# Studies of Charge/Discharge Properties of Mesocarbon microbeads Carbonized at Low Temperature for Long Times as Negative Electrode for Li-ion Batteries

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## INTRODUCTION

Mesocarbon Microbeads (MCMBs) are reported to have several benefits in negative electrodes for Li-ion cells which have attracted attentions[1]: these include their spherical shape which permits close-packing and resultant high density and low surface area which minimizes the side reactions during charge/discharge. So, it is one of the promising carbon materials among those available commercially used as anode carbon materials for rechargeable Li-ion batteries.

The anode properties of MCMBs heat treated at different temperatures have already been reported by several researchers[1-3]. However, for the MCMBs carbonized at low temperature for long times as electrodes, there have never been reported.

In this paper, the charge/discharge properties of graphitized MCMBs and low temperature treated MCMBs for different periods were investigated. It is hoped to expose the relationship of heat treatment times of MCMBs with the electrochemical behaviour in the charge and discharge.

## EXPERIMENTAL

Mesocarbon microbeads were synthesized from a Chinese medium coal tar pitch condensed at 410℃ for 10 minutes and separated from coal tar matrix with two-step solvent filtration[4]. The particle size is ca. 7 μm in average diameter.

Mesocarbon microbeads were carbonized to 700℃ with soaking times of 12h and 24h under nitrogen atmosphere after oxidized at 300℃. MCMBs were graphitized to 2500℃ after carbonization at 1000℃.

The electrochemical cells consisted of a MCMBs working electrode and a lithium counter-electrode, which the working electrodes were fabricated by mixing MCMBs and polyvinylidene (PVDF) binder with a weight ratio of 10:1. The electrolyte used was a 1M solution of $LiPF_6$ dissolved in a 50:50 mixture by volume of ethylene carbonate (EC) and diethyl carbonate (DEC). The cells were discharged and charged between 0 and 2V vs $Li^+/Li$ at a constant current density of $0.125mA/cm^2$ using a PC-controlled testing system.

## RESULTS AND DISCUSSION

Fig. 1 shows the charge and discharge curves of graphitized MCMBs for Li-ion battery. The most remarkable characteristic is the appearance of a plateau at 0.1 to 0.2V in the charge-discharge curve, which is the typical feature for graphitizing carbons. The discharge capacity of the first region is about 200mAh/g.

In comparison with graphitized MCMBs, the low temperature treated MCMBs show different charge-discharge curves presented in Fig.2 and Fig.3. The charge-discharge curves have no potential plateaus

appearing and the discharge curves exhibit decreasing drastically. It was reported that for 700℃-1h heat treated MCMBs, the charge curve shows a potential plateau at about 1V vs. $Li^+/Li$[1], which may be attributed to the side reactions. So, it is concluded that with the extension of soaking times carbonized at 700 ℃, the potential plateaus disappeared gradually, indicating the reduction of side reactions with electrolyte.

The MCMBs of 700℃-12h and 700℃-24h are shown to have almost the same capacities of 640mAh/g. From the second region, the reversible capacity of MCMBs of 700℃-24h appears to be constant at 360mAh/g, indicating the excellent cycle property. While for MCMBs of 700℃-12h, the reversible capacities decrease with the increase of cycle times. The interlayer-spacings and the elements content of two kinds of MCMBs are presented in Table 1. Although there are not remarkable difference in the element contents of these two samples, the $d_{002}$ of 700 ℃-24h shows larger than that of 700 ℃-12h, suggesting the more nano-graphene may be formed which resulting in high interlayer-spacing and excellent cycle properties.

## CONCLUSION

MCMBs heat treated at low temperature for long times show high capacity and good cycle property, which would be one of promising carbon electrode with high property/price ratio for Li-ion batteries.

## REFERENCE


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[3] J. R. Dahn, A. K. Sleigh, H. Shi et al, Electrochem. Acta 38, 1179(1993)

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Table 1 Some properties of MCMBs carbonized at 700℃

| Sample | $d_{002}$ (A) | Elemental analysis (wt%) | | | |
|---|---|---|---|---|---|
| | | C | H | N | H/C |
| 700℃-12h | 3.6245 | 93.42 | 1.09 | 0.90 | 0.130 |
| 700℃-24h | 3.6450 | 93.36 | 1.02 | 0.89 | 0.130 |

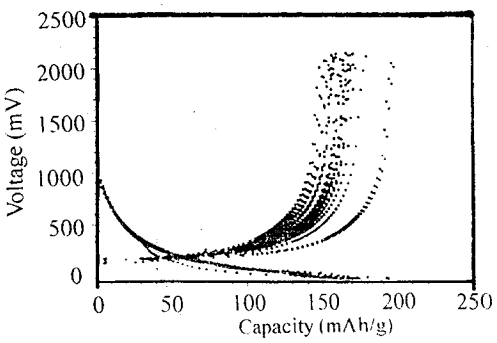


Fig. 1 The charge and discharge curves of graphitized MCMBs electrode for the Li-ion batteries

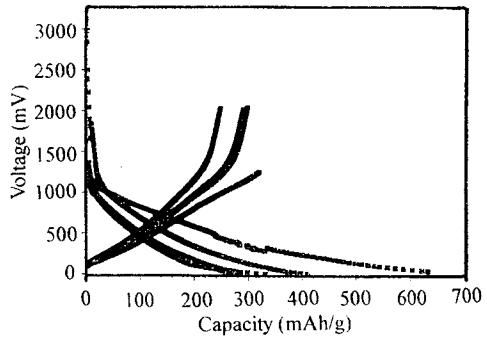


Fig. 2 The charge and discharge curves of 700℃-12h MCMBs electrode for the Li-ion batteries

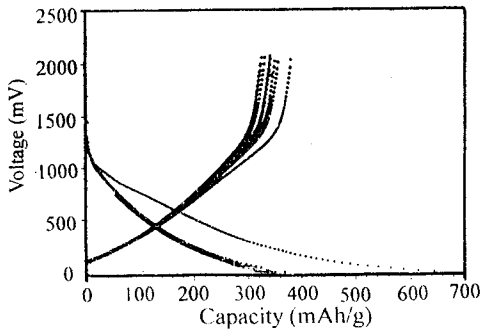


Fig. 3 The charge and discharge curves of 700℃-24h MCMBs electrode for the Li-ion batteries