Functions of Transition Metal Oxide Nanoparticles in H_2 Production from Bio-alcohols

Min Yang, Yuliana Leon and Xianqin Wang*
New Jersey Institute of Technology, Department of Chemical, Biological and Pharmaceutical Engineering
323 MLK Blvd., Newark, NJ, 07102(USA)
*xianqin.wang@njit.edu

Introduction

Biomass is a fully renewable resource. The biomass-derived clean energy, H_2, offers a cost-effective way to meet the nationwide growing demand for electricity and natural gas while reducing emissions of air pollutants and greenhouse gases. In the past several years, researchers from different groups have developed many interesting catalytic materials for the H_2 production from bio-alcohols (biomass reforming). Most of these works focused on the comparison of different metal elements in this process, while few investigated the detailed contribution from the catalyst support perspective.

.

Materials and Methods

In this work, a series of transition metal oxide nanoparticles, namely, TiO_2, CeO_2 and ZrO_2 were prepared with different methods [1,2]. Activated carbon and silica (L-90) supports (Degussa) were used as references. 1 wt% Pt ($Pt(NH_3)_4.(NO_3)_2$, Fisher) was loaded onto each oxides with the impregnation method. The impregnated samples were dried at 110°C overnight and then calcined in air at 260°C for 2 hours. The prepared samples were characterized with Brunauer-Emmett-Teller (BET), chemisorption, Temperature-programmed reduction (TPR), Temperature-programmed desorption (TPD) using the AutoChem II 2920 (Micromeritics). The structural and chemical properties are characterized using X-ray diffraction (XRD) and X-ray absorption (XAS) techniques at NSLS of the Brookhaven National Laboratory. The roles of the transition metal oxide nanoparticles in the reforming of bio-alcohols including ethanol, ethylene glycol (EG) and glycerol were tested and compared with *in situ* X-ray diffraction and X-ray absorption techniques.

Results and Discussion

Transition metal oxide supports are selected because they possess featured active centers to adsorb reaction molecules and their strong interaction with metals can inhibit the chemisorption of gases such as H_2 and CO. The metal-oxide interaction can enhance catalyst activity by increasing the production of H_2. Based on the H_2 yields (Fig. 1 and Fig. 2), Pt/ZrO_2 is the most active catalyst in ethanol reforming and Pt/CeO_2 is most catalytically active in EG reforming. In ethanol reforming, Pt/ZrO_2 and Pt/CeO_2 inhibit dehydration which can prevent catalyst coking. The interaction between Pt and oxide supports can enhance the catalytic activity. From the catalyst support perspective, the reaction mechanisms with different bio-alcohols would be discussed in this presentation.

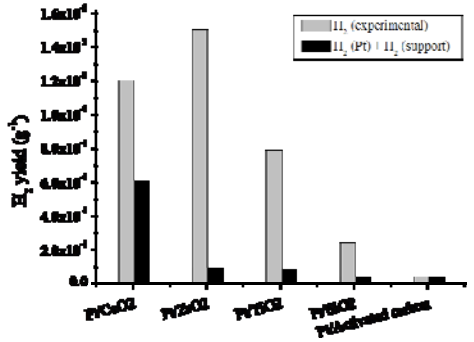

Fig. 1: H_2 yield from ethanol TPD results (TPD in He at flow rate 30cm^3/minute on each sample saturated with ethanol (99+%), with heating rate of 10°C/minute.)

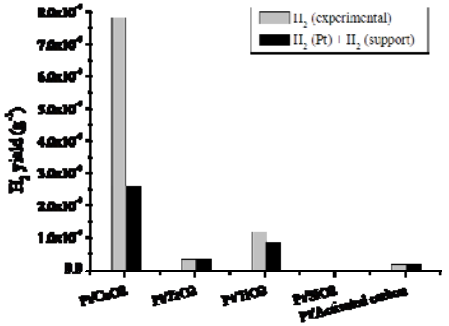

Fig. 2: H_2 yield from ethylene glycol TPD results (TPD in He at flow rate 30cm^3/minute on each sample saturated with EG (99+%), with heating rate of 10°C/minute.)

Significance

The metal- transition metal oxide interactions and reaction mechanisms studied in this work would provide significant input to direct the synthesis of more active catalysts for H_2 production with biomass feeds.

References

1. Motoi Takahashi et al. ,*J. A. Ceram. Soc*, 90, 1291 (2007).
2. Jiahe Liang et al., *Materials research bulletin*, 38, 161 (2003).