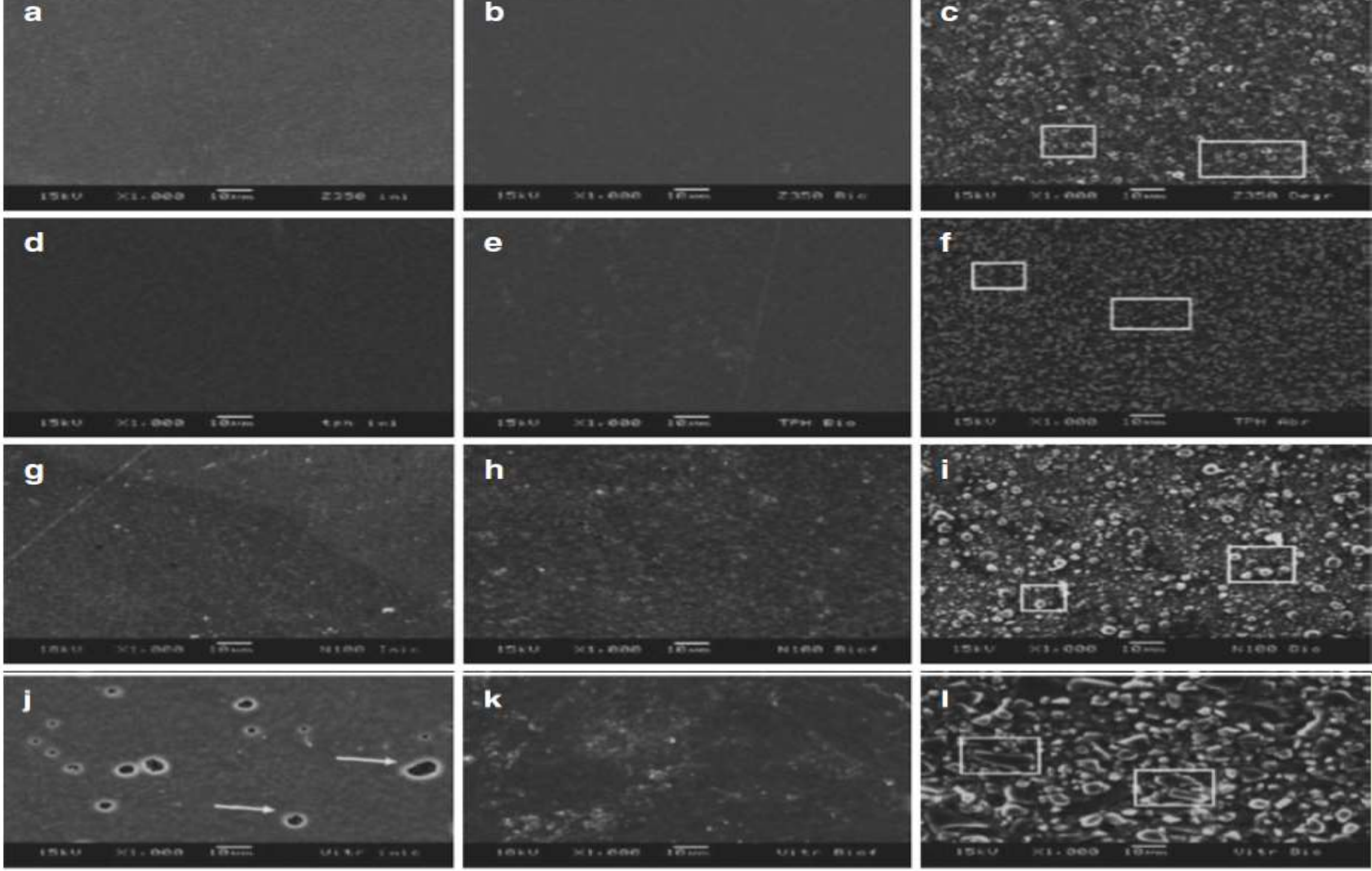

Fig. 8.1 Scanning electron micrographs of microhybrid composites Filtek Z350 (**a–c**) and TPH Spectrum (**d–f**); nano-based Ketac N100 (**g–i**), and resin-modified GIC Vitremer (**j–l**). The first column shows the relative humidity storage groups (**a**, **d**, **g**, **j**), with porosities (small spherical and irregular shapes) indicated by *arrows*. The second column represents the *S mutans* biofilm storage groups (**b**, **e**, **h**, **k**), with a severe degraded aspect of the matrix. The third column corresponds to biofilm storage plus abrasion groups (**c**, **f**, **i**, **l**), with many exposed particles at the surface of materials (*squares*) (Reprinted from De Paula et al. [43]. With permission from Operative Dentistry, Inc.)

Nano-filled Light Curing Varnish

- Another application of nanotechnology in GIC is the development of a nano-filled light curing varnish (**G-Coat Plus,GC Europe**), which is applied onto the surface of a highly viscous GIC (Fuji IX GP Extra, GC Europe). This combination has been commercially branded as EQUIA (‘Easy-Quick-Unique-Intelligent-Aesthetic’). The main purpose is to provide surface protection in the early maturation phase of the cement to avoid both water uptake and dehydration.This will lead to improved mechanical properties.

(Anil Kishen Nanotechnology in Endodontics Current and Potential Clinical Applications)

- Wear of the occlusal surface was not significant during the 2 year observation period. Although the authors concluded that the application of EQUIA restorations was considered acceptable for class I and small class II preparations, 2 years is a relatively short period of evaluation
- The influence of the nanofilled surface varnish **(G-Coat Plus, GC)** on wear resistance and flexural strength has also been investigated in coated and uncoated conventional GICs. .(**Fuji IX GP Extra, GC; Ketac Molar, 3M**.)
- Flexural strength of Fuji IX is significantly improved by the application of the nano-filled varnish, but it is still lower than the flexural strength of Ketac Molar, either coated or uncoated.
- There is no chemical interaction between Ketac Molar and the varnish layer , deposited layer is easily removed by the wear test.

2. Nanotechnology for Composites

- Resin composites with particles smaller than 100 nm have been conveniently named *nanocomposites.*
- nano particles are not only used in composites but also are used in dentin bonding agents.
- Nano hydroxyapetite (nHA) are used with dentin bonding agents helpful for the occlusion of dentinal tubules. Though they show a decrease in compressive strength.

(Anil Kishen Nanotechnology in Endodontics Current and Potential Clinical Applications)

- Dentin bonding agents contains different nano particles like
  1. Nano silver particles (nAg)
  2. Nano amorphous calcium phosphate (nACP)
  3. Nano quaternary ammonium dimethacrylate (nQADM)

among these particles nAg, nQADM act as a anti bacterial substance without altering the physical properties. nACP helps in reminerelization and helps to eliminate biofilms.

(Anil Kishen Nanotechnology in Endodontics Current and Potential Clinical Applications)

