SEVEN-MEMBERED HETEROCYCLIC COMPOUNDS CONTAINING OXYGEN AND SULFUR

This is the twenty-sixth volume in the series

THE CHEMISTRY OF HETEROCYCLIC COMPOUNDS

This Page Intentionally Left Blank

SEVEN-MEMBERED HETEROCYCLIC COMPOUNDS CONTAINING OXYGEN AND SULFUR

Edited by

Andre Rosowsky

CHILDREN'S CANCER RESEARCH FOUNDATION, INC.
BOSTON, MASSACHUSETTS

WILEY-INTERSCIENCE
A division of

JOHN WILEY & SONS, INC.
NEW YORK · LONDON · SYDNEY · TORONTO

This Page Intentionally Left Blank

THE CHEMISTRY OF HETEROCYCLIC COMPOUNDS

A SERIES OF MONOGRAPHS

ARNOLD WEISSBERGER and EDWARD C. TAYLOR

Editors

Copyright © 1972, by John Wiley & Sons, Inc.

All rights reserved. Published simultaneously in Canada.

No part of this book may be reproduced by any means, nor transmitted, nor translated into a machine language without the written permission of the publisher.

Library of Congress Cataloging in Publication Data:

Rosowsky, Andre.
Seven-membered heterocyclic compounds containing oxygen and sulfur.

(The Chemistry of heterocyclic compounds, v. 26)
Includes bibliographical references.
1. Oxepins. 2. Thiepins. I. Title.

QD405.R68 547'.595 70-39735

ISBN 0-471-38210-8

The Chemistry of Heterocyclic Compounds

The chemistry of heterocyclic compounds is one of the most complex branches of organic chemistry. It is equally interesting for its theoretical implications, for the diversity of its synthetic procedures, and for the physiological and industrial significance of heterocyclic compounds.

A field of such importance and intrinsic difficulty should be made as readily accessible as possible, and the lack of a modern detailed and comprehensive presentation of heterocyclic chemistry is therefore keenly felt. It is the intention of the present series to fill this gap by expert presentations of the various branches of heterocyclic chemistry. The subdivisions have been designed to cover the field in its entirety by monographs which reflect the importance and the interrelations of the various compounds, and accommodate the specific interests of the authors.

In order to continue to make heterocyclic chemistry as readily accessible as possible new editions are planned for those areas where the respective volumes in the first edition have become obsolete by overwhelming progress. If, however, the changes are not too great so that the first editions can be brought up-to-date by supplementary volumes, supplements to the respective volumes will be published in the first edition.

ARNOLD WEISSBERGER

Research Laboratories
Eastman Kodak Company
Rochester, New York

EDWARD C. TAYLOR

Princeton University
Princeton, New Jersey

This Page Intentionally Left Blank

Preface

The field of heterocyclic chemistry has undergone many significant developments during recent times, both in theory and at the more practical levels of laboratory synthesis and commercial application. Not the least among these developments has been a rapidly growing interest on the part of chemists throughout the world in the chemistry of heterocyclic systems other than the classically popular five- and six-membered varieties.

In recognition of the impact made upon the chemical literature by this trend, there appeared in 1964 in the Heterocyclic Compounds Series a two-part volume which contained upward of 4000 references and dealt entirely with three- and four-membered rings. After the publication of this volume, it became apparent that heterocyclic systems containing *more than six members* had suffered the same neglect as their small-ring counterparts, and that a survey of such systems was very clearly justified. In the present volume a start in this direction will be made by giving an account of the current state of knowledge concerning *seven-membered* oxygen-containing rings (oxepins) and sulfur-containing rings (thiepins). Nitrogen-containing seven-membered rings (azepines) and mixed heteroatomic seven-membered rings (oxathiepins, oxazepines, thiazepines, etc.) will form the subject of subsequent volumes to be published at a later date.

The unique physical and chemical properties conferred upon the oxepin ring by its valence tautomeric character, which is reminiscent of cyclooctatetraene, have engendered considerable theoretical excitement. Particularly elegant contributions have been made in this area by Vogel and his collaborators, as indicated in Chapter I. Other noteworthy recent studies—only a few of the many that have been published during the past decade—are those of van Tamelen and Carty, and of Paquette and co-workers, on the photochemical synthesis and photochemically induced rearrangement of oxepins; of Rhoads and Cockroft on the synthesis of 2,5-dihydrooxepin by thermolytic rearrangement of *cis*-2-vinylcyclopropanecarboxaldehyde; and of Schweizer and Parham, as well as Ando and co-workers, on the thermal isomerization of 2-oxanorcaranes to 2,3-dihydrooxepins. The important investigations of these workers, and others too numerous to mention here, attest to the fact that heterocyclic chemistry has come of age.

