REFERENCES

Adebajo, M., Long, M.A., and Howe, R.F. (2000) Methane activation over zeolite catalysts: the methylation of benzene. Research on Chemical Intermediates, 26(2), 185-191.

Adebajo, M.O. and Frost, R.L. (2005) Oxidative benzene methylation with methane over MCM-41 and zeolite catalysts: Effect of framework aluminum, SiO_2/Al_2O_3 ratio, and zeolite pore structure. Energy & Fuels, 19(3), 783-790.

Adebajo, M.O., Howe, R.F., and Long, M.A. (2001) Methylation of toluene with methane over ZSM-5 catalysts. Energy & Fuels, 15, 671-674.

Agee, K. (2005) Offshore advances. In Petroleum Economist, Fundamentals of Gas to Liquids. 2nd ed. London: Petroleum Economist Limited, pp. 30-31.

Agrafiotis, C., Storch, H.v., Roeb, M., and Sattler, C. (2014) Solar thermal reforming of methane feedstocks for hydrogen and syngas production-A review. Renewable and Sustainable Energy Reviews, 29, 656-682.

Arnoldy, P. and Moulijn, J.A. (1985) Temperature-programmed reduction of CoO Al_2O_3 catalysts. Journal of Catalysis, 93(1), 38-54.

Baba, T. (2005) Conversion of methane over Ag^+-exchanged zeolite in the presence of ethene. Catalysis Surveys from Asia, 9(3), 147-154.

Baba, T. and Abe, Y. (2003) Metal cation–acidic proton bifunctional catalyst for methane activation: conversion of $^{13}CH_4$ in the presence of ethylene over metal cations-loaded H-ZSM-5. Applied Catalysis A: General, 250(2), 265-270.

Baba, T., Abe, Y., Nomoto, K., Inazu, K., Echizen, T., Ishikawa, A., and Murai, K. (2005) Catalytic transformation of methane over In-loaded ZSM-5 zeolite in the presence of ethene. Journal of Physical Chemistry B, 109(9), 4263-4268.

Baba, T., Iwase, Y., Inazu, K., Masih, D., and Matsumoto, A. (2007) Catalytic properties of silver-exchanged zeolites for propene production by conversion of methane in the presence of ethene. Microporous and Mesoporous Materials, 101(1–2), 142-147.

Baba, T. and Sawada, H. (2002) Conversion of methane into higher hydrocarbons in the presence of ethylene over H-ZSM-5 loaded with silver cations. Physical Chemistry Chemical Physics, 4, 3919-3923.

Baba, T., Sawada, H., Takahashi, T., and Abe, M. (2002) Chemisorption study of hydrogen and methane by ^{1}H MAS NMR and conversion of methane in the presence of ethylene on Ag-Y zeolite. Applied Catalysis A: General, 231(1–2), 55-63.

Balonek, C., Lillebø, A., Rane, S., Rytter, E., Schmidt, L., and Holmen, A. (2010) Effect of alkali metal impurities on Co–Re catalysts for Fischer–Tropsch synthesis from biomass-derived syngas. Catalysis Letters, 138(1-2), 8-13.

Barrett, E.P., Joyner, L.G., and Halenda, P.P. (1951) The determination of pore volume and area distributions in porous substances. I. Computations from nitrogen isotherms. Journal of the American Chemical Society, 73(1), 373-380.

Bazin, D., Borkó, L., Koppány, Z., Kovács, I., Stefler, G., Sajó, L.I., Schay, Z., and Guczi, L. (2002) Re-Co/NaY and Re-Co/Al_2O_3 bimetallic catalysts: In situ EXAFS study and catalytic activity. Catalysis Letters, 84(3-4), 169-182.

Bazin, D., Kovács, I., Guczi, L., Parent, P., Laffon, C., De Groot, F., Ducreux, O., and Lynch, J. (2000) Genesis of Co/SiO_2 catalysts: XAS study at the cobalt $L_{III,II}$ absorption edges. Journal of Catalysis, 189(2), 456-462.

Beyer, H., Jacobs, P.A., and Uytterhoeven, J.B. (1976) Redox behavior of transition metal ions in zeolites part 2: kinetic study of the reduction and reoxidation of silver-Y Zeolites. Journal of the Chemical Society, Faraday Transactions, 72(1), 674-685.

