

## CHAPTER IV

### SELECTIVE CO OXIDATION ACTIVITY OF Pt/CeO<sub>2</sub> AND Pt/CeO<sub>2</sub>.Al<sub>2</sub>O<sub>3</sub> CATALYSTS

In this chapter, a comparative study of the catalytic performance of the Pt/CeO<sub>2</sub> and Pt/CeO<sub>2</sub>.Al<sub>2</sub>O<sub>3</sub> catalysts will be presented as a function of catalyst preparation technique and reaction condition. The main focus of this chapter was on the investigation of low temperature catalysts for the selective CO oxidation activity.

#### 4.1 Pt/CeO<sub>2</sub> Catalysts

As mentioned in Chapter III, three catalyst preparation methods gave significantly different catalysts. Therefore, the impregnation method was used with high and low surface area CeO<sub>2</sub> to produce different catalysts. Likewise, the sol-gel technique catalysts were prepared by using different procedures as described below.

There are five methods of catalyst preparation in this chapter; impregnation methods A and B, co-precipitation, and the sol-gel methods A and B, were conducted to prepare Pt/CeO<sub>2</sub> catalysts.

*Impregnation method A* The catalyst was obtained by impregnation of the low surface area CeO<sub>2</sub> support with an aqueous solution of H<sub>2</sub>PtCl<sub>6</sub>.6H<sub>2</sub>O containing appropriate amount of Pt.

*Impregnation method B* The catalyst was prepared by the same procedure as method A except high surface area CeO<sub>2</sub> support was used. The low and high surface area of CeO<sub>2</sub> have surface areas of 10 and 119 m<sup>2</sup>/g, respectively.

*Co-precipitation method* An aqueous solution of Na<sub>2</sub>CO<sub>3</sub> was added to an aqueous mixture of H<sub>2</sub>PtCl<sub>6</sub>.6H<sub>2</sub>O and Ce(NO<sub>3</sub>)<sub>3</sub>.6H<sub>2</sub>O and the mixture was kept at room temperature and at constant pH of 8.0. The precipitate formed was aged for an hour and then was washed several times with distilled water until the solution conductivity did not change.

*Sol-gel method A* The catalyst was prepared by hydrolyzing a solution of Ce acetate and H<sub>2</sub>PtCl<sub>6</sub>.6H<sub>2</sub>O with NH<sub>4</sub>OH. The reaction mixture was kept at 80°C

while the pH was maintained between 9.0-9.5. Then,  $\text{HNO}_3$  was added until gelation, the catalyst was dried overnight at  $110^\circ\text{C}$  and calcined at  $500^\circ\text{C}$  for 5 h.

*Sol-gel method B* The catalyst was prepared by following procedure:

a) The solutions used for this method were salts of platinum, cerium and urea. They were prepared by dissolving in deionized water.

b) The sample was made by mixing equal volumes of stock solutions of  $\text{CeO}_2$  and urea together.

c) The mixture was measured into the Glass Schott bottle; the bottle was sealed and put in the oven at  $100^\circ\text{C}$  for 50 h.

d) After the desired reaction time was passed, the sample was taken outside the oven, and allowed to cool down.

e) The sample was separated by centrifuging at 2,000 rpm for five minutes. The washing procedure was repeated several times until the conductivity change of supernatant was insignificant.

f) The sample was washed in the same way with ethanol to prevent the hydroxides from forming agglomerates after the sample had dried. The sample was dried at  $110^\circ\text{C}$  overnight and calcined in air at temperature of  $500^\circ\text{C}$  for 5 h.

#### 4.1.1 Catalyst Characterization

The catalysts were characterized by BET and XRD, to determine approximate surface area and phases present. In summary, the catalysts can be ranked from the one having the highest to the lowest physical properties as shown in Table 4.1.

Surface area: impregnation method B > co-precipitation > sol-gel method B > sol-gel method A > impregnation method A

Pore volume : impregnation method B > co-precipitation > impregnation method A > sol-gel method B > sol-gel method A

Pore volume of the catalysts follows the same trend as the surface area.

**Table 4.1** Physical properties of 1%Pt/CeO<sub>2</sub> catalysts.

Method of preparation	Surface area (m <sup>2</sup> /g)	Pore volume (cc/g)
Sol-gel method A	55.00	7.03 x 10 <sup>-3</sup>
Sol-gel method B	68.54	6.27 x 10 <sup>-3</sup>
Impregnation method A	8.50	3.55 x 10 <sup>-3</sup>
Impregnation method B	116.10	4.64 x 10 <sup>-2</sup>
Co-precipitation method	114.00	5.29 x 10 <sup>-2</sup>

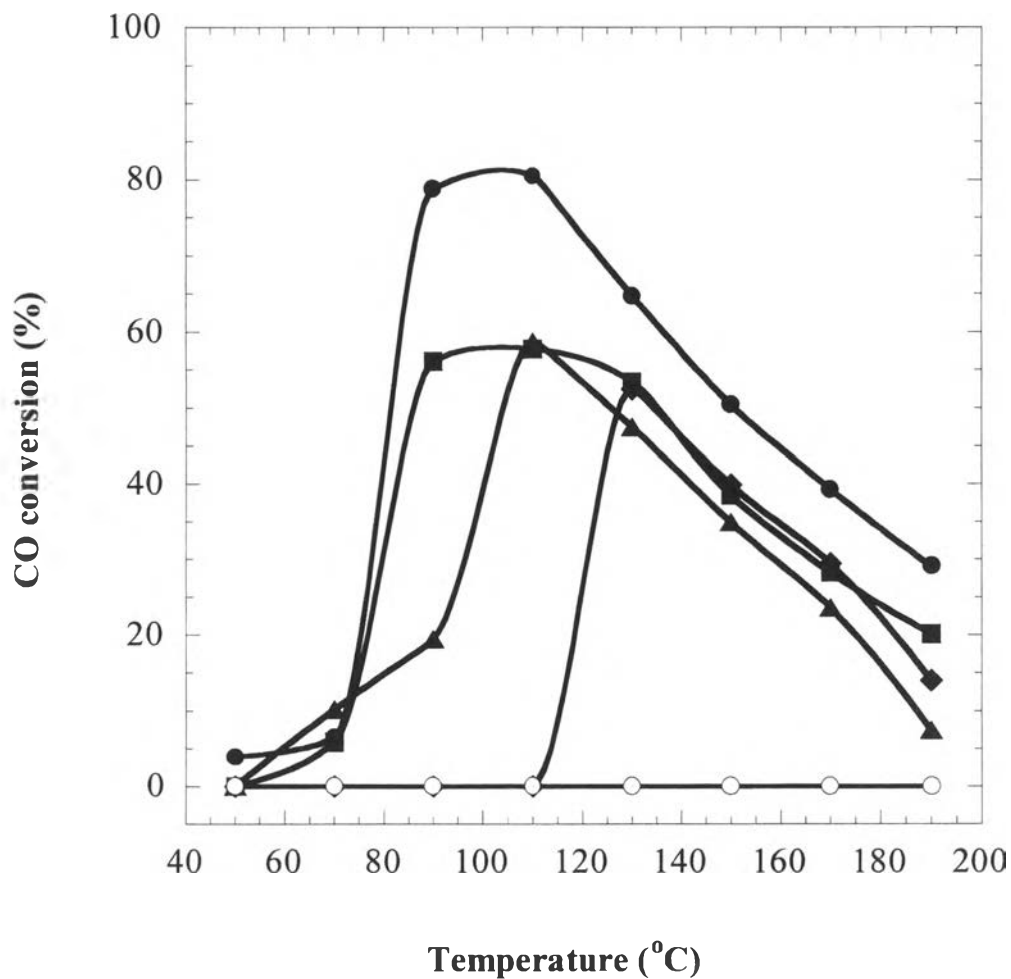
#### 4.1.2 Effect of Catalyst Preparation Method on Pt/CeO<sub>2</sub> Catalysts

All experiments reported in the following sections were conducted with catalysts in the temperature range of 50-190°C. The feed contained 1% CO, 1% O<sub>2</sub>, 2.6% H<sub>2</sub>O, 2% CO<sub>2</sub>, 40 % H<sub>2</sub> and helium.

