

Preparation of high ion conductive $\text{Li}_2\text{S}-\text{P}_2\text{S}_5$ solid electrolytes by a liquid phase process

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Summary

Sulfide solid electrolytes in the $\text{Li}_2\text{S}-\text{P}_2\text{S}_5$ system were synthesized by an instantaneous liquid phase process under ultrasonic irradiation and heat treatments at low temperatures [1]. The study revealed that the formation and distribution of PS_4^{3-} , $\text{P}_2\text{S}_7^{4-}$ and $\text{P}_2\text{S}_6^{4-}$ units in the local structure of the sulfide electrolytes are key factors to achieve higher ionic conductivity.

Methods

Li_2S and P_2S_5 were mixed in anhydrous acetonitrile. Each mixture was ultrasonicated at 60°C for 30 min under 28 kHz using an ultrasonic bath. A drying process at 180°C was applied for 3 h under vacuum to remove the solvent and obtain solid powders. Subsequently, the powders were heat treated at 220°C or 250°C for 1 h to promote the crystallization. Crystal phase, structure, morphology and ionic conductivity of the sulfide electrolytes were examined.

Results and conclusions

Heat treatment at 220°C was enough to promote the formation of the $\text{P}_2\text{S}_7^{4-}$ units, favoring a high ionic conductivity. The heat treatment at 250°C promote the formation of the $\text{P}_2\text{S}_6^{4-}$ units leading to the reduction of the ionic conductivity. A small particle size of around 500 nm was observed. The heat treatment temperatures do not significantly affect the powder morphology. The $\text{Li}_7\text{P}_3\text{S}_{11}$ crystalline phase was observed in the XRD patterns of all the studied compositions after the heat treatment at 220°C . However, the distribution of P_xS_y units was different for each composition. A higher Li_2S content promotes a higher formation of $\text{P}_2\text{S}_7^{4-}$ units, which was found to be determinant to obtain high ionic conductivity. The high ionic conductivity of $1 \times 10^{-3} \text{ S cm}^{-1}$ at 22°C was obtained in the solid electrolyte with Li_2S content of 74 mol% after the heat treatment at 220°C . The ionic conductivity of the sulfide electrolytes synthesized by the liquid phase process exhibited a similar behavior to that of the glasses synthesized by mechanical milling [2] (at higher Li_2S content, higher ionic conductivity).

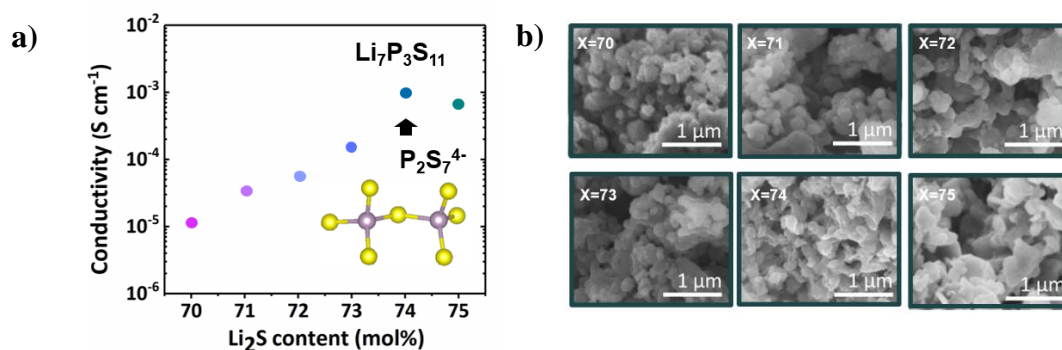


Fig 1. a) Ionic conductivity and b) SEM micrographs of the $x\text{Li}_2\text{S} \cdot (100-x)\text{P}_2\text{S}_5$ solid electrolytes.

References:

- [1] Calpa, M., Rosero-Navarro, N. C., Miura, A., & Tadanaga, K, RSC Advances 7.73 (2017): 46499-46504.
- [2] F. Mizuno, A. Hayashi, K. Tadanaga and M. Tatsumisago, Solid State Ionics, 2006, 177, 2721-2725.