

The Characteristics of Sulfur Electrode with Carbon Nanotube

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Abstract

We investigated on the additive effect of carbon nanotube in the sulfur electrode on the first discharge curve and cycling property of lithium/sulfur cell. The sulfur electrode with carbon nanotube had two discharge plateau potentials and the first discharge capacity about 1200 mAh/g sulfur. The addition carbon nanotube into the sulfur electrode did not affect the first discharge behavior; but improved the cycling property of lithium/sulfur cell. The optimum content of carbon nanotube was 6 wt% of sulfur electrode

Keywords : lithium battery, sulfur electrode, carbon nanotube

1. Introduction

The lithium/sulfur cell was an extremely attractive because of high theoretical specific energy of 2600 Wh/kg(1672 mAh/g), assuming complete reaction to Li_2S . However, it was very difficult to make a high utilization lithium/sulfur cell because of high resistivity and reactivity of sulfur [1,2]. Recently, some researchers overcame the problem of the insulating character of elemental sulfur in composite cathode by homogeneous mixing of an electronically conductive material such as acetylene black powder [3-6]. However, the discharge capacity drastically decreased during charge-discharge cycling[4]. Gorkoyenko mixed the vanadium oxides, silicates, aluminum oxide to the sulfur electrode[7]. And, Han et al[8] reported the cycle life of Li/S battery could be improved by addition of MWNT(multiwall carbon nanotubes) to the sulfur electrode. In this study, we investigate the effect of the addition of carbon nanotube and the optimum amount of nanotube in sulfur cathode for lithium/sulfur battery.

2. Experimental and Results

Sulfur cathode was prepared by casting of the slurry of sulfur, poly ethylene oxide(PEO), electric conductor and Lithium salt on a aluminum current collector. Figure 1 shows SEM photograph of powder for sulfur electrode. The carbon powder had sub-micrometer diameter with a very large surface area and multiwall carbon nanotube(MWNT) had about a few hundreds nanometer diameter bundle. The sulfur electrode slurry was stirred for 24 h before 2 h attrition ball milling. The cathode consists of 50 wt% sulfur,

30wt% electric conductor, 15 wt% PEO and 5 wt% Li-salt. The electric conductor was mixture of acetylene black powder and carbon nanotube. The electrolyte prepared from organic solvent of 0.5 M LiCF_3SO_3 in tetraethylene glycol dimethylether (Tetra glyme, TEGDME). The configuration of the Li/S cells was Li/electrolyte/sulfur electrode. The cells were assembled in an argon-filled glove box. Cell tests were conducted under galvanostatic conditions between 1.5V and 3.4 V with constant current density of 100 mA/g.

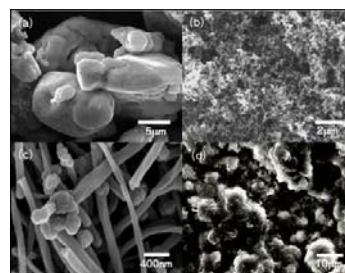


Fig. 1. SEM photographs of raw materials in the sulfur electrode. (a) sulfur, (b) acetylene black, (c) multi-wall carbon nanotube, (d) PEO

Figure 2 shows the first discharge curves of sulfur electrodes with various carbon nanotube contents. Although the content of carbon nanotube in the sulfur electrode changed from 0 to 9 wt.%, all lithium/sulfur cells had two discharge plateau potentials and similar discharge capacity about 1200 mAh/g. Discharge curves are similar to others [3-8]. The sulfur electrode had two different electric conductors, i.e. carbon nanotube and acetylene black. The

content of carbon nanotube did not affect the first discharge behavior of lithium/sulfur cells. In order to obtain high capacity during first discharge, the acetylene black was more important factor than MWNT.

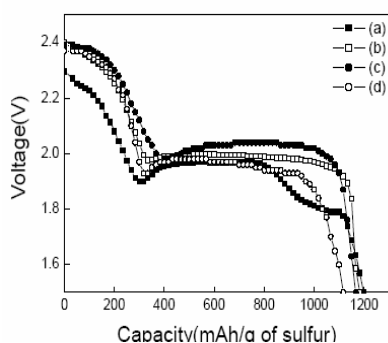


Fig. 2. The first discharge curves of sulfur electrode with various carbon nanotubes contents (a) 0wt%, (b) 3wt%, (c) 6wt% and (d) 9wt%

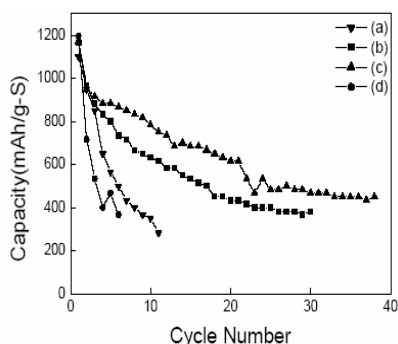


Fig. 3. Cycle properties of sulfur electrode with various carbon nanotubes contents (a) 0wt%, (b) 3wt%, (c) 6wt% and (d) 9wt%.

Fig. 3 represents the changes of discharge capacities as a function of charge-discharge cycles. The discharge capacities drastically decreased with repeated cycling. Especially, sulfur electrode contained 0 wt% and 9 wt% carbon nanotube showed severe degradation by cycling, which represented low capacity of 400 mAh/g after 6th cycle. The sulfur electrode with optimum contents, 6wt% carbon nanotube showed the best cycling property and remained above 600 mAh/g after 20th cycle. The content of carbon nanotube is an important factor for cycling properties. The SEM photographs of sulfur electrode are shown in Fig. 4. The sulfur electrode with low MWNT content showed homogenous mixing of sulfur and carbon. However, the sulfur electrode with 9 wt% carbon nanotube represented agglomeration of each material shown in Fig. 4(d). It is related to poor cycling property because of segregation of carbon nanotube.

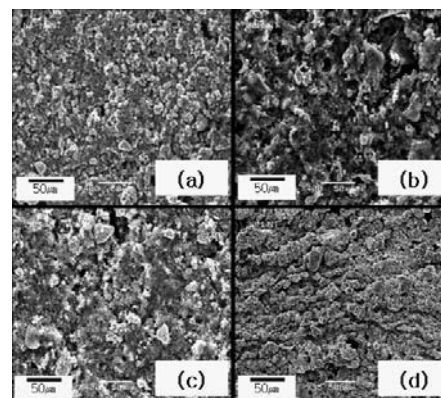


Fig. 4. SEM morphologies of sulfur electrode with addition of carbon nanotube (a) 0wt%, (b) 3wt%, (c) 6wt% and (d) 9wt%

3. Summary

The addition of carbon nanotube in the sulfur electrode did not affect the first discharge property but cycling property of lithium/sulfur battery. In this experiment, the optimum content of carbon nanotube was from 3 to 6 wt%, because a lot of carbon nanotube, i.e. 9 wt%, induced the agglomeration of sulfur electrode. The sulfur electrode with optimum contents, 6 wt% carbon nanotube showed the best cycling property and remained above

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