The effect of preparation method on CO conversion activity as a function of reaction temperature is shown in Figure 4.1. The catalyst prepared by the sol-gel method A has the higher activity of CO conversion than sol-gel method B the impregnation method B gives higher activity than impregnation method A and the co-precipitation method which showed very low activity. Therefore, the overall order activity is: sol-gel method A, sol-gel method B, impregnation method B, impregnation method A and then co-precipitation.

The sol-gel method A catalyst reaches a maximum conversion of 85% at a temperature of 110°C. The sol-gel method B catalyst reaches a maximum activity of 60% conversion at 110°C. Not unexpectedly the higher surface area ceria impregnation catalyst is more active than the low surface area ceria impregnation catalyst and reaches a conversion of 55% at 110°C. The low surface area impregnation catalyst also has respectable activity and gives a conversion of 50% at 130°C.

impregnation catalyst also has respectable activity and gives a conversion of 50% at 130°C.



**Figure 4.1** The activity of 1% Pt/CeO<sub>2</sub> catalysts prepared by different methods versus temperature. Reactant composition: 1% CO, 1% O<sub>2</sub>, 2% CO<sub>2</sub>, 2.6% H<sub>2</sub>O, 40% H<sub>2</sub> and helium; (●) sol-gel A; (■) sol gel B; (◆) impregnation A; (▲) impregnation B; (○) co-precipitation.

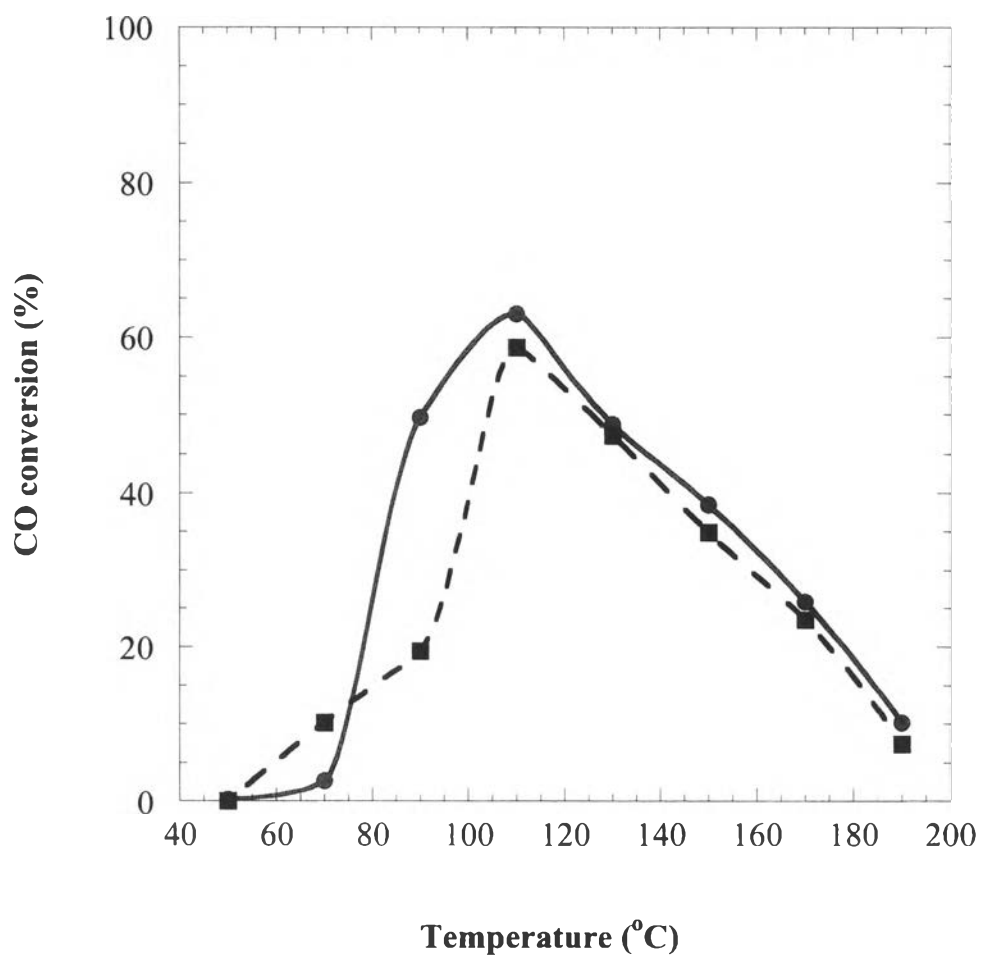
#### 4.1.3 Response of the Pt/CeO<sub>2</sub> Impregnation Method B Catalyst to Presence of Water Vapor

Because the impregnation method catalyst B has the highest surface area and pore volume and as a result we tested this catalyst further as discussed below.

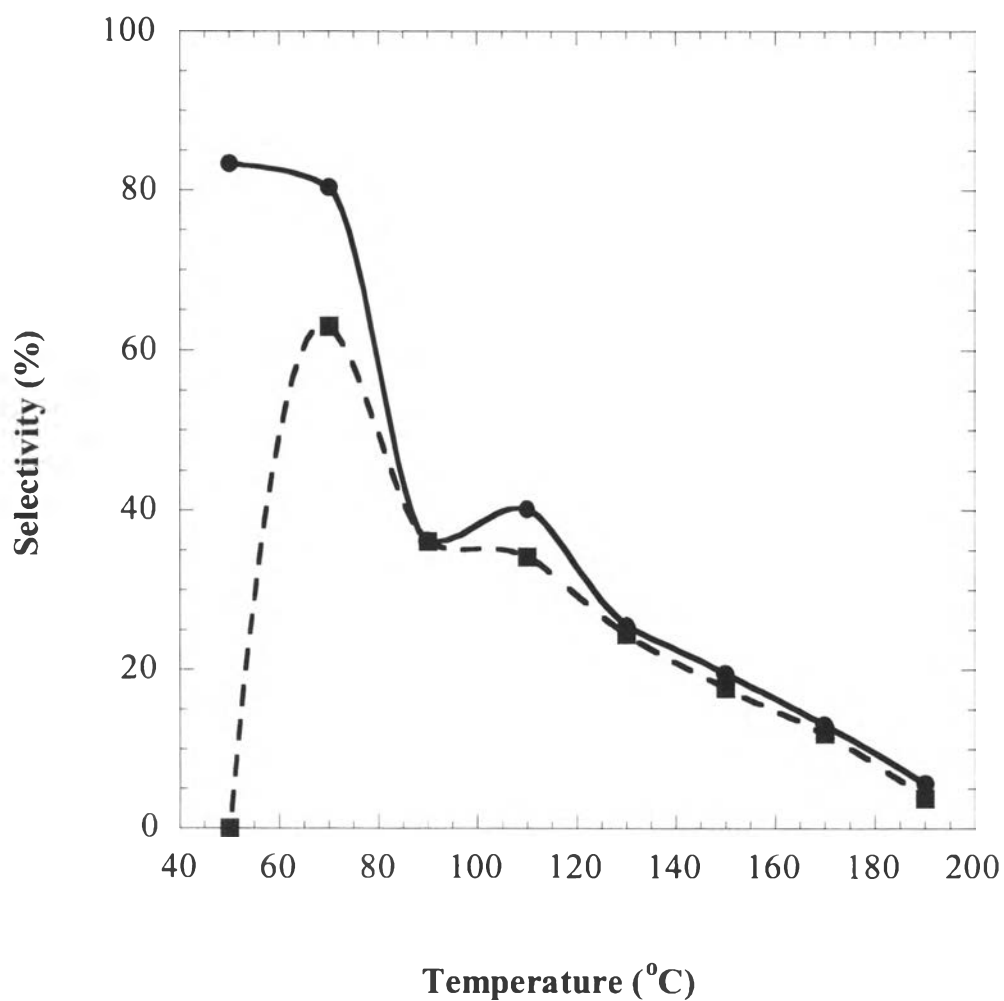
##### *Effect of Water Addition*

In this section, the roles of surface area of the catalysts are investigated by considering the catalytic performance in dry and wet gas stream as a function of temperature.

The experiments were performed over the temperature range from 50-190°C. The reactant streams were humidified by bubbling through a temperature controlled water bubbler, yielding 2.6% water vapor in the reactant gas. The activity and selectivity of Pt/CeO<sub>2</sub> impregnation method B is illustrated in Figures 4.2 and 4.3. Figure 4.2 compares the CO conversion of impregnation method B catalysts in the presence of 2.6% water vapor and without water. It is clear that for this catalyst, water vapor has a little negative effect over the wide range of temperature window. The maximum conversion of impregnation catalysts decreases to about 60% from 65%. It was found that the addition of water have no effect on the temperature at maximum CO conversion. Figure 4.3 shows the effect of water on the selectivity of impregnation method B catalysts. It was found that water has a little effect on selectivity of this catalyst.



