CONTENTS

Preface ix

About the Authors xi

1 Catalytic Conversion of Methane to Synthesis Gas by CO_2 Reforming 1

Introduction 1

1.1 Role of Support in CO_2 Reforming of CH_4 to Syngas over Ni Catalysts 5

1.2 Carbon Dioxide Reforming of Methane over Nickel/Alkaline Earth Metal Oxide Catalysts 14

1.3 An Optimum NiO Content in the CO_2 Reforming of CH_4 with NiO/MgO Solid Solution Catalysts 27

1.4 The Characterization of Highly Effective NiO/MgO Solid Solution Catalyst in the CO_2 Reforming of CH_4 32

1.5 Carbon Dioxide Reforming of Methane to Synthesis Gas over Supported Cobalt Catalysts 39

1.6 CO_2 Reforming of CH_4 over Co/MgO Solid Solution Catalysts Effect of Calcination Temperature and Co Loading 46

1.7 Carbon Deposition and Catalytic Deactivation during CO_2 Reforming of CH_4 over Co/γ-Al_2O_3 Catalysts 55

1.8 Carbon Dioxide Reforming of Methane to Synthesis Gas over Supported Rhodium Catalysts: The Effect of Support 60

1.9 Transient Response Analysis Via a Broadened Pulse Combined with a Step Change or an Isotopic Pulse: Application to CO_2 Reforming of Methane over NiO/SiO_2 70

2 Catalytic Conversion of Methane to Synthesis Gas by Partial Oxidation 73

Introduction 73

2.1 Effect of Support on Partial Oxidation of Methane to Synthesis Gas over Supported Rhodium Catalysts 76

2.2 Temperature-Programmed Reduction and XRD Studies of the Interactions in Supported Rhodium Catalysts and Their Effect on Partial Oxidation of Methane to Synthesis Gas 85

2.3 Methane Partial Oxidation over NiO/MgO Solid Solution Catalysts 92

2.4 Partial Oxidation of Methane to Synthesis Gas over Alkaline Earth Metal Oxide Supported Cobalt Catalysts 100

2.5 Transient Kinetic Studies of Partial Oxidation of CH_4 109

2.6 Isotopic GCMS Study of the Mechanism of Methane Partial Oxidation to Synthesis Gas 116
2.7 Broadened Pulse-Step Change—Isotopic Sharp Pulse Analysis of the Mechanism of Methane Partial Oxidation to Synthesis Gas 120
2.8 CH_4/CD_4 Isotope Effect and the Mechanism of Partial Oxidation of Methane to Synthesis Gas over Rh/γ-Al_2O_3 Catalyst 124

3 Catalytic Combustion of Clean As Well As Nitrogen-Bound Fuels over Transitional Metal Oxides 129

Introduction 129
3.1 Catalytic Combustion of Propane Using Transitional Metal Oxides 132
3.2 Oxidation of Fuel-Bound Nitrogen in a Transitional Metal Oxide Catalytic Combustor 142
3.3 Catalytic Combustion 152

4 Zeolites and Their Applications As Catalysts and/or Catalyst Supports 211

Introduction 211
4.1 Comparison between Zeolite β and γ-Al_2O_3 Supported Pt for Reforming Reactions 215
4.2 Synergism of Pt/γ-Al_2O_3 and Pt/β-zeolite in the Reforming of Naphthenes 232
4.3 Effect of the Platinum/Aluminum Sites Ratio on the Performance of Platinum/β-zeolite in the Reforming of Alkylcyclopentanes 243
4.4 Increased Aromatization in the Reforming of Mixtures of N-Hexane, Methylcyclopentane and Methylcyclohexane over Composites of Pt/BaKL Zeolite with Pt/β or Pt/USY Zeolites 265
4.5 Different Activities and Selectivities of Silica-Alumina Catalysts Synthesized in Aqueous and Alcohol Solvents 295
4.6 Conversion of Methanol to Hyrocarbons over Silica-Alumina Selective Formation of Lower Olefins 301
4.7 Oligomerization of Ethene and Propene over Composite Zeolite Catalysts 320
4.8 The Synthesis and Cracking Behavior of Zeolite-Amorphous Silica-Alumina Composites Prepared Using Gels with High Alumina and Low Organic Template Content 335

5 Synthesis of Mesoporous V–Mg–O Oxides and Their Applications As Catalysts 349

Introduction 349
5.1 Synthesis of Mesoporous V–Mg–O Nanofibers 352
5.2 Effect of the Nature of the Templating Surfactant on the Synthesis and Structure of Mesoporous V–Mg–O 356
5.3 Noncatalytic and Catalytic Conversion of Ethane over V–Mg Oxide Catalysts Prepared Via Solid Reaction or Mesoporous Precursors 366
5.4 V–Mg–O Prepared Via a Mesoporous Pathway: A Low-Temperature Catalyst for the Oxidative Dehydrogenation of Propane to Propene 381

6 Synthesis of Polymer-Supported Catalysts and Polymer-Coated Silica Supports and Their Applications in Catalysis **387**

Introduction 387
6.1 Preparation of Polymer-Supported Catalysts Containing Phosphorus Palladium Complexes and Quaternary Onium Groups, and Their Application to the Vinylation Reaction 389
6.2 Hydrophilic Recognition by Polymer-Supported Phase Transfer Catalysts and Its Effect on Reaction Activity and Selectivity 406
6.3 Onium Chains-Silica As Catalytic Support Application to Hydroformylation 420
6.4 Liquid Polymer Catalyst Immobilized on Polymer-Coated Silica: Application to Hydroformylation 432
6.5 Immobilization of Alkoxylated Phosphine Ligands and Their Rh Complexes to a Silica Surface Coated with an Organic Mono- or Multilayer 434

7 Metal Sintering during Heating in Various Atmospheres **453**

Introduction 453
7.1 Growth Kinetics and the Size Distributions of Supported Metal Crystallties 456
7.2 Ostwald Ripening: A Stochastic Approach 478
7.3 Mechanisms of Aging of Supported Metal Catalysts 494
7.4 Sintering of Palladium on Alumina Model Catalyst in a Hydrogen Atmosphere 508
7.5 Role of Interfacial Phenomena in the Behavior of Alumina-Supported Palladium Crystallites in Oxygen 528
7.6 Wetting Phenomena during Alternation Heating in O_2 and H_2 of Supported Metal Crystallites 535
7.7 Redispersion of Pt/Alumina Via Film Formation 546
7.8 Events Observed and Evidence for Crystallite Migration in Pt/Al_2O_3 Catalysts 566
7.9 Role of Physical and Chemical Interactions in the Behavior of Supported Metal Catalysts: Iron on Alumina—A Case Study 596

8 Heterogeneous Catalysis: A Theoretical Approach **645**

Introduction 645
8.1 Effects of Chemisorption of Electron Acceptor Elements on the Stability of Platinum Clusters 647
8.2 Poisoning and Promoting Effects of Additives on the Catalytic Behavior of Metal Clusters 666
8.3 Adsorption Isotherms and Catalyst Selectivity for a Uniform Surface: The Role of Multiple Landing Areas 682
8.4 Role of Multiple Landing Areas for Adsorption in Facile or Demanding Activity 713
8.5 Path of Oxygen in a Bismuth Molybdate Lattice during Selective Oxidation 724
8.6 Removal of Oxygen from Bismuth Molybdate during Prereduction and Catalytic Oxidation: Initiation and Steady-State Steps 737