



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

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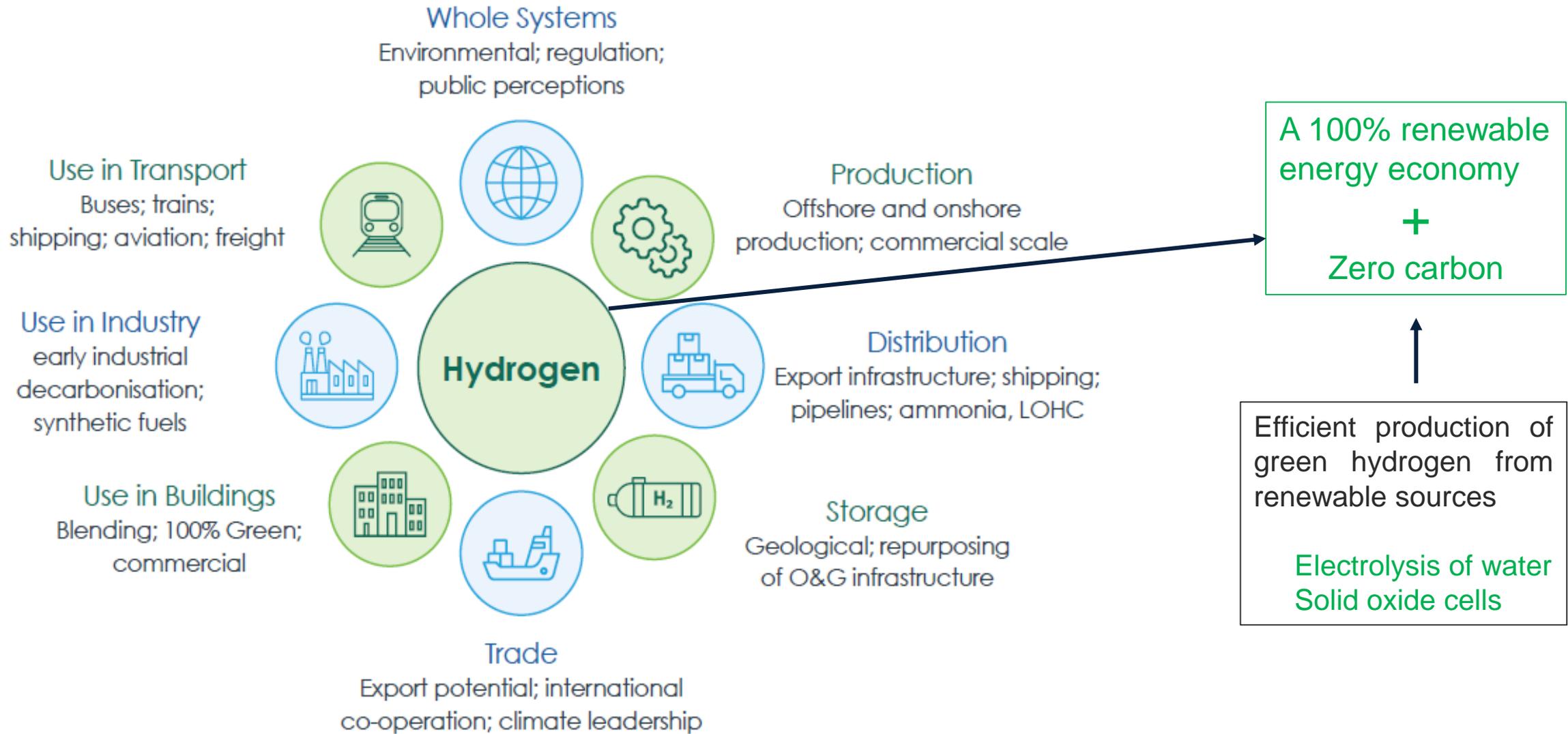
14th June 2023

Presentation Outline

- ❖ Introduction
- ❖ Background of the Study
- ❖ Research Focus
- ❖ Materials and Method
- ❖ Results
- ❖ Conclusion

