CHARACTERISTICS AND MODIFICATION OF ANODE MATERIALS FOR LITHIUM-ION BATTERY

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Introduction

Graphite is one of the most promising anode materials for lithium-ion secondary batteries due to its high volume energy density, low irreversible capacity, good rate capability, and stability [1]. Several kinds of commercially available artificial graphites were evaluated and modified to improve their properties in view of the discharge capacity and coulombic efficiency in this study.

Experimental

Five artificial graphite powders (AG, KG, AD, SD, and LZ) were used as raw anode materials. Their surfaces were modified by three methods (A, B, and C) with various heat treatment temperatures between 700 and 1200°C in each method. The physical properties of the raw and modified artificial graphites were characterized by X-ray diffraction, particle size analyzer, elemental analyzer, and scanning electron microscopy. Their specific surface areas were measured in a nitrogen adsorption instrument by using BET equation. The electrochemical characteristics were measured using a three-electrode cell with a lithium counter electrode and a lithium reference electrode.

Results and Discussion

Figure 1 shows the coulombic efficiency and discharge capacity of the raw artificial graphite powders. Relatively low discharge capacities (about 320mAh/g) of AG and SD seem to be caused by their low purities. The low efficiency of AD irrespective of its highest purity may be related to its fine particle size (1-2μm). KG and LZ show the highest efficiency (87%) and the largest capacity (359mAh/g) among the raw materials, respectively. The average particle size of KG and LZ was very similar to be about 15μm, but the texture of the particles was different as shown in figure 2. The particles of LZ consist of a single grain, while KG shows many grains within each particle. The particle size, particle size distribution, and particle orientation of graphite anodes were reported to affect the electrochemical performance of cells [2]. The effect of intraparticle textures, however, on the electrochemical properties needs further study.

Figure 3 shows the electrochemical properties of raw artificial graphite KG and its modified ones. The discharge capacity increased in some treatment conditions. One condition of treatment C shows 369mAh/g of capacity, which is close to the theoretical value (372mAh/g) of graphite. The efficiency, however, was very hard to increase with the modification treatments.

Figure 4 shows the dependence of coulombic efficiencies of modified materials from KG and LZ on the their specific surface areas. The efficiency, a measurement of reversible capacity, increased with decreasing surface area in both series. Irreversible capacity is known to be caused by formation of solid electrolyte interface on the carbonaceous anode and to increase with carbon surface area [3]. The trends shown in KG and LZ series are coincident with the explanation. But the efficiencies of KG series were higher than those of LZ series with the same range of surface areas, which may be related to the higher efficiency of the raw KG than that of the raw LZ. This indicates that the selection of raw materials is the first step to be solved in the modification treatment.

Conclusions

The surface modification of artificial graphite powders was effective to increase their discharge capacities. Their coulombic efficiencies depended on those of raw materials as well as the specific surface areas, which were changed during the modification treatment.

References

1. Kasuh T, Mabuchi A, Tokumitsu K and Fujimoto H. Recent trends in carbon negative electrode materials. J. Power Sources 1997;68:99-101.
2. Liu Q, Zhang T, Bindra C, Fischer JE and Josefowicz JY. Effect of morphology and texture on electrochemical properties of graphite anodes. J. Power Sources 1997; 68:287-290.
3. Ogumi Z and Inaba M. Electrochemical lithium intercalation within carbonaceous materials: intercalation processes, surface film formation, and lithium diffusion. Bull. Chem. Soc. Jpn. 1998; 71:521-534.

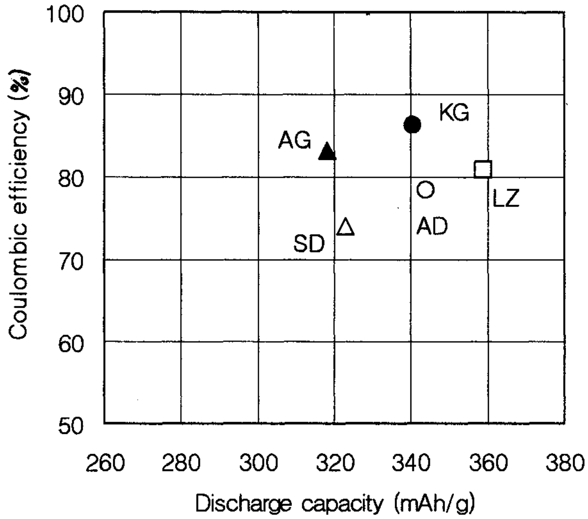

Figure 1. Coulombic efficiency and discharge capacity of raw artificial graphites.

