CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

A study of steam reforming of methanol (SRM) over supported gold catalyst was carried out and had been some conclusions as follow:

The catalytic activity strongly depends on the preparation technique which affecting to crystallite size of gold particle. In case of Au/CeO_2, DPS catalyst shows a best performance both in term of methanol conversion and hydrogen production. The Au (220) crystallite size of prepared catalysts are 28.98, 13.77, and 4.12 nm which belonging to IWI, 5%CP, and DPS catalyst, respectively. The catalyst activity of SRM prefers small Au (220) crystallite size. The main byproducts of SRM can be either CO or CO_2, especially CO which seriously poison the fuel cell electrode. The CO/CO_2 molar ratio is represented CO content in the H_2 stream. The CO/CO_2 also depends on Au (220) crystallite size, for minimizing CO content Au (220) should not too large or to small evidenced by in case of 1%CP, the Au (220) can not be detected by XRD, the CO/CO_2 molar ratio is very high. The IWI catalyst, Au (220) crystallite size of 28.98 nm, also gives high value of this ratio. Hence, the proper preparation techniques, co-precipitation (CP) and deposition precipitation (DP), and proper gold loading (5% atomic) are required to prepare suitable Au crystallite size (~ 5 nm) in SRM.

For the effect of the reaction temperature on SRM, the higher reaction temperature, the higher of methanol conversion was observed but the reaction temperature should not exceed 400°C to avoid high concentration of CO and CH_4.

For the effect of steam to methanol (s/m) molar ratio, SRM (s/m = 1.33 or 2.00) is more advantage than decomposition of methanol (DM), s/m = 0, both in methanol conversion and minimum desired byproducts (CO and CH_4). The presence of steam can improve methanol conversion and minimize CO content in H_2 stream. The CO content trends to decrease when changing s/m ratio from 1.33 to 2.00 and H_2 production rate also decreases by this information the H_2 source is mainly extracted from methanol.

For the effect of support, Au/ZnO that prepared by CP method shows better methanol conversion than Au/CeO_2 (DPS). Au (220) of Au/ZnO is 5.11 nm so the idea that there is a critical crystallite size may be true. The critical crystallite size might be around 5 nm because the high methanol conversion was observed when Au (220) crystallite around that value for both Au/CeO_2 (DPS) and Au/ZnO (CP).

For the stability test, high performance of catalysts, Au/CeO_2 (DPS), Au/CeO_2 (5%CP), and Au/ZnO (CP), was tested for more than 900 min. All catalysts shows very stable in products distribution along the period of study. Thus supported gold catalysts can be used for producing hydrogen by steam reforming of methanol for a long time prior the deactivation of catalyst.

5.2 Recommendations

Even though, steam reforming of methanol for producing hydrogen showed a good catalytic activity in this work. It also requires the further study to improve the best catalytic activity as follow:

ZnO is preliminary studied for SRM and it shows better in catalytic activity so the more detail of this type of support might be further evaluated. The study might include the preparation technique that reflecting Au particle size and attempt to relate gold particle size and catalytic activity then comparing with CeO_2 support.

For the deposition-precipitation method, surface area of the support is very crucial factor for the amount of gold that can deposit onto the surface of the catalyst. It is better to check surface area before preparing the catalyst because the amounts of gold that can upload to the catalyst also depend on the surface area of the support.

The chemical state of Au that presents on the surface of catalyst, X-ray photoelectron spectroscopy (XPS) is recommended to determine state of gold particle (Au^o, $Au^{\delta+}$, and Au^{3+}) and try to relate the relationship between catalytic activity. The example for Au state and catalytic activity was done for water-gas-shift (WGS) reaction (Fu *et al.,* 2005). it revealed that the Au^o is not a active part for WGS reaction.