

## Separator

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( ) ,<sup>R</sup>  
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### The Effect of Polymer Blending and Extension Conditions on the Properties of Separator Prepared by Wet Process for Li-ion Secondary Battery

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: (HDPE) (UHMWPE)  
2 separator ,  
가 . Separator UHMWPE  
1000 kg/cm<sup>2</sup> , UHMWPE 6 wt% 5  
0.1~0.12  $\mu$ m , shut - down 130 . Separator 160  
2 가 가 .

ABSTRACT : The separator made from the blends of high density polyethylene (HDPE) and ultrahigh molecular weight polyethylene (UHMWPE) was prepared by wet processing to use as Li - ion secondary battery. We investigated effects of the blending of the polymers and the film extension on the mechanical properties of the separator. The mechanical strength of separator increased with increasing molecular weights and contents of UHMWPE, for instance about 1000 kg/cm<sup>2</sup> with the five times extended film of 6 wt% UHMWPE. The pores of the separator were very uniform with the size of 0.1~0.12  $\mu$ m. The shut - down characteristic quickly increased at around 130 and the fusion temperature was 160 , so it could be applied to the lithium ion secondary battery.

**Keywords** : separator; Li-ion secondary battery; wet process.

가 2 ,  
21 가  
2 . 2  
(Ni - Cd) 가 cycle (lithium ion  
, 가 battery; LIB) , PC  
2 가 , 90

separator LIB (PP) (PE) 가

160 PP shut - down 가

2 LiCoO<sub>2</sub> 가 PE shut - down

LiMnO<sub>2</sub> soft - 가 120~130

carbon, 2 가

4.1~4.2 V, 3.6~3.7 V, Nitto Denko

Wh/dm<sup>3</sup>, 120~140 Wh/kg , Ni - Cd PE ,<sup>2</sup> PE/PP

90~160 Wh/dm<sup>3</sup>, 50~70 Wh/kg Tohnen, Asahi - Kasei, Hoechst Celanese

(1000~1200 ), PP PE 2 3 <sup>4</sup> lamination

(10 %/ ) Ni - Cd 가 가 PE

LIB 가 shut - down PP

graft <sup>5</sup>

shut - down 가 Ni - Cd

(separator) separator 가

separator 가

(1) separator , 2

(2) 가 (ethylene

carbonate; EC, propylene carbonate; PC)

(3) 가 가

(4) , (5) PP separator

(6) 가 PP PE

(7) graft

가 casting

2 가 ,

shut - down <sup>6</sup>

down 가 ,

가 가 Asahi - Kasei<sup>9</sup> 가 Tonen,<sup>3,8</sup>

shut - down Hoehchst <sup>10</sup> Nitto Denko

down 110 <sup>11</sup>

가 PVDF

Separator

T - die  
 2  
 7  
 casting drum , 2  
 miscibility parameter  
 가  
 가  
 가  
 8,12  
 T - die blow  
 가  
 6  
 separator  
 (high  
 density polyethylene; HDPE)  
 (ultra high molecular weight polyethylene;  
 UHMWPE) LIB  
 separator  
 10  
 mixer  
 (HDPE, )  
 (UHMWPE, Mitsui Chemical )  
 (Teric, ICI ) (Irganox1010, Ciba

**Table 1. Polymer Composition of Samples for Separator Manufacturing**

	blending conditions				
	HDPE	UHMWPE (M <sub>w</sub> :2400000)	UHMWPE (M <sub>w</sub> :3400000)	oil (Teric)	additive (Irganox 1010)
sample 1	27	3		70	0.15
sample 2	27	1.5	1.5	70	0.15
sample 3	27		3	70	0.15
sample 4	24	2	4	95	0.15

Specialty Chemicals ) Table 1  
 180  
 가 . Double helical impeller  
 , UHMWPE  
 . 180 2  
 T - die  
 casting . Casting 2  
 125~130 (pre - heating)  
 2~5 10~40  
 mm/sec 가  
 methylene chloride 가  
 separator  
 25 mm separator  
 casting  
 , 5 , 1/25  
 가 , casting  
 625 mm . Separator  
 25 mm 가  
 가  
 Instron 4201 (Instron)  
 (SEM; Jeol JSM840)  
 automatic perm - porometer(Porous Materials Inc.  
 APP2100E) , DSC(Perkin Elmer  
 DSC7)

(MD) (TD)  
 , 2 1  
 TD  
 가 MD 가

25 mm MD  
 1000 kg/cm<sup>2</sup>  
 ASTM D-882  
 separator  
 가 가  
 가  
 separator 가  
 Shut - down Ni  
 separator  
 Ni

