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5th Edition

BASIC DENTAL MATERIALS







John J Manappallil



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8
CHAPTER

Dental Cements

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Dental cements are materials of multiple uses including restorations, luting (cementing or bonding) and therapeutic. They are generally materials of comparatively low strength, but have extensive use in dentistry. The first dental cement is said to have been introduced in 1785 by Sorel who created the 'zinc-oxide-chloric-cement'. Nearly a hundred years later Rostaing and then Fleck developed and introduced the zinc phosphate cement. Around the same period silicates were also developed.

Over the years many of them have been improved considerably. Some cements like the silicates had good initial esthetics but were discontinued due to its high solubility which caused staining and degradation and discoloration around the margins. Cements like glass ionomer and polycarboxylate have adhesive properties and form a chemical bond to dentin and enamel. Regardless of some inferior properties, they possess so many desirable features that they are widely used in dentistry.

CLASSIFICATION

Cements have a wide variety of uses, properties and reaction mechanisms. This makes them generally difficult to classify.

ISO Standards Covering Cements

ISO 9917-1:2007	Water-based cements–Part 1: Powder/liquid acid-base setting
ISO 9917-2:2017	Water-based cements–Part 2: Sets by combination of acid-base and polymerization reactions
ISO 3107:2022	Zinc oxide/eugenol and zinc oxide/noneugenol cements
ISO 4049:2019	Polymer-based filling, restorative and luting materials

ISO Classification

Water-based cements Zinc phosphate, glass ionomer, etc.

Oil-based cements ZOE and noneugenol cements

Resin or polymer-based cements Resin cements, compomer, etc.

Classification based on Setting Reaction

The materials may be classified as

- Acid-base reaction cements
- Polymerizing cements
- Hydration reaction
- Dual cure cements
- Tricure cements

Acid-base reaction cements They are formulated as powder and liquid. The liquid acts as the acid and the powder as the base. On mixing the two an acid-base reaction takes placing resulting in a viscous paste, which hardens to a solid mass, (e.g., zinc phosphate cement.)

Polymerizing cements These cements set by polymerizing reaction which may be light activated or chemically activated, e.g., resin cements.

Dual and tricure cements Dual cure cements set by acid base and any one of the polymerization (light activated or chemically activated) mechanisms. Tricure cements utilize all three mechanisms for hardening [e.g., Vitremer tricure GIC (3M).}

Hydration reaction These cements set on contact with water or moisture (e.g., MTA)

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Classification of Cements based on Application (ISO 9917-1:2007)*

a. Luting
b. Bases or lining
c. Restoration

* Current ISO specifications no longer classify cements as Type 1, 2 or 3. The prefix 'Type' has been discontinued. Only a single type of luting cement with a maximum film thickness of 25 µm is described. Medium grain (film thickness 40 µm) from previous editions have been discontinued. Similarly, only a single class of restorative cement is described; sub-classification (a) esthetic restorative and (b) reinforced restorative cements have been discontinued.

GENERAL STRUCTURE

On mixing the powder and liquid, only a part of the powder reacts with the liquid and the final set material is composed of

- *A core* of unreacted powder, surrounded by
- *A matrix* formed by the reaction product of the powder and the liquid. This surrounds and binds the core.

USES OF CEMENTS

Cements have a wide variety of usage in dentistry.

Function	*Cement used*
Long term cementation (crowns, FDPs, inlays, onlays, posts, etc)	Zinc phosphate, zinc silicophosphate, EBA cement, zinc polycarboxylate, glass ionomer, resin cement
Long term cementation (restorations in esthetic zones, e.g., laminates, veneers, translucent crowns, fiber and ceramic posts)	Resin cements
Temporary cementation	Zinc oxide eugenol, noneugenol zinc oxide
Bases	Zinc phosphate, reinforced zinc oxide eugenol, zinc polycarboxylate, glass ionomer, zinc oxide eugenol, calcium hydroxide
Long-term restorations	Glass ionomer, compomer, metal modified GIC
Temporary and intermediate restorations	Zinc oxide eugenol, reinforced zinc oxide eugenol, zinc polycarboxylate, glass ionomer, compomer
Pulp therapy/ capping	Calcium hydroxide, MTA
Obtundant (pain relief)	Zinc oxide eugenol
Liners	Calcium hydroxide in a suspension
Root canal sealer	Zinc oxide eugenol, zinc polycarboxylate, epoxy, salicylate based
Perforation repair	MTA

GENERAL PROPERTIES OF CEMENTS

Though cements are formulated to serve a variety of functions, the two most common applications of dental cements are luting and restorations ***(Box 8-1).*** Some of the minimum requirements for water based dental cements are presented in ***Table 8-1***.

