

Table of Contents

Table of Contents	i
Acknowledgement	iii
Abstract	v
Zusammenfassung	vii
1. Introduction	1
1.1. Electrochemical production of H ₂ O ₂	1
1.2. ORR electrocatalysts for H ₂ O ₂ production	6
1.3. Goals and objectives	15
2. Experimental section	19
2.1. Chemicals	19
2.2. Synthesis procedures of catalysts	19
2.2.1. Synthesis of nitrogen-doped mesoporous carbon (NCMK3ILX_YT)	19
2.2.2. Synthesis of polyethylenimine-derived nitrogen-doped porous carbon catalysts (PEIXCMK3_YT)	19
2.2.3. Synthesis of a series of metal-N-C catalysts (metal= Co, Ni, Fe, Cu, and Mn)	20
2.3. Structure and composition characterization	21
2.3.1. Scanning electron microscopy (SEM) and transmission electron microscopy (TEM))	21
2.3.2. X-ray diffraction (XRD)	21
2.3.3. Elemental analysis (EA)	22
2.3.4. X-ray photoelectron spectroscopy (XPS)	22
2.3.5. Inductively coupled plasma optical emission spectroscopy (ICP-OES) measurement	23
2.3.6. Zeta potential	24
2.3.7. Thermo gravimetric analysis (TGA)	25
2.3.8. Brunauer Emmet Teller (BET) Surface area analysis	25
2.3.9. Raman spectra	26
2.3.10. Ultraviolet-visible spectroscopy (UV-Vis)	26
2.4. Density function theory (DFT) Calculation	26
2.5. Electrochemical characterization	27
2.5.1. Ink preparation	27
2.5.2. Reference electrode calibration	27
2.5.3. Oxygen reduction reaction (ORR) measurement	29
2.5.4. Bulk H ₂ O ₂ production	30
2.5.5. Micro-flow cell	32
3. Efficient Electrochemical Hydrogen Peroxide Production on Nitrogen-Doped Mesoporous Carbon Catalysts	35
3.1. Structure-activity relationship screening of suitable carbon catalysts	36
3.2. Preparation and characterization of nitrogen-doped mesoporous carbons	39

Table of Contents

3.3.	Non-stationary faradaic H ₂ O ₂ selectivity and the number of transferred electrons	43
3.4.	H ₂ O ₂ productivities during bulk electrolysis over extended test time	47
3.5.	Summary	49
4.	Structure, Activity, and Faradaic Efficiency of Nitrogen-doped Porous Carbon Catalysts for Direct Electrochemical Hydrogen Peroxide Production	51
4.1.	Results and discussion	52
4.1.1.	Structural and composition characterization of nitrogen-doped porous carbon catalysts	52
4.1.2.	Electrochemical characterization	55
4.1.3.	Ex-situ x-ray photoelectron measurement to investigate the catalytic active sites	59
4.2.	Summary	61
5.	Trends in the Catalytic Activity and Selectivity of Metal–Nitrogen–Carbon Catalysts for Electrochemical Oxygen Reduction to Hydrogen Peroxide	63
5.1.	Results and discussion	64
5.2.	Summary	73
6.	Conclusions and Perspectives	75
Bibliography		79
Abbreviations		83
List of Figures		87
List of Tables		93
List of publications during Ph.D.		95
Appendix		97