eebrothers.com, for detailed information on dental books, visit our website www.jaypeebrothers.com, for detailed information on dental books



Exam Preparatory Manual for Undergraduates

DENTAL MATERIALS

Editor
Lovely M

Foreword
K Chandrasekharan Nair

Contents

ESSAYS

1. Define proportional limit, yield strength and ultimate tensile strength. Draw and label a stress-strain diagram. 1
2. Describe the various tests for the evaluation of biocompatibility of dental materials. 4
3. Classify dental impression materials. What is the composition of an ideal irreversible hydrocolloid impression material? How is it manipulated? What are the failures associated and merits with the use of this material? 7
4. What are colloids? Discuss the composition, manipulation and properties of agar. 14
5. What are the ideal requisites of an impression material? Mention the composition, properties, advantages and disadvantages of addition silicone rubber base impression material. 18
6. Classify elastomeric impression materials. Write in detail about polysulfide rubber. 21
7. What are elastomers? Mention the composition of condensation silicone rubbers. Enumerate the common merits and demerits encountered with the use of non-aqueous elastomeric impression materials. 26
8. Classify elastomeric impression materials. Describe the chemistry, composition, setting reaction and properties of polyether rubber base impression material. 30
9. Classify impression materials. Write about the composition, chemistry, manipulation and physical properties of zinc oxide-eugenol impression paste. Discuss the factors controlling its setting time. 32
10. Classify gypsum products used in dentistry. How do plaster of Paris and dental stone differ from each other? How do you control setting times and setting expansion of various products? 36
11. Mention the composition and applications of any three types of gypsum. Describe their properties, ideal requirements and manipulation. Add a note on recent advances in gypsum. 42
12. Enumerate the ideal properties of a denture base material. Describe the compression molding technique used in the processing of heat cure acrylic resin denture. 45
13. Classify denture base materials. What are the stages in polymerization? Give the composition of heat cure acrylic resins and discuss the causes of porosity. Why is it objectionable? How would you avoid it in your denture prosthesis? 49
14. Compare and contrast heat cure acrylic resin with self-cure acrylic resin with reference to: 55
    a. Strength 55
    b. Composition and chemical reaction 55
    c. Color defects 55
    d. Defects/porosities. 55

15. Mention the various types of base metal alloys. Give the composition, advantages and uses of Cr-Co alloy along with its manipulation and recent advances. Give your reasons for alloying of metals for use in dental restoration work. 61

16. Classify noble metal alloy and their applications. What is casting shrinkage of gold alloys? Describe methods to compensate casting shrinkage. 64

17. Classify dental waxes. Give the composition of dental casting wax and describe the properties of the same. 69

18. Give the composition of phosphate-bonded dental investment and function of each component. Describe the chemical reaction and methods by which casting shrinkage is compensated. Add a note on the factors affecting working and setting time. 74

19. Classify the investment materials. State the composition of gypsum-bonded investments. Mention the functions of each ingredient and add a note on the type of expansions occurring in investment materials. 76

20. Enumerate the die materials. What are the requirements of a die material? Write the advantages and disadvantages of each. 81

21. Write briefly on casting failures and measures to avoid them. 86

22. Describe dental porcelain as a restorative material. Classify the types of dental porcelain. Describe the composition, condensation, firing of porcelain jacket crowns and methods of strengthening porcelain. Add a note on recent advances. 90

OR

Classify ceramics. Enumerate its advantages and disadvantages. Explain the mechanism of bonding and describe the laboratory steps involved in the fabrication of different ceramics. 90

23. Discuss the bonding of dental porcelain to casting alloys. Which types of alloys are suitable? 99

24. What are the ideal properties of the casting alloys? Discuss the various types of casting alloys, their properties and uses. 104

25. What are abrasive and polishing agents? Give their desirable characteristics with examples. 111

26. What are tarnish and corrosion? Describe the types of corrosion. What precautions would you take while making silver amalgam restoration in order to reduce tarnish and corrosion? 113

27. Classify dental amalgam. Write in detail about the composition, advantage and disadvantage of each ingredient and the uses of dental amalgam. 116

28. What are low copper and higher copper amalgam alloys? Write in brief about the types of low copper alloys and add a note on high copper alloys. 119

29. What is high copper amalgam? Enumerate its advantages over conventional silver amalgam. What is the percentage of copper present in high copper amalgam? Add a note on the steps in the manipulation of amalgam. 121

30. What is a creep? How do you measure an amalgam creep? What is the significance of creep with respect to amalgam performance? Write in detail about the dimensional changes that occur in the use of amalgam and its control. 125

31. What is direct filling gold? Enumerate various forms of direct filling gold and its fabrication. Classify direct filling gold. Describe its physical properties, manipulation, advantages and disadvantages. 128

32. Classify gold foils. Give the rationale and technique of fabrication of gold foil. Add a note on their properties. 134

33. Define soldering and welding. Describe the precaution that you would take to obtain a good solder joint. Add a note on fluxes. 138

OR

Define solders. Give examples, composition and uses. Explain the technique of soldering in bridgework prosthesis. 138

OR

What is soldering? Describe the properties and general requisites of gold alloy solders. 138

34. Write in detail about silicate cement, its composition and properties. Write in detail about its dimensional stability and strength. 141

35. Describe the composition, setting reaction, manipulation and uses of zinc polycarboxylate cement. 144

36. Classify composite restorative resins. Write about the composition, properties and clinical performance of hybrid composites and their uses. Add a note on the light-activated composite resins. 148