BOX 8-1

Cements manufactured for various applications would have been modified slightly to suit the particular application. For example, glass ionomer manufactured for luting may be slightly different from glass ionomer used for restorations. Luting cements are usually more fine grained and use a different powder-liquid ratio. Restorative GIC has greater translucency and esthetics when compared to the luting GIC which may be more opaque.

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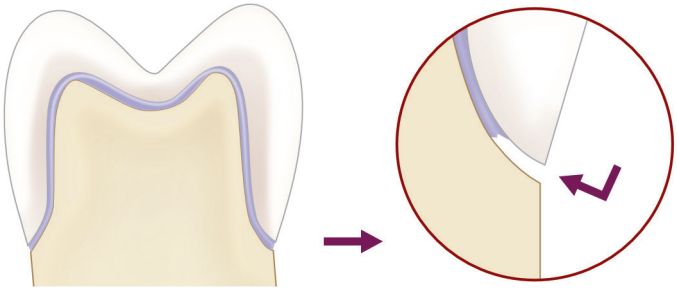
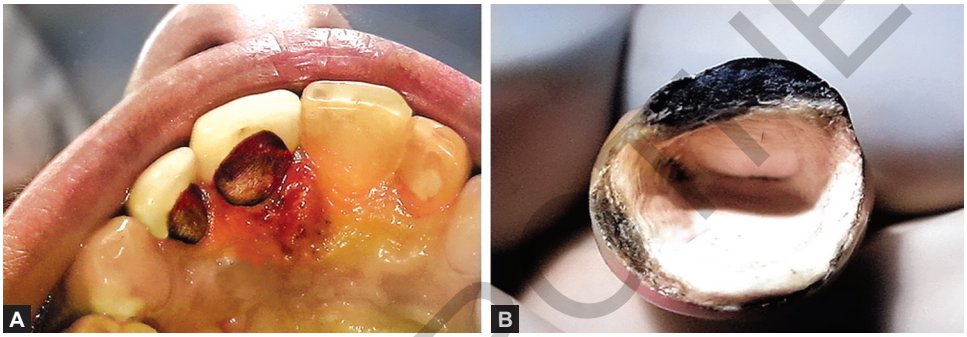


FIGURE 8-1 One cannot rely entirely on the cement for sealing an open margin. Most cements slowly dissolve and disintegrate in the oral cavity leading to microleakage and subsequent failure. A good marginal fit of the crown is therefore essential.



FIGURES 8-2A AND B Cement dissolution. **(A)** Area of inflammation in relation to the leaking margin (arrow). **(B)** On removing the crown, area of cement dissolution is clearly visible (arrows).

NET SETTING TIME

Net setting time is the period of time, measured from the end of mixing, until the material has set (as per ISO criteria).

STRENGTH

Most cements are comparatively weak when compared to restorative materials like amalgam and composites. The strength required depends on the application. For example, a cement used as a base under amalgam should have sufficient strength to withstand condensation forces. Many dental cements as well as restorative materials continue to gain strength with time. For this reason patients are often advised to wait at least 2 hours before any food is placed in the mouth. In addition the side in which the restoration has been placed is avoided for a further 24 hours period.

MODULUS OF ELASTICITY (MOE)

This is a measure of the stiffness of the cement. Cements under ceramic crowns should have sufficient stiffness to withstand masticatory loads. A low MOE can result in flexing of the restoration resulting in fracture.

SOLUBILITY AND DISINTEGRATION

This is an important property as it can determine the long-term survivability of restorations ***(Figs. 8-1, 8-2A and B)***. Solubility and disintegration of the cement at the margins can eventually lead to problems like inflammation, caries, sensitivity, etc. Most cements exhibit varying degrees of solubility. *ISO specification No. 9917-1:2007* uses in vitro testing with 0.1 mol/L lactic acid with pH of 2.74. However, a more reliable test would be an in vivo test as

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conditions in the mouth are far more complex. Solubility and disintegration can be reduced by proper manipulation, minimizing the exposure of the cement to the oral environment and protecting of the cement during setting and the initial 24 hours period.

FILM THICKNESS

Film thickness is an important property especially for luting cements. A thinner film is more advantageous for luting.

1. It improves the seating of the restoration.
2. It helps in greater flow and wetting of the tooth and restoration surface, thus improving bonding.
3. It minimizes the air spaces and structural defects present in the bulk of the cement.

