Characterization of redox behaviour of perovskites-oxides for reversible solid oxide electrochemical cells and CO_2 valorization

Marta Boaro

University of Udine, Polytechnic Department of Engineering and Architecture

Reversible Solid Oxide Electrochemical Cells (R-SOECs), integrating electrolysers and fuel cells into a single device, represent a promising technology for advancing the ongoing energy transition towards renewable resources and low carbon footprint energy supply chains[1]. To effectively penetrate the market, it is imperative to enhance their operational versatility and reversibility through the design of innovative, cost-effective materials and processes[2].

In recent years, there has been increasing research interest in simple perovskite (ABO_3) and double perovskite ($A_2BB'O_6$) materials as suitable components for R-SOECs. This interest stems from their relative ease of functionalization and composition modification via doping[3,4]. However, for the development of reversible devices, it is crucial to investigate the stability of these materials under various reaction atmospheres to understand how their redox properties depend on structural and surface characteristics. Exposure to different atmospheres can alter the pristine structure, thereby impacting the electrochemical and catalytic properties of perovskite oxides.

Understanding the transformations occurring during reducing and oxidizing cycles, and establishing the relationship between structural changes, redox properties, and electrochemical behaviour, is vital for identifying optimal compositions and efficient operational conditions.

In this presentation, we will outline our recent studies focusing on characterizing the redox behaviour of $PrBaMn_2O_{5+\partial}$[5] and $Sr2FeNi_{0.4}Mo_{0.6}O_{6-\delta}$[6] for the development of CO_2-reducing electrocatalysts for reversible devices. Our approach utilizes a multi-analytical strategy based on in situ temperature programmed redox cycles and XRD characterization to correlate redox behaviour with structural changes of these materials. The aim is to demonstrate the validity of this approach in assessing the suitability of the materials for the development of reversible electrodes for CO_2 valorisation.

Acknowledgement

Author thanks MUR for funding (PRIN project-DIRECTBIOSOFC, 2017FCFYHK, 2019–2022).

References

1. M B Mogensen, M Chen, H L Frandsen, C Graves, J B Hansen, K V Hansen, A Hauch, T Jacobsen, S H Jensen, T L Skafte, X Sun, Clean Energy, **3**, 2019, 175–201, https://doi.org/10.1093/ce/zkz023.
2. Y.Yang, J. Lei, X. Huang,Z. Liao,Y. Liu, Z. Tu, ChemElectroChem, **11**, 2024, 1-19, https://doi.org/10.1002/celc.202300593
3. W.-J Yin, B. Weng, J. Ge, Q. Sun, Z. Li, Y. Yan Oxide Perovskites, Double Perovskites and Derivatives for Electrocatalysis, Photocatalysis, and Photovoltaics. Energy Environ. Sci. 2019, 12 (2), 442–462. https://doi.org/10.1039/C8EE01574K. Energy Environ. Sci., **12**, 2019, 442-462, https://doi.org/10.1039/C8EE01574K
4. P. Goel, S. Sundriyal, V. Shrivastav, S. Mishra, D. P. Dubal, K.-H. Kim, A. Deep Nano Energy, **80**, 2021, 105552, https://doi.org/10.1016/j.nanoen.2020.105552.
5. A. Felli, S. Mauri, M.Marelli, P. Torelli, A. Trovarelli, M. Boaro ACS Appl. Energy Mater. **5**, 2022, 6687–6699, https://doi.org/10.1021/acsaem.2c00163
6. A. Felli, L. Duranti, M. Marelli, M. Dosa, E. Di Bartolomeo, M. Piumetti, M. Boaro J. Electrochem. Soc., **170** ì, 2023, art. no. 114511, https://doi.org/10.1149/1945-7111/ad06e7