ORGANIC REACTION MECHANISMS · 2002
An annual survey covering the literature dated January to December 2002

Edited by
A. C. Knipe
University of Ulster
Northern Ireland

An Interscience® Publication

John Wiley & Sons, Ltd
ORGANIC REACTION MECHANISMS · 2002

An annual survey covering the literature dated January to December 2002

Edited by

A. C. Knipe
University of Ulster
Northern Ireland

An Interscience® Publication

John Wiley & Sons, Ltd
Contributors

S. K. ARMSTRONG  Department of Chemistry, University of Glasgow, Glasgow, G12 8QQ
C. T. BEDFORD  Department of Chemistry, University College London, Gordon Street, London, WC1H 0AJ
A. BRANDI  Department of Organic Chemistry Ugo Schiff, University of Florence, Sesto Fiorentino (FI), Italy
M. CHRISTLIEB  Chemistry Research Laboratory, University of Oxford, South Parks Road, Oxford, OX1 3QY
R. G. COOMBES  Department of Biosciences, School of Health Sciences and Social Care, Brunel University, Uxbridge, Middlesex, UB8 3PH
M. R. CRAMPTON  Chemistry Department, The University of Durham, Durham, DH1 3LE
N. DENNIS  University of Queensland, PO Box 6382, St Lucia, Brisbane, Queensland 4067, Australia
M. GENZINI  Department of Organic Chemistry Ugo Schiff, University of Florence, Sesto Fiorentino (FI), Italy
E. GRAS  Laboratoire de Synthèse et Physico-Chimie des Molecules d’Intérêt Biologique, Université Toulouse, Ill-Paul Sabatier, Toulouse, France
D. M. HODGSON  Chemistry Research Laboratory, University of Oxford, South Parks Road, Oxford, OX1 3QY
A. C. KNIPE  School of Biomedical Sciences The University of Ulster, Coleraine, Co. Londonderry, BT52 1SA
P. KOČOVSKÝ  Department of Chemistry, The Joseph Black Building, The University of Glasgow, Glasgow, G12 8QQ
R. A. McCLELLAND  Department of Chemistry, University of Toronto, 80 St George Street, Toronto, Ontario, M5S 1A1, Canada
R. N. MEHROTRA  Department of Chemistry, JNV University, Jodhpur 342005, India
B. A. MURRAY  Department of Applied Science, Institute of Technology Tallaght, Dublin 24, Ireland
F. PISANESCHI  Department of Organic Chemistry Ugo Schiff, University of Florence, Sesto Fiorentino (FI), Italy
J. SHORTER  29A Meadowfields, Whitby, North Yorkshire, Y021 1QF
Preface

The present volume, the thirty-eighth in the series, surveys research on organic reaction mechanisms described in the available literature dated 2002. In order to limit the size of the volume, it is necessary to exclude or restrict overlap with other publications which review specialist areas (e.g. photochemical reactions, biosynthesis, electrochemistry, organometallic chemistry, surface chemistry and heterogeneous catalysis). In order to minimize duplication, while ensuring a comprehensive coverage, the editor conducts a survey of all relevant literature and allocates publications to appropriate chapters. While a particular reference may be allocated to more than one chapter, it is assumed that readers will be aware of the alternative chapters to which a borderline topic of interest may have been preferentially assigned.

In view of the considerable interest in application of stereoselective reactions to organic synthesis, we now provide indication, in the margin, of reactions which occur with significant diastereomeric or enantiomeric excess (de or ee).

There have been two changes of authorship since last year. Dr R. N. Mehrotra has agreed to alternate with Prof. K. K. Banerji in reviewing ‘Oxidation and Reduction’, and the chapter on ‘Molecular Rearrangements’ has been divided into two parts, written by Dr S. K. Armstrong and Prof. A. Brandi (with Drs M. Gensini and F. Pisaneschi), respectively.

I wish to thank the production staff of John Wiley and Sons and the team of experienced contributors for their efforts to ensure that the review standards of this series are sustained.

A.C.K.
# CONTENTS

1. **Reactions of Aldehydes and Ketones and Their Derivatives** by B. A. Murray .................................................. 1

2. **Reactions of Carboxylic, Phosphoric and Sulfonic Acids and their Derivatives** by C. T. Bedford ........................................ 45

3. **Oxidation and Reduction** by R. N. Mehrotra .................. 105

4. **Carbenes and Nitrenes** by D. M. Hodgson, M. Christlieb and E. Gras 169

5. **Nucleophilic Aromatic Substitution** by M. Crampton ........ 195

6. **Electrophilic Aromatic Substitution** by R. G. Coombes .......... 209

7. **Carbocations** by R. A. McClelland ................................ 223

8. **Nucleophilic Aliphatic Substitution** by J. Shorter .............. 261

9. **Carbanions and Electrophilic Aliphatic Substitution** by A. C. Knipe 297

10. **Elimination Reactions** by A. C. Knipe .......................... 347

11. **Addition Reactions: Polar Addition** by P. Kočovský ........... 373

12. **Addition Reactions: Cycloaddition** by N. Dennis ............. 411


14. **Molecular Rearrangements: Part 2** by A. Brandi, M. Gensini and F. Pisaneschi ............................................ 515

