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Biosmart Materials in Dentistry: The Future Is Here

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ABSTRACT

With the advancement of dentistry there is urge of more latest combinations of materials which need to be more biomimic to oral environment, more dynamic and patient compatible. The reuirement of denetisty cannot be fulfilled by a single material as an ideal material.While the need for an "ideal material" a newer generation of materials came in use. The adjective "smart" says that these materials are able to locate the changes in their environments and then respond to these changes in required manners. These materials can be altered in a required manner by spur which includes stress, electric or magnetic field ,temperature, moisture as well as pH. They can work as long lasting esthetic & restorative materials, cement, root repair materials, root canal sealers & filling materials which have primacy of enhanced biocompatibility, high stress, sealing ability & antibacterial properties. The notion of innovating new materials in dentistry has gathered pace since their properties simulate natural tooth substance such as enamel or dentine.

Keywords: Smart materials, fluoride release, glass-ionomers, Smart ceramic, Smart composite Shape memory Burs

INTRODUCTION

Dental materials are one of the key materials used in oral cavity for different therapeutic purposes. The key feature of early used materials was being biocompatible and its longitivity. Traditionally used materials like amalgams, composites and cements are often judged on their ability to survive without reacting to the oral environment. With advancing ages the properties of material also changed with developing technologies according to need of the dentist for its better performance in oral cavity. These advances lead to development of SMART materials which were not only smart in their properties but also they were more reliable. McCabe Zrinyi[1] defined smart materials as "the materials which have ability to be altered by stimuli and can get revert back into the originality after removing the stimuli". The material shows its smart behavior when it come along stimulus from environment and react to it in reproducible, and reversible manner.

The various types of smart materials used in the field of dentistry includes piezoelectric materials, shape memory alloys or shape memory polymers, pH sensitive polymers, polymer gels and others that have shown their own smart behavior. Researchers insist that as opposed to being simply responsive the material strats acting smart. They also say that being smart is not just a matter of developing a response in proportion to a stimulus; it also includes principles, such as adaptation and feedback. These materials in the field of dentistry are referred to as "Biosmart dentistry."[2]

In general, properties of smart materials are:

• Piezoelectric — an electric current is generated when a mechanical stress is applied.

• Shape memory — after heat is applied the materials can return to their original shape even after deformation.

• Thermo chromic —change in color in response as changes in temperature.

• Photo chromic — change color in response as there is deviation of the light conditions.

• Magneto rheological — change in state of the fluid material to solid when placed in a magnetic field.

• PH sensitive — swelling or collapsing of the material as there is change of the pH of the surrounding media.

• Bio film formation— formation of bio film on the material by alteration of the interaction of the surface with the environment.

Table 1 shows the classification of smart material in dentistry according to use in different branches.

Table 1: Classification of smart materials in dentistry according to use

I.Passive smart restorative materials: Material which without any outer control respond to external change
•Glass ionomer cement (GIC)
• Resin-modified GIC
• Compomer
• Dental composites
II. Active smart restorative materials: material which utilize a feedback loop which lead to function like a cognitive response through an actuator circuit.
1 Restorative dentistry
• Smart GIC
• Smart composites
– Ariston pHc
– Aluminium composite panel (ACP) composites
• Smart prep burs
2 Prosthetic dentistry
• Smart ceramics
• Smart impression materials
3 Orthodontics
• Shape memory alloys (SMAs)

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4 Pediatric and preventive dentistry

• Fluoride-releasing pit and fissure sealants

• ACP-releasing pits and fissure sealants

5 Endodontics

• Nickel-titanium (NiTi) rotary instruments

6 Oral surgery

• Smart suture

7 Smart fibers for laser dentistry

8 Smart antimicrobial peptide

MATERIAL & METHOD:

This paper reviews the current literature from the year 1998 to 2018. An electronic literature search was made in MEDLINE/PubMed, EBSCO host, and Google Scholar databases. MeSH terms used were: Smart materials, fluoride release, glass-ionomers, Smart ceramic, Smart composite Shape memory Burs.. The data was also compiled manually from comprehensive textbooks. Some recommendations were also acknowledged on the opinion of experienced researchers and clinicians.

SMART MATERIALS WITH SIGNIFICANT APPLICATION IN DENTISTRY

Dentistry has been through associate degree era that has seen widespread use of passive and inert materials. They were designed in such how that they are doing not act with body tissues and/or fluids. Supported their interactions with the atmosphere, dental materials are presently generally classified as bioinert (passive), bioactive, and bioresponsive or sensible materials. the primary sensible dental materials to be utilized in medical specialty were the nickel-titanium alloys, or SMAs used as orthodontic wires .