37. Describe the composition, properties and clinical performance of composite resins classified based on filler particles. 152

Add a note on newer developments in composites. 152

38. Classify dentin-bonding agents. What are adhesive materials? Write a note on composition. Enumerate the uses and advantages of direct bonding materials. 158

39. What are the ideal requirements of restorative dental cements? Classify them. Write in detail about $ZnPO_4$ cement including the control of setting time and technical considerations. 161

40. Describe briefly the composition, chemical reaction, manipulation, types, uses and properties of glass ionomer. 166

41. Discuss in detail zinc oxide eugenol cement. Add a note on modified zinc oxide eugenol cement. 171

42. Compare and contrast the physical, mechanical, biologic and esthetic properties of anterior and posterior restorative materials. 179

43. Write in detail about the various cavity varnishes, liners and bases used in dentistry. 186

44. Classify gold alloys with their composition. Describe the various heat treatment procedures for these alloys to alter their physical properties. Add a note on white alloys with their uses. 190

45. Compare and contrast the general properties of Co-Cr-Mo with a Type-IV dental casting gold alloy. Make particular reference to composition, strength and rigidity. What are the ideal requirements of these alloys used in dentistry? 194

46. Discuss the materials (alloy, resin cement) which may be used in resin-bonded bridge restoration. What are the various special pretreatments of the enamel and alloy contact surfaces required before bonding? 195

47. Describe in detail the various materials used for implants. 200

SHORT NOTES

1. American Dental Association Acceptance Program. 207
2. Adhesion and Bonding. 209
3. Color, Color Perception, Color Matching and Bezold-Brücke Effect. 212
4. Metamerism and Fluorescence. 214
5. Three Dimensions of Color. 216
6. Creep and Flow. 218
7. Stress and Strain. 220
8. Young's Modulus. 223
9. Elastic Limit/Proportional Limit. 226
10. Importance of Yield Strength of a Restorative Material. 228
11. Hardness Tests. 230
12. Brittleness. 232
13. Ductility and Malleability. 234
14. Poisson's Ratio. 236
15. Strength. 238
16. Viscosity. 244
17. Contact Angle. 247
18. Surface Tension/Surface Energy. 249
19. van der Waals Forces. 251
20. Contact Stomatitis. 252
21. Microleakage. 254
22. Dentin Hypersensitivity. 256
23. Solid Solution. 257
24. Composition, Requirements, Types, Properties and Uses of Impression Compounds. 260
25. Composition of Alginate Impression Material. 262
26. Laminate Technique. 263
27. Noneugenol Paste. 264
28. Electroplating of Impressions. 265
29. Imbibition and Syneresis. 267
30. Manipulation of Agar. 268

31. Polysulfide Impression Material. 269
32. Condensation Silicone/Polysilicone Impression Material. 271
33. Addition Reaction Silicone (Vinyl Polysiloxane). 273
34. Describe the composition, Manipulation, Properties and Uses of Impression Plaster. 275
35. Compare and Contrast Between Dental Plaster and Dental Stone. 277

OR

What is the Difference Between Dental Plaster and Dental Stone? Add a Note on Setting Time and Expansion. 277
36. Accelerators and Retarders in Gypsum Products. 280
37. Terra Alba. 281
38. Space Lattice. 282
39. Explain Copolymerization with the help of Suitable Examples. 284
40. Types of Polymerization/Addition Polymerization. 285
41. Thermoplastic Materials. 288
42. What is Meant by Curing Cycle in Acrylic Resin? 290
43. Describe the Physical and Chemical Changes that Take Place during Polymerization of Acrylic. 291
44. Resilient Liners and Tissue Conditioners. 294
45. Maxillofacial Materials. 298
46. Cold Cure Acrylic (ADA-13). 300
47. Denture Base Materials. 302
48. Cold Mold Seal. 305
49. Eutectic Alloys. 306
50. Phase Diagrams and Homogenization. 308
51. Types of Heat Treatments. 311
52. Annealing. 312
53. Type III Gold Alloys. 314
54. Galvanic Cell Corrosion. 316
55. Concentration Cell Corrosion. 317
56. Inlay Wax. 318
57. Base Plate Wax. 321
58. What are the Causes for the Distortion of Wax Pattern? 322
59. What is the Composition of Investment used for Base Metal Alloys? 323
60. Spherical Alloys. 325
61. Hygroscopic Setting Expansion. 326
62. Thermal Expansion. 329

63. Ethyl-silicate-bonded Investment. 330
64. Explain the following Terms: 331
a. Green Shrinkage 331
b. Green Strength 331
65. Casting Machines and Crucibles Used. 333
66. Porosities/Defects in Noble Metal Castings. 335
67. Sprue Former. 337
68. Die Materials and Different Dies. 339
69. Dispersion Alloys. 340
70. Porosities in Casting. 341
71. Subsurface Porosities. 344
72. Metal Ceramics/Types of Bond/Technique. 344
73. Choice of alloys in ceramics, benefits, requirements and drawbacks of bonded ceramics. 347
74. Acid Pickling. 349
75. Condensation and Firing of Porcelain Jacket Crown. 350
76. Methods of Strengthening Ceramics. 352
77. Aluminous Porcelain/Dicor. 354
78. Explain the following: 355
a. Greening in Porcelain. 355
b. Green State. 355
79. Ring Liners/Ringless Castings. 356
80. Define Solders. Give Examples, Composition and Uses. Explain the Technique of Soldering in a Bridge Work Prosthesis. 358
81. Flux/Antiflux. 362
82. Beilby Layer. 363
83. Hard Solders. 364
84. All-Ceramic Restoration. 365
85. Weld Decay. 369
86. Classify Steels. Add a Note on 18/8 Stainless Steel. 370
87. Wrought Stainless Steel Alloys. 373
88. Wrought/Dental Casting Alloys. 375
89. Silver-palladium Casting Alloys (White Gold). 379
90. Nickel-titanium Alloys (Shape Memory and Superelasticity). 380
91. Swaging. 382
92. Types of Implants. 382
93. Implant Materials. 385