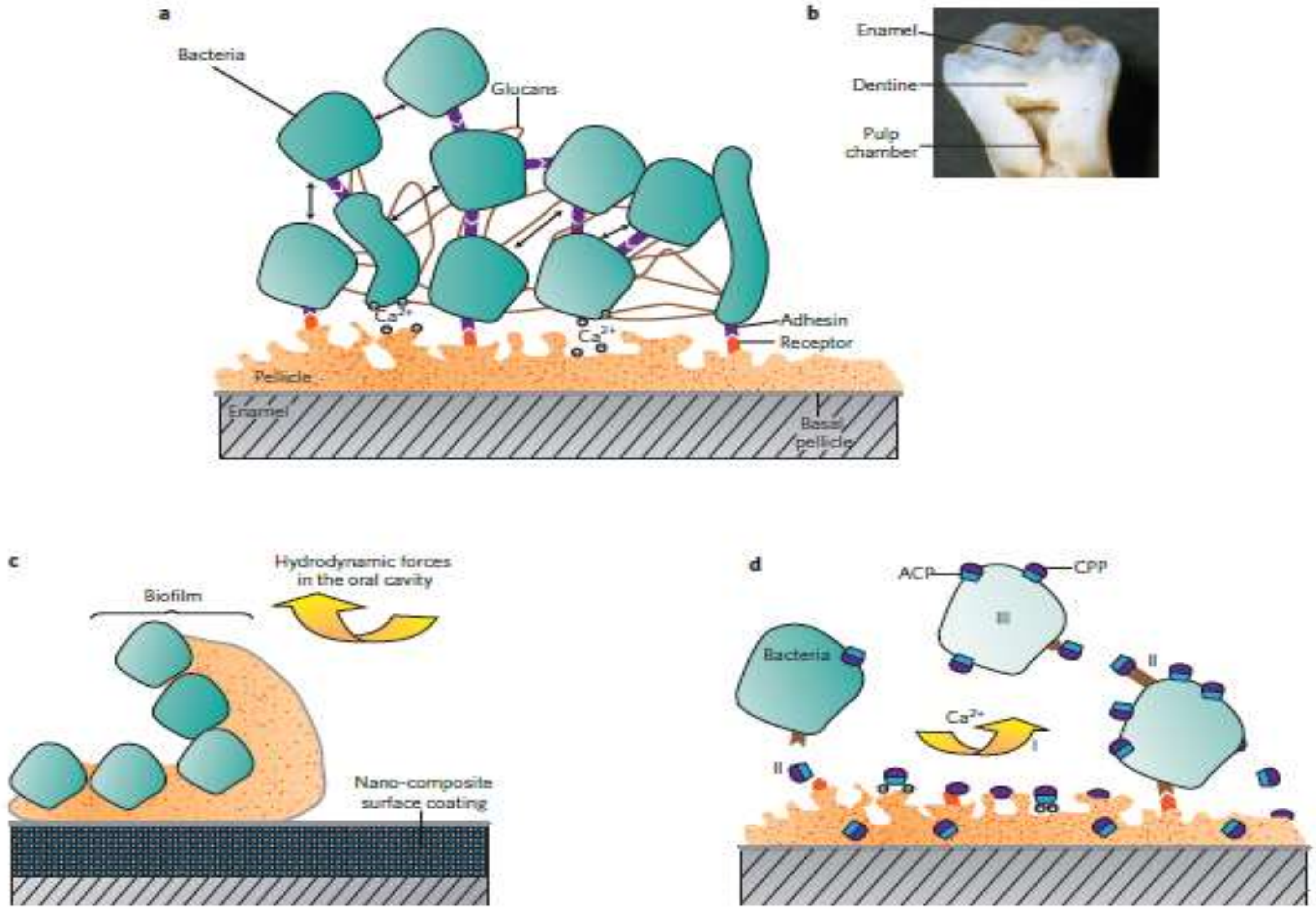

Figure 1 | Bioadhesion and biofilm management in the oral cavity. a, Bioadhesion in the oral cavity. Proteins interact with the enamel surface to form a proteinaceous pellicle layer. Bacteria adhere to this conditioning film through calcium bridges and specific adhesin–receptor interactions (purple and red). Bacteria are surrounded by an extracellular matrix of water-insoluble glucans, and they communicate through quorum sensing (arrows). **b**, Cross-section of a human molar tooth showing the enamel, dentine and pulp chamber. **c**, Easy-to-clean nanocomposite surface coating. The low-surface-free-energy coating (blue) causes poor protein–protein binding. Shear forces in the mouth (yellow arrow) can easily detach the outer layer of the pellicle and bacterial biofilm from the surface. **d**, CPP-ACP inhibits bacterial adhesion and oral biofilm formation. CPP attaches to the pellicle and limits bacterial adhesion. It competes with calcium for plaque–calcium binding sites (I), and decreases the amount of calcium bridging the pellicle and bacteria, and between the bacterial cells. Specific receptor molecules (red) in the pellicle layer and on the bacterial surfaces (brown) are blocked, further reducing adhesion and co-adhesion (II). This affects the viability of the bacteria (III).

Progress article nanomaterials in preventive dentistry Matthias hannig1* and christian hannig2
nature nanotechnology | VOL 5 | AUGUST 2010 |y doi: 10.1038/nnano.2010.83

- Colloidal platinum nanoparticles (CPN) increases the bond strength twice as much as that presented by the sample bonded with 4-META/MMA-TBB.
- It has been investigated. the highest bond strength is observed when CPN is applied before etching, evidencing that the platinum effect remained after etching.

(Anil Kishen Nanotechnology in Endodontics Current and Potential Clinical Applications)

Spherical zirconia (ZrO_2) nanoparticles (size **range ~20–50 nm**) have been added to either primer or adhesive of a commercial **system (Adper Scotchbond Multi-Purpose,3M Espe)** , which stabilizes the hybrid layer

(**Anil Kishen Nanotechnology in Endodontics Current and Potential Clinical Applications**)

- Apart from filler addition, the polymeric chain of the adhesive may also be reinforced by adding functionalized prepolymers into the adhesive formulation. Nanogels are 10- to 100-nm cross- linked globular particles that can be swollen by and dispersed in monomers such as Bis- GMA and HEMA.

- These are anticipated to carry nanoparticles into the demineralized dentin when added to adhesives.

- It provides significantly higher bond strength to dentin and stable mechanical properties (flexural modulus and flexural strength.

(Anil Kishen Nanotechnology in Endodontics Current and Potential Clinical Applications)

