DENTAL AMALGAM

Introduction

Dental amalgam is one of the most versatile restorative materials used in dentistry. It constitutes approximately 75% of all restorative materials used by dentists. It has served as a dental restoration for more than 165 years. It has a myriad of uses: rather low technique sensitivity, self-sealing property and its longevity.

Although there is evidence of a decrease in its use in the world, amalgam's cost, durability and ease of manipulation have persuaded many dentists to continue to use it as their first choice for restoring posterior teeth. However, care must be taken in the diagnosis of the type of restoration to be placed.

Where there is so much loss of tooth structure that support of the tooth must be given by the restoration, a gold inlay may be indicated, although there are some instances where even very extensive restorations of amalgam may be the choice.

Dental amalgam is the most widely used restorative material. Dental amalgam is a mixture of a silver alloy with mercury. The silver alloy is a fine powder that is composed mostly of silver, tin and copper, and sometimes zinc, palladium or indium. When the silver alloy and mercury are mixed, a chemical reaction occurs that forms dental amalgam. This reaction between alloy and mercury is termed as amalgamation reaction.

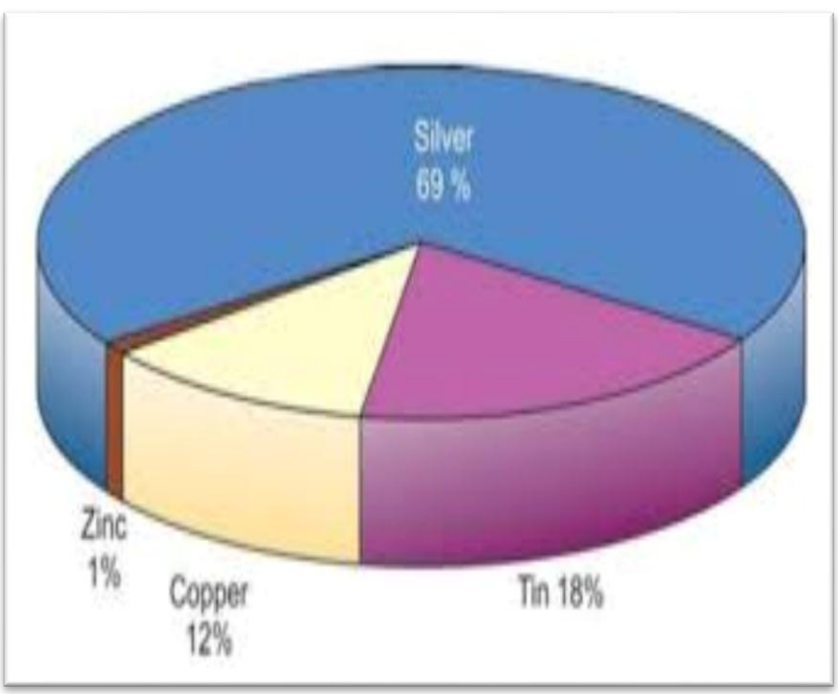
Although some forms of mercury are hazardous, the mercury in amalgam is chemically bound to the other metals to make it stable and therefore safe for use in dental applications. Dental amalgam is used in all surfaces of posterior teeth and occasionally in the lingual pits of anterior teeth. Amalgam restorations account for a significant portion of all dental restorations. However, because of its silvery-gray appearance, restorations are limited to posterior teeth.

The popularity of dental amalgam results from its cost-effectiveness, durability and the ease of use. Furthermore, surveys have shown that the percentage of failures among amalgam restorations is smaller than that with any other restorative material. However, the failures that do occur are more frequently due to improper design of the cavity preparation and faulty manipulation of the material. Therefore, every step, from the time the alloy is selected until the restoration is polished has a definite effect on the physical properties and potentially on the success or failures of the restoration.

COMPOSITION OF AMALGAM ALLOY

Composition of currently used alloy is silver 40–70%, tin 12–30% and copper 12–24%. It may also include indium 0–4%, palladium 0.5% and zinc up to 1%.

