Design of Composite SOFC Cathodes via Spray Pyrolysis: Synergistic Effects of Perovskite and Ruddlesden–Popper Phases

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doi: 10.5937/MESCIS26018C

Intermediate-temperature solid oxide fuel cells (IT-SOFCs, 600–800 °C) have attracted considerable attention due to their potential for high efficiency and reduced operating costs. However, the sluggish oxygen reduction reaction (ORR) kinetics at lower temperatures remains a key limitation, making the development of high-performance cathode materials essential.

Perovskite-type oxides such as LSC113 exhibit high electronic conductivity and excellent catalytic activity, whereas Ruddlesden–Popper (RP) phases like LSC214 provide enhanced oxygen ion transport and improved structural stability. The combination of these two structures is expected to synergistically enhance both surface oxygen exchange and bulk diffusion processes. In addition, Fe-containing counterparts (LSCF-based systems) offer improved thermal stability and better compatibility with electrolyte materials.

In this study, composite cathodes based on LSC and LSCF based systems were synthesized using a solution-assisted deposition approach that enables the formation of homogeneous and porous microstructures. The electrochemical performance of the prepared cathodes was evaluated through area-specific resistance (ASR) measurements to assess their ORR activity and identify compositions with improved performance for intermediate-temperature SOFC applications.

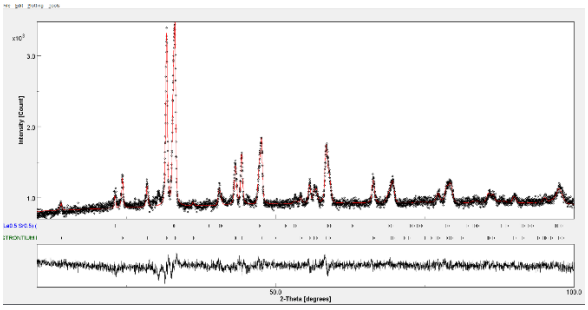


Figure 1. XRD plot of LSC113 and LSC214 cathode material coated on GDC by Ultrasonic Spray Pyrolysis.

The precursor solution used for the coating process was prepared using a solution-based approach involving metal salts dissolved in a mixed solvent system. The synthesis parameters were adjusted to obtain a stable solution suitable for controlled deposition, and further optimization was carried out based on experimental observations.

X-ray diffraction analysis (Figure 1) revealed that the synthesized sample predominantly consists of an RP-type phase, accompanied by a minor perovskite contribution. This indicates that the selected synthesis conditions favor the formation of the RP structure while allowing partial coexistence of both phases. The refinement results demonstrated good agreement between experimental and calculated patterns, confirming the reliability of the phase identification and structural analysis.

A solution-based deposition technique (Figure 2) was employed for the fabrication of SOFC cathodes, offering several advantages over conventional methods. One of its key benefits is the ability to produce homogeneous and compositionally controlled films, which is particularly important for multi-component oxide systems such as LSC and LSCF. The process enables the formation of fine and uniform microstructures with high surface area and tailored porosity, which are essential for enhancing oxygen reduction reaction (ORR) kinetics.

In addition, the employed approach provides a scalable and cost-effective route for coating on various substrates, including complex geometries. It also allows flexible control over processing conditions, facilitating the optimization of cathode performance. Furthermore, the direct formation of oxide phases during deposition minimizes the need for extensive post-treatment steps, making this technique a promising strategy for the development of efficient and high-performance SOFC cathodes.

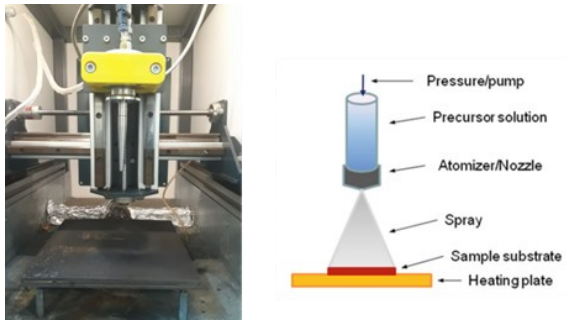
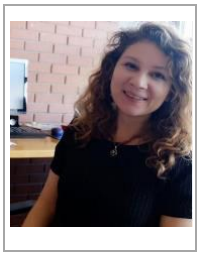


Figure 2. Ultrasonic Spray Pyrolysis.

References

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