PRIYADARSHINI DENTAL COLLEGE

CEMENTS IN ORTHODONTICS

INTRODUCTION

A variety of cements have been used in dentistry through the years. In general, cements one employed for two primary purposes.

1) To serve as restorative filling material either alone or in conjunction with another material, and.
2) To retain restorations or appliances in a fixed position with in the mouth.

Less frequently, certain newer cements are used for specialized purposes in the restorative, endododntic, and periodontal, orthodontic and surgical fields of dentistry.

Numerous dental treatments necessitate attachment of indirect restorations and appliances to the teeth by means of a cement.

These include metal, resin, metal-resin, metal-ceramic, and ceramic restorations, provisional or interim restorations; laminate, veneers for anterior teeth; orthodontic appliances; and pins and posts used for retention of restoration.

The word Luting is often used in textbooks to describe the use of moldable substance to seal a space or to cement two components together; hence the term is descriptive cements.

The use of dental cements for attachment of orthodontic bands to the teeth was

first described in latter part of 19th century.
The cementation of band is a routine process in orthodontics.

Much of preventive, interceptive, and corrective orthodontic relies upon the use for appliances retained by bands. Probably no dental practitioner is more dependent upon the performance of dental cements than the orthodontists.

For no matter how skillful an orthodontic band maybe constructed it will not remain on the tooth throughout its functional use without the aid of cement.

In addition, to attachment it is equally important to protect the tooth under band from caries.

For this reason physical characteristic of dental cement and their manipulation are of particular interest to orthodontists,

Although, dental cements are used by orthodontists to such extent their application to orthodontic per se has received little attention in literature.

While investigation is still on regarding decalcification of enamel under orthodontic bands

a)Adhesive force of cement with the band .

b)Physical properties for cement.

c)Fluoride usage in cements.

The preparation of a cement mix to be used for cementation of orthodontic bands appear to be achieved arbitrarily

Orthodontists are generally agreed that the consistency used for cementation for orthodontic bands lies b/w cementation for inlays and consistency used for cement base and the best mix for orthodontic to use is the mix which combines the maximum amount of powder consistency with the time requirements for clinical practice.

These cements as differentiated from cement bases, liners and restorations.

A numbers of materials are available for cementation purposes. These include.

1) Zinc phosphate cement.
2) Zinc silicophosphate.
3) Zinc polycarboxylate cement.
4) Glass Ionomer cement.
5) Resin – based cements.

Securing the band or bonding the bracket requires a luting cement. It seems paradoxical that the retention, seal, and survival of the orthodontic bracket and bond depend so much upon this relatively weak thin film of cement.

An ideal cementing agent capable of withstanding oral condition over the long terms has proven difficult to develop.

History:- The zinc oxychloride cements were among the first dental cements to be used as filling materials during the middle 1850's. Other chemical combinations, described as magnesium oxychloride and zinc oxysulfate cement, also were employed in this early period, but all of these materials were found to be highly irritating to pulp tissues and unsatisfactory as cementing media.materials.

They all exhibited a high degree of solubility in the mouth fluids and generally did not withstand the oral environment. In 1878, the zinc phosphate cement was introduced to overcome some of the objections just mentioned.

This cement proved to be much more acceptable and elicited a more favorable response from members of the profession than did its predecessors.

Restorations in which the zinc phosphate and earlier cements were used displayed poor esthetic qualities because of the opacity of the cementing

Although transluscent cement introduced by Fletcher in England in about 1971 it did not become popular, the widespread use of the transluscent silicates began with the improved German products about 1904 by Paul Steenbock as Ascher's Artificial Enamel.

The introduction of polycarboxylate cement by Smith in 1968 was a major advance towards true adhesive attachment by molecular bonding to tooth surface.

In 1972, A D.Wilson and B.E.Kent made a hybrid of silicate and polycarboxylate cement, which was designed to combine the optical and fluoride-releasing properties of silicate particles with adhesive and biocompatibility of polycarboxylate & called it as glass ionomer cement. With a generic same of ASPA [aluminosilicatepolyacrylate]

In 1950, unfilled acrylic resins were introduced but they had lot of disadvantage of shrinkage and thermal expansion.

In 1955, Buonocore used acid–etch technique to increase the adhesion of acrylic filling materials to enamel.

In 1962, Bowen developed a new type of resin which were called composite resin. His main innovation's were the use of bisphenol A- glycidyl methacrylate [BISGMA] and use of silane to coat filler particles to bond chemically to resin. By early to 70's, the composites has virtually replaced the unfilled acrylics and is widely use till today.

CLASSIFICATION AND USES OF DENTAL CEMANETS

CEMENT	PRINCIPAL USES	SECONDARY USES
1) Zinc Phosphate	Luting agent for restoration and orthodontic appliances.	Intermediate restoration thermal insulting bases
2) Zinc oxide – evgenol	Temporary and intermediate restoration. Temporary & permanent luting agent for luting agent for restoration. Thermal insulating base; cavity liners; pulp capping.	Root canals restoration periodontal surgical dressing.
3) Polycarboxylate	Luting agent for restorations; thermal Insulating bases;	Luting cement for orthodontic appliances;

		Intermediate restorations.
4)Silicate	Anterior restorations	
5)Silicophosphate	Luting agent for restorations.	Intermediate restorations luting cement for orthodontic appliances
6) Glass ionomer	Anterior restorations, luting cements for restorations and orthodontic appliances; cavity liners.	Pit & fissure sealant thermal insulating bases.
7)Metal-modified Glass Isomer	Conservative posterior restorations; core buildup	
8) Resin	Luting agent for restoration and orthodontic appliances	Temporary Restorations
9)Calcium Hydroxide	Pulp capping agent; thermal Insulating bases.	

CLASSIFICATION

a) Acid- base reaction cements
   1) Zinc oxide Cements
   2) Ion- leachable glasses.

b) Polymerising Materials;
   1) Cyanoacrylates
   2) Dimethacrylate Polymers.
   3) Polymer-ceramic composites.

c) Others Materials :

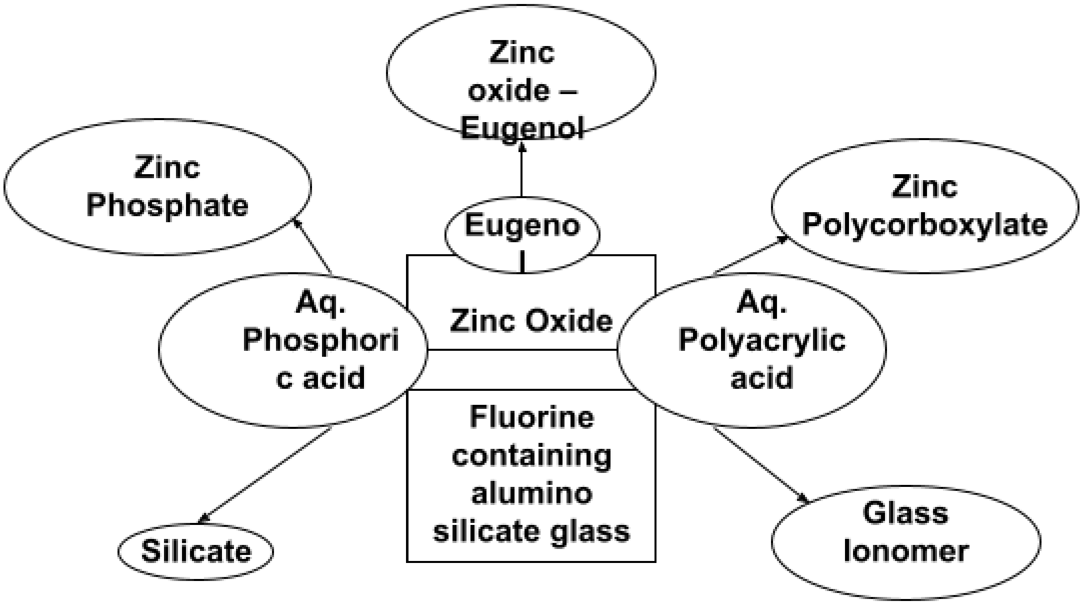
1) Calcium hydroxide
2) Gutta percha.
3) Varnishes.

