

# DENTAL MATERIAL

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# **GLASS-IONOMER CEMENTS (GICs)**

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**The glass-ionomer cements were first described by Wilson and Kent in 1971, and, at the time, presents a natural extension to the zinc polycarboxylate cements that had become available in 1960s.**

## Uses:

- 1) Mainly for the restoration of erosion lesions.
- 2) Luting agent for crown and bridge restorations.
- 3) Their clinical application is now being extended by the introduction metal reinforced GIC and resin modified GIC.

## **Unique characters of GICs:**

Glass-ionomer cements are interesting materials when compared to the zinc phosphate cements because:

- 1) Their composition can be varied widely, giving many different properties.

**2) There are numerous combinations of polyacids that are suitable for copolymerization.**

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3) zinc phosphate cements, once composition is optimized in terms of the p/l ratio and the concentration of the phosphoric acid, there is little scope for improvement.

## Types of GICs:

- A. Conventional GICs.
- B. Metal reinforced GICs.
- C. Resin modified GICs.



## A. Conventional glass ionomer cements:

### Powder

The glass contains three main compositions:

- 1) Silica ( $\text{SiO}_2$ )
- 2) Alumina ( $\text{Al}_2\text{O}_3$ )
- 3) Calcium fluoride ( $\text{CaF}_2$ ) and NaF

**Manufacturing:** sintering process to reduce reactivity.

## **Function of the glass powder:**

- (a) Release ions needed for setting and properties of the hard cement.
- (b) Contributes to aesthetics.

## **Liquid**

**The polyacids used are copolymers of:**

- 1. Acrylic acid: main reactant.**
- 2. Itaconic acid: to reduce viscosity of the liquid and inhibit gelation caused by intermolecular hydrogen bonding.**
- 3. Tartaric acid: is an important hardener, and controls the pH during the setting process which in turn controls the rate of dissolution of the glass.**

## **Presentation:**

- 1) Powder /liquid form (conventional).
- 2) Anhydrous cements (water settable).
- 3) Capsules: pre-proportioned capsules.

## **Setting reaction:**

It is an acid-base reaction and involves three overlapping stages:

**1) Dissolution:** The acid attacks Ca Al silicate powder and lead to the release of  $\text{Ca}^{++}$ ,  $\text{Al}^{+++}$ ,  $\text{Na}^+$ , and  $\text{F}^-$  from surface layer becomes depleted in these ions, so that only a silica remains at powder surfaces.

## 2) Gelation:

(a) The initial setting is due to rapid action of  $\text{Ca}^{++}$ , which, being divalent and more abundant initially. React more readily with the  $\text{COOH}$  groups of the acid than do the trivalent  $\text{Al}^{+++}$ .

(b) The efficiency with which the  $\text{Ca}^{++}$  cross-link the polyacid molecules is not as good as it might be, because they are also able to chelate  $\text{COOH}$  groups on the same molecule.



(c) Protect GIC form environment during this critical phase to avoid cement weakening due to:

i.  $Al^{+++}$  loss from the cement, thereby being unable to cross-link polyacrylic acid chains.

ii. Water loss by evaporation or water gain from environment.

N.B.

- 1) To avoid these effects paint the surface with varnish.
- 2) Some of newer GIC formulation have rapid setting so do not need protection against moisture.

### **3) Hardening stage:**

- a. It comes after the gelation stage and can last as long as 7 days.

b. It takes some 30 minutes for the uptake of  $Al^{+++}$  to become significant, but it is the  $Al^{+++}$  which provides the final cement strength, as they are responsible for the introduction of the cross-links.

c. There is a continuation of the formation of aluminium salt bridges, and water becomes bound to the silica gel, which now surrounds the residual core of each of the glass particles.

d. Once the cement has fully reacted, the solubility is quite slow.

## **Microstructure of set GIC:**

Cored structure consisting of glass particles cores, each of which, is surrounded by a silica gel, embedded in a matrix of cross-linked polyacrylic acid.



# Properties of GIC:

## **I. Working and setting times**

It is less than that  $\text{ZnPO}_4$ . Water settable systems have longer working time and slower initial set than the hydrous systems.

## **II. Mechanical properties:**

- 1) its compressive strength is comparable to that of  $\text{ZnPO}_4$  cement.
- 2) Its tensile strength is slightly higher than  $\text{ZnPO}_4$ .
- 3) Its modulus of elasticity is less  $\text{ZnPO}_4$  cement.

**III. Film thickness:** Similar to or less than that of  $\text{ZnPO}_4$  cement ( $25\mu\text{m}$  or less).

**IV. Solubility:** Good resistance to dissolution under oral conditions and improved by varnish protection.

**V. Bonding to tooth structure and restorative materials:** Its adhesive character is comparable with that of zinc polycarboxylate cement because both are polyacids.

## **VI. Anticariogenic properties (fluoride release)**

GICs possess anticariogenic properties as a result of slow and long-term fluoride release. The released fluoride is taken up by both tissues surrounding the restoration.

## **Mechanism of action of fluoride in caries fighting:**

**1) Fluoride contributes to the formation of acid-resistant crystals and reduces the risk of caries development. It reacts with the calcium hydroxyl-apatite to form calcium fluoro-apatite. The latter apatite is more resistant to acid dissolution than the former.**



**2) The fluoro-apatite has lower surface energy than the hydroxyl-apatite, hence less adhesion of the bacterial flora and food debris to the former apatite than the latter.**

**3) Fluoride inhibits the enzymes responsible for fermentation of carbohydrates by microorganism.**

**4) Fluoride shifts the equilibrium balance between demineralization and remineralization toward remineralization. This is because fluorides act as a catalyst for uptake of Ca & phosphate ions**

## **VII. Biocompatibility:**

**GICs are as compatible as zinc polycarboxylate cements for the same reasons discussed before with polycarboxylate cements.**

## **VIII. Aesthetics:**

**(a) Earlier GICs were considered inferior to many composite resins in aesthetic appearance because of their inadequate translucency.**

**(b) GICs appeared dull and lifeless, and this limited their application to the restoration of erosion lesions and non-critical class III cavities.**

**(c) In fact, GICs translucency was more closely matched to that of dentine than that of enamel.**

## **Advantages of GICs:**

- 1) Chemical bonding to tooth structures.
- 2) Biocompatible.
- 3) Long term fluoride release.
- 4) Good compressive strength.
- 5) Low solubility in oral fluids.

## **Disadvantage:**

- 1) Technique sensitive as they are very sensitive to rather water contamination or dehydration.
- 2) Low abrasion resistance.
- 3) Short working time and long setting time.
- 4) Brittleness and low fracture toughness.



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