REFERENCES

Au, C.T., Wang, H.Y., and Wan, H.L. (1996). Mechanistic Studies of CH_4/O_2 Conversion over SiO_2-Supported Nickel and Copper Catalysts. Journal of Catalysis, 158, 343-348.

Chen, L., Lu, Y., Hong, Q., Lin, J., Dautzenburg, F.M. (2005). Catalytic partial oxidation of methane to syngas over Ca-decorated-Al_2O_3-supported Ni and NiB catalysts. Applied Catalysis A: General, 292, 295-304.

Choudhary, V.R., Uphade, B.S., Belhekar, A.A. (1996). Oxidative conversion of methane to syngas over $LaNiO_3$ perovskite with or without simultaneous steam and CO_2 reforming reactions: Influence of partial substitution of La and Ni. Journal of Catalysis, 163, 312–318.

Claridge, J.B., Green, M.L.H., Tsang, S.C., York, A.P.E., Ashcroft, A.T.,Battle, P.D. (1993). A study of carbon deposition on catalysts during the partial oxidation of methane to synthesis gas. Catalysis Letters, 22, 299-305.

de Araujo, G.C., de Lima, S.M., Assaf, J.M., Pena, M.A., Fierro, J.L.G., Rangel, M.d.C. (2008). Catalytic evaluation of perovskite-type oxide LaNi1-xRuxO3 on methan dry reforming. Catalysis Today, 133-135, 129-135.

Diskin, A.M., Cunningham, R.H., Ormerod, R.M. (1998) The oxidative chemistry of methane over supported nickel catalysts. Catalysis Today, 46,147-154.

Dissanayake, D., Rosynek, M.P., Kharas, K.C.C., Lunsford, J.H. (1991). Partial oxidation of methane to carbon monoxide and hydrogen over a Ni/Al_2O_3 catalyst. Journal of Catalysis, 132, 117-127.

Dong, W.S., Roh, H.S., Jun, K.W., Park, S.E., Oh, Y.S. (2002). Methane reforming over Ni/Ce-ZrO_2 catalysts: effect of nickel content. Applied Catalysis A: General, 226, 63-72.

Fornasiero, P., Balducci, G., Monte, R.D., Kaspar, J., Sergo, V., Gubitosa, G., Ferrero, A., Graziani, M. (1996). Modification of redox behaviour of CeO_2 induced by structure doping with ZrO_2. Journal of Catalysis, 164, 173-183.

Gavalas, G.R., Phichitkul, C., Voecks, G.E. (1984). Structure and activity of NiO/α-Al_2O_3 and NiO/ZrO_2 calcined at high temperatures: I. Structure. Journal of Catalysis, 88, 54-64.

Gonzalez-Velasco, J.R., Gutierrez-Ortiz, A.M., Jean-Louis, M., Botas, A.J., Gonzalez-Marcos, P.M., Blanchard, G. (1999). Contribution of cerium/zirconium mixed oxides to the activity of a new generation of TWC. Applied Catalysis B: Environmental, 22, 167-178.

Hickman, D.A., Schmidt, L.D. (1993). Production of Syngas by Direct Catalytic Oxidation of Methane. Science, 259, 343-346.

Kirchnerova, J., Alifanti, M., Delmon, B. (2002) Evidence of phase cooperation in the $LaCoO_3$–CeO_2–Co_3O_4 catalytic system in relation to activity in methane combustion. Applied Catalysis A: General, 231, 65-80.

Koerts, T., Van Santen, R.A. (1991) A low temperature reaction sequence for methane conversion. Journal of the Chemical Society, Chemical Communications, 18, 1281-1282.

Lago, R., Bini, G., Pena, M.A., Fierro, L.G. (1997). Partial oxidation of methane to synthesis gas using $LnCoO_3$ perovskites as catalyst precursors. Journal of Catalysis, 167, 198-209.

Libby, W.F. (1971). Promising catalyst for auto exhaust. Science, 171, 499-500.

Lu, Y., Xue, J., Yu, C., Liu, Y., Shen, S. (1998). Mechanistic investigations on the partial oxidation of methane to synthesis gas over a nickel on alumina catalyst. Applied Catalysis A: General, 174, 121-128.