- *Zinc prevents the oxidation of other metals in the alloy during manufacturing process. Zinc also inhibits corrosion. Some researchers believe that if zinc containing amalgam is contaminated with moisture, it causes delayed expansion.*
- *Indium containing admixed high-copper amalgam exhibited a reduction in creep and increase in strength.*
- *Youdel is also found that less mercury is required for mixing amalgam when it contains indium in concentration up to 10%. The reason for lower mercury emission is that amalgam prepared with indium rapidly forms indium oxide and tin oxide films which reduce mercury release.*
- *Palladium reduces tarnish and corrosion.*



Dental amalgam is classified into:

1. *Low-copper dental amalgam*

2. High-copper dental amalgam

LOW-COPPER AMALGAM

These are also known as ‘traditional’, ‘conventional’ amalgam. Low-copper amalgams were used earlier on. Now low-copper amalgam has been replaced by high-copper amalgams.

HIGH-COPPER AMALGAM

High-copper amalgam was developed in1962 by the addition of silver-copper eutectic particles to low-copper silver-tin lathe cut particles.

Compared to low-copper amalgam counterparts, high-copper alloys exhibit the following properties:

1-*greater strength.*

2-Less tarnish and corrosion.

3-Less creep.

4-Less sensitive to handling variables.

5-Produce better long-term clinical results.

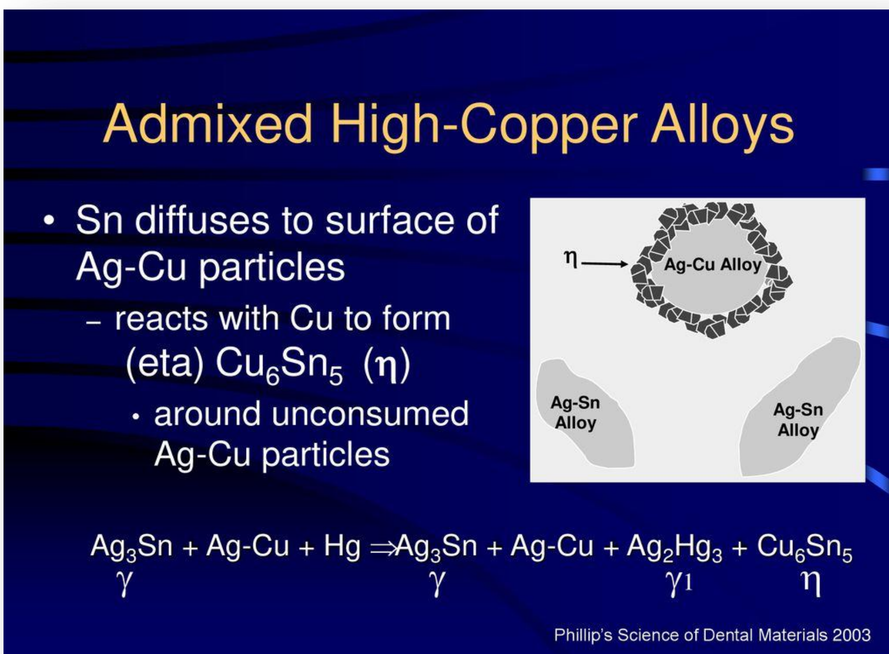
High-copper amalgam restorations also have a much lower incidence of marginal failure compared to low-copper amalgam. The copper content may vary from one brand to another.

There are 2 basic types of high-copper alloys:

Admixed and single composition.

