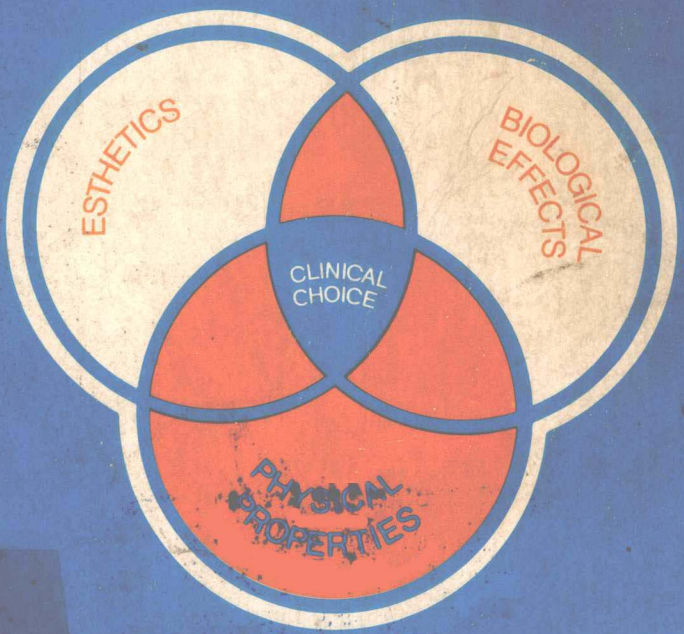
An Outline of DENTAL MATERIALS AND THEIR SELECTION



O'BRIEN AND RYGE

An Outline of DENTAL MATERIALS AND THEIR SELECTION

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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

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