Mallens, E.P.J., Hoebink, J.H.B.J., Marin,G.B. (1997). The Reaction Mechanism of the Partial Oxidation of Methane to Synthesis Gas: A Transient Kinetic Study over Rhodium and a Comparison with Platinum. Journal of Catalysis, 167, 43-56.

Miao, Q., Xiong, G., Sheng, S., Cui, W., Xu, L., Guo, X. (1997). Partial oxidation of methane to syngas over nickel-based catalysts modified by alkali metal oxide and rare earth metal oxide. Applied Catalysis A: General, 154, 17-27.

Otsuka, K., Wang, Y., Sunada, E., Yamanaka, I. (1998). Direct partial oxidation of methane to synthesis gas by cerium oxide. Journal of Catalysis, 175, 152-160.

Otsuka, K., Wang, Y., Nakamura, M. (1999). Direct conversion of methane to synthesis gas through gas–solid reaction using CeO_2–ZrO_2 solid solution at moderate temperature. Applied Catalysis A: General, 183(2), 317-324.

Pena, M.A., Gómez, J.P., Fierro, J.L.G. (1996). New catalytic routes for syngas and hydrogen production. Applied Catalysis A: General, 144, 7-57.

Pengpanich, S., Meeyoo, V., Rirksomboon, T., Bunyakiat, K. (2004). Methane partial oxidation over Ni/CeO_2-ZrO_2 mixed oxide solid solution catalysts. Catalytic Today, 93-95, 95-105.

Pengpanich, S., Meeyoo, V., Rirksomboon, T., Bunyakiat, K. (2006). Hydrogen production from partial oxidation of iso-octane over Ni/$Ce_{0.75}Zr_{0.25}O_2$ and Ni/β''-Al_2O_3 catalysts. Applied Catalysis A: General, 302, 133-139.

Pengpanich, S., Meeyoo, V., Rirksomboon, T., Schwank, J. (2007). The effect of Nb loading on catalytic properties if Ni/$Ce_{0.75}Zr_{0.25}O_2$ catalyst for methane partial oxidation Journal of natural gas chemistry, 16, 227-234.

Pengpanich, S., Meeyoo, V., Rirksomboon, T. (2008). Iso-octane partial oxidation over Ni-Sn/$Ce_{0.75}Zr_{0.25}O_2$ catalyst. Catalysis Today, 136, 214-221.

Qi, A., Wang, S., Fu, G., Ni, C., and Wu, D. (2005). La-Ce-Ni-O monolithic perovskite catalyst potential for gasoline autothermal reforming System. Applied Catalysis A: General, 281, 233-246.

Roh, H., Jun, K., Dong, W., Chang, J., Park, S., Joe, Y. (2002). Highly active and stable Ni/Ce-ZeO_2 catalyst for H_2 production from methane. Journal of Molecular Catalysis A: Chemical, 181, 137-142.

Rostrup-Nielsen, J.R., Hansen, J.H. B. (1993). CO_2-Reforming of Methane over Transition Metals. Journal of Catalysis, 144, 38-49.

Ruckenstein, E., Hu, Y.H. (1999). Methane partial oxidation over NiO/MgO solid solution catalysts. Applied Catalysis A: General, 183, 85-92.

Ruckenstein, E., Wang, H.Y. (2002). Carbon Deposition and Catalytic Deactivation during CO_2 Reforming of CH_4 over Co/γ -Al_2O_3 Catalysts. Journal of Catalysis, 205, 289-293.

Shishido, T., Sokenobu, M., Morioka, H., Kondo, M., Wang, Y., Takaki, K., Takehira, K (2002). Partial oxidation of methane over Ni/Mg-Al oxide catalysts prepared by solid phase crystallization method from Mg-Al hydrotalcite-like precursors. Applied Catalysis A: General, 223, 35-42.

Silva, F.A., Martinez, D.S., Ruiz, J.A.C., Mattos, L.V., Hori, C.E., Noronha, F.B. (2008). The effect of the use of cerium-doped alumina on the performance of $Pt/CeO_2/Al_2O_3$ and $Pt/CeZrO_2/Al_2O_3$ catalysts on the partial oxidation of methane. Applied Catalysis A: General, 335, 145-152.