**Figure 4.2** Effect of water vapor on CO conversion of the 1% Pt/CeO<sub>2</sub> impregnation catalyst. Reactant composition: 1% CO, 1% O<sub>2</sub>, 2% CO<sub>2</sub>, 2.6% H<sub>2</sub>O, 40% H<sub>2</sub> and helium; (●) w/o water; (■) water.



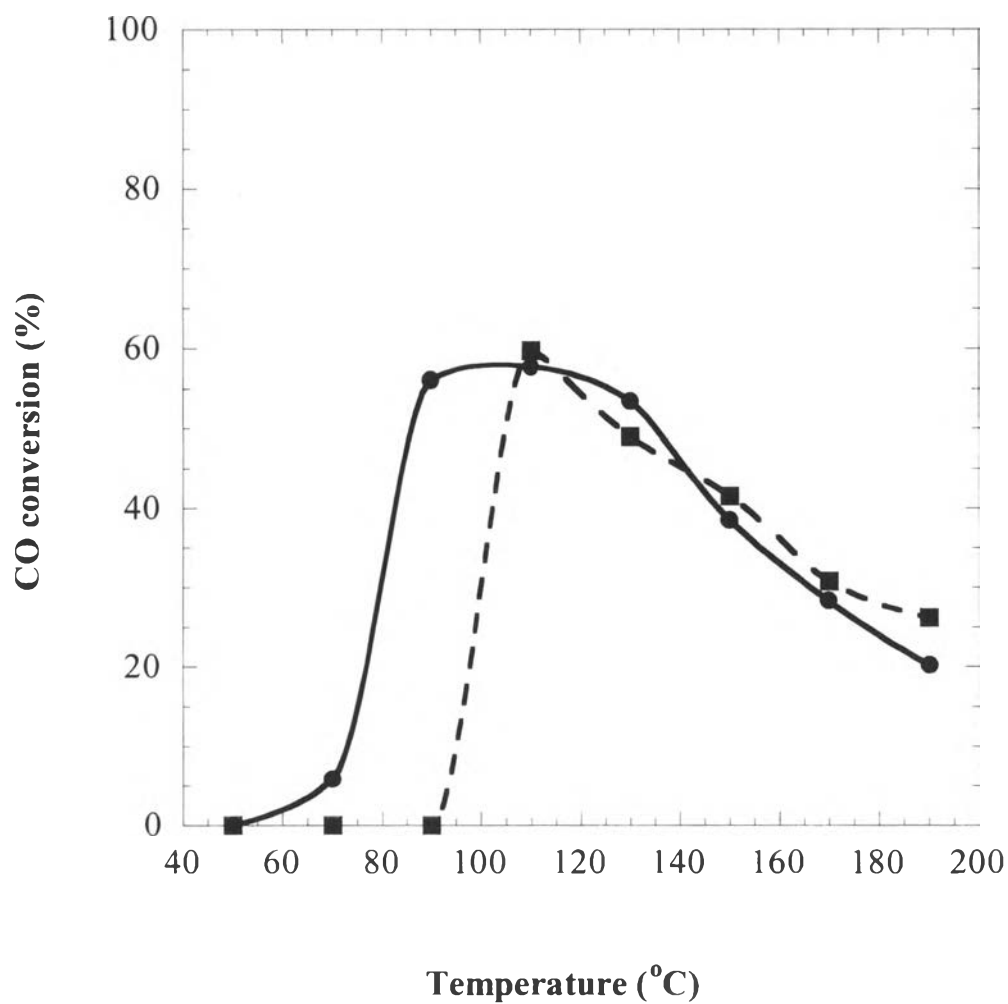
**Figure 4.3** Effect of water vapor on selectivity of the 1%Pt/CeO<sub>2</sub> impregnation catalyst. Reactant composition: 1% CO, 1% O<sub>2</sub>, 2% CO<sub>2</sub>, 2.6% H<sub>2</sub>O, 40% H<sub>2</sub> and helium; (●) w/o water; (■) water.

#### 4.1.4 Response of the Pt/CeO<sub>2</sub> Sol-gel Method B Catalyst to Various Pretreatments and Oxygen Concentration

##### *Effect of Pretreatment*

The effect of pretreatment was tested over the temperature range of 50 to 190°C. The reactant stream consisted of 1% CO, 1% O<sub>2</sub>, 2% CO<sub>2</sub>, 2.6% H<sub>2</sub>O, 40% H<sub>2</sub> and helium. Figure 4.4 shows the effect of pretreatment on CO conversion of sol-gel method B catalysts. The maximum conversion of H<sub>2</sub> pretreatment sol-gel method B catalyst O<sub>2</sub> pretreatment are the same. However, the reductive pretreatment of Pt/CeO<sub>2</sub> catalyst gave a broader activity peak and reached maximum activity at a temperature ~20°C lower (90°C versus 110°C). This result can be understood through activation of Pt by partial reduction of CeO<sub>2</sub> close to Pt, which induces a high oxygen transport to platinum (Holmgren *et al.*, 1999).

