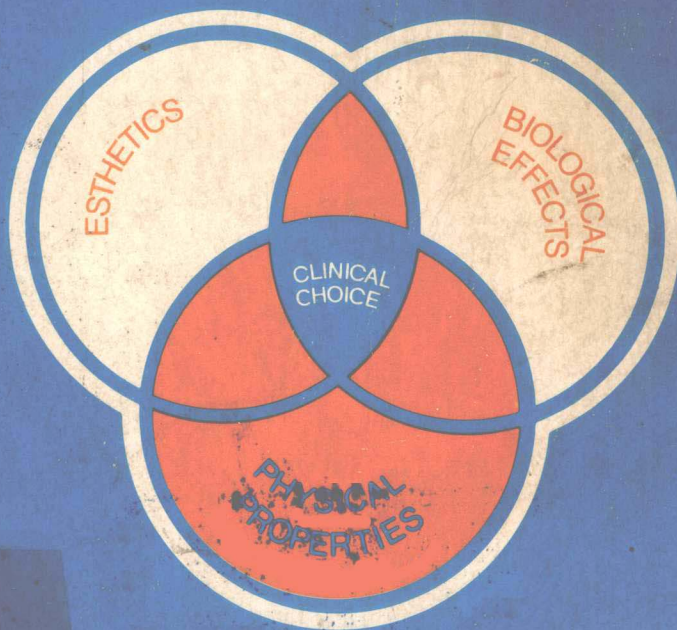


**An Outline**  
**of DENTAL**  
**MATERIALS**  
**AND THEIR SELECTION**



**O'BRIEN AND RYGE**

**An Outline  
of DENTAL  
MATERIALS  
AND THEIR SELECTION**

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**1978**

**W.B. SAUNDERS COMPANY**

**Philadelphia • London • Toronto**

W. B. Saunders Company: West Washington Square  
Philadelphia, Pa. 19105

1 St. Anne's Road  
Eastbourne, East Sussex BN21 3UN, England

1 Goldthorne Avenue  
Toronto, Ontario M8Z 5T9, Canada

### Library of Congress Cataloging in Publication Data

Main entry under title:

An outline of dental materials and their selection.

- I. Dental materials. I. O'Brien, William Joseph  
II. Ryge, Gunnar. [DNLM: 1. Dental materials—Outlines.  
WU18 013o]

RK652.5.O97 617.6'95 77-80751

ISBN 0-7216-6896-8

An Outline of Dental Materials and Their Selection

ISBN 0-7216-6896-8

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Last digit is the print number: 9 8 7 6 5 4 3 2 1

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# Foreword

The past few decades have witnessed an astronomic increase in the kinds and quality of materials available to the dental profession. These advances have been largely due to interactions between clinical dentists and dental materials specialists. A prodigious body of knowledge has evolved which has grown beyond the interests and the understanding of the practicing dentist.

The myriad products competing for the dentists' attention are baffling. For example, hardly a month goes by without the introduction of a new composite restorative or high copper amalgam. In many cases not much difference in composition exists between many of these products. How, then, can the practitioner choose the materials that will provide the best service for his patients? If a dentist does not emerge from dental school equipped with sufficient materials background, it is likely that selection of materials for a modern dental practice will present some problems.

The authors of this book have adopted a rather unusual approach to the presentation of dental materials. It is unusual in the sense that the intricate detail generally associated with the science of dental materials has been relaxed. Instead, the topics are presented in outline form with sufficient information to result in a coherent whole. It provides enough detail to complement lecture and laboratory presentation for dental students. It is also brief enough to serve as a valuable reference book for the practicing dentist. The dental student and practitioner desiring more information can obtain it from the current standard texts or the dental literature.

Conditions are such that educators have more difficulty than ever in teaching materials concepts that are the mainstay of dental practice. In many respects the current standard dental materials texts are, at the same time, too complex and yet almost instantaneously obsolete. The need for a concise, well-organized body of information which can easily be assimilated into dental curricula and practice has become more and more evident. This work will satisfy the needs of the dental student *and* practitioner by providing essential materials knowledge in a form that is amenable to easy updating.