94. Dentifrices. 388
95. Tooth-cutting Instruments. 390
96. Polishing Agents/Types of Abrasives. 394
97. Platinum Group. 398
98. Duplicating Impression Materials. 400
99. Pulp Response of Restorative Dental Cements. 401
100. Sensitization. 403
101. Eames Technique. 404
102. Ethoxy Benzoic Acid Cement. 406
103. Resin-modified Glass Ionomer Cement/Hybrid Ionomer. 408
104. Percolation. 408
105. Single-composition Alloys/Admixed Alloys. 410
106. Trituration. 411
107. Mulling. 413
108. Condensation. 413
109. Carving/Polishing. 415
110. Amalgam Bond. 416
111. Amalgam Capsule. 417
112. Mercury Hazard and Mercury Hygiene. 418
113. Cohesive Gold Foil and Manipulation of Gold Foil. 420
114. Advantages and Disadvantages of Composite Resin Restoration. 421
115. Macrofilled Composites. 423
116. Acid Etch Composite Resins / Technique. 424
117. Light-cured Composites. 427
118. Microfilled Resins and Small-sized Resins. 428
119. Hybrid Composites. 430
120. Describe the Improvements in the Development of Newer Composite Resins. 431
121. Nanocomposites. 433
122. Gutta-percha. 433
123. Dentin-bonding Agent. 435
124. Ozokerite Waxes. 437
125. Coupling Agent. 438
126. Cement for Temporary Restoration. 439
127. Explain the Role of Various Cements and their Indications. 440
128. Metal Modified Glass Ionomer Cements/Ketac-Silver/Miracle Mix. 441

129. Mechanical Bonding. 442
130. Cavity Liners used in Dentistry. 443
131. Cavity Varnishes. 445
132. Resin-bonded Cement (Kalzinol). 446
133. Dimensional changes occurring in amalgam and its control. 447
134. Types of High Copper Amalgam and its Advantages Over Conventional Silver Amalgam. 448
135. What are the Steps in the Manipulation of Amalgam? 450
136. Germicidal Cements. 452
137. Adhesive Cements/Any one in detail. 453
138. Calcium Hydroxide. 457
139. Pit and Fissure Sealants. 459
140. Chemistry of Silicate Cement. 461
141. Degassing. 463
142. What is Abrasive and Erosive Wear? Name the Methods of Bonding in the Bonded Abrasives. Explain the Truing and Dressing Procedures. 464
143. Cast Metal Bases/Metal Denture Bases. 466

MULTIPLE CHOICE QUESTIONS

Prosthodontics 469
Conservative Dentistry 488

ANSWERS TO MULTIPLE CHOICE QUESTIONS

Prosthodontics 503
Conservative Dentistry 506

INVITED REVIEW ARTICLES

1. Recent Advances in Restorative Dental Materials 509
2. Recent Advances in Dental Materials 522

Index *531*

Essays

1. Define proportional limit, yield strength and ultimate tensile strength. Draw and label a stress-strain diagram.

PROPORTIONAL LIMIT

Proportional limit is defined as the greatest stress that a material will sustain without a deviation from the linear proportionality of stress to strain.

A material does not deform if the stress applied to a material is below the proportional limit value. Also, after the applied stress is removed, the material regains its original dimension.

YIELD STRENGTH/YIELD STRESS

The yield strengths is defined as the stress at which a material exhibits a specified limiting deviation from proportionality of stress to strain.

It is the stress at which the material starts to function in a plastic manner in which a limited permanent strain has occurred in the material.

The amount of permanent strain may be indicated as 0.1%, 0.2%, or 0.5% of permanent strain. The amount of percent strain may be referred to as the percent offset.

On the stress-strain curve, the yield strength is represented by the value *y*. The parallel line bisecting the stress-strain curve is yield strength.

ULTIMATE TENSILE STRENGTH

The ultimate tensile strength is defined as the maximum stress that a material can withstand before failure in tension occurs.

After a maximum stress is applied to a material, it begins to elongate, and the stress calculated from the force and the original cross-sectional area before the final fracture occurs is the ultimate tensile strength.

The stress at the end of the curve is less than at some intermediate point on the curve.

An alloy that has been stressed to near the ultimate tensile strength will be permanently deformed.

Tensile Properties of Brittle Materials

Brittle materials are made into dumbbell-shaped specimens of known cross section and held in special grips to permit axial tensile loading with a minimum of localized stress concentration.

The other methods of testing brittle materials are by diametral compression test for tension, the Brazilian test, or the indirect tensile test.

JAICO BROTHERS

The tensile stress is directly proportional to the load applied in compression.

$$\text{Tensile stress} = \frac{\text{Load}}{(\text{Diameter} \times \text{thickness})}$$

At stresses above the proportional limit (point PL), the actual stress curve (dashed line) terminates at the higher UTS (ultimate tensile strength) value, or at the point of fracture.

