Investigation of $La_{0.6}Sr_{0.4}Fe_{0.8-x}M_xCo_{0.2}O_{3-y}F_y$ (M= Cu, Ni) perovskite oxides as electrocatalysts for clean energy transition

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The development of innovative technologies, like solid oxide cells (SOCs) able to produce green energy and/or convert CO_2 into valuable fuels is pivotal in the energy transition due to their high efficiency, versatility, and ability to integrate with various energy systems. Reversible solid oxide cells (SOCs) can operate in solid oxide fuel cell (SOFC) mode in order to generate green energy and, as well, in solid oxide electrolysis cells (SOECs) mode to recycle CO_2 [1]. Perovskite oxides with the nominal formula $AA'BB'O_3$ are recognized as one of the most promising classes of electrocatalysts for SOC application [2]. In the present study we have investigated doping strategies to fine-tune perovskite electrode materials with potential application in the electrochemical CO_2 reduction reaction (CO_2RR). To this aim $La_{0.6}Sr_{0.4}Fe_{0.8}Co_{0.2}O_3$ powders were co-doped using three different strategies: (i) B-site doping with Cu or Ni (x=0; 0.1), (ii) fluorine-doping at O sites (y=0, 0.1), and (iii) co-doping at B- and O-sites with Cu/Ni and F (x=0; 0.1; y=0, 0.1). Solution combustion synthesis (SCS) and the complexing citrate method were employed as effective synthesis techniques for producing perovskite oxides. X-ray diffraction combined with Rietveld analysis confirmed the incorporation of Cu, Ni, and F into the rhombohedral perovskite crystal structure. H_2-temperature programmed reduction profiles indicated that these materials exhibit reduction properties and oxygen mobility within the SOC working temperature range. The impact of co-doping strategies on the surface chemical composition, evaluated by X-ray photoelectron spectroscopy, and on the oxygen vacancies distribution, investigated by using O_2 and CO_2 thermogravimetric analyses, suggested a positive effect induced by copper and fluorine. Preliminary electrochemical impedance spectroscopy analyses, in a pure CO_2 atmosphere, on symmetrical cells, with $Ce_{0.8}Sm_{0.2}O_2$ as the electrolyte, revealed an ASR value as low as 0.3 Ωcm^2 at 850°C.
The above reported results were used to fill the excel data sheet of Italian Energy Materials Acceleration Platform (IEMAP) giving a concrete contribute to enhance the database. The integrated use of experiments and modeling can lead to the development of new materials with improved performance.

References

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