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Thesis outline

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Thesis title
Study on novel synthesis of porous carbon microspheres dispersed with iron compound nanoparticles and their application to rechargeable batteries

Rechargeable lithium-ion (Li-ion) batteries have played a crucial role in the development of portable electronic devices and electric vehicles (EVs). Moreover, advances in material properties and synthesis routes have the potential to expand the application fields of Li-ion batteries and facilitate the development of new battery technologies. Therefore, novel synthesis strategies were developed based on spray pyrolysis to rationally engineer porous carbon microspheres dispersed with iron compound nanoparticles for rechargeable battery applications. Specifically, the porous structure and crystalline phase of the microspheres were controlled to enhance the electrochemical properties of Li-ion and lithium-sulfur (Li-S) batteries.

Chapter 1 Introduction

This chapter provides a general review of Li-ion batteries and reviews alternative anode materials to overcome the limitations of traditional graphite anodes in conventional Li-ion batteries. Then, this chapter critically evaluates the advantages of Li-S batteries as next-generation rechargeable batteries, along with a comprehensive analysis of the diverse strategies employed to overcome their fundamental limitations. Eventually, the extensive literature review presented in this chapter draws the boundaries and scope of the study.

Chapter 2 Synthesis of porous C/Fe_3O_4 microspheres by spray pyrolysis with $NaNO_3$ additive for lithium-ion battery applications

This chapter reports on a synthesis of porous carbon microspheres dispersed with Fe_3O_4 nanoparticles (porous C/Fe_3O_4 microspheres) as an anode material for Li-ion batteries using spray pyrolysis with a sodium nitrate ($NaNO_3$) additive in the precursor solution. The effect of $NaNO_3$ additive on a phase conversion of Fe_3O_4 nanoparticles, morphology evolution of C/Fe_3O_4 microspheres, and their electrochemical performances have been studied in detail by various physical and electrochemical characterization techniques.

Chapter 3 Synthesis and characterization of porous-crystalline C/Fe_3O_4 microspheres by spray pyrolysis with steam oxidation as anode materials for Li-ion batteries

This chapter introduces a novel synthesis route for the Fe_3O_4 nanoparticles dispersed on porous-graphitic carbon (porous-crystalline C/Fe_3O_4) microspheres by spray pyrolysis with steam oxidation to further improve the performance of the Li-ion

batteries. The synthesis parameters have been optimized to obtain porous-crystalline C/Fe_3O_4 microspheres with appropriate microstructure and crystalline phases. The synergy between well-developed porous structure and highly conductive graphitic carbon on the electrochemical properties of the porous-crystalline C/Fe_3O_4 microspheres has been systematically studied.

Chapter 4 Porous-crystalline C/Fe_3O_4 microspheres with highly accessible conductive and adsorptive/catalytic interfaces to manipulate polysulfide shuttling in Li-S batteries

This chapter reports on the application of the C/Fe_3O_4 microspheres discussed in Chapter 3 to investigate the synergetic effect of conductive and adsorptive/catalytic interfaces on the adsorption and conversion of polysulfides, aiming to enhance the electrochemical performances of the Li-S batteries. The polysulfide adsorption and conversion properties of these microspheres have been extensively investigated using various physical and electrochemical characterization techniques to enhance the electrochemical properties of the Li-S batteries.

Chapter 5 Synthesis of advanced sulfur cathode with porous-crystalline C/Fe_3C electrocatalyst and three-dimensional (3D) current collector for Li-S batteries

This chapter introduces the synthesis of advanced sulfur cathode incorporating porous-crystalline C/Fe_3C microspheres as an electrocatalyst and carbon fiber paper (CFP) as a 3D current collector through vacuum filtration technique, eliminating the need for complex procedures associated with cathode production in Li-S batteries. The effect of the C/Fe_3C microspheres on electrochemical properties of the Li-S batteries have been systematically studied in comparison with the porous-crystalline C/Fe_3O_4 microspheres discussed in Chapter 4. Moreover, extensive research has been conducted to explore the impact of electrode composition and types of current collectors on the electrochemical properties of the Li-S batteries.

Chapter 6 Summary

This chapter provides the main conclusions of this study.