論 文 の 内 容 の 要 旨

論文題目　Solid polymer electrolyte based on polyrotaxane
(ポリロタキサン固体電解質)

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Solvent-free solid polymer electrolyte (SPE) that can work as separator and electrolyte in the same time is a promising material for the fabrication of lithium battery. It has been proved to enhance the safety of lithium battery by suppressing the growth of lithium dendrite[1]. Furthermore, the light weight and flexible liquid-free batteries can also be fabricated with SPE[2]. However, the ionic conductivity of SPE has been too low to be commercially available[3]. PEG is the most studied SPE material because the backbone ether bonds in PEG provides flexibility and hence high chain mobility and dipole moment leading to high dissociating efficiency of lithium salt[4]. However, the most of PEG crystalizes and loses mobility, and thus reduces the conduction of lithium ions.

In this work, we introduce a new “mobile crosslink” concept to the fabrication of solid polymer electrolyte by crosslinking the polyrotaxane that comprises of poly(ethylene glycol) (PEG) and α-cyclodextrin (α-CD). The axis PEG can contribute to the conduction of lithium ions and the crosslinked CDs that are not chemically bound to the PEG can form the mobile crosslink which is able to suppress the crystallization of PEG and the mobility of PEG is also expected to be preserved even after crosslinking reaction. However, the strong hydrogen bonding comes from the abundant hydroxyl groups on CDs have restricted the mobility of PEG chain and cause the low ionic conductivity. To eliminate the effect of hydrogen bonding, functionalizing agent was applied. By adding appropriate amount of propyl isocyanate as functionalizing agent, the SPE had an enhanced ionic conductivity and good mechanical property which are essential for SPE.

To further enhance the ionic conductivity and ductility of polyrotaxane based SPE, macromolecular crosslinker that can prevent the aggregation of cyclodextrins as well as conducts the lithium ion were applied to the fabrication of SPE. In this research, we used two kinds of crosslinking reaction to make the polyrotaxane based SPE with macromolecular crosslinker. The SPE crosslinked by macromolecular Poly(ethylene glycol) diglycidyl ether (PEGDE) shows a great enhancement in both ionic conductivity and ductility compared with the SPE crosslinked by short ethylene glycol diglycidyl ether (EGDE). By applying the two-step process, the loading of the PEG crosslinker was promoted and the ionic

conductivity of the SPE was enhanced to 10^{-5} S/cm. The unique mechanical property which the strength was not affected by heating makes it a valuable SPE material in the fabrication of lithium battery.

In the last part of the research, single ion conducting SPE was made from the ionized polyrotaxane. We successfully synthesized ionized polyrotaxane with LiOH and 1,3-propane sultone and make the SPE by hot-pressing method. Due to the low ionic conductivity of the ionized polyrotaxane based SPE, graft polyrotaxane with flexible ion conducting PCL block was also used to make the single ion conducting SPE. **Figure 1** shows the summary of the overall research.

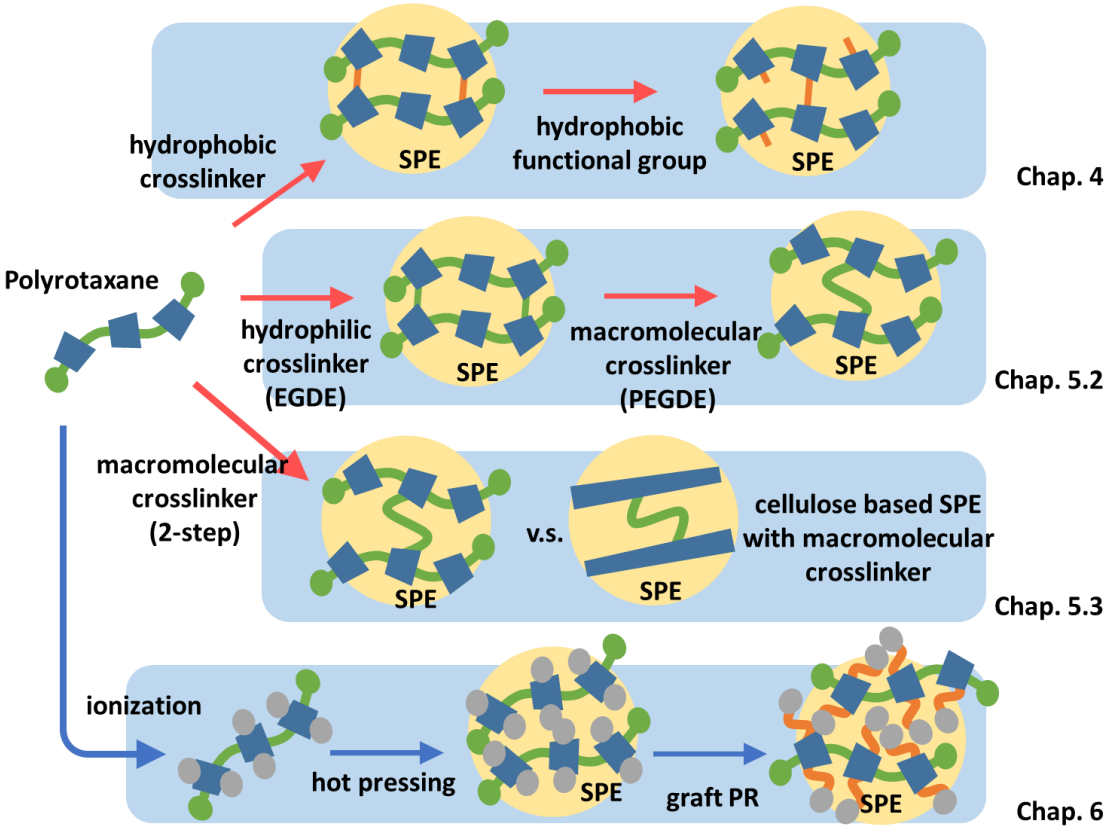

Figure 1. Summary of the research

References

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