Cross-section of the wire decreases as it lengthens under tensile stress.

The ultimate tensile strength is based on the initial area (lower UTS value).

The decrease in cross-sectional area of the wire and the actual or true stress-strain curve is indicated by the upper solid line.

STRESS-STRAIN CURVES

The stress-strain relationship of dental materials can be measured by calculating the load and deformation.

The testing of many materials requires loads of 220 N (500 lb) or more and the measurement of deformations of 0.02 mm or less at uniform rates.

Method of Measurement

- The load is measured electronically with a strain-gauge transducer and recorded on the horizontal axis of the strip-chart recorder
- The deformation is measured when an extensometer is clamped over a given length of the sample and the deformation is recorded on the vertical axis of the recorder
- The measurements can be converted to a plot of stress versus strain by simple calculations
- The area of specimen remains constant during the test. This curve is called an engineering stress-strain curve
- Stress-strain curves for two hypothetical materials of different composition are shown as stress-strain curve **(Fig. 1)**
- The stress in MN/nv is plotted vertically and the strain is plotted horizontally
- Hence, it is seen that for each material as the stress is increased, the strain is increased and as the stress is doubled, the amount of strain is also doubled.

Properties of Stress-strain Curves

The stress-strain curves represent materials with various combinations of physical properties. The stiffness, strength, ductility and toughness can be evaluated. This can be done in the same stress-strain graph **(Fig. 2)**.

The material obeys Hooke's law; the elastic stress will be proportional to elastic strain.

For such a material, the stress-strain diagram starts from the origin (O) as a straight line. Along this linear path, the material behaves elastically and it springs back to its initial shape and size at the instant the force is removed.

After a certain stress value, the line becomes nonlinear and stress is no longer proportional to strain.

The stress value at P, the point above which the curve begins from a straight line, is known as the *proportional limit*.

JAYPEE BROTHERS

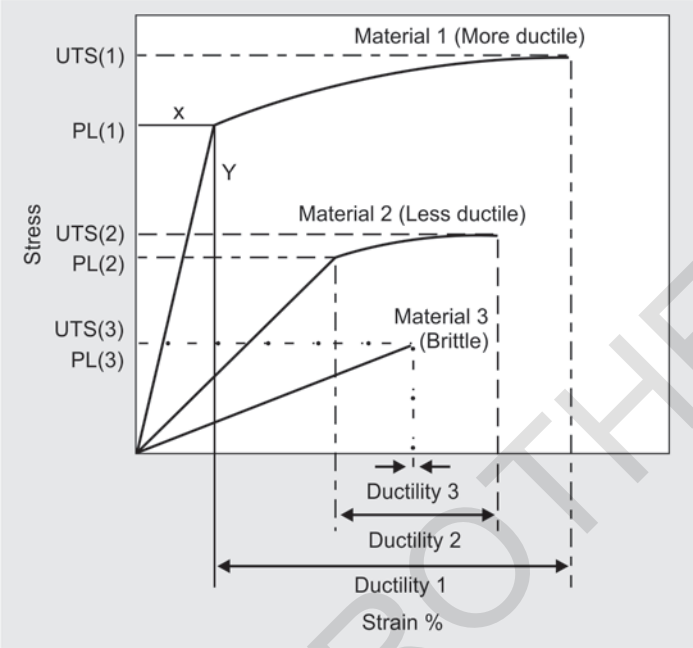

Fig. 1: Stress-strain plots of materials that exhibit different mechanical properties
Abbreviations: UTS, ultimate tensile strength; PL, proportional limit

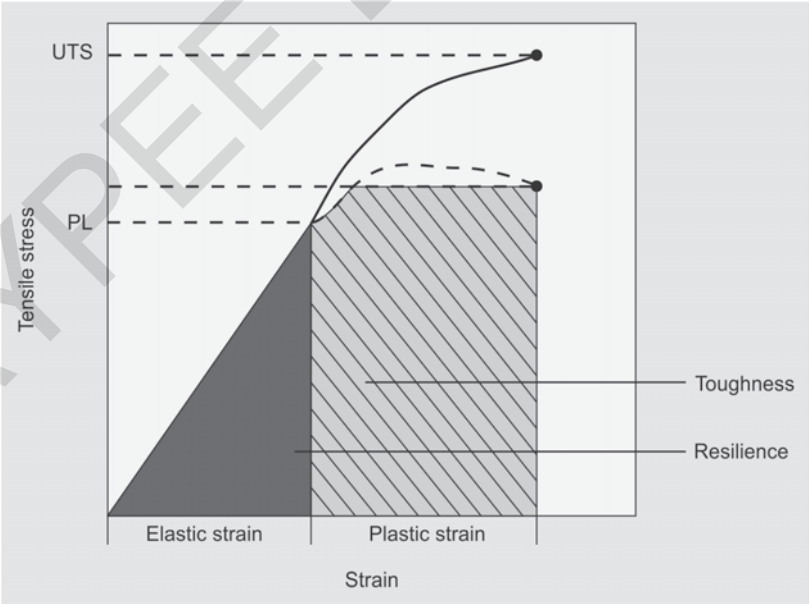

Fig. 2: Proportional Limit
Abbreviations: UTS, ultimate tensile strength; PL, proportional limit

JAYPEE BROTHERS

The proportional limit (stress corresponding to point P) is the greatest elastic stress possible according to Hooke's law. It represents the maximum stress above which stress is no longer proportional to the strain.