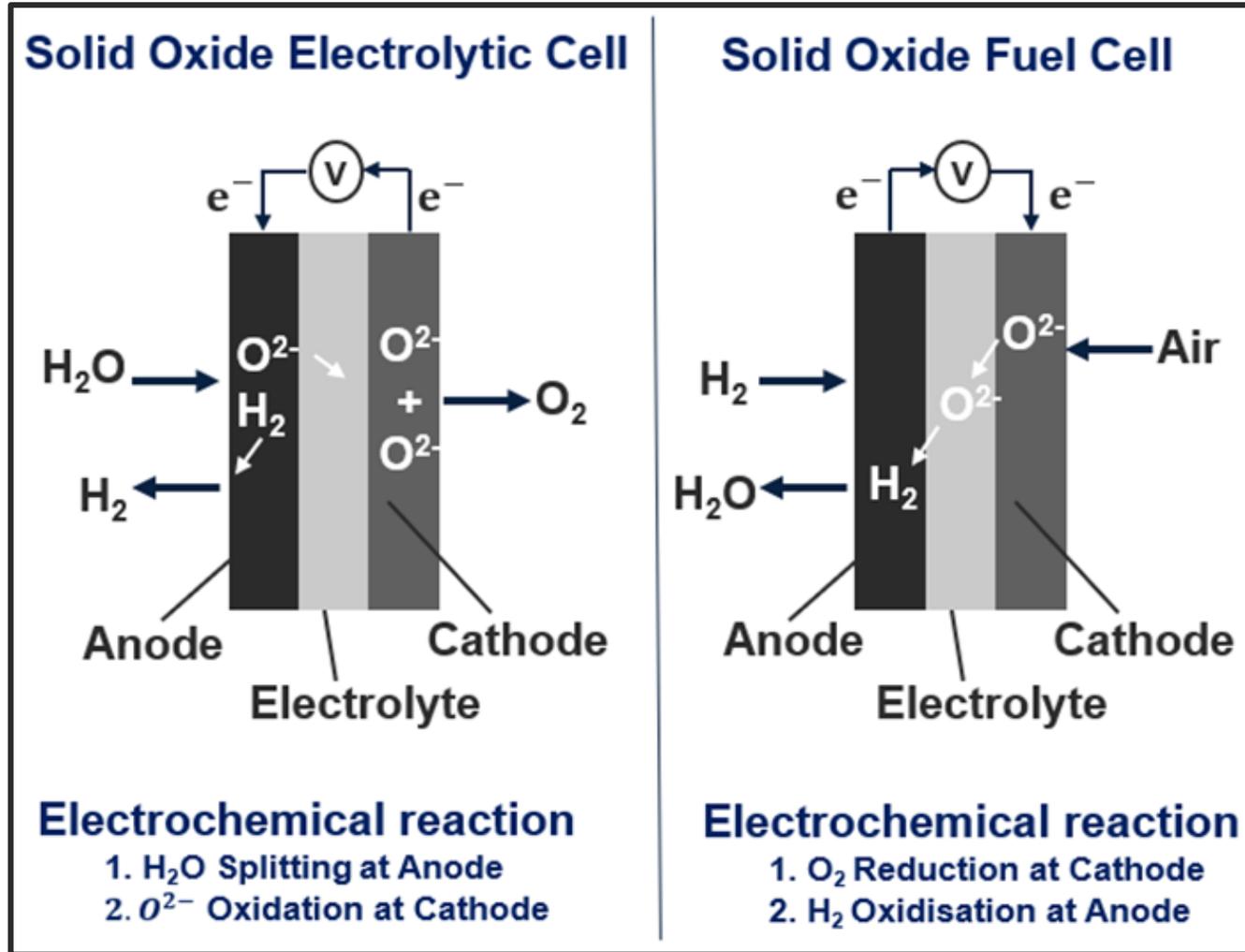
Introduction

❖ A Net-zero or Hydrogen Economy



Background of the Study

❖ Solid Oxide Cells

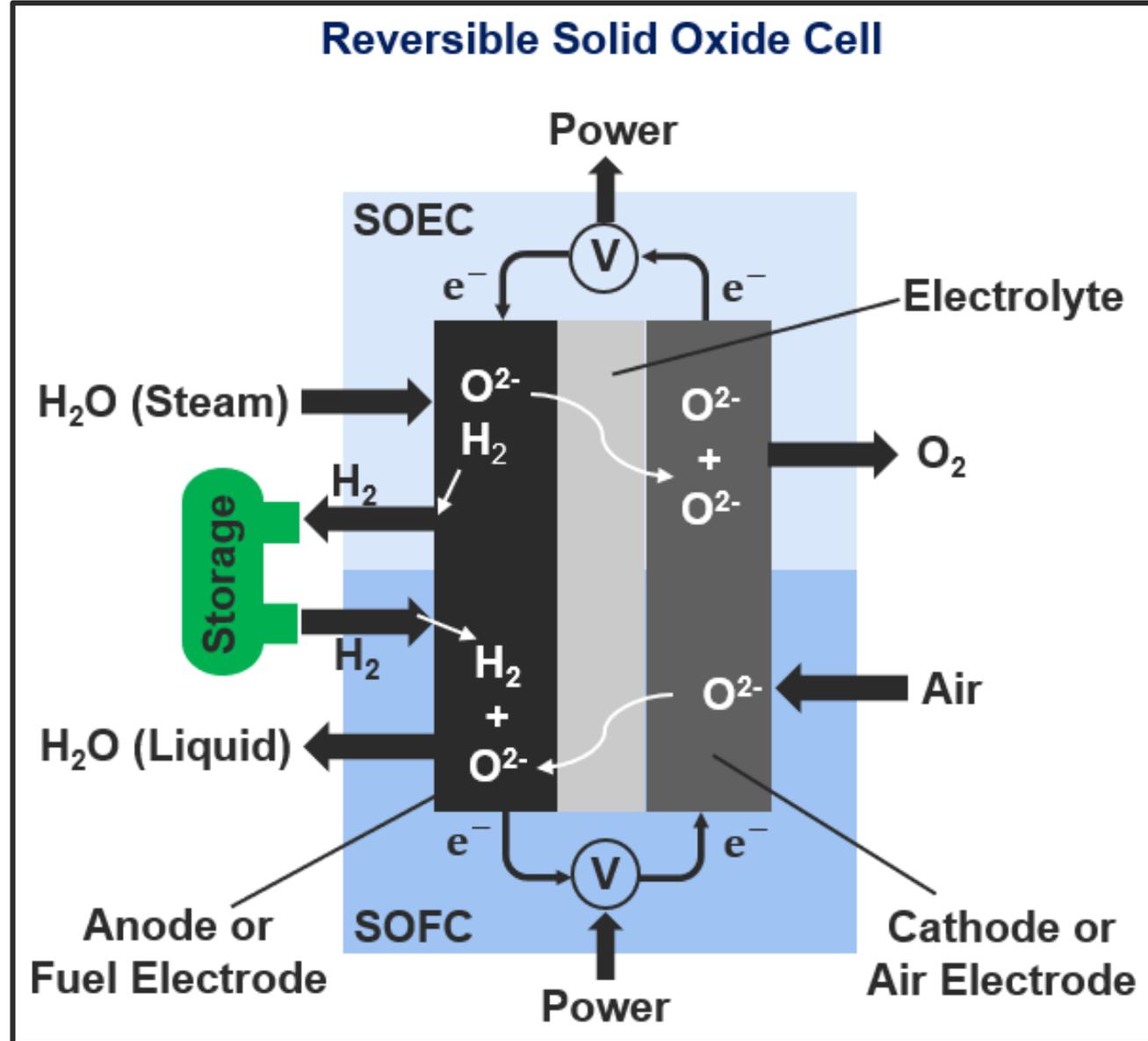


Challenges

- ❑ Stability and durability of the catalyst for extended usage

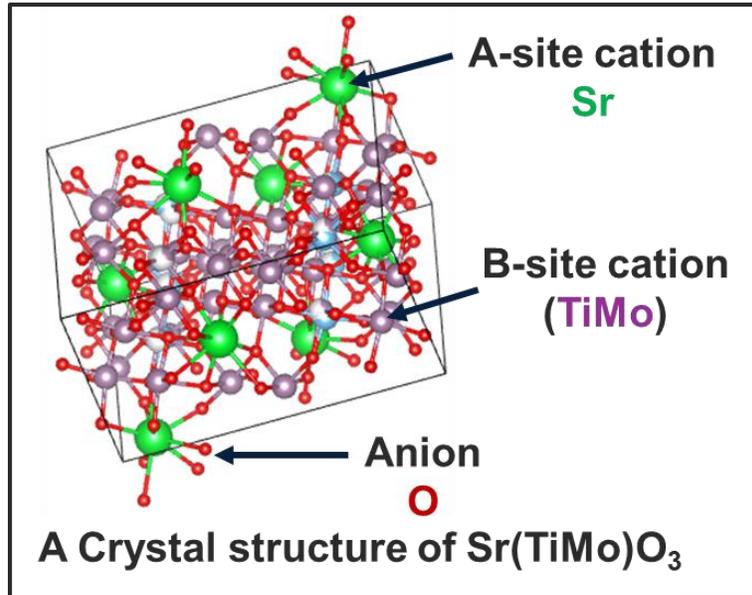
Background of the Study

❖ The Reversible Solid Oxide Cell (RSOC)



Background of the Study

