

INDUSTRIAL APPLICATIONS OF HOMOGENEOUS CATALYSIS

Edited by

A. MORTREUX AND F. PETIT



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INDUSTRIAL APPLICATIONS OF HOMOGENEOUS CATALYSIS

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PREFACE

Catalysts are now widely used in both laboratory and industrial-scale chemistry. Indeed, it is hard to find any complex synthesis or industrial process that does not, at some stage, utilize a catalytic reaction.

The development of homogeneous transition metal catalysts on the laboratory scale has demonstrated that these systems can be far superior to the equivalent heterogeneous systems, at least in terms of selectivity. Thus, there is an increasing interest in this field of research from both an academic and industrial point of view.

In connection with the rapid developments in this area, four universities from the E.E.C (Aachen, FRG; Liège, Belgium; Milan, Italy; and Lille, France) have collaborated to organise a series of seminars for high-level students and researchers. These meetings have been sponsored by the Commission of the E.E.C and state organizations.

The most recent of these meetings was held in Lille in September 1985 and this book contains updated and expanded presentations of most of the lectures given there.

These lectures are concerned with the field of homogeneous transition metal catalysis and its application to the synthesis of organic intermediates and fine chemicals from an academic and industrial viewpoint.

The continuing petroleum crisis which began in the early 1970s has given rise to the need to develop new feedstocks for the chemical industry. Up to the present, interest has focussed on carbon monoxide and methanol, the latter now being available at the competitive price of \$100 per ton. Thus, the opening chapter of this book is concerned with new catalytic processes for the synthesis of chemical building blocks from these feedstocks.

The second part of this book describes the use of coordination catalysts for the activation of small molecules like CO, H₂, etc. and fine chemical synthesis.

The next section contains lectures given on the chemistry of processes already used by the chemical industry. For example, alkene oligomerization and polymerization, together with new findings in this field. Included

in this section is a treatment of hydrocarbon activation in the alkene metathesis reaction, and is concluded by a report of recent work in the important and challenging field of alkane activation.

The last section contains two unusual examples of catalytic processes, namely photochemically induced catalysis and supported molecular cluster catalysis. The latter is a new and promising area of research, since it combines the advantages of both heterogeneous and homogeneous catalysis.

Professor Keim, who organized the first of these meetings in Aachen in 1982, concludes this book by an overview of homogeneous catalysis and discusses its future: a future in which changing raw material supply, engineering requirements and environmental considerations are all important.

Lille, September 1987.

A. M. ORTREUX
F. PETIT

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- La Société Chimique des Charbonnages de France.

TABLE OF CONTENTS

PREFACE	xv
ACKNOWLEDGEMENTS	xvii
M. RÖPER: <i>Chemicals from Methanol and Carbon Monoxide</i>	1
1. Introduction	1
2. Carbonylation of Methanol and of Methanol Derivatives	2
2.1. Transition Metal Catalyzed Carbonylation	2
2.1.1. Side Reactions	5
2.1.2. Rhodium Catalysts	5
2.1.3. Cobalt Catalysts	7
2.1.4. Nickel Catalysts	8
2.2. Base Catalyzed Carbonylation	9
3. Reductive Carbonylation of Methanol and Methanol Derived Substrates	10
3.1. Methanol Homologation	10
3.2. Homologation of Methoxy Derivatives	12
3.3. Reductive Carbonylation of Formaldehyde	13
4. Oxidative Carbonylation	13
5. Conclusions	14
References	15
J. GAUTHIER-LAFAYE AND R. PERRON: <i>Carbon Monoxide and Fine Chemicals Synthesis</i>	19
1. Basis of Carbon Monoxide Chemistry	19
2. Carbonylation of Organic Halides	22
2.1. Synthesis of Aldehydes	23
2.1.1. Aromatic and Vinylic halides	23
2.1.2. Alkyl Halides	23
2.2. Synthesis of Acids and Esters	24
2.2.1. Aromatic and Vinylic Halides	24
2.2.2. Aliphatic Halides	24