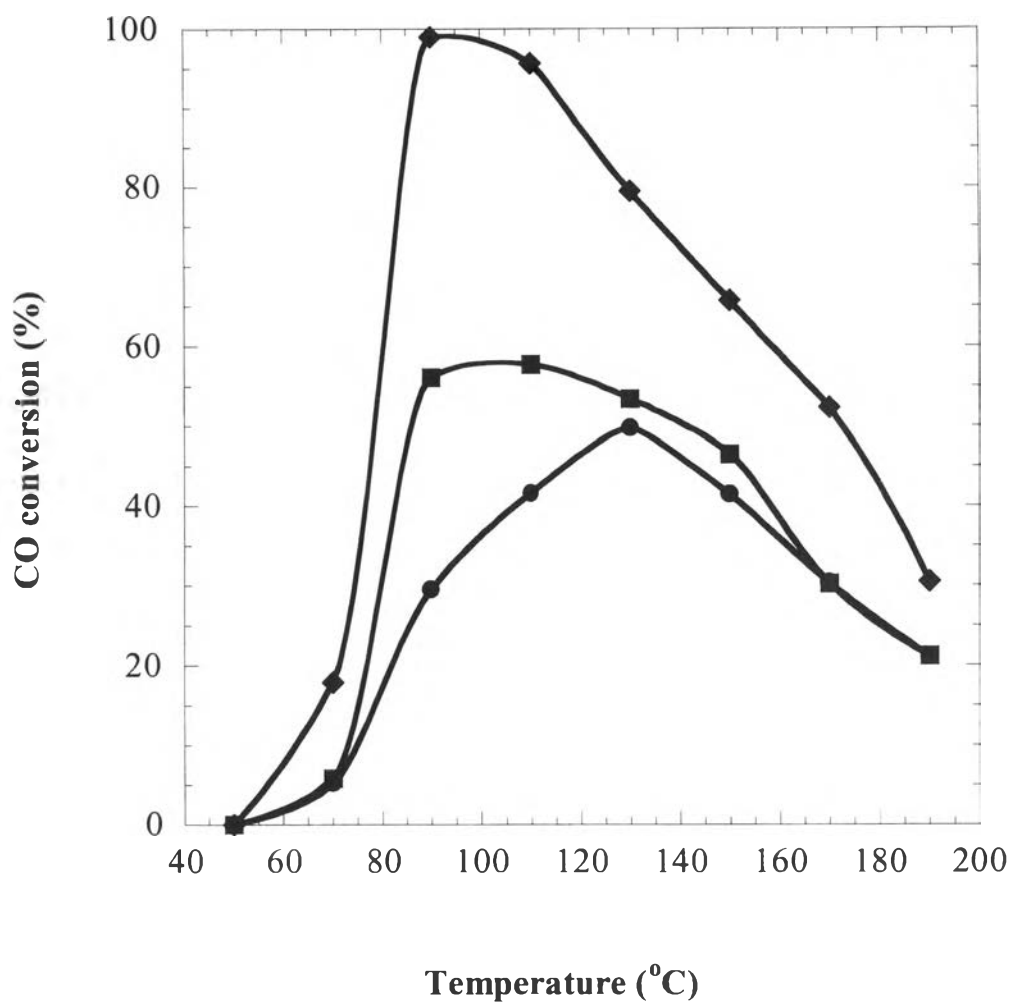




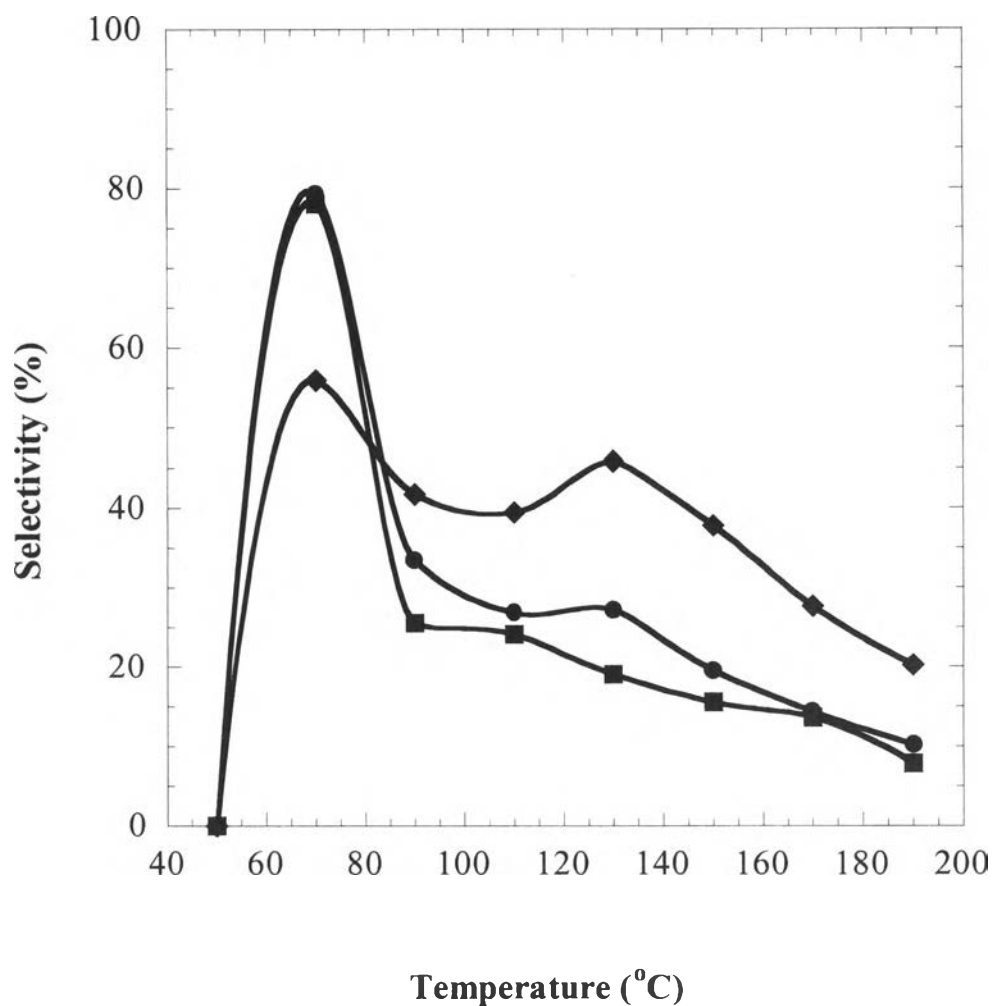
**Figure 4.4** Effect of pretreatment method on performance of 1% Pt/CeO<sub>2</sub> sol-gel method B catalyst. Reactant composition: 1% CO, 1% O<sub>2</sub>, 2% CO<sub>2</sub>, 2.6% H<sub>2</sub>O, 40% H<sub>2</sub> and helium; (●) H<sub>2</sub> pretreatment; (■) O<sub>2</sub> pretreatment.

### *Effect of Oxygen Concentration*

The effects of O<sub>2</sub> concentration on CO conversion and selectivity over Pt/CeO<sub>2</sub> sol-gel catalyst are shown in Figures 4.5 and 4.6, respectively. The O<sub>2</sub> concentration in the feed was varied from 0.5 to 2%. With 0.5, 1 and 2% O<sub>2</sub> the maxima in CO conversion are ~ 56, 58 and 99% at 110°C, respectively, while selectivities at the point of maximum conversion for the three O<sub>2</sub> concentrations are 79, 78 and 56% at 70°C, respectively. The CO conversion increases with increasing O<sub>2</sub> concentration while selectivity decreases with increasing O<sub>2</sub> concentration.



**Figure 4.5** Effect of O<sub>2</sub> concentration on CO conversion of 1% Pt/CeO<sub>2</sub> sol-gel method B catalyst. Reactant composition: 1% CO, 0.5-2% O<sub>2</sub>, 2% O<sub>2</sub>, 2.6% H<sub>2</sub>O, 40% H<sub>2</sub> and helium; (●) 0.5% O<sub>2</sub>; (■) 1% O<sub>2</sub>; (◆) 2% O<sub>2</sub>.



**Figure 4.6** Effect of O<sub>2</sub> concentration on selectivity of 1% Pt/CeO<sub>2</sub> sol-gel method B catalyst. Reactant composition: 1% CO, 0.5-2% O<sub>2</sub>, 2% CO<sub>2</sub>, 2.6% H<sub>2</sub>O, 40% H<sub>2</sub> and helium; (◆) 0.5% O<sub>2</sub>; (●) 1% O<sub>2</sub>; (■) 2% O<sub>2</sub>.

## 4.2 Pt/CeO<sub>2</sub>.Al<sub>2</sub>O<sub>3</sub> Catalysts

Over the past several years, CeO<sub>2</sub> and CeO<sub>2</sub> containing materials have come under intense scrutiny as catalysts and as structural and electronic promoters of heterogeneous catalytic reaction (Martinez-Arias *et al.*, 1998). CeO<sub>2</sub> is considered one of the essential ingredients of modern automotive exhaust catalysts where it functions synergetically with precious metal components such as Pt, Pd, and Rh. It has been also reported that the addition of CeO<sub>2</sub> generally improves the behavior of alumina-based catalysts used for automotive emission control. Pt/CeO<sub>2</sub>.Al<sub>2</sub>O<sub>3</sub> catalysts have been found to show high activity in CO oxidation as reported by Summers and Ausen (1979). A review of the literature reveals only the influence of CeO<sub>2</sub> on the activity of Pt in automotive exhaust catalysis. Therefore, a comprehensive investigation on the role of CeO<sub>2</sub> as a promoter in selective CO oxidation is needed. The effects of CeO<sub>2</sub> addition, pretreatment and Pt loading to Pt/Al<sub>2</sub>O<sub>3</sub> catalysts were studied to optimally design an effective catalyst for this reaction.

### 4.2.1 Catalyst Preparation

The catalysts were prepared by impregnation of sol-gel Al<sub>2</sub>O<sub>3</sub> support with aqueous solutions of Ce(NO<sub>3</sub>)<sub>3</sub> for CeO<sub>2</sub> and H<sub>2</sub>PtCl<sub>6</sub> for Pt. Samples with 5 and 10 wt% of promoter were studied. The Pt/CeO<sub>2</sub>.Al<sub>2</sub>O<sub>3</sub> catalysts were obtained by successive impregnations, of CeO<sub>2</sub> first, followed by the impregnation of platinum. After each impregnation, samples were dried overnight at 110°C and subsequently calcined at 400°C for 2 h in air before storage in a dessicator.

### 4.2.2 Catalyst Characterization

The catalysts were characterized by BET and XRD as shown in Table 4.2 and Figures 4.7 and 4.8.