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# Preface

AN OUTLINE OF DENTAL MATERIALS AND THEIR SELECTION is intended to supplement existing textbooks in the preclinical and clinical dental sciences, as well as those in Dental Materials Science.

The "knowledge explosion" which in recent years led to an ever-increasing body of knowledge in all fields has intensified the need for condensing current concepts about dental materials and their selection into an outline format.

Newer concepts of curriculum design have, in many dental schools, reduced or eliminated laboratory courses in dental materials, or transferred them to basic technique courses where the principal aim usually is to teach the students *how* to use materials. The present outline is intended to tell the students *why*.

Modern textbooks in the clinical dental sciences usually cover, in considerable detail, the manipulation of the various dental materials needed for the clinical procedures discussed, again mostly from the "how," rather than from the "why," point of view.

In the format chosen, each chapter begins with specific objectives and ends with questions and answers which relate to the stated objectives. Most chapters provide, in outline form, applications, composition, mechanisms, properties, manipulation, commercially available products, and a glossary, as well as selected references.

The enthusiasm and excellent cooperation of the many contributors in following the format developed by the editors is hopefully an indication that the outline format will be helpful to students, practitioners, and teachers of the subjects covered. Also, the brevity of the presentations is expected to make the OUTLINE useful as an easy reference. The last five chapters of the book (Biological Responses, Clinical Performance, Trouble Shooting, Tabulated Values of Physical and Mechanical Properties, and Directory of Dental Materials Products) should be particularly helpful to practicing dentists as handbook information.

The editors wish to acknowledge the excellent work of the many contributors, all of whom were selected not only for their special knowledge but also because of their demonstrated ability to present their material in a concise manner.

Also, the valuable assistance of Mr. Robert W. Reinhardt and Mr. Carroll Cann of the W. B. Saunders Co. is gratefully acknowledged. Finally, we thank Dr. Hazel Stedman, Dr. P. L. Fan, and Larry G. Tolley for their suggestions and encouragement.

WILLIAM J. O'BRIEN  
GUNNAR RYGE



# Contents

## **Part 1**

### **NATURE AND MANIPULATION OF MATERIALS ..... 1**

#### *Chapter 1*

### **ATOMIC BONDING ..... 3**

*J. David Eick*

#### *Chapter 2*

### **PHYSICAL AND MECHANICAL PROPERTIES ..... 13**

*J. David Eick*

#### *Chapter 3*

### **COLOR AND APPEARANCE ..... 31**

*Pui L. Fan*

#### *Chapter 4*

### **SURFACE PHENOMENA AND ADHESION ..... 44**

*William J. O'Brien*

#### *Chapter 5*

### **GYPSUM MATERIALS ..... 59**

*Richard Earnshaw*

#### *Chapter 6*

### **INTRODUCTION TO POLYMERS ..... 73**

*R. H. Roydhouse*

#### *Chapter 7*

### **ACRYLIC AND BIS-GMA POLYMERS ..... 82**

*Brian Causton*

Denture Base Polymers ..... 83

Restorative Materials ..... 88

Pit and Fissure Sealants ..... 94

Miscellaneous Acrylic Resins ..... 97

## Chapter 8

MOUTH PROTECTOR MATERIALS .....	103
<i>Robert E. Going, Ronald E. Loehman, and Ming Sam Chan</i>	

## Chapter 9

TISSUE CONDITIONERS AND DENTURE RELINE MATERIALS .....	112
<i>Andrew Koran, III, and Brien R. Lang</i>	
Tissue Conditioners .....	112
Resilient Denture Reline Materials .....	115
Hard Denture Reline Materials .....	118

## Chapter 10

IMPRESSION MATERIALS .....	122
<i>William J. O'Brien</i>	
Dental Compound (Types I & II) .....	122
Zinc Oxide–Eugenol .....	124
Agar Hydrocolloid .....	126
Alginate Hydrocolloid .....	129
Polysulfide Rubber .....	131
Silicone Rubber .....	134
Polyether Rubber .....	136

