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Effect of the fuel type on the synthesis of yttria stabilized zirconia by combustion method

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Abstract

Nano-sized 8 mol% yttria stabilized zirconia (YSZ) powders were synthesized by the combustion method using two different fuels (urea and glycine). The effect of the nature and amount of the fuel was investigated on the phase structure, particle size and microstructure of the resulted YSZ ceramics. The results showed that YSZ powders synthesized using urea presented larger crystallite size and lower specific surface area than those derived from glycine route. This behavior is closely related to the combustion flame temperature. The elevated temperature during combustion synthesis with urea favored the formation of large aggregates, instead of loose and porous particles as observed for glycine route. As a consequence, the best result in terms of densification was obtained for the pellets prepared by sintering of powders synthesized through glycine route.

Keywords: A: Powders: chemical preparation; B: X-ray methods; D: ZrO_2; E: Fuel cells

1. Introduction

Yttria stabilized zirconia (YSZ) exhibits high oxygen ionic conductivity and good mechanical properties at elevated temperatures making its use ideal for various applications, such as oxygen sensors, oxygen separation membranes and electrolyte materials in solid oxide fuel cells (SOFC). The ionic conductivity of the YSZ electrolyte is related to processing technology of the powders, particle sizes and sintered density [1].

For YSZ electrolytes, the electrical and mechanical properties can be enhanced by preparing a fully dense ceramic after sintering, which requires ultrafine powders with a narrow size distribution [2]. The conventional solid-state reaction for preparation of YSZ powders usually yields large particle sizes, inhomogeneity and poor reactivity [3]. A distinct advantage of using nano-crystalline YSZ powders in the fabrication of sintered compacts is the lower sintering temperature needed [4]. Thus, different processing methods have been developed for production of nano-crystalline YSZ, such as co-precipitation technique [5], sol–gel preparation [6,7], hydrothermal synthesis [8], sonochemical process [9], and Pechini method [10]. However, these methods are generally complicated, require multi-step reaction routes and/or long processes.

Combustion synthesis is an attractive method for preparing multicomponent oxide powders that are crystalline, homogeneous, with high-purity and a narrow particle size distribution [11]. The combustion technique consists of a self-propagating high-temperature synthesis (SHS), discovered by Merzhanov and co-workers, which involves a wide variety of chemical routes and products [12]. The main feature of SHS is a very short time required for attaining high combustion temperatures due to heat released during exothermic reactions [12]. This paper deals with solution combustion synthesis that is based on the principle of thermal decomposition of metal nitrate and fuel gel to produce a spontaneous flame with no controlled temperature leading to a foamy but well crystallized single-phase powder [13]. The stability of the gel depends essentially on the nature of the fuel; different fuels have been used in combustion synthesis, such as urea, glycine, citric acid, sucrose, carbohydrazide, among others [14,15]. The combustion method does not require special igniting equipment and the operation is simple and easy as well [16].

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