EFFECT OF MICROWAVE PROCESSING ON THE PROPERTIES OF NICKEL OXIDE/ZIRCONIA/CERIA COMPOSITES

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Keywords: coprecipitation, microwave-assisted hydrothermal, impedance spectroscopy

Introduction

Ni/ZrO_2:8 mol%Y_2O_3 (Ni/YSZ) cermets are the standard anode for solid oxide fuel cells (SOFC). Such composites have excellent properties, unheard by any other alternative material proposed for H_2 fuelled SOFCs. Chemical syntheses are preferred as compared to solid state methods to attain the highly dispersed Ni particles and homogenous phase distribution. The co-precipitation method can provide homogeneous and small-sized powders for SOFC anodes with superior properties. In the present study, NiO and CeO_2 were synthesized by co-precipitation in a suspension of YSZ, forming the NiO/YSZ/CeO_2 composite. The coprecipitation was followed by a microwave-assisted hydrothermal treatment. The effect of the MW was investigated and the results were compared with samples prepared by conventional heat treatment.

Experiments

NiO/YSZ/CeO_2 (60/20/20 wt.%) composites were prepared by coprecipitation. YSZ (Tosoh) powder was kept under stirring in NH_4OH solution in which nickel acetate and cerium nitrate (Aldrich) water solutions were added dropwise. After washing with water and ethanol the as-prepared powder was treated in a conventional oven (CT) or in a microwave-assisted hydrothermal (MW) reactor, both at 130 °C for 2 h. Calcining was carried out at 500 °C for 4 h in air. Uniaxially pressed cylindrical pellets were sintered at 1250 °C for 3 h. Samples were studied by simultaneous thermogravimetric and differential thermal analysis (TG/DTA) and X-Ray diffractometry. The linear retraction during sintering of green ceramic compacts was followed by dilatometry up to 1400 °C. The electrical properties of sintered samples were studied by impedance spectroscopy in the 200-700 °C temperature range.

Results and Discussion

Figure 1 shows the TG/DTA data in the temperature range in which the main mass loss (~10 %) of co-precipitated powders is observed. The mass loss was associated with exothermic and endothermic events occurring at 260-280 °C and 305 °C, respectively. The MW treatment results in a decrease of the exothermic peaks, which correspond to the crystallization of ceria and nickel hydroxide, respectively, indicating that the MW favors the crystallization of such phases.

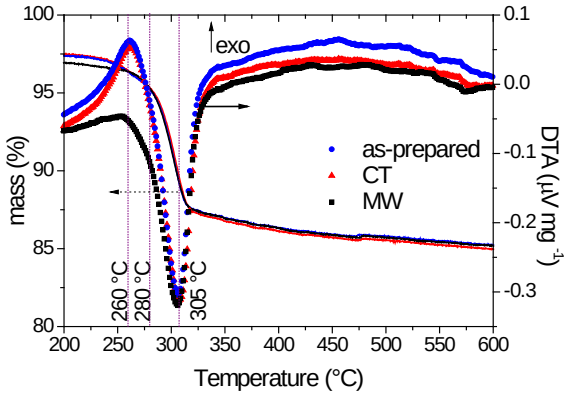

Fig. 1. TG/DTA of the as-prepared, CT, and MW powders of NiO/YSZ/CeO_2 composites.

Samples sintered at 1250 °C have apparent density corresponding to ~90% of the theoretical density, irrespectively of the thermal treatment. The Arrhenius plot of the total electrical conductivity of sintered pellets is shown in Fig. 2. The electrical conductivity values are similar for the three samples. Calculated activation energies (~380 meV) are in good agreement with previously reported values for NiO in this temperature range.

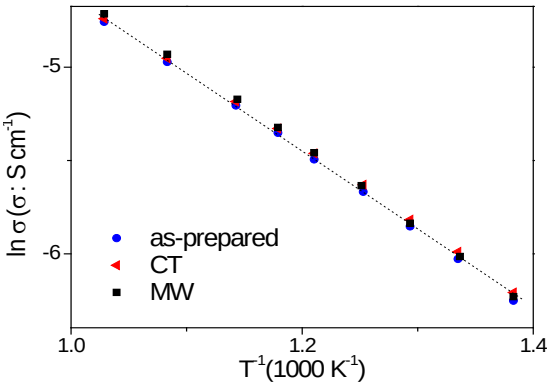

Fig. 2. Arrhenius plots of the total electrical conductivity of NiO/YSZ/CeO_2 composites.

Conclusions

The microwave-assisted hydrothermal treatment on coprecipitated NiO/YSZ/CeO_2 promotes the crystallization of nickel and ceria phases at low temperatures. However, such an effect has little influence on the electrical properties of sintered samples of the composite.

Acknowledgements

CNPq, CAPES, FAPESP.