## Chapter 11

CAVITY VARNISHES AND LINERS .....	143
<i>Carlos L. Suárez</i>	
Cavity Varnishes .....	143
Linings .....	148

## Chapter 12

DENTAL CEMENTS .....	152
<i>Dennis C. Smith</i>	
Zinc Phosphate Cement .....	152
Modified Zinc Phosphate Cements .....	156
Silicophosphate Cements .....	156
Zinc Oxide–Eugenol Cements .....	158
Reinforced Zinc Oxide Cements .....	160
EBA Cements .....	162
Polycarboxylate (Carboxylate) Cements .....	164
Acrylic Resin Cements .....	166
Resin Composite Materials .....	168
Glass Ionomer Cements .....	169

## Chapter 13

SILICATE CEMENTS .....	173
<i>Joseph B. Dennison</i>	

<i>Chapter 14</i>	
DENTAL PORCELAINS .....	180
<i>William J. O'Brien</i>	
<i>Chapter 15</i>	
STRUCTURE OF METALS AND ALLOYS .....	195
<i>Peter C. Moon</i>	
<i>Chapter 16</i>	
AMALGAM .....	210
<i>Carl W. Fairhurst</i>	
<i>Chapter 17</i>	
TOXICITY OF MERCURY .....	219
<i>Mauricio Sotillo</i>	
<i>Chapter 18</i>	
GOLD FOIL .....	226
<i>Harold E. Schnepfer</i>	
<i>Chapter 19</i>	
PRECIOUS METAL CASTING ALLOYS.....	239
<i>Duane F. Taylor</i>	
<i>Chapter 20</i>	
WAXES.....	253
<i>Harvey D. Moskowitz</i>	
<i>Chapter 21</i>	
INLAY CASTING INVESTMENTS.....	259
<i>Richard Earnshaw</i>	
<i>Chapter 22</i>	
GOLD CASTING .....	272
<i>Leonard N. Johnson</i>	
<i>Chapter 23</i>	
BASE METAL ALLOYS .....	284
<i>Eugene F. Huget</i>	
Partial Denture Alloys .....	284
Surgical Alloys .....	289
Crown-and-Bridge Alloys .....	292

*Chapter 24*

HIGH HEAT INVESTMENTS .....	298
-----------------------------	-----

*J. A. Tesk, P. Kosmos, and E. L. Dahowski*

High Heat Investment Types .....	298
Applications in Dentistry .....	298
Phosphate Bonded Investments .....	298
Ethyl Silicate Bonded Investments.....	300

*Chapter 25*

ORTHODONTIC WIRES.....	307
------------------------	-----

*Morris H. Reisbick*

*Chapter 26*

SOLDERING AND WELDING .....	320
-----------------------------	-----

*Stephen T. Rasmussen*

Soldering.....	320
Welding.....	326

*Chapter 27*

ABRASION AND POLISHING.....	333
-----------------------------	-----

*Marc Rosenblum*

*Chapter 28*

SYNTHETIC IMPLANT MATERIALS.....	343
----------------------------------	-----

*Dale E. Grenoble and Ronald Voss*

**Part 2**

<b>SELECTION OF DENTAL MATERIALS .....</b>	<b>349</b>
--	------------

*Chapter 29*

APPLICATION OF DENTAL MATERIALS .....	351
---------------------------------------	-----

*William N. von der Lehr*

*Chapter 30*

BIOLOGICAL RESPONSES.....	361
---------------------------	-----

*Malcolm D. Jendresen*

*Chapter 31*

CLINICAL PERFORMANCE.....	366
---------------------------	-----

*Gunnar Ryge*

*Chapter 32*  
TROUBLE SHOOTING ..... 370  
*Karl F. Leinfelder*

*Chapter 33*  
TABULATED VALUES OF PHYSICAL AND MECHANICAL  
PROPERTIES ..... 385  
*John M. Powers*

