Metal and metal alloys

Alloys: an alloy is a metal-containing two or more elements at least one of which is metal and all of which are mutually soluble in the molten state.

Requirements of casting alloys:

- They must not tarnish or corrode in the mouth.
- They must be sufficiently strong for the intended purpose.
- They must be biocompatible (non-toxic, nonallergic).
- They must easy to melt, cast, cut, grind (easy to fabricate).
- They must flow well and duplicate fine details during casting.
- They must have minimum shrinkage on cooling after casting.
- Easy to solder.

Applications:

- Construction of metallic framework of the removable partial denture.
- Construction of metalcore of crown and bridge.
- Making orthodontic wires, bands, brackets, etc…
- Making endodontic instruments.
- Construction of dental implants.

Classification of metals:

- Noble metals like (gold, platinum, rhodium, ruthenium, osmium, silver, however in the oral cavity silver is not considered noble because of tarnish.
- Non-noble (base metal) like (chromium, cobalt, nickel, iron, copper, etc…

Classification of dental alloys:

A. According to the number of elements:

- Binary:2 elements.
- Tertiary:3 elements.
- Quaternary:4 elements.

B. According to nobility:

- High noble alloys: contain 40% gold or more and 60% noble or more.
- Noble alloys: contain 25% or more noble metals.
- Base metal alloys: contain less than 25% noble.

C. According to major elements:

- Gold alloys.
- Silver alloy.
- Palladium alloys.
- Nickel alloys.
- Cobalt alloys.
- Titanium.

D. According to 3 major elements:

- Gold- palladium-silver alloys.
- Palladium silver – tin alloys.
- Nickel- chromium-molybdenum alloys.
- Cobalt-chromium-molybdenum alloys.

Gold: gold foil filling (pure gold)

Pure gold is very malleable and ductile. Gold foil is in the form of a very thin sheath or foils about 0.001 mm thickness. Its condensed into 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 depends on the skill of the operator.

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 mastication stress like cl V cavities and cl III cavities.
- **Type II:** the medium is indicated for large inlay restoration.
- **Type III:** hard it is indicated for crown and bridge.
- **Type IV:** extra hard it is indicated for crown and bridge and removable partial dentures.

Composition of gold alloys:

- **Gold**, copper, silver, palladium, and some platinum, Zinc, Tin, and iron.
- **Copper:** reduce the melting point and density, increase hardness, gives a red color to gold. If high % it reduces corrosion and tarnishes resistance.
- **Silver:** whiten the alloy, increase strength and hardness slightly. In large amount reduce tarnish resistance.
- **Platinum:** increases strength and corrosion resistance and melting point, has a white color.

- **Palladium:** It hardens and whitens the alloy, raises fusion temp., increases tarnish resistance. It is less expensive than gold.
- **Zinc:** Act as a scavenger for oxygen.

Properties:

- **Color:** yellow and white gold depending on the whitening elements present (silver, platinum, palladium).
- **Melting range:** 920-960.

Alternative to gold alloys:

- **Palladium alloys:**

These are cheaper than gold alloys, whiter in color, their properties are similar to type III and VI gold alloys but:

- lower ductility and corrosion resistance.
- lower density.
- **Titanium and titanium alloys.**

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 a natural tooth appearance. Porcelain is brittle so these alloys reinforce porcelain (ceramic).

Requirments of metal-ceramic alloys:

- The melting temperature should be higher than the porcelain firing temp.
- It should resist creep.
- Should be able to bond with porcelain.
- Should have high stiffness (high modulus of elasticity).

- Should not stain or discolor porcelain.

Types of metal-ceramic alloys:

- High noble (gold alloys) like gold-palladium, gold-palladium- platinum. Gold-palladium silver.
- Noble (palladium) like palladium- silver, palladium- gold, palladium-copper.
- Base metal alloys like nickel-chromium, pure titanium, titanium-aluminum.

Removable denture alloys

Requirements:

Besides all requirements of metal casting alloys partial denture alloys:

- Should have low weight, because it is large in structure.
- Should have high stiffness which helps in making casting thinner which is important in the palate.
- Should have good fatigue resistance. It is important for the clasp.
- Should not react with denture cleaners.
- Should have a low cost.

Types:

Cobalt chromium, Nickel chromium, Aluminum alloys, and type IV gold alloys

Cobalt chromium alloys:

They are also called satellites because of their shiny- star-like appearance. Have high strength, excellent corrosion resistance, hard.

Application:

- Denture base.
- Cast removable partial denture framework.
- Crown and bridge.
- Bar connectors.

Composition:

- Cobalt-35-65%-decrease hardness-strength and rigidity.
- Chromium-23-30%- passivity effect, decrease melting point.
- Nickel-0-20%- decrease strength and hardness, increase ductility.
- Molybdenum-0-7% increase hardness.
- Iron-0-5%- increase hardness.
- Carbon-0.4%.

Nickle cause sensitivity in some patients.

Properties:

1. **Density:** It is half of the gold alloys (8-9) gm\cm.
2. **Fusion temp.:** Higher than gold alloy (1250-1480c).
3. **Yield strength:** Higher than gold alloys(710Mpa).
4. **Elongation:** less than gold (1-12%).
5. **Modulus of elasticity:** Twice than gold alloys (225*10 Mpa).

Advantages of base metal alloys

- Lighter in weight.
- Better mechanical properties.
- As corrosion resistance as gold alloys (due to passivity effect).
- Less expensive than gold.

Disadvantages:

- More technique sensitive.
- Complexity in the production of the dental appliance.
- High fusing temp.
- Extremely hard. So, require special equipment for finishing.
- High harden cause wear of restoration and natural teeth contracting then.

Titanium and titanium alloys(Ti-6A1-4V):

Titanium and its alloys are newly used in metal-ceramic and for removable partial denture and implants. It has excellent biocompatibility, lightweight, good strength, and ability to passivity.

Application in dentistry:

- Metal ceramic restoration.
- Dental implant.
- Partial denture framework.
- Complete denture base.
- Bar connectors.

Properties:

- Color-white color metal.
- Density-light metal (1-4) (gm\cm).
- Modulus elasticity-110 GPa, half rigid as base metals.
- Melting temp.: high(1668c) special equipment is needed.
- Biocompatibility- it is non-toxic and excellent biocompatibility with soft and hard tissues.
- Tarnish and corrosion resistance- passivity effect and formation of oxide larger to protect the metal from further oxidation.
- Investment-phosphate and ethyl silicate bonded investment is used.

Nickel chromium alloys:

They are used for metal-ceramic crowns and bridges.

Composition:

- Nickel-61-81% minor elements Beryllium.
- Chromium-11-27%.
- Molybdenum-2-9%.
- Minor elements Beryllium.
- Aluminum.
- Silicate.
- Copper.

Properties:

- Color-white.
- Melting point-1155-1304c.
- Density-7.8-8.4gm\cm.
- Casting-sensitive technique.
- Hardness-175-360VHN, the high hardness makes them difficult to cut, grind, and polish.
- Porcelain bonding- this alloy forms an adequate oxide layer that bonds to porcelain.
- The aesthetic- dark oxide layer may be seen at porcelain metal junction.

Wrought stainless steel alloys:

Wrought alloys are defined as alloys that are shaped without applying heat (room temperature) by hammering cold working.

Stainless steel is an alloy of iron and carbon that contains Chromium, Nickel, and manganese.

Cold working: the alloy is hammered, drawn, or bent into shape at room temp. It is called wrought alloy and it is used for making instruments, burs, wires.