Acid – base reaction Cements

Dental cements are formulated as powders and liquids. The powders are amphoteric or basic (proton acceptors) and liquids are acids or protons donors.

On mixing the two together a viscous paste is formed, which subsequently hardens to a solid mass.

5 Principal types of cements of acid-base reaction



IDEAL REQUIREMENTS OF LUTING CEMENTS

1. The material should ideally be non-irritant, non toxic to pulp and other tissues.

2. The setting characteristics should allow sufficient time for mixing the material applying to the restoration and/or tooth preparation and for seating the restoration in place in the mouth..

3. The material should ideally be of low initial viscosity or be pseudo plastic to allow flow of the cement so that proper banding can occur.

4. Luting cements should ideally give thermal & electrical insulation since many of restorations commonly cemented to the teeth are based on alloys. Ex. gold crowns

5. Retention may be improved if cement chemicals adheres to the tooth surface & band, but not to dental instruments.

6. The solubility of a cements should be low because cement margins are often exposed to oral fluids.

7. It should be anticariogenic and long-term fluoride releasing.

ZINC PHOSPHATE CEMENT

Zinc phosphate is the oldest of cementation agent and this is the one that has the longest track record. It was originally developed more than 100 years ago. It services as “Gold Standard” for all dental cements. It was adopted by A.D.A. in 1935, with specification no 8. & it designates them as two types on the basis of intended use.

Type I: for cementation of precision casting.

Type II: for all others uses.

The difference in two types is that type I cements are finer grained & must be capable of forming films of 25um or less. Where as the maximum allowable film thickness for type II cements is 40um.

COMPOSITION :-

Powder:- Zinc oxide – 90%

Magnesium oxide –10%

-Helps in hydration process during setting reaction.

- Silicon dioxide:- inactive fillers, helps in calcination process.
- Bismuth trioxide:- impart smoothness to freshly mixed cement mass & increased setting time.

Miscellaneous:- Barium oxide, Barium sulfate, calcium oxide.

The ingredients of the powder are sintered at temperatures blw 1000'c to 1400'c into a cake that is ground into fine powders.

Colors :- Yellow & gray are most popular, & these, combined with others yellows, grays, golden browns, and pinks, are advantages for some cementation.

Copper oxide, manganese dioxide, plantium black, & powdered charcoal have been used to produce shades of gray. Yellow by yellow bismuth oxide, certain chromate's or organic pigments. Iron oxide or titanium compound, to produce brown or cream colour.

LIQUID:-

- Phosphoric acid – 55%, reacts with zinc oxide.

- Waters - 35%, controls of ionization of liquid which influences rate of liquid-powder (acid-base reaction).

Some instance zincphosphate – 16.2 % reduces rate of reaction.

CHEMISTRY:-

When the powder is mixed with the liquid the phosphoric acid attacks the surface of the particles and releases zinc ions into the liquid. The aluminum, which already forms a complex with the phosphoric acid, reacts with the zinc and yields a zinc alumuniphosphate gel on the surface of the remaining portion of the particles. Thus, the set cement is a cored structure consisting primarily of unreacted zinc oxide particles embedded in a cohesive amorphous matrix of zinc aluminophosphate.

$2ZNO + 2\ H_3\ Po_4 + 4H_20 \longrightarrow 2Zn\ Hpo_4.\ 3H_2o \xrightarrow{Zno}$

Zinc Phosphoric acid Zinc acid

Oxide + water Phosphate

$Zn_3\ (Po_4)_2\ .\ 4H2O+3H_2O$

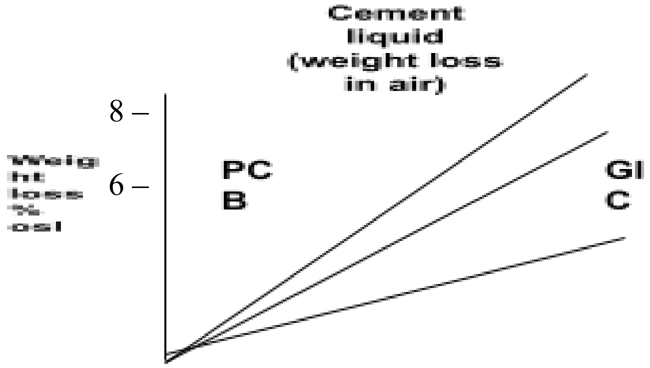
Tertiary zinc phosphate.

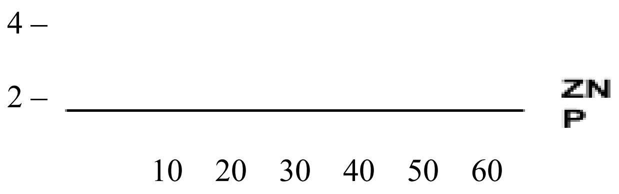
[Of all the contemporary dental cements zinc phosphate is the only one with a crystalline reaction product matrix. This allows, diffusion, leakage of small molecules than other cement system, also tends to be more brittle than others cements as they have amorphous matrix]

<u>MANIPULATION:-</u> In summary, the following points should be observed in the manipulation of zinc phosphate cements.

1) It is probably, not necessary to use a measuring device for proportioning the powder & liquid, because the desired consistency vary to some degree with the clinical situation. However, the maximal amount of powder possible for the operation at hand should be used to ensure minimum solubility and maximum strength.
2) A cool mixing slab should be employed. The cool slab prolongs the working and setting time and permits the operator to incorporate the maximum amount of powder before the matrix formation proceeds to the point at which the mixture stiffens.

   The liquid should not be dispensed onto the slab until mixing is to be initiated because waters will be lost to air by evaporation.





3) Mixing is initiated by addition of a small amount of powder. Small quantities are incorporated initially with brisk spatulation. A considerable area of the mixing slab should be used. A good rule to follow is to spatulate each increment for 15 seconds before adding another increment. Completion of the mix usually requires approximately 1 minute and 30 seconds. The desired consistency is always attained by adding more powder & never by allowing a thin mix to stiffen.
4) The band should be seated immediately, if possible before matrix formation occurs after placement it should be held under pressure until the cement sets to minimize the air space. The field of operation should be kept dry during the entire procedure.
5) Excessive cement can be removed after it has set. It is recommended that a layer of varnish or other non permeable coating should be applied to the margins.

   This allows the cement more time to mature & develop an increased resistance to dissolution in oral fluid.

WORKING AND SETTING TIME

Working time is the time measured from the start of mixing during which the viscosity [consistency] of the mix is low enough to flow readily under pressure to form a thin film. It is obvious that the rate of matrix formation dictates the length of working time.

Setting time, means that the matrix formation has reached a point where external physical disturbance will not cause permanent dimensional changes.

It can be measured with a 4.5N [1-pound] Gillmore needle at a temperature of 37^0c and relative humidity of 100%. It is defined as the elapsed time from the start of mixing until the point of the needle no longest penetrates the cement as the needle is lowered onto the surface.

Practically, it is the time at which the zinc phosphate cement flash should be removed from the margin. Setting time for zinc phosphate cement according to A.D.A. specification No.8 is 5 to 9 min.

FACTORS INFLUENCING WORKING AND SETTING TIME:-

Working and setting time of a commercial product are inherent properties controlled by the manufacturing process. It is desirable to extend the setting time of cement to provide sufficient work time for manipulation.