Like the monocyclic oxepins, condensed oxepins have received extensive attention during recent years. Of the many known systems composed of two rings (Chapter II), the isomeric 1-benzoxepins, 2-benzoxepins, and 3-benzoxepins have been studied most thoroughly. Again, only a few outstanding investigations can be cited here. They include the work of Vogel and co-workers, as well as Sondheimer and Shani, on the synthesis of 1-benzoxepin by valence tautomerization of 9,10-oxidonaphthalene; of Schweizer and co-workers on the synthesis of 1-benzoxepin and 2,3-dihydro-1-benzoxepin via several ingenious applications of the Wittig reaction; and of Dimroth and co-workers, as well as Jorgenson and more recently Ziegler and Hammond, on the preparation and chemical transformations of 3-benzoxepins.

Condensed oxepin systems composed of three rings (Chapter III) and more than three rings (Chapter IV) bear witness to the seemingly limitless variety of chemical structures that can be generated in the laboratory through the creative efforts of imaginative and perseverant synthetic organic chemists. No fewer than sixty different systems containing three or more rings are reviewed (excluding those derived from, or related to, complex natural products, which are treated in separate chapters), and their number is multiplying at an astonishing rate. Work of fundamental theoretical importance which has been done with polycyclic oxepins includes, for example, the classic preparation and characterization by Linstead and Doering of the six possible stereoisomeric perhydrodiphenic anhydrides (dodecahydrodibenz[*c*,*e*]oxepin-5,7-diones), and elegant spectroscopic studies by Mislow and co-workers with optically active, sterically-hindered 5,7-dihydrodibenz[*c*,*e*]oxepins of the bridged biphenyl type. Far from being merely of routine interest, these investigations have played a significant role in the formulation of modern conformational theory.

Oxepin chemistry is not devoid of important practical aspects, as evidenced by the eminent position enjoyed in the polymer field by two members of the oxepin family, the 1,3-dioxepins (Chapter V) and ε-caprolactones. The latter class of compounds, whose commercial importance is reflected in a voluminous patent literature, was to have been reviewed in a separate chapter, together with the chemistry of adipic anhydrides. Regrettably, illness has prevented the author of this chapter from completing his task in time for publication in the present volume. If possible, this material will appear at a later date as part of the Heterocyclic Compounds Series.

Seven-membered oxygen heterocycles also occupy a prominent place in the chemistry of natural products. In the terpene field (Chapter VI), a number of polycyclic ε-lactones of plant origin have been described, one well-known example being the bitter principle limonin. In addition, many oxepins are encountered in the terpene literature, as well as among steroids (Chapter VII), in the form of ε-lactones derived from six-membered ketone rings via Baeyer-Villiger oxidation. Many of these oxidative degradation products have performed key roles in the structural elucidation of the parent terpene or steroid. In the domain of sugar chemistry (Chapter VIII), numerous 1,6-anhydrohexoses and 2,7-anhydroheptuloses are known which can be viewed as bridged oxepin derivatives, the naturally occurring compound sedoheptulosan being a familar example of the latter category. Finally, oxepins are encountered even among alkaloids (Chapter IX), the best-known being strychnine and cularine.

Less widely studied but nonetheless of considerable theoretical and practical interest are the monocyclic seven-membered sulfur heterocycles (Chapter X) and their condensed systems (Chapter XI). Although thiepin itself apparently lacks the relative stability of oxepin and has thus far successfully eluded synthesis, the sulfone of thiepin has recently been prepared and subjected to thorough physicochemical investigation by Mock and co-workers. Sulfoxides and sulfones of reduced thiepins and dithiepins have been examined in some detail by a number of workers because of the insight which these compounds might afford into the stereochemical and conformational aspects of sulfur *d*-orbitals. Among the condensed thiepins, 1-, 2-, and 3-benzothiepins, as well as their sulfoxides and sulfones, have been accorded much attention in the past few years. Sulfur extrusion reactions have been of particular interest as evidenced by the continuing studies in this area by Traynelis and co-workers, among others. Also of great interest are the recently described syntheses by Schlessinger and Ponticello of thieno-[3,4-*d*]thiepin and furo[3,4-*d*]thiepin, and of the corresponding sulfoxides and sulfones. These studies, and other which are undoubtedly in progress as this is being written, are unfolding many of the most exciting new horizons in sulfur chemistry.

I acknowledge with admiration and gratitude the efforts of the eight expert authors who collaborated so patiently with me in the preparation of this volume. I also wish to give heartfelt thanks to Dr. Arnold Weissberger and Dr. Edward C. Taylor for their stimulating encouragement throughout the planning and execution of this work, and to the publishers and their staff for their efficient handling of the project at every stage. Finally, special thanks are due to my own family for their devoted support from the outset of this long and very arduous endeavor.

ANDRE ROSOWSKY

Laboratories of Organic Chemistry
Children's Cancer Research Foundation
Boston, Massachusetts
October 1971

This Page Intentionally Left Blank

Contents

Tables

This Page Intentionally Left Blank