Film thickness is measured in μm. ISO 9917-1:2007 specifies maximum film thickness for luting cements as 25 μm.

BIOLOGICAL PROPERTIES

Most cements are placed within the dentin and in many instances in close proximity to the pulp. Thus it is important that the cement should not be irritant or toxic to the pulp.

PH of the cement Most cements are acidic. The exceptions are zinc oxide eugenol, calcium hydroxide and resin cements. The acidity of cements is higher at the time of placement but gradually decrease with time.

Pulpal response The pulp response may be classified as mild, moderate or severe. Originally silicate cement was used as a reference to compare the pulpal response to various cements. Because of its high acidity, silicates were classed as severe irritant. High acidity can irritate and sometimes lead to irreversible pulpal damage. In some patients it can cause severe pain and sensitivity. Monomer present in resin-based cements is also a potential irritant.

Pulp protection In case of deep cavities and where the cement is classed as an irritant measures to protect the pulp are indicated.

1. Avoid thin mixes.
2. Pulp protection should be carried out in deep cavities through the use of an intervening liner or base.

FLUORIDE RELEASE

Some cements contain fluoride which is gradually released over a period of time to impart adjacent teeth structure with caries resistance. Glass ionomer is an example of a fluoride releasing cement.

Fluoride Recharging

The process by which a restorative material, specifically glass ionomer cement, absorbs fluoride from a solution with a high fluoride concentration.

SILICATE CEMENTS

Silicate cements ***(Fig. 8-3)*** are said to have been introduced in *1873* by *Fletcher* as an anterior esthetic filling material. They were translucent and resembled porcelain in appearance. Though the initial esthetics was satisfactory, over a period of time silicates degraded and stained. Leakage around the margins result in dark margins. Silicates are attacked by oral fluids and in time degrade.

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The average life of a silicate restoration is four years. Some may last as long as 25 years, others may require replacement in a year or even less.

The incidence of secondary caries is markedly less around silicate restorations. This is surprising when considering that severe leakage takes place at its margins. Also the incidence of contact caries is less when compared to amalgam restorations (contact caries is the term applied to caries occurring on the proximal surface of the tooth adjacent to the restoration). The anticariogenic property is due to presence of 15% fluoride. Fluoride release is slow and occurs throughout the life of the restoration. Silicate cements were classed as a severe irritant to the pulp because of its low pH (acidic). For many years silicate served as a standard for comparing the pulpal response to other material. In deep cavities the pulp had to be protected with varnish or calcium hydroxide.



FIGURE 8-3 Silicate cement.

With the development of better alternate materials like composite resin and glass ionomer cements, silicates gradually fell out of favor. By the 1980s and 1990s they were gradually phased out of the market and are rarely used. However, silicate cements are of historical interest as they were the first tooth colored filling materials. It also forms the basis for the glass ionomer system.

ZINC PHOSPHATE CEMENT

Zinc phosphate is the oldest (developed by Rostaing in 1858 in Dresden) of the luting cements and thus serves as a standard with which newer cements can be compared. The terms 'Crown and Bridge' and 'Zinc Oxyphosphate' have also been used for this cement.

APPLICATIONS

1. Luting of restorations (inlays, crowns, fixed dental prostheses, etc.)
2. High strength bases.
3. Temporary restorations.
4. Luting of orthodontic bands and brackets.

CONTRAINDICATIONS

1. In deep cavities or other situations where the cement is in direct contact or close proximity to the cement.
2. Because of its high opacity it is not particularly suited for use in esthetic zones where the cement line is visible or with translucent ceramic restorations like lithium disilicate glass crowns and veneers.

CLASSIFICATION

ISO 9917-1:2007 designates them as

a. Luting (Maximum film thickness—25 μm)
b. Bases and lining

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FIGURE 8-4 Three representative zinc phosphate cements.

AVAILABLE AS

- Powder and liquid system.
- Capsules of preproportioned powder and liquid.

Supplied in shades of yellow, gray, golden brown, pink and white.

