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Short communication

Preparation and characterisation of SOFC anodic materials based on Ce–Cu☆

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Abstract

Ce–Cu mixed oxide precursors with varing Ce:Cu atomic ratio have been prepared by freeze-drying and microemulsion coprecipitation methods. Nanostructured particles having different properties have been obtained. Physicochemical properties have been studied with X-ray diffraction, UV–vis spectroscopy, nitrogen adsorption–desorption, mercury intrusion porosimetry, ICP-AES, conductivity measurement and thermal expansion coefficient. All samples show fluorite structure with slight copper surface enrichment for samples having high copper content. Microemulsion method allows the introduction of a large quantity of copper into the cerium oxide structure, obtaining a nanostructured mixed oxide of high surface area. On the other hand, freeze-drying samples does not show evidence of copper incorporation to the lattice of cerium oxide. All materials have a thermal expansion coefficient similar to other components of SOFC.

Keywords: SOFC anodes; Ce–Cu mixed oxides; Freeze-drying; Microemulsion coprecipitation

1. Introduction

Nickel–zirconia cermet is the most common anode for solid oxide fuel cells (SOFC), due to goal electrochemical behaviour and high catalytic activity. However, this material shows some drawbacks, the most important of which is the carbon deposition on the anode surface catalysed by nickel when hydrocarbon fuels are used, instead of pure hydrogen. The formation of these carbon deposits could be avoided by replacing nickel for other electrical conductor. In this sense, copper–ceria-based anodes have recently received a special interest [1]. Copper is a relative inert metal for carbon deposition reactions and provides electrical conductivity to the anode. On the other hand, it is necessary to add an active phase, ceria, to the anode in order to achieve reasonable performance [2]. Examples of this type of composite anode have shown effective behaviour with a variety of hydrocarbon fuels [3], and are highly resistant to deactivation by carbon deposition, even considering the direct conversion of hydrocarbon fuels without previous reforming to CO and H_2 [4]. These Cu-based anodes have the additional advantage of being reasonably tolerant to sulphur [5].

Preparation of Ce–Cu-based anodes has required the development of new synthetic methods, different from those used to produce Ni–YSZ cermet, in order to control the microstructure, which is a principal characteristic determining electrode activity.

A series of Ce–Cu-based materials has been synthesised by two methods, freeze-drying and microemulsion coprecipitation. Both methods allow for the control of structure of materials to a certain degree. We studied the influence of the synthesis method employed on the physicochemical characteristics of the materials and the influence of the doping level of copper on their structure. The effect caused by the incorporation of ion Cu^{2+} to the lattice of cerium oxide on the structure and properties is explored in this report and focused on the use of these new materials as SOFC anodes capable to work using alternative fuels. It will be shown that preparation method based on microemulsion coprecipitation allows insertion of up to ca. 21 at.% Cu in substitutional positions of the fluorite structure. To assist in interpreting the main characterisation of new materials, reference systems consisting of CeO_2, which were prepared following the same two synthetic methods, were also analysed.

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