# CHAPTER V
# CONCLUSIONS AND RECOMMENDATIONS

## 5.1 Conclusions

The OSRM is efficiently catalyzed by the supported Au catalyst to produce hydrogen. The catalytic performance was carried out over a series of $Au/CeO_2$ catalysts prepared by deposition-precipitation technique. The influences of main parameters considered are the $H_2O/CH_3OH$ and $O_2/CH_3OH$ feed molar ratios, content of Au loading, calcination temperature, and operating reaction temperature. In summary, the conditions of the $H_2O/CH_3OH$ and $O_2/CH_3OH$ molar ratios at 2/1 and 1/25/1, respectively, were responsible for the existing of OSRM leading to the combination of SRM and POM with higher hydrogen yield and methanol conversion in the low-temperature range (200–300°C). The highest Au loading of 5%wt was considered as the optimum value for the highest performance with the largest Au particle size, high metal-metal interaction, and also the highest amount of metallic Au ($Au^0$) species, compared to the low Au loading. The catalyst calcined at 400°C seemed to be the suitable calcination temperature, because it gave the highest catalytic activity with a 100 % methanol conversion and 24.5 % $H_2$ yield, which was definitely affected by the Au sintering effect, when compared to higher calcination temperature. The optimum size for Au particle was 10.04 nm which was suitable for OSRM reaction. It can be demonstrated in the stability test of 5%wt $Au/CeO_2$ during 168 hrs that the methanol conversion dropped rapidly from 100 % to 88.8 % after 40 h due to a blocking of pores by coke formation and the sintering effect; whereas an average $H_2$ yield of 16.12 % was obtained. The Au plays an important role for the catalytic activity in OSRM due to the fact that only the support did not show any activity in the whole temperature range. For side reactions; DCM, POM, and WGSR, the 5%wt $Au/CeO_2$ could also exhibit the catalytic activity in those side reactions in the whole range of reaction temperature (200–400°C).

## 5.2 Recommendations

The consistent preparing catalysts seemed to be a significant factor that will affect the catalytic activity. Thus, the catalyst should be prepared in the same batch.

The oxidation state of Au plays an important role for the catalytic performance. There are many important parameters, which affect the oxidation state of Au. X-ray photoelectron spectroscopy (XPS) is recommended for further characterize the prepared catalysts, in order to explain the chemical state of gold that presents on the surface of catalyst and determine efficiently the relationship between states of gold and catalytic performance.

To achieve higher the hydrogen production in the low-temperature range of the OSRM, the bi-metallic containing Au and Cu metal over the $CeO_2$ support is recommended, which may be active for this reaction.