The impact of nanoparticles exsolved from double perovskite on the efficiency of biogas-fueled SOFC

Nowadays, because of the global climate crisis, many efforts are being put to reduce the emission of greenhouse gases into the atmosphere. Unfortunately, a constant rise in electrical energy demand is observed. These issues have resulted in the increasing interest in the development of alternative energy sources. Among others, wind or solar energy remains the most popular source of energy, however, it suffers from a strong dependence on weather conditions which results in intermittent overproduction. Another method to produce electricity is the use of Solid Oxide Fuel Cells (SOFCs), being able to directly convert the chemical energy of the fuel into electrical one. Hydrogen is the most common fuel in SOFC applications, however, it also suffers from difficulties in storage or transportation. Alternative fuels such as biogas (a mixture of methane and carbon dioxide) can also be utilized in SOFC, yet conventional state-of-the-art cermet material is prone to carbon deposition and deactivation when fed with hydrocarbons. Thus, the development of novel electrode materials with good catalytic properties and stability is required.

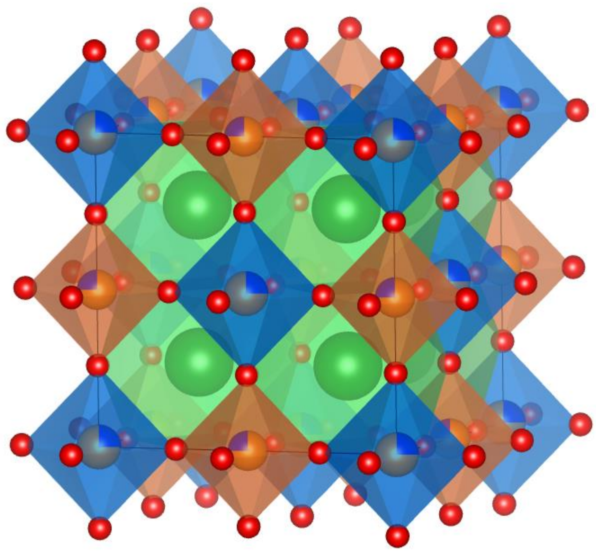

Fig. 1. $Sr_2Fe_{1.5}Mo_{0.5}O_{6-\delta}$ crystal structure simulated in VESTA software. Sr-green, Fe-orange, Mo-blue, O-red

One of the most promising materials for SOFC anodes are perovskites (general formula ABO_3) or double perovskites ($A_2BB'O_6$). The exemplary crystal structure of the double perovskites is presented in **Fig. 1**. Perovskites are characterized by high stability and high electrical conductivity in both oxidizing and reductive atmospheres. To enhance catalytic properties, active metals are incorporated into material e.g. by deposition or infiltration. However, such modifications are susceptible to agglomeration at higher temperatures and carbon deposition, leading to deactivation. Nanoparticles exsolution has no such disadvantages, as exsolved NPs are highly dispersed on the surface and strongly embedded into the lattice.

During the implementation of the project, a series of compounds with the general formula $Sr_2M_xFe_{1.5-0.75x}Mo_{0.5-0.25x}O_{6-\delta}$ (SFM), where M = Co, Ni, Cu, $x \leq 0.2$ will be synthesized and characterized. Under reductive treatment, the transition metals will be exsolved from a double perovskite lattice forming M-Fe nanoalloys, which will act as catalytically active centres for fuel oxidation. Then the composite of SFM and doped ceria will quasi-symmetrically deposited on the LSGM electrolyte, and the novel cell will be thoroughly examined when fueled with synthetic biogas. Furthermore, a long-term test will be performed to establish degradation rates and sulfur tolerance will be measured when fed with controlled addition of H_2S.

The novelty of the project presented here comes from the alternative application of SFM-based material as quasi-symmetrical electrodes for SOFC fed with biogas. The implementation of this research will provide a deep insight into the mechanisms of nanoparticle formation from a double perovskite host and the properties of these compounds under simulated working conditions with biogas. To the best of our knowledge, there is a lack of research considering the use of SFM-based compounds in SOFCs fueled with alternative gases.