Representative commercial products Confit, Harvard, Zinc cement (DPI), Modern Tenacin, Poscal (VOCO), De Trey Zinc (Dentsply), Hy Bond, etc. Some representative products are shown in ***Figure 8-4.***

COMPOSITION

Powder

Ingredient	*Weight (%)*	*Function*
Zinc oxide	90.2	Principal constituent
Magnesium oxide	8.2	Aids in sintering
Other oxides (like bismuth trioxide, calcium oxide, barium oxide, etc.)	0.2	Improves smoothness of mix, improves radiopacity
Silica	1.4	Filler, aids in sintering

Liquid

Ingredient	*Weight (%)*	*Function*
Phosphoric acid	38-59	Reacts with zinc oxide
Water	30-55	Controls rate of reaction
Aluminum phosphate (alternatively zinc phosphate 10%)	2-3	Buffers, to reduce rate of reaction

(Adapted From Phillips Science of Dental materials. 2nd South Asia Ed.)

MANUFACTURE

The ingredients are mixed and heated at temperatures between 1,000 °C and 1,400 °C (sintering). After sintering, the cake formed is cooled quickly. This causes the material to crack which helps in grinding of the material to a fine powder. This process is known as *fritting*.

The liquid is produced by adding aluminum and sometimes zinc or their compounds into orthophosphoric acid solution.

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SETTING REACTION

When the powder is mixed with liquid, phosphoric acid dissolves the powder particle surface and releases zinc ions. The zinc ions complexes with aluminum and the phosphoric acid to form a *zinc aluminophosphate gel* matrix . The reaction is *exothermic.*

STRUCTURE OF SET CEMENT

The set cement consists primarily of unreacted zinc oxide particles embedded in a matrix of zinc aluminophosphate.

NET SETTING TIME

According to ISO 9917-1:2007, the net setting time can vary from 2.5 to 8 minutes for luting and 2.5 to 6 for base and lining type ***(Box 8-2)***.

BOX 8-2

The setting time of cements in general vary widely. The setting time varies between different manufacturers. Climatic conditions too have a significant effect. Warm humid climatic conditions accelerate the setting. The portion of the material placed in the mouth sets faster than that on the table. This is because of the warm and moist conditions in the mouth.

CONTROL OF SETTING TIME

Manufacturing Process

1. *Sintering temperature* The higher the temperature, the more slowly the cement sets.
2. *Particle size* Finer particles react more quickly as a greater surface area is exposed to the liquid.
3. *Water content of liquid* Water accelerates setting, thus loss of water from the liquid can retard the reaction.
4. *Buffering agents* When added slow down the reaction.

Factors Under Control of Operator

1. *Temperature* Higher temperatures accelerate the reaction. Cooling the mixing slab is an effective way of slowing the reaction and prolonging the working time.
2. *Powder-liquid ratio* More the liquid, slower the reaction.
3. *Rate of addition of powder to liquid* The reaction is slower if the powder is added slowly.
4. *Mixing time* The longer the mixing time (within practical limits), the slower the reaction.
5. Addition of water during mixing can accelerate the reaction

PROPERTIES

COMPRESSIVE STRENGTH

The fully set zinc phosphate cement has a relatively high compressive strength ranging from 104 to 119 MPa. The set cement gains approximately 70% of its maximum strength in the first 30 minutes. The strength continues to rise with time and maximum strength is attained at the end of 24 hours ***(Box 8-3)***.

The strength of zinc phosphate cement is sufficient when used as a base or luting agent. However, when it is exposed to the oral environment, e.g., temporary restorations, its brittleness and low strength causes it to fracture and disintegrate. Also, the prolonged contact with the oral fluids or water gradually reduces its strength. This may be due to the slow dissolution of the cement.

BOX 8-3

When used as a base for an amalgam or a DFG restoration, the operator must allow the cement to gain sufficient strength before proceeding with the condensation.

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Factors affecting Strength

1. *Powder-liquid ratio* More the powder, greater the strength.
2. *Water content of the liquid* Both loss or gain, reduces the strength.

TENSILE STRENGTH

The set cement is weaker in tension (5.5 MPa), thus making it brittle.

MODULUS OF ELASTICITY (STIFFNESS)

It is comparatively high (13 GPa). This makes it stiff and resistant to elastic deformation. This is beneficial when it is used to cement restorations that are subjected to high masticatory stresses.

SOLUBILITY AND DISINTEGRATION

This property is important for cements used for permanent cementation. When tested according to ISO specification, maximum solubility permitted is 0.3 ***(Table 8-1)***.

However, in the mouth they show greater disintegration over a period of time. This shows that other factors are involved (like wear, abrasion, chemical attacks by products from decaying food, etc.). The solubility is greater in dilute organic acids like lactic, acetic and especially citric acids, all of which are present in the human diet (butter milk, vinegar and lemon juice). Thus it is important to minimize the exposure of the cement in the mouth by having minimum gaps at the margins of restorations.

