Monosaccharide Sugars: Chemical Synthesis by Chain Elongation, Degradation, & Epimerization

MONOSACCHARIDE SUGARS

Chemical Synthesis by Chain Elongation, Degradation, and Epimerization

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Dedicated to our Master, the late Professor Rezsö Bognár,
on the occasion of his 85th birth anniversary

FOREWORD

Carbohydrate chemistry has been an important part of organic chemistry for well over a century. In the hands of Emil Fischer it played a major role in the historical evolution of stereochemistry. Then came the protracted disagreement between Hudson and Haworth about the size of the sugar rings. Another important advance was the recognition of the importance of ascorbic acid and Reichstein's beautiful synthesis thereof. Many other natural products were recognized to be carbohydrates. Even polymers such as starch and cellulose are carbohydrates. Indeed, nature has the habit of attaching sugars to all kinds of molecules, even triterpenoids and steroids. The aminoglycoside antibiotics again played an important role in stimulating the further growth of carbohydrate chemistry.

However, this is not the end of the story. Carbohydrates play an almost infinite role in the immune system and in cell recognition. Also, we cannot forget that DNA, RNA, and a host of modified nucleosides are all based on a carbohydrate component. Thus, carbohydrate chemistry will remain a major interest of organic chemists, biochemists, molecular biologists, and synthetic chemists for an indefinite period into the future.

This book by Drs. Zoltán Györgydeák and István F. Pelyvás is entitled *Monosaccharide Sugars: Synthesis by Chain Extension, Degradation, and*

Epimerization. It provides the chemist with a very useful summary of the synthetic manipulation of monosaccharides, which are the simplest kind of carbohydrate. Nevertheless, you cannot build up complex carbohydrates, such as are needed in cell regulation, without beginning with something simpler and more readily available.

This book presents a critical appreciation of synthetic methods for monosaccharides. It also deals with the use of monosaccharides for the production of "chirons" as defined by Stephen Hanessian. The synthesis of isotopically labeled carbohydrates is also covered. There are suitable experimental procedures included in each chapter.

This book will be of benefit to anyone who has to deal with carbohydrate chemistry. It is concerned with the fundamental building blocks—the monosaccharides. In a world sinking under an avalanche of published journals, the struggle with the retrieval of important facts can be avoided by simply reading this book. Those who do will be grateful.

D. H. R. Barton

PREFACE

The synthesis of new chiral organic compounds, and the improved synthesis of known substances, will always be a major task for the professional chemist. The stereoisomerism which can arise even when two appropriately substituted sp^3-hybridized carbons are contained in a molecule makes it inevitable that the synthesis of such a molecule will call for the exercise of stereocontrol.

For constructing a target molecule with multiple chirality centers, either total synthesis or assembly from smaller chiral blocks may be considered. The present book intends to help in recognizing such chiral units as have been employed, or can be used as readily available chiral starting materials for buildup of complex organic structures.

Saccharides represent a unique family of polyfunctional compounds which can be chemically manipulated in a multitude of ways. This book presents, with the aid of illustrations and about 1700 references, previously applied and potentially useful strategies for the *synthesis* and *degradation* of monosaccharides. The result is a general overview and comparison of the construction of hardly available higher-carbon sugars, as well as smaller chiral synthons.

When describing the individual methods in each chapter, unique supplementary collections of the prepared sugar derivatives are provided in the form of Tables, while representative, well-established experimental procedures illustrate the practical potential of the discussed synthetic transformation. We hope that these features will save tedious literature searching by the reader engaged in research and education on the chemistry and biochemistry of saccharides and many other natural products.

We are indebted to our colleagues who helped us by making copies of some early papers available, and to Mr. Miklós Hornyák for his invaluable technical assistance in editing the artwork of the book. We thank the Alexander von Humboldt Foundation (Bonn, Germany) and the Hungarian Science Foundation (Budapest, Hungary; Grants OTKA 19327 and 23138) for financial support in various stages of our research and in the preparation of this manuscript.

Zoltán Györgydeák
István F. Pelyvás

ABBREVIATIONS AND ACRONYMS

Ac	acetyl
AIBN	2,2′-azobisisobutyronitrile
All	allyl
Ar	aryl
Bn	benzyl
BOC	*tert*-butoxycarbonyl
Bu	butyl
Bz	benzoyl
chxn	diisobutylcyclohexenediamine
CpFe(CO)	cyclopentadienyl-dicarbonyliron
DAST	diethylaminosulfur trifluoride
DBU	1,5-diazabicyclo[5.4.0]undec-5-ene
DCC	dicyclohexylcarbodiimide
DCHA	dicyclohexylamine
DIPEA	diisopropyl ethylamine
DMAP	4-dimethylaminopyridine
DMF	*N,N*-dimethylformamide
DMSO	dimethyl sulfoxide
DOPSA	[dimethyl(oxy)propyl](dimethylsilyl)acetylene

DQQ	2,3-dichloro-5,6-dicyano-1,4-benzoquinone
ee	enantiomeric excess
HMPA	hexamethylphosphoric triamide
HPLC	high performance liquid chromatography
KDO	3-deoxy-D-*manno*-2-octulosonic acid
LDA	lithium diisopropylamide
MCPBA	3-chloroperoxybenzoic acid
MEM	2-methoxy-ethoxymethyl
MOM	methoxymethyl
Ms	methanesulfonyl, mesyl
NMR	nuclear magnetic resonance
Ph	phenyl
Phth	phthaloyl
Piv	pivaloyl
p.p.m.	parts per million
Py	pyridine
TBDMS	*tert*-butyldimethylsilyl
TBDPS	*tert*-butyldiphenylsilyl
TBSOP	2-*tert*-butyldimethylsilyloxypyrrole
tetmen	*N*,*N*,*N'*,*N'*-tetramethylene diamine
Tf	trifluoromethanesulfonyl
THF	tetrahydrofuran
THP	tetrahydropyranyl
TLC	thin layer chromatography
TMS	trimethylsilyl
Tr	trityl (triphenylmethyl)
Ts	*p*-toluenesulfonyl (tosyl)
Z	carbobenzyloxy

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