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Hydrogen production from oxidative steam reforming of bio-butanol over CoIr-based catalysts: Effect of the support

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HIGHLIGHTS

- Hydrogen from oxidative steam reforming of butanol:acetone:ethanol mixture.
- Effective reforming of bio-butanol over ceria-zirconia-supported Co–Ir catalysts.
- Support effect on Co–Ir catalysts in bio-butanol oxidative steam reforming.
- Low Co sintering and coke formation on CoIr/18CeZrO$_2$ under reforming of bio-butanol.

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ABSTRACT

This paper studies the influence of the support on the behavior of bimetallic CoIr-based catalysts (6.5 wt.% Co, 0.4 wt.% Ir) for hydrogen production from the oxidative steam reforming of bio-butanol raw mixture (butanol/acetone/ethanol = 6/3/1 mass ratio). Catalytic tests were carried out at 500 °C for 60 h with raw mixture/water/air/Ar = 1/10/7.5/12 molar ratio and GHSV = 7500 h^{-1}. Over CoIr/18CeZrO$_2$ and CoIr/ZnO the main process which took place was the oxidative steam reforming of the raw mixture. CoIr/18CeZrO$_2$ showed the better catalytic performance. Characterization of the used catalysts indicated that both active metal sintering and coke formation was prevented on the CoIr/18CeZrO$_2$ catalyst.

1. Introduction

There is current interest to introduce renewable sources in the energy scenario and the use of several new energy carriers derived from biomass has been proposed. Hydrogen is a clean energy carrier with the potential for highly efficient generation of electricity via fuel cell systems. However, since its direct distribution and storage remain the main drawbacks for domestic or remote area application, on-site generation from various hydrogen-containing feedstocks deserves to be contemplated. In this context, substrates derived from biomass have attracted great interest due to their renewable character and to the development of new processes of biomass transformation and use (Fatsikostas and Verykios, 2004; James et al., 2011; Nahar and DuPont, 2012; Ramírez de la Piscina and Homs, 2008; Wang et al., 2011).

Although current main routes for hydrogen production are based on catalytic reforming processes using hydrocarbons, the steam reforming of methanol and dimethylether has been also demonstrated industrially feasible (Rostrup-Nielsen and Christiansen, 2011). The use of other alcohols in reforming processes is of interest because large amounts of C2–C4 alcohols such as bio-ethanol, glycerol and bio-butanol are available. However, during the steam reforming of ethanol or other higher alcohols, severe carbon deposits and diverse by-products are usually formed; the development of new catalysts for hydrogen production from these renewable biomass-derived resources is of great interest.

The oxidative steam reforming of alcohols combines partial oxidation (exothermic reaction) and steam reforming (endothermic reaction) and requires less external energy supply than conventional steam reforming, whilst keeping a relatively high hydrogen yield (Cai et al., 2007; Kugai et al., 2006; Pereira et al., 2008; Silva et al., 2010):

$$C_xH_yO_z + kH_2O + (x - 0.5k - 0.5z)O_2 \rightarrow xCO_2 + (k + 0.5y)H_2 \quad (1)$$

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