Factors affecting Solubility

1. ***Powder-liquid ratio*** Thicker mixes show less solubility.
2. ***Water content of liquid*** Any change in the water content can increase the solubility.
3. ***Effect of moisture contamination*** Premature contact of the incompletely set cement with water results in the dissolution and leaching of the surface. Varnish application over the exposed cement margin is beneficial.

FILM THICKNESS

The smaller the particle size, the lesser is the film thickness. The thickness is lesser than the size of the particles because, during mixing the particle partially dissolve. The thickness can also be reduced by applying pressure on the restoration during seating.

THERMAL PROPERTIES

Zinc phosphate cements are good thermal insulators and may be effective in reducing galvanic effects.

ADHESION PROPERTY

The primary retentive mechanism of zinc phosphate is *micromechanical*. The cemented restoration is held by mechanical interlocking of the set cement with surface roughness on the tooth and restoration.

BIOLOGICAL PROPERTIES

pH of the Cement The acidity is high at the time of insertion due to phosphoric acid. At the time of cementation, the pH is 3 to 3.5 (approx.). The acidity reduces with time. By the end of 24 hours the pH is around 6. Though still acidic this value much more acceptable biologically (neutral value is 7).

Pulpal Response The pulp response may be classified as *moderate*.

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Pulp Protection A thickness of dentin as great as 1.5 mm can be penetrated by the acid of the cement. If dentin is not protected against infiltration of this acid, pulpal injury may occur, especially during the first few hours.

1. Avoid thin mixes.
2. Pulp protection should be carried out in deep cavities through an intervening liner or base. Varnish is applied on prepared abutment teeth before cementing crowns.
   - Zinc oxide eugenol
   - Calcium hydroxide
   - Cavity varnish
3. Some patients are extremely sensitive to the acid. Cementation of a restoration such as a crown or FDP on to vital teeth can cause severe sensitivity or pain. An anesthesia should be used in these instances.

OPTICAL PROPERTIES

The set cement is opaque. It is not ideal for use with translucent restorations or in esthetic areas where the cement line is visible.

MANIPULATION

Spatula used Stainless steel.

Mixing time 1 minute and 15 seconds.

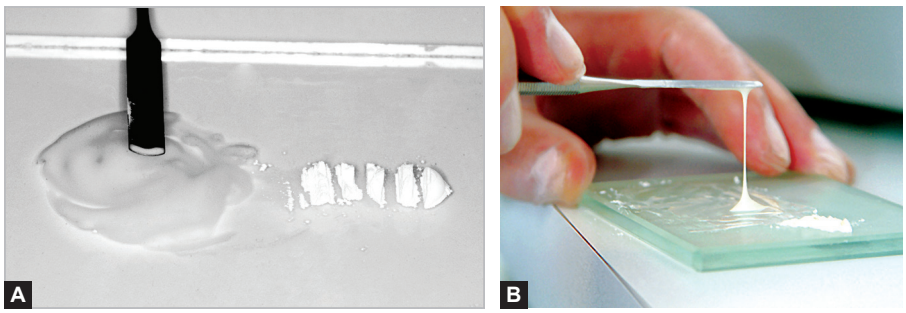
Powder to liquid ratio 1.4 g/0.5 mL

A cool glass slab (not exceeding the dew point) is used in order to delay the setting and allow more powder to be incorporated before the matrix formation occurs. The liquid should be dispensed just before mixing.

PROCEDURE

The manufacturer's instruction should be followed. The powder is added in *small increments*. Mixing is done with stainless spatula using brisk circular motion. Each increment is mixed for 15 to 20 seconds. A large area is covered during mixing in order to dissipate the exothermic heat ***(Figs. 8-5A)***. Adequate amount of powder should be incorporated in the liquid to ensure minimum solubility and maximum strength.

Note: An appropriate consistency is attained by addition of adequate powder to the liquid and not by allowing a thin mix to thicken. Luting consistency is checked by lifting the spatula from the surface of the mixed cement. A string should form not exceeding 10 -15 mm ***(Figs. 8-5B)***. If it exceeds this, the cement may be too viscous for luting.



FIGURES 8-5A AND B Manipulation of zinc phosphate. **(A)** The cement is mixed over a large area to dissipate heat. **(B)** Luting consistency.

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Insertion

The field of operation should be dry. The restoration should be seated immediately and held under pressure till set. Varnish is applied at the margins, after removing excess cement. This protects the cement from oral fluids during the early stages after cementation until it matures and develops resistance to dissolution.