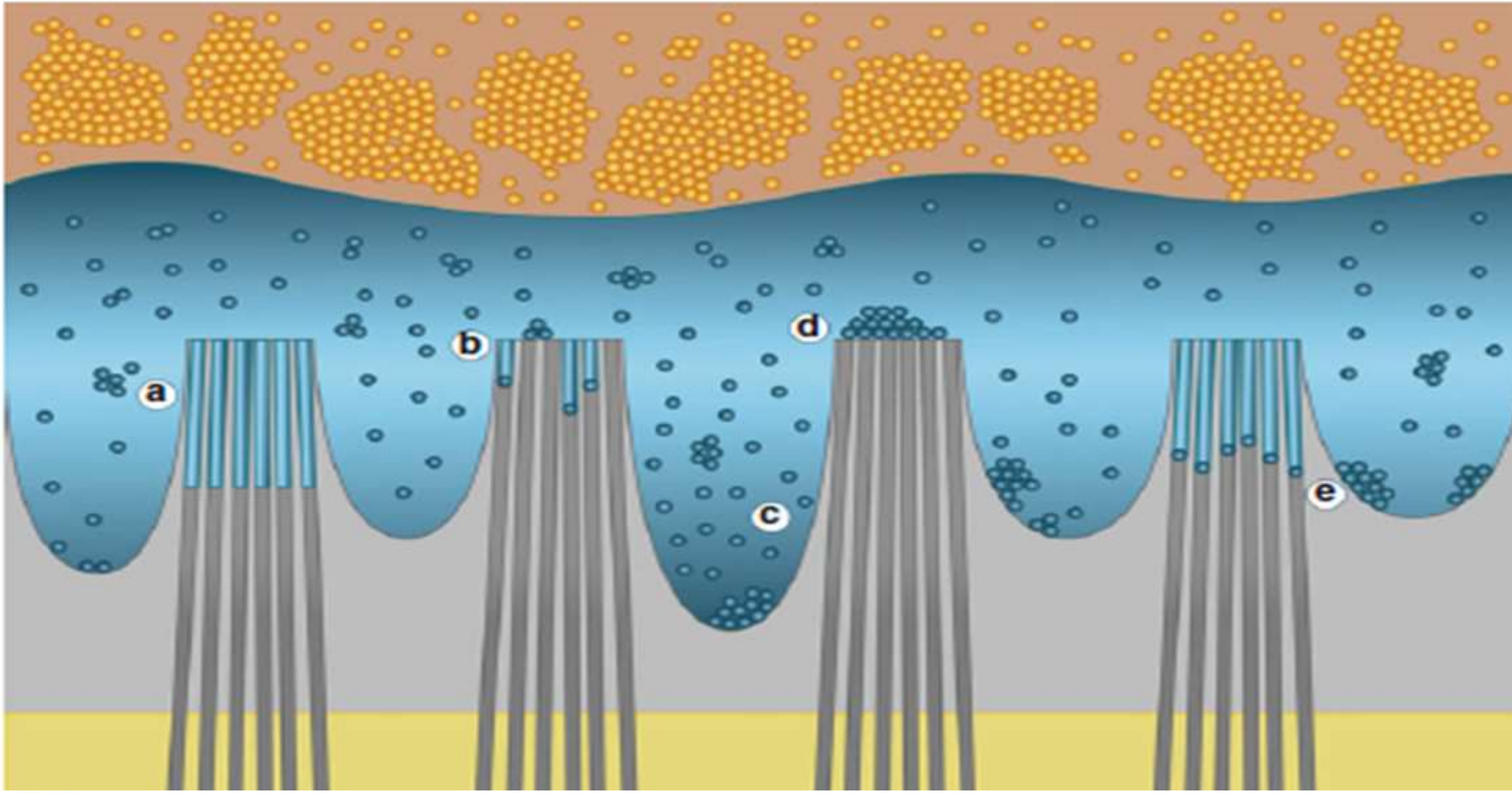

Fig. 8.2 Schematic representation of the dentin/adhesive hybrid layer (*orange* composite resin, *blue* adhesive resin, *gray* demineralized dentin, *yellow* intact dentin) with the effect of different nanoparticles application: (*A*). Wagner et al. 2013: Hydrothermally-grown HA with smaller surface area are embedded within the adhesive and not deposited on top of the hybrid layer. (*B*) Besinis et al. 2012: Hydrophobic diluent combined with smaller nHA improves infiltration ability of demineralized dentin. (*C*) Hoshika et al. 2010: Longer and denser resin tags obtained when CPN nanoparticles are added to the primer composition, by either improving monomer infiltration or enhancing monomer conversion. (*D*) Lohbauer et al. 2010: Spherical zirconia nanoparticles are unable to penetrate the interfibrilar spaces, compromising hybrid layer formation. (*E*) Osorio et al. 2011: Zinc oxide nanoparticles infiltrate the interfibrilar spaces and remain at the bottom of the hybrid layer, in contact with the demineralized dentin (Courtesy of Grace M De Souza and published with permission from University of Toronto)

- nACP has got the more surface area than microACP which aids in more ion release and appears to have more reminerelization potential.
- The nACP + QADM + nAg composite greatly reduces *S. mutans* biofilm growth.
- Bioactive glass nanoparticles (~45 nm) may improve fluoride release and reduce micro leakage scores of experimental dental sealants.
- Chlorhexidine (CHX) particles have been combined with nCaF 2 and nACP in experimental composites, to release CHX in an attempt to achieve a restorative material that promotes remineralization, is antibacterial and withstands load-bearing applications . But this materials show low flexure strength and poor aesthetic properties.

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OTHER USES OF NANOTECHNOLOGY IN DENTISTRY

Topics to be discussed:

1. Improving Endodontics
2. Nanosolutions
3. Nanodiagnostics
4. Impression Materials
5. Nano-Composite Denture Teeth
6. Nanotechnology in implants
7. Local drug delivery
8. Tooth repositioning
9. Therapeutic aid in oral diseases
10. Nano Needles and nano tweezers
11. Nanoencapsulation

Available in market

Yet to be developed
Under clinical trial

1. <u>IMPROVING ENDODONTICS</u>

- various nano particles are added in various endodontic materials to improve their properties.

I. <u>Chitosan Nanoparticles</u>

- Chitosan (poly (1, 4), β-d glucopyranosamine), a derivative of chitin, the second most abundant natural biopolymer, has received significant interest in biomedicine.
- Chitosan and its derivatives such as carboxymethylated chitosan showed a broad range of :
  - antimicrobial , antiviral and antifungal activity,
  - biocompatibility,
  - biodegradability.

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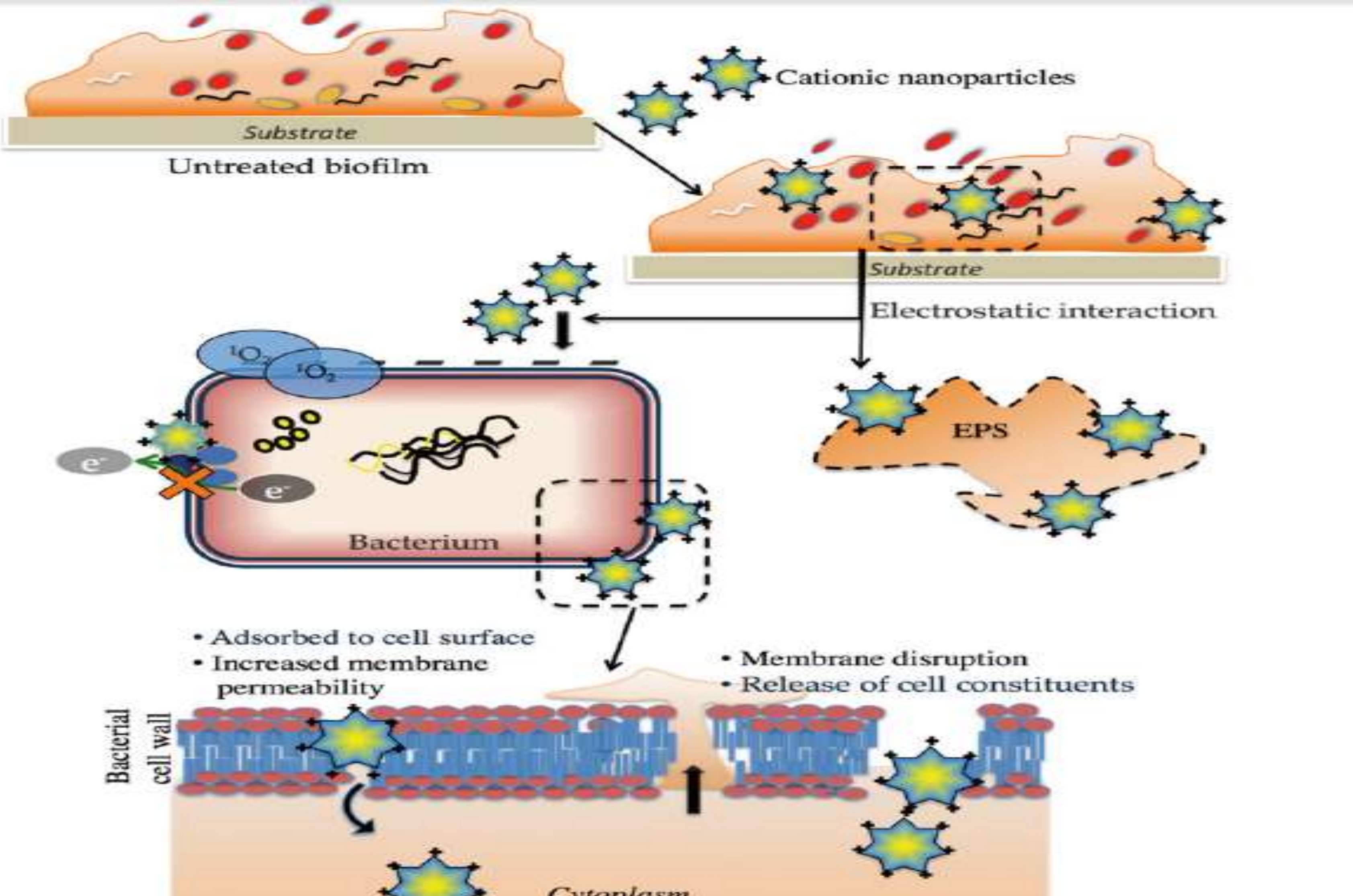

Fig. 6.5 A schematic diagram illustrating the antibacterial mechanism of nanoparticles with positive charge (e.g. Chitosan). Mature bacterial biofilm consisting of abundant EPS and bacteria enclosed. When cationic nanoparticles are introduced for treatment of biofilms, it can interact with both EPS and bacterial cells. The initial electrostatic interaction between positively charged nanoparticles and negatively charged bacterial surface. Bacterial killing occurs upon contact mediated lipid peroxidation via production of reactive oxygen species (ROS). The membrane damage and increased permeability of unstable membrane eventually leads to ingress of nanoparticles into the cytoplasm and release of cytoplasmic constituents. EPS secreted by bacteria in biofilm may interact with the nanoparticles and prevent from interacting with bacteria and thus reducing the antibacterial efficacy

II. Bioactive Glass Nanoparticles

- Bioactive glass (BAG) received considerable interest in root canal disinfection due to its antibacterial properties.
- bioactive glass (BAG) used by Zehnder et al. was amorphous in nature,ranging from 20 to 60 nm in size. They highlighted that the increase in pH is mainly responsible for the antimicrobial activity.

