



## ADVANCES IN DENTAL COMPOSITES- A REVIEW

## Dentistry

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## ABSTRACT

The chronicle of tooth-coloured aesthetic restorations began with silicate cement followed by polymethylmethacrylate. Both materials demonstrated decent initial aesthetics, but had poor physical properties. Therefore, composite resins were introduced to overcome the inherent shortcomings of previous materials. Initially, composites' use was limited to restoration of anterior teeth only. However, today by virtue of their improved mechanical properties, they are used even in posterior areas. Not only this, their versatility has also led to their utilization in other areas of dentistry including splinting and bonding orthodontic brackets. Therefore, this article gives a review of the advancements of composite materials that had taken place over the years.

## KEYWORDS

Composite, Advances, Aesthetic Restoration

## INTRODUCTION

Restorative dental materials have undergone more of a revolution than an evolution since their introduction. They have constantly and rapidly improved, shifting their focus from unaesthetic amalgam restorations to aesthetic composite restorations. Contemporary history of tooth-coloured aesthetic restorations began with silicate cement followed by polymethylmethacrylate (PMMA). Both materials demonstrated decent initial aesthetics but had poor physical properties. Moreover, other disadvantages like dissolvability in oral fluids and polymerization shrinkage stopped them from being the preferred materials for restorations.<sup>1</sup>

Therefore, to enhance properties and to overcome drawbacks of previous materials, R Bowen introduced a dental restorative material fortified with silica particles (1962),<sup>2</sup> widely called "composites". Its decent properties and excellent appearance helped it phase out previous unaesthetic materials. Initially, use of composites was limited to restoration of anterior teeth only. However, today because of their improved mechanical properties, they are used even in posterior areas. Not only this, their versatility has also led to their utilization in other areas of dentistry including splinting and bonding orthodontic brackets. Therefore, this article gives a review of the advancements of composite materials that had taken place over the years.

## Advances In Dental Composites

## 1. Compomers

Developed in early 1990s. They are more precisely entitled Polyacrylic acid Modified Composite Resins (PMCRs). Compomers are a new category of dental materials that impart integrated benefits of Composites and Glass ionomers. Compomers are designed for non-stress bearing areas and have adequate aesthetics, handling ease, and tooth structure adherence, but poor physical qualities. They do release fluoride, however only at a very low level (<10% of glass ionomer release).<sup>3</sup>

## 2.Ormocers

Introduced by Dr. Herbert Wolters, Fraunhofer Silicate Research Institute, Wurzberg, Germany and is patented in 1994.<sup>4</sup> The term "Ormocer" is a registered trademark of Fraunhofer Gesellschaft (FHG), Germany. ORMOCER stands for Organically Modified Ceramic. These are advanced restorative materials having an ingenious matrix technology and filler particles. Its structure consists of a certain pre-shaped copolymeric network. Unlike Conventional

polymers, Ormocers have a wide back bone, operationalized with polymerizable organic units. This produces a concrete three-dimensional polymeric composites.<sup>5</sup>

## 3. Antibacterial Composites

Several studies have shown that plaque and bacteria gather on resin-composite surfaces than on other restorative surfaces.<sup>6</sup> Hence, antibacterial composites have proved beneficial and promising in reducing bacterial load on restorative surfaces. Chlorhexidine was added in resin materials but proved unsuccessful since release was not uniform and led to disadvantages like toxicity, short-lived antibacterial property and decline of physical and mechanical properties of material. Imazato et al.<sup>7</sup> included a non-releasing freshly synthesized monomer MDPB (Methacryloxydecylpyridium bromide) having antibacterial properties into resin composites (1994). The methacryloyl structure of MDPB molecule co-polymerizes with other methacrylate monomers, hence, on curing it binds to matrix resin chemically. Also, mechanical properties of Bis-GMA based composites were not affected by inclusion of MDPB into composite. Since then various materials like silver, zinc oxide, bioactive glass, etc., have been added to resins to produce antibacterial effect of composites.<sup>7</sup>

## 4. Whiskers composite

Introduced in 1996. Here, silica glass particles and high-strength fine sized ceramic crystalline whiskers are fused at high temperatures. Whiskers are then silanized & integrated into dental resin. It has increased fracture toughness, is resistant to contact damage and micro-cracking and has improved bimodal distribution of fillers in matrix. However, unfortunately the crystals are colored and not suited for aesthetic considerations. They also have roughened whisker surfaces and enhanced crack pinning.<sup>8</sup>

## 5. Flowable composites

In late 1996, flowable resin composites were introduced in response to an appeal for distinct handling properties. These are activated by light and have low viscosity which are advocated for use in pediatric restorations, cervical lesions and areas of small non-stress bearing restorations. Flowable composites are modifications of restorative composite resin, containing larger resin matrix and lower filler content. They reveal higher polymerization shrinkage and lower wear resistance than microhybrid composites because of their lower filler content. Its high organic content permits higher water sorption and

discoloration with time. As they have a lower viscosity, they are dispensed easily by a syringe, making their handling easy.<sup>2</sup>