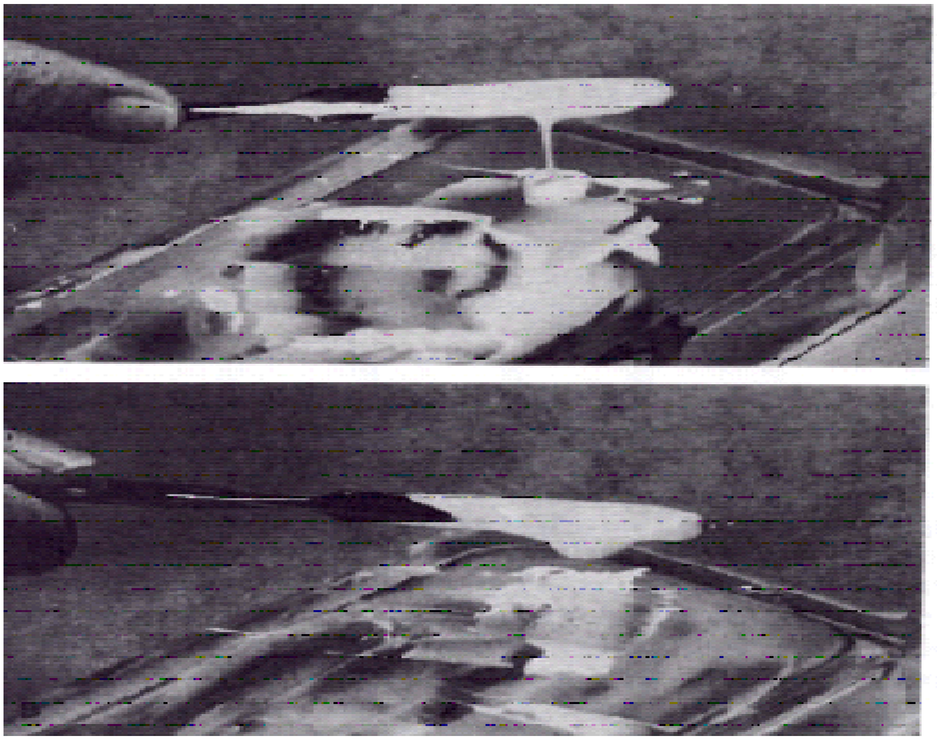
The following are means to extend the setting time at chair side.

a) Powder:Liquid ratio:- Working and setting times can be increased by reducing the power:liquid ratio, this is not acceptable means of extending setting time because it impairs the physical properties & results in decreased pH of the cement & decrease in compressive strength.

b) Rate of powder incorporation:- Introduction of small quantity of powder into the liquid for first few increments increases working and setting times by reducing the amount of heat generated and permits more power to be incorporated into the mix.

SPATULATION TIME:- Prolong spatulation time effectively destroys the matrix that was forming. Fragmentation of the matrix means extra time is needed to rebuild the bulk of the matrix.

TEMPERATURE OF MIXING SLAB:- The most effective method of controlling the working and setting times is regulate the temperature of the mixing slab. Cooling the slab markedly retards the chemical reaction between the power and the liquid so that matrix formation is retarded. This permits incorporation of the optimum amount of powder into the liquid without the mix developing an unduly high viscosity.



PHYSICAL AND BIOLOGIC PROPERTIES:-

Two physical properties of the cement that are relevant to the retention are the mechanical properties and the solubilities. The band can become dislodged if the underlying cement is stressed beyond it strength. High solubility can induce loss of the cement needed for retention and may create plaque retention sites.

Zinc phosphate cements, exhibit a compressive strength of 104MPa and diametrial tensile strength of 5.5 MPa. Thus, it is quite stiff and should be resistant to elastic deformation even when it is employed for cementation of restorations that are subjected to high masticatory stress.

The compressive strength vary with P:L ratio. The recommended P:L ratio for zinc phosphate cement is about 1.4g to 0.5 mL.

The increase in strength is attained by addition of powder in excess of the recommended amount is modest as compared with the reduction incurred by decreasing the amount of powder in the mix.

A reduction in the P:L ratio of the mix produces a markedly weaker cement.

A loss or gain in water content of liquid reduces the compressive and tensile strength of the cement.

RETENTION:- Setting of the zinc phosphate cement does not involve any reaction with surrounding hard tissue or other restorative materials. Therefore, primary bonding occurs by mechanical interlocking at interfaces and not by chemical interaction.

BIOLOGIC PROPERTIES:- The presence of the phosphoric acid, the acidity of the cement is quite high at the time when a band is placed on a prepared tooth.

Two minutes after the start of the mixing, the pH is approximately 2. The pH then increases rapidly but still is only about 5.5 at 24 hours. Through radioactive phosphoric acid it has been seen, the acid can penetrate a dentin thickness as great as 1.5 mm.

COMMERCIAL NAMES:-

Confit, Harvard, Zinc cement improved, Modern Tenacin,

Factors govering the rate of set of zine phosphate cement.

Controlled by manufactures	**Controlled by operator**

a) Powder composition

b) Degree of power calumniation

c) Particle size of power

d) New tralization of liquid

e) Water content of liquid

a) Powder liquid ratio

b) Rate of power incorporation

c) Mixing temperature

d) Manner of spatulation

e) Water contamination or loss from liquid.

ZINC POLYCARBOXYLATE CEMENT

The cement was introduced by D.C.Smith in 1968, this was a major advance towards true adhesive attachment by molecular bonding to tooth surface.

The cement is formed by mixing zinc oxide powder with polycarboxylic acid liquid.

COMPOSITION AND CHEMISTRY

The polycarboxylate cement are powder – liquid systems.

Liquid: An aqueous solution of polyacrylic acid or a co-polymer of acrylic acid with other unsaturated carboxylic acid such as itaconic acid. The liquid is an approximately 40% aqueous solution of polyacrylic acid, of average molecular weight b/w 20,000 and 50,000. The lower viscosity 20,000 is used for cementing where as more viscous of 50,000 is used for cavity living.

Powder : Composition and manufacturing procedure for the powder are similar to those of Zinc phosphate cement.

- The Powder contains mainly zinc oxide with some magnesium oxide.
- Stannic oxide may be substituted for magnesium oxide.
- Other oxides, such as bismuth and aluminium can be added.

The powder may also contain small amount of stannous fluoride, which modify setting time and enhance manipulative properties. It also increases strength However, the fluoride released from this cement is only fraction 15% to 20% of amount released from silicophosphate and G.I.C. strength.

SETTING REACTION : - Involves particle surface dissolution by the acid that releases zinc, magnesium, and tin ions, which bind to the polymer chain via the carboxyl group.

These ions react with carboxyl groups of adjacent polyacid chains so that a cross-linked salt is formed as the cement sets. The hardened cement consists of as amorphous get matrix in which unreacted particles are dispersed.

BONDING TO TOOTH STRUCTURE : This cement bonds chemically to the tooth structure. The mechanism is not entirely understood but is probably analogous to that of the setting reaction.

The polyacrylic acid is believed to react via the carboxyl groups with calcium of hydroxyapatite. The inorganic component and the homogeneity of enamel are greater than those of dentin. Thus, the bond strength to enamel is greater than the to dentin.

GENERAL PROPERTIES :

Film Thickness : When carboxylate cements are mixed at the recommended P:L ratio, they appear to be much more viscous then is a comparable mix of zinc phosphate cement. However, the polycarboxylate mix is classified as pseudoplastic and undergoes thinning at or increased shear rate.

Clinically, this means that the action of spatulation and seating with a vibratory action reduce the viscosity of the cement, and produces a film thickness of 25um or less.

