



Dental Materials

METAL ALLOYS

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Metal :In dentistry, metals represent one of the three major classes of materials used for the reconstruction of damaged or missing oral tissues.

Classification of metals

Metals can be classified according to nobility as:

- **Noble metals** like (Gold , Platinum , Palladium, Rhodium, Ruthenium , Iridium , Osmium and Silver.
- **Non noble (base metal)** like (chromium, cobalt, nickel, iron, copper, manganese.)

Nobility in relation to Tarnish and corrosion resistance

Tarnish: is loss of luster from the surface of metal or alloy due to the formation of a surface coating of metal oxide.

Corrosion: is the gradual destruction of materials (usually metals) by chemical or electric-chemical reaction with their environment.

*Noble metals usually have a good tarnish and corrosion resistance except **Silver** which has low tarnish resistance.

*Non noble (base metal) generally have low tarnish and corrosion resistance

Gold foil filling (pure gold)



Pure Gold is very malleable and ductile. Gold foil is in the form of thin sheet or foil about 0.001 mm thickness. It is condensed

in to the cavity and each layer of foil become welded to material already condensed

Advantages of gold foil filling:

- Perfect corrosion resistance
- Adequate mechanical properties
- Very durable

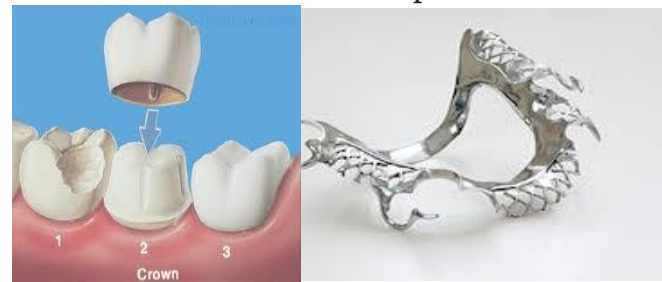
Disadvantages of gold foil filling

- Highly expensive
- Not esthetic
- The technique is time consuming and depend on the skill of operator

Alloys: An alloy is substance with metallic properties that consists of two or more chemical elements, at least one of which is a metal.

Applications of alloys in dentistry

1. Construction of metallic framework of removable partial denture
2. Construction of crown and bridge
3. Making orthodontic wires, bands, brackets.
4. Making endodontic instrument
5. Construction of dental implants



Classification of dental alloys

A- According to nobility

That is mean the alloy is classified according to percentage of noble (precious) metal especially gold for example:

1. **High noble alloys “precious”**: at least 60% noble. 40% of which is gold. The remaining 40% is base metal
2. **Noble alloys (semiprecious)**: at least 25% noble (no gold requirements). 75% base metal
3. **Base metal alloys**: contain less than 25% noble.

B- According to major element

That is mean the alloy is classified according to metal that has high percentage in alloy for example: gold based alloys, silver based alloys, nickel alloys, cobalt alloys, titanium alloy

C- According to principal elements

That is mean the alloy is classified according to metals that has high percentage in alloy for example: (Cobalt –chromium alloys), (Nickel –chromium alloy), (Palladium – silver alloy) (Gold – palladium- silver alloys), (Titanium – aluminum – vanadium alloys).

Shaping the alloys Alloys used in dentistry are either wrought alloy or casting alloy.

1- Wrought alloys Defined as alloys which are shaped without applying heat (room temperature) by hammering, drawn or bent into shape (cold working). **Stainless steel** is a wrought alloy of iron, carbon, chromium, nickel and manganese. it is used for making dental instruments, burs, wires.

2- Casting alloy



Defined as alloys which are shaped by heating the material until it becomes molten, when it can be forced into an investment mold which has been prepared from a wax pattern.

Requirements of casting alloys:

1. They must not tarnish or corrode in the mouth
2. They must be sufficiently strong
3. They must be biocompatible (non toxic, non allergic)
4. They must be easy to melt, cast, cut, grind (easy to fabricate)
5. They must flow well and duplicate fine details during casting
6. They must have minimum shrinkage on cooling after casting
7. They must be easy to solder.



Applications of casting alloys in dentistry

1- Removable denture alloys Casting dental alloys used to make the metal part of removable denture.

Requirements of Removable denture alloys :

- Should have low weight
- Should have high stiffness which help in making casting thinner which is important in the palate
- Should have good fatigue resistance it is important for clasp
- Should not react with denture cleaners
- Should have low cost

2- Metal ceramic alloys



They are alloys that are compatible with porcelain and capable of bonding to it (a layer of porcelain is fused to the alloys to give it natural tooth like appearance) Metal ceramic alloy can be High noble (gold alloys), Noble (palladium alloy) or Base metal alloys

Requirements of metal ceramic alloys

1. Melting temp should be higher than the porcelain firing temp.
2. Coefficient of thermal expansion should be compatible with that of porcelain
3. Should be able to bond with porcelain
4. Should have high stiffness (high modulus of elasticity)
5. Should not stain or discolor porcelain
6. It should resist **creep**.