For the stress-strain curve of dentin, the strain corresponding to the proportional limit is important because it represents the percent deformation that can be sustained in dentin before it becomes damaged permanently.

2. Describe the various tests for the evaluation of biocompatibility of dental materials.

BIOCOMPATIBILITY TESTING

It is done to eliminate any potential product or component of a product that can cause harm or damage to oral or maxillofacial tissues.

CLASSIFICATION OF BIOCOMPATIBILITY TESTS

- Primary tests
- Secondary tests
- Preclinical usage tests.

Group I: Primary Tests

These tests are done rapidly and are economical.

Types

- Cytotoxic evaluations
- Genotoxicity test.

Cytotoxic evaluations: A fresh or cured dental material is placed directly on tissue culture cells or on membranes such as dentin disks, and the reaction to the effects of products or components that leach through the barriers is evaluated.

If products are found to be cytotoxic, further modifications can be made by the manufacturer to prevent cytotoxicity before the product is marketed.

Genotoxicity test: Mammalian or nonmammalian cells, bacteria, yeasts or fungi are used to determine whether gene mutations, changes in chromosomal structure, or other deoxyribonucleic acids or genetic changes are caused by the test materials, devices and extracts from materials.

JAYPEE BROTHERS

Group II: Secondary Tests

At this level, the product is evaluated for its potential to create systemic toxicity, inhalation toxicity, skin irritation, and sensitization and implantation responses.

Systemic Toxicity Tests

In the systemic toxicity tests such as the oral median lethal dose (LD50) test, the test sample is administered daily to rats for 14 days either by oral dosage or by dietary inclusion. If 50% of the animals survive, the product has passed the test.

Efforts are being made to develop other systemic toxicity tests that require far fewer animals.

Dermal Toxicity Tests

The dermal toxicity test is important because of the great number of chemical substances that are capable of producing an inflammatory response in most susceptible people after the first exposure. Once a toxic material, product, or component is identified, it can be replaced, diluted, neutralized and chelated to reduce the risk for toxicity.

Irritation is defined as an inflammation brought about without the intervention of an antibody or immune system.

Sensitization is an inflammatory response requiring the participation of an antibody system specific for the material allergen in question.

To simulate dermal toxicity, the test material is held in contact with the shaved skin of albino rats/guinea pig for periods ranging from 24 (one exposure) to 90 days (with repeated exposures). The animal must receive an occlusive covering to prevent mechanical loss of the contacting agent, even by evaporation.

An *allergen* is defined as a substance that is not primarily irritating on the first exposure but produces reactions more rapidly in subsequent exposure to similar concentrations.

Method of testing:

- The test material is introduced intradermally and, after 24 hours, the resulting dermal reaction is assessed
- For the main test, the highest concentration of the test material that causes no more than slight erythema and edema is selected
- After an interval of 7 days, the test material of the same concentration is placed on gauze patches and applied to cover the previously injected sites
- Fourteen days later, the test material is applied to the shaved flank of the animals. After removal of the dressings at 24, 48 and 72 hours, the skin reactions at the sites are evaluated and graded.

Inhalation Toxicity Tests

- These are performed on rats, rabbits or guinea pigs in an exposure chamber with aerosol preparations by releasing the spray material around the head and upper trunk of the animals. The animals are subjected to 30 seconds of continuous spray at 30-minute intervals
- After 10 consecutive exposures, the animals are observed over a 4-day period
- If any animal dies within 2–3 minutes, the agent is considered very toxic.

JAYPEE BROTHERS

Implantation Tests

- The use of in vivo implantation techniques helps to review the physical characteristics of the product, such as form, density, hardness and surface finish that can influence the character of the tissue response
- The animal species is selected according to the size of the implant test specimen and the duration of the test in relation to the life span of the animal
- For short-term tests (12 weeks) in subcutaneous tissue or muscle, animals such as mice, rats, hamsters, guinea pigs and rabbits are commonly used
- For long-term tests (2–12 weeks) in muscle or bone, animals such as rabbits, dogs, sheep, goats and subhuman primates are used. For subcutaneous and muscle implantation, the test implant material is packed into various types of plastic tubes (variations of polyethylene or teflon)
- For bone implantation, the lateral cortex of a femur or a tibia or both are exposed and holes are drilled using low-speed, intermittent cutting under profuse irrigation with physiologic saline solution to prevent overheating of the bone
- Cylinders of the test implant material are inserted into the drilled holes by finger pressure
- The diameter of the implant and the implant bed in the bone must match well
- Histopathologic evaluation for the formation of new bone without intervening connective tissue is done.

Group III: Preclinical Usage Tests

The US Food and Drug Administration (FDA) can approve a product after passing the primary and secondary tests

Dental materials have a long 7-year period to prove efficacy after the product has reached the open market with FDA approval.

The product is required to have the ADA Seal of Acceptance after all the biologic, laboratory and clinical evaluations.

Implant materials require more long-term data.

Pulp and Dentin Usage Test

- This test is designed to assess the biocompatibility of dental materials placed in dentin adjacent to the dental pulp
- Nonrodent mammals with recently erupted, intact permanent teeth are selected and Class V cavity preparations are done with 1 mm or less of tubular dentin between the floor of the cavity preparation and the pulp. Some cavities are retained for control specimens
- As a negative control, zinc oxide-eugenol (ZOE) is used
- For a positive control, Class V cavity preparations are done and are luted under pressure
- The animals are then sacrificed after 7 days, 28 ± 3 days and 70 ± 5 days, routine histopathologic processing of the specimens are done and are graded for degree of inflammatory response, reparative dentin formation in the pulp and microleakage.

