spectral analyses. Such criteria left no doubt that the original structural assignment (1) was correct.

(1) T. O. Soine and L. B. Kier, *J. Pharm. Sci.*, **52,** 1013(1963).
(2) R. L. Douglas and J. M. Gulland, *J. Chem. Soc.*, **1931,** 2893.
(3) K. W. Rosenmund, M. Nothnagel, and H. Riesenfeldt, *Ber.*, **60,** 392(1927).
(4) W. M. Whaley and T. R. Govindachari, in "Organic Reactions," vol. 6, Wiley, New York, N. Y., 1951, p. 74.
(5) M. Tomita and J. Kunimoto, *J. Pharm. Soc. Japan*, **80,** 1245 (1960).
(6) K. H. Lee and T. O. Soine, *J. Pharm. Sci.*, **57,** 1922(1968).
(7) D. H. R. Barton, R. H. Hesse, and G. W. Kirby, *J. Chem. Soc.*, **1965,** 6379.
(8) A. R. Battersby and R. Binks, *J. Chem. Soc.*, **1955,** 2888.

CHUNG-HSIUNG CHEN
TAITO O. SOINE*
Department of Medicinal Chemistry
College of Pharmacy
University of Minnesota
Minneapolis, MN 55455

KUO-HSIUNG LEE
Department of Medicinal Chemistry
School of Pharmacy
University of North Carolina
Chapel Hill, NC 27514

Received April 16, 1970.
Accepted for publication June 17, 1970.
This investigation was supported by Grant No. NB 08427 from the National Institutes of Health, U. S. Public Health Service, Bethesda, Md.
* To whom requests for reprints should be directed.

Improved Method for Measuring Output Potential of Specific Ion Electrodes

Keyphrases □ Ion electrodes, specific—output potential measurement □ pH meter, expanded scale—ion electrode potential output determination

Sir:

Since Frant and Ross (1) announced the invention of a single crystal lanthanum fluoride electrode for the determination of fluoride-ion activity, numerous articles have appeared in the literature describing applications of the device. It has been used to determine fluoride in bone (2), urine (3), chromium plating baths (4), tungsten (5), toothpaste (6), and numerous other samples.

In these methods, either an expanded scale analog or digital pH meter was used to measure fluoride-ion activity electrode potential. When using an expanded scale pH meter, it is possible to read electrode potentials to about ±1 mv. According to the report of Lingane (7), this would represent an error of ±0.017 pF unit, or a relative accuracy of ±1.7%. With a digital pH meter, it is possible to measure potentials to ±0.1 mv., with a correspondingly greater relative accuracy.

When determining the fluoride content of some pharmaceutical preparations without a digital pH meter, it was necessary in the authors' laboratory to devise a method of measuring the electrode potential more accurately than can be done directly with an expanded scale analog instrument. This was accomplished by using an expanded scale pH meter as an electrometer coupling between the electrode and a variable range strip-chart recorder, which involves simply connecting the recorder into the appropriate electrical output jacks of the meter. By so doing, and by choosing the proper input range of the recorder, it is possible to expand almost any portion of a standard curve [*i.e.*, almost any millivolt range of the plot: log (concentration F^-) *versus* millivolts] to full-scale deflection on the chart.

The most convenient way is to operate the pH meter in the pH (expanded scale) mode. This is done to keep the calibration circuit of the meter activated.

For the present work, a Corning model 10 expanded scale pH meter was used. While some of its characteristics (*i.e.*, deactivation of the calibration circuit when operated in the millivolt mode) may not be common, simple modifications of this procedure should make it applicable to individual needs.

After choosing the desired concentration range for the standard curve, the fluoride and reference electrodes are placed in the least concentrated standard sample. The calibration knob of the pH meter is then adjusted to bring the recorder pen to zero. Thus, at this concentration, the recorder will sense a zero potential from the electrode. The electrodes are then placed in the most concentrated standard, and the span control of the recorder is adjusted to bring the pen to fullscale deflection. To do this, the span control of the recorder must be infinitely variable between any two coarse span settings. One or two standards of intermediate concentrations are then used, and the pen deflection is noted.

When this is done, the numbers read from the chart become arbitrary units, not millivolts. However, the relationship, log (concentration F^-) *versus* recorder reading, is still linear. The concentration range is chosen on the basis of a compromise between a range narrow enough to allow sufficient accuracy and one wide enough to suppress electronic noise from the electrode. In the authors' laboratory, a three or fourfold concentration range was found reasonable. This range requires the recorder to have a fullscale deflection of about 1.5 mv.

In addition to a high degree of accuracy, several advantages are realized with the use of the recorder:

1. It provides a superb method of determining when the electrodes reach equilibrium; one need only note the point at which the needle ceases to drift. In extremely dilute solutions, equilibration time may be 30–45 min.

2. As reported by Strinivasan and Rechnitz (8), the electrode was found to drift, necessitating frequent recalibration. Because the slope of the calibration curve did not change, recalibration could be accomplished in a few minutes by adjusting the reading of one of the standard solutions to its original value on the recorder with the calibration knob of the pH meter.

3. The recorder gives a graphic presentation of the electronic noise produced by the electrode. This can be significant when the recorder is operated in the 1–2 mv. range. With the recorder, one can read potentials in spite of noise.

While work using this procedure in the authors' laboratory was conducted with a fluoride electrode, the

method should be equally applicable to all other specific ion electrodes.