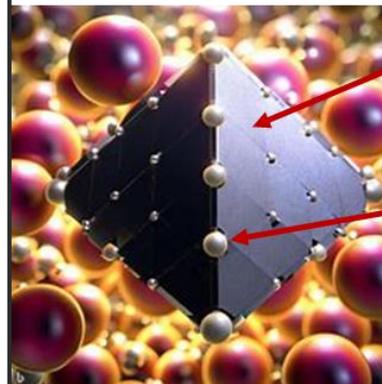
❖ The Need for a Novel Perovskite Material



The Challenges of RSOCs

- The Multiple Electrochemical Requirements of RSOCs:
 - ❑ High ionic and electronic conductivity,
 - ❑ High catalytic activity.
- Cell components' stability

Innovate Material



Perovskite Material

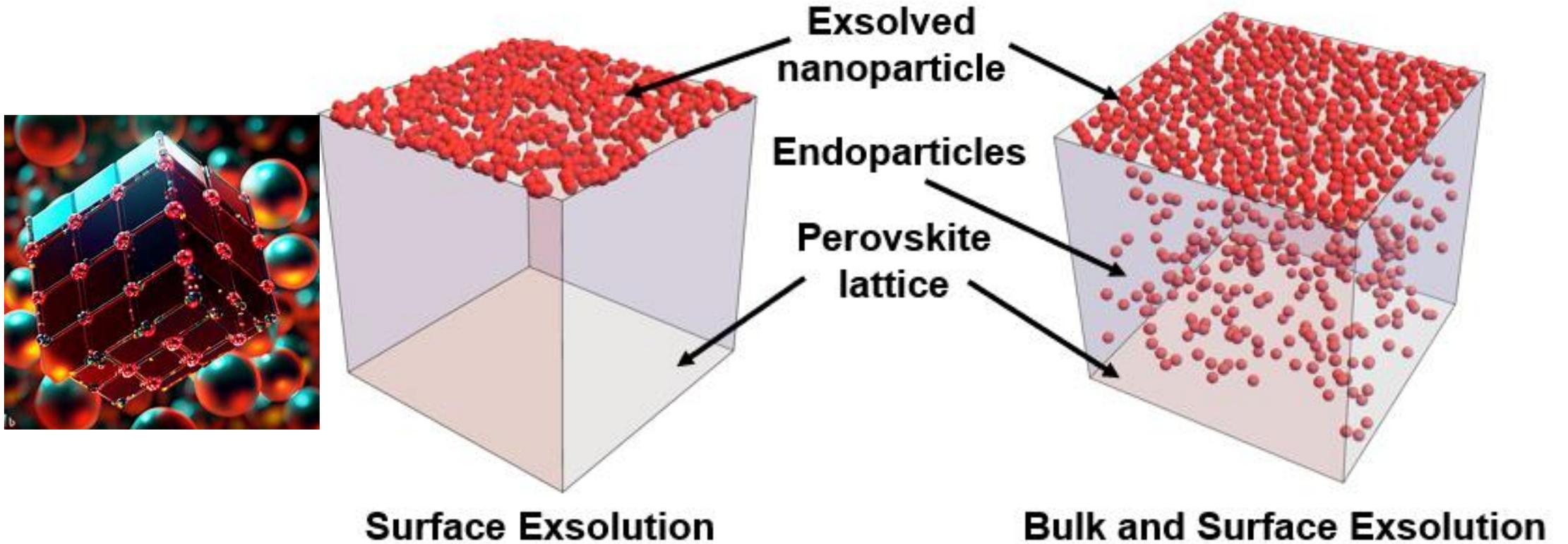
- Properties tuning?
- Exsolution rate?
- ...?

