Preparation of High Performance Carbon for EDLC by Controlling Optical Texture

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Introduction

Electric double-layer capacitors (EDLCs) have attracted much interest since they are expected to be used as an electric power source for cars, due to their rapid charge and discharge abilities [1,2]. Hence, the better carbon for the electrode of higher capacity is extensively looked for. In the present study, coal tar derived cokes of different optical texture were activated with KOH. The raw and calcinated cokes were also compared since their graphitic extents are very different with the calcinations temperatures although their optical textures were not extensively different. A larger capacitance by volume as well as by weight can be achieved by finding better porous carbon materials with optimum surface functions for the electrode. The optical texture was found one of the important factors for the electrode carbon of double layer capacitor.

Experimental

Cokes

In this study, CTP(coal tar pitch) and CTP with FB(furnace black) or TB(thermal black) were examined as precursors of activated carbon for the electrode carbons of EDLC. Cokes were calcinated at 800 ^{o}C for 1h under Ar flow before activation. The cokes were activated with KOH, at a coke/ KOH ratio of one to four by weight at 700 ^{o}C for 1h under Ar flow in a nickel-made holder. The holder was heated in the stainless steel tube. The coke activated was washed with water for three times to remove KOH almost perfectly and dried at 120 ^{o}C under vacuum.

Determination of specific capacitance

The electrode for EDLC was prepared from activated coke, carbon black (Ketjenblack-E) and polytetrafluoroethylene (PTFE) at a weight ratio of 8:1:1. The diameter of the electrode was 12 mm. The specific capacitance was measured by the two-electrode system using tetraethylammonium tetrafluoroborate ($Et_4NBF_4$1M) in propylenecarbonate (PC) as an electrolyte. The test cell was charged to 2.7 V at a constant current (100 mA/g) and voltage, and then discharged at a constant current (100 mA/g) to 0V. The charge was kept at 2.7 V in the first cycle while the current decreased to 0.3 mA, for not longer than 80 min, to obtain sufficient charge by the electric field activation. The specific capacitance was calculated by the following equation (1) [3].

$$C = \frac{I \times (T_2 - T_1)}{(V_1 - V_2)(W)} \qquad (1)$$

where V_1 and V_2 are 2.16V and 1.08V for 2.7V charging, or 2.96V and 1.48V for 3.7V charging, respectively, and W is the weight or volume of each electrode.

Results and discussion

The optical textures of coke from CTP and CTP with CB (FB or TB) of different amount were shown in Figure 1. The optical texture of CTP was flow. The addition of CB made it smaller, mosaic texture being prevailed by the addition of 10 wt% of CB of both FB and TB. Activation conditions and the performance of EDLC were summarized in Table 1. The highest capacitance of 34.9 F/ml was achieved at 3.7 V for CTP/ TB5. It decreased by the addition of FB from 5 to 10 wt% to 26.9 and 34.2 F/ml, respectively. However, capacitance at 3.7 V of CTP/FB10 was 38.3F/g, being kept at higher level even after the addition of FB. The expansion ratios of electrode after the charge at 3.7V were also include in Table 1.The lower expansion ratios of CTP/ FB5 and CTP/ FB10 were noted indicating that smaller optical texture suppress the expansion at charge.

Table 1. Performance of activated CTP/CB 0wt%, 5wt% and 10wt%

Sample	Activated temperature	Capacitance 2.7V		Capacitance 3.7V		Charge-discharge expansion ratio(3.7V)
		(F/g)	(F/ml)	(F/g)	(F/ml)	
CTP		20.4	17.7	29	25.2	1.84
CTP/FB5		28.3	24.6	30.8	26.9	1.69
CTP/FB10	700°C	33.8	30.8	37.5	34.2	1.65
CTP/TB5		30.1	28.6	36.8	34.9	1.78
CTP/TB10		32.1	27.4	38.4	32.2	1.77

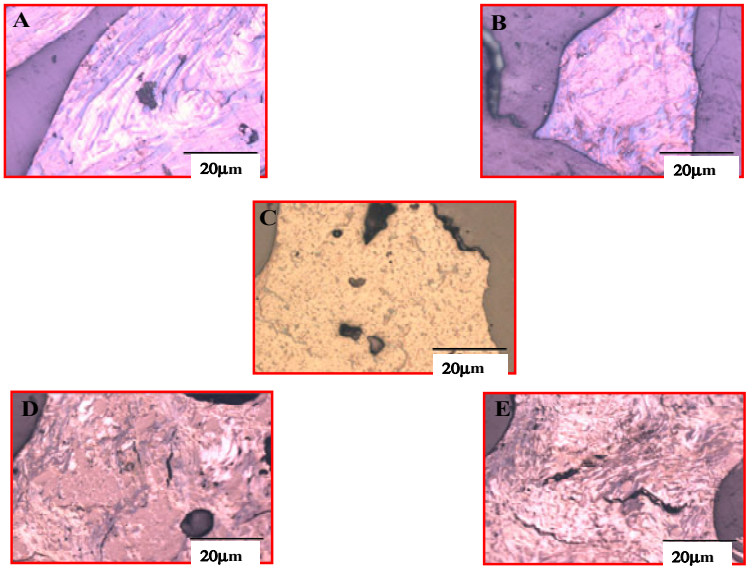

Figure 1. Optical texture of coke from CTP the amount of FB or TB

A: CTP, B: CTP/FB5, C: CTP/FB10, D: CTP/ TB5, E: CTP/TB10

References

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