Tang, S., Lin, J., Tan, K.L. (1998). Partial oxidation of methane to syngas over Ni/MgO, Ni/CaO and Ni/CeO_2. Catalysis Letters, 51, 169-175.

Utaka, T., Al-Drees, S.A., Ueda, J., Iwasa, Y., Takeguchi, T., Kikuchi, R., Eguchi, K., (2003). Partial oxidation of methane over Ni catalysts based on hexaaluminate- or perovskite-type oxides. Applied Catalysis A: General, 247, 125-131.

Weng, W.Z., Chen, M.S., Yan, Q.G., Wu, T.H., Chao, Z.S., Liao, Y.Y., Wan, H.L. (2000). Mechanistic study of partial oxidation of methane to synthesis gas over supported rhodium and ruthenium catalysts using in situ time-resolved FTIR spectroscopy. Catalysis Today, 63, 317-326.

Xiaoping, D., Changchun, Y., Ranjia, L., Qiong, W., Kaijiao, S., Zhengping, H (2008). Effect of calcination temperature and reaction conditions on methane partial oxidation using lanthanum-based perovskite as oxygen donor. Journal of Rare Earths, 26, 341-346.

York, A.P.E., Xiao, T., and Green, M.L.H. (2003). Brief overview of the partial oxidation of methane to synthesis gas. Topics in Catalysis, 22, 345-358.

Zhu, T., Stephanopoulos, M.F. (2001). Catalytic partial oxidation of methane to synthesis gas over Ni–CeO_2. Applied Catalysis A: General, 208, 403-417.

APPENDICS

Appendix A Experimental data of gas calibration of GC-8A

1. Nitrogen

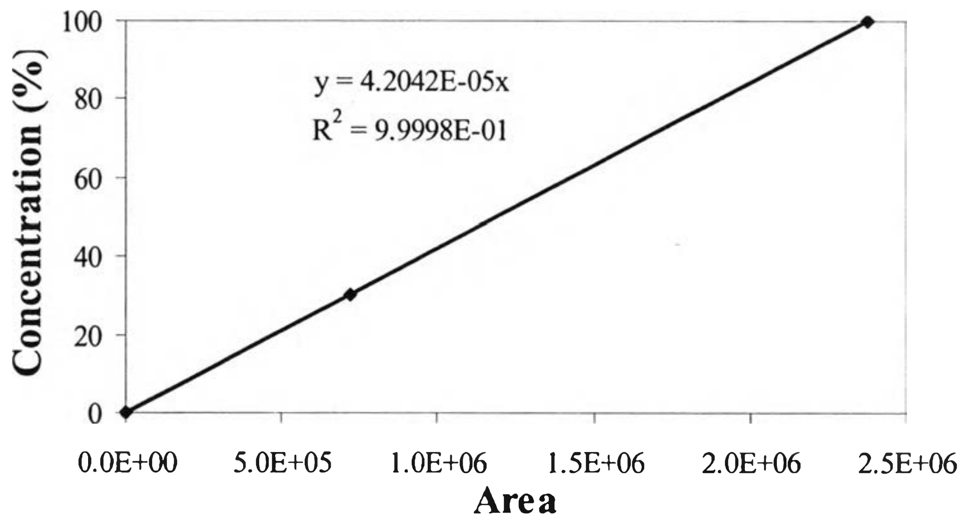

Figure A1 Relationship between area and concentration of nitrogen.