2.3. Synthesis of Amides	24
2.4. Synthesis of Ketones	27
2.5. Synthesis of Acid Halides	27
2.6. Synthesis of Keto-Acids and Keto-Amides	29
2.7. Synthesis of Anhydrides	30
3. Carbonylation of Alcohols	30
3.1. Synthesis of Alcohols and Aldehydes	31
3.2. Synthesis of Carboxylic Acids	31
3.3. Synthesis of Oxalates and Carbonates	32
4. Carbonylation of Nitro Compounds	33
4.1. Isocyanates, Carbamates and Ureas	33
4.2. Synthesis of Formamides	35
5. Carbonylation of Amines	35
5.1. Synthesis of Formamides	35
5.2. Synthesis of Isocyanates, Carbamates and Ureas	36
6. Carbonylation of Alkenes	36
6.1. Synthesis of Aldehydes and Alcohols	37
6.2. Synthesis of Carboxylic Acids	42
6.3. Synthesis of Ketones	45
6.4. Oxidative Carbonylation of Alkenes	45
7. Carbonylation of Alkynes	47
7.1. Synthesis of Unsaturated Acids	48
7.2. Synthesis of Hydroquinones	48
8. Carbonylation of C—H Bonds	50
8.1. Synthesis of Aldehydes	50
8.2. Synthesis of Carboxylic Acids	52
8.2.1. Synthesis of Aromatic Carboxylic Acids	52
8.2.2. Synthesis of Aliphatic Carboxylic Acids	53
8.3. Synthesis of Ketones	56
9. Synthesis of Amino Acids	57
10. Conclusion	59
References	60

A. F. NOELS AND A. J. HUBERT: *Transition Metal Catalyzed Reductions of Organic Molecules by Molecular Hydrogen and Hydrides: An Overview*

1. Activation of Molecular Hydrogen	65
1.1. H ₂ Activation by Oxidative Addition (OA)	66
1.2. H ₂ Activation by Homolysis	67
1.3. H ₂ Activation by Heterolytic Addition	68

1.4. The Case of Pentamethylcyclopentadienyl Rh and Ir Complexes	69
1.5. Organolanthanides and Actinides as Catalysts for Olefin Hydrogenation	70
2. Some Recent Developments in Hydrogenation: Activation of Hydrides by Transition Metal Derivatives	71
2.1. Examples	71
2.1.1. LiAlH_4 with First Row Transition Metal Halides	71
2.1.2. LiAlH_4 with Hard Lewis Acids	72
2.1.3. NaBH_4 with Ni or Co Salts in MeOH	73
2.1.4. Hydroboration with NaBH_4	73
2.1.5. Reduction of Acid Chlorides and Nitro Groups	74
2.1.6. Vanadium Chloride and Lithium Hydride	75
2.1.7. Complex Reducing Agents	75
2.2. Unusual Chemoselectivity	75
2.2.1. Reversal of Normal Reduction Sequences with Lanthanide- NaBH_4 Systems	75
2.2.2. Selective Hydrogenation of Unsaturated Aldehydes and Ketones	76
2.3. Reduction of α,β -Unsaturated Nitriles	76
2.4. Hydrogenation of Aromatic Nuclei	78
3. Hydrosilylation	80
3.1. Extensions of Hydrosilylation Reactions	81
3.1.1. Ring Closure	81
3.1.2. Hydrosilylation of Conjugated Dienes	82
3.1.3. Hydrosilylation of Acetylenes	82
3.1.4. Reduction of $\text{C}=\text{O}$	82
3.1.5. Reduction of α,β -Unsaturated Carbonyl Compounds	84
3.1.6. Hydrosilylation of $\text{C}=\text{N}$ Bonds	86
4. Hydrozirconation	87
4.1. Functional Group Compatibility	89
References	90

A. J. HUBERT, A. DEMONCEAU, AND A. F. NOELS: *Application of Transition Metals in Natural Product and Heterocycle Synthesis*

1. Introduction	93
1.1. Introduction of Functional Groups	93
1.2. Improvement of Classical Organic Reactions	94
1.3. Construction of the Skeleton of Organic Molecules	94

2. Stoichiometric Reactions: Organocopper Derivatives	96
2.1. Preparation of Organocopper Reagents	96
2.2. Stability of Cuprates	97
2.3. Conjugate Additions — Organocuprates	97
2.4. Some Particular Applications of Addition Reactions of Organocuprates	99
2.4.1. 1,6-Conjugate Addition	99
2.4.2. Homoallylic Addition to Epoxides	99
2.4.3. Ring Opening Reactions	99
2.4.4. Substitution to Acetoxy Groups	99
2.5. Coupling Reactions	100
2.5.1. Aromatic Coupling Reactions	100
2.5.2. Copper Mediated Coupling of an Organometallic Reagent with an Alkyl or Vinyl Halide	101
3. Catalytic Reaction: Palladium and Nickel Organometallic Reagents	101
3.1. The Key Intermediates	102
3.2. Activation by π -Complex Formation	103
3.3. Remark	103
4. Applications of Palladium and Nickel Complexes in Natural Product Synthesis	104
4.1. Coupling Reactions	104
4.1.1. Typical Cross Coupling Reactions of Allyl Groups	106
(A) Cross Coupling Reaction of Allyl Halides	106
(B) Cross Coupling Reactions of Aromatic Halides	106
(C) Cross Coupling Reactions of Aryl Halides with π -Allyl—Nickel Complexes	106
(D) Palladium Catalyzed Cross Coupling Reactions of Organometallics	107
4.2. Alkylation Reactions	107
4.2.1. Examples of Nucleophiles Useful in π -Allyl—Palladium Substitution Processes	108
(A) Malonates	108
(B) Sulfones	108
(C) Nitroalkanes	108
4.3. Cyclizations	109
4.4. 1,4-Addition to Conjugated Systems	110
4.5. Telomerizations and Oligomerizations	111
4.5.1. Preparation of Linear Telomers and Oligomers	111
4.5.2. Preparation of Cyclic Oligomers	112
4.6. Carbonylation Reactions	112
4.7. Prototropic Isomerizations and Rearrangements	114

