

# THE CHEMISTRY OF GOLD

RICHARD J. PUDDEPHATT

*Senior Lecturer,  
Department of Inorganic, Physical and Industrial Chemistry,  
The University of Liverpool,  
Grove St., P.O. Box 147,  
Liverpool L69 3BX, England*



ELSEVIER SCIENTIFIC PUBLISHING COMPANY

Amsterdam — Oxford — New York  
1978

## CONTENTS

Preface . . . . .	v
-------------------	---

Chapter 1. *Introduction to the Chemistry of Gold*

Occurrence of gold . . . . .	1
Gold in sea water . . . . .	3
Recovery and purification of gold . . . . .	4
Properties of the element . . . . .	5
Colloidal gold . . . . .	6
Isotopes of gold . . . . .	7
Chemical reactivity of gold . . . . .	9
Oxidation states of gold and the stereochemistries of gold complexes . . . . .	10
Ionisation energies and electron affinities of the Group IB elements . . . . .	14
Co-ordination number in gold(I) complexes . . . . .	15
Oxidation-reduction potentials . . . . .	18
Stability of gold complexes . . . . .	22
Theoretical studies of bonding in gold complexes . . . . .	24
The <i>trans</i> -effect and <i>trans</i> -influence . . . . .	26
References . . . . .	28

Chapter 2. *Binary Compounds of Gold*

Hydrides of gold . . . . .	30
Halides of gold . . . . .	31
Pseudohalides of gold . . . . .	37
Oxides and hydroxides of gold . . . . .	38
Sulphides, selenides and tellurides of gold . . . . .	38
Gold(III) fluorosulphate and nitrate . . . . .	39
Nitrides and other Group V derivatives . . . . .	40
References . . . . .	40

Chapter 3. *Gold(I) Complexes*

Carbonyl complexes . . . . .	43
Isocyanide complexes . . . . .	44
Cyanide complexes of gold(I) . . . . .	45
Nitrogen donor complexes . . . . .	47
Phosphorus, arsenic and antimony donor complexes . . . . .	51
Complexes with gold—oxygen bonds . . . . .	58
Complexes with sulphur and selenium donor ligands . . . . .	58
Halide complexes of gold(I) . . . . .	63
References . . . . .	66

Chapter 4. *Gold(II) Complexes*

Dithiolate and related complexes of gold(II) . . . . .	70
Other stable gold(II) complexes . . . . .	72
Gold(II) complexes as reaction intermediates . . . . .	74
References . . . . .	74

Chapter 5. *Gold(III) Complexes*

Complexes with carbon-donor ligands . . . . .	76
Nitrogen-donor complexes of gold(III) . . . . .	77
Complexes with phosphorus, arsenic and antimony donor ligands . . . . .	83
Nitratogold(III) complexes . . . . .	85
Complexes with sulphur and selenium donor ligands . . . . .	85
Complex halides of gold(III) . . . . .	90
References . . . . .	93

Chapter 6. *Gold(V) Complexes*

References . . . . .	97
----------------------	----

Chapter 7. *Organogold Complexes*

$\sigma$ -Bonded organogold(I) complexes . . . . .	98
Reactions of organogold(I) complexes . . . . .	109
$\sigma$ -Bonded organogold(III) complexes . . . . .	121

Reactions of organogold(III) complexes . . . . .	138
Carbene complexes of gold . . . . .	144
Alkene and alkyne complexes of gold . . . . .	148
References . . . . .	151

#### Chapter 8. *Compounds with Gold—Metal Bonds*

Gold—gold bonded complexes . . . . .	157
Gold cluster compounds . . . . .	160
Alloys and ligand-free gold—metal bonded compounds	164
Compounds with gold main-group-metal bonds . . . . .	165
Compounds with gold transition-metal bonds . . . . .	169
References . . . . .	176

#### Chapter 9. *Reaction Mechanisms in Gold Chemistry*

Ligand substitution reactions in gold(III) complexes . . . . .	179
Substitution reactions in gold(I) complexes . . . . .	193
Electrophilic substitution reactions . . . . .	194
Homolytic substitution reactions . . . . .	200
Oxidation of gold(I) complexes . . . . .	201
Reduction of gold(III) complexes . . . . .	203
References . . . . .	208

#### Chapter 10. *Spectroscopic Studies of Gold Complexes*

Vibrational spectroscopy . . . . .	210
Nuclear magnetic resonance spectroscopy . . . . .	223
Mössbauer spectroscopy . . . . .	226
Nuclear quadrupole resonance spectroscopy . . . . .	234
Photoelectron spectroscopy . . . . .	234
Ultraviolet-visible spectroscopy . . . . .	236
References . . . . .	240

#### Chapter 11. *Analysis and Applications of Gold Complexes*

Analytical methods for gold . . . . .	243
Biological applications of gold . . . . .	247

Catalytic properties of gold . . . . .	. 253
Methods of gold coating . . . . .	. 256
Other applications of gold . . . . .	. 257
References . . . . .	. 257

*Appendix*

Gold-element bond lengths . . . . .	. 261
References . . . . .	. 267

<i>Subject Index</i> . . . . .	. 270
--------------------------------	-------