Exsolved nanoparticle

- How many?
- Where?
- What size and shape?
- Catalytic activity
- ...?

Background of the Study

❖ The Exsolution Process



Research Focus

This research aims to develop a novel perovskite material capable of surface and bulk exsolution to fulfil the multiple electrochemical requirements of RSOC.

❖ Target Material

An A-site deficient perovskite of the family with a $(\text{Sr,Ca})_{1-\alpha}(\text{Ti,Fe,Ni})\text{O}_3$ stoichiometry.

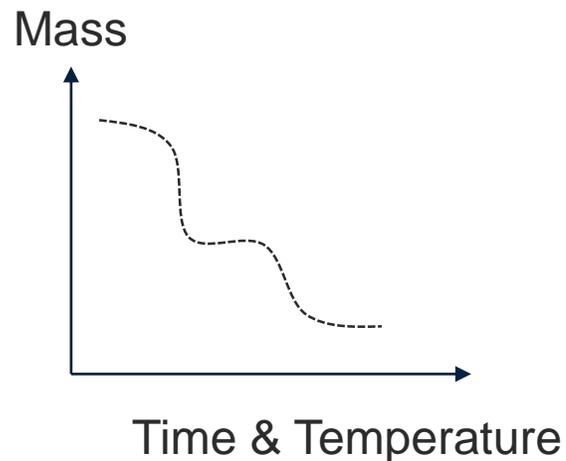
Materials and Method

❖ Materials selection and study of parameters related to the new perovskite material synthesis

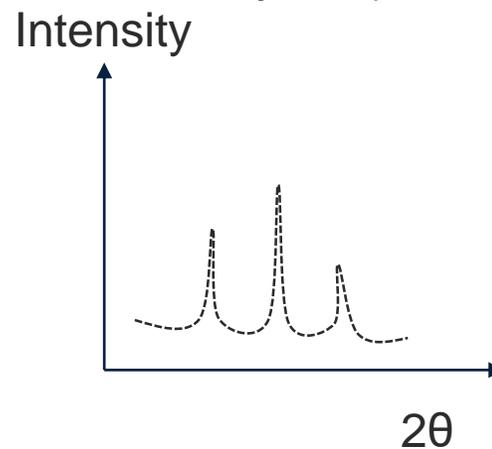
✓ Characterization of potential precursor materials:

$\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$, $\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$, CaCO_3 , SrCO_3 , TiO_2 , CuNO_3

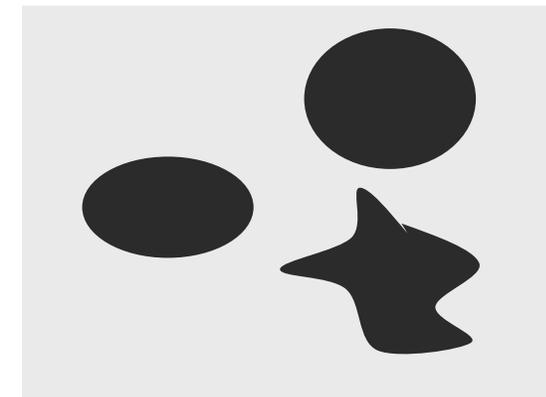
Thermogravimetry analysis (TGA)



X-Ray diffraction analysis (XRD)