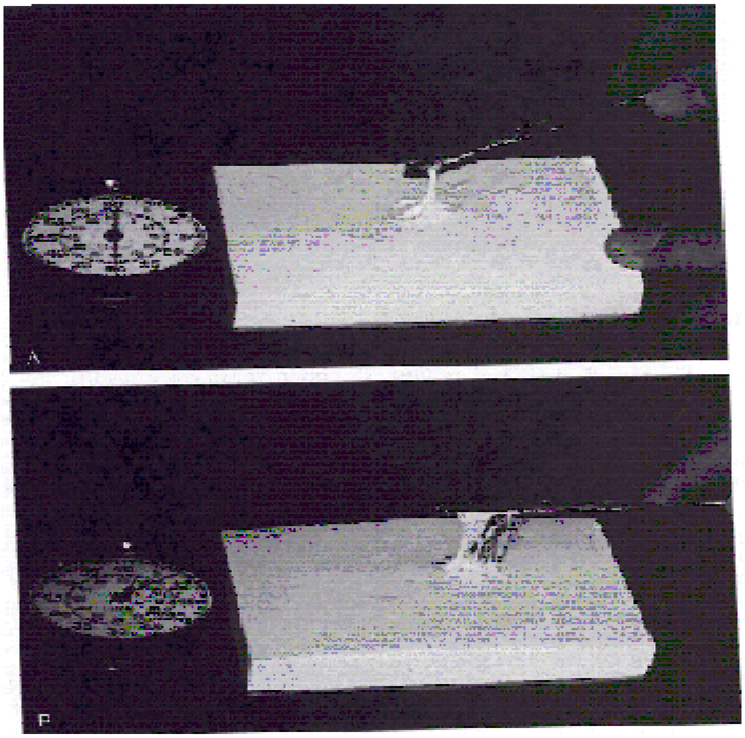
WORKING AND SETTING TIMES :

The working time for polycarboxylate cement is much shorter than for zinc phosphate cement, that is, approximately 2.5 minutes as compared to 5 min for zinc phosphate.

Cooling the glass slab unfortunately can cause the polyacrylic acid to thickness and which makes increased viscosity making mixing procedure more difficult.

If is suggested that only powder be refrigerated before mixing. The rationale for this procedure is that reaction occurs on surface and the cool temperature retards the reaction without thickening the liquid.

The setting time range from 6 to 9 minutes, which is acceptable range for a luting cement.



MECHANICAL PROPERTIES:-

Compressive strength of polycarboxylate cement is approximately 55 MPa ; hence, the cement is inferior to zinc phosphate cement in this respect. However, the diametrial tensile strength is slightly higher. It is not as stiff as zinc phosphate cement. Its modulus of elasticity is less than half that of zinc phosphate. It us not brittle as zinc phosphate cement. So difficult to remove after set.

SOLUBILITY:- The solubility of cement in water is low, but when it is exposed to organic acids with a pH 4.5 or less, the solubility markedly increases.

Also, reduction in P:L ratio results in significantly higher solubility and disintegration rate in oral cavity.

BIOLOGIC CONSIDERATION:- The pH of the cement liquid is approximately 1.7. However, the liquid is rapidly neutralized by the powder. The pH of a polycarboxylate cement is higher than that of a zinc phosphate cement at various time intervals. This cement is minimal irritation to the pulp.

Several theories have been put forth to explain the reaction of pulp to polycarboxylate and zinc phosphate cements

The pH of polycarboxylate cement rises more rapidly than that of zinc phosphate cement. In addition, it is possible that the larger size of the polyacrylic acid molecule. Compared with phosphoric acid which limits the diffusion through the dentinal tubules.

MANIPULATION: - To obtain satisfactory results, the operator must follow instructions carefully & take every precaution to avoid undesirable complications. Areas of major concern are the mixing of the cements, the surface of the band. The nature of the tooth surface receiving the band, and the time at which the excess cement is removed.

MIXING:- The cement liquids one quite viscous. The viscosity is a function of the molecular weight concentration of the polyacrylic acid and there by varies from one brand to another. Generally, they are in the range of 1.5 parts of powder, to 1 part of liquid by weight.

This cement should be mixed on a surface that does not absorb liquid. A glass slab affords the advantage over paper pads supplied by manufacturers, because once it is cooled it maintains the temperature longer.

Under no circumstance should the liquid be cooled in refrigerator.

The liquid is dispersed just before the time when the mix is made as it loses water to atmosphere rapidly & results in marked increase in its viscosity.

The power is rapidly incorporated into the liquid in large quantities. Usually the cement is mixed with in 30 sec if it is mixed more than that then cement becomes tacky.

If good bonding to tooth structure is to be achieved the cement must be placed on the tooth surface before it loses its glossy appearance.

The glossy appearance indicates a sufficient number of free carboxylic acid groups on the surface of the mixture that are vital for bonding to tooth structure.

SURFACE PREPARATION AND RETENTION:-

Despite the adhesion of the cement to tooth structure, polycarboxylate cements are not superior to zinc phosphate cement in the retention of band or bracket.

If force is applied to remove the bond with zinc phosphate & polycarboxylate cement. On examination, the fracture surface shows that failure usually occurs at the cement-tooth interface with zinc phosphate cement. In case of polycarboxylate cement, the failure occurs usually at cement-metal interface rather then at cement tooth interface.

The surface of the metal is abraded with a small stone(or it can be sand blasted with high pressure air) to improve wetability and mechanical bond at cement metal interface.

A recommended procedure is meticulous clear tooth surface is necessary to ensure intimate contact. A recommended procedure is to apply a 10%. Polyacrylic acid solution for 10 to 15 seconds followed by rinsing with water, for removal of smear layer before placement. After cleansing, the tooth is isolated to prevent further contamination by oral fluids. Blotting the surface before cementation is considered sufficient drying procedure.

REMOVAL OF EXCESS POLYCARBOXYLATE CEMENT:-

During setting, the polycarboxylate cement passes through a rubbery stage that makes the removal of the excess cement quite difficult. If the excess is removed at this stage. There may be possibility of pulling cement beneath the margin & creating a void.

The excess in not removed until the cement becomes hard. The outer surface is coated carefully with separating medium, such as petroleum jelly, to prevent excess cement from adhering, but care should be taken so that it doesn't touch the margin. Another approach is to start removing excess cement as soon as seating is completed.

ZINC SILICO PHOSPHATE:

This cement is a hybrid resulting from the combination of zinc phosphate and silicate powders. Also termed as silicate zinc.

Type I: Cementing media.

Type II: Temporary posterior filling material.

Type III: Used as dual purpose cement for cementing purposes and as temporary post filling material.

COMPOSITION:

Powder	Liquid
Silica powder	Phosphoric acid-50%
Zinc oxide	Zinc salts-4 – 9%
Magnesium oxide	Aluminum salt-2%
Fluoride	13.25%

SETTING TIME is 3-5 minutes.

Mixing time is 1 minute.

Due to presence of fluoride, it imparts anticariogenic effect. It exhibit semitransulcency for cementation purposes.

Ph is less than that of zinc phosphate and hence varnish protection for pulp is indicated

Solubility is 1% higher than the value allowed by ADA specification which is 0.2%.

ADVANTAGES OF THIS CEMENT ARE MAINLY

1)better strength and toughness than zinc phosphate.

2)considerable fluoride release.

3)translucency

4)lower solubility.

SHORT COMINGS

Rheological property of the cement leading to higher film thickness.

Need for pulpal protection.s

RESIN – BASED CEMENTS

Synthetic resin cements were made available to the dental profession in 1952 for use in the cementation of inlays, crowns, and appliances.

A variety of resin-based cements have now become available because of the development of the direct-filling resins with improved properties, the acid-etch, technique for attaching resins to enamel, and molecules with a potential to bond to dentin conditioned with organic or inorganic acid.

Some one designed for general use and others for specific uses such as attachment of orthodontic brackets.

Requisites

Methacrylate polymers have earned great popularity in dentistry, because they can be processed easily using relatively simple technique.

BIOLOGIC CONSIDERATIONS:- They should be tasteless, odorless, nontoxic, and nonirritating to oral tissues. To fulfill this it should be completely insoluble in saliva or in any other fluids taken into the mouth, and it should be impermeable to oral fluids to the extent that it does not become unsanitary or disagreeable in taste or odor.

It should bond to tooth structure to prevent microbial ingrowth along the cement borders.

PHYSICAL PROPERTIES:- It should possess adequate strength & resilience and resist biting or chewing forces, impact forces, and excessive wear that can occur in oral cavity.

