SMART COMPOSITE: A REVIEW ARTICLE


ABSTRACT

Science and technology in the 21st century relies heavily on the development of new materials that are expected to respond to the environmental changes and manifest their own functions according to the optimum conditions. Smart materials are an answer to this requirement of environment friendly and responsive materials which alter their properties to perform specific functions. They are called smart because they sense conditions in their environment and respond to those conditions. Dentistry is a branch of science which is heavily dependent on use of various materials to provide treatment solutions of varied nature. Dental practitioners 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 solution to dental problems.

Key Words: Canting, Mini implants, intrusio

Introduction:

“Technology should serve mankind and not vice-versa.”

Dental composite traditionally consists of a mixture of silicate glass particles, within an acrylic monomer i.e. Polymerized during application.

Contemporarily, resin based composite (RBCs) materials are the most prominent aesthetic restorative materials because of their universal usage, minimal loss of tooth structure and ability to be directly placed without laboratory procedures. Advances in the resin materials and usage techniques have further allowed RBCs to fulfil almost all the ideal requisites of a restorative material.

Dental composites are esthetically pleasing since they possess tooth like appearance, are stable within the oral environment, are relatively easy to handle and do set on demand via LED or other blue light curing.

Dental composites, however, still have several drawbacks. These include their polymerization shrinkage, potential failure of the resin-dentin interface leading to secondary caries, a relatively high coefficient of thermal expansion and a relatively low wear resistance compared to metal based restorations. Leaching of uncured monomers from the composite may lead to cytotoxic effects in the surrounding gingival tissues. Much of recent research on resin based dental material focussed on these
challenges and significant progress was made, although the basic principles of composition and effects of dental composites remained unchanged during the last decades.

**Recent advances and future perspective in composite resins**-

**RBCs (Resin based composite) for posterior restorations**-
Posterior RBCs have shown an acceptable clinical performance with proper application of restorative techniques. They possess excellent resistance to wear with a low annual failure rate of 0% to 10%. Following modified RBCs are used primarily in the posterior region.

Condensable/packable RBCs or polymeric rigid inorganic matrix material (PRIMM) - because of their highly plastic composition in the pre-cured state, composites cannot be packed vertically into a cavity in such a way that the material flows both laterally and vertically to ensure intimate contact with the cavity walls. The development of packable RBCs is thus an attempt to accomplish two goals: easier restoration of a proximal contact; and handling properties similar to that of amalgam.

This new concept was developed by Dr. Lars Ehrnfors of Sweden in 1995. This system is composed of a resin matrix, and an inorganic ceramic component. Rather than incorporating the filler particles into the composite resin matrix, he devised a unique system by which the resin is incorporated into the fibrous ceramic filler network. The filler mainly consist of aluminium oxide and silicon dioxide glass particles or barium aluminium silicate or strontium glasses.

This new concept resulted in advantages like better marginal adaptation, lower potential for incorporation of microscopic porosities, lesser polymerization shrinkage, optimal mechanical characteristics like flexural strength, modulus of elasticity and coefficient of thermal expansion and greater wear resistance.

Packable RBCs feature less stickiness and stiffer consistency than conventional RBCs and a wear rate similar to that of amalgam. Because of increased viscosity and resistance to packing, some lateral displacement of the matrix band is possible, which allows for convenient placement and easier establishment of interproximal contacts in the posterior teeth.

**Indirect posterior RBCs** (laboratory RBCs)-
Because of the major clinical problems clinicians have experienced with direct composite
resins, the indirect inlay or onlay systems were introduced. Since the restoration is made on a die rather than directly on the tooth the restoration has superior adaptation, contour and proximal contact. On the whole there is a dramatic improvement in the general clinical performance. A number of highly improved indirect resin restorative systems have been introduced with unusually good properties like wear resistance, aesthetics, marginal adaptation, control over polymerization shrinkage. Art glass - it is a non conventional dental polymer marketed since 1995. It is most commonly used in inlays, onlays and crowns. The resin matrix is composed of bisGMA/UDMA. This configuration provides a higher level of cross linking and better control over the positions along the carbon chain where cross linking occurs. This aids in improving the wear resistance and other physical and mechanical properties of the resin matrix. Filler is radio-opaque barium glass. A moderate amount of colloidal silica is also incorporated for the purpose of enhancing certain handling characteristics.

Art glass is photo cured using a special xenon stroboscopic light. The emission ranges from 320-500 nm. Art glass has the advantages of having considerably more wear resistance than conventional light cured composites, good marginal adaptation, aesthetics and superior proximal contact.

**Belle glass hp**

It was introduced by belle in 1996 as an indirect restorative material. Resin matrix contains bisGMA and fillers. The belle glass is polymerized under pressure of 29 psi at elevated temperature of 138 degree centigrade and in the presence of nitrogen, an inert gas. The elevated temperature increases the polymerization rate. The increased atmospheric pressure reduces the vaporization potential of the monomers at elevated temperatures. Use of nitrogen gas during polymerization process relates to an increase in the wear resistance i.e. Nitrogen provides an oxygen free environment, which in turn results in higher levels of polymerization; more translucency of cured mass. Oxygen if gets entrapped in the composite, it interferes with polymerization and reduces translucency. It is aesthetically appealing and highly wear resistant.

**FLOWABLE COMPOSITES**

They were developed mainly in response to requests for special handling properties for composite resins rather than any clinical
performance criteria. Hence their physical properties had limitations.

A modification of the small-particle-filled and hybrid RBCs has resulted in the so called flowable RBCs.