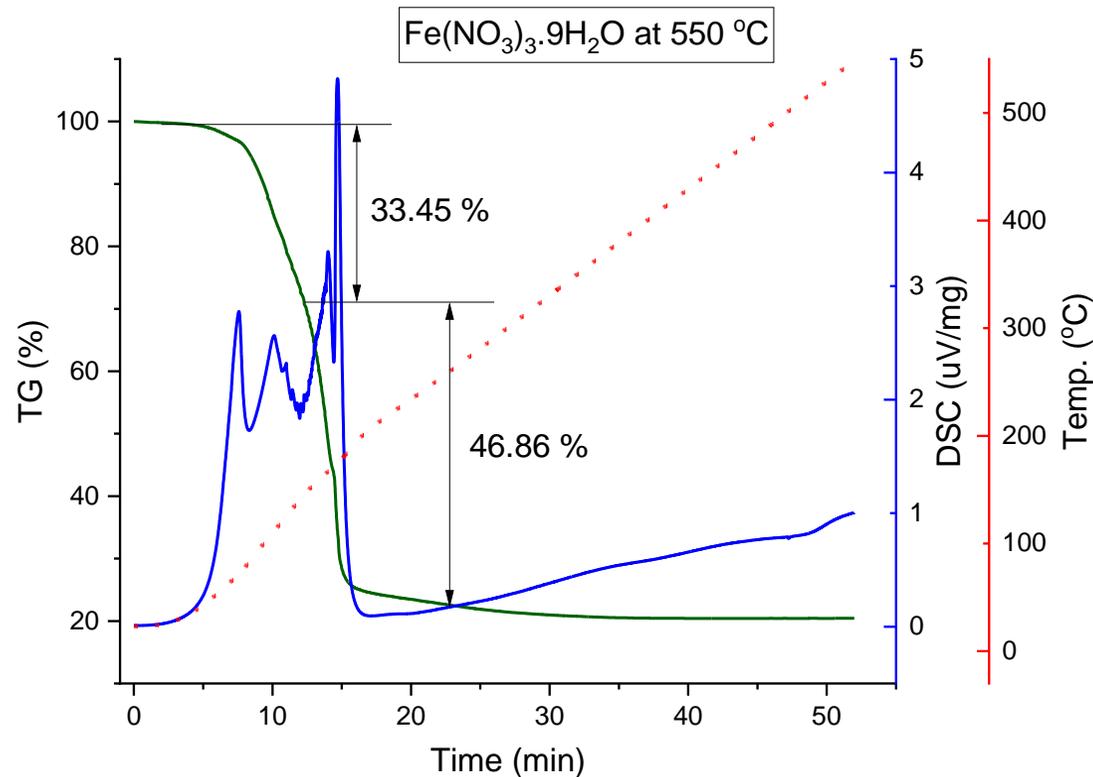


Scanning electron microscopy (SEM),

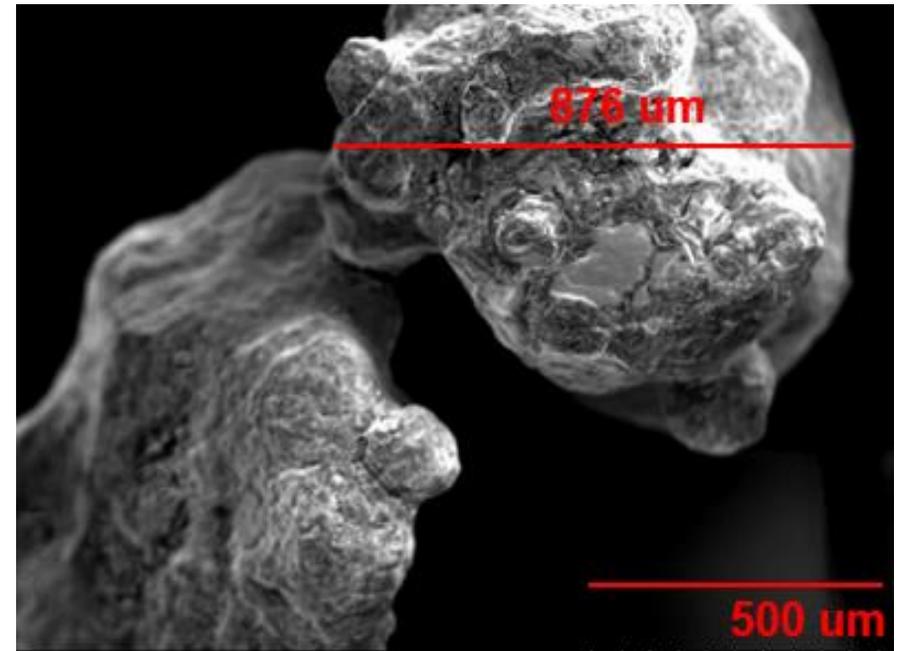


Materials and Method

- ❖ Selection of synthesis route from the preliminary study on the precursor materials



(a)