ADVANTAGES AND DISADVANTAGES OF ZINC PHOSPHATE

Advantages

1. Long track record with proven reliability.
2. Good compressive strength.

Disadvantages

1. No chemical adhesion. Not indicated if the retention is poor.
2. No anticariogenic property.
3. Possibility of pulp irritation.
4. Poor esthetics because of its high opacity.

COPPER CEMENTS

Copper cements are basically modified zinc phosphate cements. Silver salts or copper oxide are sometimes added to the powders of the zinc phosphate cements to increase their '*antibacterial*' properties. Copper cements gradually fell out of favor because of their poor biological properties. It was highly acidic and the copper was considered toxic to the cell. This may have been due to the extremely high copper content (97%) in certain cements (Ames). There has been a renewed interest in copper cements recently. New formulations have come out with lower copper content (2%). It is claimed that these new generation copper cements are safe and is especially recommended for indirect pulp capping and where there is active caries.

APPLICATIONS

1. Temporary fillings in children.
2. Intermediate restorations.
3. For retention of silver cap splints in oral surgery.
4. Indirect pulp capping.
5. As base beneath composite restorations.



FIGURE 8-6 White and red copper cements.

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CLASSIFICATION

Classified according to the percentage of the copper oxide that is used as a replacement for the zinc oxide.

Commercial Examples Doc's best red and white copper kit ***(Fig. 8-6)***.

COMPOSITION

- Copper oxide (if cuprous oxide is used, the cement is red, if cupric oxide is used, the cement is black)
- Zinc oxide
- Liquid used is clear phosphoric acid

PROPERTIES

1. Biological properties: They have poor biological properties. Its pH of 5.3 is highly acidic and irritant to the pulp.
2. They are bactericidal or bacteriostatic.

MANIPULATION

The chemistry of the copper cements is very similar to that of the zinc phosphate cements and they are manipulated in the same manner.

ZINC POLYCARBOXYLATE CEMENT

Canadian biochemist Smith developed the first polycarboxylate cement in 1968 by substituting the phosphoric acid of zinc phosphate cement with polyacrylic acid. Polycarboxylate became the first cement system developed with potential for adhesion to tooth structure.

APPLICATIONS

1. Primarily for luting permanent restorations.
2. As bases and liners (under restorations).
3. Used in orthodontics for cementation of bands and other appliances.
4. As temporary/intermediate restorative materials.
5. Also used as root canal fillings in endodontics.

AVAILABLE AS

- Powder and liquid in bottles ***(Fig. 8-7A)***
- Water settable (Anhydrous) cements ***(Fig. 8-7B)***
- As precapsulated powder/liquid system



FIGURES 8-7A AND B (A) Representative zinc polycarboxylate cement products. **(B)** A water settable cement.

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Commercial Examples Poly F (Dentsply), Durelon and Durelon Maxicap (encapsulated) (3M ESPE), Carboco (Voco), Imibond P (Imicryl), Hy Bond polycarboxylate (Shofu),Tylok® Plus (water settable by Dentsply).

COMPOSITION

Powder

Ingredient	*Function*
Zinc oxide	Main ingredient
Magnesium oxide	Principal modifier and also aids in sintering
Oxides of bismuth and aluminum	Small amounts
Stannous fluoride	Increases strength, modifies setting time and imparts anti-cariogenic properties

Liquid

Contains water solution of polyacrylic acid (30%–40%) or copolymer of acrylic acid with other carboxylic acids, i.e., itaconic, maleic, or tricarballylic acid.

Water Settable Cements

In this cement the *polyacrylic acid* is *freeze dried* and added to the cement powder.

Distilled water is used as the liquid. When the powder is mixed with water, the polyacrylic acid goes into the solution and the reaction proceeds as described for the conventional cements.

MANUFACTURE

The powder mixture is sintered at high temperature in order to reduce the reactivity and then ground into fine particles.

SETTING REACTION

When the powder and liquid are mixed, the surface of powder particles is dissolved by the acid, releasing zinc, magnesium and tin ions. These ions bind the carboxyl groups. They also cross-link with carboxyl groups of adjacent polyacid chains to form cross-linked salts.

Structure of Set Cement

The hardened cement consists of an amorphous gel matrix of zinc polyacrylate in which unreacted powder particles are dispersed.

PROPERTIES

MECHANICAL PROPERTIES

Compressive Strength ISO requires a minimum compressive strength of 50 MPa for this cement ***(Table 8-1)***. Polycarboxylate cement is inferior to zinc phosphate cement in this respect.