Bianchi, C. (2001) TPR and XPS investigations of Co/Al_2O_3 catalysts promoted with Ru, Ir and Pt. Catalysis Letters, 76(3-4), 155-159.

Borodziński, A. and Bond, G.C. (2008) Selective hydrogenation of ethyne in ethene-rich streams on palladium catalysts, Part 2: Steady-state kinetics and effects of palladium particle size, carbon monoxide, and promoters. Catalysis Reviews - Science and Engineering, 50(3), 379-469.

Brunauer, S., Emmett, P.H., and Teller, E. (1938) Adsorption of gases in multimolecular layers. Journal of the American Chemical Society, 60(2), 309-319.

Bunluesin, T., Gorte, R.J., and Graham, G.W. (1998) Studies of the water-gas-shift reaction on ceria-supported Pt, Pd, and Rh: Implications for oxygen-storage properties. Applied Catalysis B: Environmental, 15(1-2), 107-114.

Choudhary, V.R., Kinage, A.K., and Choudhary, T.V. (1997) Low-temperature nonoxidative activation of methane over H-galloaluminosilicate (MFI) zeolite. Science, 275, 1286-1288.

Choudhary, V.R. and Rajput, A.M. (1996) Simultaneous carbon dioxide and steam reforming of methane to syngas over NiO-CaO catalyst. Industrial and Engineering Chemistry Research, 35, 3934-3939.

Christensen, S.T., Elam, J.W., Rabuffetti, F.A., Ma, Q., Weigand, S.J., Lee, B., Seifert, S., Stair, P.C., Poeppelmeier, K.R., Hersam, M.C., and Bedzyk, M.J. (2009) Controlled growth of platinum nanoparticles on strontium titanate nanocubes by atomic layer deposition. Small, 5(6), 750-757.

Claeys, M., van Steen, E., Visagie, J., van de Loosdrecht, J. (2011, June) Characterization of Fischer-Tropsch catalysts using a novel in-situ magnetometer. Paper presented at 22nd Meeting of the North American Catalysis Society, Detroit, USA.

Cook, K.M., Poudyal, S., Miller, J.T., Bartholomew, C.H., and Hecker, W.C. (2012) Reducibility of alumina-supported cobalt Fischer–Tropsch catalysts: Effects of noble metal type, distribution, retention, chemical state, bonding, and influence on cobalt crystallite size. Applied Catalysis A: General, 449, 69-80.

Cronauer, D.C., Elam, J.W., Kropf, A.J., Marshall, C.L., Gao, P., Hopps, S., Jacobs, G., and Davis, B.H. (2012) Fischer–Tropsch synthesis: Preconditioning effects upon Co-containing promoted and unpromoted catalysts. Catalysis Letters, 142(6), 698-713.

Cronauer, D.C., Jacobs, G., Linganiso, L., Kropf, A.J., Elam, J.W., Christensen, S.T., Marshall, C.L., and Davis, B.H. (2011) CO hydrogenation: exploring

iridium as a promoter for supported cobalt catalysts by TPR-EXAFS/XANES and reaction testing. Catalysis Letters, 141(7), 968-976.

Das, T.K., Jacobs, G., Patterson, P.M., Conner, W.A., Li, J., and Davis, B.H. (2003) Fischer-Tropsch synthesis: Characterization and catalytic properties of rhenium promoted cobalt alumina catalysts. Fuel, 82(7), 805-815.

De Klerk, A. (2012a) Gas-to-liquid conversion. In Natural Gas Conversion Technologies Workshop of ARPA-E., Houston, TX.: US Department of Energy.

Demidov, D.V., Mishin, I.V., and Mikhailov, M.N. (2011) Gibbs free energy minimization as a way to optimize the combined steam and carbon dioxide reforming of methane. International Journal of Hydrogen Energy, 36, 5941-5950.

Ding. B., Huang, S., and Wang, W. (2008) Methane activation over Ag-exchanged ZSM-5 zeolites: A theoretical study. Applied Surface Science, 254, 4944-4948.

