# Contents

1 Introduction and Structure of the Thesis

1.1 Research Background

1.1.1 Significance of Development of Natural Gas Vehicle

1.1.2 Current Situation of the Development of Natural Gas Vehicle

1.1.3 Control Technology for Emission Pollution of Natural Gas Vehicle

1.2 Research Progress of Catalytic CH₄ Combustion Catalyst

1.2.1 Nonstoichiometry in Perovskite Mixed Oxide (ABO₃)

1.2.2 Perovskite Metal Oxide Catalysts

1.2.3 Partial Substitution Property of Perovskite Structure

1.2.4 Precious Metal Perovskite Catalyst

1.3 Research Purpose, Idea, and Motivation

1.3.1 Purpose and Significance

1.3.2 Content and Technical Route

References

2 Experimental Materials and Methods

2.1 Preparation of Catalyst

2.1.1 Main Chemical Reagent

2.1.2 Main Equipments

2.1.3 Preparation of 1D Single-Crystalline LSCO Nanowires

2.1.4 Synthesis of Monodisperse PMMA Microspheres

2.1.5 Preparation of Three-Dimensionally Ordered Macroporous LSMO

2.1.6 Preparation of ywt% Ag/3DOM LSMO Series

2.2 Catalytic Activity Measurement

2.2.1 Gas Flow Measurement

2.2.2 Gas Chromatography

References
2.3 Further Characterization for Catalyst Tests
2.3.1 X-Ray Diffraction (XRD) Pattern
2.3.2 Scanning Electron Microscopy (SEM)
2.3.3 Energy-Dispersive Spectroscopy (EDS)
2.3.4 Transmission Electron Microscopy (TEM) and Selected-Area Electron Diffraction (SAED)
2.3.5 BET Surface Area and N2 Adsorption–Desorption
2.3.6 Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES)
2.3.7 H2 Temperature-Programmed Reduction (H2-TPR)
2.3.8 Temperature-Programmed Reduction of Methane (CH4 TPR-MS)

References

3 Performance of the 1D LSCO Nanowires for Methane Combustion
3.1 Introduction
3.2 Catalyst Characterization of PTOs
3.2.1 ICP-AES Results
3.2.2 XRD Patterns of the Oxides
3.2.3 SEM/HRSEM Results
3.2.4 TEM/HRTEM Results
3.2.5 BET Surface Area
3.2.6 N2 Adsorption/Desorption Isotherm
3.2.7 Reducibility of Catalysts H2-TPR Profiles
3.2.8 Oxygen Species O2-TPD Profiles
3.3 Activity Evaluation of Catalyst
3.3.1 Influence of Preparation Method on Catalytic Activity
3.3.2 Influence of Stability and Calcinations at Different Temperatures
3.3.3 Effects of Space Velocity on the Activity of Catalyst
3.4 Conclusion and Discussion

References

4 3DOM LSMO with High Surface Areas for the Combustion of Methane
4.1 Introduction
4.2 Catalytic Characterization of 3DOM LSMO
4.2.1 Crystal Structure (XRD)
4.2.2 Scanning Electron Microscopy (SEM)
4.2.3 Transmission Electron Microscopy (TEM)
4.2.4 BET Surface Area and N2 Adsorption/Desorption Isotherms
4.2.5 CH4 TPR-MS Results
<table>
<thead>
<tr>
<th>Section</th>
<th>Title</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.2.6</td>
<td>Surface Composition, Metal Oxidation State, and Oxygen Species (XPS)</td>
<td>52</td>
</tr>
<tr>
<td>4.2.7</td>
<td>Reducibility (H₂-TPR)</td>
<td>53</td>
</tr>
<tr>
<td>4.3</td>
<td>Catalytic Performance</td>
<td>55</td>
</tr>
<tr>
<td>4.3.1</td>
<td>Study on Different Surfactant Added to the Catalyst</td>
<td>56</td>
</tr>
<tr>
<td>4.3.2</td>
<td>Influence of the Temperature of Calcination on the Catalyst</td>
<td>56</td>
</tr>
<tr>
<td>4.4</td>
<td>Conclusion and Discussion</td>
<td>59</td>
</tr>
<tr>
<td>References</td>
<td></td>
<td>61</td>
</tr>
</tbody>
</table>

### 5 3DOM LSMO-Supported Ag NPs for Catalytic Combustion of Methane

5.1 Introduction

5.2 Characterization and Activity Evaluation of ywt% Ag/3DOM LSMO

5.2.1 X-ray Diffraction (XRD) Patterns

5.2.2 Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES)

5.2.3 Thermo Gravimetric Analysis (TGA) and (FT-IR) Spectroscopy

5.2.4 HRSEM and EDS Results

5.2.5 HRTEM and SAED Pattern Results

5.2.6 Pore Structure and Surface Area (BET)

5.2.7 X-ray Photoelectron Spectroscopy (XPS)

5.2.8 Reducibility (H₂-TPR)

5.3 Activity Evaluation of Catalyst

5.3.1 Influence of Different Ag Loading on the Activity of Catalyst

5.3.2 Influence of H₂O and SO₂ on the Activity of Catalyst

5.3.3 Study on Activation Energy of the Catalyst

5.4 Conclusion and Discussion

References

### 6 Summary

6.1 Conclusions

6.2 Recommendations for Future Works

Appendix
Methane Combustion over Lanthanum-based Perovskite Mixed Oxides
Arandiyan, H.
2015, XXII, 103 p. 66 illus., 13 illus. in color., Hardcover
ISBN: 978-3-662-46990-3