Biocompatible materials cause minimum or no pulpal response.

JAYPEE BROTHERS

Pulp Capping and Pulpotomy Usage Tests

- A calcium hydroxide (CH) product is used as a negative control. The animals are sacrificed after 7 ± 2 days and 70 ± 5 days
- Biocompatible materials form a bridge directly against the capping material, with minimal destruction of pulp tissue at the time the pulp capping agent was applied.

Endodontic Usage Tests

- For this test, the same types of animals are used, but the pulp is completely or almost completely removed from the pulp chamber and root canals, and replaced by the obturating test material and control material ZOE alone or ZOE combined with a sealer
- The animals are sacrificed after 28 ± 3 days and 13 ± 1 weeks
- The teeth are removed together with their surrounding apical periodontal (soft and hard) tissues in a single block, and degree of inflammation is evaluated in the periapical tissues.

Amalgam Controversy the Latest Update

The use of mercury in dental fillings is considered safe and effective in all countries practicing modern dentistry except Norway and Sweden, that have introduced legislation to prohibit or restrict use of amalgam fillings.

World Health Organization (WHO) has suggested phasing down of Amalgam use over a period of time.

3. Classify dental impression materials. What is the composition of an ideal irreversible hydrocolloid impression material? How is it manipulated? What are the failures associated and merits with the use of this material?

CLASSIFICATION OF IMPRESSION MATERIALS

- Elastic
- Inelastic/Rigid impression materials.

Elastic Impression Materials

- Hydrocolloids
- Elastomeric impression materials.

JAYPEE BROTHERS

Hydrocolloids

- Agar (reversible)
- Alginate (irreversible).

Elastomeric Impression Material

- Addition silicone
- Condensation silicone
- Polyether
- Polysulfide.

Rigid Impression Materials

- Impression plaster
- Impression waxes
- Zinc oxide eugenol
- Impression compound
- American Dental Association (ADA) classification
- Classification of impression materials.

Nonelastics

- Impression compound
- Impression plaster
- Waxes
- Zinc oxide-eugenol.

Aqueous Elastomers

- Reversible hydrocolloids (agar)
- Irreversible hydrocolloids (alginate).

Nonaqueous Elastomers

- Polysulfides
- Condensation polymerizing silicones
- Addition polymerizing silicones [poly(vinyl siloxanes)]
- Polyethers.

ALGINATE

- ANSI/ADA Specification No. 18.

Composition

Substance	%	Function
Potassium alginate	(18%)	Reacts with calcium ions
Calcium sulfate dihydrate	(14%)	Reacts with potassium alginate to form insoluble calcium alginate gel

Contd...

JAYPEE BROTHERS

Contd...

Potassium sulfate/Potassium zinc fluoride	(10%)	Gypsum hardener
Tri-sodium phosphate	(2%)	Retarder (Increases the working time)
Diatomaceous earth	(56%)	Filler
Organic glycols	Traces	For dustless alginates
Wintergreen, peppermint	Traces	For flavor
Pigments	Traces	Color
Ammonium salts and chlorhexidine	2%	Disinfectant

Components and their Functions

Filler

Diatomaceous earth increases the strength and stiffness of the alginate gel, produces a smooth texture and ensures a firm gel surface that is not tacky. It also aids in forming the sol by dispersing the alginate powder particles in the water.

Zinc oxide acts as a filler and influences the physical properties and setting time of the gel.

The amount of filler present controls the flexibility of the set impression material from what is called soft-set to hard-set. The injection type is more fluid after mixing and more flexible after setting.

Retarder

The concentration of sodium phosphate differs depending on regular and fast-set alginates. There are tray and injection types available.

Retarders are sodium or potassium phosphate, potassium oxalate, or potassium carbonate, trisodium phosphate, sodium tripolyphosphate and tetrasodium pyrophosphate. The latter two are now the most commonly used.

If approximately 15 g of the powder is mixed with 40 mL of water, gelation will occur in about 3 to 4 minutes at room temperature.

Reactor

Any type of calcium sulfate can be used as the reactor. The dihydrate form is generally used, but sometimes the hemihydrate form is used as it produces an increased shelf life of the powder and gives better dimensional stability of the gel.

Gypsum Hardener

Potassium titanium fluoride is added as an accelerator for the setting of the stone to ensure that a hard, dense stone cast surface is produced against the impression.

Shelf Life

Materials should be stored in a cool environment.

JAYPEE BROTHERS

Gelation Process

Reaction

- Alginic acid is prepared from a plant and is a linear polymer of anhydro-β-D-mannuronic acid of high molecular weight
- The potassium, sodium and ammonium salts of alginic acid when reacted by a calcium salt produce an elastic gel
- When potassium alginate salt reacts with calcium sulfate dihydrate, calcium alginate gel and Potassium sulfate is formed
- The soluble alginate and the calcium sulfate dihydrate are both included in the powder and as the powder is mixed it reacts with sodium phosphate to form insoluble calcium phosphate
- Calcium sulfate reacts rapidly to produce the insoluble calcium alginate from the potassium or sodium alginate in an aqueous solution
- A third water-soluble salt, trisodium phosphate, prolongs the working time
- Calcium sulfate will react with the other salt in preference to the soluble alginate till the trisodium phosphate is exhausted.

$$2NaPO_4 + 3CaSO_4 \rightarrow Ca(PO_4)_2 + 3Na_2SO_4$$

When the supply of trisodium phosphate is exhausted, the calcium ions begin to react with the potassium alginate to produce calcium alginate as follows:

$$K_2\ n\ Alginate + n\ CaSO_4 \rightarrow n\ K_2SO_4 + Ca\ Alginate$$

Gel Structure

In a sodium or potassium alginate, the cation is attached at a carboxyl group to form an ester or a salt.