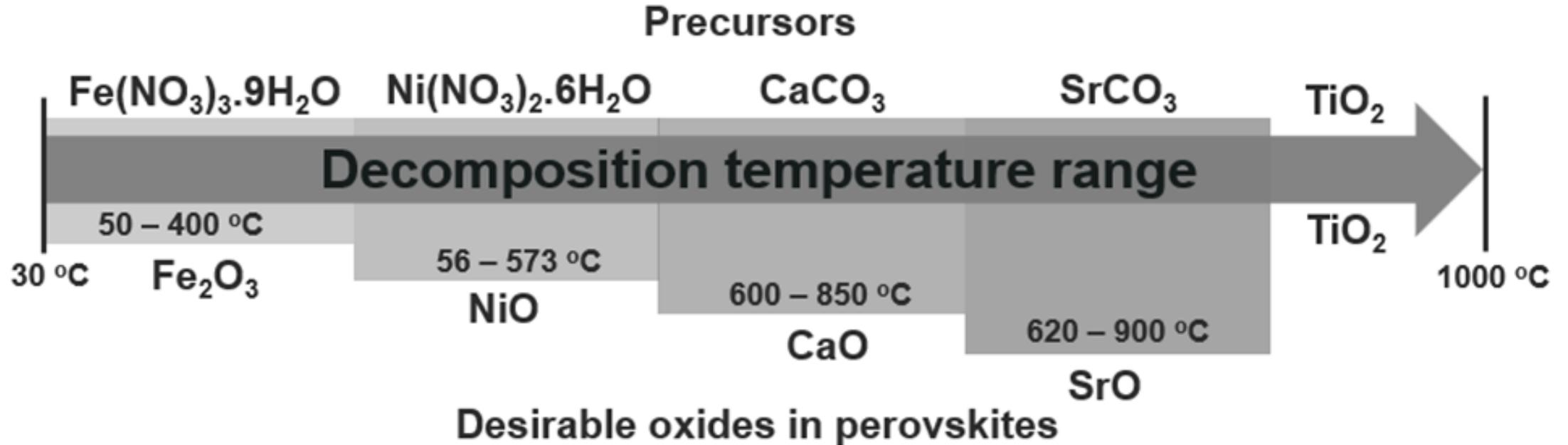


(b)

A combined TG curve, DSC curve, and temperature response for (a) Fe(NO₃)₃·9H₂O and (b) SEM image of Fe(NO₃)₃·9H₂O

Materials and Method

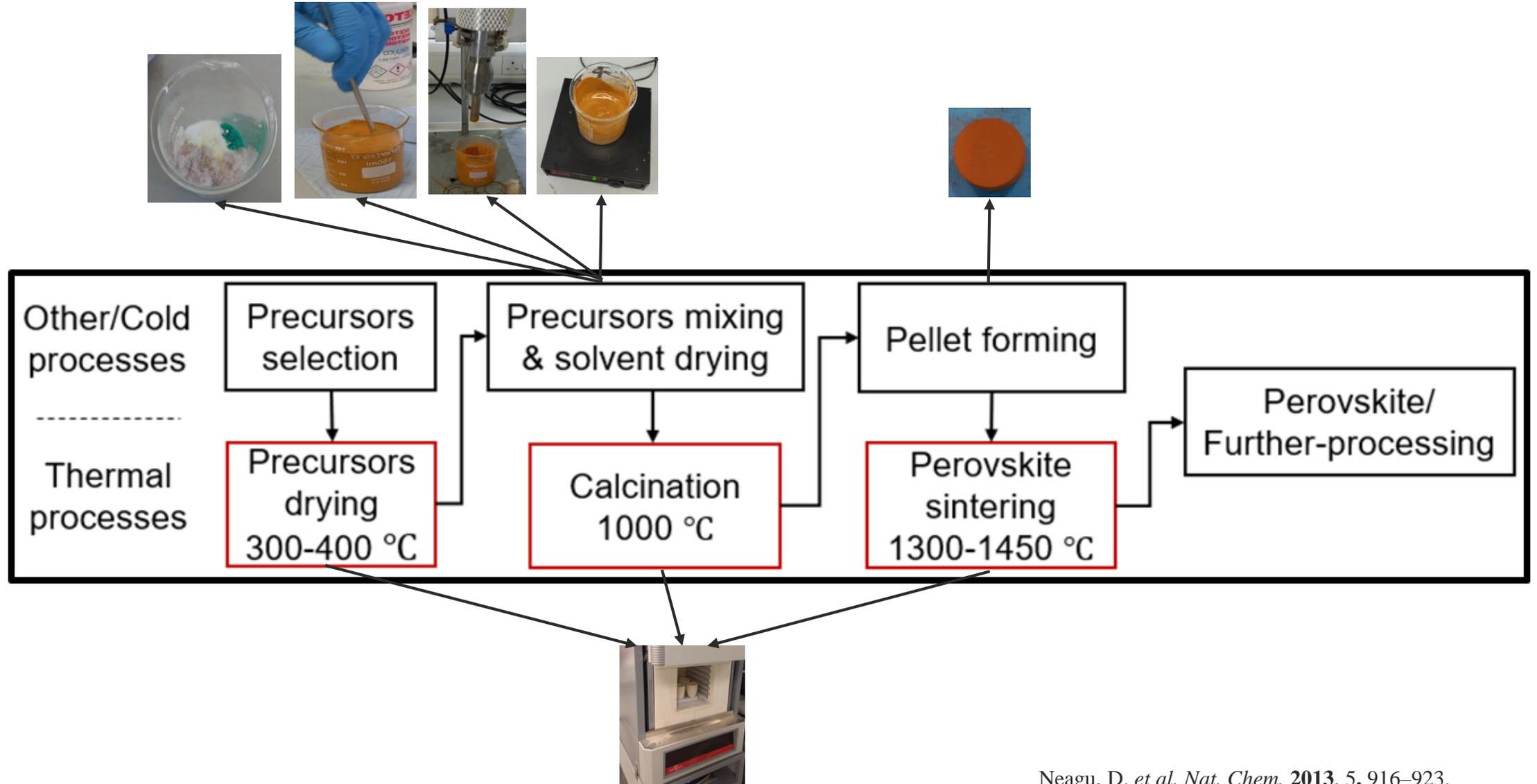
- ❖ Selection of synthesis route from the preliminary study on the precursor materials



Key findings from TGA of the precursor materials, predicting 1000 °C as the calcination temperature for the novel perovskite

