

# Carbon Monoxide Adsorption and Oxidation on CeO<sub>2</sub>/Co<sub>3</sub>O<sub>4</sub> Catalyst studied by *In Situ* IR Spectroscopy

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## Introduction

*In situ* infrared (IR) spectroscopy is useful apparatus in the characterization of surface properties of both metal and metal oxide *via* CO adsorption. Besides to the surface species investigation that further can study the CO oxidation and preferential CO oxidation. [1-4]. Therefore, studies the mechanism on catalysts of CO oxidation is an important field for the reaction process. Recently, many researchers were focused the reaction mechanism about CO oxidation over metal oxide by *in situ* IR spectroscopy. Such as Carlsson et al. [1] reported that Pt/Al<sub>2</sub>O<sub>3</sub> catalyst during the extinction the partially oxidized platinum surface is reduced by chemisorbed CO which should be apparently described for in the modeling of the reaction mechanism. Bao et al. studied that CO adsorbed on the Ag/SiO<sub>2</sub> catalyst depends strongly on the CO partial pressure and the temperature.[2] Previous studies of CO oxidation over cobalt oxide(Co<sub>3</sub>O<sub>4</sub>) and supported cobalt (Co/Al<sub>2</sub>O<sub>3</sub>, Co/SiO<sub>2</sub> and Co/TiO<sub>2</sub>) catalysts reported by our group [3-4] have shown that differently reaction mechanism *via* CO adsorption and oxidation. In this paper, we present results and discussion of a spectroscopic study of CO adsorption and oxidation, and its surface adsorbed species of CeO<sub>2</sub>/Co<sub>3</sub>O<sub>4</sub> catalyst by means of the *in situ* FTIR technique.

## Materials and Methods

A self-supporting wafer was prepared by compressing sample and was mounted in a self-designed high temperature IR quartz cell with KBr window. One set of stainless steel gas lines was built and connected to the cell that allowed in situ measurement of spectra of CO and CO/O<sub>2</sub> probe gases.

## Results and Discussion

Table 1 shown that surface species formed during adsorption of CO on ceria, cobalt oxide and CeO<sub>2</sub>/Co<sub>3</sub>O<sub>4</sub> have been investigated. For CO adsorption at room temperature, ceria only has the gas phase at 2143 cm<sup>-1</sup>, cobalt oxide has two adsorption species to separate the CO adsorption (linear : 2166, 2120 and 2064 cm<sup>-1</sup>) and two kinds carbonate adsorption (unidentate: 1600 cm<sup>-1</sup> and bidentate: 1300 cm<sup>-1</sup>) and CeO<sub>2</sub>/Co<sub>3</sub>O<sub>4</sub> has to observe the apparent carbonate adsorption at 1391 and 1216 cm<sup>-1</sup> (Figure 1) that attributed to the interface of CeO<sub>2</sub> and Co<sub>3</sub>O<sub>4</sub> and then the other similar adsorption from the cobalt oxide. Figure 2 shown that CO/O<sub>2</sub> desorption of CeO<sub>2</sub>/Co<sub>3</sub>O<sub>4</sub> of these species at raise temperature shows that the order of thermal stability is interface bidentate carbonate < interface unidentate carbonate < bidentate carbonate < unidentate carbonate species. The results revealed that interface adsorption on CeO<sub>2</sub> and

Co<sub>3</sub>O<sub>4</sub> can mainly promoted the CO to conversion CO<sub>2</sub> via carbonate species. The reaction mechanism is also discussed.

Table 1. Types of adsorbed species over catalysts

Catalysts	Adsorbed species (cm <sup>-1</sup> )							
	Linear			Carbonates				
	ν-CO <sub>g</sub> <sup>a</sup>	ν-CO <sub>s</sub> <sup>b</sup>		ν <sub>(i)</sub> -CO <sub>(uni)</sub> <sup>c</sup>	ν-CO <sub>(uni)</sub> <sup>d</sup>	ν-CO <sub>(bi)</sub> <sup>e</sup>	ν <sub>(i)</sub> -CO <sub>(bi)</sub> <sup>f</sup>	
							asy	sy
CeO <sub>2</sub>	—	—	—	—	—	—	—	—
Co <sub>3</sub> O <sub>4</sub> <sup>g</sup>	2166	2120	2064	—	1600	1300	—	—
CeO <sub>2</sub> /Co <sub>3</sub> O <sub>4</sub>	—	—	—	1611	1595	1300	1391	1216

<sup>a</sup>: Catal. Lett. 86, (2003) 63 (our study); <sup>b</sup>: Weak of Linear adsorption; <sup>c</sup>: Strong of Linear adsorption; <sup>d</sup>: Unidentate carbonate adsorbed on the interface(i); <sup>e</sup>: Bidentate carbonate adsorption; <sup>f</sup>: Unidentate carbonate adsorption; <sup>g</sup>: Bidentate carbonate adsorbed on the interface(i); asy, asymmetric vibration; sy, symmetric vibration.

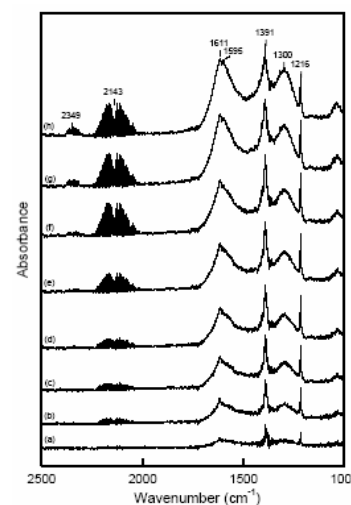


Figure 1. FT-IR spectra of CeO<sub>2</sub>/Co<sub>3</sub>O<sub>4</sub> catalyst exposure under various amounts of CO: (a). 0.1 torr (b). 0.5 torr (c). 1.0 torr (d). 2.0 torr (e). 5.0 torr (f). 10.0 torr (g) 30 minutes (h) 60 minutes at room temperature.

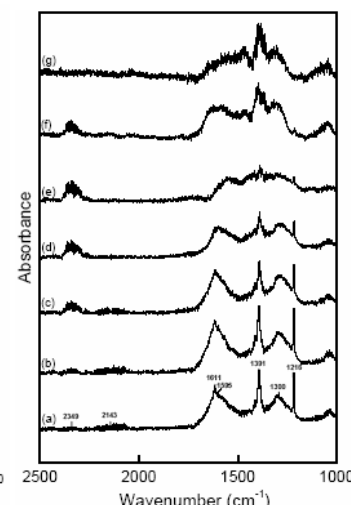


Figure 2. *In situ* FT-IR spectra of CeO<sub>2</sub>/Co<sub>3</sub>O<sub>4</sub> catalyst after exposure to 1.0 torr CO and 1.0 torr O<sub>2</sub> at various temperatures: (a) 1.0 torr CO (b). 1.0 torr O<sub>2</sub> (c). 50 °C (d). 75 °C (e) 100 °C (f) cooling to RT (g) evacuation.

## References

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