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- An ideal preparation of bioactive glass suspensions/slurries for root canal disinfection should combine high pH induction with capacity for continuing release of alkaline species.

- They demonstrated that BAG nanometric slurry has a 12-fold higher specific surface area than the micrometric counterpart.

III. Silver Nanoparticles

- At macroscopic level, silver nanoparticles are known to destabilize the bacterial cell membrane and increase it's permeability leading to leakage of cell and cell death.

- Studies have assessed that it's antimicrobial activity is the main characteristic for it's selection to be used as an irrigant.

- Two main disadvantages of using silver nanoparticles are:

1. the potential browning/blackening of denti
2. and it's cytoxicity towards cells.

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Wu D, Fan W, Kishen A, Gutmann JL, Fan B. Evaluation of the antibacterial effi cacy of silver nanoparticles against Enterococcus faecalis biofi lm. J Endod. 2014;40:285–90.

- A study showed that the antibiofilm efficacy of AgNPs for root canal disinfection depended on the mode of application, gel being more effective than solution. A 0.02 % AgNP gel as medicament significantly disrupted the structural integrity of the biofilm and resulted in the least number of post-treatment residual viable E. faecalis cells compared with 0.01 % AgNP gel, calcium hydroxide groups, and syringe irrigation with 0.1 % AgNP solution.

IV.Nanoparticle-Incorporated Root Canal Sealers

- It was highlighted that the addition of antibacterial NPs in root canal sealers would improve the direct and diffusible antibacterial effects of the root canal sealers.
- Studies also showed that the application of CS NPs reduced the adherence of *E. faecalis* to root canal dentin.
- (QAPEI) nanoparticles were also utilized to improve the antibacterial efficacy of various root canal sealers and temporary restorative materials.

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- Incorporation of these nanoparticles into sealers increase the wettability of sealer .
- BAG nanoparticles have been recommended to promote closure of the Interfacial gap between the root canal walls and core filling materials.

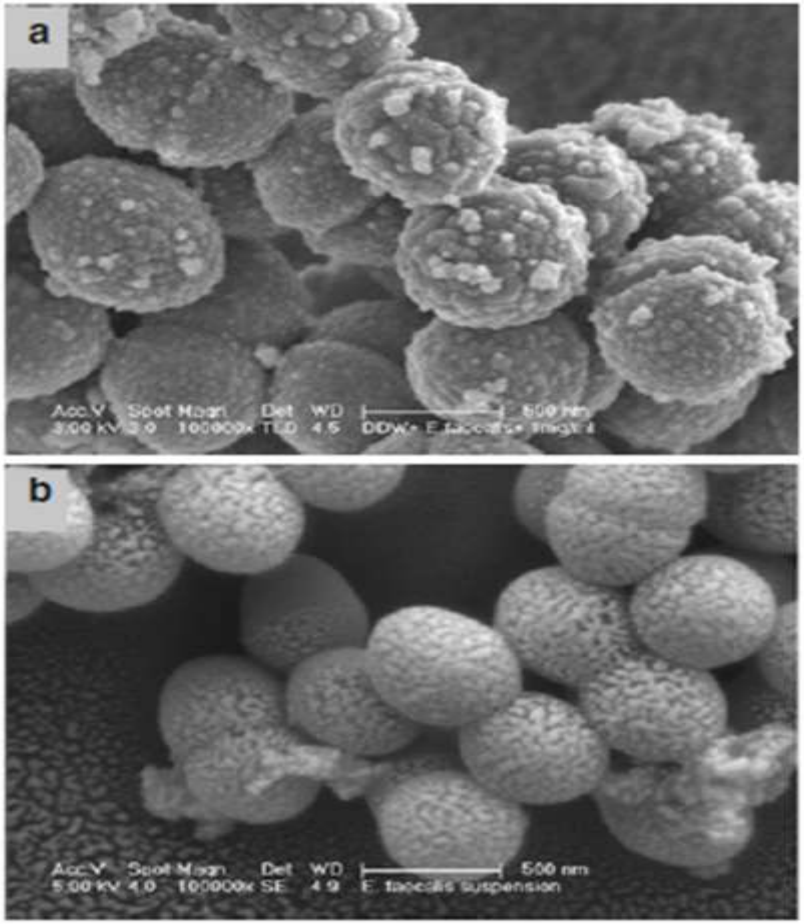

Fig. 6.7 Determination of the antibacterial activity of QPEI nanoparticles in suspension. Scanning electron micrographs of *E. faecalis*. **(a)** In DDW with QPEI nanoparticles- depicting attached nanoparticles on bacterial membranes; **(b)** In DDW- depicting regular bacterial membranes (Adapted from Beyth et al. [120]. With permission from PLoSOne.org)

2. NANOSOLUTIONS

- Nanosolutions produce unique and dispersible nanoparticles, which can be used in bonding agents. This ensures homogeneity and ensures that the adhesive is perfectly mixed everytime. Types of nano solution.

1.**Nanomeric**: These are monodisperse non aggregated and non agglomerated silica nanoparticles. They reduce the interstitial spacing and increase the filler loading.

2. **Nanoclusters**: These are zirconia-silica particles (2 to 20 nm) and zirconyl salt (from 75 nm) which are spheroidal agglomerated particles. They have Dentin, Enamel and body shades because of radiopacity and there is high gloss retention with silica nanomer

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3. LOCAL DRUG DELIVERY

- Nanotechnology is opening new therapeutic opportunities for many agents that cannot be used effectively as conventional oral formulations because of their poor bioavailability.

- In some cases, reformulation of a drug with smaller particle size may improve oral bioavailability. Nanoparticles formulations provide protection for agents susceptible to degradation or denaturation in regions of harsh pH, and also prolong the duration of exposure of a drug by increasing retention of the formulation through bioadhesion.

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- Ideally, all these systems would improve the stability, absorption, and therapeutic concentration of the drug within the target tissue, as well as permit reproducible and long-term release of the drug at the target site.

- Nanomaterials For Brachytherapy
  BrachySilTM (Sivida, Australia) delivers 32P, clinical trial.

- Drug Delivery Across The Blood-Brain Barrier
  More effective treatment of brain tumours, Alzheimer's,Parkinson's are in development

Nanotechnology in dentistry Saravana Kumar R , 2Vijayalakshmi R1 2 Reader, Post Graduate Student, Department of Periodontics, Meenakshi Ammal Dental College 2006

4. <u>TOOTH REPOSITIONING</u>

- Orthodontic nanorobots could directly manipulate the periodontal tissues, including gingivae, periodontal ligament, cementum and alveolar bone, allowing rapid and painless tooth straightening, rotating and vertical repositioning within minutes to hours. This offers an advantage over molar uprighting techniques currently in use, which require weeks or months to complete.

5. NANODIAGNOSTICS

- Nanotechnologies already afford the possibility of intracellular imaging through attachment of quantum dots (QDs) or synthetic chromophores to selected molecules.
- By the incorporation of naturally occurring fluorescent proteins that, with optical techniques such as confocal microscopy and correlation imaging, allow intracellular biochemical processes to be investigated directly. The techniques which are being used in this process are

I. Nano Electromechanical Systems(NEMS)

- Nanotechnology based NEMS biosensors that exhibit exquisite sensitivity and specificity for analyte detection, down to single molecular level.They convert biochemical to electrical signal.