Düren, T., Sarkisov, L., Yaghi, O.M., and Snurr. R.Q. (2004) Design of new materials for methane storage. Langmuir, 20(7), 2683–2689.

Economist, T. (2012) "An unconventional bonanza." Economist. 12 July 2012. 21 Febuary 2014. <http://www.economist.com/node/21558432>.

Enger. C.B., Lødeng, R., and Holmen, A. (2008) A review of catalytic partial oxidation of methane to synthesis gas with emphasis on reaction mechanisms over transition metal catalysts. Applied Catalysis A: General, 346(1–2), 1-27.

ESP. (2014) "Gas-to-Liquids." Energy Security Partners. 10 Febuary 2014. <http://www.espgtl.com/gas-to-liquids/>.

Espinoza, R.L., Visagie, J.L., Van Berge, P.J., Bolder, F.H. (1998). US Patent 5,733,839.

Feltes, T., Fischer, N., and Claeys, M. (2013, March) The reversibility of the size dependent re-oxidation of a Co/Al_2O_3 Fischer-Tropsch catalyst by in-situ magnetic measurements. Paper presented at 10th Natural Gas Conversion Symposium, Doha, Qatar.

Fischer, N., Clapham, B., Feltes, T.E., van Steen, E., and Claeys, M. (2012, April) The reoxidation of cobalt Fischer-Tropsch catalysts. Paper presented at 2012 Syngas Convention, Cape Town, South Africa.

Fleisch, T.H., Basu, A., and Sills, R.A. (2012) Introduction and advancement of a new clean global fuel: the status of DME developments in China and beyond. Journal of Natural Gas Science and Engineering, 9, 94-107.

Gesser, H.D. and Hunter, N.R. (1998) A review of C-1 conversion chemistry. Catalysis Today, 42, 183-189.

Greenwood, N.N. and Earnshaw, A. (1997) Chemistry of the Elements. 2nd ed. Oxford: Butterworth Heinemann (pp. 1116).

Grenoble, D.C., Estadt, M.M., and Ollis, D.F. (1981) The chemistry and catalysis of the water gas shift reaction. 1. The kinetics over supported metal catalysts. Journal of Catalysis, 67(1), 90-102.

Guczi, L., Bazin, D., Kovács, I., Borkó, L., Schay, Z., Lynch, J., Parent, P., Lafon, C., Stefler, G., Koppány, Z., and Sajó, I. (2002) Structure of Pt-Co/Al_2O_3 and Pt-Co/NaY bimetallic catalysts: Characterization by in situ EXAFS, TPR, XPS and by activity in Co (carbon monoxide) hydrogenation. Topics in Catalysis, 20(1-4), 129-139.

Hamilton, T. (2008) "Natural gas to gasoline." Technology Review (MIT) 15 August 2008. 19 Febuary 2014. <http://www.technologyreview.com/energy/21261/>.

He, S.J.X., Long, M.A., Attalla, M.I., and Wilson, M.A. (1994) Methylation of naphthalene by methane-carbon-13 over copper-exchanged silicoaluminophosphate. Energy & Fuels, 8(1), 286–287.

He, S.J.X., Long, M.A., Wilson, M.A., Gorbaty, M.L., and Maa, P.S. (1995) Methylation of benzene by methane-^{13}C over zeolitic catalysts at 400 °C. Energy & Fuels, 9(4), 616-619.

Hilmen, A.M., Schanke, D., Hanssen, K.F., and Holmen, A. (1999) Study of the effect of water on alumina supported cobalt Fischer–Tropsch catalysts. Applied Catalysis A: General, 186(1–2), 169-188.

Hilmen, A.M., Schanke, D., and Holmen, A. (1996) TPR study of the mechanism of rhenium promotion of alumina-supported cobalt Fischer-Tropsch catalysts. Catalysis Letters, 38(3-4), 143-147.

Iglesia, E., Soled, S.L., Fiato, R.A., and Via, G.H. (1993) Bimetallic synergy in cobalt ruthenium Fischer-Tropsch synthesis catalysts. Journal of Catalysis, 143(2), 345-368.

Smith, J.M., Van Ness, H.C., and Abbott, M.M. (2005). Introduction to Chemical Engineering Thermodynamics, 7th ed., Boston: McGraw Hill.