Tensile Strength 6.2 MPa. Its tensile strength is slightly higher than that of zinc phosphate cement.

The strength of the cement depends on

- Increase in P/L ratio increases strength.
- Molecular weight of polyacrylic acid also affects strength. A mix from a lower viscosity liquid is weaker.

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TABLE 8-1 Requirements for water-based dental cements (ISO 9917-1:2007)

Chemical type	*Application*	*Film thickness mm*	*Net setting time min*		*Compressive strength MPa*	*Acid erosion mm*	*Opacity $C_{0,70}$*		*Acid-soluble As content mg/kg*	*Acid soluble Pb content mg/kg*
			max.	*min.*	*min.*	*max.*	*min.*	*max.*	*max.*	*max.*
Zinc phosphate	Luting	25	2.5	8	50	0.30			2	100
Zinc polycarboxylate	Luting	25	2.5	8	50	0.40			2	100
Glass polyalkenoate	Luting	25	1.5	8	50	0.17				100
Zinc phosphate	Base/lining		2	6	50	0.30			2	100
Zinc polycarboxylate	Base/lining		2	6	50	0.40			2	100
Glass polyalkenoate	Base/lining		1.5	6	50	0.17				100
Glass polyalkenoate	Restoration		1.5	6	100	0.17	0.35	0.90		100

SOLUBILITY AND DISINTEGRATION

It tends to absorb water and is slightly more soluble (0.6% wt.) than zinc phosphate. Thus the marginal dissolution is more when used for cementing. It is more soluble in organic acids like lactic acid. Low P/L ratio results in a significantly higher solubility and disintegration in the oral cavity.

BIOCOMPATIBILITY

pH of the Cement Despite the high acidity of the liquid (1.7), the pH of the freshly mixed cement rises quickly to 6 as it sets. After 24 hours, pH 6 or near neutral.

Pulpal Response Pulpal response is classified as mild.

They are less irritant with lower postoperative sensitivity than zinc phosphate cement because:

- The liquid is rapidly neutralized by the powder. The pH of polycarboxylate cement rises more rapidly than that of zinc phosphate.
- Penetration of polyacrylic acid into the dentinal tubules is less because of its higher molecular weight and larger size. The histological reactions are similar to zinc oxide eugenol cements but more reparative dentine is observed with polycarboxylate.
- Polycarboxylate cement (and glass ionomer) exhibit a property called chelation, which is the ability to bond to the Ca ions of the tooth. It is possible that this bond reduces microleakage microorganisms that can cause irritation to the pulp, thus contributing to the cement's biocompatibility.

Pulp Protection Pulp protection is indicated in deep cavities or other situations where the cement is in direct contact or close proximity to the pulp.

ADHESION

An outstanding characteristic of zinc polycarboxylate cement is that the cement *bonds chemically* with the tooth structure through the process of chelation mentioned earlier. The *carboxyl group* in the polymer molecules chelates with calcium in the tooth structure.

Bond strength to enamel is 3.4–13.1 MPa and to dentine 2.07 MPa.

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Factors affecting Bond

1. A clean dry tooth surface improves bonding.
2. If the inside surface of the metal crown is not clean, the cement cannot bond with the metal. So to improve the mechanical bond, the surface should be carefully abraded with a small stone or with airborne abrasives.
3. The presence of saliva reduces bond strength.
4. Unlike zinc phosphate cements, the adhesion is better to a smooth surface than to a rough surface.
5. Does not adhere to gold or porcelain.
6. Adhesion to stainless steel is excellent. Thus it is used in orthodontics.

OPTICAL PROPERTIES

They are very opaque due to large quantities of unreacted zinc oxide.

ANTICARIOGENIC PROPERTIES

Some manufacturers have attempted to incorporate fluoride within the cement. However, the fluoride release is limited (only 15 to 20%) when compared to glass ionomer cement.

THERMAL PROPERTIES

They are good thermal insulators.

MANIPULATION

CONDITIONING

The tooth structure should be meticulously clean for proper bonding. To clean the surface, 10% polyacrylic acid solution followed by rinsing with water, or 1 to 3% hydrogen peroxide may be used. Then dry and isolate the tooth.

PROPORTIONING

The ratio of powder to liquid ratio depends upon its intended use. For bases the powder to liquid ratio is higher when compared to luting. It also varies depending on whether the liquid is polyacrylic acid solution or water. Manufacturers recommendation would be followed.