Nanotechnology in dentistry Saravana Kumar R , 2Vijayalakshmi R1 2 Reader, Post Graduate Student, Department of Periodontics, Meenakshi Ammal Dental College 2006

II. Oral Fluid NanoSensor Test(OFNASET)

- OFNASET technology is used for multiplex detection of salivary biomarkers for oral cancer.

It has been demonstrated that the combination of two salivary proteomic biomarkers (thioredoxin and IL-8) and four salivary mRNA biomarkers (SAT,ODZ, IL-8, and IL-1b) can detect oral cancer with high specificity and sensitivity.

III. Optical Nanobiosensor

- The nanobiosensor is a unique fiberoptics-based tool.
- It allows the minimally invasive analysis of intracellular components such as cytochrome c.
- These are very important protein to the process which produces cellular energy and is well-known as the protein involved in apoptosis, or programmed cell death.

6. THERAPEUTIC AID IN ORAL DISEASES

- Nanotechnologic packaging of therapeutics will provide the ability to co-localize delivery of multiple and complimentary therapeutic agents.
- Additionally, materials that now require injection potentially could be inhaled or swallowed using nano engineered delivery devices, thus improving patient comfort and compliance.

(Anil Kishen Nanotechnology in Endodontics Current and Potential Clinical Applications)

7. IMPRESSION MATERIALS

Nanosilica fillers are integrated in vinylpolysiloxanes, producing a unique edition of siloxane impression material. The material has a

1. better flow.
2. improved hydrophilic properties.
3. tear strength.
4. enhanced detail precision.

The presence of the nanostructure increases the fluidity of the material, especially when pressure is applied.

8. NANO FILLED-COMPOSITE DENTURE TEETH

- Wear resistance is the most important physical properties of denture teeth .Porcelain denture teeth are mostly wear resistant, but they are brittle, lack bonding to the denture base, and difficult to polish. Acrylic resin denture teeth are easier to recontour, but undergo excessive wear. Nanocomposite denture teeth comprises of Polymethylmethacrylate (PMMA), and uniformly dispersed nano -sized filler particles.

- Advantages:

• Highly polishable, stain and impact resistant material
• Lively surface structure
• Superior surface hardness and wear resistance.

8. NANO NEEDLES AND NANOTWEEZERS AND NANOENCAPSULATIONS

- Nano Suture needles, nano needles for delivering local anesthetics for surface anesthesia,, nanotips for scalling, nanoencapsulations are now being developed.

10.NANOTECHONOLOGY IN IMPLANTS

- Nanotechnologies may produce surfaces with controlled topography and chemistry that would help understanding biological interactions and developing novel implant surfaces with predictable tissue-integrative properties.

- Apart from using nano implants in dentistry several materials are there which are added to the implant surface (using nano technology) to increase oseointegration. These are-

1. Yttria-stabilized zirconia nano particles reinforced in BAG- This yttria-stabilized zirconia bioglass is deposited on the titanium implant (Ti6Al4V) using electrophoretic deposition. This implants have better bio-compatibility, more strength. These nano particles also help in the expression of genes responsible for oseointegration.

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Nanotopography Improves Biointegration of Titanium Implants-

When exposed to an *in vivo* microenvironment, a titanium surface spontaneously forms an evasive TiO 2 layer that is highly bioinert and provides excellent corrosion resistance.

- Despite these favourable characteristics,the chemically inert surface of titanium implants is not able to form a firm and permanent fixation with the biological tissue to last for lifetime . Additionally, fibrous tissue encapsulation around the titanium implants leads to implant failure.

- Nanotopography significantly modifies the biochemical and physiochemical characteristics of the implant surface and directly interacts with cellular components, favouring extracellular matrix deposition or formation of mineralized tissue at the dental implant surface.
- Moreover, nanostructured titanium implants promote cell adhesion, spreading and proliferating as these nano surfaces directly interact with membrane receptors and proteins.

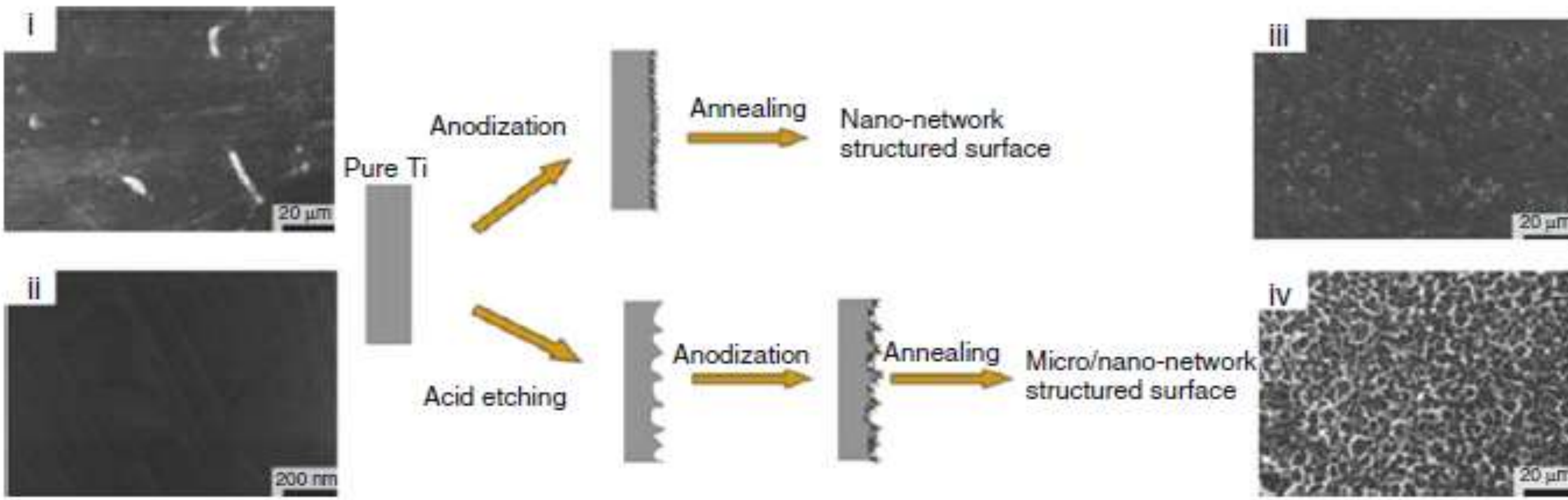

Fig. 2.5 Schematics showing surface modification of titanium implant using anodization and chemical surface etching. SEM images showing (*i*, *ii*) blank titanium, (*iii*) nano structured modified titanium surface and (*iv*) micro/nano modified surface (Adapted from Jiang et al. [50]. With permission from Elsevier)

CONVENTIONAL GIC

category	Brand name	Classification	Particles	Characteristic
GLASS IONOMER CEMENT	**GC Fuji II**	RESTORATIVE CEMENT	4-5 µm	Anti cariogenic. Esthetic restoration. Moisture sensitive. Less compressive strength than amaglam.
	GC Fuji II LC	RESIN MODIFIED CEMENT	<50µm	Less setting time. Less compressive strength. More bond strength.

NANO GIC

Category	Brand name	Classification	Particles	Characteristics (reference #)
Glass ionomer materials	*Ketac Nano* *3M Espe* St Paul, MN, US	Nano-GIC	1 µm clusters containing 5–25 nm spherical particles [41]	Good resistance to biomechanical degradation [44] Fluoride release similar to other GIC's [46] Marginal staining under clinical conditions [48]
	G-Coat Plus *GC America* Alsip, IL, USA	Nano-filled light curing varnish	No information available	May reduce occlusal wear [50] and improve flexural strength of some GIC's [53]

CONVENTIONAL ENAMEL AND DENTIN BONDING AGENTS

category	Brand name	Classification	Particles	Characteristic
Enamel/ dentin Bonding agent	**Clearfil SE bond**	2 bottle 2 step bondig system	NA	Less technique sensitive Less volatile Less bond strength.