Jacobs, G., Chaney, J.A., Patterson, P.M., Das, T.K., and Davis, B.H. (2004) Fischer–Tropsch synthesis: study of the promotion of Re on the reduction property of Co/Al_2O_3 catalysts by in situ EXAFS/XANES of Co K and Re L_{III} edges and XPS. Applied Catalysis A: General, 264(2), 203-212.

Jacobs, G., Chaney, J.A., Patterson, P.M., Das, T.K., Maillot, J.C., and Davis, B.H. (2004) Fischer-Tropsch synthesis: Study of the promotion of Pt on the reduction property of Co/Al_2O_3 catalysts by in situ EXAFS of Co K and Pt L_{III} edges and XPS. Journal of Synchrotron Radiation, 11(5), 414-422.

Jacobs, G., Chaudhari, K., Sparks, D., Zhang, Y., Shi, B., Spicer, R., Das, T.K., Li, J., and Davis, B.H. (2003) Fischer–Tropsch synthesis: supercritical conversion using a Co/Al_2O_3 catalyst in a fixed bed reactor. Fuel, 82(10), 1251-1260.

Jacobs, G., Das, T.K., Patterson, P.M., Li, J., Sanchez, L., and Davis, B.H. (2003) Fischer–Tropsch synthesis XAFS: XAFS studies of the effect of water on a Pt-promoted Co/Al_2O_3 catalyst. Applied Catalysis A: General, 247(2), 335-343.

Jacobs, G., Das, T.K., Zhang, Y., Li, J., Racoillet, G., and Davis, B.H. (2002) Fischer–Tropsch synthesis: support, loading, and promoter effects on the reducibility of cobalt catalysts. Applied Catalysis A: General, 233(1–2), 263-281.

Jacobs, G. and Davis, B.H. (2010) Surface interfaces in low temperature water-gas shift: The metal oxide synergy, the assistance of co-adsorbed water, and alkali doping. International Journal of Hydrogen Energy, 35(8), 3522-3536.

Jacobs, G., Ji, Y., Davis, B.H., Cronauer, D., Kropf, A.J., and Marshall, C.L. (2007) Fischer–Tropsch synthesis: Temperature programmed EXAFS/XANES investigation of the influence of support type, cobalt loading, and noble metal promoter addition to the reduction behavior of cobalt oxide particles. Applied Catalysis A: General, 333(2), 177-191.

Jacobs, G., Ma, W., Gao, P., Todic, B., Bhatelia, T., Bukur, D.B., Khalid, S., and Davis, B.H. (2012) Fischer-tropsch synthesis: Differences observed in local atomic structure and selectivity with pd compared to typical promoters (Pt, Re, Ru) of Co/Al_2O_3 catalysts. Topics in Catalysis, 55(11-13), 811-817.

Jacobs, G., Patterson, P.M., Das, T.K., Luo, M., and Davis, B.H. (2004) Fischer–Tropsch synthesis: effect of water on Co/Al_2O_3 catalysts and XAFS characterization of reoxidation phenomena. Applied Catalysis A: General, 270(1–2), 65-76.

Jacobs, G., Patterson, P.M., Zhang, Y., Das, T., Li, J., and Davis, B.H. (2002) Fischer–Tropsch synthesis: deactivation of noble metal-promoted Co/Al_2O_3 catalysts. Applied Catalysis A: General, 233(1–2), 215-226.

Jacobs, G., Ribeiro, M.C., Ma, W., Ji, Y., Khalid, S., Sumodjo, P.T.A., and Davis, B.H. (2009) Group 11 (Cu, Ag, Au) promotion of $15\%Co/Al_2O_3$ Fischer–Tropsch synthesis catalysts. Applied Catalysis A: General, 361(1–2), 137-151.

Jacobs, G., Sarkar, A., Ji, Y., Luo, M., Dozier, A., and Davis, B.H. (2007) Fischer–Tropsch synthesis: Assessment of the ripening of cobalt clusters and mixing between Co and Ru promoter via oxidation–reduction-cycles over lower Co-loaded $Ru–Co/Al_2O_3$ catalysts. Industrial & Engineering Chemistry Research, 47(3), 672-680.

