INVESTMENT MATERIALS

Dental Materials
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Overview

- **Investment Materials**
  - ADA Specification 2
  - Chemistry: Composition, Setting reaction
  - Physical Properties: Setting, Expansion, Strength
  - Types of Investments
    - Gypsum-bonded Investments
    - Phosphate-bonded Investments
    - Ethyl silicate-bonded Investments
Casting Procedures

- The lost wax casting process: a metal casting is made using a refractory mold made from a wax replica or pattern.
Steps

- Spruing of wax pattern
- Investing
- Wax burn-out
- Casting with molten alloy
Spruing & Investing:

- Surrounding wax pattern with a material that can accurately duplicate its shape and anatomic features while leaving a channel for entry of molten alloy.
• (O’Brien, 1997)
Burnout:

- Removal of wax pattern to create mold into which molten alloy can be placed.
Casting:

- Introducing molten alloy into the mold.
- **Shrinkage**
  - wax
  - gold

- **Expansion**
  - setting
  - hygroscopic
  - thermal
  - wax
Shrinkage Compensation:

- Molten alloys shrink on solidification
- Mold must be made correspondingly larger than original wax pattern
- Mechanisms to produce expanded mold
  - Wax pattern expansion
  - Setting expansion
  - Hygroscopic expansion
  - Thermal expansion
Types of Investments

- **Gypsum-bonded investments**
  - Used for casting gold alloys

- **Phosphate-bonded investments**
  - Used for alloys used in ceramometal restorations

- **Ethyl silica-bonded investments**
  - Used for casting base metal alloy partial dentures
Gypsum-bonded investments

- The mold materials most commonly used in the casting of dental gold alloys.
- Decomposes at high temperatures; not suitable for casting high-melting gold alloys, or base metal alloys.
Gypsum-Bonded Investments

- Uses
  - Casting gold alloys w/ metal < 700-1000 C
Gypsum-bonded investments: ADA Specification No. 2

- **Type I**
  - THERMAL expansion
  - Inlays or crowns

- **Type II**
  - HYGROSCOPIC expansion
  - Inlays or crowns

- **Type III**
  - Partial dentures with gold alloy
Gypsum-Bonded Investments

Composition

- Refractory
  - Crystalline polymorphs of silica (quartz or cristobalite)
  - 55-75%

- Binder
  - Calcium sulfate hemihydrate (plaster or stone)
  - 25-45%
  - In setting, hemihydrate binder combines with water to form dihydrate (gypsum)

- Modifiers
  - Accelerators, retarders, reducing agents or additives that reduce the thermal contraction of the binder. Coloring agents.
Microstructure of a set gypsum-bonded investment. The large particles are cristobalite: the small acicular crystals are gypsum formed during setting. (SEM at x 3,000) (O’Brien, 1997)
Types of Expansion:

- **Purpose:** to enlarge the mold to compensate for the casting shrinkage of the gold alloy

  1. **Normal setting expansion:** occurs as investment hardens in air
  2. **Hygroscopic setting expansion:** occurs as investment hardens while immersed in water
  3. **Thermal expansion:** occurs as investment is heated
Normal Setting Expansion:

- **Mechanism:** silica particles interfere with the interlocking of crystals; the outward thrust of the crystals increases the expansion of investment.
- **Maximum expansion in air** 0.6%
Hygroscopic setting expansion:

- **Mechanism**: a continuation of normal setting expansion b/c immersion in water encourages continued growth of crystals.
- **Expansion range**: 1.2-2.2%
Factors that **increase** hygroscopic expansion:

- **Composition**: more silica, finer particles lead to more outward growth of crystals
- **W:P ratio**: less water, more powder in mix
- **Spatulation**: more mixing time
- **Time of immersion**: immerse in water before initial set
- **Confinement**: less opposing force from walls of casting ring (wet cellulose)
- **Water**: more immersion water
- **Shelf life**: fresher investment
Thermal expansion:

- In quartz and cristobalite, the high-temp phase is less dense than low-temp phase; result in expansion.
- Thermal expansion: 1-1.6%
- At high temp, sulfur dioxide gas is released causing discoloration and embrittlement of alloy.
- W:P ratio--- more powder, less water result in increased thermal expansion
**Compressive strength**: minimum strength is necessary to prevent fracture of investment from the impact of metal entering the mold---more powder, less water increase investment strength.

**Fineness**: a finer particle size leads to higher hygroscopic expansion and smoother surface on casting.

**Porosity**: venting the mold, air must be eliminated through the pores of investment to prevent buildup of pressure so that molden metal can flow into the mold during casting.

**Storage**: preweighed packages
Phosphate-Bonded Investments

- Uses
  - Casting ceramometal alloys w/ metal < 1200 °C (2192 °F)
Phosphate-Bonded Investments

- **Composition**
  - **Binder**
    - Magnesium-oxide (basic) and phosphate (acid, mono-ammonium)
  - **Refractory**
    - Colloidal silica liquid. Increases expansion and enhances casting surface smoothness
  - **Modifiers**
    - Carbon: to produce clean castings and facilitate the devesting. Don’t use with palladium-containing alloys because carbon embrittles alloy)
Phosphate-Bonded Investments

Properties

- Complex reaction.
- Setting and thermal expansion
  - Water gives less thermal expansion than silica sol
Phosphate-Bonded Investments

- Working and Setting time
  - Markedly affected by temperature
    - The warmer the mix, the faster the set
  - Increased spatulation increases set and gets greater rise in temperature
  - Increased Liquid/Powder ratio increases working time
Ethyl Silicate-Bonded Investments

- **Uses:**
  
casting high-fusing metal partial denture alloys
Ethyl Silicate-Bonded Investments

- **Composition**
  - **Binder**
    - Silica gel that reverts to silica (cristobalite) on heating
  - **Refractory:**
    - Quartz or cristobalite
Ethyl Silicate-Bonded Investments

- Properties
  - Setting: drying/gelation causes contraction
  - Complicated and time-consuming procedures involved
  - Heating temp from 1090 – 1180 C (2000-2150 F)
  - Fragile cast
Reference: