

Development and Characterization of Perovskite Based Solid Electrolytes for Solid-State Lithium-Ion Batteries

Ramin Jahangirov^{1,3}, Berke Pişkin^{1,2,3}

¹Mugla Sıtkı Kocman University Dep. of Energy, Muğla, Turkey

²Mugla Sıtkı Kocman University, Engineering Faculty, Dept. of Metallurgical and Materials Engineering, Muğla, Turkey

³Energy Materials Laboratory, Muğla Sıtkı Koçman University, Muğla, Turkey

Liquid electrolytes cause safety problems used in lithium-ion batteries during overcharge-discharge and cause fires and explosions. This is due to the low operating temperature of liquid electrolytes (-15 to 60 °C) [1]. One solution to this problem is to switch from organic liquid electrolytes to solid electrolytes which have resistant to high temperatures. However, one of the most important obstacles to the use of solid electrolytes is their low ionic conductivity (on the order of 10^{-4} S/cm) [2]. The perovskite-oxide family which has ABO₃ structure draws attention due to its high ionic conductivity (10^{-3} S/cm), wide operation temperature (usually -40 to 150 °C). However, the ionic conductivity of the perovskite oxide family is not as high as the liquid electrolyte conductivity (10^{-2} S/cm), which limits their usage for practical applications. That is why there are studies focusing to enhance the ionic conductivity of perovskite oxides. One of the most important strategies is that doping A-site with an element having large ionic radius. The reason is that it causes an increase in ionic conductivity with expansion of octahedral channels in the A-site where Li ions are transported [3].

In this study, $\text{Li}_{1-x}\text{M}_x\text{FeO}_3$, ($x=0,1, 0,3, 0,5, 0,7, 0,9$) (M=Sr, Ba, Ce ($r=1.44, 1.61, 1.34$ Å)) were selected which was synthesized by Pechini method. It was aimed to observe effect of A-site doping and have higher ionic conductivity ($>10^{-3}$ S/cm). LCFe371, LBFe371, and LSF371 perovskites were synthesized with/without pH control to obtain perovskites without an impurity. The produced perovskites have been subjected to calcination at 900 °C for 6 hrs. X-ray diffraction (XRD) was performed to determine the crystal structure of perovskite materials synthesized. XRD patterns were collected with a scan rate of 2°/min as shown in Figure 1.

In conclusion, under the same experimental conditions, it was observed that the addition of Sr resulted in the formation of a cubic structure in the synthesized perovskites, while the addition of Ba led to the formation of a hexagonal structure. In both structures, LiFeO₂ was formed as a secondary phase. In the case of the Ce-doped structure, the formation of a perovskite structure was not observed. When the pH was adjusted to 7.5 for all three compositions, although there was

a slight increase in material purity, the overall results remained the same (Figure 1).

To overcome this issue, in the next step, the calcination temperature will be increased to 1000 °C for the analysis.

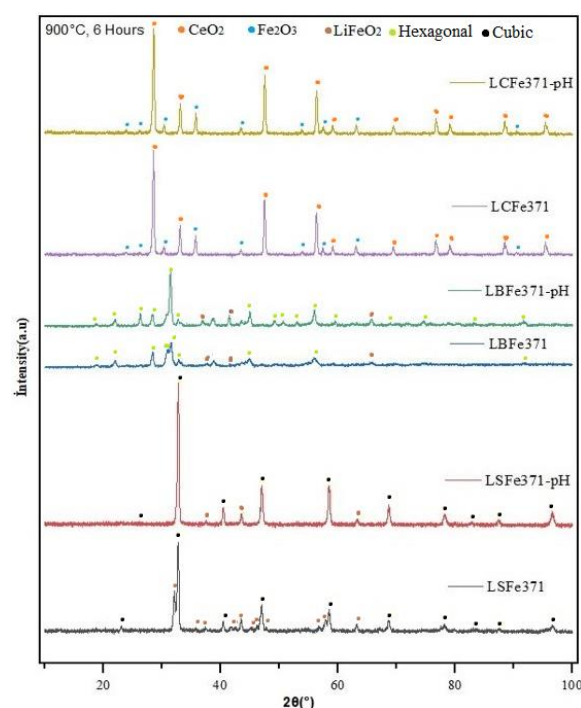


Figure 1. XRD model of pH comparison of LSF, LBF, LCF.

After obtaining the perovskite materials in their pure form, impedance spectroscopy (EIS) will be employed to measure the ionic conductivity of the samples.

References

- [1] Jiang, L., Wang, Q., Li, K., Ping, P., Jiang, L., & Sun, J. (2018). *Sustainable Energy & Fuels*, 2(6), 1323–1331.
- [2] Yue, L., Ma, J., Zhang, J., Zhao, J., Dong, S., Liu, Z., Cui, G., & Chen, L. (2016). *Energy Storage Materials*, 5, 139–164.
- [3] Takada, K. (2013). *Progress and prospective of solid-state lithium batteries. Acta Materialia*, 61(3), 759–770.



Ramin Jahangirov, Graduate Student at Sıtkı Koçman University, Department of Energy. Graduated from Azerbaijan Oil and Industry University in 2021. His research interest is solid lithium-ion batteries / solid electrolytes, and renewable energy sources.

Ramin Jahangirov, e-mail: 2142110703@posta.mu.edu.tr tel: +90 5528270357