Jacobs, G., Sarkar, A., Ji, Y., Patterson, P.M., Das, T.K., Luo, M., and Davis, B.H. (2006, November) Fischer-Tropsch synthesis: Characterization of interactions between reduction promoters and Co for Co/Al_2O_3–based GTL catalysts. Paper presented at 2006 AIChE Annual Meeting, San Francisco, California, USA.

Jacobs, G., Zhang, Y., Das, T.K., Li, J., Patterson, P.M., and Davis, B.H. (2001). Deactivation of a Ru promoted Co/Al_2O_3 catalyst for FT synthesis. In Spivey, J.J., Roberts, G.W., Davis, B.H. (Eds.). Catalyst deactivation 2001: proceeding of the 9th international symposium (pp. 415-422). Amsterdam: Elsevier.

Jacoby, M. (2001). X-ray absorption spectroscopy. Chemical and Engineering News, 79(32), 33-38.

Jalama, K., Coville, N.J., Hildebrandt, D., Glasser, D., Jewell, L.L., Anderson, J.A., Taylor, S., Enache, D., and Hutchings, G.J. (2007) Effect of the addition of Au on Co/TiO_2 catalyst for the Fischer-Tropsch reaction. Topics in Catalysis, 44(1-2), 129-136.

Jermwongratanachai, T., Jacobs, G., Ma, W., Shafer, W.D., Gnanamani, M.K., Gao, P., Kitiyanan, B., Davis, B.H., Klettlinger, J.L.S., Yen, C.H., Cronauer, D.C., Kropf, A.J., and Marshall, C.L. (2013) Fischer-Tropsch synthesis: comparisons between Pt and Ag promoted Co/Al_2O_3 catalysts for reducibility, local atomic structure, catalytic activity, and oxidation-reduction (OR) cycles. Applied Catalysis A: General, 464-465, 165-180.

Jongsomjit, B., Panpranot, J., and Goodwin, J.G.Jr. (2001) Co-support compound formation in alumina-supported cobalt catalysts. Journal of Catalysis, 204(1), 98-109.

Kalamaras, C.M., Olympiou, G.G., and Efstathiou, A.M. (2008) The water-gas shift reaction on $Pt/\gamma\text{-}Al_2O_3$ catalyst: Operando SSITKA-DRIFTS-mass spectroscopy studies. Catalysis Today, 138(3–4), 228-234.

Kennedy, E.M., Lonyi, F., Ballinger, T.H., Rosynek, M.P., and Lunsford, J.H. (1994) Conversion of benzene to substituted aromatic products over zeolite catalysts at elevated pressures. Energy & Fuels, 8(4), 846-850.

Khodakov, A.Y., Chu, W., and Fongarland, P. (2007) Advances in the development of Novel cobalt Fischer–Tropsch catalysts for synthesis of long-chain hydrocarbons and clean fuels. Chemical Reviews, 107(5), 1692-1744.

Kinoshita, K. (1977) Differential thermal analysis of PtO_2/carbon. Thermochimica Acta, 20(3), 297-308.

Kogelbauer, A., Goodwin, J.G.Jr., and Oukaci, R. (1996) Ruthenium promotion of Co/Al_2O_3 Fischer-Tropsch catalysts. Journal of Catalysis, 160(1), 125-133.

Kuzmin, A., Dalba, G., Fornasini, P., Rocca, F., and Šipr, O. (2006) X-ray absorption spectroscopy of strongly disordered glasses: Local structure around Ag ions in $g\text{-}Ag_2O{\bullet}nB_2O_3$. Physical Review B - Condensed Matter and Materials Physics, 73(17), 174110-1-174110-12.

Leclercq, L., Provost, M., Pastor, H., Grimblot, J., Hardy, A.M., Gengembre, L., and Leclercq, G. (1989) Catalytic properties of transition metal carbides: I. Preparation and physical characterization of bulk mixed carbides of molybdenum and tungsten. Journal of Catalysis, 117(2), 371-383.

Ledoux, M.J., Huu, C.P., Guille, J., and Dunlop, H. (1992) Compared activities of platinum and high specific surface area Mo_2C and WC catalysts for reforming reactions: I. Catalyst activation and stabilization: Reaction of n-hexane. Journal of Catalysis, 134(2), 383-398.