2. Oxygen

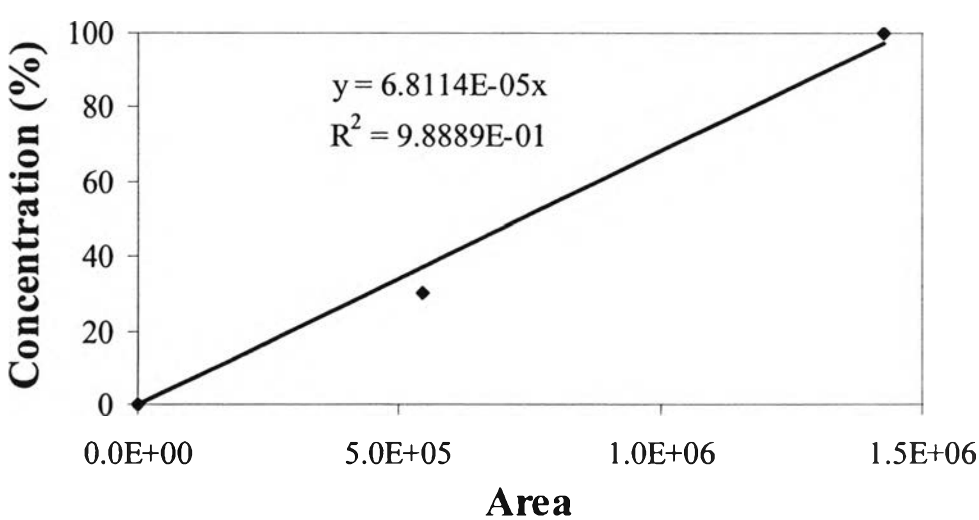

Figure A2 Relationship between area and concentration of oxygen.

3. Carbon dioxide

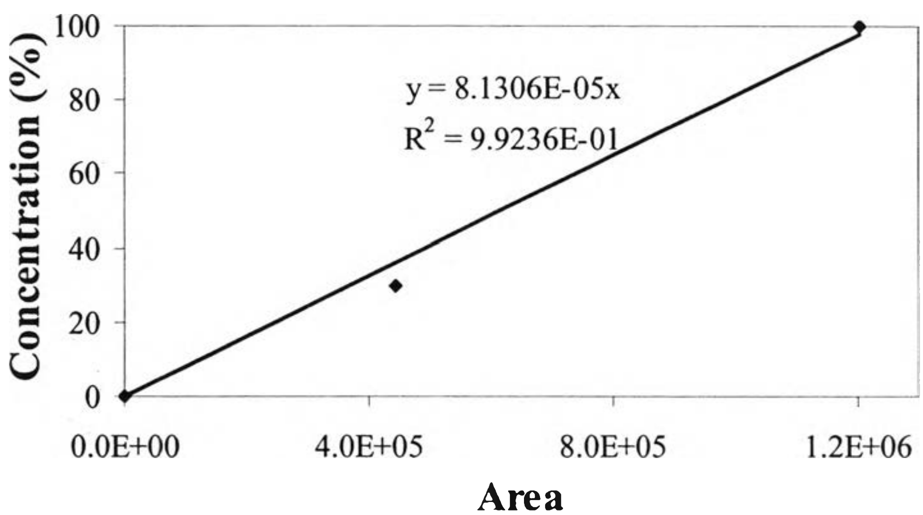

Figure A3 Relationship between area and concentration of carbon dioxide.

4. Methane

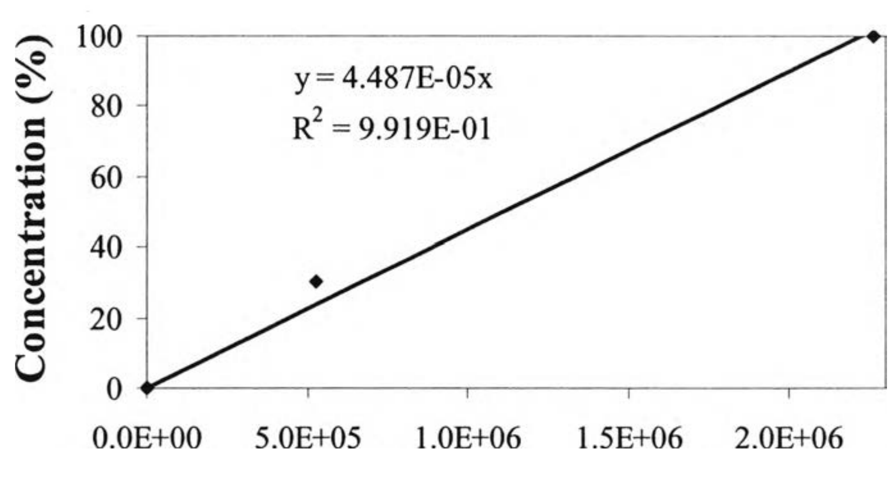

Figure A4 Relationship between area and concentration of methane.