It should also be dimensionally stable under all conditions of service, including thermal changes and variation in loading.

AESTHETIC PROPERTIES:- The material should exhibit sufficient translucency or transparency such that it can be made to match the appearance of oral tissues. It should be capable of being tinted or pigmented and there should be no change in color or appearance after curing.

Handling characteristics:-

It should be easy to mix, insert, shape & cure.

It should be insensitive to variations in these handling procedures.

Clinical complications. Such as oxygen inhibition. Saliva contamination

and blood contamination should have little or so effect on final out come

The final product should be easy to polish & should be easily repairable if breakage occurs.

ECONOMICS:- The cost of the resin and its processing method should be low, & processing's should not require complex & expensive equipment.

COMPOSITE MATERIALS:-

Composite material may be defined, as a compound of two or more distinctly different materials with properties that one superior or intermediate to those of the individual constituents.

COMPONENTS:-

Resin matrix:- Use monomers that are aromatic or aliphatic diacrylates.

Bis–GMA[bisphenol A-glycidyl methacrylate], UEDMA[urethane dimethacrylate] and TEGDMA [triethylene glycol dimethacrylate] are the most commonly used dimethacrylates.

As BIS-GMA is viscous, TEGDMA is added to reduce viscosity.

A blend of 75% wt bis.GMA & 25% wt TEGDMA has viscosity of h 300 cP (centipoise), where as viscosity of 50/50 blend is 200 cP.

But TEGDMA increases polymerization shrinkage.

FILLER PARTICLES:- Improves the properties of matrix material. Polymerization shrinkage is reduced. Filler particles one most commonly produced by grinding or milling quartz or glass to produce size from of too 100 um.

Silica filler:- 0.04um & referred as microfiller, & composites are classified on the basis of average size of major filler particles inorganic filler particles generals account for b/w 30 to 70% volume or 50 to 85 Wt.% of the composite.

The refractive index is 1.5 (BISGMA, TEGDMA and silica)

QUARTZ:- Has been extensively used in first generations of composites. It is chemically inert & hard. The radiopacity of filler materials is provided by a number of glasses and ceramics that contain heavy metals such as barium (Ba.), Strontium (Sr), and Zirconium (Z.R.)

These glasses also have refractive index of about 1.5 to match resin.

COUPLING AGENTS : It is important that the filler particles are bonded to resin matrix. This allows the move flexible polymer matrix to transfer stresses to the stiffen filler particles. The bond b/w the two phases of composite is provided by a coupling agent.

It improves physical and mechanical properties and provide hydrolytic stability by preventing water from penetrating filler resin interface.

Although, Titanates and Zirconates can be used as coupling agents. Organosilanes such as V-Methacryloxy propyltrimethoxy silane are used most commonly.

ACTIVATOR – INITIATOR SYSTEM : Composite use light or chemical for activation.

CHEMICALLY ACTIVATED RESIN : Two pastes, one which contains the benzoyl peroxide initiator and other a tertiary amine activator (N,N.dimethyl – p-toluidine). When two pastes are spatulated, the amine reacts with the benzoyl peroxide to form free radicals and addition polymerization is initiated. These materials are used for restoration and build-ups that are not readily cured with a light source.

LIGHT –ACTIVATED RESINS :- The first activated systems used UV light to initiate free radicals. Today, the UV light cured composites have been replaced by visible light activating systems with a greatly improved ability to polymerize thicker increments upto 2mm.

Also, visible light-activated composites are much more widely used than chemically activated materials.

Light-curable dental composites are supplied as a single paste contained in a syringe. The free radical initiating systems, consisting of the photo initiator molecule and as amine activator, is contained in this paste.

When these two components are left unexposed to light, they do not interact. However, exposure to light of the correct wavelength (approx 468nm) produces on excited state of the photo initiator and an interaction with the amine to form free radicals that initiate addition polymerization.

A commonly used photo initiator is camphoroquinone, which has an absorption range between 400 to 500 nm that us in the blue region of the visible light spectrum.

The amine accelerators that are suitable for interaction with camphoroquinone dimethylaminoethyl methacrylate is present in the paste.

INHIBITORS : To minimize or prevent spontaneous polymerization of monomers inhibitors are added to the resin systems.

The inhibitor reacts with free radical and thus inhibits chain propagation by terminating the ability of the free radical to initiate the polymerization process.

A typical inhibitor is butylated hydroxy toulene.

OPTICAL MODIFIERS : To match the appearance of teeth dental composites must have visual coloration (shading) and translucency that can simulate tooth structure.

To increase the opacity, titanium dioxide and aluminum oxide in minute amounts.

CURING : The first composites were chemically cured also called as cold curing or self curing Two pastes were mixed to initiate polymerization.

sDisadvantages : a) Air bubbles
b) So control on working time.

Then light cure was used as initiator.

Advantages : a) Controlled working time.
b) 40sec for curing of 2mm thickness.

Limitation : a) Shrinkage.
b) Light source.

Modern light source are hand held devices with light source which are equipped with a relatively short, rigid light guide made of fused optical fibers.

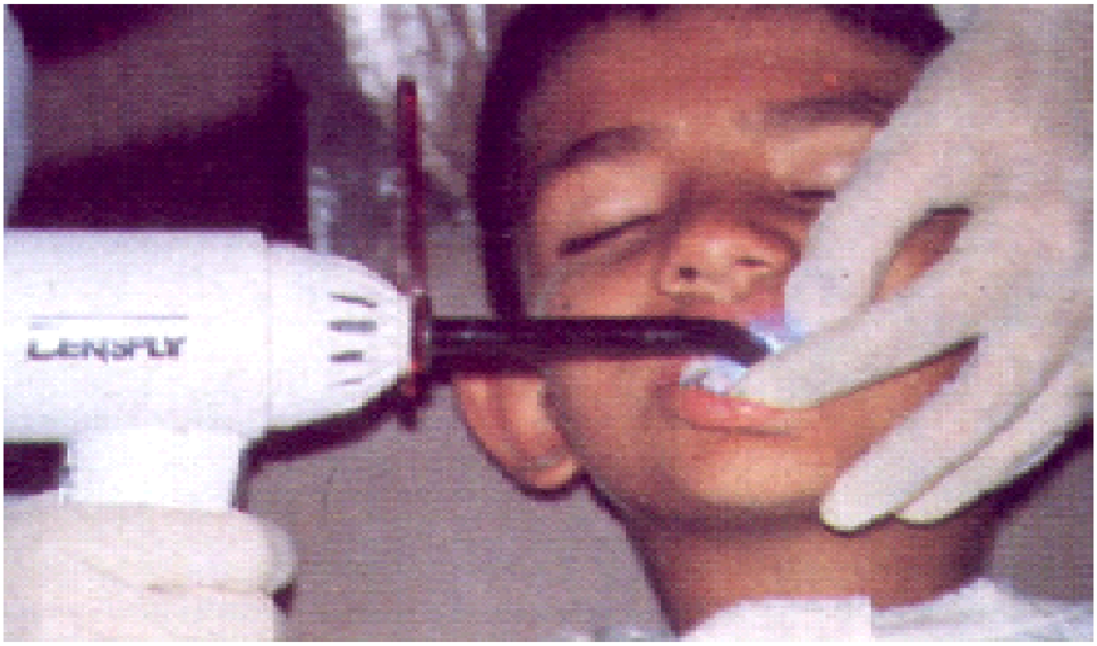
The light source is a

a)quartz-tungsten-halogen light bulb.
b) plasma curing
c) Laser curing diode.
d) Light emitting diode.

White light generated by bulb passes through a filter that removes the infrared and visible spectrum for wavelength greater than 500nm. (the tip should be 2mm off the composite to be effective) different material of light are with different shades require different curing cycle.

To overcome disadvantages of light cured materials and chemically cured materials have come which cure both chemically and light curable.