NANO ENAMEL AND DENTIN BONDING AGENTS

Category	Brand name	Classification	Particles	Characteristics (reference #)
Enamel/ dentin bonding	*Prime&Bond NT* Dentsply International York, PA, USA	Nano-filled adhesive	7–12 nm SiO_2 particles	Higher microtensile bond strength to dentin than one-bottle self-etch adhesive systems [69] Low microtensile bond strength to feldspathic porcelain [70]

CONVENTIONAL COMPOSITE

category	Brand name	Classification	Particles	Characteristic
Composite resin	Durafill vs	MICROFILLED	.4-.7µm silica Filler 60 wt%	Good esthetic. Good surface smoothness High polymerization shrinkage.
	charisma	MICROHYBRID	.02-2µm silica Filler 75 wt%	Good surface smoothness
	Solitaire 2	PACKABLE	.7-20µm silica Filler 75 wt%	High compressive strength High wear resistant. Less esthetic.
	Filtek z350xt	FLOWABLE	.6-3µm silica	More wear resistant High polymerization shrinkage.

NANO COMPOSITE

Category	Brand name	Classification	Particles	Characteristics (reference #)
Composite resin	*Filtek DEB* 3M Espe St Paul, MN, USA	Nanofill	Zirconia-silica nano-filled clusters (0.6–1.4 μm; 90 %) and nanoparticles (5–20 nm; 10 %) dispersed in the matrix *79 wt%*	Fracture strength lower than for ormocer-based composite [66] Higher polymerization shrinkage, water sorption and solubility [65] Decrease in flexural strength and flexural modulus after 30 days water storage [65] Higher chance of occlusal staining [71], Relatively high monomer elution [72] Low clinical roughness values [67], Reduced polishability after cyclic loading [73] Decreased Knoop hardness after 6 months water storage [74] Color instability after additional heat post-curing [75] Good resistance to biomechanical degradation [43]
	Filtek translucent 3M Espe	Nanofill	Nanoparticles (~75 nm) and minor amount of silica nano-filled clusters (0.6–1.4 μm; 50 %) *70 wt%*	High polymerization shrinkage, water sorption and solubility [65] Decreases flexural strength and flexural modulus after 30 days water storage [65]
	Tetric EvoCeram Dentsply	Nanohybrid	Barium glass (1 μm), Ba-aluminum-silicate glass (0.4–0.7 μm) and Ytterbium trifluoride (550 nm) *82–83 wt%*	Fracture strength lower than for ormocer-based composite [67] Low roughness values [67] Reduced polishability after cyclic loading [73]
	Grandio/Grandio Nano Voco Briarcliff Manor, NY, USA	Nanohybrid	Silica dioxide (20–60 nm) and barium-aluminaborosilicate (0.1–2.5 μm) *87 wt%*	Minimum polymerization shrinkage when compared to nanofill and Tetric EvoCera[m] lower water sorption and solubility, high and stable flexural strength and flexural modulus after 30 days water storage [65] Higher degree of conversion and lower color stability than microhybrid materials [76]
	Clearfil Majesty Dentsply	Nanohybrid	Silanated Barium glass filler and pre-polymerized organic filler including nanoparticles (0.2–100 μm) with average particle size of 0.7 μm *78 wt%*	Color instability after additional heat post-curing [75]

NANOTECHNOLOGY-BASED STRATEGIES FOR DENTAL CARIES MANAGEMENT

Silver nanoparticles, zinc oxide nanoparticles,Quarternary Ammonium Polyethylemine

- Silver nanoparticles (NAg) , ZnO nanoparticles , Quarternary ammonium polyethylemine have been used in many dental materials as they provide the bactericidal effect
- Ag nanoparticles interacts with the peptidoglycan cell wall and the plasma membrane, prevent bacterial DNA replication by interacting with the exposed sulfhydryl groups in bacterial proteins, especially with the enzymes involved in vital cellular processes such as the electron transport .
- Nag , NZnO exhibit antibacterial effects against a large number of bacterial species, including S. mutans and Lactobacillus spp.

- The antibacterial mechanism of NZn is credited to modified cell membrane activity and oxidative stress; these generate active oxygen species such as H2O2 that inhibit growth of microbes.
- Another potential antimicrobial mechanism of NZn is the leaching of Zn2+ into the growth media decreasing biofilm formation by inhibiting the active transport and metabolism of sugars.
- disrupting enzyme systems by displacing magnesium ions essential for enzymatic activity of the of dental biofilms.
- The detailed antimicrobial mechanism of QAS is yet to be established. QAS materials appear to cause bacterial lysis by binding to the cell membrane and causing cytoplasmic leakage.

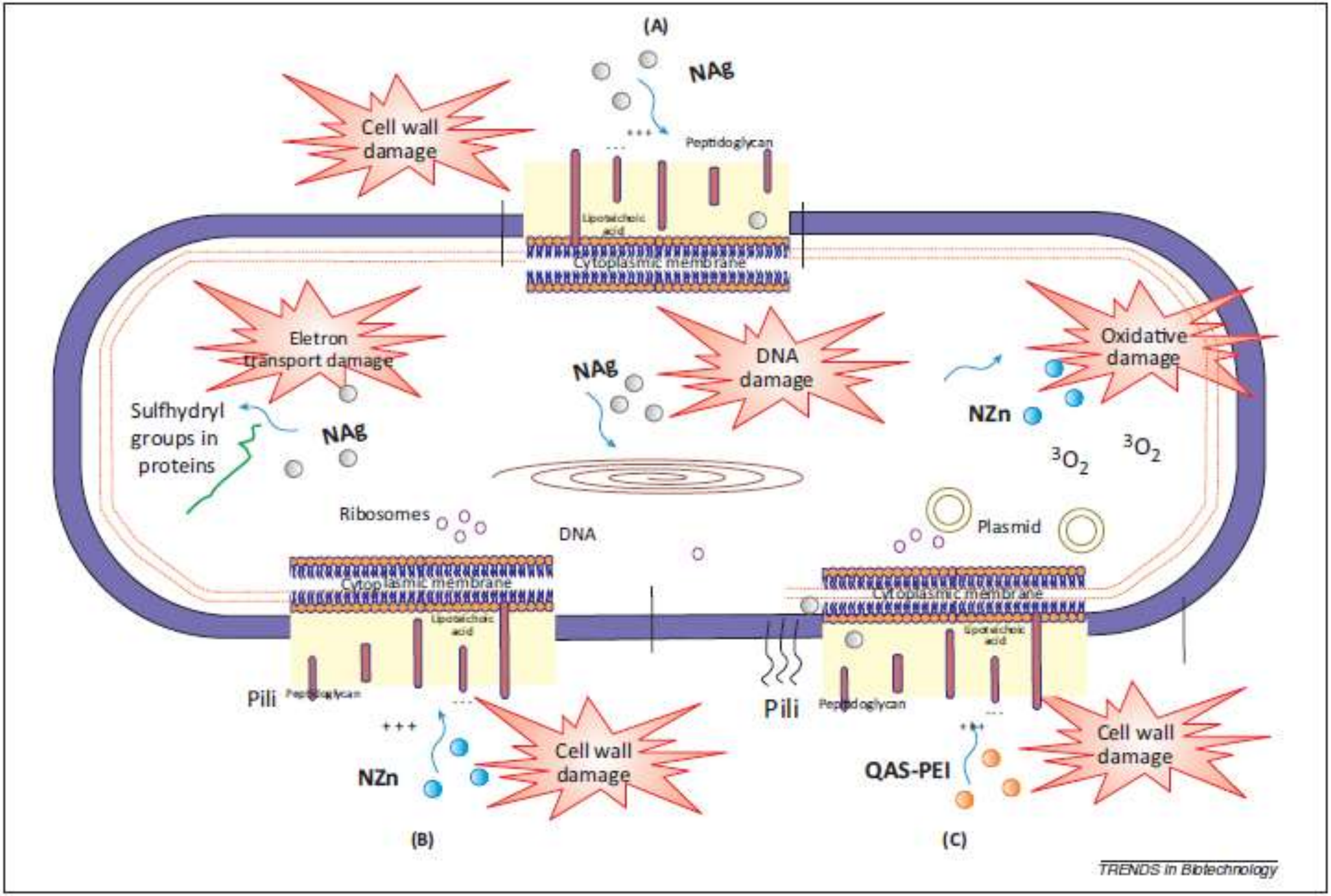

Figure 1. Schematic representation of a bacterial cell showing the components targeted by different antibacterial agents incorporated in dental materials. **(A)** Silver nanoparticles (NAg): NAg have been incorporated in restorative materials to combat the cariogenic bacteria colonization in the marginal gaps and on their surfaces. **(B)** Zinc oxide nanoparticles (NZn): the primary cause of the antibacterial function of NZn is credited to the disruption of cell membrane activity. **(C)** Quaternary ammonium polyethylenimine (QAS-PEI) nanoparticles: the mechanism of action may be related to absorption of positively charged polymers onto negatively charged cell surfaces of the bacteria. This process is thought to be responsible for the increase of cell permeability and may disrupt the cell membranes [41].