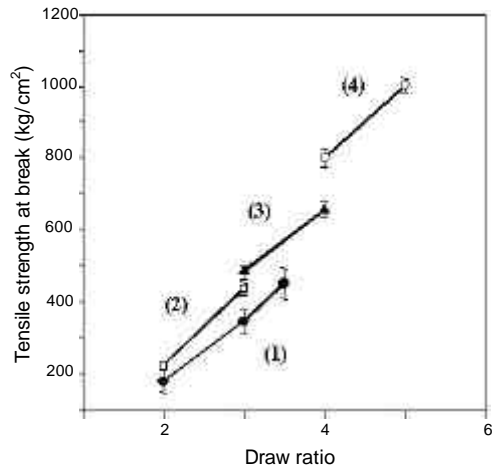
1M LiPF<sub>6</sub>/PC 1  
 kHz, 25 180 2 /min

separator

가 separator  
 가 separator  
 가 separator

Table 1

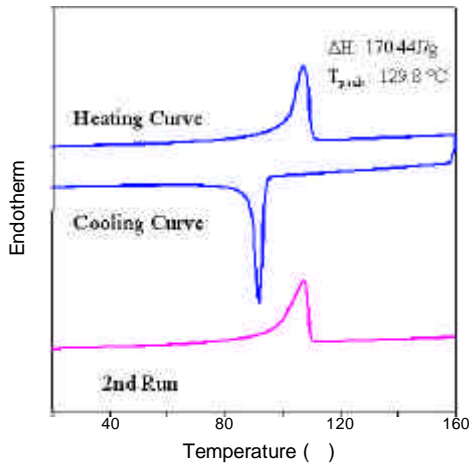
1(HDPE가 27 wt% UHMWPE( ; 2400000) 3 wt% ), 2(HDPE 가 27 wt% UHMWPE( ; 2400000) 1.5 wt% UHMWPE( ; 3400000) 1.5 wt% ), 3(HDPE가 27 wt% UHMWPE( ; 3400000) 3 wt% ), 4(HDPE가 24 wt% UHMWPE ( ; 2400000) 2 wt% UHMWPE ( ; 3400000) 4 wt% ) UHMWPE 4 wt% 가



**Figure 1.** Mechanical strengths of separator according to the polymer blending and extension conditions. (1) HDPE(27 wt%)/UHMWPE(M<sub>w</sub>: 240000, 3 wt%); sample 1, (2) HDPE(27 wt%)/UHMWPE(M<sub>w</sub>: 240000, 1.5 wt%)/UHMWPE(M<sub>w</sub>: 340000, 1.5 wt%); sample 2, (3) HDPE(27 wt%)/UHMWPE(M<sub>w</sub>: 340000, 3 wt%); sample 3, and (4) HDPE(24 wt%)/UHMWPE(M<sub>w</sub>: 240000, 2 wt%)/UHMWPE(M<sub>w</sub>: 340000, 4 wt%); sample 4.

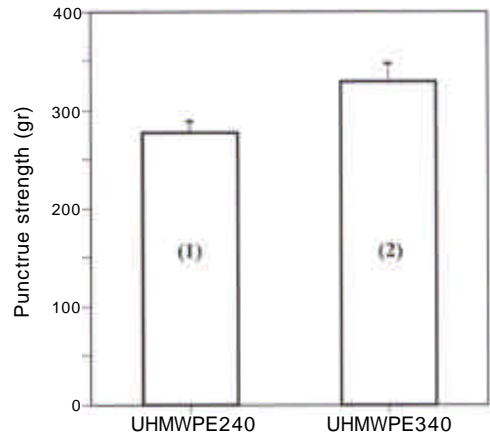
가 8 × 10<sup>5</sup>  
 4%, 1.5 × 10<sup>6</sup> 3%, 4 × 10<sup>6</sup>  
 1% UHMWPE  
 가 UHMWPE

Figure 1 UHMWPE  
 가  
 240000 340000 UHMWPE  
 10% , Figure 1  
 (2), (3), (4) 가  
 3400000 UHMWPE , 4  
 650 kg/cm<sup>2</sup>



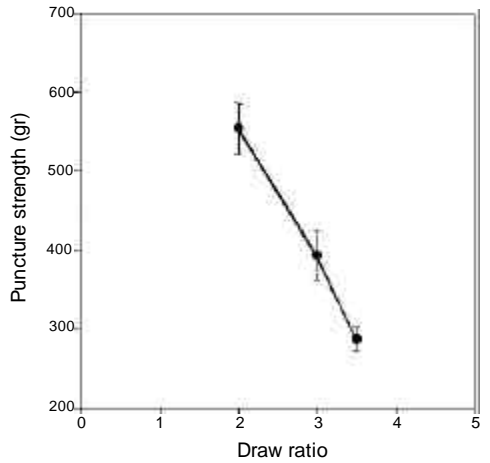
**Figure 2.** DSC Thermogram ; sample 3.