*Chapter 34*  
DIRECTORY OF DENTAL MATERIALS PRODUCTS ..... 414  
*William M. Johnston*

*Appendix A*  
LONGEVITY OF RESTORATIONS COMMONLY USED  
IN DENTISTRY ..... 424  
*Gordon J. Christensen*

*Appendix B*  
PERIODIC CHART OF THE ELEMENTS ..... 425

*Appendix C*  
UNITS AND CONVERSION FACTORS ..... 426

*Index* ..... 427

**Part 1**

# **Nature and Manipulation of Materials**





# Chapter 1

## Atomic Bonding

J. DAVID EICK

### OBJECTIVES

---

1. Define primary bond, ionic bond, covalent bond, metallic bond, van der Waals forces, and chelation.
  2. Explain the importance in dentistry of a knowledge of atomic bonding.
  3. Explain the difference between primary and secondary forces.
  4. List the characteristic properties of each type of bond.
  5. Give examples in dentistry of chelation reactions.
  6. Draw a force diagram and corresponding energy diagram for interatomic bonding in a material.
  7. Draw potential energy curves for two different materials, and relate these curves to the amounts of elastic deformation, the melting points, and the coefficients of thermal expansion of the materials.
- 

### APPLICATIONS IN DENTISTRY

1. Help to explain the behavior of dental materials.
2. Help to predict certain characteristic properties of dental materials.

### INTERATOMIC ATTRACTIONS

Most materials used in restorative dentistry are pastes or liquids that convert to solids during a technical procedure. The main forces of attraction that bond atoms or molecules of these materials together are usually quite strong (bond energies of about 100 kcal./mole). These strong or primary bonds consist of three types: ionic, covalent, and metallic. There are also weaker or secondary attractive forces (bond energies less than 10 kcal./mole), often called van der Waals forces. In some cases secondary forces are the only ones present and determine the behavior of the material. In other instances, primary bonds may act in a particular part of the material (for example, the covalent bonds within individual polymer chains), while secondary bonds determine much of the behavior of the material (for example, secondary bonds between polymer chains).

Table 1-1 CHARACTERISTIC PROPERTIES OF BONDS

TYPE OF BOND	BOND STRENGTH, KCAL./MOLE	CHARACTERISTIC PROPERTIES
Ionic	100-200	(a) insulators as solids (b) conductors in solution (c) important bond for glasses and ceramics
Covalent	200-400	(a) highly directional bond (chain forming) (b) insulators (c) important bond for polymers
Metallic	100	(a) high electrical conductivity (b) high thermal conductivity (c) opaque (d) conducive to producing crystallinity in metals, which in turn affects mechanical properties
Secondary	1-30	(a) relatively weak (b) important in the behavior of waxes and some polymers (c) important for wetting and adhesion

The properties of the various types of bonds are summarized in Table 1-1.

Interatomic attractions are associated with the electronic configuration of atoms, and in most bonding the atoms strive to achieve the highly stable configuration of eight electrons in the outer or valence electron shells (2 for He). This configuration is obtained through one of the following means: (1) receiving extra electrons to complete the outer electron shell; (2) releasing electrons so that the outer shell has eight electrons; or (3) sharing electrons so that the outer shells of two or more atoms are complete.

PRIMARY BONDS

1. **Ionic Bonds.** Electron transfer to produce atoms having eight electrons in their outer electron shells, therefore producing negatively and positively charged ions. The electrostatic or coulombic attraction between ions of unlike charges produces strong ionic bonds. Figure 1-1 shows an example of ionic bonding in NaCl.

2. **Covalent Bonds.** Sharing of electrons between atoms to complete the outer shell. This bond is very directional and is considered to be a bond between the negatively charged electrons and positively charged nuclei of the atoms. Figure 1-2 shows a bond between two fluorine atoms.

Examples of covalent bonds in other diatomic molecules are shown in Figure 1-3.

Covalent bonds in polyatomic combination are represented by those in methane, shown in Figure 1-4.

3. **Metallic Bonds.** When only a few valence electrons are present in the outer shell of an atom (particularly a metal), they may