**NANOCOMPOSITES**

Nanofillers feature filler particles in the size range of 1nm to 100nm (greater than 0.1 micron). Nanosized colloidal silica filler particles have been used for fabrication of optimal sized particle RBCs. The newer generations of nano RBCs are basically nanohybrid RBCs, containing either a combination of nanofillers with nanoclusters or a combination of different types of filler particles, including nanofillers. The size of nanofillers used in RBCs is below the wavelength range for visible light (0.02-2.00 micron) and thus, they do not produce light scattering or absorption. These RBCs have high filler loading, workable consistency, excellent polishability, as well as good handling, strength and wear properties.

1) **FIBRE REINFORCED RBCS:**
Fibre-reinforced RBCs consist of a reinforcing component, which provides strength & stiffness, and a surrounding matrix that offers ort and enables workability. Generally, polyethylene, carbon fibres, or glass fibres are incorporated into the composite. The fibres may be arranged in various configurations; unidirectional fibres (long, continuous and parallel) are the most popular, followed by braided and woven fibres. Orientation of fibres is found to have a significant effect on direction of shrinkage strain. Their main application are in dental splints, reinforced composite structures and root posts, reinforcement of denture bases, fixed partial dentures, and reinforced bio medical implants.

2) **ORGANICALLY MODIFIED CERAMICS (ORMOCER)**

Ormocers are a packable restorative material that contains a novel inorganic-organic copolymer matrix based on multifunctional urethane and thioether (meth)-acrylate alkoxy silanes. Ormocers do not release any detectable residual substances, show reduced polymerization shrinkage (1.88%) and have high abrasion resistance.

3) **GIOMER**

Representing a true hybridization of glass ionomer and RBCs, giomer restoratives have the fluoride-release
and recharge properties of glass ionomer cements along with the excellent aesthetics, easy polishability, and strength of RBCs. Giomers offer increased wear resistance, high radio-opacity and shade conformity, and a high and sustained level of fluoride release and recharge.

4) ANTIMICROBIAL MATERIALS-

Antimicrobial properties of composites may be accomplished by introducing agents silver or one or more antibiotics into the material. Microbes are subsequently killed on contact with the materials or through leaching of the antimicrobial agents into the body environment.

Silver and titanium particles were introduced into dental composites respectively to introduce antimicrobial properties and enhance biocompatibility of the composites. Alkylated ammonium chloride derivatives and chlorohexidine diacetate have also been introduced as antimicrobial agent into dental composites.

There are sometimes problems with introducing antimicrobial agents into composites, such as decrease of the antimicrobial properties with the time or reduced ability of the composites to light cure.

5) RBCs WITH ANTICARIOGENIC PROPERTIES-

Yet another innovation in composite resins is to produce materials with anti cariogenic properties. Different monomer systems have been formulated to achieve this goal, like Incorporation of chlorhexidine, Anticariogenic monomeric systems, Fluoride releasing RBCs, but most of these materials are not commercially available and still have to reach the markets.

STIMULI RESPONSE MATERIALS / SMART MATERIALS-

Stimuli response materials also called smart materials possess properties that may be considerably changed in a controlled fashion by external stimuli. Such stimuli may be for example changes of temperature, mechanical stress, ph, moisture, or electric or magnetic fields.

Stimuli responsive dental composites may be quite useful for example for “RELEASE ON COMMAND” of antimicrobial compounds or fluoride to fight microbes or secondary caries respectively. These materials are classified on the basis of their fluoride releasing capacity as “active” and “passive” smart materials.
LOW-SHRINKAGE RBCS-

Various materials have been developed, tested and tried for the purpose of minimizing the polymerization shrinkage and associated stresses of RBCs. One of the earlier developments includes the introduction of eutectic monomer system such as bis (2-methacrylyloxyethyl) esters of phthalic (MEP), isophthelic (MEL), and terephthalic acids (MET) and the use of liquid crystalline monomers that shrink less when photo cured. Low shrink experimental oxirane RBCs have also been tested that have decreased wear resistance compared to methacrylate based RBCs. The most recent additions to this RBC category are silorane based RBCs.

SELF ADHERING (SELF ETCH) RBCs:

Recently a new type of RBCs has been manufactured by effectively fusing together self adhesive bonding agent and the resin based composite restorative technology. These self adhering RBCs can bond to both dentin and enamel without the use of separate adhesive bonding system, thus reducing the chances of post operative sensitivity and allowing for a faster restoration that can safe operator’s time and patient’s money.

12.). SELF REPAIRING /SELF HEALING COMPOSITES (BIOINSPIRED MATERIALS)-

Materials have usually a limited lifetime and degrade due to different physical, chemical and/or biological stimuli. These may include external static (creep) or dynamic (fatigue) forces, internal stress states, corrosion, dissolution, erosion or biodegradation. This gradually leads to a deterioration of the material structure and finally failure of the material. Nature has inspired scientists and researchers to develop materials which can repair by themselves.

These principles inspired material scientists and engineers worldwide to develop synthetic so-called self healing or self repairing materials. One of the first self repairing synthetic materials reported, interestingly shows some similarities to resin based dental materials, since it is resin based. This was an epoxy system which contained resin filled microcapsules. If a crack occurs in the epoxy composite material, some of microcapsules are destroyed near the crack and release the resin. The resin subsequently fills the crack and reacts with a Grubbs catalyst dispersed in the epoxy composite,
resulting in a polymerization of the resin and repair of the crack.

CONCLUSION-
There is much room for the improvement and further development of resin based dental materials, such as composites. A new quality of dental composites may, however be created if nanotechnology is used and other new developments in material science and biomaterials are considered in composites in the future.

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