NANOPARTICLES AND THEIR ROLE IN DENTIN STABILIZATION

- Dentin at a structural level exists as a fiber reinforced composite.
- The less mineralized intertubular dentin forms the matrix, and the highly mineralized peritubular dentin forms the fibre reinforcements.
- These provides mechanical properties of the dentin collagen matrix.
- The structural integrity of dentin provided by the inorganic and organic fraction is crucial to retain the function of a tooth.
- The mechanical stability of biological composites depends on the optimum balance between toughness and stiffness.
- The mechanical properties of dentin such as Young’s modulus, strength, and fracture toughness are the result of the complex interactions of its constituents as well as the microstructural arrangement.

- Tissue stabilization is the process of rendering the ultrastructure of a tissue more stable in order to provide or enhance its mechanical properties and resistance to chemical-mediated degradation.
- Dentinal collagen stabilization has been explored extensively to improve the resistance to degradation in hybrid layers.
- to improve the bond strength in case of adhesive restorations, to manage dentinal hypersensitivity and also to stabilize surface dentin of root canal walls.

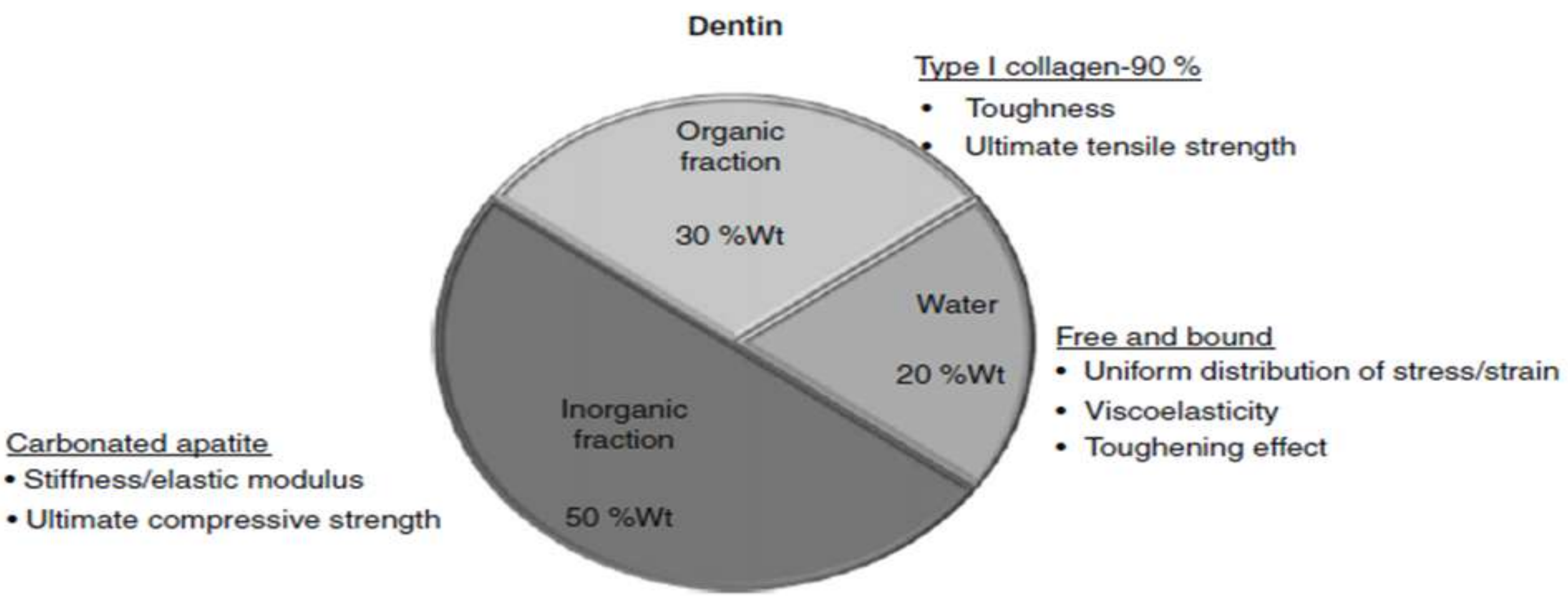

Fig. 7.3 The role of different constituents of dentin on its structural integrity

These dentin stabilization is done by dentin cross linking in order to improve its stability.

Table 7.1 Various methods available to obtain crosslinking of collagen

Enzyme mediated	Chemical agents	Photoactivated	Others
Transglutaminase	1. Crosslinking of amino groups	1. Riboflavin + UVA [1–4]	1. Synthetic polymers
	Glutaraldehyde	2. Rose bengal + light (545 nm) [5–7]	Poly (vinyl alcohol)
	Glyceraldehyde	3. Tris(bipyridine) ruthenium(II) chloride + [8]	Poly (acrylic acid)
	Epoxy compounds		Polyethylene
	Genipin		Poly (vinyl pyrrolidone)
	2. Direct crosslinking of polypeptide chains		2. Hyaluronic acid
	Carbodiimides (EDC/NHS/MES)		3. Heparin
	3. Chlorhexidine		4. Chondroitin-6-sulfate

1-ethyl-3-(3-dimethylaminopropyl)carbodiimide (EDC), and N-hydroxysuccinimide (NHS)

Role of nanoparticles in dentin stabilization

- Nanoparticles of bioactive polymers such as chitosan showed ability to enhance the mechanical properties of dentin collagen.
- Chitosan composites with collagen could reinforce the collagen scaffolds as well as create a more suitable biomimetic environment for cells.
- Chitosan nanoparticles consist of reactive free amino and hydroxyl groups that can be utilized for chemical modifications and conjugation. Other reactive molecules/proteins could be attached to the chitosan nanoparticles to obtain a multifunctional nanoparticle.
- Chitosan is known to be a non-toxic, biologically compatible polymer allowing its widespread use in biomedical applications.
- Chitosan nanoparticles and their derivatives interact with and neutralize MMPs or bacterial collagenase, thereby improving dentinal resistanceto degradation.

- They possess structural similarity to the extracellular matrix glycosaminoglycans. Extracellular matrix proteins such as proteoglycans and glycosaminoglycans provide mechanical stability and compressive strength to the collagen by intertwining with the fibrous structure.

