Sulfur nanocomposite cathodes for lithium batteries prepared by a combination of powder technology and heat treatment

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Introduction

Among all known battery chemistry based on lithium, the elemental sulfur cathode has almost the highest theoretical capacity of 1675 mAh g^{-1} [1]. The critical drawbacks of lithium/sulfur (Li/S) cells are poor electronic conductivity of material and dissolution of lithium polysulfides in liquid electrolytes, which shortens the cycling life of the cathodes. The low conductivity issues and dissolution of polysulfides could be reduced by impregnation of sulfur into high surface carbon. Naturally excellent absorption properties of carbon and ability to trap the polysulfides, and high electronic conductivity of a carbon matrix allows overcoming of both of these problems. A variety of carbon materials including acetylene black [2] and carbon nanotubes [3] were used to prepare S/C composites, and remarkable improvements have been achieved. However, the preparation methods used are non-continuous batch processes, consisting of multiple steps along with the heating stages. In our previous studies, we have developed the innovative, inexpensive conductive S/C composites [4]; however, novel continuous preparation techniques are crucial to make these materials attractive for large scale practical use.

In this work we report on the development of continuous preparation techniques for conductive sulfur nanocomposites based on a combination of powder technology and heat treatment, and evaluation of electrochemical performance of the materials as cathode for lithium batteries.

Experimental

Conductive sulfur nanocomposites were prepared by a combination of powder technology and heat treatment. Low temperature absorption of sulfur by a mesoporous carbon was conducted to obtain a precursor composite, which was further heat treated at 150 ^{o}C in in N_2 flow. The prepared nanocomposites were characterized using BET, chemical analysis, scanning electron microscopy and XRD. The nanocomposites were used to prepare composites cathodes. The electrochemical properties of the nanocomposite cathodes were studied in coin type half cells using cyclic voltammetry, ac impedance spectroscopy and charge-discharge tests.

Results and discussions

The conductive sulfur nanocomposites were successfully prepared via the present continuous synthetic technique. The powder characterization studies have shown that the prepared S/C nanostructured composites have narrow particle size distribution along with homogeneous distribution of the components. The sulfur content in the nanocomposite was about 50 wt.%. The conductivity of the composites was remarkably improved compared with the bare sulfur cathode which led to the improved electrochemical performance in rechargeable lithium battery. The battery exhibited high coulombic efficiency along with enhanced cyclability.

Further details and progress of this work will be reported at the meeting.

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