## 6. Packable composites

Introduced by Dr. Lars Ehrnford of Sweden in 1997. These are traded as composites having properties similar to amalgam but also possessing the ability of being cured by light upto a depth of 5mm. They are highly viscous, have low surface tackiness and are condensable but not like amalgam. Flat faced instruments can be used to compress these materials and enforced to flow. Their composition includes dimethacrylate resins which are light activated and coarse ceramic fibers (aluminium oxide and silicon dioxide) instead of conventional inorganic filler particles that possess filler loading of 66%-70% by volume. Numerous proprietary manufacturing procedures, like raising viscosity, increasing filler content above 80%-85% by weight, and creating unique particle shape and size distribution, have given these composites packable features.<sup>9</sup>

## 7. Bioactive/ Smart composite

Attempts for combining composite resin and glass ionomer has led to development of ion-releasing polyacid modified composite, known as smart composite. Ariston pHc is a product of this group of composites, which was developed by Skrict and released in 1998. Ariston pHc is a composite substance that releases ions. As pH in the area directly adjacent to restorative material decreases, fluoride, hydroxyl, and calcium ions are released. Smart composites are based on a newly designed alkaline glass filler that inhibits bacterial growth at restoration's margins, reducing secondary caries formation. As a result, there is less demineralization and acid produced by caries-causing microorganisms is buffered.<sup>4</sup>

## 8. Giomer (PRE-REACTED GLASS-IONOMER)

Introduced by Shofu Inc. in 2000. (Kyoto, Japan). It is also known as PRG composites because it uses pre-reacted glass ionomer (PRG) technology to generate a stable phase of GIC in restoration. Before being incorporated into silica-filled urethane resin, fluoroaluminosilicate glass of these materials is made to react with polyalkenoic acid in water. This method varies from compomers in that a variable portion of dehydrate polyalkenoic acid is introduced into resin matrix, but acid does not interact with glass until restoration absorbs water. Giomers are light polymerized, like compomers, and require a bonding mechanism to bind to enamel and dentin. Reactmer bond is the current bonding system in market (Shofu Inc. Kyoto, Japan). Reactmer bond is PRG-based glass ionomer-based, tricurable, all-in-one, filled adhesive that contains 4-AET, 4-AETA, UDMA, HEMA, PRG filler, fluoroaluminosilicate glass, acetone, water, and initiator. Giomers' surface finish is superior to that of ordinary GICs and resin-modified GICs, but is similar to composites and compomers. Average particle size of giomer (excluding PRG particles) <1µm. Clinical stability, biocompatibility, fluoride release, superb aesthetics, and flawless surface finish are just a few of the benefits.<sup>10</sup>

## 9. Nanocomposites

These have recently entered the market, and their producers claim that these resin-based materials offer adequate characteristics for usage in stress-bearing locations like posterior restorations. Nanocomposites (Nano-fillers) are made up of extremely small filler particles (0.005–0.01 µm). As these tiny particles agglomerate easily, a wide range of filler sizes is conceivable, leading to enhanced physical and aesthetic qualities.

There are two types of nanofiller particles:

- 1) Nanomeric (20 and 75nm in diameter) are monodisperse nonaggregated and nonagglomerated silica nanoparticles.
- 2) Nanoclusters (2-20nm) are spherical agglomerated particles like zirconia-silica particles (2-20nm) and zirconyl salt (75nm).<sup>11</sup>

## 10. INDIRECT AESTHETIC MATERIALS

### I) Fiber-reinforced Composites

Introduced by Smith in 1960s.<sup>12</sup> Fiber reinforcement of polymer resins has been available since then. Silane-treated glass fibers and plasma treated polyethylene are commonly used.

Vectris™ FRC Material (Ivoclar Williams, Amherst, NY) is a light cured, tooth-colored, translucent material built from FRC technology which serves as framework for Targis system. Its composition and shading are ideally coordinated with natural dentition. It is made up of a couple of layers of fibre wafers and fibre bundles that are positioned

uniaxially. The same variety of organic polymer matrix used in Targis is utilised to reinforce the material (Ceromer). These features ensure life-like aesthetic restorations, surpassing their ceramo-metal counterparts. Their translucency enhances their optical characteristics. Unlike metal, Vectris presents elasticity similar to dentin, accounting for a positive effect on distribution of stress within the material itself and abutment teeth during mastication.

### II) Indirect Ceromer (targis™ Ceromer)

Ceromers merge the benefits of ceramics with those of cutting-edge composite resin technology owing to their structure and composition. They are made up of submicrometer-sized fine ceramic fillers (0.04 and 1.0µm) that are densely packed (about 80% by weight) and embedded in sophisticated organic matrix with best light and heat curing capabilities. Ceromer technology is far more complicated, as it contains polyfunctional groups. Such designs have potential to provide larger levels of cross linking and double-bond conversion, resulting in increased material strength. Adjusted optical properties permit simulation of natural dentition, facilitating a harmonious blend of restoration with remaining tooth structure.