**Author index** .......................................................... 581

**Subject index** .......................................................... 625
CHAPTER 1

Reactions of Aldehydes and Ketones and their Derivatives

B. A. Murray

Department of Applied Sciences, Institute of Technology Tallaght, Dublin, Ireland

Formation and Reactions of Acetals and Related Species ................... 1
Reactions of Glucosides and Nucleosides ........................................ 4
Reactions of Ketenes ................................................................. 6
Formation and Reactions of Nitrogen Derivatives ............................... 7
  Imines ............................................................................. 7
  Iminium Ions ..................................................................... 11
  Oximes ............................................................................. 11
  Hydrazones ....................................................................... 12
C−C Bond Formation and Fission: Aldol and Related Reactions ............ 12
  Regio-, Enantio-, and Diastereoselective Aldol and Related Reactions 12
  The Mukaiyama Aldol and Related Reactions .............................. 16
  The Baylis–Hillman Reaction .................................................. 17
  Allylations .......................................................................... 19
Other Addition Reactions ............................................................... 20
  General and Theoretical ....................................................... 20
  Addition of Organozincs ....................................................... 22
  Addition of Other Organometallics ........................................... 23
  The Wittig Reaction and Variants ........................................... 24
  Miscellaneous Additions ....................................................... 26
Enolization and Related Reactions .................................................... 27
  Quinone Methides ............................................................... 30
Oxidation and Reduction of Carbonyl Compounds ............................... 30
  Regio-, Enantio-, Diastereoselective, and Other Reductions ............ 30
  Oxidation Reactions ............................................................ 32
  Atmospheric Reactions ........................................................ 34
Other Reactions ......................................................................... 35
References ............................................................................. 36

Formation and Reactions of Acetals and Related Species

2,4,4,6-Tetrabromo-2,5-cyclohexadienone (1, TABCO) is an efficient and chemoselective catalyst for the acetalization (and transacetalization) of carbonyl compounds and for the preparation of acetonides from epoxides and acylals from aldehydes.¹ TABCO, formed in the bromination of phenol, appears to act through its equilibrium with the corresponding bromonium phenolate, a ‘non-traditional’ Lewis acid.
Results for diastereoselective nucleophilic substitution reactions of oxasilacyclopentane acetals (2, X = OMe, OAc, NR₂) have been explained in terms of the ‘inside attack’ model for reactions of five-membered ring oxocarbenium ions.²

Both α- and β-aminoacetals (e.g. 3) form dicationic electrophiles (4, cis–trans mixture) in superacids, as observed by low-temperature NMR. These electrophiles can react with benzene to give gem-diphenylamines (5).³

α-Propargyl ethers have been prepared by two related methods: (i) reaction of acetals with allenylsilanes and (ii) a three-component reaction of an aldehyde, alkoxyasilane, and an allenylsilane.⁴ Both reactions are catalysed by Lewis acids.

Two mixtures, 1:2 Me₃SiNEt₂–MeI and 1:1 Et₃SiH–MeI, act as iodosilane equivalents and can bring about ring-opening reactions on cyclic acetals and 1,3-oxazolidines.⁵ For aromatic ketone ethylene acetals, they act as mild deprotection agents.

Hydrogenation and alkylation of cyclic acetals have been reviewed, examining variations in acetal structure and the influence of catalyst type on the rate and direction of the process.⁶

Compound (6) is a symmetrical formaldehyde acetal of 4-hydroxybenzofuran-3-carboxylic acid.⁷ Hydrolysis gives two molecules of 4-hydroxybenzofuran-3-carboxylic acid, but this occurs in two steps. Initially, one acid product is formed, plus cyclic acylal (7). The latter is then hydrolysed to give the second mole of product.
(plus formaldehyde). pH–rate profiles for the two steps indicate that the most reactive form of (6) is its monanion, and that the carboxylate anion acts as a nucleophile to assist the general acid-catalysed cleavage of the C–O bond to the leaving group, in a concerted fashion. The neighbouring nucleophile participation enhances the rate 100-fold, out of a total enhancement of $10^5$ over the rate expected for specific acid catalysis. The implications for the mechanisms of lysozymes are discussed.

In a stereoselective investigation of ring opening of oxazolidines, the role of $n(N) \rightarrow \sigma^*(C-O)$ electron delocalization (i.e. an endo-anomeric effect) in the cleavage of the intramolecular C–O bond has been explored, as has the reduction in reactivity – both hydrolytic and reductive ring opening – in N-acyloxazolidines.8 Bicyclo[4.1.0]heptan-7-one $N,O$-hemiacetals (8) undergo substitution by Wittig reagents, Ph$_3$P=CHR$_3$, to give 7-exo-amino-7-endo-substituted bicyclo[4.1.0]heptanes (9) stereoselectively.9 An iminium cation intermediate is proposed.

Rates of hydrolysis of 1,3,5-tris(2-hydroxyethyl)hexahydro-s-triazine (10) in aqueous solution are first order in hydronium ion, with a pH-independent term competing above pH 11.10 Reaction with hydrogen sulfide has also been characterized.