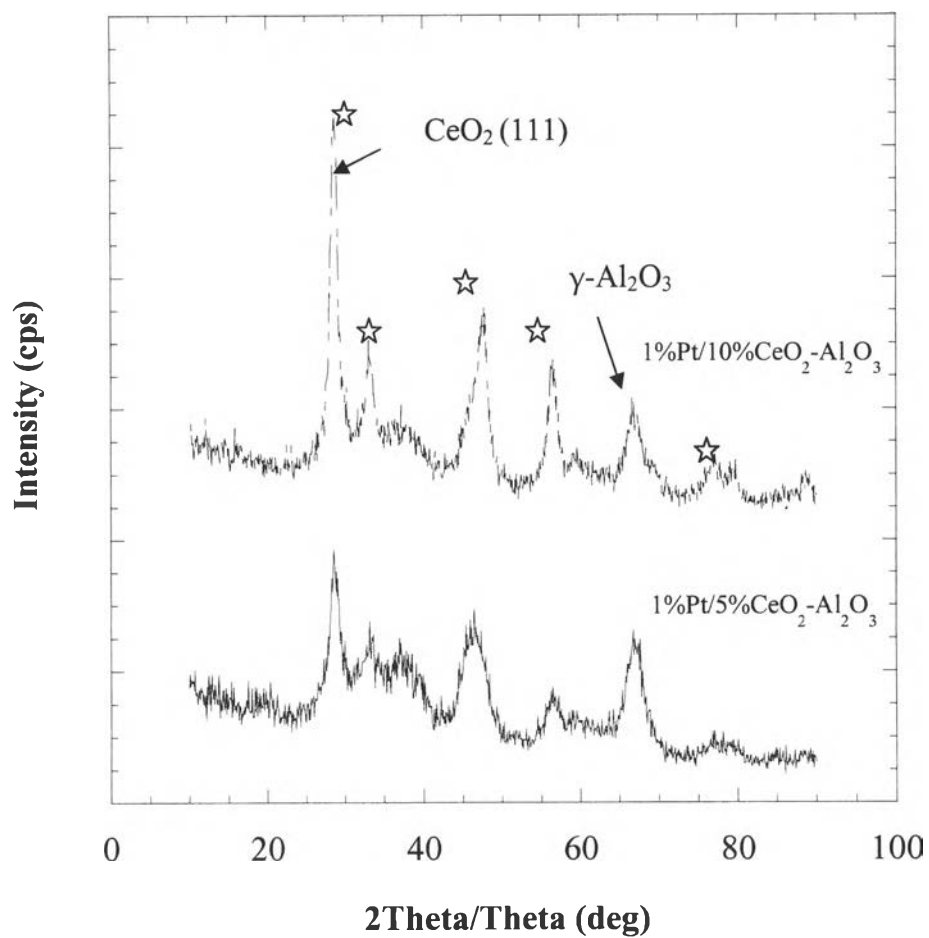
BET measurements were done to determine the surface areas and pore sizes of the catalysts Table 4.2 shows the BET areas corresponding to the fresh catalysts with different Pt and CeO<sub>2</sub> loadings. The 1%Pt/10%CeO<sub>2</sub>.Al<sub>2</sub>O<sub>3</sub> catalyst has the lowest surface area and pore size. The surface areas of all catalysts were less

than that measured for the  $\text{Al}_2\text{O}_3$  support material itself. Summers and Ausen (1979) showed that the effect of Ce addition to  $\text{Al}_2\text{O}_3$  was to plug some of the pores of the  $\text{Al}_2\text{O}_3$  support and thereby cause a decrease in pore volume with a concomitant loss of surface area. The 2%Pt/5%CeO<sub>2</sub>.Al<sub>2</sub>O<sub>3</sub> catalyst has the highest surface area and pore size. It is interesting to note that the activities closely parallel the surface area. The 2%Pt/5%CeO<sub>2</sub>.Al<sub>2</sub>O<sub>3</sub> is the best catalyst among the three catalysts and has highest surface area and pore size.

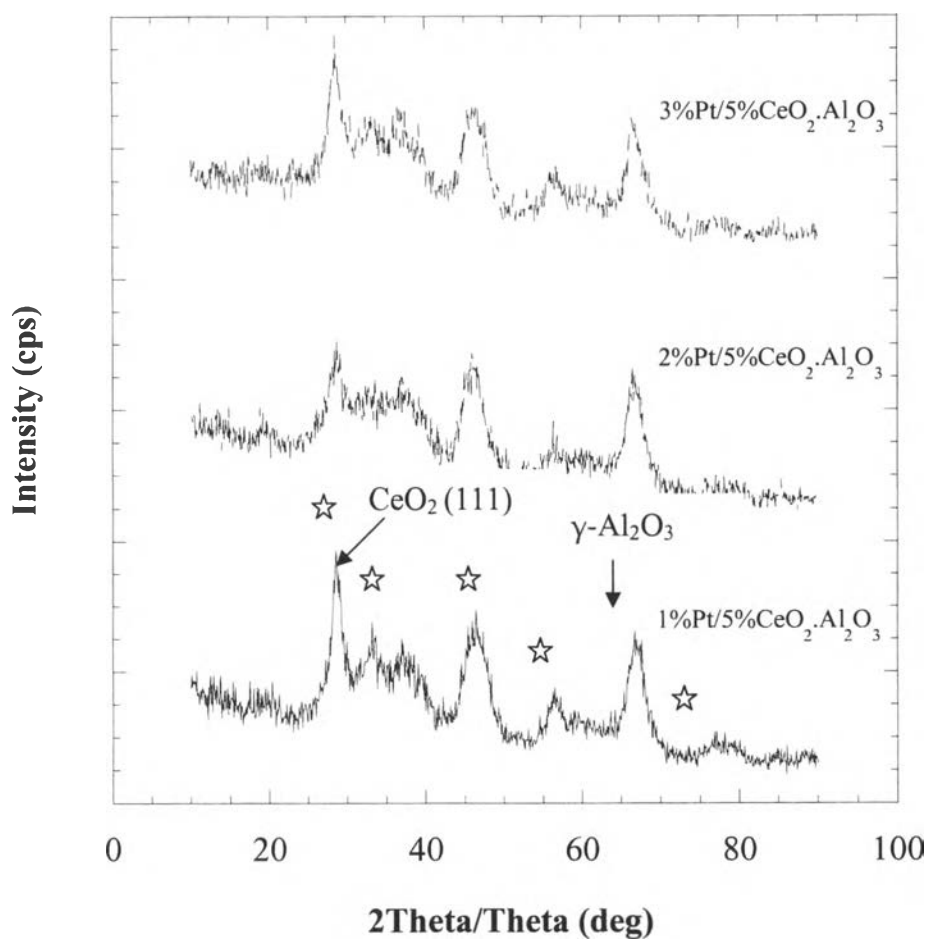
**Table 4.2** Physical properties of Pt/CeO<sub>2</sub>.Al<sub>2</sub>O<sub>3</sub> catalysts.

Method of preparation	Surface area (m <sup>2</sup> /g)	Pore radius (Å)
1%Pt/5%CeO <sub>2</sub> .Al <sub>2</sub> O <sub>3</sub>	276.7	72.54
1%Pt/10%CeO <sub>2</sub> .Al <sub>2</sub> O <sub>3</sub>	271.2	69.36
2%Pt/5%CeO <sub>2</sub> .Al <sub>2</sub> O <sub>3</sub>	296.3	78.02
3%Pt/5%CeO <sub>2</sub> .Al <sub>2</sub> O <sub>3</sub>	290.1	81.16

The X-ray diffraction peaks from the CeO<sub>2</sub> were analyzed to determine integrated intensities and width widths. The average crystallite size determined from the broadening of the diffracted peaks was approximately 100 Å.



**Figure 4.7** XRD patterns of 1%Pt/5%CeO<sub>2</sub>.Al<sub>2</sub>O<sub>3</sub> and 1%Pt/10%CeO<sub>2</sub>.Al<sub>2</sub>O<sub>3</sub> catalysts; (☆) CeO<sub>2</sub>.