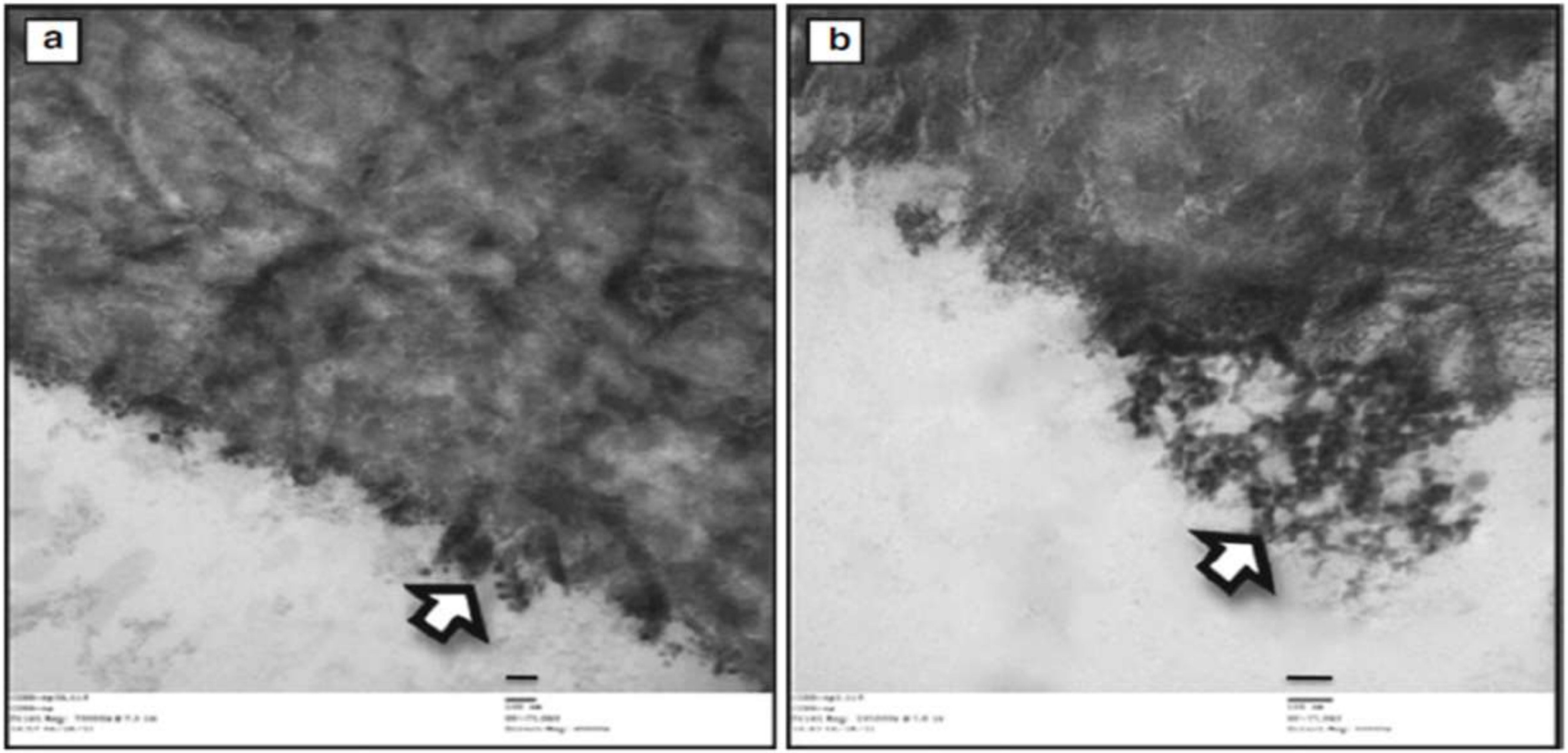

Fig. 7.6 (**a**, **b**) Transmission electron microscopy image of dentin collagen following photodynamic crosslinking using photosensitizer conjugated chitosan nanoparticles. *Arrow* indicate the nanoparticles lining the surface of the dentin collagen (Adapted from Shrestha [76]. With permission from Elsevier)

- The nanoparticle-conjugated photosensitizers such as Rose Bengal–conjugated chitosan nanoparticles (CSRBnps) could be used to stabilize dentin collagen.
- Rose Bengal–conjugated chitosan in micro- and nanoparticles (CSRBnps) produce singlet oxygen upon photoactivation with a green light(540 nm wavelength).
- This singlet oxygen produces additional cross-linking between collagen molecules as well as collagen and chitosan nanoparticles.

REVIEW OF LITTERATURE

Improving Mechanical Properties Of Glass Ionomer Cements With Fluorhydroxyapatite Nanoparticles

Kevin J. Roche and Kenneth T. Stanton

- **Objectives-** Glass ionomer cements show great potential as low cost, minimally invasive dental restorative materials. However, their use is limited by relatively poor mechanical properties, especially fracture toughness. One possibility for improving their fracture toughness is through the addition of uorhydroxyapatite nanoparticles, which resemble the crystals found in tooth enamel.

- **Method**- Hydroxyapatite and uorhydroxyapatite nanoparticles with fuoride substitution levels ranging from 0 to 95% and a small amount of AB-type carbonate substitution have been prepared and added to commercially available Fuji IX glass ionomer cement to examine the effect of the nanoparticles on the cement mechanical properties. The fluoride substitution level and other nanoparticle properties were accurately determined using a combined approach of XRD, XPS, TEM and FTIR.
- The material was in the form of agglomerated single crystal nanorods with volume average dimensions of approximately 30 30 60{80 nm. This combination of chemistry and morphology closely resembles the crystals in enamel and makes these particles perfect candidates for producing reinforced glass ionomer dental restorative material.

- **Results**- Preliminary tests have been carried to assess the aect of these particles on the compressive strength, hardness, and fracture toughness of Fuji IX hand mixed cement. A significant increase was found for hardness, but no significant change was found for fracture toughness or compressive strength, although there appeared to be a slight trend of increasing compressive strength with wt% nanoparticle addition.
- **Conclusions**- Initial mechanical testing of modfiied cements suggests that Fluorhydroxyapatite nanoparticles can increase compressive strength and hardness of the cement, but that the method of incorporating the nanoparticles is crucial to realizing the benefits and avoiding unwanted effects on the working properties of the cement.

- **Flexural Strengths Of Conventional And Nanofilled Fiber-reinforced Composites: A Three-point Bending Test** (Dental Traumatology 2014; 30: 32–35; doi: 10.1111/edt.12055)

-Maria Francesca Sfondrini, Sarah Massiron, Giulia Pieraccini,Andrea Scribante, Pekka K. Vallittu,Lippo V. Lassila2, Paola Gandin.

Objectives: The purpose of this study was to evaluate the effect of the introduction of nanofillers on the mechanical properties of fiber reinforced composites (FRCs) for stabilization and conservative treatment of multiple traumatized anterior teeth. In particular, the aim of the research was to point out the force levels of two sizes (diameters 0.6 and 0.9 mm) of both conventional and nanofilled FRCs.

- **Methods**: Eighty FRCs samples were divided into eight groups, each consisting of 10 specimens.Conventional (groups 1, 2, 3, and 4) and nanofilled (groups 5, 6, 7,and 8) FRC samples were evaluated. Conventional FRCs are constituted by 600/900 Eglass fibers (Ahlstrom, Helsinky, Finland), silanated and preimpregnated with polymethylmethacrylate and bis-GMA. Nanofilled FRCs are constituted by an impregnating solution containing about the 32% of nanofilled resin (Nanocryl, Hanse Chemie, Geesthacht,Germany). Each FRC was tested in two diameters(0.6 and 0.9 mm) and under two deflections (1 and 2 mm). Each sample was polymerized with the same halogen curing unit and then evaluated with a 3-point bending test on a universal testing machine after 48 h ofdry storage.

- **Results**: Nanofilled FRCs showed significantly higher load values than conventional FRCs. Moreover, 0.9-mm-diameter FRCs showed significantly higher load value than 0.6-mm-diameter FRCs. Specimens tested at 2-mm deflection showed significantly higher load values than those tested at 1-mm deflection.
- **Conclusion**s: Nanofilled FRCs showed significantly higher load values than conventional FRCs. Higher flexuralstrength values were recorded with 1-mm deflection for both FRC tested. Nanofilled FRCs can be used for stabilization and conservativetreatment of multiple traumatized anterior teeth.

CONCLUSION

- Nano technology will be the future of dentistry as well as restorative and conservative dentistry. With the implementation of new technologies the use of nanotechnology in materials will be increased along with the enhancement of their properties. But we must explore the possibility of cost effectiveness of nanotechnology to make it approachable to everyone. Besides that the safety and cytotoxic effects of these materials must be evaluated..

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THANK YOU

THAT'S IT

FOR NOW...