Development of High Entropy Oxides for Use in Solid Oxide Fuel Cells

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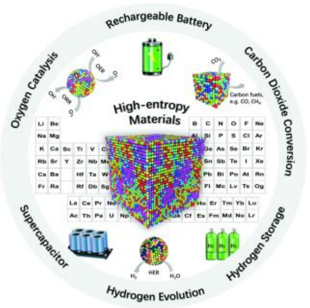
In recent years, energy consumption has been increasing with technological and industrial developments. This leads to the search for clean, efficient, economical, and sustainable energy sources. Among these sources, ceramic-based solid oxide fuel cells, which are considered among the most efficient FCs, draw attention. (Campanari et al., 2016)Solid oxide fuel cell is an electrochemical energy conversion device that converts the chemical energy of the fuel directly into electrical energy, attracting great attention due to its high efficiency, fuel flexibility, and environmental friendliness. However, high operating temperatures (800− 1000 ◦C) cause the cells to be short-lived. Reducing the operating temperatures to 600− 800 ◦C is one of the effective approaches to solving this problem. $La_{0.7}Sr_{0.3}MnO_3$ LSM shows outstanding electronic conductivity, excellent electrocatalytic activity, and good stability for oxygen reduction in the temperature range of 800-1000 °C, but its electrochemical performance is significantly reduced at reduced operating temperature. (Carter et al., 1992; Jiang & Wang, 2005)



In recent years, high entropy oxides have received increasing attention. High entropy oxides usually contain 5 or more elements with small proportions of minor elements and have high mixing entropy. They can be easily synthesized, produced and analyzed. (Oses et al., 2020) ABO3-type perovskite oxide is of interest for solid oxide fuel cells due to its unique dielectric, ferroelectric, pyroelectric properties, and catalyst properties.

Many high entropy oxides have been found to improve thermal characteristics, magnetic properties, catalytic activity, and energy storage and conversion performance, but have less application in solid oxide fuel cells. In this study, the potential application of $La_{0,5}Sr_{0,5}Co_{0,25}Fe_{0,25}Ni_{0,25}Cu_{0,25}O_3$ perovskites in medium temperature solid oxide fuel cells was investigated

LSCFNC powder was synthesized using the sol-gel method. As starting chemicals, nitrates of all of the considered cations were used: $La(NO_3)_3{\cdot}6H_2O$, $Sr(NO_3)_2$, $Co(NO_3)_2{\cdot}6H_2O$, $Fe(NO_3)_3{\cdot}9H_2O$, $Ni(NO_3)_2{\cdot}6H_2O$, $Cu(NO_3)_2 \cdot 3H_2O$.

First, the stoichiometric amount of these nitrates was dissolved in distilled water, then citric acid was added to the solution. The molar ratio of all cations and citric acid in the mixture was 1:2. The solution was heated to 80°C with continuous stirring with the aid of a magnetic stirrer. The resulting gel was dried at 250°C for 2 hours to remove residual organics and nitrates. The dried gel was calcined at 700°C, 900°C, 1100 and 1300°C for 6 hours.

YSZ Synthesis

Yttria-stabilized zirconia (YSZ) with general formula $(ZrO_2)_{1-x}(Y_2O_3)_x$ and $0.08 \leq x \leq 0.1$, is the most studied electrolyte for SOFCs. The best value of conductivity is obtained for the compound containing 8 mol% of yttrium oxide. In this study, zirconia powders stabilized with 8 mol% yttria were synthesized using the sol-gel process. $ZrO(NO_3)_2.xH_2O$ and $Y(NO_3)_3.6H_2O$ were dissolved in and mixed in ethylene glycol, citric acid, and purified water, respectively. Then, $Y(NO_3)_3.6H_2O$ was added to $ZrO(NO_3)_2.xH_2O$ solution drop by drop and mixed to make YSZ solution. The molar ratio of citric acid to total metal ions (Zr + Y) is 4:1 and CA/EG is 1:1.

After mixing, the temperature was raised to 80°C and the pH was adjusted to 3.6 with HNO_3. The resulting suspension was mixed until homogeneous. This white and milky mixture was dried at 120°C and sintered at 1200°C for 2 hours.

References

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