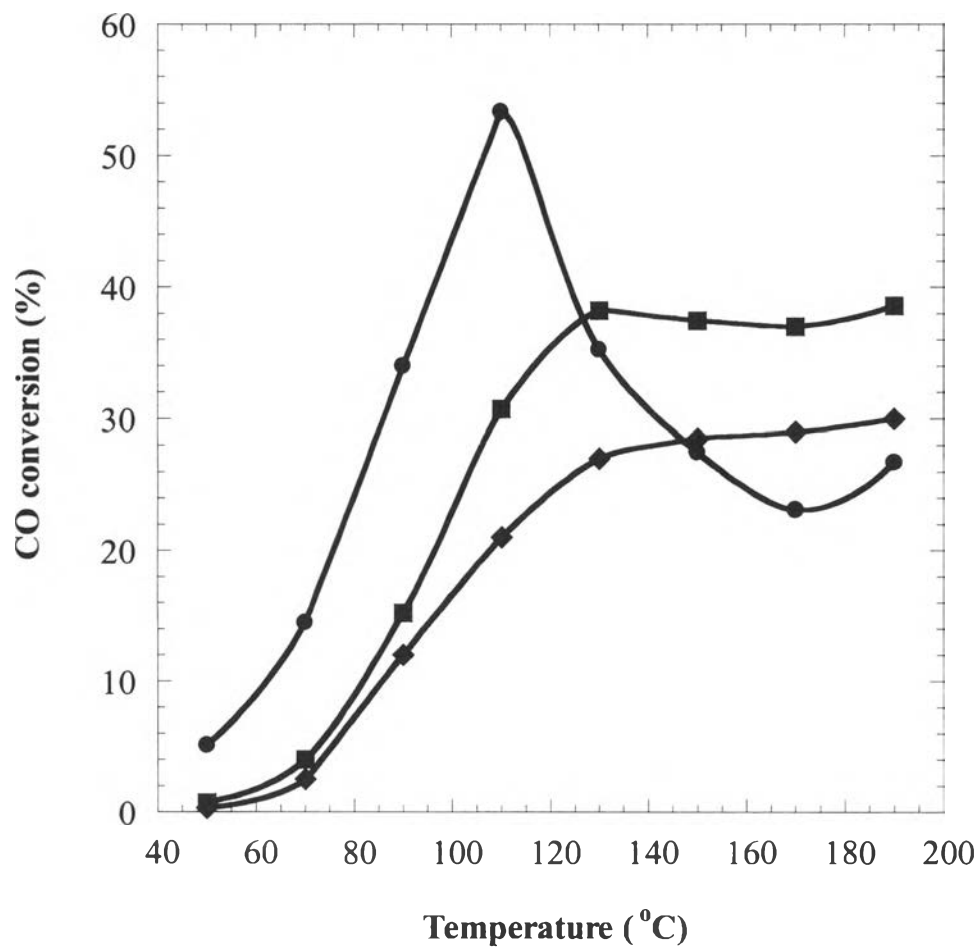
**Figure 4.8** XRD patterns of 1%Pt/5%CeO<sub>2</sub>.Al<sub>2</sub>O<sub>3</sub>, 2%Pt/5%CeO<sub>2</sub>.Al<sub>2</sub>O<sub>3</sub> and 3%Pt/5%CeO<sub>2</sub>.Al<sub>2</sub>O<sub>3</sub> catalysts; (☆) CeO<sub>2</sub>.



### 4.2.3 Effect of Cerium Loading

The increased levels of CeO<sub>2</sub> present in three way catalysts have focused some attention on CeO<sub>2</sub> physical properties and thermal stability. In this work we studied the activity of CeO<sub>2</sub> promoted on Pt catalysts in this system. Two Ce loadings were used 5 and 10% Ce (by weight percent of the metal Ce). The performance of these catalysts in the simulated reformer stream clearly demonstrated CeO<sub>2</sub>-promotion of activity for CO conversion. From Figure 4.9, it is seen that the introduction of 10% Ce on alumina resulted in changing the activity curve (compared to pure ceria support) the maximum activity remained essentially constant but the higher temperature side activity decreased significantly. However, the catalyst with 5% Ce had only a maximum conversion of ~40% but its activity did not decrease from 100°C to 200° C. This result shown in Figure 4.9 agree with Summers and Ausen (1979) who found that at higher Ce:Pt ratios, CO conversion over the catalyst seriously deteriorated. It has been reported that high amounts of promoters generally decrease catalytic activity due to the coverage of active sites. For the fresh 1%Pt/CeO<sub>2</sub>.Al<sub>2</sub>O<sub>3</sub> catalysts, the apparent Pt dispersion decreases with increasing Ce content.

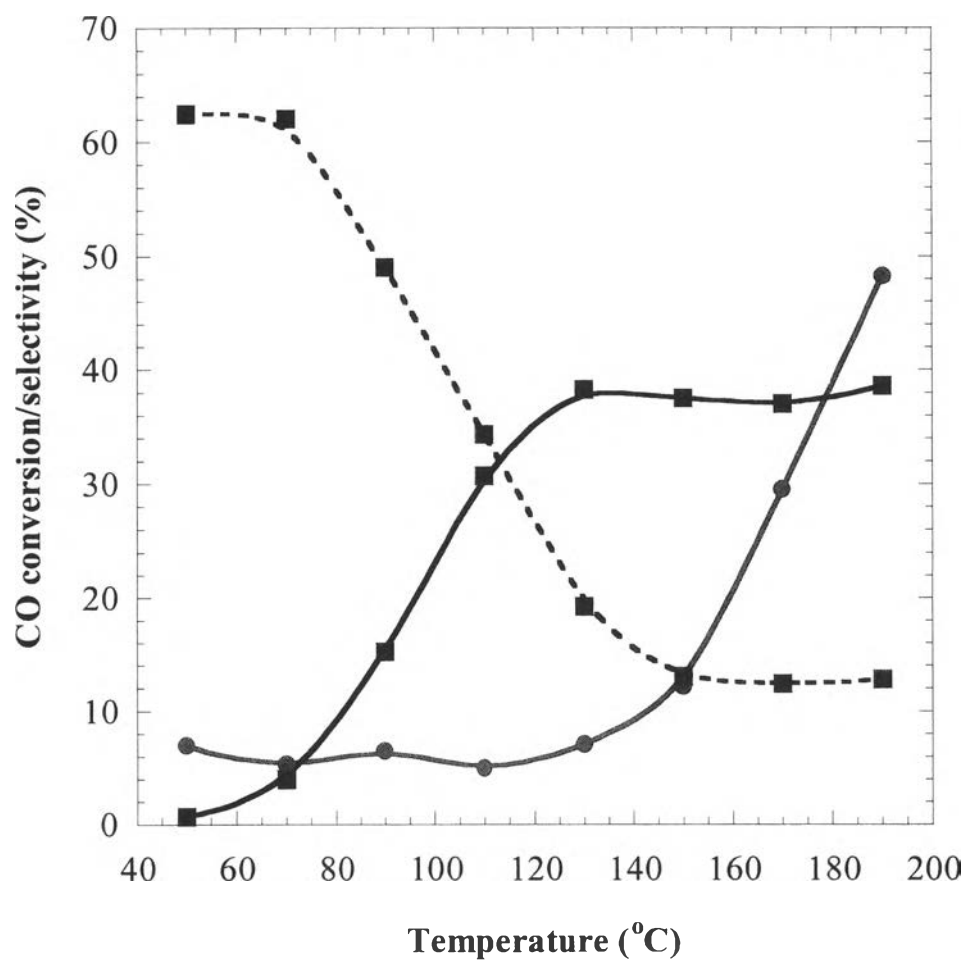
Improvements in the CO oxidation activity have been investigated by several researchers to the donation of lattice oxygen from CeO<sub>2</sub> for participation in the oxidation of adsorbed CO to CO<sub>2</sub> (Jin *et al.*, 1987 and Serre *et al.*, 1993). The enhancement of CO oxidation occurs at lower Ce loadings. This phenomenon must be due to Pt-Ce interactions (Serre *et al.*, 1993) since CeO<sub>2</sub>.Al<sub>2</sub>O<sub>3</sub> by itself does not significantly oxidize CO under the conditions that activity measurements were carried out. They believed that a slight increase in Pt oxidation state may reflect charge transfer from metal to ceria, indicating that Ce is slightly reduced which was supported by TPR measurements (Tieman and Finlayson 1998).



**Figure 4.9** Effect of Ce addition over 1% Pt/CeO<sub>2</sub>.Al<sub>2</sub>O<sub>3</sub> catalysts. Reactant composition: 1% CO, 1% O<sub>2</sub>, 2% CO<sub>2</sub>, 2.6% H<sub>2</sub>O, 40% H<sub>2</sub> and helium; (●) 10% Ce; (■) 5% Ce; (◆) 0% Ce.