Leite, L., Stonkus, V., Ilieva, L., Plyasova, L., Tabakova, T., Andreeva, D., and Lukevics, E. (2002) Promoting effect of gold on the structure and activity of Co/kaolin catalyst for the 2,3-dihydrofuran synthesis. Catalysis Communications, 3(8), 341-347.

Li, J., Jacobs, G., Das, T., Zhang, Y., and Davis, B. (2002) Fischer–Tropsch synthesis: effect of water on the catalytic properties of a Co/SiO_2 catalyst. Applied Catalysis A: General, 236(1–2), 67-76.

Li, J., Zhan, X., Zhang, Y., Jacobs, G., Das, T., and Davis, B.H. (2002) Fischer–Tropsch synthesis: effect of water on the deactivation of Pt promoted Co/Al_2O_3 catalysts. Applied Catalysis A: General, 228(1–2), 203-212.

Liander, H. (1929) The utilisation of natural gases for the ammonia process. [10.1039/TF9292500462]. Transactions of the Faraday Society, 25, 462-472.

Liu, Z., Li, W., and Zhou, X. (2010) Product oriented oxidative bromination of methane over Rh/SiO_2 catalysts. Journal of Natural Gas Chemistry, 19, 522-529.

Lukyanov, D.B. and Vazhnova, T. (2009) Selective and stable benzene alkylation with methane into toluene over PtH-MFI bifunctional catalyst. Journal of Molecular Catalysis A: Chemical, 305, 95-99.

Lunsford, J.H. (2000) Catalytic conversion of methane to more useful chemicals and fuels: a challenge for the 21st century. Catalysis Today, 63, 165-174.

Luzgin, M.V., Gabrienko, A.A., Rogov, V.A., Toktarev, A.V., Parmon, V.N., and Stepanov, A.G. (2010) The "Alkyl" and "Carbenium" Pathways of Methane Activation on Ga-Modified Zeolite BEA: ^{13}C Solid-State NMR and GC-MS Study of Methane Aromatization in the Presence of Higher Alkane. Journal of Physical Chemistry, 114(49), 21555–21561.

Ma, W., Jacobs, G., Ji, Y., Bhatelia, T., Bukur, D., Khalid, S., and Davis, B. (2011) Fischer–Tropsch synthesis: Influence of CO conversion on selectivities, H_2/CO usage ratios, and catalyst stability for a Ru promoted Co/Al_2O_3 catalyst using a slurry phase reactor. Topics in Catalysis, 54(13-15), 757-767.

Mcketta, J.J. (1993). Chemical Processing Handbook, New York: Marcel Dekker.

Miao, S., Ma, Y.W.D., Zhu, Q., Zhou, S., Su, L., Tan, D., and Bao, X. (2004) Effect of Ag^+ Cations on nonoxidative activation of methane to C_2-Hydrocarbons. Journal of Physical Chemistry, 108, 17866-17871.

Minnie, R. (2005) Where it all began. In: Fundamentals of Gas to Liquids. 2nd ed., London: Petroleam Economist Limited, pp. 27-29.

Moodley, D.J., Saib, A.M., van de Loosdrecht, J., Welker-Nieuwoudt, C.A., Sigwebela, B.H., and Niemantsverdriet, J.W. (2011) The impact of cobalt aluminate formation on the deactivation of cobalt-based Fischer–Tropsch synthesis catalysts. Catalysis Today, 171(1), 192-200.

Naccache, C.M., Meriaudeau, P., Sapaly, G., Tiep, L.V., and Taarit, Y.B. (2002) Assessment of the low-temperature nonoxidative activation of methane over H-galloaluminosilicate (MFI) zeolite: A C-13 labelling investigation. Journal of Catalysis, 205, 217-220.

Newville, M., Ravel, B., Haskel, D., Rehr, J.J., Stern, E.A., Yacoby, Y. (1995) Analysis of multiple-scattering XAFS data using theoretical standards. Physica B: Condensed Matter, 208-209, 154-156.

Olah, G.A. (1987) Electrophilic methane conversion. Accounts of Chemical Research, 20, 422-428.

