Ion mobility and tortuosity of the pathways in separator membranes

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Ionic mobility governs the high-rate charge-discharge performance of the battery system. In order to improve the battery power, mobilities of the carrier ions not only of the electrolyte itself but also in separator and electrode sheets have to be increased.
The process for making lithium-ion battery separators can be broadly divided into dry and wet processes. The dry process involves melting a polyolefin resin, extruding it into a film, thermally annealing it to increase the size and amount of lamella crystallites, and precisely stretching it to form tightly ordered micropores.[1] It is expected that the ionic mobility in the separator membrane depend on the chemical composition and crystallinity of the material, and porous morphology such as the pore size and tortuosity[2, 3] of the pathway for ion transport.
In this research, we prepared porous morphological samples composed of the polyethylene (PE) particles and measured the ionic conductivity and diffusion coefficients of them filled with the electrolyte solution in order to investigate the dominant factors of ionic mobility associated with the structural features of the ion transport pathways.
We prepared three types of materials, 1) pasty composition of polyethylene (PE) particles (figure 1) and electrolyte solution (1 M $LiPF_6$ in 1:1 (v/v) ethylene carbonate (EC)/diethyl carbonate (DEC)), 2) compression molded plate of PE particles with the solution, and 3) conventional PE separator membrane[4] prepared by wet method with the solution. Table 1 shows the comparison of the volume ratio of the solution in each sample.
We would like to discuss the correlation between the ionic mobility and tortuosity or interactive effect of the ion transport pathways based on the analyses of conductivity and diffusion coefficients.

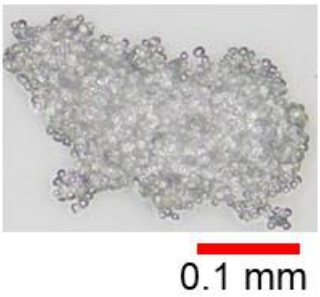

Figure 1 A snapshot of fine particles without electrolyte solution

Table 1 Volume ratio of the pore space of three samples

	PE Compression	PE Past			PE Separator
Porosity [vol.%]	42	45	50	55	54

References:
[1] Pankaj Arora and Zhengming (John) Zhang, Chem. Rev. 104 (10) (2004) 4419–4462.
[2] Norman Epstein, Chemical Engineering Science 44(3) (1989) 777-779.
[3] D. Djian et al., Journal of Power Sources 172 (2007) 416-421.
[4] Y. Saito et al., J. Phys. Chem. C 121 (2017) 2512-2520.