#### 4.2.4 Effect of Reductive and Oxidative Pretreatments on Activity and Selectivity

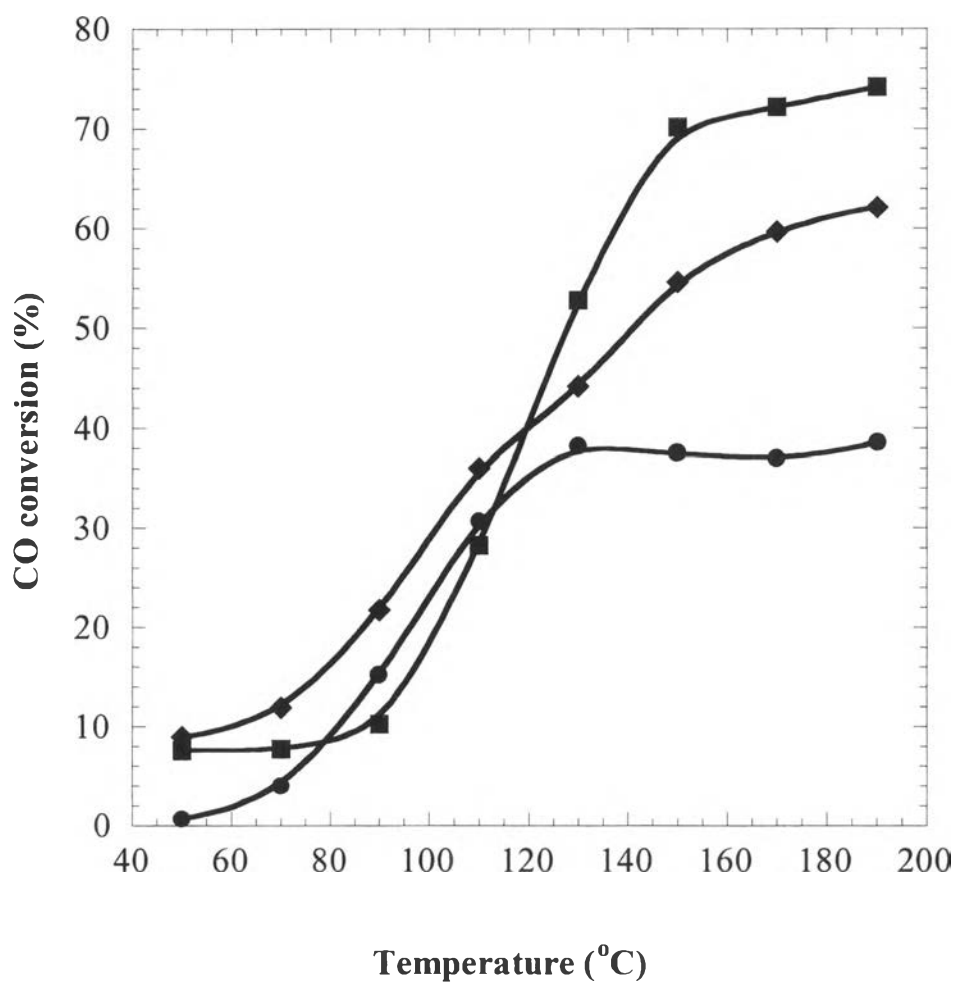
We tested the effect of reductive and oxidative pretreatments with the 1%Pt/5%Ce.Al<sub>2</sub>O<sub>3</sub> impregnation catalyst. Figure 4.10 shows the relationship between CO conversion versus temperature for the 1%Pt/5%Ce.Al<sub>2</sub>O<sub>3</sub> impregnation catalysts, which were tested after either a pure H<sub>2</sub> pretreatment and pure O<sub>2</sub> pretreatment at 300°C for 2 h. It can be observed that pure H<sub>2</sub> pretreatment gives higher conversions when compared to pure O<sub>2</sub> pretreatment over the temperatures below 180°C. Obviously, the pretreatment atmosphere affects considerably the activity of the Pt/Ce.Al<sub>2</sub>O<sub>3</sub>. Diwell *et al.* (1991) found that the pre-reduction of a 0.9% Pt/CeO<sub>2</sub> catalyst resulted in enhanced conversion of CO, NO, H<sub>2</sub> and C<sub>3</sub>H<sub>6</sub>. It was proposed that an induced Pt-CeO<sub>2</sub> interaction occurred during reduction which greatly affected the nature and activity of the catalytic sites. The high low temperature activity of the pre-reduced Pt/CeO<sub>2</sub>.Al<sub>2</sub>O<sub>3</sub> catalyst has been attributed to Pt-CeO<sub>2</sub> sites localized at the Pt-CeO<sub>2</sub> interface. The key point of the low temperature activity would be the oxidation of CO adsorbed on Pt by migration of atomic oxygen from CeO<sub>2</sub> (Serre *et al.*, 1993).



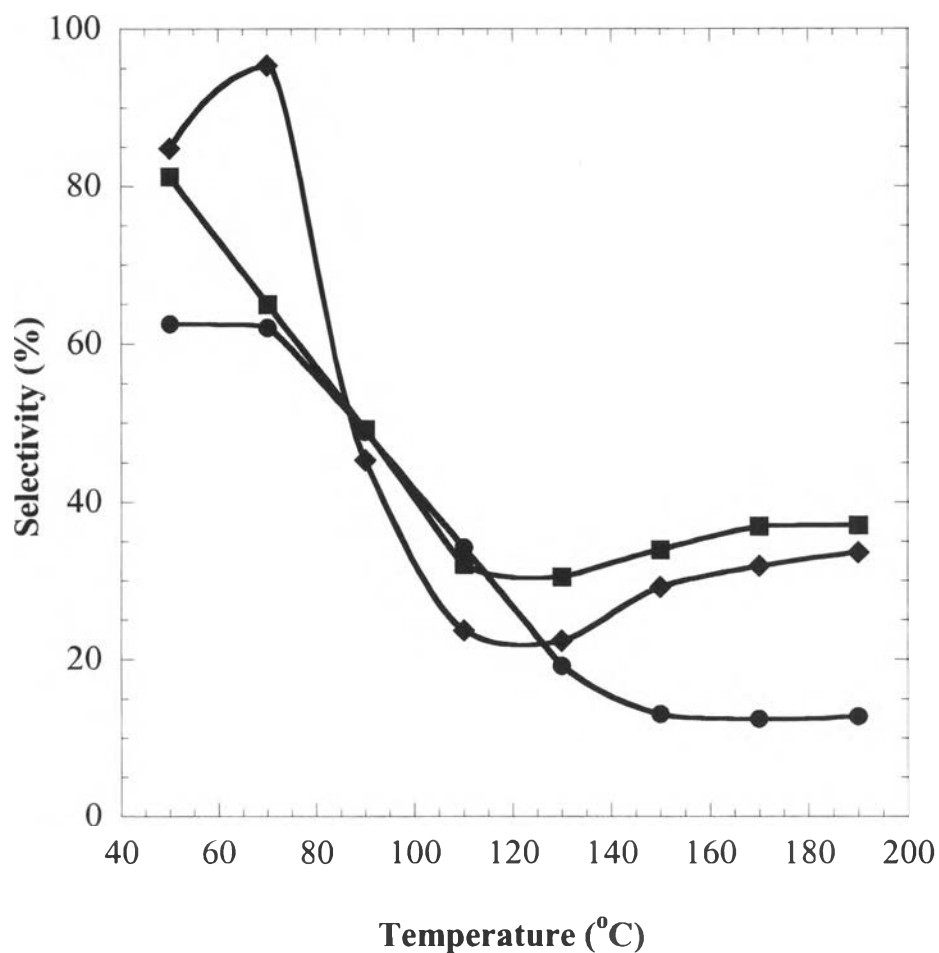
**Figure 4.10** Effect of pretreatment over 1%Pt/5%Ce.Al<sub>2</sub>O<sub>3</sub> catalyst. Reactant composition: 1% CO, 1% O<sub>2</sub>, 2% CO<sub>2</sub>, 2.6% H<sub>2</sub>O, 40% H<sub>2</sub> and helium; (●) O<sub>2</sub> pretreatment; (■) H<sub>2</sub> pretreatment; (— conversion, --- selectivity) .