When the insoluble salt formed by the reaction of the sodium alginate in solution reacts with the calcium salt, the calcium ions replace the sodium ions in two adjacent molecules to produce a cross-linking between the two molecules.

As the reaction progresses, a cross-linked molecular complex or polymer network forms. This network resembles a brush-heap structure of the gel.

The final structure is a brush heap of a calcium alginate fibril network enclosing unreacted sodium alginate sol, excess water, filler particles and reaction byproducts, such as sodium sulfate and calcium phosphate.

Availability

- Preweighed for an individual impression
- Bulk form in a can
- The two-component system consists of two pastes; one contains the alginate sol and the other contains the calcium reactor.

MANIPULATION

Proportioning and Mixing

Water/Powder Ratio

- 15 g in 40 mL of water

JAYPEE BROTHERS

- A powder and water scoop is provided for accurate proportioning by volume
- Changes in the water/powder ratio will alter the consistency, setting times of the mixed material and the strength and quality of the impression.

Mixing Time

- For regular alginate, it is 1 minute
- For fast-set alginates, it is 45 seconds.

Working Time

- The fast-set materials have working times of 1.25 to 2 minutes
- Mixing time of 45 seconds for the fast-set types
- The working time of the regular-set materials may be from 3 minutes to 4.5 minutes
- Mixing time should not exceed 60 seconds.

Setting Time

- Setting times range from 1 to 5 minutes
- The ANSI/ADA specification requires no less than 1 minute or more than 2 minutes for the fast-set materials and no less than 2 minutes or more than 4.5 minutes for the regular-set materials.

Factors Affecting Setting Time

Setting time can be increased by:

- Reducing the temperature of the water, not advisable to use water cooler than 18°C or warmer than 24°C for mixing
- Altering the water-powder ratio will reduce the strength and accuracy of the alginate
- Slow setting alginate can be used.

Controlling Gelation Time

- The gelation time is measured from the beginning of mixing until gelation occurs. It is the time from the start of mixing until the material is no longer tacky or sticky when it is touched
- The optimal gelation time is between 3 and 4 minutes at room temperature (20°C)
- For fast setting (1–2 minutes) and normal setting alginate (2.5–4 minutes)
- Gelation time is best regulated by the amount of retarder added during manufacturing
- The higher the temperature, the shorter is the gelation time.

MERITS AND DEMERITS OF IRREVERSIBLE IMPRESSION MATERIAL

Strength

- Maximum gel strength is required to prevent fracture and to ensure elastic recovery of the impression on its removal from the mouth
- Strength is altered if too much or too little water is used in mixing. Insufficient spatulation results in failure of the ingredients to dissolve sufficiently. Over-mixing breaks up the calcium alginate gel network as it is forming and reduces its strength.

Viscoelasticity

The tear strength is increased when the impression is removed with a snap. The speed of removal must be a compromise between a rapid movement and the comfort of the patient.

JAYPEE BROTHERS

Accuracy

- Most alginate impression materials are not capable of reproducing the finer details as that of other elastomeric impression materials
- The roughness of the impression surface is sufficient to cause distortion at the margins of prepared teeth
- Surfactants can be used to produce a smooth surface, but addition of a layer of solution over the surface of the impression also obscures the accuracy.

Dimensional Stability

Once the impression is removed from the mouth and exposed to the air at room temperature, shrinkage or evaporation results in **syneresis** and, if the impression is immersed in water, swelling will occur due to **imbibition**.

Compatibility with Gypsum

All forms of gypsum are compatible with hydrocolloid impression as gypsum hardener (titanium fluoride) or accelerator is used in the material.

Disinfection

- The irreversible hydrocolloids may be disinfected by 10-minute immersion in, or spraying with, an antimicrobial agent such as sodium hypochlorite and glutaraldehyde
- After disinfecting, the impression is wrapped in a disinfectant-soaked paper towel, placed in a sealed plastic bag for 10 minutes and later the model is poured.

FAILURES WITH REVERSIBLE AND IRREVERSIBLE HYDROCOLLOID IMPRESSION MATERIALS

Effects of Mishandling

Grainy Material

- Improper mixing
- Prolonged mixing
- Undue gelation
- Water-powder ratio too low.

Separation of Tray

- Adhesive not applied
- Lack of mechanical interlocking.

Tearing

- Inadequate bulk
- Premature removal from mouth
- Moisture contamination
- Premature removal from when tray seated in mouth
- Prolonged mixing.

JAYPEE BROTHERS

External Bubbles

- Air incorporated during mixing.

Irregularly Shaped

- Material too cool or grainy
- Moisture or debris on tissue voids.

Rough or Chalky

- Inadequate cleansing of impression
- Inadequate cleaning of stone model
- Excess water or potassium sulfate solution left in impression
- Premature removal of impression
- Improper manipulation of stone
- Premature removal of model
- Leaving model in impression pouring too long.

Distortion

- Impression not poured immediately
- Movement of tray during gelation
- Premature removal from mouth
- Movement of tray during gelation
- Improper removal from mouth.

