PREPARTION AND CHARACTERIZATION OF HIGH-POWER ANODE MATERIALS USING SOFT CARBON PRECURSORS FOR LITHIUM ION SECONDARY BATTERY

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Introduction

In order to apply the lithium ion secondary batteries for electric vehicles and hybrid electric vehicles, they require not only high energy density but also high power density [1]. Previous studies on high-power density Li-ion secondary batteries have been focused on the improvement of the cathode materials and electrolyte [2-6]. Carbonaceous materials have received considerable interest as anode materials for a lithium ion secondary battery. Surface modification is one of the effective methods for improving the electrochemical characteristics of carbonaceous anodes for lithium ion secondary batteries. Electrode characteristics are governed by crystallinity, surface area, surface pore volume distribution, surface chemical species such as oxygen and so on [7].

In this work, we investigated the high-power anode materials for Li-ion secondary battery by using various cokes samples, which were prepared by milling, pitch coating, and heat treatment. The objective of this study is to demonstrate the effect of those modifications with cokes anode materials on the electrochemical properties such as power capability and charge-discharge capacity.

Experimental

Sodiff coke (S-coke) was regular cokes prepared from coal tar pitch and CCP-C10 was obtained by coating coal tar pitch on the surface of regular cokes. CCP-C10 cokes were heat treated at 500, 800, 1000, 1100, 1200 and 1300 ℃ for 1 h under nitrogen atmosphere. S-coke, various petroleum pitch/S-coke composites with different weight ratios at 1:4, 1:3, and 1:2, and mesophase pitch/S-coke composites at 1:4 weight ratio were heat treated at 1000℃ for 1 h under nitrogen atmosphere. The obtained products after heat treatment were milled and sieved at 325 mesh to gain anode base materials with particle sizes below 40 µm. Then 9.3g of anode base materials and 0.7 g of PVDF (polyvinylidene fluoride) were dissolved in 13 wt.% NMP (1-methyl-2-pyrrolidinone) by stirring at 4000 to 5000 rpm with a homogenizer to yield slurry anode materials. Finally, the charge/discharge characteristics of cokes electrodes were tested in a half cell which was assembled in a glove box maintaining water content below 1 ppm and further measured at cut-off range from 0.005 to 2.0 V employing a constant current by a battery tester. All batteries tested in this study were cycled under constant charge rate of 0.2 C and different discharges rates of 0.2 C, 1 C, 2 C, 3 C and 5 C, respectively.

Results and Discussion

The charge-discharge characteristics of CCP-C10 cokes treated at different temperatures were shown in Fig. 1 and Table 1. For CCP-C10 cokes, although the reversible capacities were pretty high around 380~590 mAh/g with low heat treatment temperatures, the initial charge-discharge efficiencies and power capabilities were relatively poor. However, with high heat treatment temperatures over 1000℃, the reversible capacities were moderate around 200~240 mAh/g, but the initial charge-discharge efficiencies and power capabilities were improved significantly. The power capabilities in Table 1 were calculated through dividing discharge capacity at 5 C rate by that of at 0.2 C rate.

Since CCP-C10 cokes heat treated above 1000℃ showed more preferable charge-discharge characteristic and the highest average charge-discharge capacities were around 1000℃, various petroleum pitch/S-coke composites with different weight ratios at 1:4, 1:3, and 1:2, and mesophase pitch/S-coke composites at 1:4 weight ratio were also heat treated at 1000℃. As shown in Fig. 2 and Table 2, petroleum pitch/cokes composites at 1:4 and 1:3 weight ratio exhibited the highest reversible capacities around 235 mAh/g and their initial charge-discharge efficiencies and power capabilities were higher than those of CCP-C10 cokes heat treated at 1000℃. S-coke and petroleum pitch/S-coke composites at 1:2 weight ratio showed relatively low reversible capacities around 220 mAh/g but the highest initial charge-discharge efficiencies and power capabilities were obtained at 1:2 weight ratio.

Conclusions

In order to improve the power capability of Li-ion secondary battery, various coke samples, which were prepared by milling, pitch coating, and heat treatment, were studied as the anode materials. As the coal tar pitch coated cokes were heat treated in the range of 1000~1300℃, the reversible capacities showed moderate values around 200~240 mAh/g but the initial charge-discharge efficiencies and power capabilities were improved significantly. The petroleum pitch/S-coke composites at 1:4 and 1:3 weight ratio presented the highest reversible capacities and their initial charge-discharge efficiencies and power capabilities were higher than those of CCP-C10 cokes heat treated at 1000℃.

References

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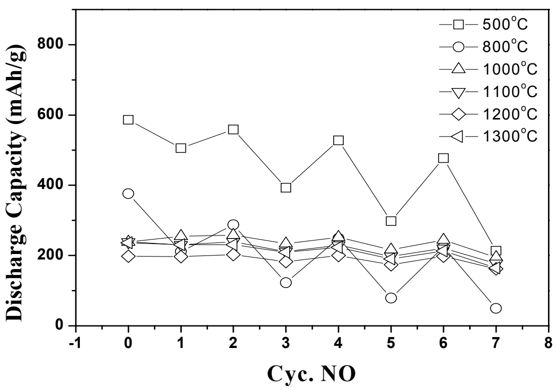

Fig. 1. Discharge characteristics of CCP-C10 at various heat treatment temperatures.

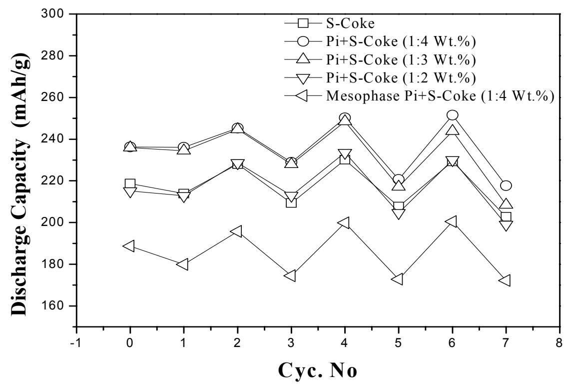

Fig. 2. Discharge characteristics of S-coke and petroleum pitch/S-coke composites with different compositions heat treated at 1000℃.

Table 1. Performance of various anode materials heat treated at different temperatures

	CCP-C10 500℃	CCP-C10 800℃	CCP-C10 1000℃	CCP-C10 1100℃	CCP-C10 1200℃	CCP-C10 1300℃
Power capability (%)	51	23	81	83	84	81
Initial efficiency (%)	68	44	81	81	85	78
Reversible capacity (mAh/g)	586	376	238	239	198	237

Table 2. Performance of S-coke and petroleum pitch/S-coke composites with different compositions heat treated at 1000℃

	S-Coke	Pi+S-Coke (1:4 wt. %)	Pi+S-Coke (1:3 wt. %)	Pi+S-Coke (1:2 wt. %)	Mesophase Pi+S-Coke (1:4 wt. %)
Power capability (%)	90	88	86	88	88
Initial efficiency (%)	82	81	85	95	82
Reversible capacity (mAh/g)	219	236	235	215	189