#### 4.2.5 Effect of Pt Loading on Activity and Selectivity

The percentage loading of Pt was varied from 1, 2 and 3% and the percentage loading of cerium was kept at 5% by weight. The  $\text{Al}_2\text{O}_3$  support was prepared by the sol-gel method and had a surface area of approximately  $300 \text{ m}^2/\text{g}$ . All experiments were conducted in the range of  $50\text{-}190^\circ\text{C}$ . The feed consisted of 1% CO, 1%  $\text{O}_2$ , 2%  $\text{CO}_2$ , 2.6%  $\text{H}_2\text{O}$ , 40%  $\text{H}_2$  and helium. As we see from Figure 4.11 the activity does not parallel the loading. 2% Pt has the highest and 1% Pt has the lowest activity. All of the conversion curves are S shaped and do not exhibit a decrease in activity at high temperatures. The 2%Pt/5%CeO<sub>2</sub>.Al<sub>2</sub>O<sub>3</sub> gave the highest CO conversion of 75% at  $190^\circ\text{C}$ . Figure 4.12 shows that 2%Pt/5%CeO<sub>2</sub>.Al<sub>2</sub>O<sub>3</sub> has the highest selectivity at temperatures above  $110^\circ\text{C}$ . However, the selectivities are all relatively poor for all three catalysts.



**Figure 4.11** Effect of Pt loading on CO conversion over Pt/CeO<sub>2</sub>.Al<sub>2</sub>O<sub>3</sub> impregnation catalysts. Reactant composition: 1% CO, 1% O<sub>2</sub>, 2% CO<sub>2</sub>, 2.6% H<sub>2</sub>O, 40% H<sub>2</sub> and helium; (●) 1% Pt; (■) 2% Pt; (◆) 3% Pt.

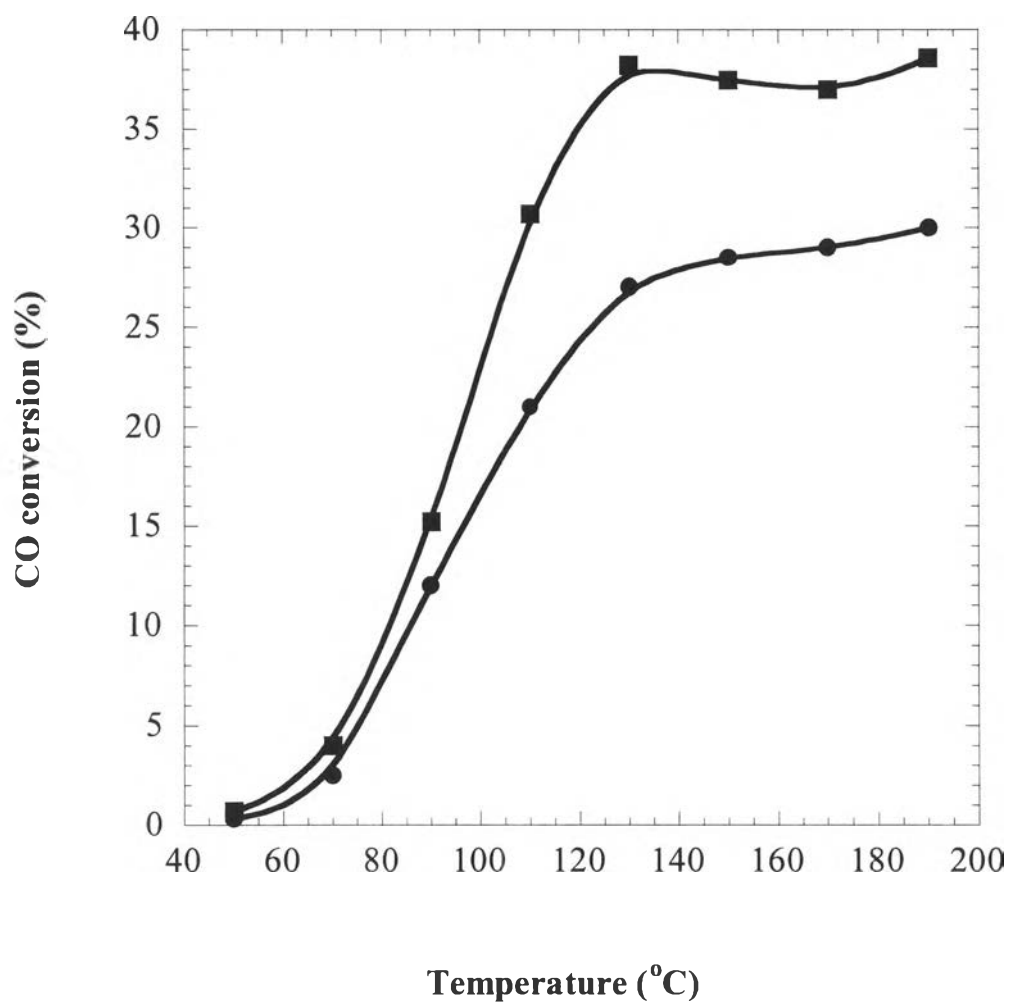


**Figure 4.12** Effect of Pt loading on selectivity over Pt/CeO<sub>2</sub>.Al<sub>2</sub>O<sub>3</sub> impregnation catalysts. Reactant composition: 1% CO, 1% O<sub>2</sub>, 2% CO<sub>2</sub>, 2.6% H<sub>2</sub>O, 40% H<sub>2</sub> and helium; (●) 1% Pt; (■) 2% Pt; (◆) 3% Pt.

#### 4.2.6 Comparison of Promoted Pt Catalyst with Pt/Al<sub>2</sub>O<sub>3</sub> Catalyst

In order to clearly discern the promotional effect of CeO<sub>2</sub>, we compared the performance of 1%Pt/5%Ce.Al<sub>2</sub>O<sub>3</sub> and 1%Pt/Al<sub>2</sub>O<sub>3</sub> catalysts under identical conditions. As shown in Figure 4.11, 1%Pt/5%Ce.Al<sub>2</sub>O<sub>3</sub> gives significantly higher than 1%Pt/Al<sub>2</sub>O<sub>3</sub> and ceria promotion increases activity by about 20-30% which confirms the outstanding role of ceria in this reaction. The loading of Ce introduced has been shown to improve the CO oxidation activity. These activity changes were attributed to Pt-Ce interactions because Ce-Al<sub>2</sub>O<sub>3</sub> did not appreciably catalyse CO oxidation under conditions used in these experiments. Several previous studies have reported that the presence of CeO<sub>2</sub> can improve the CO total oxidation activity of pre-reduced noble metal catalysts (Holmgren *et al.*, 1997 and Martinez-Arias *et al.*, 1998). The promoting effect of ceria on the low-temperature activity was also observed by Törnborn *et al.* (1997). The light-off temperatures for CO and propene over the Pt/Ce.Al<sub>2</sub>O<sub>3</sub> catalyst is about 100°C lower than over Pt/Al<sub>2</sub>O<sub>3</sub>. This result was also supported by Korotkikh and Farrauto (2000). They reported that the activity of Pt/Al<sub>2</sub>O<sub>3</sub> catalyst was increased from 13.2 to 68% at 90°C for a Fe<sub>2</sub>O<sub>3</sub> promoted catalyst. They believe that the promoter metal oxide provides sufficient dissociated O<sub>2</sub> to enhance the oxidation rate. Furthermore, Törnborn *et al.* (1997) found that the amount of adsorbed CO on Pt/CeO<sub>2</sub>.Al<sub>2</sub>O<sub>3</sub> is six times more than that adsorbed on the Pt/Al<sub>2</sub>O<sub>3</sub> catalyst, which would correspond to an increase of the Pt dispersion from 6 to 34%.





**Figure 4.13** Comparison of promoted Pt catalyst with conventional Pt/Al<sub>2</sub>O<sub>3</sub> catalyst. Reactant composition: 1% CO, 1% O<sub>2</sub>, 2% CO<sub>2</sub>, 2.6% H<sub>2</sub>O, 40% H<sub>2</sub> and helium; (●) 1% Pt/Al<sub>2</sub>O<sub>3</sub>; (■) 1% Pt/5%Ce.Al<sub>2</sub>O<sub>3</sub>.

### 4.3 Conclusions

In this chapter, it was found that the catalytic activity and selectivity of the 1% Pt/CeO<sub>2</sub> catalyst had a strong correlation with the catalyst preparation method. Among the three catalyst preparation methods, 1% Pt/CeO<sub>2</sub> sol-gel catalyst exhibited the highest activities. Furthermore, this present work showed that Ce and Pt loadings have a significant effect on the activity of Pt/Al<sub>2</sub>O<sub>3</sub> catalyst. It was found that the surface interactions were formed between all components. To summarize, the effects of the base-metal oxide on catalyst activity depended on the loading of CeO<sub>2</sub> and Pt and the pretreatment method to which the catalysts were exposed resulting in CO oxidation activity.