Olah, G.A. and Molnar, A. (2003). Hydrocarbon Chemistry, New Jersey: John Wiley.

Perego, C., and Pollesel, P. (2009) Advances in Aromatics Processing Using Zeolite Catalysts. Advances in Nanoporous Materials 1, 97-146.

Phatak, A.A., Koryabkina, N., Rai, S., Ratts, J.L., Ruettinger, W., Farrauto, R.J., Blau, G.E., Delgass, W.N., and Ribeiro, F.H. (2007) Kinetics of the water–gas shift reaction on Pt catalysts supported on alumina and ceria. Catalysis Today, 123(1–4), 224-234.

Rahmim, I.I. (2003, June) Gas-to-Liquid Technologies: Recent Advances, Economics, Prospects. Paper presented at 26th IAEE Annual International Conference, Prague, Czech Republic.

Ravel, B. (2001) ATOMS: Crystallography for the X-ray absorption spectroscopist. Journal of Synchrotron Radiation, 8(2), 314-316.

Redjala, T., Remita, H., Apostolescu, G., Mostafavi, M., Thomazeau, C., and Uzio, D. (2006) Bimetallic Au-Pd and Ag-Pd clusters synthesised by γ or electron beam radiolysis and study of the reactivity/structure relationships in the selective hydrogenation of buta-1,3-diene. Oil and Gas Science and Technology, 61(6), 789-797.

Rehr, J.J., Albers, R.C., and Zabinsky, S.I. (1992) High-order multiple-scattering calculations of x-ray-absorption fine structure. Physical Review Letters, 69(23), 3397-3400.

Ressler, T. (1997) WinXAS97. Version 1.0.

Ribeiro, M.C., Jacobs, G., Pendyala, R., Davis, B.H., Cronauer, D.C., Kropf, A.J., and Marshall, C.L. (2011) Fischer–Tropsch synthesis: Influence of Mn on the carburization rates and activities of Fe-based catalysts by TPR-EXAFS/XANES and catalyst testing. Journal of Physical Chemistry C, 115(11), 4783-4792.

Riekert, L. (1969) Redox equilibria in zeolites. Berichte der Bunsengesellschaft für Physikalische Chemie, 73(4), 331-338.

Rønning, M., Nicholson, D., and Holmen, A. (2001) In situ EXAFS study of the bimetallic interaction in a rhenium-promoted alumina-supported cobalt Fischer–Tropsch catalyst. Catalysis Letters, 72(3-4), 141-146.

Rønning, M., Tsakoumis, N.E., Voronov, A., Johnsen, R.E., Norby, P., van Beek, W., Borg, Ø., Rytter, E., and Holmen, A. (2010) Combined XRD and XANES studies of a Re-promoted Co/γ-Al_2O_3 catalyst at Fischer–Tropsch synthesis conditions. Catalysis Today, 155(3–4), 289-295.

Rygh, L.E.S. and Nielsen, C.J. (2000) Infrared study of CO adsorbed on a Co/Re/γAl_2O_3-based Fischer-Tropsch catalyst. Journal of Catalysis, 194(2), 401-409.

Sadeqzadeh, M., Karaca, H., Safonova, O.V., Fongarland, P., Chambrey, S., Roussel, P., Griboval-Constant, A., Lacroix, M., Curulla-Ferré, D., Luck, F., and Khodakov, A.Y. (2011) Identification of the active species in the working alumina-supported cobalt catalyst under various conditions of Fischer–Tropsch synthesis. Catalysis Today, 164(1), 62-67.

Saib, A.M., Borgna, A., van de Loosdrecht, J., van Berge, P.J., and Niemantsverdriet, J.W. (2006) XANES study of the susceptibility of nano-sized cobalt crystallites to oxidation during realistic Fischer–Tropsch synthesis. Applied Catalysis A: General, 312, 12-19.

Saib, A.M., Moodley, D.J., Ciobîcă, I.M., Hauman, M.M., Sigwebela, B.H., Weststrate, C.J., Niemantsverdriet, J.W., and van de Loosdrecht, J. (2010) Fundamental understanding of deactivation and regeneration of cobalt Fischer–Tropsch synthesis catalysts. Catalysis Today, 154(3–4), 271-282.

