Novel high efficiency steam reforming of acetic acid for hydrogen production by Cu–Zn–Co catalyst

Gongxuan Lu* and Xun Hu
State Key Laboratory for Oxy Synthesis and Selective Oxidation, Lanzhou Institute of Chemical Physics, Chinese Academy of Sciences, Lanzhou 730000,( China)
*s.glxu@lzb.ac.cn

Introduction
Hydrogen is an important fuel that can be used in internal combustion engines or as the raw material for future economy [1]. Now most hydrogen is produced from fossil fuels such as natural gas, naphtha, and coal[2]. The world-wide interest in energy area now is strongly focused on the production of hydrogen from alternative fuels. Some methods of producing hydrogen from biomass have been investigated: for example, gasification [3] or flash pyrolysis of biomass to bio-oil and its steam reforming [4]. However, bio-oil was a complex mixture of oxygenate compounds, and design of an effective catalyst requires the use of model oxygenate components to establish structure activity correlations. Acetic acid was one of the major components in bio-oil [5,6]. In addition, acetic acid itself is renewable and can be easily obtained from biomass by fermentation, and acetic acid, unlike methanol and ethanol, is noninflammable, hence, it is a safe hydrogen carrier. Up to now, there are very limited works focused on producing hydrogen from acetic acid steam reforming, for example, ICI 46-1, UC G-90C, Ni–Al, Pt/ZrO2, Pt, Rh and Pd based catalysts[5-8]. Usually, the temperature conducted in the reforming reactions over these catalysts was higher than 873 K, and there were always appreciable amounts organic compounds generation during the reactions, which resulted in the low selectivity to hydrogen. In this work, we reported a novel catalyst for steam reforming of acetic acid, Cu–Zn–Co catalyst, which was more active, selective and also very stable. In the temperature range of 573–673 K, acetic acid could be converted completely and selectivity to hydrogen exceeded 90%, to our knowledge, such results have not been reported at such low reaction temperature.

Materials and Methods
Catalysts were prepared by co-precipitation method. Catalytic performances tests were carried out in a fixed bed continuous flow quartz reactor at normal pressure. The gas phase effluents were analyzed on on-line chromatographs equipped with TCD detectors. Liquid products were separated and analyzed by means of a flame ionization detector (FID). The XRD measurements were performed on a Philips X pert MPD instrument using Cu Kα radiation. The TPR experiments were carried out in a conventional flow system built in our laboratory. The XPS measurements were carried out at a room temperature on a VG ESCALAB 210 spectrometer, calibrated by the C1s binding energy of 285.0 eV. The BET area measurements were performed on a Micromeritics ASAP-2010 at 77K with N2 as the absorbent.

Results and Discussion
The XRD patterns for the fresh and used Cu–Zn–Co catalysts (1:1:1). A: the fresh catalyst; B: the used catalyst. Figure 2. Effects of reaction temperature on the conversions of acetic acid and selectivities to the products. Experimental conditions: catalyst: Cu–Zn–Co (1:1:1); S/C mol ratio 7.5:1; LHSV = 5.1 h-1; P = 1 atm.

Significance
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References