Separator



**Figure 3.** Puncture strengths according to the polymer blending (HDPE : UHMWPE=27 : 3). (1) sample 1 (UHMWPE,  $M_w$  : 240000) and (2) sample 3 (UHMWPE,  $M_w$  : 340000).

separator UHMWPE  
 가 가  
 UHMWPE 6 wt%  
 (Figure 1(4)), 5 1000 kg/cm<sup>2</sup>  
 UHMWPE  
 UHMWPE  
 10 wt%  
 separator  
 6 wt% 1, 2, 3  
 2~4  
 5  
 DSC , Figure  
 2 129.8  
 separator 가  
 가  
 dentrite  
 separator가  
 separator  
 Figure 3 240000 UHMWPE  
 340000 UHMWPE HDPE 27:3  
 (25 mm)



**Figure 4.** Puncture strength according to the draw ratios; sample 3.

UHMWPE가 가  
 (Figure 3),  
 (Figure 4). , Figure 4  
 가 가  
 separator

가  
Separator  
Li

dentrite가

가

SEM  
Figure 5 6

porometer

separator

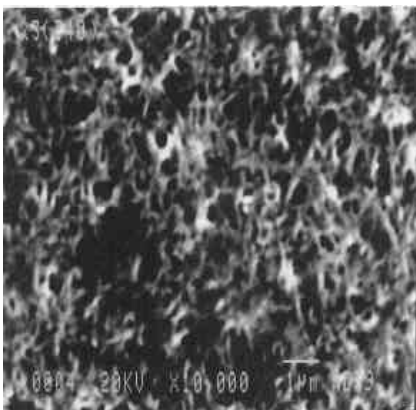
Figure 5

0.10~0.12  $\mu\text{m}$

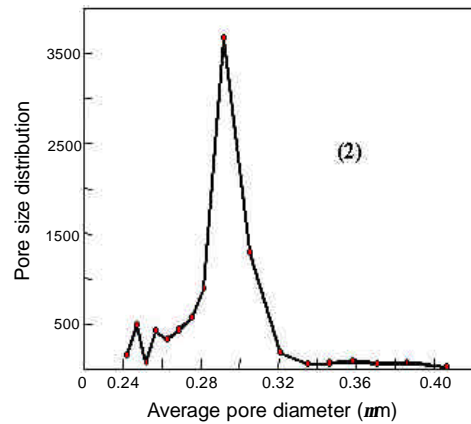
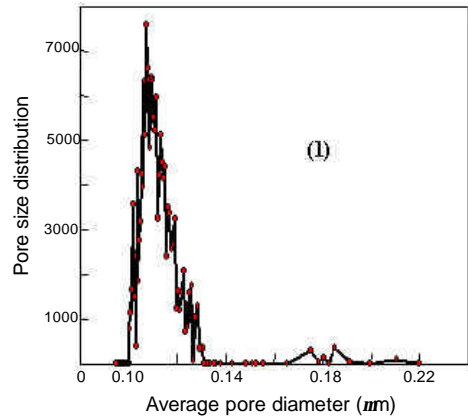
2

Separator

가



**Figure 5.** SEM photograph of the surface ( $\times 10000$ ); sample 3.



**Figure 6.** Pore size distribution of Separator measured by Porometer; sample 3. (1) solvent extraction after extension and (2) extension after solvent extraction.

가

auto perm - porometer

(Figure 6). Figure 6 (1)

separator

, Figure 6 (2)

separator

0.10 0.13  $\mu\text{m}$

(Figure 6 (1)),

separator

0.24 0.34  $\mu\text{m}$

(Figure 6 (1))

Separator

Chemical separator Mitsui Chemical Asahi  
 separator Tonen separator 가  
 가 가  
 separator 가  
 shut - down Shut - down 가  
 separator가 가  
 separator  
 shut - down separator  
 Figure 7 separator  
 shut - down 130  
 가  
 가  
 160 가 가  
 Separator가  
 가  
 short 가  
 Separator Figure 7  
 Separator Shut - down 가  
 ( )가 가  
 Shut -  
 down separator  
 PE 130~160  
 , shut - down  
 가  
 shut - down  
 2  
 separator UHMWPE HDPE  
 UHMWPE

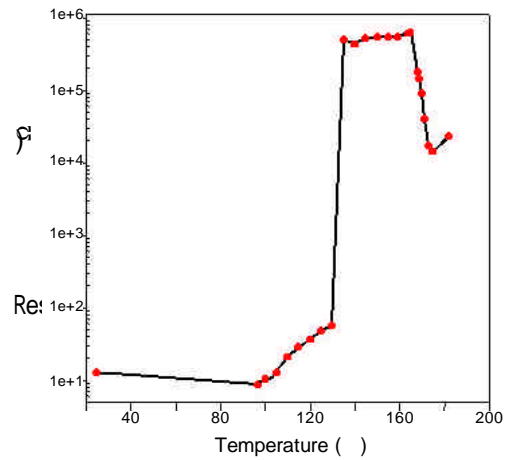


Figure 7. Shut - down curve ; sample 3.

HDPE UHMWPE 가 9:1  
 2 separator  
 UHMWPE  
 UHMWPE  
 6 wt% 5 1000 kg/cm<sup>2</sup>  
 separator 0.1~0.13  $\mu$ m  
 , shut - down 130  
 160

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