5. Carbon monoxide

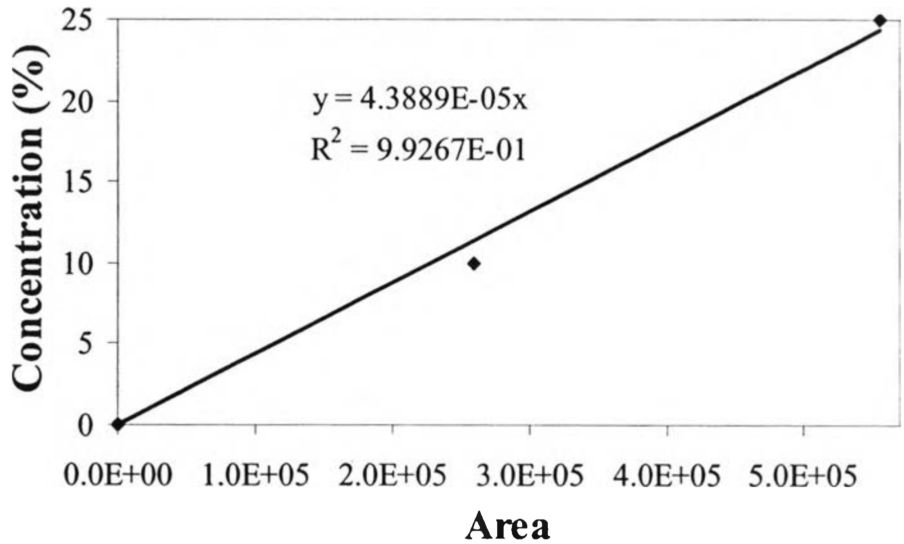

Figure A5 Relationship between area and concentration of carbon monoxide.

6. Hydrogen

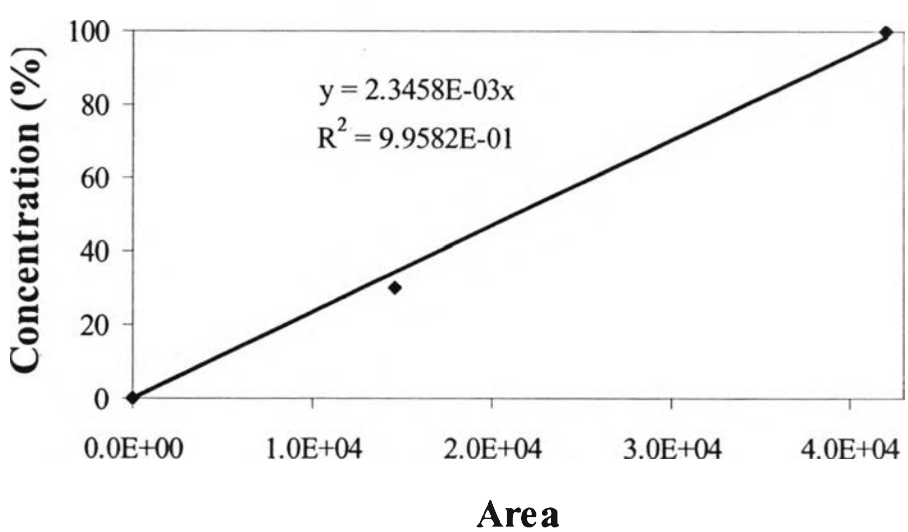

Figure A6 Relationship between area and concentration of hydrogen.

