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Synthesis and characterization of Na_3PS_4 and $Na_{2.85}P_{0.85}W_{0.15}S_4$ as solid electrolytes

Alisson A. Iles¹, Marta Mirolo¹, Sergio F. Mayer²

¹ European Synchrotron Radiation Facility, Grenoble, France ² Laboratoire d'Electrochimie et de Physico-chimie des Matériaux et des Interfaces (LEPMI), Grenoble, France L <u>e</u> P MI Grenoble - Chambéry UGA Université **Grenoble Alpes**



PS_4 Na

INTRODUCTION

The next generations of postlithium systems are already under development. These hold the promise of overcoming some of the remaining challenges associated with current lithium-ion battery technology related to safety, the need for scarce resources and their environmental impacts. **Figures obtained** from [1] and [2]



PROBLEM



Na as a solution?



Na₃PS₄ (NPS) is a sodium superionic conductor that

METHODOLOGY

Mechanochemical synthesis following procedure described in [3].



Fritsch Pulverisette 7

Operation conditions: Rotation speed: 600 rpm

ZrO2 jars and

grinding balls

• Balls size: 10 mm • Milling time: 40 min

Disk rotation

Material characterization - XRD

TECHNIQUES AND RESULTS

(110)

(200)

Intensity [a.u.]

NPS

 WS_2





SEM - Energy Dispersive X-ray (EDX)





Cross-section of the pellets (NPS and NPWS)

Jar rotation

Na2S Departure materials

Heat treatment (HT) based on procedure described in [4].

Sample HT-1

Sample HT-2 (NPS only)

• **HT**: 270°C, 1.5 h

- **HT**: 300°C, 16 h
- Atmosphere: vacuum, pellet contained in Macor® spacer disk
- Atmosphere: argon, pellet covered by Na₂S in alumina crucible





S

 \mathbf{O}

- Evidence of reaction with Macor® holder during with treatment due to the presence of O and Si in the samples.
- Presence of high porosity.

View of the contact surface between Macor® and electrolyte



Electrochemical characterization - EIS



References

- [1] J. F. Peters, M. Baumann, J. R. Binder, and M. Weil, "On the environmental competitiveness of sodium-ion batteries under a full life cycle perspective-a cell-chemistry specific modelling approach," Sustain. Energy Fuels, vol. 5, no. 24, pp. 6414-6429, 2021, doi: 10.1039/d1se01292d.
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- ESRF The European Synchrotron 71 Avenue des Martyrs, Grenoble, FRANCE Tel +33 (0)4 76 88 20 00

CONCLUSIONS

- X-ray diffractograms show a cubic crystalline phase of Na₃PS₄ and a mixture of Na₃PS₄ and WS_2 for the $Na_{2.85}P_{0.85}W_{0.15}S_4$ sample.
- SEM-EDX results confirmed that a reaction occurs between the sample holder (Macor®) and the solid electrolytes during the heat treatments.
- Electrochemical results show that a heat treatment under Ar slightly improves the ionic conductivity for the NPS sample, while the HTs in presence of Macor® spacer turn the materials into ionic insulants.