approach to identifying clay mixtures, which in the book is avoided and substituted by the Gaussian decomposition technique.

One closes this book with the impression that if this glossary was put in front and then followed, this would have been a better book. But even in its current state, it is worthy of careful study. With all its pitfalls, this book offers a vision which makes you think about illite, its intriguing nature, properties and potential applications to solving geological and technical problems.

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Douglas McCarty improved the English of this review.

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Handbook of Layered Materials, edited by Scott M. Auerbach, Kathleen A. Carrado and Prabir K. Dutta. Marcel Dekker Inc, New York, Basel, 2004, 646 pp. [ISBN 0-8247-5349-6]. Price $195

In present-day chemistry a whole range of layered materials exists but only a few of them are as widely used as those described in this book. As the authors suggest, this book is intended to give a general background and does not imply an up-to-date review of the existing literature. Having bought *Handbook of Zeolite Science and Technology* by the same editors (Auerbach *et al*., 2003), I had high expectations of this accompanying volume on layered materials, and in general I was not disappointed.

The contents of the book can be roughly divided into two sections, the first of which, in six chapters, describes clays and their modifications. The second part, comprising five chapters, describes other layered materials such as layered double hydroxides, zirconium phosphate and phosphonates, manganese oxides, *etc*.

Chapter 1 (Carrado) gives a general introduction to clay mineralogy and clay mineral structures, at a level appropriate for those who are not experts in the subject. An overview follows of the most common characterization techniques used in the study of clay minerals such as X-ray diffraction, infrared spectroscopy, nuclear magnetic resonance, N_2 adsorption and desorption, cation exchange capacity and surface acidity. The chapter concludes with a short introduction to the use of clay minerals in catalysis, a topic dealt with more extensively in Chapter 6.

Chapter 2 (Park and Sposito) focuses on the molecular modeling of clay mineral structures and their surface chemistry to provide molecular-scale details of, *e.g.* surface reactions. Even though molecular modeling is based on physical concepts (quantum mechanics) and the use of mathematics, the mathematical descriptions have been kept to an absolute minimum, whilst still demonstrating what can be achieved. It clearly shows the power of modeling in the description of spectral information and visualization of what is actually happening on a clay surface. More detailed information on the use of molecular modeling can be found in the recently published Clay Minerals Society Workshop Lectures volume (Kubicki and Bleam, 2003).

Chapter 3 (Ruiz-Hitzky, Aranda and Serratosa) focuses on the modification of clays through interaction with organic molecules. The sorption of organic molecules, with different types of functionalities, on clay surfaces strongly influences the properties of these clay surfaces and can therefore be used in a variety of applications. This chapter firstly describes the interactions of organic cations and neutral organic molecules on 2:1 clays followed by a section on the intercalation of kaolinite with organic molecules and adsorption on palygorskite and sepiolite. Also in this chapter there is a general overview of the relatively new area of nanocomposites formed through the interactions between clay and polymers. Finally, descriptions of some applications of organoclays as selective adsorbents, in membranes, as supports for organic reactions and heterogeneous catalysts, in photoactive materials and as ionic and electric conductors are given.

Chapter 4 (Johnston, Boyd, Teppen and Sheng), which seems to be somewhat out of line with the general emphasis of the book, describes the chemical mechanisms involved in the interactions between clay surfaces and the nitroaromatic compounds. The environmental

problems associated with nitroaromatic compounds are approached by describing the different types of active sites on clay surfaces, and detailing the interactions of various nitroaromatic compounds with clays. Emphasis is on adsorption experiments and the use of vibrational spectroscopy to determine the molecular interactions. A future edition would be strengthened by adding more general information about the use of vibrational spectroscopy; this book assumes significant knowledge of this technique on the part of the reader.

Chapter 5 (Ogawa) deals with the photophysical and photochemical processes in clay-organic complexes. There is emphasis on the use of dyes and how spectroscopy is a valuable tool in studying the host-guest interactions at a microscopic scale. Examples are given using luminescence, UV-Vis and infrared spectroscopy. This chapter also describes applications such as photochromism and photochemical reactions, photoisomerization, electron transfer and energy transfer reactions.