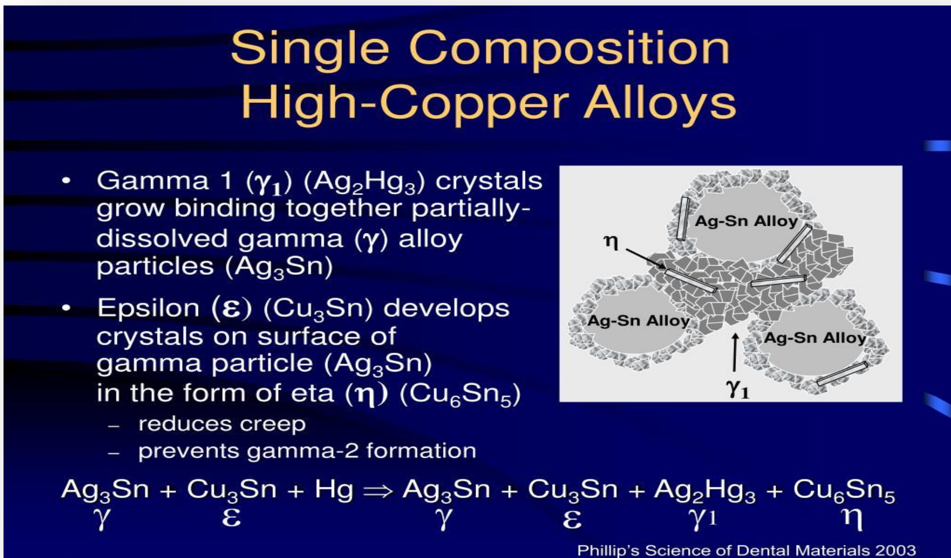
I. <u>Admixed Alloys</u> .

This is the oldest type of high-copper alloy. The alloy powder purchased from the manufacturer is a mixture of powders of 2 alloys. One is traditional low-copper alloy. The other is a powder – often a silver-copper eutectic. Addition of these two increases the overall copper content. The total copper content of commercial admixed alloys ranges from about 9-20%. The alloy particles are either spheres or lathe-cut.



II. <u>Single-composition</u> .

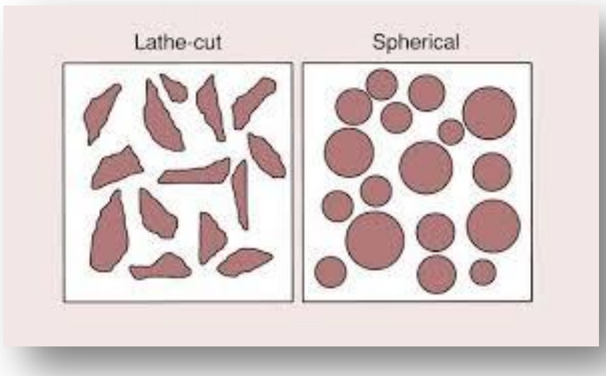
This type of amalgam has an increased amount of copper in the silver-tin-copper alloy particles. It contains powder particles of only one composition. The copper content varies ranging from about 13-30%. Some single-composition alloys contain small amounts of indium and palladium.

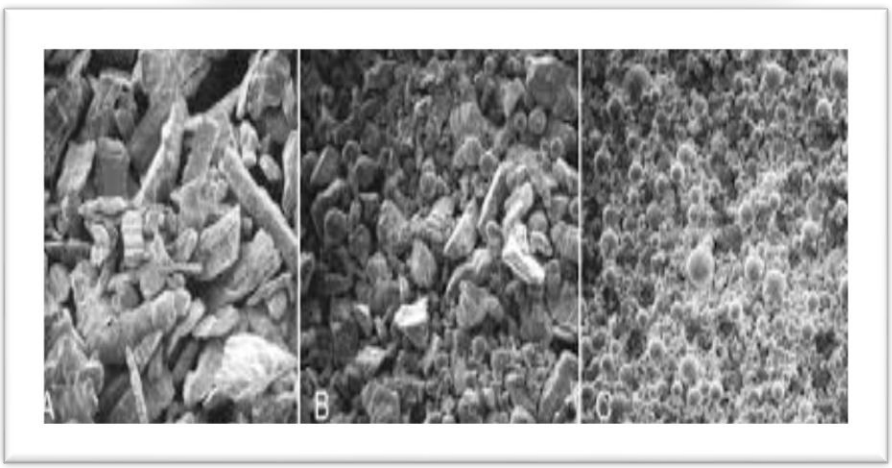


Alloy Particles

The shape and size of the alloy powder particles vary. There are 2 types of alloy particles: ***Lathe-cut alloys (irregular) and spherical alloys*.**