For luting the ratio ranges from 1:2 to 1:2.5

For bases the ratio ranges from 1:1 to 1:1.5

Always fluff the powder by repeatedly inverting bottle before scooping. Failure to fluff can affect the powder liquid ratio.

PROCEDURE

The powder and liquid are taken on a cooled glass slab. The liquid is dispensed just prior to the mixing, otherwise its viscosity increases. The powder is incorporated into the liquid in bulk (90%) with a stiff cement spatula and remaining powder is added to adjust consistency. The mix appears quite thick, but this cement will flow readily into a thin film when seated under pressure.

MIXING TIME AND SETTING TIMES

Mixing time ranges from 30 to 40 seconds. Setting time ranges from 7 to 9 minutes (The setting time can be increased by cooling the glass slab.)

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Points to Note

- The cement should be used while the surface is still *glossy*. Loss of lustre indicates that the setting reaction has progressed to an extent that proper wetting of the tooth surface by the mix is no longer possible. If the surface is not creamy and shiny and is matted and tends to form cobwebs, the mix should be discarded.
- After insertion the excess is not removed immediately as it passes through a *rubbery stage,* it tends to get lifted from the cavity. Remove excess cement only when it has hardened and breaks off.
- The powder may be cooled. If the liquid is a polyacrylic acid solution, it should not be refrigerated as its viscosity may increase.

Polycarboxylate cement adheres to instruments

- Use alcohol as release agent for mixing spatula.
- Instruments should be cleaned before the cement sets.
- Excess cement from the spatula can be chipped off. Any remaining material is removed by boiling in sodium hydroxide solution.

ADVANTAGES AND DISADVANTAGES

Advantages

1. Comparatively less irritating to the pulp.
2. Chemical bond to tooth structure.

Disadvantages

Limited fluoride release when compared to GIC.

ZINC OXIDE EUGENOL CEMENT

These cements have been used extensively in dentistry since the 1890s. Depending on their use they vary widely in their properties. In general, they are cements of low strength. They are the least irritating of all dental cements and are known to have an obtundant (sedative) effect on exposed dentin.

To improve the strength many modified zinc oxide eugenol cements have been introduced, e.g., EBA—alumina modified and polymer—reinforced zinc oxide eugenol cements noneugenol zinc oxide cements are also available. They are suitable for patients sensitive to eugenol.

CLASSIFICATION (ISO 3107:2022)

Type I—for temporary cementation

Type II—for bases and temporary restorations

An earlier version of this classification (ISO 3107:2004) * listing 4 classes, was replaced in 2011.

* ISO 3107:2004: Type I ZOE — Temporary cementation: Class I — Setting cement, Class II — non-setting cement; Type II ZOE — Permanent cementation; Type III ZOE — Bases and temporary restorations; Type IV ZOE — Cavity liners

Type I Cements are meant for short term luting (1 to 6 weeks—***Fig. 8-8A***). They are used to cement provisional restorations for the period it takes to make the definitive restoration. Permanent restorations are also sometimes cemented for a short period for various reasons. They have low strength which allows easy removal of the restoration without damage to the restoration or the tooth.

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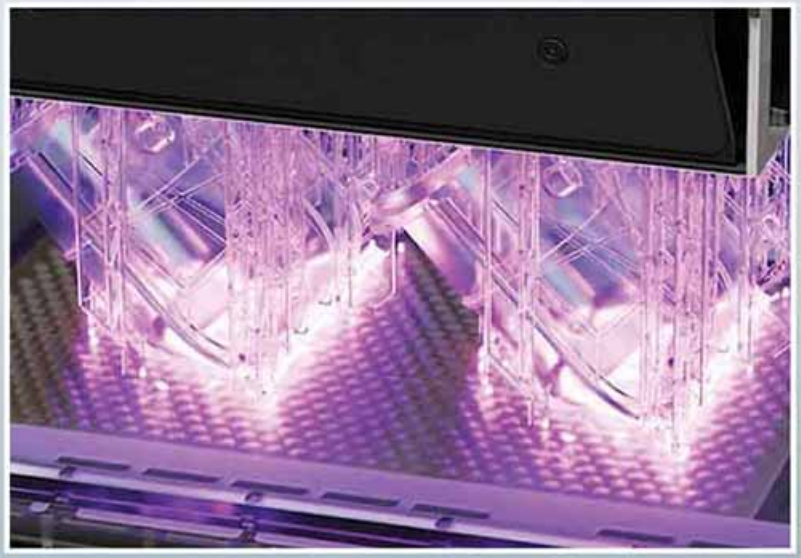

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