4.8. Elimination and Decarboxylation Reactions	115
4.9. Transmetallation	116
4.10. Metallation	117
4.11. Applications of Oxidation and Hydrogenation	117
4.11.1. Oxidations	117
4.11.2. Hydrogenations	119
5. Particular Applications of Transition Metals	120
5.1. Group Protection by Complex Formation	120
5.2. Iron Complexes: Cationic Complexes	121
5.3. Anionic Transition Metal Reagents	122
5.4. Titanium and Zirconium	123
5.5. Metathesis	123
6. Applications of Transition Metals in Hydride Chemistry	124
6.1. Organoboron Chemistry	124
6.2. Alane Chemistry	125
6.3. Tin Hydride Chemistry	125
6.4. Hydrozirconation	126
6.4.1. Applications of Hydrozirconation to the Synthesis of Biologically Active Compounds	127
6.4.2. Particular Applications of Organozirconium Rea- gents	127
6.5. Hydrosilylation	128
7. Application of Transition Metal Catalysis in Heterocyclic Synthesis (Typical Examples)	129
7.1. Typical Examples of Heterocyclic System Synthesis	129
7.2. Pyrrole Synthesis	130
7.3. Isoquinoline and Quinoline	131
7.4. β -Lactam Chemistry	132
7.5. Lactone Synthesis	132
7.6. Cyclic Ether Synthesis	132
7.7. Miscellaneous Examples	133
8. Transition Metal-Catalyzed Reactions of Carbenes	133
8.1. Catalytic Reaction	134
8.1.1. Cycloaddition of Carbenes to Alkenes	134
8.1.2. Insertion Reactions	134
8.2. Stoichiometric Reactions of Carbenoids and Ylides	135
References	136
 <i>A. BEHR Application of Telomerization and Dimerization to the Synthesis of Fine Chemicals</i>	
1. Telomerization Reactions	141

1.1. Telomerization of Butadiene with Acetic Acid	141
1.2. Telomerization of Butadiene with Alcohols and Phenol	144
1.3. Telomerization of Butadiene with C—H-Acidic Compounds	146
1.4. Telomerization of Butadiene with Nitroalkanes	148
1.5. Carboxy-Telomerization of Butadiene	149
1.6. Telomerization of Isoprene	150
1.7. Telomerization of Piperylene	153
1.8. Telomerization of 2,3-Dimethylbutadiene	154
2. Dimerization Reactions	155
2.1. Dimerization of Functionalized Olefins	156
2.2. Codimerization of Different Olefins	164
2.3. Codimerization of Dienes with Functional Olefins	167
2.4. Dimerization of Dienes Followed by Functionalization	169
2.4.1. Dimerization of Isoprene	170
2.4.2. Functionalization of Isoprene Dimers	170
3. Conclusions	171
References	171
 Y. CHAUVIN: <i>Oligomerization of Monoolefins</i>	177
1. The Main Catalysts for Oligomerization	179
1.1. Catalysts with Some Isomerizing Activity	179
1.2. Catalysts Forming Linear Oligomers from Ethylene	182
1.3. Catalysts Without Any Isomerizing Activity	183
2. Mechanistic Considerations	184
3. Heterogeneous and Supported Catalysts	188
4. Industrial Developments	189
4.1. Shop Process	189
4.2. Dimersol Process	189
4.3. Alphabutol Process	190
References	190
 PH. TEYSSIE: <i>Coordination Polymerization of Monoolefins and Diolefins</i>	193
1. Introduction: The Discovery	193
2. Polymerization of Monoolefins	195
2.1. Phenomenological Aspects of the Reaction	195
2.1.1. Importance	195