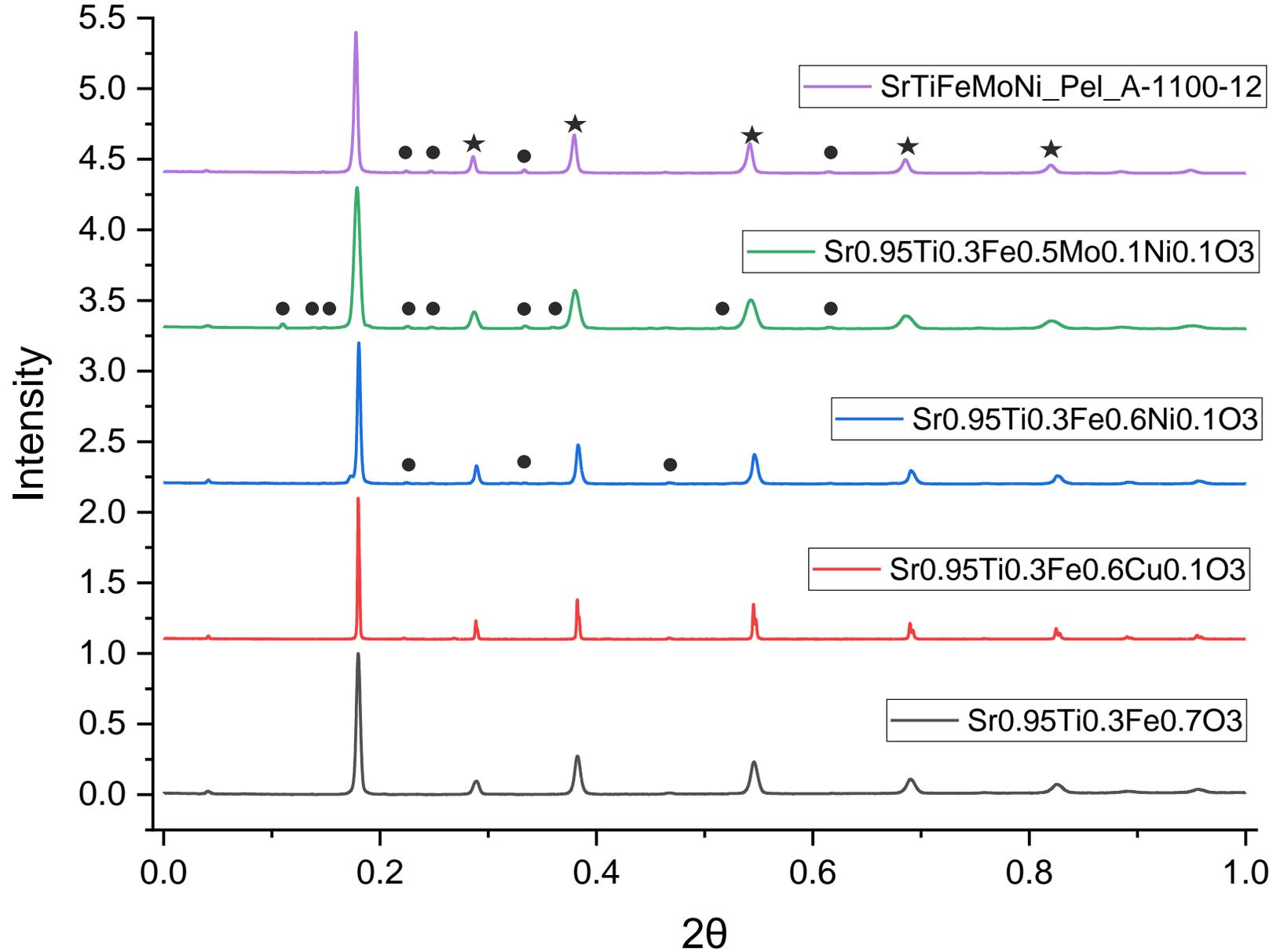
Materials and Method

- ❖ Selection of synthesis route: a modified solid-state synthesis method



Result

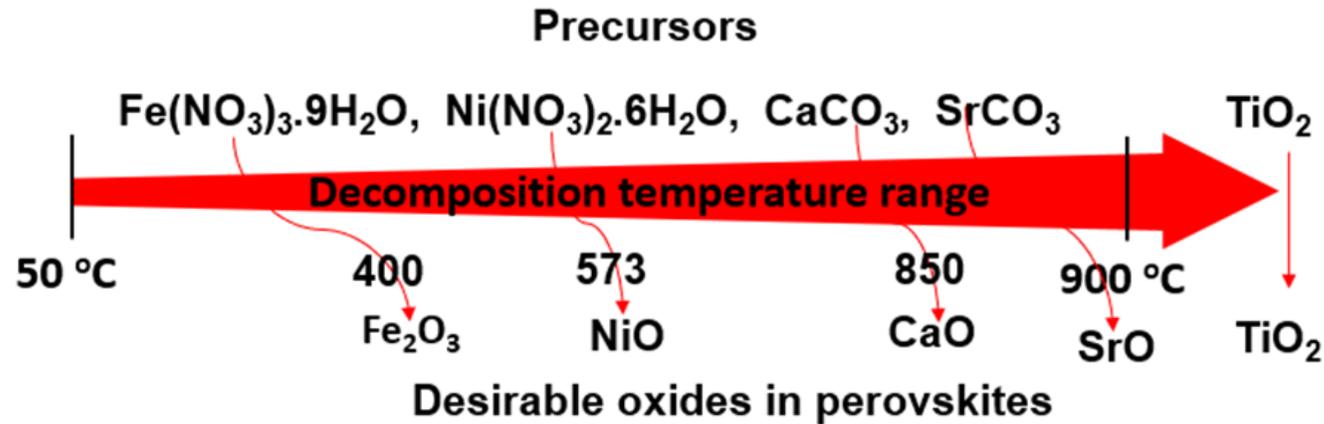
❖ XRD Peaks of Synthesized Perovskites



● New XRD peaks resulting from new phases formed due to doping

★ Sharper XRD peaks indicate further refinement of existing phases upon further processing.