Appendix B Experimental data of flow meter gas calibration of Brooks 5850E mass flow controllers

1. Methane

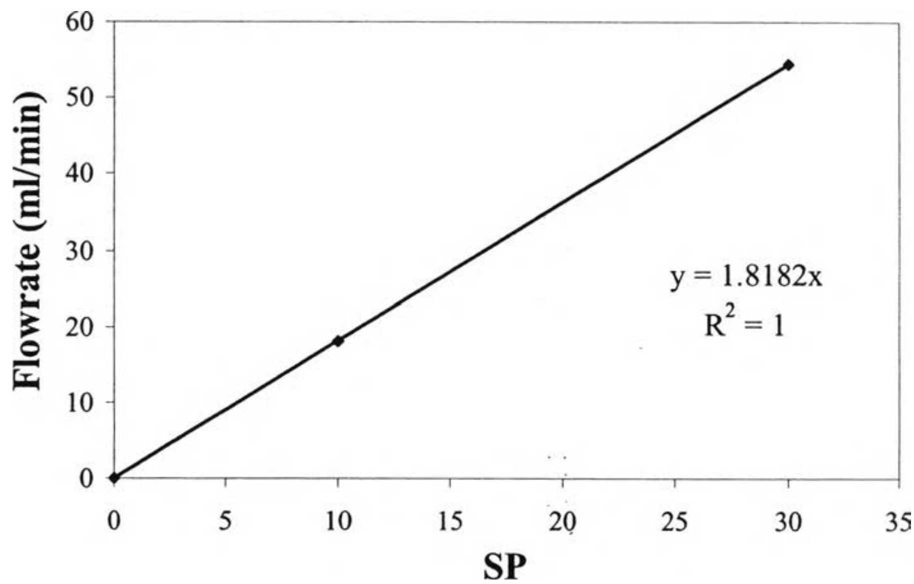

Figure B1 Relationship between SP and flowrate of methane.

2. Oxygen

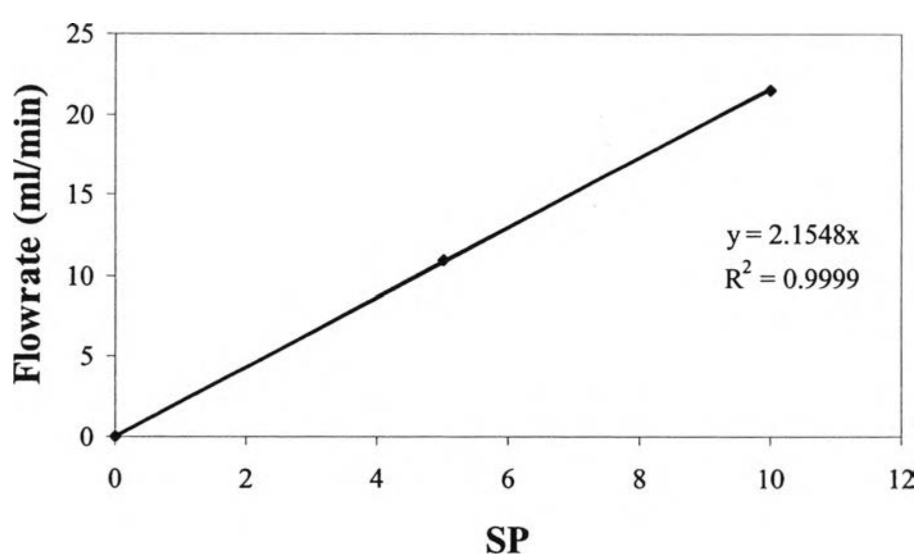

Figure B2 Relationship between SP and flowrate of oxygen.