1. *Lathe-cut alloys – are irregular* in shape, they may be fine-grain or coarse-grain. They are heat-treated to produce a uniform composition and regulate properties. The alloy may be dispensed in the form of preweighed tablets or pellets.
2. *Spherical alloys* – alloy particles are made in the form of small spheres. One method of preparing this is known as atomizing procedure. Spherical alloys amalgamate very readily. Amalgamation can be accomplished with smaller amount of mercury than that required for lathe-cut alloys.





STORAGE REQUIREMENTS

Amalgam capsules should be stored at a temperature no higher than 25°C.

Reaction of mercury of alloy

LOW-COPPER DENTAL AMALGAM

COMPOSITION

The composition of low-copper, ‘traditional’, ‘conventional’ amalgam alloy is based on G V Black’s composition of approximately 65% silver, 25% tin, less than 6% copper and sometimes 1% zinc.

Reaction

Excess Ag_3Sn + Hg -® unreacted Ag Sn + Ag Hg + Sn Hg

1. When the liquid mercury is mixed with the amalgam alloy, the mercury is both absorbed by the particles and dissolves the surface of the particles.
2. Silver and tin continue to dissolve in the liquid mercury, which becomes saturated with silver and tin.
3. The gamma-1 (Ag-Hg) and gamma-2 (Sn-Hg) phases begin to precipitate. Precipitation is a process in which a solid is formed from material dissolved in a liquid.
4. Precipitation of the gamma-1 and gamma-2 phases continues until the mercury is consumed and a solid mass results. The setting reaction may take as long as 24hours to complete, when strength reaches a maximum.

HIGH-COPPER DENTAL AMALGAMS

COMPOSITION:

High-copper amalgam contains 40-60% silver, 27-30% tin and 13-30% copper and 1% zinc. Sometimes it also contains Indium and Palladium.

1- Silver causes setting expansion and increases strength and corrosion resistance.
2- Tin causes setting contraction and decreases strength and corrosion resistance.
3- Copper increases strength, reduces tarnish and corrosion, reduces creep, and lowers cases of marginal leakage.
4- Zinc reduces oxidation of the other metals in the alloy. Recently, clinical research has shown that zinc – containing dental amalgams have a longer clinical life expectancy than nonzinc amalgams.
5- Indium reduces creep and increases strength.
6- Palladium reduces tarnish and corrosion.

Reaction

The setting reaction of high-copper amalgams is a little more complex than in low-copper amalgams. Its notable feature is the lack of a gamma-2 (Sn-Hg) product.

Excess AgSnCu (the alloy) + Hg ------> unreacted alloy + Ag Hg + Cu Sn

1. The alloy contains 10% to 30% copper.

2. Silver reacts in the same manner as a low-copper amalgam, forming a gamma-1 (Ag-Hg) product.

3. Tin reacts with copper to form several Cu-Sn reaction products. No Sn-Hg reaction product is formed as occurs in the low-copper amalgam reaction.

PROPERTIES OF AMALGAM

MECHANICAL PROPERTIES

- ***STRENGTH***

The strength of an amalgam restoration must be high enough to resist the biting forces of occlusion. The strength of the amalgam depends on the phases that are present. Having more of the stronger phases results in a stronger material.

The two types of strength are:

- *Compressive strength*
- *Tensile strength.*

Dental amalgam has high compressive strength (380MPa for low-copper amalgam and 414MPa for high-copper amalgams). However, the tensile and shear strengths are comparatively low. Therefore, amalgam should be supported by tooth structures for clinical success in the long term. The rate at which an amalgam develops strength is an important clinical characteristic. Spherical particle alloys and copper-enriched alloys develop strength more rapidly than conventional lathe-cut materials. Fine-grain, lathe-cut products develop strength more rapidly than coarse-grain products. If the amalgam restoration is subjected to chewing or other oral forces before sufficient strength develops, it is at risk for fracture.