(1) M. S. Frant and J. W. Ross, Jr., *Science*, **154,** 1553(1966).
(2) L. Singer and W. D. Armstrong, *Anal. Chem.*, **40,** 613(1968).
(3) M. W. Sun, *J. Amer. Ind. Hyg. Ass.*, **30,** 133(1969).
(4) M. S. Frant, *Plating*, **54,** 702(1967).
(5) B. A. Raby and W. E. Sunderland, *Anal. Chem.*, **39,** 1304 (1967).
(6) N. Shane and D. Miele, *J. Pharm. Sci.*, **57,** 1260(1968).
(7) J. J. Lingane, *Anal. Chem.*, **39,** 881(1967).
(8) K. Strinivasan and G. A. Rechnitz, *ibid.*, **40,** 509(1968).

LAWRENCE T. SENNELLO
RONALD J. GORSKI
Analytical Research Department
Abbott Laboratories
North Chicago, IL 60064

Received May 8, 1970.
Accepted for publication June 25, 1970.

BOOKS

REVIEWS

Editor's Note: *While it is not usual Journal practice to run more than one review on a particular book, "The Theory and Practice of Industrial Pharmacy" appeared to warrant a broader approach as it is an initial attempt to produce a textbook in the area of industrial pharmacy. For this reason, we are providing the opinions of two reviewers in the book reviews which follow.*

The Theory and Practice of Industrial Pharmacy. Vol. 1. Edited by LEON LACHMAN, HERBERT A. LIEBERMAN, and JOSEPH L. KANIG. Lea & Febiger, Philadelphia, PA 19106, 1970. xii + 811 pp. 15.5 × 23 cm. Price $24.50.

In their preface, the editors state that a good textbook on industrial pharmacy has been sorely needed. This is indeed the case and this book represents the first modern comprehensive treatment of industrial pharmacy to be published in the English language.

The book has three coeditors and thirty-eight contributors. As a result some chapters are truly outstanding and others are distinctly disappointing.

The book is written in four sections. These sections deal with the principles of pharmaceutical processing, dosage forms, quality control, and industrial pharmaceutical law and structures of pharmaceutical companies.

The first third of the book deals with principles of pharmaceutical processing and is written from a unit operations standpoint. Unit operations which are of particular importance in pharmaceutical processing are covered in separate chapters and include drying, mixing, milling, dispersion, clarification and filtration, compaction and compression, heat transfer, and fluid flow. Other specialized pharmaceutical processes treated are sterilization and tablet coating. One of the most outstanding chapters in the entire book appears to be very much out of place in the pharmaceutical processing or unit operations section and that is the chapter on biopharmaceutics. This chapter which was contributed by Professor Gibaldi is perhaps the most outstanding single chapter on the subject of biopharmaceutics to have been written to this date.

Section two treats on an individual chapter basis all of the various major classes of pharmaceutical dosage forms, including tablets, capsules, liquids, emulsions, semisolids, suspensions, suppositories, sterile products, aerosols, and sustained-release products. This section is entitled in the table of contents, "Dosage Forms: Design and Evaluation." Unfortunately dosage form design principles and drug product evaluation are either inadequately treated or are virtually missing from many of the chapters in this section. For example, in the chapter on capsules, no mention is made of the importance of availability studies or methods of characterizing *in vitro* availability. In most of the chapters in this section mechanical methods of manufacture are stressed. In the approximate 40% of the book dealing with dosage forms the chapter on sustained-action dosage forms by Eriksen, the chapter on sterile products by Avis, and the chapter on aerosols by Sciarra are outstanding in organization and content. The chapter on pilot plant scale-up techniques by Michelson is also well done, but seems strangely out of place, not to have been located in part one of the book dealing with pharmaceutical processing.

The nearly 100 pages of the book dealing with quality control contain two chapters coauthored by Dr. Lachman, one dealing with kinetic principles of stability testing and the other with quality assurance. These are very well written and represent a significant textbook compilation on these subjects to the literature.

In the design, organization, and writing of their book the editors have overlooked one important aspect of industrial pharmacy today. That aspect is the role of preformulation research and the application of physical-chemical principles in a systematic manner for the rational design of pharmaceutical drug products and dosage forms. It is obvious from the examination of the table of contents that the authors were at some loss as to the location of the section on biopharmaceutics. This excellent chapter together with a section on preformulation, its implications in drug product design, and the components of a total preformulation system would have provided a very good foundation for the dosage form section of the book. Unfortunately the preformulation concept is not treated by the book, making the foundation for the following dosage form section inadequate, and accentuating the lack of total information on basic principles of dosage form design and evaluation.

Even though this book contains some obvious omissions, quite often is incomplete on the subjects of dosage form design principles and evaluation, and is questionably organized in two instances, the book does represent a creditable and laudable effort to cover a broad and very difficult area. This book is recommended as a textbook for any advanced pharmaceutics or manufacturing graduate course. The book warrants consideration for elective undergraduate manufacturing pharmacy courses. It is doubtful that the book will find wide-scale acceptance as an undergraduate text based on the specialized subjects treated and the nature of the material being covered. The book should, however, have a prominent place on the shelf of every pharmacy school and pharmaceutical laboratory library. It will also undoubtedly be a valuable contribution to the working bookshelf of many industrial and development pharmacists.

Reviewed by Gilbert S. Banker
School of Pharmacy and Pharmacal Sciences
Purdue University
Lafayette, IN 47907 ■

The Theory and Practice of Industrial Pharmacy. Vol. 1. Edited by LEON LACHMAN, HERBERT A. LIEBERMAN, and JOSEPH L. KANIG. Lea & Febiger, Philadelphia, PA 19106, 1970. xii + 811 pp. 15.5 × 23 cm. Price $24.50.

The preparation of this first attempt at a text on industrial pharmacy was undoubtedly difficult. The very scope of the subject must have given rise to many hard decisions finally arrived at with much hesitation, breadth *versus* depth alone being one of the most weighty of these.