The material's ceramic (inorganic) phase provides long-lasting aesthetic quality, resistance to abrasion, and excellent stability. The material's resin (organic) phase impacts polishability, successful bonding with luting resin, low brittleness, reduced fracture susceptibility, and convenience of ultimate correction and chairside repair. Targis Indirect Ceromer System is heat and light cured, aesthetic, high strength, perfect fitting, bondable posterior crown and bridge system without any metal. Targis provides an attractive, wear-compatible, high-strength material which can be utilized with metal in crown, bridge, inlays/onlays, partial dentures, implant cases, and combination cases when combined with Targis Link, a covalent metal bonding agent.

### III) Ribbon

Ribbon was invented by Smith in which glass fibres were utilised to strengthen polymethyl methacrylates. Ribbon reinforced prostheses have unrivalled strength and fracture toughness due to its unique blend of ultrahigh strength fibres, increased bondability, and revolutionary cross-link lock stitch leno weave.<sup>13</sup>

### IV) Artglass

Launched in 1995 by Heraeus-Kulzer. Artglass is a new multi-functional methacrylate. Its matrix may create three-dimensional molecular networks with a dense cross-linking structure. In chemical literature, these heavily cross-linked, amorphous organic polymers have been referred to as "organic glasses." Artglass contains only 75% filler (55% microglass; 20% silica filler), however, when matrix is cured, amorphous, highly cross-linked organic glass known as 'Polymer glass' emerges, which is a robust, elastic material.

## 11. Orthodontic Composites

### I) Moisture-active Adhesives –

For effective polymerization, they demand moisture rather than tolerating it. These materials come in paste form and have an entirely separate composition and polymerization mode, thus requires no bonding agent. Prior to application, however, surface must be wetted on purpose. Smart-bond (Gestenco International AB, Sweden), a modern product based on acryanoacrylate formulation, has exhibited exceptional characteristics, good in vitro performance, and ease of clinical application without requiring etching and liquid resin coating.<sup>14</sup>

### II) Antibacterial Orthodontic Adhesives-

Some particles, primarily silver nanoparticles, are added to adhesives to assist in reducing bacterial burden surrounding brackets. Incorporation of nanoparticles into adhesive had challenges with dispersion and consistency, but when properly mixed, showed good bacterial suppression without affecting physical qualities. Other research, on the contrary, found that adding nanoparticles to adhesives reduces their bond strength.<sup>23</sup> In recent investigations, an antibacterial quaternary ammonium salts (QAS) monomer, 2-methacryloxyethyl hexadecyl methyl ammonium bromide (MAE-HB), was combined with orthodontic adhesive and showed excellent effects.<sup>15</sup>

### III) Remineralizing Adhesives–

ACP (amorphous containing phosphate) possesses both preventive and restorative characteristics because of which it is used in dental

cements, sealants, composites, and orthodontic adhesives. ACP-filled composite resins proved to recover 71% of decalcified tooth's lost mineral content. Aegis-Ortho (The Bosworth Co, Skokie, Illinois, USA), an ACP-containing adhesive, has been proposed for use as light-cured orthodontic adhesive with qualities similar to formerly used resins. This critical situation can be maintained for long periods, acting as a potent antagonist to demineralization and promoting prevention of further white spots following orthodontic treatment.<sup>16</sup>

changing adhesives-Transbond Plus, Blugloo, Grengloo. *J Adv Med Dent Sci Res.* 2020;8(1):1-8.

#### IV) Color Changing Adhesives –

It is easy to detect color-changing light-cured composites on enamel of a tooth during bonding & debonding procedures (eg. Transbond Plus, Blugloo and Grengloo).<sup>17</sup>

- (a) Transbond™ Plus (3M Unitek) (Monrovia, CA) is a color-changing orthodontic bonding adhesive that claims to have good bond strength with both metal and ceramic brackets. When Transbond Plus is exposed to light (both ambient light and curing), it activates pink indicator incorporated in it.
- (b) Blugloo™, a dual color-changing adhesive (Ormco Corporation) (Glendora, CA), promises an advanced formulation suited for aesthetic brackets. When adhesive is exposed to lower temperatures, it has blue tint, which transforms to translucent colour when adhesive is exposed to warm body temperatures.
- (c) Grengloo™ (Ormco Corporation) is a dual-color-change adhesive designed exclusively for metal brackets. It polymerizes more quickly than conventional light-cured orthodontic adhesives, resulting in a higher proportion of overall bond strength at initial force loading. It is also made to withstand up to 118% more impact, thus decreasing bond failures caused by traumatic impact.

#### CONCLUSION

Composites have been found to have good tooth adhesion and aesthetic properties with low thermal conductivity ever since their introduction which has led to the spread of their application in various fields of dentistry. With evolution of nanotechnology, nanostructuring and hybridization, the material now possesses properties to actively fight microbes and also promote tissue regeneration. However, despite acquiring these properties, composite has not compromised on the property of durability and can provide excellent service for many years, if performed with appropriate methodology. Therefore, clinicians should have a thorough knowledge of tooth morphology, tooth shade analysis, composite systems and manipulative techniques to create restorations that will mimic natural tooth. Even as materials improve and become easier to handle, special attention should be paid to these variables, which are still critical for clinical success. Finally, with growing demand for aesthetics, the necessity for better composite materials is greater than ever and will continue the drive to explore forward.

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