High Energy Electrode Materials for Lithium Sulfur Batteries

A thesis presented for the degree of Master of Science

By

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Certificate of Originality

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Signature of Student

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Kefei Li 05/03/2012

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Abstract

This thesis described the research work on high energy electrode materials for lithium sulfur batteries. The literature review of high energy electrode materials was presented, including the advantages and disadvantages of different anode and cathode materials and related synthesis techniques. The lithium-sulfur battery and sulfur cathode are the major focus due to their advantages in energy density, cost and environmental sustainability. Different sulfur cathodes based on amorphous carbon, graphene and mesoporous carbon were synthesized to study the correlation between morphology of carbonaceous material and the performance of the sulfur cathode. The as-prepared electrode materials have been characterized by X-ray diffraction, field emission scanning electron microscopy, backscattered imaging, energy disperse spectroscopy element mapping and thermogravimetric analysis. The synthesized sulfur composites are tested as cathode materials in subsequent electrochemical tests. The electrochemical tests performed on sulfur cathodes include cyclic voltammetry, galvanostatic charge-discharge cycle tests and electrochemical impedance measurements. The synthesized graphene-sulfur composite was tested as cathode material and achieved both high sulfur utilization rate with a high specific capacity of 1593 mAh /g and good rate capability at 1.0 C and 2.0 C discharge rates. Graphene within the sulfur composite greatly improved the electrochemical performance of Li-S battery. The effect of sulfur particle size and size distribution within the cathode to the performance of Li-S battery was

investigated through the synthesis of carbon-sulfur nanocomposite by an innovative solution-based synthesis technique. The modification of synthesis method has helped to reduce the particle size of sulfur to the level of about 200 nm. The as-prepared sulfur nanocomposite with a homogeneous dispersion of sulfur particles was applied as the cathode material in Li-S battery and exhibited a high reversible capacity of 1220 mAh/g and maintained favorable cycle stability.

Table of Content

List of Publications

Portions of the work presented in this thesis have been published, or have been submitted for publication. The following is a list of the citations for these publications:

Kefei Li, Bei Wang, Dawei Su, David Wexler, Hyojun Ahn, and Guoxiu Wang,

"Enhance electrochemical performance of lithium sulfur battery through a solution-based processing technique"

Journal of Power Sources, 2011, DOI information: 10.1016/j.jpowsour.2011.11.073

Bei Wang, **Kefei Li**, Dawei Su, David Wexler, Hyojun Ahn, and Guoxiu Wang,

"Superior electrochemical performance of sulfur/graphene nanocomposite material for high capacity lithium sulfur batteries"

Electrochimica Acta, 2011, submitted.

List of Abbreviations

LIB	Lithium-ion Battery
BEV	Battery-Electric Vehicle
ICEV	Internal-Combustion-Engine Vehicle
LOMO	Lowest Occupied Molecular Orbital
HOMO	Highest Occupied Molecular Orbital
Li-Air Battery	Lithium-Air Battery
Li-S Battery	Lithium-Sulfur Battery
XRD	X-ray diffraction
SEM	Scanning Electron Microscope
TGA	Thermogravimetric Analysis
CV	Cyclic Voltammetry
EIS	Electrochemical Impedance Spectroscopy
wt%	Weight Percent
MO	Metal Oxide
MS	Metal Sulfide
DMSO	Dimethyl Sulfoxide
DME	1,2-dimethoxyethane
DOX	1,3-dioxolane
TEGDME	Tetra(ethylene glycol)dimethyl ether
THF	Tetrahydrofuran
EMS	Ethyl methyl sulfone
DGDE	Diethylene glycol dimethyl ether
EC	Ethylene carbonate
DMC	Dimethyl carbonate
LiTFSI	$LiN(SO_2CF_3)_2$

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