It consisting of two light-curable pastes, one of which contains benzoyl peroxide, where a tertiary amine is added to other when the clinician mixes these two pastes and expose them to light both light curing and cold curing is achieved.



CLASSIFICATION :	**AVERAGE PARTICLE SIZE**
Traditional composite	8-12 MM
Small particle filled composite	1-5 mm
Microfilled	0.04-0.4
Hybrid composite	0.6 – 1.0.

Classification of composites based on the range of filler particle size.

Microfiller - 10-100um.

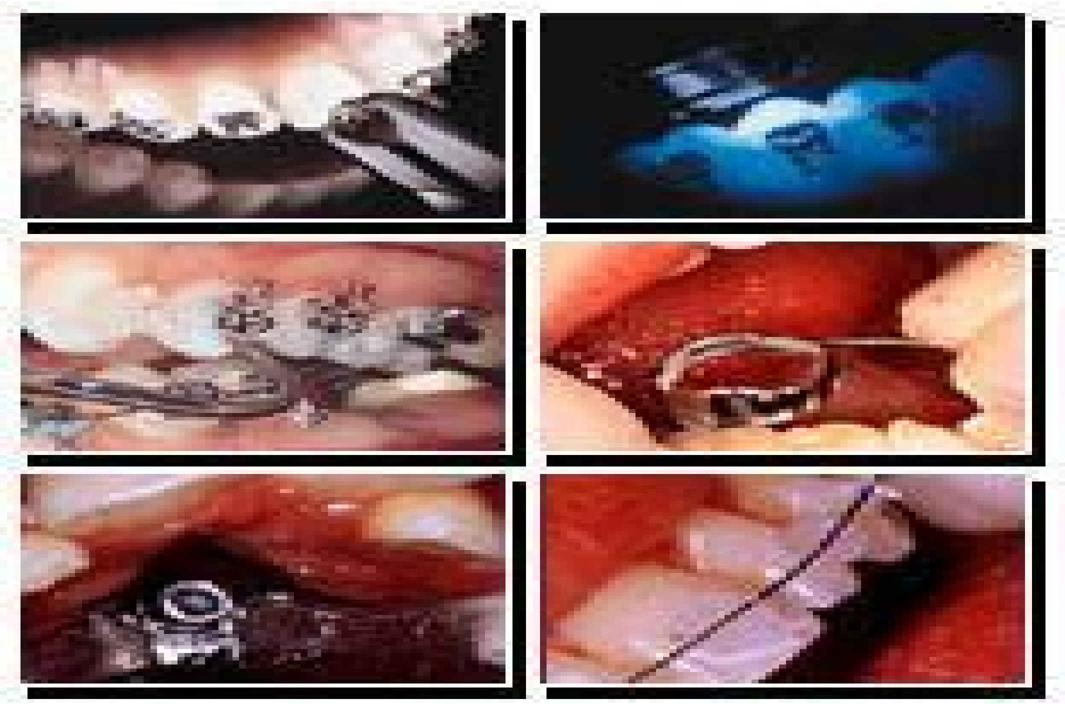
Midifiller - 1 to 10um

Minifiller - 0.1 to 1um

Microfillers - 0.01 to 0.1mm

Nanofillers - 0.005 to 0.01mm

- Composites with mixed ranges of particle sizes are called hybrids.
- If the composite simply consists of filler and uncured matrix material. It is classified as homogenous.
- It is includes precured composite or other unusual filler,
- It is called heterogeneous.



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The polymerization shrinkage is 2 vol % and thermal expansion is approx 30x10-6 per degree centigrade.

Hardness is 55 KHN and radiopacity is less than that of dentin.

CLINICAL CONSIDERATION: Is rough surface that develops during abrasive wear of the soft-resin matrix and leaves filler particles elevated, discolors over time, fractures in resin is elevated, discolors over time , fractures in high stress bearing areas.

MICROFILLED: Inorganic filler – colloidal silica with size of 0.04um in size. The filler is thoroughly mixed in resin at elevated temperature to decrease viscosity then initiator benzoyl peroxide is added.

These composite particles along with addition silane-coated colloidal silica, are then mixed into the matrix resin to form the composite paste. The weakness is that bond b/w composite particles and curable matrix is weak and cause chipping of the material and are unsuitable for stress bearing area.

PROPERTIES OF MICROFILLED COMPOSITES

These have physical and mechanical properties inferior to traditional composites as 50 to 70 vol % of restorative material is made up of resin.

The more amount of resin compared to filler particles results in increase absorption of water.

A higher coefficient of thermal expansion and decreased elastic modulus decreased tensile strength.

But they provide a smoother surface finish than the other composites as inorganic filler particles are smaller then the abrasion particles.

CLINICAL CONSIDERATIONS

This material is not given in stress bearing area as it chips due to debonding of the prepolymerized composite filler but can be given in non-stress bearing area.

SMALL PARTICLES-FILLED COMPOSITES

This was done to achieve the surface smoothness of microfilled and to improve on the physical and mechanical properties of traditional composites.

Average size of filler particles is 1 to 5 um with fairly broad distribution of size with filler particles being 60-65 vol %.

The filler particles are quartz, but most incorporate glasses that contain heavy metal like silane-coated ground particles and colloidal silica of about 5 wt%.

The composite strength and elastic modulus of small particle-filled composite exceed those of both traditional and microfilled composite. Tensile strength is double the microfilled and 1.5 times more than traditional. The coefficient of thermal expansion is less than other composites, wear resistance is decreased and decreased polymerization.

CLINICAL CONSIDERATION

Can be given in large stress bearing area and they attain a smooth surface.

HYBRID COMPOSITES: To get more surface smoothness than small particles while maintaining the properties of small particles.

Hybrid because two kind of filler particles are added like colloidal silica and ground particles of glasses containing heavy metals and constitute 75 to 80 wt%.

The particles size is about 0.6 to 1.0um

The physical and mechanical properties range b/w those of traditional and small particle filled composites. They have radiopacities greater than enamel as they have heavy metal.

CLINICAL CONSIDERATION:

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penetration, and the leakage of oral fluids often occurs adjacent to these restorations.

They are extremely technique sensitive.

They most effective way to improve mechanical bonding and the marginal seal is by use of the acid –etch technique.

This provides strong bond b/w enamel and resin :

Etched channel has a high surface energy, unlike the normal enamel surface, and allows a resin to readily wet the surface and penetrate into the micro porosities.

Once it penetrates into microporosity, it can be polymerized to form a mechanical bond to the enamel. The resin “tags” may penetrate 10 to 20um into the enamel porosity but their lengths are dependent on the enamel etching time. A number of acids have been used to produce the required microporosity, but the universally used acid is phosphoric acid at a concentration between 30% and 50% with 37%, being the concentration most commonly provided.

Concentration greater than 50% results in the formation of monocalcium phosphate monohydrate on the etched surface that inhibits further dissolution.

Although aqueous solutions are available, generally etchant is supplied in a gel form to allow control over the area of placement.

These gels are after made by adding colloidal silica or polymer beads to the acid.

Brushes are used to place the gel material, or the acid is supplied in a syringe.

During placement, air bobbles should be checked as this interface will not be etched.

Primary tooth require move etching time than permanent as it is move aprismatic.

Currently, the length of application of etchant is of the 15 seconds. A few years ago it was 60 – seconds to produce a bond equivalent.

Once tooth is etched, the acid should be rinsed off thoroughly with stream of water for 20 seconds, aid enamel dried. It should have a white, frosted appearance for indicative of a successful etch. The surface must be kept clear and dry until the resin is placed to form a good bond. If contamination occurs it reduces the energy level of the etched surface. Contaminates like saliva, blood, oil from compressor can decrease the bonding.

