Electronic Supplementary Material (ESI) for RSC Advances.

Electronic supplementary information for

A novel yttrium stabilized zirconia and ceria composite electrolyte lowering solid oxide fuel cells working temperature to 400 °C

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The stability of Ce^{4+} ion in the electrolyte (7YSZ-3CeO_2) under fuel cell working atmosphere has been characterized by XPS. As shown in Figure S1, the ratio of Ce^{3+}/Ce^{4+} in the original electrolyte is about 3:7, while it increased to about 4:6 for the electrolyte which had experienced fuel cell test. This is because Ce^{4+} can be reduced to Ce^{3+} by H_2, which will increase the electronic conductivity of the electrolyte[1]. Therefore, the electronic conductivity of the SOFC with 7YSZ-3CeO_2 electrolyte which has been treated by H_2 (anode) under 450 °C for 90 min was tested by chronoamperometry method in N_2 atmosphere. As shown in Figure S2, the current decreased sharply at the beginning and then tended to be stable with the increase of time. Although there was no O^{2-} source in N_2 atmosphere, there was also some residual air in the electrode. Therefore, the original current included both electron conduction and O^{2-} conduction. With the consumption of air, the contribution of O^{2-} conduction to the current decreased, and when the residual air was exhausted, the current density only came from electron conduction. The electronic conductivity of the electrodes are much higher than the 7YSZ-3CeO_2 electrolyte, thus the resistance of the electrodes can be ignored. Accordingly, the resistance of the electrolyte layer (R) can be obtained by the applied voltage (1 V) and the stable current of the above i-t curve (1.07 mA), the electronic conductivity of the electrolyte (σ_e) can be calculated according to the equation (1):

$$\sigma_e = \frac{l}{RA} \tag{1}$$

Where l and A are the thickness of electrolyte layer (0.0623 cm) and area of the fuel cell device (1.33 cm^2), respectively. The value of calculated σ_e is 5.01×10^{-5} S cm^{-1}. For comparison, the conductivity of the electrolyte layer (σ_t) under SOFC working atmosphere was also calculated according to the EIS fitting results (Table 1 in the manuscript) according to the equation (1). R is the sum of R_0 and R_1 in Table 1, and l is effective area of the fuel cell (0.64 cm^2). The value of calculated σ_e is 0.324 S cm^{-1}.

The ionic conductivity of the electrolyte layer (σ_i) can be calculated by σ_t-σ_e, which is about 0.324 S cm^{-1}. It can be seen that the ratio of σ_i:σ_e is over 6000. According to our previous study[2], the effect of electronic leakage of the electrolyte layer on the SOFC performance can be ignored.

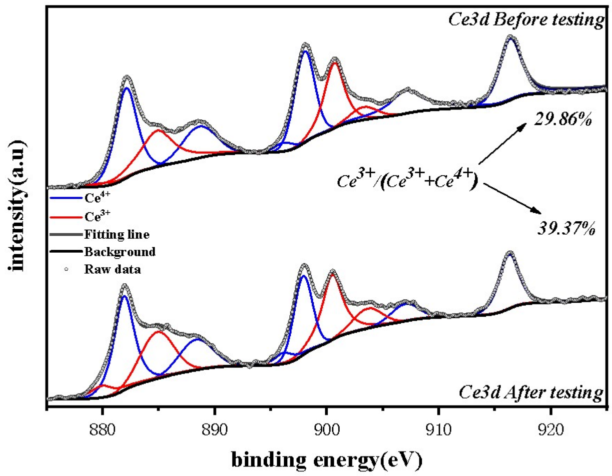

Fig. S1 XPS spectra of the Ce elements in the composite electrolyte before and after fuel cell test.

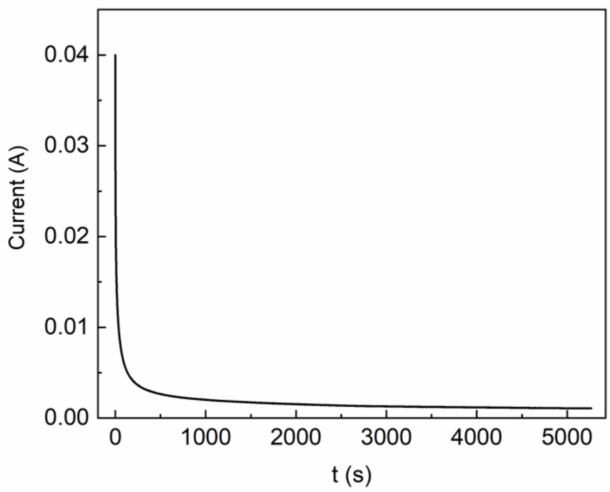

Fig. S2 Chronoamperometry curves (tested in the N_2 environment under 450 ℃) of the SOFC with 7YSZ-3CeO_2 electrolyte which has been treated by H_2 (anode) under 450 ℃ for 90 min.

References

[1] P. Vinchhi, M. Khandla, K. Chaudhary and R. Pati, Inorganic Chemistry Communications, 2023, **152**.

[2] W. Dong, Z. Xiao, M. Hu, R. Ruan, S. Li, X. Wang, C. Xia, B. Wang and H. Wang, Journal of Power Sources, 2021, **499**.