

CHAPTER VII

SUMMARY AND RECOMMENDATIONS

7.1 Summary of Results

The main objectives of this research are to find the alternative selective CO oxidation catalysts and to increase the understanding of the parameters affecting the catalytic performance of the catalysts. The attempts were performed through: (1) the development of alternative selective CO oxidation catalysts, (2) the development of catalyst preparation methods, (3) the investigation of the effect of all parameters affecting the catalytic performance, (4) the investigation of the activities of the catalysts on low-temperature water-gas shift reaction. Regarding possible applications in PEFC technology, both high CO conversion and high selectivity towards CO oxidation are crucial. However, due to the restrictions of CO poisoning the best results were found for Au/CeO₂ and Pt/CeO₂ catalysts. Au/CeO₂ is able to oxidize CO completely in the presence of H₂. In addition, the catalyst preparation method has a strong effect on the morphology and activity of those catalysts. The presence of water has a significant effect on the activities and selectivity of Pt but no significant effect on Au catalysts. On the other hand, the presence of CO₂ has a negative effect on the activities of Pt and Au catalysts.

This work is compared to the results in the literature as shown in Table 7.1.

Table 7.1 A comparative study of selective CO oxidation catalysts.

Reference	Catalyst	Reactant Composition	Conversion /Selectivity (%)	Temperature (°C)
Oh <i>et al.</i> (1993)	0.5%Ru/Al ₂ O ₃	0.09%CO, 0.08%O ₂ , 0.85%H ₂ , 20000 h ⁻¹	100/-	180
Kahlich <i>et al.</i> (1997)	0.5%Pt/Al ₂ O ₃	1%CO, 1%O ₂ , 75%H ₂ ,1 x 10 ⁴ ml/g.h	80/40	225
Haruta <i>et al.</i> (1997)	Au/MnO _x (Au/Mn=1/19)	1%CO, 1%O ₂ , and H ₂ , 1 x 10 ⁴ ml/g.h	95/-	80-120
Igarashi <i>et al.</i> (1997)	6%Pt/Zeolite	1%CO, 1%O ₂ , and H ₂ , W/F = 0.06 gscm ⁻³	80/45	200
Kahlich <i>et al.</i> (1999)	3%Au/Fe ₂ O ₃	1%CO, 1%O ₂ , 75%H ₂ ,1 x 10 ⁴ ml/g.h	99/60	80
Korotkikh <i>et al.</i> (2000)	0.5%Pt/Al ₂ O ₃ / monolith	0.1%CO, 0.1%O ₂ , 20%H ₂ , 10%H ₂ O, 8 x 10 ⁴ h ⁻¹	100/50	90
This work	1%Au/CeO ₂	1%CO, 1%O ₂ ,	92/60	110
	1%Pt/CeO ₂	2%CO ₂ , 2.6% H ₂ O, 40%H ₂ , 3 x 10 ⁴ ml/g.h	78/45	100

The major outcomes of water gas shift reaction are listed below:

1. We could not reproduce the high activities reported for Au/Fe₂O₃ by Andreeva *et al.*
2. To some extent CO poisons all of the catalysts.
3. The catalytic activity increases with increasing H₂O/CO ratio.

4. Pt/CeO₂ and Au/Fe₂O₃ catalysts are relatively robust and show small decay over 48 h.
5. In the presence of hydrogen only the Pt/CeO₂ catalyst is suitable. The activities of all of the other catalysts decrease dramatically when there is hydrogen in the feed.

7.2 Recommendations

From the results of this dissertation, selective oxidation of CO in the hydrogen-containing reformat is a suitable procedure and only the part of catalyst activity has been carried out. This reaction places high demands on the catalyst, as the hydrogen losses must remain low. We screened available catalysts for this application. In order to understand about the effect of CeO₂ support and the important role over Pt/CeO₂ and Au/CeO₂ catalyst, surface mechanism should be carried out by using in-situ FT-IR and CO chemisorption.

In addition, the regeneration process should be carried out. The deactivated catalysts will be regenerated at various conditions to recover the activity. After regeneration process, the catalysts should be tested again to observe the recovery activity and to make sure they are suitable for fuel cell applications.

1. To investigate the surface science of Pt/CeO₂ and Au/CeO₂ catalysts in selective CO oxidation and low temperature water gas shift reaction.
2. To investigate the oxidation state of Au which active for selective CO oxidation and low temperature water gas shift reaction.