Properties of composites Restorative materials

Property	**Traditional**	**Microfilled**	**Small Particles**	**Hybrid.**

Inorganic filler Vol% Wt%	60-65 70-80	20-25 35-60	65-77 80-90	60-65 75-80
Compressive strength (Mpa)	250-300	250-350	350-400	300-350
Tensile strenth (Mpa)	50-65	30-50	75-90	70-90
Elastic modulus (Gpa)	8-15	3-6	15-20	7-12
Thermal Expansion Co-efficient (10-61oC)	25-35	50-60	19-26	30-40
Water Sorption (Mg / Cmk2)	1.3 – 0.7	0.4 – 1.7	0.5 – 0.6	0.5 – 0.7
Knoop hardness number	55	5-30	50-60	50-60

Supplied as :

1. Powder liquid system.
2. Two paste system.
3. Single paste with accelerator in bonding agent.
4. Or dual cured – two paste system.

Advantage :

1. High Mechanical properties.
2. How solubility.
3. Good esthetics.

Disadvantage :

1. High film thickness.
2. Chemical and thermal injury to pulp.
3. Poor dentin adhesive properties.
4. Polymerization shrinkage.
5. Lack of anticariogenic effect.

GLASS IONOMER CEMENT :

Glass Ionomer is the generic name of a group of materials that use silicate glass powder and as aqueous solution of polyacrylic acid.

This materials acquires its same from its formulation of a glass powder and an ionomeric acid that contains carboxyl groups.

It is also referred to as “Polyalkenoate cement”

Originally, the cement was designed for the aesthetic restoration of anterior teeth for use in restoring class III and V cavity preparations.

The cement produces a truly adhesive bond to tooth structure. The use of GICs has broadened to encompass formulations as luting cements, liners, restorative material for conservative class I and class II restorations and core buildups and pit and fissure sealant.

There are 3 types of GICs based on formulation and potential uses.

Type I – for luting cement.

Type II – restorative material.

Type III – use as liner or base.

Light curable versions of GICs are also available, because of the need for incorporating light curable resin in formulation, this type is also called “resin-modified GICs” or “compomers.”

Advantages:

1) Compressive strength greater than zinc phosphate.
2) An adhesiveness to enamel, dentin, and cementum.
3) Compatibility with the oral tissues.
4) Ability to leach fluoride.

Disadvantage:

1) brittleness.
2) Low tensile strength.
3) Esthetic problems due to insufficiency translucency.

COMPOSITION

The glass ionomer powder is an acid-soluble calcium fluoroaluminosilicate glass.

The raw materials are fused to a uniform glass by heating them to a temperature of 1100 degrees centigrade to 1500 degrees centigrade. Lantanum, strontium, barium, or zinc oxide additions provide radiopacity. The glass is ground into a powder having particles in the range of 20 to 50um.

COMPOSITIION OF TWO GLASS IONOMER CEMENT POWDERS

SPECIES	A weight %	B weight %
Sio_2	41.9	35.2
$Al_2 O_3$	28.6	20.1
AlF_3	1.6	2.4
CaF_2	15.7	20.1
NaF	9.3	3.6
$AlPO_4$	3.8	12.0

LIQUID: Originally, the liquids for GICs were aqueous solutions of polyacrylic acid in concentration acid in concentration of about 50%. The liquid was quite viscous and tended to gel over time. In most of the current cements, the acid is in the form of copolymer with itaconic, maleic, and tricarboxylic acid.

These acids tend to increase the reactivity of the liquid, decrease the viscosity and reduce the tendency for gelation. Tartaric acid improves handling characteristics and increases working time; however, it shortens the setting time.

To extend the working time, one glass ionomer formulation consists of freeze-dried acid powder in one bottle and water or water with tartaric acid in another bottle as the liquid component.

When the powders are mixed with water, the acid dissolves to reconstitute the liquid acid. The chemical reaction then proceeds in the same manner as traditional powder liquid system. These cements have a longer working time with a shorter setting time. They are referred as "water settable GICs" also wrongly as anhydrous GICs.

CHEMISTRY OF SETTING:

When the powder and liquid are mixed to form a paste, the surface of glass particles is attacked by the acid. Calcium, aluminum, sodium, and fluorine ions are leached in to the aqueous medium. The polyacrylic acid chains are cross-linked by the calcium ions and form a solid mass within the next 24 hours anew phase forms in which aluminum ions become bound with in the cement mix. This leads to more rigid set cement. Some of the sodium ions may rest combine with fluorine ions forming sodium fluoride uniformly dispersed within the set cement.

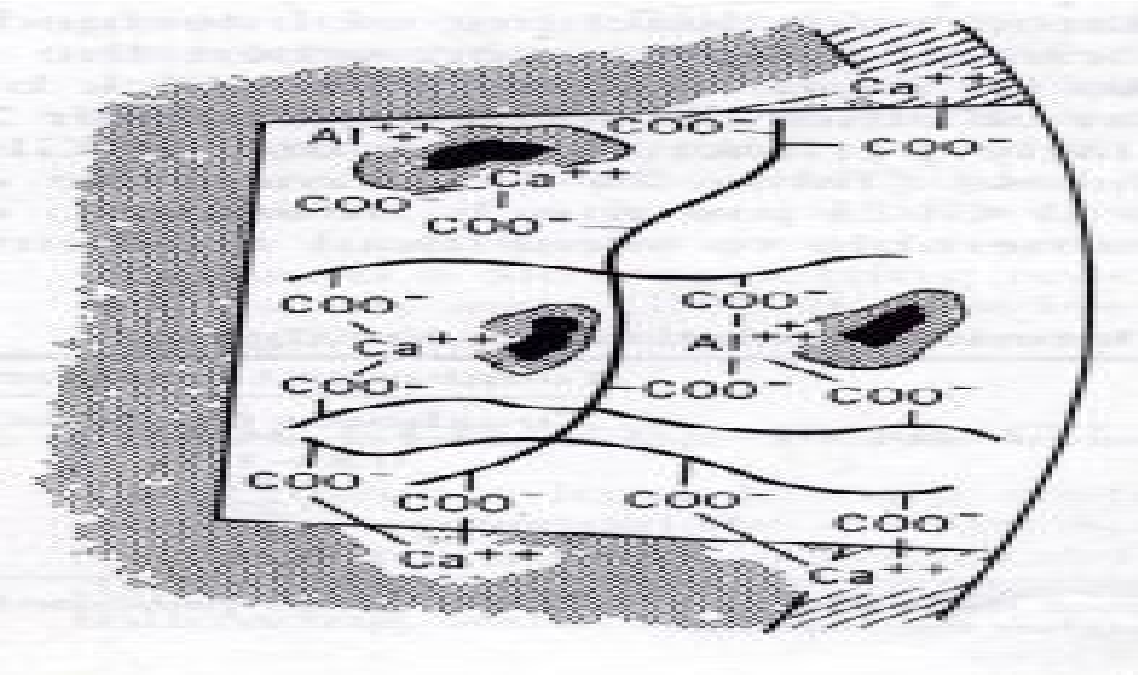
During the maturing process, the cross-linked phase is also hydrated by the same water used as the medium.

The unreacted portion of glass particles are sheathed by silica gel that develops during removal of the cations from the surface of the particles. Thus, the cement consists of an agglomeration of unreacted powder particles surrounded by a silica gel in an amorphous matrix of hydrated calcium and aluminum polysalts.

STRUCTURE OF THE GLASS IONOMER CEMENT

The solid black particles represent unreacted glass particles surrounded by the gel(shaded) that form when Al+ ++ and Ca++ ions are leached from the glass as a result of attack by the polyacrylic acid.

The calcium and aluminium form polysalts with Coo- groups of the polyacrylic acid to form a cross-linked structure. The carboxyl groups react with the calcium of the enamel and dentin.



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critical in yielding a stable gel structure and building the strength of the cement.

If freshly mixed cement is isolated from the ambient air, the loosely held water will slowly become tightly bound water over time. This phenomenon results in cement that is stronger and less susceptible to moisture.

If the same mixes are exposed to ambient air without any covering,, the surface will craze and crack as a result of desiccation. Any contamination by water that occurs at this stage can cause a dissolution of the matrix forming cations and anions to the surrounding areas.

