

Think Smart, Think of Biosmart Materials

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Abstract: Earlier, materials which were used in dentistry were passive and inert. Later the application of smart materials started with magnetostrictive technologies. These materials are also known as "Responsive Materials". These materials are able to be altered by different stimuli such as pH, Temperature, Moisture etc. Smart behaviour of these biosmart materials hold a good promise to the future of dentistry.

Keywords: Active Smart Materials, Biomimetic, Bioresponsive, Fluoride Release, Passive Smart Materials,

I. Introduction

Earlier, materials which were used in dentistry were passive and inert. That is, they were designed to exhibit no interaction with body tissues and/or fluids. Later, it was studied that some materials have caliber to act as 'active' materials. The first active behaviour noted was the release of 'Fluoride' from some dental materials.

The use of the terms "smart" and "intelligent" materials started from the USA in 1980s. And the application of smart material started with magnetostrictive technologies. In it, Nickel was used as a sonar source during World War I for finding German boats by Allied forces.

McCabe and Zrinyi first defined smart materials as "Materials that are able to be altered by stimuli and transform back into the original state after removing the stimuli."^[1] These stimuli are pH, temperature, moisture, electricity, chemical, biomedical agents, stress and/or magnetic fields. This smart behaviour of materials grabbed fascination of the scientists in biomedical science and dentistry as well. Later, dental materials were categorized as bioinert (passive), bioactive, and bioresponsive or smart materials. This categorization was based on their interactions with the environment. As Smart materials give response by sensing and responding to some environmental changes, these materials are also known as "Responsive Materials"^[2]

Classification:

A) *Passive Smart Restorative Materials*

-Respond to external change without external control.

- GIC
- Resin Modified GIC
- Compomer
- Dental Composites

B) *Active Smart Restorative Materials*

- Utilize a feedback loop to enable them to function like a cognitive response through an actuator circuit.

1. *Restorative Dentistry*

- Smart GIC
- Smart composites
- Ariston Phc

Prosthetic Dentistry

- Smart ceramics
 - Smart impression materials
- 2. Orthodontics**
 - Shape memory alloys.
 - 3. Paediatric and Preventive Dentistry**
 - Fluoride releasing pit and fissure sealants
 - ACP releasing pits and fissure sealants
 - 4. Periodontics**
 - Smart antimicrobial Peptide
 - 5. Endodontics And NiTi rotary instruments**
 - 6. Smart Fibers for Laser Dentistry**
 - Hollow-core Photonic-Fibers

1. Restorative Dentistry:

1.1. Smart Glass Ionomer Cement-

Credit for the discovery of smart behaviour of GIC goes to *Davidson*. Restorative materials placed in this environment may show thermal expansion or contraction in response to thermal stimuli. If this expansion and contraction do not match with each other, it can cause stress development at the interface of a tooth and restoration resulting in microleakage.

GICs have a coefficient of thermal expansion close to that of dental hard tissues. Through observation, there were minimal or no dimensional changes in GICs on heating (expansions) and cooling (contractions) in wet conditions but the materials demonstrated a marked contraction when heated at 50° C in dry conditions^{[2][7]}. It mimics the behaviour of human dentin by showing movement of water in or out of the structures. Due to this smart behaviour of GIC, it provides good marginal adaptation to the restorations. The other aspect of the smart behaviour of GIC is the fluoride release and recharge capacity^[3]

Resin modified glass ionomer cement, compomer or giomer also shows these smart characteristics: Example- GC Fuji IX GP EXTRA (Zahnfabrik Bad Säckingen, Germany).^[4]

1.2 Smart Composites:

It contains ACP, which releases calcium, fluoride and hydroxyl ions when intraoral pH values drop below the critical pH of 5.5^[5] And thus prevents demineralization of the tooth surface and also aids in remineralisation. Also material can be cured upto the depth of 4mm^{[6][7]}

Example- Ariston pH control — introduced by Ivoclar — Vivadent (Liechtenstein) Company.

1.3 Smart Ceramics/ Cercon:

Ceramics, are used since long back to fabricate crowns, and these are used as a porcelain fused metal (PFM) meaning porcelain with a metal substructure. This metal substructure reduces the aesthetic quality of the restoration.^[8]

Smart Ceramics have strength that allows bridges to be produced without using metal substructure of stainless steel or any other metal. Conventional Ceramics require baking in layers on metal substructure, but Zirconia based smart ceramics can be baked in single layer. Cercon Smart Ceramics gives fascinating aesthetics as the problem of dark margins and artificial grey shadow at metal ceramic interface because of underlying metal has been solved. Flexural strength and fracture toughness of these zirconia based ceramics is considerably higher than conventional ceramics.^[9]

2. Endodontic files:

The smart behaviour of NiTi alloys is because of two properties-

- superelasticity
- shape memory.

In endodontics, the root canal treatment causes stress to NiTi files and a stress-induced martensitic transformation occurs from the austenitic to the martensitic phase within the speed of the sound. A change in shape occurs, together with volume and density changes. This ability of resisting stress without permanent deformation, going back to initial lattice form, is called superelasticity. Shape memory effect is the ability of the NiTi file to come back to its original straight form without showing any sign of lasting deformation. The superelasticity of NiTi rotary instruments provides improved access to curved root canals during biomechanical preparation. This allows more centered canal preparation and also less chances of canal transportation and reduced canal aberrations cases.

3. **Fluoride Releasing Pit and Fissure Sealants:**

The most appropriate period for the placement of occlusal sealants is soon after eruption of the permanent molars, because recently erupted teeth are less mineralized and has not undergone post maturation phase. Methods of fluoride incorporation in to fissure sealant materials are the anion exchange system (organic fluoride compound chemically bound to the resin and addition of fluoride salt to the unpolymerised resin ^[7].

Examples: Fluoroshield and Deltonplus

4. **Smart Prep burs-**

Smart prep burs are the polymer burs that cuts only infected dentin. ^[11]

5. **Smart Seal Obturation Technique:**

Obturation of Root canal should provide three dimensional filling of main canal, accessory canals, and dead spaces.

C Point system- Root canal filling technique. The points are hydrophilic and are premade. These points absorb residual water from the canal space and expand laterally without expanding axially. Points are composed of Trogamid T and Trogamid CX. Three dimensional obturation ensures long-term success of root canal treatment. ^[11]

Smart paste bio- A resin-based sealant which gives excellent dimensional stability inside the root canal. Hydroxyapatite and calcium hydroxide are produced as by products which provides both antibacterial effect and are biocompatible ^[11]

6. **Smart impression material:**

Smart impression materials provide void free impression as these are hydrophilic materials. These impression materials also have Shape memory during elastic recovery which resists distortion and set behaviour results in precise fitting restorations without distortion, property known as Snap. It has low viscosity which gives better flow. ^[11]

Example- Impregim™, Imprint™ 3 VPS, Aquasil ultra.

II. **Conclusion**

New era in dentistry has begun with introduction of biosmart materials in dentistry. And no doubt the smart behaviour of these biosmart materials hold a good promise to the future of dentistry.

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