3. Helium

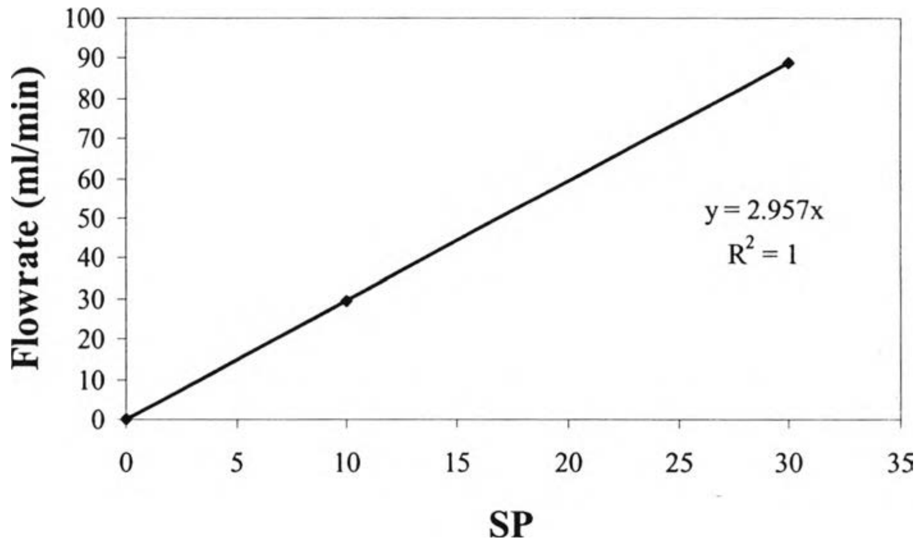

Figure B3 Relationship between SP and flowrate of helium.

Appendix C Experimental data of catalytic activity tests for MPO

Table C1 Catalytic activity test of $(Ce_{0.75}Zr_{0.25})_{2.14}Ni_{0.86}O_3$ calcined at 500°C

Temperature (°C)	X_{CH_4} (%)	S_{H_2} (%)	S_{CO} (%)	S_{O_2} (%)
400	6.66	0.00	0.00	13.45
450	8.05	0.00	0.00	30.41
500	15.84	0.00	0.00	58.44
550	23.63	0.00	0.00	94.19
600	34.72	0.00	0.00	99.87
650	91.59	88.57	90.07	99.92
700	93.12	88.62	90.57	99.93
750	96.27	89.09	92.28	99.92
800	96.53	93.44	93.47	99.09

Table C2 Catalytic activity test of $(Ce_{0.75}Zr_{0.25})_{2.14}Ni_{0.86}O_3$ calcined at 700°C

Temperature (°C)	X_{CH_4} (%)	S_{H_2} (%)	S_{CO} (%)	S_{O_2} (%)
400	9.76	0.00	0.00	19.87
450	10.38	0.00	0.00	31.99
500	10.62	0.00	0.00	45.93
550	23.41	0.00	0.00	77.84
600	29.12	0.00	0.00	96.15
650	92.28	92.60	91.77	99.97
700	92.78	92.60	92.32	99.98
750	93.72	92.99	94.01	99.76
800	94.27	93.01	95.50	99.71

Table C3 Catalytic activity test of $Ce_{2.14}Ni_{0.86}O_3$ calcined at 500°C

Temperature (°C)	X_{CH_4} (%)	S_{H_2} (%)	S_{CO} (%)	S_{O_2} (%)
400	4.69	0.00	0.00	14.88
450	9.54	0.00	0.00	30.98
500	15.11	0.00	0.00	58.82
550	23.50	0.00	0.00	90.41
600	34.94	0.00	0.00	99.72
650	91.23	88.07	90.25	99.97
700	92.96	88.16	90.85	99.97
750	94.79	89.02	91.59	99.70
800	95.40	89.84	91.96	98.75

Table C4 Catalytic activity test of $Ce_{2.14}Ni_{0.86}O_3$ calcined at 700°C

Temperature (°C)	X_{CH_4} (%)	S_{H_2} (%)	S_{CO} (%)	S_{O_2} (%)
400	4.31	0.00	0.00	19.86
450	6.76	0.00	0.00	24.24
500	10.52	0.00	0.00	44.89
550	22.71	0.00	0.00	75.08
600	28.65	0.00	0.00	95.68
650	90.50	86.79	87.66	99.97
700	91.19	87.29	89.58	97.13
750	91.77	87.43	91.55	97.45
800	92.30	87.41	91.57	97.55

Appendix D Experimental data of stability tests for MPO

Table D1 Stability test of $(Ce_{0.75}Zr_{0.25})_{2.14}Ni_{0.86}O_3$ calcined at 500°C