This process results in a weak and more soluble cement. That is why the ionomer cement must be protected against water changes in the structure during placement and for a few weeks after placement if possible.

PROPERTIES OF GLASS IONOMER CEMENT

PHYSICAL PROPERTIES: The initial solubility is associated with leaching of intermediate products or those not involved in matrix formation.

However, when the GIC is tested in vitro conditions, it tends to be more resistant to attack by acids.

In vivo, solubility is compared with that of other cements. GICs are much inferior to composites in fracture toughness when subjected to in vitro tooth brush abrasion tests and simulated occlusal wear tests.

However, GICs are attractive in that they are biocompatible, they bond to enamel and dentin and they provide an anticariogenic benefit.

MECHANISM OF ADHESION

Bonding of glass ionomer is achieved in part by mechanical retention and in part by chemical chelation.

Good mechanical bonding is much more important that chemical bonding. Thus the potential of glass ionomers for chemical bonding is only an advantage in situation in which it is difficult or impossible to produce effective micromechanical retention inorganic content of enamel. The mechanism primarily is it involves chelation of carboxyl groups of the polyacids with the calcium in the apatite of enamel and dentin.

BIOLOGIC PROPERTIES

The glass ionomer cement bonds adhesively to tooth structure and they inhibit infiltration fo oral fluids at the cement –tooth interface. The pH initially at 2 minutes of polyacid liquid is 2 and water settable is 1 after 10 minutes they are approximately same at around 3.5 after 24 hours they reach around 6.

WORKING TIME: is 3 to 5 minutes with water settable tend to be longer. The setting time depending on brands is usually b/w 5-9 minutes.

SURFACE PREPARATION : Clean surface is essential to promote adhesion. A pumice wash to remove the smear layer, then apply 10% polyacrylic acid solution for 10 to 15 seconds, followed by a 30 seconds water rinse. This procedure si called “conditioning” Then the surface is dried but not be desiccated and prevention by saliva and blood is taken care of.

PREPARATION OF THE MATERIAL: The recommended P:L ratio is in range of 1.25 to 1.5g of powder per 1mL of liquid. A cool, dry glass slab may be used to slow down the reaction and extend working time. The glass slab is not used if it is cooled below dew point as the moisture condensation on glass slab can alter the acid water balance needed for proper reaction.

The powder and liquid is just dispensed before mixing.

The mixing time should not exceed 45 to 60 seconds. At this time, the mix should have a glossy surface. The shiny surface indicates the presence of polyacid that has not participated in the setting reaction. This residual acid ensures adhesive bonding participated in the setting reaction.

Type II glass ionomer are also supplied in capsules containing pre-proportioned powder and liquid. The mixing is accomplished in an amalgamator after the seal that separates the powder and liquid is broken. The capsule contains a nozzle, so the mix can be injected directly on the tooth.

The main advantages of capsule are convenience, consistent control of P:L ratio, and elimination of variation associated with hand spatulation.

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provided by manufacturers.

SUMMARY: Three parameters that must be controlled to ensure success

1) Conditioning of tooth surface.
2) Proper manipulation.
3) Protection of cement during setting.

RESIN-MODIFIED GLASS IONOMER CEMENT

Moisture sensitivity and low early strength of GICs are the results of slow acid base setting reactions.

Some polymerizable functional groups have been added to the formulations to impart additional curing process that can over come these two inherent drawbacks and allow the bulk of the material to mature thorough the acid-base reaction . both chemical-curing and light-curing products are available. This group of materials have been identified with several names including light cure GICs, dual cure GICs(for light-cured and acid-base reaction), tircure GICs (dual cure plus chemical cure), resin–ionomers, compomers, and hybrid ionomers.

None of the terms can truly describe the group of materials. We can use the term resin-modified GICs until a universal term is adopted.

COMPOSITION AND SETTING REACTION

The powder component of a typical light cured material consists of ion-leachable glass and initiator for light or chemical curing or both.

The liquid component usually contains water, polyacarylic acid or polyacarylic acid with some carboxylic groups modified with methacrylate and hydroxyethyl methacarylate monomers.

The last two ingredients are responsible for the unique maturing process and the final strength.

To accommodate the polymerizable ingredients the overall water content is less for this type of material.

The setting reaction is dual cure process, once the powder and liquid are mixed the acid base reaction of GIC commences releasing cement forming ions that continue to a final set in the absence of the light.

The resin monomers also react by polymerization to produce a resin matrix that surrounds the glass particles.

PHYSICAL PROPERTIES: Variation of properties from conventional glass ionomer can be attributed to the presence for polymerizable resins and lesser amount of water and carboxylic acids in liquid.

The most notable one is probably the reduction for translucency of resin-modified material because of a significant difference in the refractive index b/w powder and set resin matrix.

These materials release levels of fluoride comparable to those of conventional GICs.

STRENGTH: The diametral tensile strengths of resin-modified glass ionomer are higher than those of conventional GICs compressive strength of 105Mpa , diametral tensile strength 20 Mpa. Hardness 40 KHN with anticariogenic properties.

ADHESION: Bonding mechanism is similar to that of conventional GIC, shear bond strength tests are higher for resin-modified materials.

CLINICAL CONSIDERATION: same precautions should be followed as followed for conventional GIC.

The first products used for band cementation were polycarboxylate, and zinc phosphate, recently GICs became popular because they could be used in a wet environment, release fluoride and have high compressive strength.

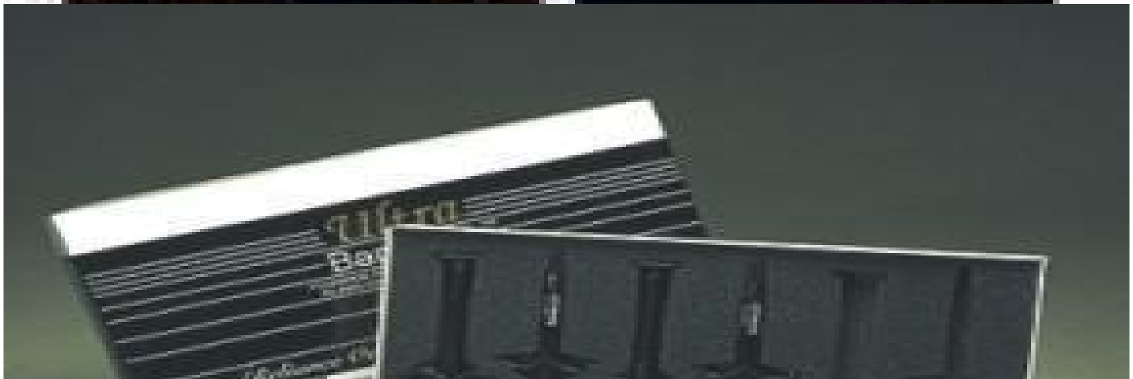
None of these cements, however, bond chemically to metal, which means that cement cleanup often tedious and time consuming because adhesive stays bonded to the tooth rather than remaining in band when band is removed.

The newer compomers even bond chemically to band material than zinc phosphate or GIC.

TECHINQUE: The bands should be roughened lightly with a fine diamond bur or microetcher. Tooth should be prophied, flossed, rinsed, dried, and isolated. Then if two paste dual cure adhesive is used the equal parts of pastes is placed on mixing pad, with 1 inch of paste 4 bands can be banded to the teeth. The two portions of adhesive are mixed for 10 seconds, and then the internal side of band covered in cement. The band is seated and excess adhesive is removed before the material is light cured.

Non-tooth colored band cements in blue and pink color are available for clean up process after the bands are removed.

Before mixing the cement metal instruments are wiped in was or cooking spray can be applied to the same.



CONCLUSION

There are number of dental cements for luting currently in use in orthodontics for banding and bonding which exhibit good physical properties and which are capable of providing good service only if orthodontist disciplines himself to a standard technique of manipulation of cements.

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