

Effect of calcination temperature on the structural characteristics and catalytic activity for propene combustion of sol–gel derived lanthanum chromite perovskite

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Abstract

The perovskite type lanthanum chromite LaCrO_3 has been synthesized by a sol–gel method. Its bulk structural and surface characteristics have been examined by X-ray diffraction (XRD), SEM, S_{BET} measurements, Fourier Transform Infrared (FTIR) and X-ray photoelectron spectroscopy (XPS) as a function of the calcination treatment performed between 200 and 1000 $^{\circ}\text{C}$ over the precursor powder and in correlation with information achieved from TG-DTA thermal analysis. The characterization results are employed to rationalize the catalytic behaviour of the system towards propene complete oxidation. It is shown that the catalytic activity becomes optimized when a single perovskite LaCrO_3 phase is achieved upon calcination at $T > \text{ca. } 700$ $^{\circ}\text{C}$. In contrast, coexistence of perovskite LaCrO_3 and monazite LaCrO_4 at lower calcination temperatures appears detrimental to the combustion activity of the system.

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1. Introduction

Perovskite-type oxides ABO_3 (where A is usually a rare earth and B, a transition metal) are interesting as combustion catalysts or for other high temperature catalytic processes due to their high thermal and chemical stability [1–8]. Such properties along with electrical and mechanical ones make them also most interesting as components of solid oxide fuel cells (SOFC), and most particularly as electrode or interconnect material [9–14]. Among this type of systems, lanthanum chromite related materials have been proposed as most adequate for that purpose, as well as for high temperature furnace electrodes or treatment of exhaust gases or particles since they are highly refractory and generally show a good match in their thermal expansion properties with materials typically employed as electrolytes (for instance YSZ) [9–12,14,15].

The LaCrO_3 ceramics usually display difficulties to form the stoichiometric compound during high temperature sintering under air, which has been attributed to the relatively high vapour pressure of its chromium constituent. Many efforts have been made in this sense to improve the sinterability of LaCrO_3 by using a reducing atmosphere, adding appropriate sintering promoters or through partial substitution of a small fraction of the lanthanum with other elements [16,17]. Morphological and compositional aspects can be also of relevance and extensive studies have been dedicated to prepare fine spherical LaCrO_3 powder with good compositional homogeneity and stoichiometry in order to improve its sinterability [18]. On the other hand, in spite of its strong interest as SOFC material, the lanthanum chromite system has attracted relatively little attention as combustion catalyst when compared to other systems of this type, which can be likely due to its lower oxidation activity [7,15]. In this sense, the catalytic activity of this type of materials can be favoured by changes in the compound stoichiometry which could lead to generation of active defects favouring the activation of oxygen species and which could be modified upon changing the calcination temperature during preparation [7].

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