

Catalytic properties of Au-Ir/TiO₂ catalyst in CO oxidation

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Introduction

Since the discovery in the late 80's that gold can be catalytically active when it is dispersed as small particles (<5 nm) on an oxide support, the preparation of gold-based catalysts has been widely studied in order to prepare active and stable catalysts. The most remarkable catalytic property of supported gold was first evidenced for the CO oxidation at sub-ambient temperature. The catalytic activity of the gold-containing systems decreases gradually during the catalytic run, meaning insufficient stability [1]. Therefore, most of the interest in gold catalysts has geared to find more efficient and stable catalysts. On their side, iridium has been also investigated as a catalyst for the CO oxidation [2]. Recently, it has been found that Au in combination with Ir shows high catalytic activity for the decomposition of dioxins at temperature below 200 °C [3]. In order to clarify the synergetic effect of the combination of Au with Ir for that reaction, Akita et al. [4] deposited gold and iridium on a rutile TiO₂ single crystal by deposition-precipitation method. Au and IrO₂ particles were formed and self-organized ordered structures were observed in which Au particles were placed on top of IrO₂ pillars formed on the TiO₂ substrate. Liu et al. [5] showed by DFT calculations on the Au/IrO₂/TiO₂ system that the introduction of the dual-oxide support permits the presence of an active Au/IrO₂ interface that could increase the resistance to sintering of gold nanoparticles. In this work were prepared a series of Au-Ir supported on TiO₂ catalysts by deposition-precipitation with urea (DPU) in order to study the catalytic performance of this material in the CO oxidation reaction. It is shown by the first time that deposition precipitation with urea is able to deposit Ir and Au-Ir nanoparticles on TiO₂. Also, Au-Ir/TiO₂ catalyst presented a synergetic effect and stability is improved with respect to the Au/TiO₂ catalyst.

Materials and Methods

The preparation of gold and iridium nanoparticles (NP) on TiO₂ (Degussa P25) was achieved by DPU following the previously reported procedure [6]. The preparation of bimetallic catalysts was done in two steps: Ir was first deposited on the support by the DPU method, calcined in air at 400 °C for 4 h and then gold was deposited. Samples were characterized by EDS, H₂-TPR, HRTEM, HAADF and CO+O₂ reaction followed by DRIFTS. The CO+O₂ reaction was studied in the temperature range from room temperature to 400°C in a flow reactor at atmospheric pressure. Typically, 0.010 g of catalyst was activated for 2 h in either an air flow at 400 °C or H₂ at 300 °C, before the catalytic run. After this treatment the sample was cooled to room temperature under He. The composition of the reactant gas mixture was 2.5% CO, 2.5% O₂ and balance He. The total flow of reactant gas mixture was 60 mL/min.

Results and Discussion

Catalyst pretreatment had an important effect on the structure of the iridium phase. In calcined samples Ir spreads over the TiO₂ mainly as a thin layer of IrO₂ preferentially deposited on the rutile phase of TiO₂. In reduced samples, Ir particles were homogeneously dispersed on all the TiO₂ crystals. It is shown that in samples reduced at 300 °C, IrO₂ was still present in the mono and bimetallic catalysts. The Ir/TiO₂ samples, calcined in air or reduced in H₂ were not active in CO oxidation at room temperature. The low reactivity displayed by iridium catalysts at low temperature is in line with the DRIFT results showing that iridium metal strongly chemisorbs CO. The combination of gold and iridium produced more active catalyst as compared to Au/TiO₂. While Au/TiO₂ strongly deactivates with time on stream, Au-Ir/TiO₂ seems more stable. This could be related to the presence of a Au/IrO₂ interface as suggested by Liu et al. [5]. On the other hand, it is shown that the conditions of thermal treatment have great influence on the structure and catalytic activity of Au-Ir/TiO₂ samples.

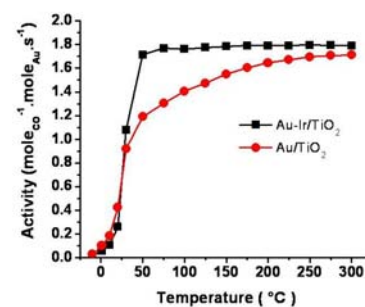


Figure 1. Comparison of CO oxidation activity displayed by Au/TiO₂ and Au-Ir/TiO₂ catalysts

Significance.

This paper is a contribution to the development of stable and active Au-based catalysts.

Acknowledgements

To L. Rendón of LCMIF for HREM images and to PUNTA project for funding. RZ acknowledges CONAC 55154 and PAPIIT IN 106507 projects.

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