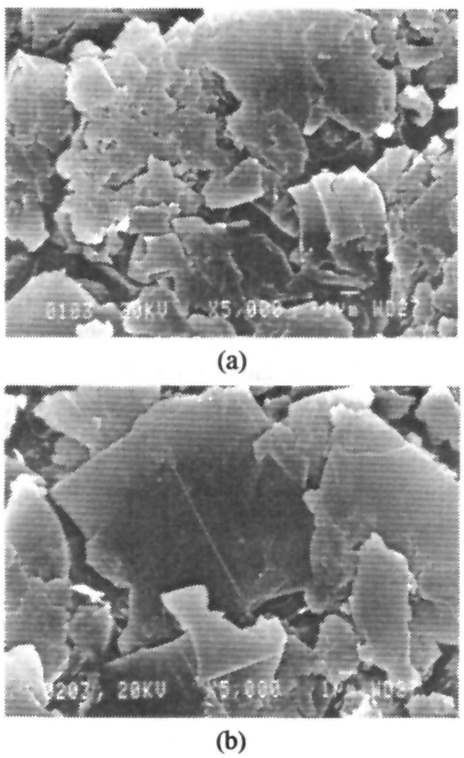

Figure 2. Scanning electron microscopy of raw artificial graphites (a) KG and (b) LZ.

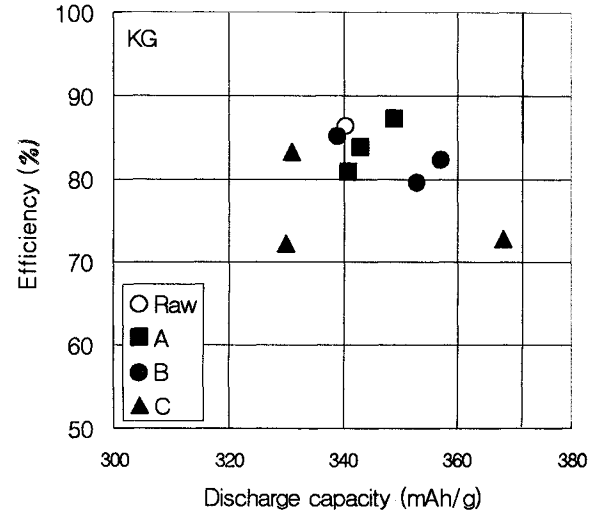

Figure 3. Electrochemical properties of raw artificial graphite KG and modified materials.

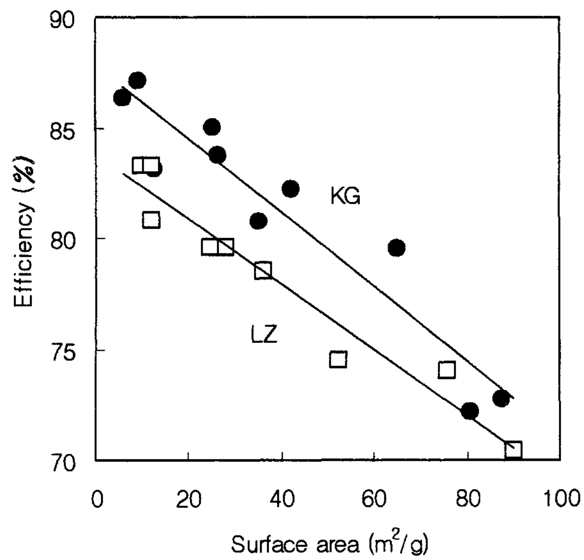

Figure 4. Variation of coulombic efficiency of modified graphites from artificial graphites KG and LZ versus their suface areas.