ADDITIONAL APPLICATIONS OF HYDROCOLLOIDS

Laminate Technique

This is the combined agar-alginate technique. The tray hydrocolloid is replaced with a mix of chilled alginate that bonds to the syringe agar.

Disadvantages

- The bond between the agar and the alginate is not always strong
- The higher viscosity alginate displaces the agar during seating
- The dimensional inaccuracy of the alginate limits the use to single units.

Duplicating Materials

To duplicate dental casts or models, hydrocolloid-type duplicating materials are used. They have the same composition as the impression materials, but their water content is higher.

Recent Developments

Dustless Alginates

The material is coated with a glycol.

Ionized Alginates

Two-paste alginates have developed which incorporate a silicone component which have superior tear resistance compared to unmodified alginate.

JAYPEE BROTHERS

Color Changing Fast Setting Alginate (Kerr)

Advantages

3-step color change, 120 hours dimensional stability, optimal tear strength and low deformation:

- Working time—1.50 min
- Setting time—2.30 min.

AgiNot FS AlgiNot FS™ (Alternative to Alginate)

Advantages

- Cost-effective, good accuracy and performance
- AlgiNot is also available as fast set
- The improved thixotropic consistency reduces slumping and displacement from the impression tray
- No hand mixing (cartridge or Volume™ automix dispensing)
- A single impression can yield multiple stone pours
- Impressions remain stable and can be disinfected
- Work time (Cartridge): 1 min/Set time (Cartridge): 2 min
- Work time (Volume): 1.15 min/Set time (Volume): 2.15 min.

4. What are colloids? Discuss the composition, manipulation and properties of agar.

COLLOIDS

The word 'colloid' is derived from 'kola', meaning glue.

A colloid is a heterogenous mixture of two phases, where the two phases are not readily differentiated (the colloidal state represents a highly dispersed phase of fine particles within another phase, somewhere between a solution and a suspension).

AGAR

Agar is an organic hydrophilic colloid (polysaccharide) extracted from certain types of seaweed. It is a sulphuric ester of a linear polymer of galactose.

Filler controls the strength, viscosity and rigidity of the impression material.

JAYPEE BROTHERS

Composition

- Agar (8–15%)
- Water (80%)
- Borax (Increases the strength or density of the micelle)
- Potassium sulfate (accelerator)
- Diatomaceous earth, clay, silica, wax, rubber and similar inert powders (filler)
- Thymol (bactericide)
- Glycerine (plasticizer)
- Pigments and flavours (traces).

MANIPULATION OF AGAR IMPRESSION MATERIALS

Gelation Process

- Gelation is the conversion from sol to gel. It is a solidification process. The physical change from the sol to gel is due to temperature change. To return to sol state, the gel must be heated to a liquefaction temperature (70°–100°C)
- It transforms into a gel between 37° and 50°C.

Factors Affecting Gelation

- The molecular weight
- The purity of the agar
- Ratio of agar to other ingredients.

Availability

- The material is supplied in sealed containers to prevent evaporation of water
- It is brought to a fluid state by heating the tube in boiling water in a processing unit for 10 to 45 minutes
- After boiling, the material can be stored at 65°C for up to 8 hours
- It is important that the entire tube of material is softened.

Steps in Manipulation

- Advanced preparation of the material
- Preparation immediately before making the impression
- The making of the impression.

Preparation of the Material

- The hydrocolloid is usually supplied in two forms—syringe and tray materials
- The only difference between the syringe and tray material is the color and a greater fluidity of the syringe material
- The first step is to convert the material from gel to the sol state by placing the material in liquefaction bath at 100°C for a minimum of 10 minutes
- After it has been liquefied, the material is stored in the sol condition until it is needed for injection into the cavity preparation or for filling the tray.

JAYPEE BROTHERS

for detailed information on dental books, visit our website www.jaypeebrothers.com, for detailed information on dental books, visit our webs

Exam Preparatory Manual for Undergraduates

DENTAL MATERIALS

Salient Features

- A compilation of last ten years' question papers from various universities across the country
- A quick-revision tool for undergraduate students
- Includes the recent advances as a chapter with references
- Contains multiple choice questions (MCQs) for each chapter with answers enabling the students to recap before examinations
- Presents essays and short notes with answers helping the students to revise the topics in dental materials in this review book
- Presents references and bibliography along with synopsis and recent advances.



Lovely M is working as Professor, Department of Prosthodontics, Sree Mookambika Institute of Dental Sciences, Kulasekharam, Tamil Nadu, India, and has vast experience in teaching and clinical practice guiding undergraduates.

After completing her PhD in Maxillofacial Implants, she has carried out various research projects with Biomedical Technology Wing, Sree Chitra Tirunal Institute for Medical Sciences and Technology and Department of Maxillofacial Prosthetics, Graduate School, Tokyo Medical and Dental University.

Being an academician and practicing dentist, she is keen on benefiting the dental students by bringing out friendly teaching aids reducing the load on students, and enabling them to perform better in examinations.

She has authored the other review books as *Review in Complete and Removable Partial Denture* and *Review in Fixed Partial Denture*. Apart from being the author of review books in prosthodontics, she is also the author of Christian book, *Pandora's Box of 101 Sins*.

Available at all medical bookstores or buy online at www.jaypeebrothers.com

JAYPEE BROTHERS
Medical Publishers (P) Ltd.
www.jaypeebrothers.com

Join us on facebook.com/JaypeeMedicalPublishers

Shelving Recommendation
DENTISTRY

ISBN 978-93-86056-80-1