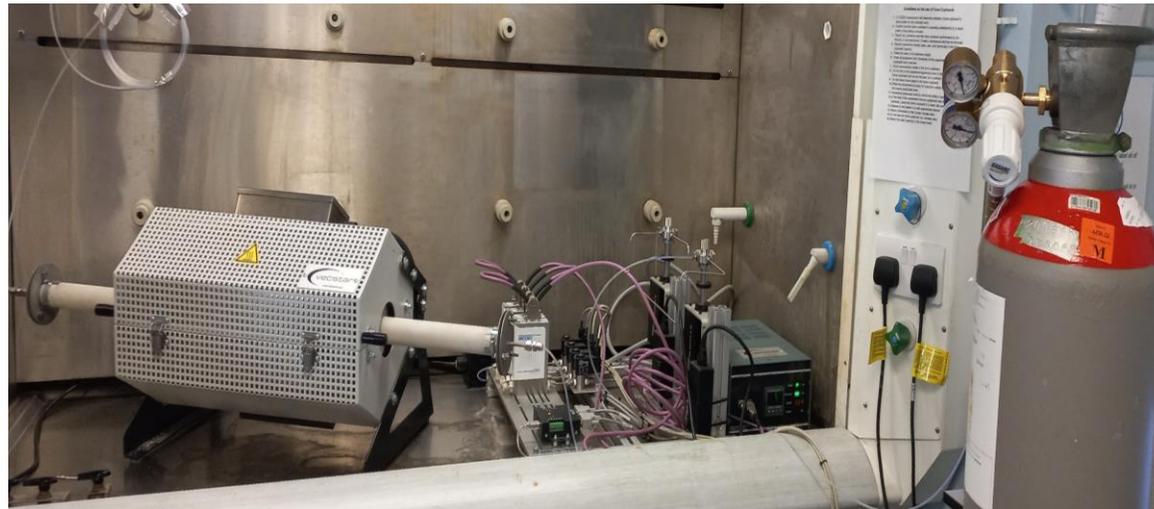
Conclusion



- ❖ The preliminary study on the precursor materials revealed their decomposition products as useful oxides desired in the novel perovskite material.
- ❖ The modified solid-state synthesis method
 - achieves homogeneous mixing of the precursors,
 - minimising phase separation in the perovskite, and
 - enable further refinement of the synthesized perovskite structure.

Future Work

- ❖ Synthesizing other compositions of the perovskite for further studies and comparison;
- ❖ Characterisation of all the synthesized perovskites and preparation into pellets for sintering;
- ❖ Carrying out electrochemical tests and exsolution analysis on the sintered button cells;

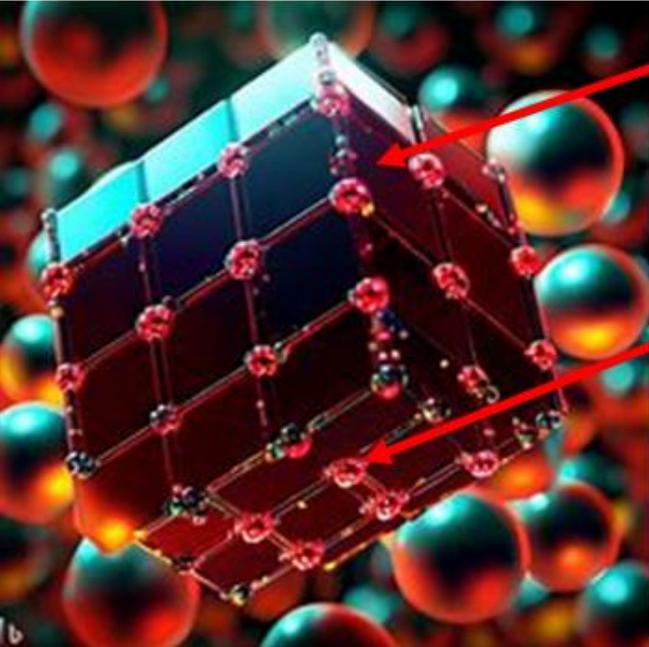


An intelligent gravimetry analysis (IGA) system for exsolution analysis recently setup by our research group

Future Work

- ❖ Modelling the exsolution process in the developed perovskite for properties tuning and performance optimisation.

Innovate Material



Perovskite Material

- Properties tuning?
- Exsolution rate?
- ...?

Exsolved nanoparticle

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- ...?

References

1. Scottish Government. Draft Hydrogen Action Plan. (2021)
2. Neagu, D. *et al. Nat. Chem.* **2013**, 5, 916–923

Acknowledgement

I acknowledge



Thank

you

for

listening