2.1.2. Heterogeneous Systems	195
2.1.3. Soluble Complexes	197
2.1.4. Role of the Two Metals	198
2.2. The Mechanism and Molecular Characteristics of Polymerization Catalysis with $\text{TiCl}_3\text{--AlR}_3$	198
2.2.1. The Initiation Step	198
2.2.2. The Propagation Steps	199
2.2.3. The Energetics of the Chain Growth	200
2.2.4. Kinetic Features	202
2.2.4.1. General Laws	202
2.2.4.2. Number of Active Sites	203
2.2.5. The Stereoregulation	204
2.2.5.1. Cossee's Proposal	204
2.2.5.2. The Rodriguez—Van Looy Model	205
2.2.5.3. More Recent Approaches	208
2.2.6. Chain Termination	210
2.3. Comparison with Soluble Catalytic Systems	212
2.3.1. Ethylene Polymerization	212
2.3.2. Propylene Polymerization	214
2.3.3. Conclusions	215
2.4. Other Related Mechanisms	215
2.4.1. Isomerization Polymerization	215
2.4.2. Green's Proposal	215
3. Polymerization of Diolefins	216
3.1. Polymerization with Ziegler—Natta Catalysts	216
3.1.1. Importance	216
3.1.2. Mechanism: Structural Aspects	217
3.1.3. Kinetic Aspects	220
3.2. π -Allyl Model Catalysts and the Concept of "Chronoselectivity"	220
3.3. Conclusions	223
4. Homo- and Copolymerization or Other Types of Monomers	223
4.1. Polar Vinyl Monomers	224
4.1.1. The Catalytic Process	224
4.1.2. The Control of Apparent Reactivity in Copolymerization	224
4.2. Oxiranes	224
5. General Conclusions	226
References	228

A. MORTREUX AND F. PETIT: <i>Olefin Metathesis and Related Reactions</i>	229
1. Introduction	229
2. Scope of the Reaction	230
2.1. Acyclic Monoolefins	230
2.2. Acyclic Polyolefins	230
2.3. Cyclic Olefins	231
2.4. Cyclic Diolefins	232
2.5. Cross Metathesis	233
2.6. Alkynes	233
2.7. Functional Olefins	234
3. Catalysts	235
3.1. Heterogeneous Catalysts	235
3.2. Homogeneous Catalysts	236
4. Mechanism of the Reaction	236
4.1. Transalkylation or Transalkyldination?	236
4.2. Pairwise Mechanisms	237
4.3. Metallacyclopentanes as Intermediates	238
4.4. Non-pairwise Mechanisms	239
4.4.1. Generation of Stable Carbenes	240
4.4.2. Model Reactions	240
4.4.3. Cross Metathesis	241
4.4.4. Ring Opening Polymerization	241
4.4.5. Reaction of Carbenes and Carbynes	242
5. Stereoselectivities	242
5.1. Terminal and Internal Acyclic Olefins	242
5.2. <i>cis</i> - and <i>trans</i> -Acyclic Olefins	243
6. Initial Production of Carbene	244
6.1. Alkylidene Generation <i>via</i> Reaction with a Metal alkyl Cocatalyst	244
6.1.1. Alkylidene Generation by Chemical Routes	244
6.1.2. Generation by Electrochemical Routes	245
6.2. Carbene Formation Without Alkyl-Containing Cocatalysts	246
7. Metallacarbenes as Catalyst	247
8. Role of Oxygen	248
8.1. Role of Oxygen	248
8.2. Application	249
9. Industrial Applications	249
9.1. Polymerization and Ring Opening Polymerization	249
9.2. Synthesis of Mono and Polyolefins	250
9.3. Synthesis of Functionally Substituted Olefins	252