Amorphous calcium phosphate releasing pit and fissure sealants

ACP is antecedent within thebiological formation of hydroxyapatite (HAP).it's each preventive and restorative properties, which justify its use in dental cements and adhesives, pit and fissure sealants and composites. Aaron S. Posner has delineated ACP for initial time in 1963. At neutral or high pH, ACP remains in its original kind. However at or below five.8 (critical pH) demineralization of tooth surface can ensue.

Advantages:

1. It acts as a reinforcement of the natural process of the tooth only required.
2. Its longlifeand there's nowashout. Patientcompliance isn't needed.
3. Casein phosphopeptide (CPP), a milk spinoff is complicatedes with ACP and this CPP — ACP complex is employed in dentifrices as a remineralizing agent within the reversal of early white spot lesions below the name ReCaldent.
4. it's marketed as Gc tooth mousse plus®- (The University of Melbourne, Victoria, Australia) and a brand new GIC containing 3%(w/w) CPP-ACP(FujiVIIEP).
5. Unstabilized ACP, CPP stable ACP, and bioactive glass containing atomic number 20atomic number 11 phosphosilicate ar a

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number of the systems available[3,4] they need each preventive and restorative properties, that justify their use in dental cements and adhesives, pit and fissure sealants and composites.

Smart GIC

The sensible behavior of GIC was initial prompt by Davidson.[5] Once samples of restorative materials were heated to see their values of constant of thermal enlargement, for composite materials, enlargement and contraction occurred within the expected method no matter dry or wet conditions. GIC shows no/ stripped - down dimensional changes in presence of wet /heat. However once it's heated in dry condition at five hundred C, shows marked contraction. This can be due to the movement of water in or out of the structures that is analogous to the behaviour of human dentin. This property makes GIC a sensible dental material. thanks to this behaviour, GlC's will give perfect marginal adaptation to the restorations. Further sensible behavior of GIC is fluoride release. Mahmud GA et al. 2007 explicit that the employment of fluoride cathartic cement will minimize the demineralisation around orthodontic brackets and demineralization doesn't dependent upon the number of fluoride free. Commercially out there as Gc Fuji IX physician additional (in corporate a "SmartGlass" filler).

These sensible ionomer mimic the behaviour of human dentin. organic compound changed glass ionomer cement, compomer or giomer all exhibit these sensible characteristics[6].

Alkaline Glass Restorative Material

It is a nano-filled glass restorative material light-activated alkaline,recommended for the restoration of class I and II lesions in deciduous and permanent teeth[7]. It is an "intelligent" restorative material because it releases calcium, fluoride, and hydroxyl ions when intraoral pH values drop below the critical pH of 5.5; it counteracts the demineralization and promotes remineralization.[8]

Smart Ceramics

Aesthetics is one of the important aspect of the dentistry. In 1995, at ETH Zurich, the first "all ceramic teeth and bridge" involved a process that enables the direct machining of ceramic teeth and bridges. The method concerned machining a prefabricated ceramic blank made of zirconia ceramics with a nanocrystalline porous structure within the presintered state, followed by sintering. These area unit metal — free biocompatible life like restorations that permits them to mix well with the encompassing natural dentition[9]. They created the method of restoring teeth to natural [10]. Ex: Cercon Zirconium Smart Ceramic System.

Smart Composites:

They are alkaline, nano-filled glass restorative material. Once intra-oral pH drops below 5.5, calcium, fluoride and hydroxyl ions are released. These free ions help in remineralization. This material can be utilized in accordance with class 1 and class 2 cavity in deciduous and permanent teeth till the depth of 4mm.Ex: Ariston pH control - introduced by Ivoclar -Vivadent (Liechtenstein) Company.

Self- healing composites

After a era of use, materials degrade due to different physical, chemical, and/or biological stimuli. This leads to degradation in the properties of the material finally leading to its failure. Self- healing has become one of the amongst foremost desired properties in material development. The first self- healing resin- based synthetic material has been developed by White *et al*. The material consisted of an epoxy system which consisted a microcapsule of dicyclopentadiene, which is a highly stable monomer with excellent shelf life.

Smart impression material

These materials exhibit more:

• Hydrophilic to get void free impression.

• Shape memory during elastic recovery resists distortion for more accurate impression,

• Snap — set behavior results in precise fi tting restorations without distortion.

• The setting times and the working cut by a minimum 33%.

• Viscosity— materials with low viscosity have high flow.

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Ex: Imprint™ 3 VPS, Impregim™, Aquasil ultra (3M ESPE Dental Products, USA).

