

Preface

Since the discovery of electrical conduction in organic materials, more than half a century has passed. During this period, highly conducting stable materials have been realized, and even organic superconductors have been discovered. Organic semiconductor devices such as organic light-emitting diodes, organic transistors, and organic solar cells have been developed. Some of them are sold in the market. Chemical constituents of organic materials are complicated in comparison with inorganic materials, but the electronic structure is simple. Organic conductors afford an excellent playground of various intriguing physics. This book provides an overview of electrical conduction and the related phenomena in organic materials and elucidates the logic behind them.

This book is based on a Japanese book originally published in 2013. Organic conductors have been studied somewhat independently of organic semiconductors, but this book deals with both fields. The focus is placed on the physics and chemistry of organic materials that conduct electricity. This is a rapidly growing field, but the fundamental aspects are emphasized. This book is intended to be more than a textbook but less than a review.

Basic knowledge of solid-state physics is necessary to understand the properties of these materials. In a physics department, solid-state physics is treated in the latter part of the curriculum, because this field requires knowledge of many other fields such as quantum mechanics, electromagnetism, and statistical mechanics. In this book, however, knowledge of these fields is not assumed. Although there are many excellent textbooks for solid-state physics, the earlier part of this book is, in a sense, an introductory textbook in solid-state physics for chemists with no background in physics.

Chapter 1 is a brief description of quantum chemistry. The systematic description is not intended, but emphases are placed on the aspects related to materials design. The Hückel approximation is extensively described as a fundamental to understand π -conjugated molecules. In Chap. 2, the band theory is introduced as a natural extension of the Hückel approximation. In Chap. 3, the energy band theory is used to understand the conducting phenomena and the Fermi surface of organic

materials. Chapter 4 outlines the theory of magnetism as a starting point of the next chapter. Chapter 5 describes various phenomena beyond the band theory and provides a plain explanation of electron correlation. Starting from the molecular orbital theory considering the electron–electron Coulomb interaction, electron correlation is examined both in molecules and solid states. Then magnetic interaction is derived from the Hubbard model. Finally, competition and coexistence of conduction electrons and localized electrons are investigated. Chapter 6 is an introductory treatment of superconductivity. Chapter 7 describes various aspects of organic charge-transfer salts. Chapter 8 deals with organic semiconductors and the devices involved. Accordingly, this book deals with several independent items. The fundamental aspects of energy bands are described in Chaps. 1–3. A concise description of strong correlation is afforded in Chaps. 4–6. Various aspects of organic conductors and semiconductors are discussed in Chaps. 7 and 8. Examples provide derivations of most equations and unit conversions.

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