select the most appropriate form of carbon for any specific purpose. It seems that the main concern of the author *K. Kinoshita* is to bridge the gaps which exist in understanding the relevance of physicochemical properties to electrochemical specifications.

The book starts with a brief description of the manufacturing processes for carbon blacks, active carbons, graphite, glassy carbon and carbon fibers. Special emphasis is given to the commercial carbon blacks, i.e. channel blacks, oil-furnace blacks and thermal blacks.

The emphasis on carbon blacks continues in Chapter 2, which describes physical properties. Here the reader finds a thorough evaluation of the literature concerning crystallographic structure, surface area and porosity, morphology, heat treatment and electrical properties. The discussion in Chapter 3 focuses on the analysis of surface groups (chemical, spectroscopic and thermal analysis) and provides the basis for a better understanding of chemical reactivity, wettability and catalysis, the relevant properties for applications in electrochemistry. *K. Kinoshita* has succeeded in providing an excellent reference source on the physical, chemical and surface properties of carbons, most particularly carbon blacks. The description reflects the present state of knowledge, and will be of great use, not only to the electrochemist. It would have been desirable to use SI units consistently throughout the text. Data on the coefficient of thermal expansion, thermal conductivity and electrical resistivity in anisotropic graphite need to be corrected (pages 12 and 23).

Chapters 4 and 5 describe the chemical reactions as well as the characteristics and properties of carbon electrodes, thus helping the user to select specific carbon materials. In the section "nonporous structures" all the forms used in electrochemical studies are treated systematically, whereas in the section "porous structures" a distinction is made between flooded electrodes and gas-diffusion electrodes. Here again carbon black is shown to be a leading material and catalyst carrier, thus justifying the special emphasis accorded to it in the introductory chapters.

The author's approach of describing the electrochemical behavior of carbon separately (Chapter 6), rather than together with the individual applications proves to be advantageous. It allows the general aspects of electrochemical oxidation and electrocatalysis to be shown very clearly. The electrochemical reactivity of coal is also dealt with in Chapter 6.

After the efficient preparation in the preceding six chapters, the discussion devoted to the actual use of carbons in electrochemical systems is relatively short (Chapter 7, 80 pages). The reader may miss MnO_2 electrolysis as well as molten salt electrolysis yielding alkali metals and aluminum—the very applications that use by far the largest portion of carbon products. In addition, the application of carbon and graphite in chlor-alkali cells, including trials aimed at the introduction of an air-consuming cathode, appears to be treated too briefly. On the other hand the use of carbon in fuel cells, especially phosphoric acid fuel cells, and also in batteries is treated thoroughly. Within this section special attention is again devoted to carbon blacks. Reference is made to the extensive efforts undertaken to increase the life of carbon black electrodes by heat-treatment, and also by preventing the material from reaching critical potentials where corrosion occurs. It is made apparent to the reader that considerable efforts are still needed to clarify the dependence of electrochemical behavior on physical and chemical properties.

The patent literature is not considered in the text. Instead a list of recent patents concerning fuel cells, bipolar electrode separators and batteries dated after 1980 is given in the Appendix.

The motivation for writing this book arose at a workshop held in 1983 where experts from materials science and the electrochemistry of carbon came together. The author's intention has clearly been to provide a reference source for researchers and technologists interested in the electrochemistry and the electrochemical applications of carbon materials. This aim has been fully achieved. Skilful subject division, a thorough evaluation of the relevant literature and properly arranged tables all combine to make *Kinoshita*'s book an easily readable work of reference which can be highly recommended.

Graphite Fluorides. By *N. Watanabe, T. Nakajima* and *H. Touhara*. Elsevier, Amsterdam 1988. xi, 263 pp., bound, DFl 220.00.—ISBN 0-444-42885-2

The preparation and study of graphite fluorides goes back to the work of *O. Ruff, O. Bretschneider* and *F. Ebert* (1934) and that of *W. Rüdorff* and *G. Rüdorff* (1947). The senior author of the book reviewed here, *N. Watanabe*, became interested in these graphite compounds while studying the "anode effect". It is undoubtedly this fact which has persuaded him to devote the first chapter of his book to the anode effect, which occurs at carbon anodes when they are used in molten fluoride electrolysis. *N. Watanabe* and his research group have worked continuously since 1961 on elucidating the chemistry of the graphite fluorides. He and his co-authors are ideally qualified to give a comprehensive account of the field.

Chapters 2 to 4 deal respectively with the preparation, the structure, and the surface properties and chemical properties of graphite fluorides. The experimental observations are described in detail with the help of numerous diagrams and tables. The interpretation of thermogravimetric data and of the X-ray, IR, NMR and X-ray photoelectron spectra is reported at considerable length, based mainly on the authors' own results. It has not been possible to avoid some repetition within the book; however this enhances its usefulness as a work of reference.