Shape Memory Alloys (SMA)

Shape memory alloys (SMA) are the metals with a power to revert the original shape/length when subjected to the thermo- mechanical load. These alloys show properties like super elasticity, shape memory, good resistance to fatigue and wear and relatively good biocompatibility[11]. Ex: Nickel – Titianium.

In orthodontics, due to limited flexibility and tensile properties the use of stainless steel was replaced by NiTi arch wires because of their superelasticity and shape memory, which make them to apply continuous gentle forces on the teeth, which are in physiologic range over a longer period of time.

NiTi alloys have also found use in rotary endodontics.Introduced by Walia *et al*. in 1988, rotary NiTi files have made instrumentation easier and faster than conventional hand instrumentation during the biomechanical preparation of root canal treatment. The advantage of using rotary NiTi files are improved access to curved root canals during cleaning and shaping with less lateral force exerted.

Smart Fibres For Laser Dentistry:

Laser means Light Amplification by Stimulated Emission of Radiation. Laser radiation of high-fluency can be delivered by Hollow-core Photonic-Fibers (PCFs) which can ablate tooth enamel been developed.. These photonic fibers are known as SMART FIBRES. 40 ps of laser pulses with a complete energy up to 2mJ coupled into a Hollow core of a Photonic Crystal Fibre having a core diameter of approximately 14 μm that are focused on a tooth surface to induce an optical breakdown, resulting in plasma formation and dental tissue ablation[12].

Smartseal Obturation System

The smartseal obturation system is a point-and-paste passageway filling technique which consisted of premade, deliquescent endodontic points and an associated sealer. The deformable point is available innumeroust tip sizes and tapers and is meant to expand laterally while not increasing the length by engrossing residual water from the instrumented canal area which naturally occurring intraradicular wetness. The Pro Point inner core is a mixture of two proprietary nylon polymers that is Trogamid T and Trogamid CX. The polymer coating is a cross-linked copolymer of acrylonitrile and vinylpyrroli done, which has been polymerized and cross-linked using allyl methacrylate and a thermal initiato[13].

SmartPrep burs (SS White, Lakewood, NJ, USA)

These are polymer burs with shovel- like straight cutting edges. The polymer material has been designed to be harder than carious, softened dentin but softer than healthy dentin. It is claimed to remove carious dentin selectively; whereas, healthy dentin is not affected (minimally invasive excavation); the cutting edges wear down in contact with harder materials. SmartPrep burs are available in three ISO sizes 010, 014, and 018 and are meant for single- use only (self- limiting action)[14]

Smart Sutures:

They are created from of thermoplastic polymers that have both shape memory and perishable properties. Smart sutures made of plastic or silk threads lined with temperature sensors and micro-heaters will be sight infections. When the temperature is raised on the top of the thermal transition temperature, the suture would shrink and tighten the knot, applying the optimum force. Ex: Novel MIT Polymer (Aachen, Germany)[15].

Smart Antimicrobial Peptide:

These are pheromone-guided ―smart‖ antimicrobial peptide, which are targeted against Streptococcus mutans causative microorganism of dental caries[16].The action of AMPs typically involves binding to the negatively charged functional groups of microbial membranes (e.g, lipopolysa-ccharides) and creating a disruption by inserting into the membranes, although it has been suggested that a number of AMPs translocate intra-cellularly and are lethal via a different mechanism. (Zasloff) Specifically targeted antimicrobial peptides (STAMP‘s) could be delivered in current oral care products such as mouthwash, toothpaste, or dental floss and could help with the suppression of cariogenic bacteria[17].

Smart Coating For Dental Implants

Researchers at North Carolina State University developed a smart coating for implants that made it

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more biocompatible and less prone to infections. These materials work by fostering bone growth into implants[18]. This smart coating has a crystalline layer close to its surface and an amorphous layer close to the bone, which over time dissolves, releasing Calcium and phosphate ions encouraging bone formation and Osseo integration[19].

CONCLUSION:

The numerous applications of smart materials have revolutionarized many areas of dentistry & there is no doubt that 'Smart Materials' hold a real good promise for the future. Smart materials are an answer to this requirement of environment- friendly and responsive materials. Smart materials are a new generation of materials which hold a good promise for the future in the field of "bio- smart dentistry."The most sophisticated class of smart materials in the upcoming future will be that which emulate biological systems of the human. This class of multi-functional materials will possess the capability to select and execute specific functions intelligently in order to respond to changes in the local environment. The benefit for the patient and the quality of dental therapy will undergo a significant improvement if suchmaterials are developed and introduced. Dentists should be aware of these innovative materials to enable their use and utilize their optimal properties in day- to- day practice to provide quality and effective holistic treatment.

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