Chapter 6 (Cool and Vansant) deals with pillared clays and related porous clay heterostructures, subjects of much interest to this reviewer. Synthesis of Al-pillared clays, the most common type, is described clearly, from preparation of the Al_{13} Keggin structure in solution to the cation exchange reaction with the clay, and the final calcination step, in order to convert the Al complex into an oxidic fixed pillar in the interlayers of the clay. It would have been of benefit to the general reader if the authors had included a short overview of other types of metal pillars as have been described in a by others (e.g. Burch, 1988; Kloprogge, 1998). Mesoporous clay-derived structures (based on intercalation of larger complexes, *e.g.* of sols containing SiO_2 and TiO_2 or imogolite), and porous clay heterostructures (formed by intragallery assembly of surfactant-inorganic precursor nanostructures) are described here also. Finally, some catalytic applications such as Friedel-Crafts alkylation reactions are given attention.

Chapter 7 (Kumar, Bhambhani and Hnatiuk) is the first chapter of the second part of the book dealing with layered structures other than clay minerals. It describes in detail the synthesis and characteristics of layered α-zirconium phosphates followed by a section on intercalation with alkyl amines analogous to the intercalation of clays with organic alkyl ammonia complexes. The latter part of the chapter focuses on various types of probe molecules used to better understand the photophysical properties, energy and electron transfer and catalytic properties (*e.g.* oxidation, dehydration, dehydrogenation, *etc.*). Zirconium phosphonates are given a similar treatment..

Chapter 8 (Braterman, Xu and Yarberry) is another favorite chapter of this reviewer. It describes the synthesis and characterization of layered double hydroxides (LDH), also known as hydrotalcites or anionic clays. Their general structure can be envisaged as positively charged hydroxide sheets (by partial substitution of a divalent metal by a trivalent metal) separated by hydrated anions in the interlayers. Reactions which use LDHs as a catalyst directly, or after pillaring, similar to the pillared clays described in chapter 6, and polymer-hydrotalcite composites are described here. There are >700 references which give a good introduction into the science of layered double hydroxides and their applications. Chapter 9 (Liu, Durand, Espinal, Garces, Gomez, Son, Villegas and Suib) describes layered manganese oxides. This relatively short chapter discusses a range of synthesis methods such as precipitation, sol-gel routes and interlayer/framework substitution for minerals such as feitknechtite, pyrochroite, birnessite and buserite. Similar to the layered double hydroxides and pillared clays, the resulting layered manganese oxides can be expanded by a range of metal oxides such as Al, Ga, Zr and Si oxides. Applications for these materials can be found in the areas of ion removal from water, degradation of organic compounds and in batteries.

Chapter 10 (Oriakhi and Lerner) introduces the reader to the layered metal chalcogenides (LMCs), which can be divided in metal dichalcogenides (MX_2), metal trichalcogenides (MX_3) and ternary compounds (e.g AM_2S_5) and metal phosphorus trichalcogenides (MPX_3) with X = S or Se. The first part of this chapter describes the synthesis of these compounds at high temperatures, through vapor-phase reactions, chemical-vapor transport and at low temperatures. A special group is formed by fullerene-like materials and nanotubes made from layered MS_2-type compounds, *e.g.* through arc discharge, laser ablation and electron beam radiation. The layered metal chalcogenides can be modified through intercalation with guest cations and neutral molecules. The specific properties of these layered materials lead to a variety of applications including tribology (solid lubricants, additives in liquid lubricants), insertion materials for positive electrodes, superconductivity and catalytic applications (hydrodesulfurization, hydrodenitrogenation, Fischer-Tropsch processes).

Chapter 11 (Schwieger and Lagaly) is the final chapter where we return to the topic of silicates in the form of alkali silicates and crystalline silicic acid. These compounds of Al-free silicates form an interesting alternative to the different common forms of silica. Emphasis on the layered sodium silicate hydrates such as magadiite is followed by a description of their structures. The second part of this chapter describes other metal silicate hydrates and their synthesis and modification (through isomorphous substitution, addition of inorganic salts or organic compounds, recrystallization). The chapter finishes with a study of the surface properties and how these can be used in a variety of applications such as ion exchange (inorganic ions, protons, organic cations), intercalation reactions with polar organic molecules, adsorption from binary liquid mixtures, intercalation and grafting of anionic surfactants and polymers (nanocomposites).

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In conclusion, this book delivers what it promises (as can be said for *Handbook on Zeolite Science and Technology*, by the same editors). The authors and editors have done a great job in compiling all the information presented. One minor point of criticism though relates to the production. A smaller font size, cheaper paper and a lower standard of printing were used here than in the *Handbook of Zeolite Science and Technology*, all of which have a negative effect on the reproduction of SEM and TEM images and on some of the other figures. This aside, the book will form an important reference that will be often used and I have no hesitation in recommending it to anyone interested in layered materials and their applications.

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