❖ ***CREEP***

Creep is a slow change in shape caused by *compression* due to dynamic intra-oral stresses. Creep causes amalgam to flow, such that unsupported amalgam protrudes from the margin of the cavity. These unsupported edges are weak and may be further weakened by corrosion. Fracture causes the formation of a 'ditch' around the margins of the amalgam restoration. Creep also creates overhangs on fillings leading to food trapping & secondary decay. The gamma-2 phase of amalgam is primarily responsible for the relatively high values of creep exhibited by some materials.

❖ ***DIMENSIONAL CHANGE***:

The net contraction or expansion of an amalgam is called its dimensional change. Dimensional change is negative if the amalgam contracts and positive if it expands during setting. In general, most amalgams expand or contract only slightly overall during setting, but the ANSI/ ADA specification No.1 requires that the dimensional change be an expansion or a contraction of no more than 20micrometres/cm.

Expansion could result in post-placement sensitivity or protrusion from the cavity, whereas contraction would leave gaps prone to leakage between the restoration and the tooth.

Dimensional change is affected by many factors, such as the mercury/alloy ratio as well as trituration and condensation techniques. During amalgamation reaction, expansion and contraction occur simultaneously. The dissolution of gamma particles generally leads to contraction, whereas the formation of gamma-1 causes expansion. The overall dimensional change is therefore the sum of these two processes. Improper manipulation that alters the ratio of gamma to gamma-1 and η in the set amalgam therefore also will alter its dimensional change.

Another Properties of Amalgam

a- DURABILITY OF AMALGAM RESTORATIONS

Recent research shows that amalgam restorations last longer than that was previously thought. The older generation of low-copper amalgams (before 1963) had a limited life span because they contained the gamma-2 phase that caused progressive weakening of the amalgam through corrosion. Several clinical studies have demonstrated that high-copper amalgams can provide satisfactory performance for more than 12 years. This appears to be true even for large restorations that replace cusps. In addition, high-copper amalgams do not appear to require polishing after placement, as was recommended for low-copper amalgams, to increase their longevity.

Plasmins *(scientist)* evaluated the long-term survival of multisurface restorations and found that extensive amalgam restoration had no influence on the survival rate, which is in accordance with the results of a retrospective study by Robins and Summitt, who found 50% survival rate for 11.5 years.

The satisfactory functioning of the extensive amalgam restorations over a long period of time results from the prevention of the most important traditional mechanical failure of amalgam restorations. These include marginal fracture, bulk fracture and tooth fracture. The zinc and copper content of the alloy has been found to have a strong impact on the survival rates of amalgam restorations since it influences the corrosion resistance of the amalgam. High-copper amalgams have higher survival rates than conventional amalgams.

Letzel investigated survival and modes of failure of amalgam restorations retrospectively. The leading mode of failure was bulk fracture (4.6%), followed by tooth fracture (1.9%) and marginal ridge fracture (1.3%). For other reasons, 0.8% of the restorations failed.

b- TOXICITY OF DENTAL AMALGAMS

The debate over the safety and efficacy of amalgam has raged since time immemorial. In recent times, it has reached such a feverish pitch that it seems to drown out all sounds of reason. Amalgam has served the dental profession for more than 165 years. Incidents of true allergy to mercury have been rare and attempts to link its usage with diseases like multiple sclerosis and Alzheimer’s disease have not been significantly proven, although there may be some association between amalgam restorations and oral lichenoid lesions.

Marshall, in his review on dental amalgam, summed it up appropriately: “if some reported values of Hg release are extrapolated to clinical life times, the entire restoration could lose its Hg in short time. For example, a 500 mg amalgam restoration contains approximately 200–250 mg of Hg, and the entire quantity of Hg would be lost in 10,000 days if the Hg was released at the rate of 25 μg/day. This estimate of release is of the order of magnitude reported in some studies of vapor release.