10. Conclusion	253
References	253
 M. EPHRITIKHINE: <i>Activation of Alkane CH Bonds by Organometallics</i>	257
1. Introduction	257
2. Oxidative Addition of Alkane CH Bonds to Organometallics	258
2.1. Background. Oxidative Addition of Activated sp^3 CH Bonds	258
2.2. Direct Observation of the Oxidative Addition Reaction	260
2.3. Reactions of Alkanes by Oxidative Addition	263
3. Activation of Alkanes by Organoactinides	268
4. Conclusions	269
References	272
 J. P. SAUVAGE: <i>Coordination Photochemistry: Photoinduced Electron Transfer and Redox Photocatalysis</i>	277
1. Introduction	277
2. Properties of the Excited State	278
2.1. Kinetic Aspect	278
2.2. Redox Properties of the Excited State	279
3. Examples of Coordination Compounds with Charge Transfer Transitions	280
3.1. Various Transitions	280
3.2. Ru(bipy) ₃ , A complex with a Long-Lived MLCT Excited State	282
3.3. Other Examples: d^6 or d^{10} Complexes	283
4. Electron Transfer Reaction of the Excited State	286
5. Photochemical Conversion and Storage of Light Energy	287
5.1. Principle	287
5.2. A Non-Redox example: Isomerization of Norbornadiene	288
5.3. Photochemical Reduction of Water	289
6. Concluding Remarks	291
References	291
 J. M. BASSET: <i>An Introduction to the Field of Catalysis by Molecular Clusters and by Supported Molecular Clusters and Complexes</i>	293
1. An Introduction to Molecular Clusters	293
1.1. Definition of Molecular Clusters	293

1.2. Bonding in Molecular Clusters	303
1.2.1. The Metal—Metal Bond in Clusters	303
1.2.2. The Metal—Ligand Bond	305
1.3. Dynamic Behaviour of Molecular Clusters	308
1.3.1. Ligand Migration over the Clusters Surface	308
1.3.2. Structural Rearrangement Within the Metal Core	309
1.3.3. Ligand Migration Within the Metal Cluster Unit	311
1.4. Reactivity of Molecular Clusters	311
1.4.1. Electrophilic Attack	312
1.4.2. Nucleophilic Addition	312
1.4.3. Nucleophilic Attack at the Ligands	312
1.4.4. Oxidative Addition	313
1.5. Molecular Clusters as Structural Models of Intermediates or Chemisorbed Species in Surface Science	314
2. Catalysis by Molecular Clusters	320
2.1. The Relationship Between Molecular Clusters and Small Metal Particles	320
2.2. Homogeneous Cluster Catalyzed Reactions	320
2.3. Catalysis by Supported Molecular Clusters	323
2.3.1. The Molecular Clusters Skeleton Remains Intact	324
2.3.2. The Supported Molecular Frame is Involved in Some Steps of the Catalytic Cycle	325
2.3.3. The Molecular Cluster is Decomposed	325
2.4. Supported Clusters and Heterogeneous Catalysis: Surface Organometallic Chemistry	328
References	332
W. KEIM: <i>Future Trends in Homogeneous Catalysis</i>	335
1. Industrial Applications of Homogeneous Catalysis	336
2. Advantages and Disadvantages of Homogeneous Catalysis	337
3. Future Applications of Homogeneous Catalysis	338
3.1. Changing Raw Material Supply	339
3.1.1. Synthesis Gas Chemistry	340
3.1.2. Alkane Chemistry	342
3.1.3. Carbon Dioxide Chemistry	344
3.2. Impacts by Engineering Requirements	344
3.3. Technological Drives	345
3.4. Society Needs	346
References	347
INDEX	349

M. RÖPER*

CHEMICALS FROM METHANOL AND CARBON MONOXIDE

1. Introduction

Methanol is a versatile, readily available C_1 -compound made from synthesis gas. Large scale industrial methanol production from CO/H_2 was started up in 1925 by BASF using ZnO/Cr_2O_3 catalysts. The present methanol production capacity has been reported to be 21 mio t/a, while the actual demand is only in the range of 12 mio t/a. This overcapacity is mainly due to the build-up of new plants in the Middle East, Eastern Europe, New Zealand and Latin America, where surplus natural gas is available at a very low price [1, 2]. The ready supply as well as the low raw material costs will keep the price of methanol low in the near future. This will stimulate methanol demand and will help to introduce new methanol-based processes for motor fuels as well as for organic base chemicals [3].

The present industrial uses of methanol include the syntheses of formaldehyde, methyl esters, methyl amines and methyl halides. In addition, methanol or its derivatives find increasing interest as a substrate for carbonylation and dehydration reactions, which are summarized in Scheme 1. Some of these processes have already been commercialized, such as the synthesis of acetic acid, of acetic anhydride, or of methyl formate. The feasibility of the MTG (methanol-to-gasoline) process has been proved by pilot plant operation and a commercial unit of a capacity of 560 000 t/a of hydrocarbons had started up operation in New Zealand by 1985. In addition there is a variety of carbon monoxide-based reactions, which convert methanol mainly into C_2 -oxygenated compounds.

These can potentially replace ethylene-based routes, e.g. in the case of ethanol, acetaldehyde, vinyl acetate, and ethylene glycol. With methanol from cheap natural gas becoming available in the near future, these processes, although uneconomic today, might become industrially attractive.

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