CO abatement via Ir-based catalysts: effect of the support and preparation method on catalytic activity and stability

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1. Introduction

- CO is a toxic gas that effects on quality of human health.
- Main sources of CO emissions: (a) automotive exhaust gases, (b) power plants, and (c) the petrochemical industry
- CO oxidation is an important reaction oxidation is a reaction with many applications such as H_2 production via hydrocarbons reforming and reduction of air pollution.
- CO oxidation has been investigated in various catalyst systems:
  - (a) noble metals (e.g., Au, Pt, Pd)
  - (b) non-noble (e.g., Cu, Ni) and
  - (c) metal-free catalytic systems.

Objectives

✓ Synthesis of noble metal-based catalytic systems, using a less costly noble metal such as Ir, dispersed on supports with high oxygen ion lability and oxygen storage capacity (OSC), such as alumina-ceria-zirconia (ACZ) mixed oxides supports

✓ Study of the effect of ACZ supports nature and preparation method on the CO abatement catalytic activity and stability.

2. Experimental

A. Catalysts preparation

- Supports Al_2O_3-Ce_xZr_{1-x} preparation (x=0,25, 0,5 0,75) via
  - ✓ Hydrothermal method (supports ACZ-H)
  - ✓ Co-precipitation method (supports ACZ-P)
- Ir catalysts preparation by wet impregnation

B. Materials characterization

- ✓ N_2 physical adsorption-desorption isotherms (BET-BJH)
- ✓ X-ray powder diffraction (XRD) analysis
- ✓ Hydrogen temperature programmed reduction (H_2-TPR)
- ✓ Isothermal hydrogen chemisorption (H_2-Chem)

C. Catalytic activity and thermal stability measurements

Feed Gas mixture: 1 % v/v CO, 5 %v/v O_2 /He, F_T=160 mL/min (wGHSV=320 000 mL/g_{cat}h)

- ✓ Pre-reduced Ir-catalysts (25% H_2/He, 350° C, 0.5 h)
- ✓ Pre-oxidized Ir-catalysts (20% O_2, 400° C, 1 h)
- ✓ Thermal stability experiments at 320°C after consecutive oxidation steps at 600°C and 700°C

3. Results

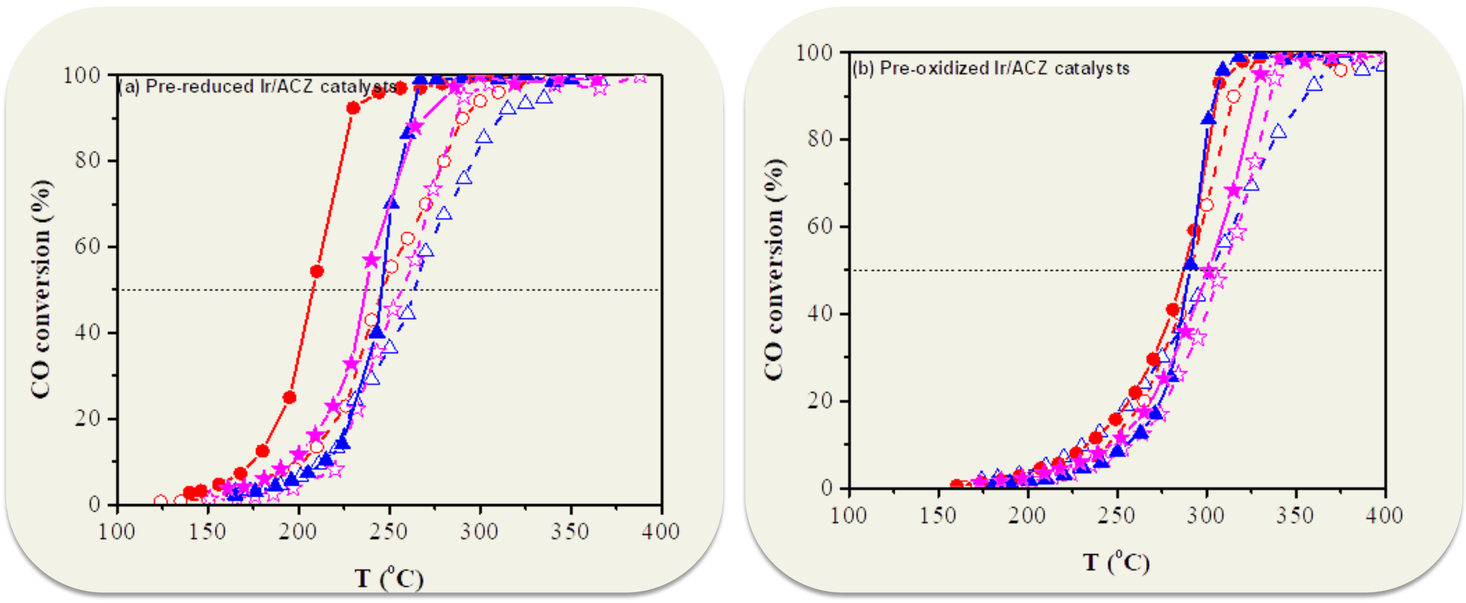

Figure 1. CO conversion light-off profiles on pre-reduced (a) and pre-oxidized (b) Ir/ACZ catalysts. Experimental conditions: 1 v/v% CO, 5 v/v% O_2 balanced with He; wGHSV=320,000 mL·g_{cat}^{-1}·h^{-1}. Filled symbols, solid lines: hydrothermally synthesized catalysts; open symbols, dashed lines: catalysts synthesized by co-precipitation. Circles: Ir/ACZ-H1 and Ir/ACZ-P1 (Ce/Zr=0.25/0.75); triangles: Ir/ACZ-H2 and Ir/ACZ-P2 (Ce/Zr=0.25/0.5); stars: Ir/ACZ-H3 and Ir/ACZ-P3 (Ce/Zr=0.25/0.75).

Table 1. Textural and morphological characteristics of the ACZ supports and counterpart Ir/ACZ catalysts prepared by hydrothermal (H) and co-precipitation (P) methods

Sample	Ce/Zr	S_{BET} (m^2/g)		Ir dispersion (%)
		Support	Catalyst	
Ir/ACZ-H1	0.25/0.75	154	216	66
Ir/ACZ-H2	0.5/0.5	172	184	66
Ir-ACZ-H3	0.75/0.25	149	157	70
Ir-ACZr-P1	0.25/0.75	113	134	70
Ir-ACZ-P2	0.5/0.5	102	100	81
Ir-ACZ-P3	0.75/0.25	115	125	70

Table 2. Temperatures for 50% CO conversion (T_{50})

Sample	T_{50} (°C)	
	Pre-reduced	Pre-oxidized
Ir/ACZ-H1	207	287
Ir/ACZ-H2	245	290
Ir-ACZ-H3	236	300
Ir-ACZr-P1	245	290
Ir-ACZ-P2	264	301
Ir-ACZ-P3	255	309

4. Conclusions

✓ The pre-treatment of catalysts as well as the preparation method, effect on Ir-ACZ activity. More specifically, pre-reduced catalysts are more active than pre-oxidized ones ignited. In addition, hydrothermally made catalysts are more active compared to their counterpart catalysts made via co-precipitation.

✓ Metallic Ir is more active than the IrO_2 phase in CO oxidation.

✓ ACZ mixed oxide supports are particularly satisfactory materials for the design of stable Ir-based catalysts for CO abatement processes as they present remarkable stability on thermal aging under oxidative conditions.

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