A considerable proportion of the book (about 100 pages) deals with technological applications. The outstanding properties of low surface energy, low bonding energy be-

tween the layers, and, most importantly, high electrochemical reactivity have contributed to the practical exploitation of graphite fluorides.

To bring lithium and fluorine together as reaction partners in an electrochemical primary battery is a worthwhile objective, because of the expected high cell e.m.f., but a fluorine partner in manageable form only became a possibility with the availability of $(C_xF)_n$ compounds. Using electrolytes in organic solvents it was found possible to attain a cell e.m.f. of 3.2 to 3.3 V. *Watanabe*'s laboratory carried out pioneering work on this development. The present state of knowledge on the electrode kinetics of graphite fluoride cathodes, and the effects of the crystallinity of the carbon, the method of preparation and the nature of the solvent in the cell are treated systematically in Chapter 5.

Chapter 6 describes how graphite fluorides are used to good effect in applying a fluoride film to aluminum. By using a graphite fluoride, or alternatively by simultaneous in-situ reaction of natural graphite and fluorine, films with large contact angles (125° for water) can be produced. In Chapter 7 the potential of $(CF)_n$ as a solid lubricant is evaluated by comparing it with graphite and MoS_2. It is noteworthy that metals and $(CF)_n$ can undergo co-deposition from certain electrolytic cells, e.g. from a Watts nickel cell, if surface active agents are added to force dispersion of the $(CF)_n$.

The final chapter summarizes the state of knowledge on C_xF, an intercalate of the acceptor type with ionically bound fluorine. The high cell e.m.f. observed for the combination of C_xF with lithium (3.9 to 4.2 V) is attributed to the release of active fluorine from the intercalate. However, at high current densities the increase of overpotential with current is steeper than for graphite fluorides.

The book does not make easy reading, due to the fact that it goes into considerable experimental detail. Nevertheless, it is indispensable for anyone whishing to gain a thorough knowledge of the preparation, properties and uses of graphite fluorides. For other readers it will be valuable as a work of reference, especially as it gives a full and up-to-date coverage of the literature.

Ferdinand von Sturm
Sigri GmbH, Meitingen (FRG)

Polymer Characterization

Polymer Microscopy. By *L. C. Sawyer* and *D. T. Grubb*. Chapman and Hall, London 1987. XIII, 303 pp., bound, £ 55.00.—ISBN 0-412-25710-6

The book "Polymer Microscopy" at least partially closes the gap between the large number of textbooks on electron and optical microscopy on the one hand and the problem oriented books about polymer morphology on the other. In general, a student of polymer science has a research problem which calls for the use of a variety of methods. It was always difficult to give him textbooks which would familiarize him with the possibilities and limits of microscopy applied to polymers, and would review what has already been done in his field of interest.

"Polymer microscopy" is not a textbook which enables the novice to avoid further reading of other books and review articles, but he (or she) will find out from the detailed reference list where additional information on a particular topic is available. An attempt has here been made to treat optical microscopy and scanning and transmission electron microscopy in one text. The result, however, is unbalanced to some extent. Whereas the treatment of electron microscopy takes most of the space, the field of optical microscopy on polymers is not sufficiently covered, even for a first introduction.

The main chapters which make the text worth reading in full, and which can also be used as a reference source, are those entitled "Specimen preparation methods" and "Polymer applications". The preparation chapter encompasses all the important stages that a sample can undergo on its way from the original state to the final specimen suitable for introducing into the microscope. Common sources of artefacts are also discussed, and some illustrations of them are reproduced. The applications chapter has to be seen in the light of a note in the authors' preface as follows: "Most of the applications come from work done by *Linda Sawyer* as a member of Celanese Research Company staff, and thus they come from the products and projects of interest to that company". Nevertheless, one does not get the impression that the idea for writing the book arose when someone had to tidy up the filling drawers in his office. The chapters are well organized, the index is very detailed, and a large number of references is listed up to 1984/85. But the statement that the text reflects the authors' experience and interests should certainly not be taken as detracting from the merit of having collected this material together.

A reader from an academic environment who has sometimes quite different problems regrets the omission of some guidance in the use of electron diffraction and dark field techniques for the investigation of polymers. These methods are very powerful when applied to semicrystalline samples to elucidate structural details or textures. The principles of these methods are explained and a few patterns are shown, but an unexperienced operator of an electron microscope who has read this text will not be able to use the instrument with the correct settings which are necessary for examining polymer specimens. And it is just this knowledge which one does not find in general textbooks on electron microscopy.