Time (hr)	X_{CH_4} (%)	S_{H_2} (%)	S_{CO} (%)	S_{O_2} (%)
0	93.36	89.59	95.35	99.38
1	93.72	89.72	95.26	99.90
4	93.84	90.35	95.57	99.96
8	93.94	91.91	95.83	99.98
12	94.16	91.82	95.79	99.89
16	94.29	92.23	96.08	99.53
18	94.16	92.93	95.65	99.63
20	94.25	91.97	95.80	99.58
21	94.39	92.37	95.98	99.60
22	94.84	91.38	96.26	99.52
23	95.47	93.58	96.54	99.54
24	96.49	94.59	96.47	98.16

Table D2 Stability test of $(Ce_{0.75}Zr_{0.25})_{2.14}Ni_{0.86}O_3$ calcined at 700°C

Time (hr)	X_{CH_4} (%)	S_{H_2} (%)	S_{CO} (%)	S_{O_2} (%)
0	96.09	90.61	94.72	99.53
1	96.53	90.66	96.80	99.61
2	96.55	90.71	96.80	99.71
3	96.11	90.08	97.56	99.69
4	95.90	91.05	98.25	99.60
5	96.16	91.94	98.47	99.62
6	96.21	93.27	98.52	99.67
7	96.38	93.56	98.52	99.61
8	96.43	93.85	98.49	99.65
9	96.08	97.14	97.90	99.66
10	96.09	97.21	98.07	99.61
11	96.10	96.72	98.10	99.62
12	96.10	96.78	98.20	99.65
13	96.09	97.78	98.29	99.59
14	96.09	96.92	98.40	99.59
15	96.09	96.55	98.40	99.62
16	96.43	96.29	98.41	99.60
17	96.45	95.73	98.25	99.62
18	96.51	97.06	98.16	99.58
19	96.63	96.76	98.18	99.61
20	96.65	97.02	98.30	99.62
21	96.65	96.41	98.42	99.60
22	96.63	96.76	98.56	99.63
23	96.64	97.07	98.50	99.54
24	96.63	96.40	98.55	99.69

Table D3 Stability test of $Ce_{2.14}Ni_{0.86}O_3$ calcined at 500°C

Time (hr)	X_{CH_4} (%)	S_{H_2} (%)	S_{CO} (%)	S_{O_2} (%)
0	0	90.27	89.36	94.37
1	1	90.64	89.72	95.30
4	4	91.00	90.26	95.79
8	8	91.01	91.65	95.30
12	12	90.66	91.74	95.02
16	16	90.94	91.30	95.41
18	18	91.41	91.07	96.16
20	20	91.57	91.79	96.13
21	21	91.68	91.71	96.33
22	22	91.72	91.64	96.29
23	23	91.92	91.65	96.31
24	24	92.37	91.79	96.23

Table D4 Stability test of $Ce_{2.14}Ni_{0.86}O_3$ calcined at 700°C

Time (hr)	X_{CH_4} (%)	S_{H_2} (%)	S_{CO} (%)	S_{O_2} (%)
0	0	92.16	89.22	90.57
1	1	92.23	89.79	91.15
2	2	92.25	90.38	92.22
3	3	92.25	90.74	92.50
4	4	92.24	90.53	92.60
5	5	92.24	90.55	92.83
6	6	92.25	90.92	92.95
7	7	92.47	91.69	93.04
8	8	93.04	91.97	94.15
9	9	93.15	92.00	94.52
10	10	93.17	91.96	94.80
11	11	93.09	91.79	94.84
12	12	93.17	92.26	94.61
13	13	93.15	91.15	94.88
14	14	93.14	91.31	95.03
15	15	93.05	91.38	94.65
16	16	93.18	91.42	95.35
17	17	93.51	91.07	93.58
18	18	93.66	90.80	94.21
19	19	93.54	90.46	94.41
20	20	93.59	90.66	94.44
21	21	93.64	90.31	94.50
22	22	93.57	90.99	94.78
23	23	93.69	91.19	94.52
24	24	93.54	91.57	94.63

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Proceedings:

1. Khamnetr, A., Rirksomboon, T., Meeyoo, V., Pengpanich, S. (2009, April 22) Hydrogen Production via Methane Partial Oxidation over Ceria-Nickel and Ceria-Zirconia-Nickel Mixed-Oxide Catalysts. Proceedings of The 15th PPC Symposium on Petroleum, Petrochemicals, and Polymers, Bangkok, Thailand.