

Development of a Novel Solid Oxide Cell Material for on-demand Production of Hydrogen and Electricity

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Reversible solid oxide cells (RSOCs) are known for producing green hydrogen in electrolytic cell mode and, in reverse, producing electricity in fuel cell mode. Hence, RSOCs have the advantage of enabling the on-demand production of hydrogen and electricity and solving the problem of intermittent supply of renewable energy.¹

However, the commercialization of RSOCs has been hindered by the need for efficient materials suitable for operation as solid oxide electrolytic cell and solid oxide fuel cell electrodes. Furthermore, multiple electrochemical requirements, including catalytic and electrochemical stability, must be met in materials needed for RSOCs electrode fabrication.

Developing materials capable of enhanced exsolution process offers some possibilities for solving this problem. Exsolution entails the segregation of metallic cations to form highly active and anchored nanoparticles on the surface of a perovskite lattice – enhancing catalytic and electrochemical stability in the material. Forming such nanoparticles within the bulk of the perovskite lattice (bulk exsolution) has recently improved ionic conductivity.^{2,3}

Therefore, this research sought to develop a novel perovskite material that is capable of surface and bulk exsolution processes to fulfil the stability and electrochemical requirements of RSOCs.

Five potential precursor materials were studied to ascertain their suitability and develop a synthesis route for the novel perovskite material. The study involved detailed characterization of the potential precursor materials via thermogravimetry analysis (TGA), scanning electron microscopy (SEM), and X-Ray diffraction (XRD) analysis.

The TGA results revealed Fe_2O_3 , NiO , SrO and CaO as the decomposition products of the respective precursor materials, which are valuable oxides desired in the novel perovskite. However, TiO_2 was stable within the other precursors' decomposition

temperature range (50 – 900 °C). The TGA result, therefore, predicted that the chemical reaction to form the

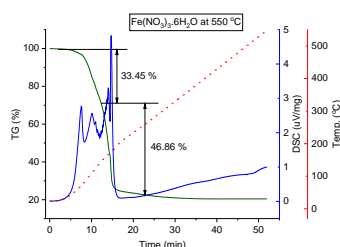


Fig. 1. A TG curve, DSC curve, and temperature response for $\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$

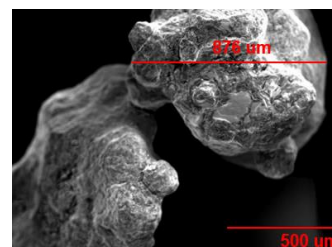


Fig. 2. The SEM image of $\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$

desired perovskite would likely be in the temperature range of 600 – 1000 °C. Hence, a modified solid-state synthesis method was adopted for the novel perovskite synthesis. Fig. 1. shows a combine thermogravimetry (TG) curve, differential scanning calorimetry (DSC) curve and temperature response for $\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$, while Fig. 2. shows the SEM image for $\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$. The TG curve shows the change in weight of the material with respect to temperature and time while the DSC curve shows the different chemical reactions and phase changes during the process. Therefore, TGA result can give additional information like the purity and stability of a material.

From the two different compositions of the perovskite samples synthesized already, it can be concluded that homogeneous mixing of the precursors prior to their calcination encouraged homogeneous dispersion of species in the perovskite particles.

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