Examples of casting alloys used in dentistry

1- Gold alloys

pure gold is too soft to maintain its shape under the forces of mastication but gold alloys are much stronger & harder.

Composition of gold alloys

Gold: give the alloy yellow color, increase ductility, corrosion, tarnish resistance and give specific gravity.

Copper: reduce melting point and density, increase hardness and strength, gives red color to gold, reduce corrosion and tarnish resistance

Silver: whiten the alloys; increase strength and hardness slightly in large amount reduce corrosion resistance

Platinum: increase strength and corrosion resistance and melting point have white color, reduce the grain size.

Palladium: similar to platinum, it hardens and whitens the alloys raises fusion temp increase tarnish resistance it is less expensive than platinum.

Also there are minor additions such as **Zinc** act as scavenger for oxygen, **indium**, **tin**, **iron** harden the alloy, **iridium**, **ruthenium**, **rhenium** decrease the grain size.

Classification of gold alloys They are classified according to yield strength and percentage of elongation

- **Type I (soft):** it is indicated for small inlay restoration not subjected to heavy forces of mastication
- **Type II (medium):** it is indicated for large inlay restoration
- **Type III (hard):** it is indicated for crown and bridge.
- **Type IV (extra hard):** it is indicated for removable partial denture frames.

Properties of gold alloys

1. **Color:** it is yellow to white depending on the whitening elements present (silver . platinum, palladium)
2. **Melting range:** 920 ---960 c
3. **Density:** pure gold is 19.3 gm/cm. gold alloys have less density
4. **Tarnish and corrosion resistance:** they are resistance to tarnish and corrosion due to high noble metal content
5. **Casting shrinkage:** it is less than 1.25 – 1.65 %
6. **Biocompatibility:** they are relatively biocompatibility
7. **Investment:** gypsum bonded investment.

Alternative to gold alloys: we can use:

Palladium -silver alloys

These alloys are cheaper than gold alloys, whiter in color, their properties are similar to type III & IV gold alloys. Disadvantage:

- Lower ductility & corrosion resistance
- Lower density



Nickel chromium alloys

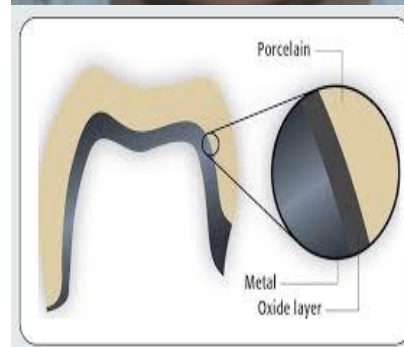
Nickel alloys are stiffer and more difficult to cast and solder than gold or palladium-silver alloys. They are used for metal ceramic crown and bridge

Composition

- **Nickel:** 70-80 % Allergic reaction of nickel (more in female than in males)
- **Chromium:** 15% passivity effect , decrease melting point
- **Molybdenum:** 2-9% increase hardness
- **Minor elements** Beryllium, Aluminum, Silicate, Copper

Properties

1. **Color:** white in color
2. **Castability:** extremely technique sensitive
3. **Porcelain bonding:** forms adequate oxide layer which bonds to porcelain.
4. **Aesthetic:** dark oxide layer may be seen at porcelain metal junction



2- Cobalt chromium alloys

They are also called satellite because of their shiny – star like appearance. Have

high strength, excellent corrosion resistance and hardness. Mostly used for Removable partial denture frame work

Composition

- **Cobalt:** (60 %) decrease hardness – strength and rigidity
- **Chromium:** (25 %) tarnish resistance decrease melting point
- **Nickel:** (0-20%) increase ductility (cause sensitivity in some patients)
- **Molybdenum:** (0-7%) increase strength and hardness
- **Beryllium:** reduce melting temperature
- **Silicone and manganese:** increase castability.

Properties

1. **Density:** It is half of gold alloys (8-9gm/cm)
2. **Fusion temp:** Higher than gold alloys (1250-1480 c)
3. **Yield strength:** Higher than gold alloys (710 Mpa)
4. **Elongation:** Less than gold (1-12%)
5. **Modulus of elasticity:** Twice than gold alloys (225*10 Mpa)
6. **Casting shrinkage:** It is about 2.3%
7. **Hardness:** Harder than gold (432HN) thus cutting grinding , finishing is difficult , special hard high speed finishing tools are needed

Titanium and titanium alloys

- Titanium is pure, white and light metal has the ability to form passive surface oxide layer immediately (formation of oxide layer to protect the metal from further oxidation)
- It has excellent biocompatibility, light weight good strength.
- Titanium cast is usually porous and Difficult to be cast because of low

density and high fusion temperature and high reactivity with the surrounding environment (Air & investment material) so special casting equipments are required

- Titanium is usually used for Dental implant and denture framework
- Coefficient of thermal expansion is low compared to porcelain so special low fusing porcelain is used with it in case of using it for crown & bridge.
- Investment is by using phosphate or ethyl silicate bonded investment.