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Structural and reduction studies of ZrO_2-CeO_2:Ni for application in SOFC anodes

R. Bacani[1], A. D. S. Bruno Costa[1], M. C. A. Fantini[1], T. S. Martins[2], S. A. Larrondo[3], D. G. Lamas[4]
[1]*Instituto de Física - Departamento de Física Aplicada, Universidade de São Paulo - São Paulo, Brazil*
[2]*Universidade Federal de São Paulo - Diadema, São Paulo, Brazil*
[3]*Consejo Nacional de Investigaciones Científicas y Técnicas - Buenos Aires, Argentina*
[4]*Universidad Nacional del Comahue - Neuquén, Argentina*

Abstract: Zirconia-ceria solid-solutions are extensively used as promoters for three-way catalysts, which are applied in the control of NO_x, CO and hydrocarbons emission from automotive exhausts. In addition, these materials can be used as anodes in solid oxide fuel cells (SOFCs) operated with hydrocarbons. There are only few works on ZrO_2-CeO_2 ordered mesoporous materials for catalytic applications and for anodes in SOFCs. The interest in these anodes relies on the fact that ZrO_2-CeO_2 materials are mixed ionic/electronic conductors in reducing atmosphere and, therefore, fuel oxidation is produced on its entire surface, while it only occurs in the [anode/electrolyte/gas] interface (triple-phase boundaries) for electronic conductors.
In this work, a synthesis method was developed using Zr and Ce chloride precursors, HCl aqueous solution, Pluronic P123 as the structure directing agent, NH_4OH to adjust the pH (3-4) and a Teflon autoclave to perform hydrothermal treatment (80°C/48 hours). The samples were dried and calcined, until 540ºC in N_2 and 4 hours in air. The X-ray diffraction data showed that powders with higher CeO_2 content are formed by a larger fraction of the cubic CeO_2 phase, while for a lower CeO_2 content the major crystalline structure is the tetragonal ZrO_2 phase. The NiO impregnation was made with an ethanol dispersion of $Ni(NO_3)\times 6H_2O$. The resulting powder was calcinated in air until 350ºC for 2 hours. Temperature-programmed reduction (TPR) data were collected in order to evaluate the reduction profiles of ZrO_2-x%CeO_2:Ni samples in H_2/Ar atmosphere. Results showed lower reduction temperatures for all ceria content in samples comparing to a NiO standard.