

Contents

1	Introduction and Structure of the Thesis	1
1.1	Research Background	1
1.1.1	Significance of Development of Natural Gas Vehicle	1
1.1.2	Current Situation of the Development of Natural Gas Vehicle	2
1.1.3	Control Technology for Emission Pollution of Natural Gas Vehicle	2
1.2	Research Progress of Catalytic CH ₄ Combustion Catalyst	3
1.2.1	Nonstoichiometry in Perovskite Mixed Oxide (ABO ₃)	4
1.2.2	Perovskite Metal Oxide Catalysts	5
1.2.3	Partial Substitution Property of Perovskite Structure	6
1.2.4	Precious Metal Perovskite Catalyst	9
1.3	Research Purpose, Idea, and Motivation	10
1.3.1	Purpose and Significance	10
1.3.2	Content and Technical Route	10
	References	11
2	Experimental Materials and Methods	15
2.1	Preparation of Catalyst	15
2.1.1	Main Chemical Reagent	15
2.1.2	Main Equipments	15
2.1.3	Preparation of 1D Single-Crystalline LSCO Nanowires	15
2.1.4	Synthesis of Monodisperse PMMA Microspheres	17
2.1.5	Preparation of Three-Dimensionally Ordered Macroporous LSMO	18
2.1.6	Preparation of ywt% Ag/3DOM LSMO Series	21
2.2	Catalytic Activity Measurement	23
2.2.1	Gas Flow Measurement	23
2.2.2	Gas Chromatography	24

2.3	Further Characterization for Catalyst Tests	25
2.3.1	X-Ray Diffraction (XRD) Pattern.	25
2.3.2	Scanning Electron Microscopy (SEM)	25
2.3.3	Energy-Dispersive Spectroscopy (EDS)	25
2.3.4	Transmission Electron Microscopy (TEM) and Selected-Area Electron Diffraction (SAED).	26
2.3.5	BET Surface Area and N ₂ Adsorption–Desorption	26
2.3.6	Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES).	26
2.3.7	H ₂ Temperature-Programmed Reduction (H ₂ -TPR).	26
2.3.8	Temperature-Programmed Reduction of Methane (CH ₄ TPR-MS)	27
	References	27
3	Performance of the 1D LSCO Nanowires for Methane Combustion	29
3.1	Introduction.	29
3.2	Catalyst Characterization of PTOs	30
3.2.1	ICP-AES Results	30
3.2.2	XRD Patterns of the Oxides	30
3.2.3	SEM/HRSEM Results	31
3.2.4	TEM/HRTEM Results	32
3.2.5	BET Surface Area	32
3.2.6	N ₂ Adsorption/Desorption Isotherm	34
3.2.7	Reducibility of Catalysts H ₂ -TPR Profiles.	36
3.2.8	Oxygen Species O ₂ -TPD Profiles.	37
3.3	Activity Evaluation of Catalyst	38
3.3.1	Influence of Preparation Method on Catalytic Activity	38
3.3.2	Influence of Stability and Calcinations at Different Temperatures	39
3.3.3	Effects of Space Velocity on the Activity of Catalyst	40
3.4	Conclusion and Discussion	43
	References	43
4	3DOM LSMO with High Surface Areas for the Combustion of Methane	45
4.1	Introduction.	45
4.2	Catalytic Characterization of 3DOM LSMO	46
4.2.1	Crystal Structure (XRD).	46
4.2.2	Scanning Electron Microscopy (SEM)	48
4.2.3	Transmission Electron Microscopy (TEM)	49
4.2.4	BET Surface Area and N ₂ Adsorption/Desorption Isotherms	50
4.2.5	CH ₄ TPR-MS Results.	51

4.2.6	Surface Composition, Metal Oxidation State, and Oxygen Species (XPS)	52
4.2.7	Reducibility (H_2 -TPR)	53
4.3	Catalytic Performance.	55
4.3.1	Study on Different Surfactant Added to the Catalyst	56
4.3.2	Influence of the Temperature of Calcination on the Catalyst	56
4.4	Conclusion and Discussion	59
	References	61
5	3DOM LSMO-Supported Ag NPs for Catalytic Combustion of Methane	63
5.1	Introduction.	63
5.2	Characterization and Activity Evaluation of ywt% Ag/3DOM LSMO	64
5.2.1	X-ray Diffraction (XRD) Patterns.	64
5.2.2	Inductively Coupled Plasma-Atomic Emission Spectroscopy (ICP-AES).	65
5.2.3	Thermo Gravimetric Analysis (TGA) and (FT-IR) Spectroscopy	65
5.2.4	HRSEM and EDS Results.	68
5.2.5	HRTEM and SAED Pattern Results	69
5.2.6	Pore Structure and Surface Area (BET)	71
5.2.7	X-ray Photoelectron Spectroscopy (XPS)	72
5.2.8	Reducibility (H_2 -TPR)	74
5.3	Activity Evaluation of Catalyst	77
5.3.1	Influence of Different Ag Loading on the Activity of Catalyst	77
5.3.2	Influence of H_2O and SO_2 on the Activity of Catalyst . . .	80
5.3.3	Study on Activation Energy of the Catalyst.	82
5.4	Conclusion and Discussion	83
	References	84
6	Summary	87
6.1	Conclusions.	87
6.2	Recommendations for Future Works.	88
	Appendix	91