Schanke, D., Hilmen, A.M., Bergene, E., Kinnari, K., Rytter, E., Ådnanes, E., and Holmen, A. (1995) Study of the deactivation mechanism of Al_2O_3-supported cobalt Fischer-Tropsch catalysts. Catalysis Letters, 34(3-4), 269-284.

Schanke, D., Vada, S., Blekkan, E.A., Hilmen, A.M., Hoff, A., and Holmen, A. (1995) Study of Pt-promoted cobalt CO hydrogenation catalysts. Journal of Catalysis, 156(1), 85-95.

Sexton, B.A., Hughes, A.E., and Turney, T.W. (1986) An XPS and TPR study of the reduction of promoted cobalt-kieselguhr Fischer-Tropsch catalysts. Journal of Catalysis, 97(2), 390-406.

Sirijaruphan, A., Horváth, A., Goodwin Jr, J.G., and Oukaci, R. (2003) Cobalt aluminate formation in alumina-supported cobalt catalysts: Effects of cobalt reduction state and water vapor. Catalysis Letters, 91(1-2), 89-94.

Smet, C.R.H.d. (2000) Partial oxidation of methane to synthesis gas: reaction kinetics and reactor modelling. Ph.D. Dissertation, Technische Universiteit Eindhoven, Netherlands.

Solymosi, F., Cserényi, J., Szöke, A., Bánsági, T., and Oszkó, A. (1997) Aromatization of methane over supported and unsupported Mo-based catalysts. Journal of Catalysis, 165(2), 150-161.

Storsater, S., Borg, O., Blekkan, E., and Holmen, A. (2005) Study of the effect of water on Fischer–Tropsch synthesis over supported cobalt catalysts. Journal of Catalysis, 231(2), 405-419.

Tang, H.Q. and Li, J.L. (2011) Performance of silica-nanotube-supported ruthenium catalysts for Fischer-Tropsch synthesis. Journal of Fuel Chemistry and Technology, 39(8), 615-620.

Tsakoumis, N.E., Rønning, M., Borg, Ø., Rytter, E., and Holmen, A. (2010) Deactivation of cobalt based Fischer–Tropsch catalysts: A review. Catalysis Today, 154(3–4), 162-182.

Tsutsumi, K. and Takahashi, H. (1972) The formation of silver in silver form zeolites. Bulletin of the Chemical Society of Japan, 45, 2332-2337.

U.S. Energy Information Admisnistration. (2013) "Natural Gas." International Energy Outlook 2013. 25 July 2013. 21 Febuary 2014. <http://www.eia.gov/forecasts/ieo/nat_gas.cfm>.

Vada, S., Hoff, A., ÅdnaneS, E., Schanke, D., and Holmen, A. (1995) Fischer-Tropsch synthesis on supported cobalt catalysts promoted by platinum and rhenium. Topics in Catalysis, 2(1-4), 155-162.

Van Berge, P.J., Barradas, S., Van De Loodsrecht, J., and Visagie, J.L. (2001) Advances in the cobalt catalyzed Fischer-Tropsch synthesis. Erdoel Erdgas Kohle, 117(3), 138-142.

Van Berge, P.J., van de Loosdrecht, J., Barradas, S., and van der Kraan, A.M. (2000) Oxidation of cobalt based Fischer–Tropsch catalysts as a deactivation mechanism. Catalysis Today, 58(4), 321-334.

Van de Loosdrecht, J., Balzhinimaev, B., Dalmon, J.A., Niemantsverdriet, J.W., Tsybulya, S.V., Saib, A.M., van Berge, P.J., and Visagie, J.L. (2007) Cobalt Fischer-Tropsch synthesis: Deactivation by oxidation? Catalysis Today, 123(1–4), 293-302.

Van Steen, E., Claeys, M., Dry, M.E., Van De Loosdrecht, J., Viljoen, E.L., and Visagie, J.L. (2005) Stability of nanocrystals: Thermodynamic analysis of oxidation and re-reduction of cobalt in water/hydrogen mixtures. Journal of Physical Chemistry B, 109(8), 3575-3577.

Velasco, J.A., Lopez, L., Velasquez, M., Boutonnet, M., Cabrera, S., and Jaras, S. (2010) Gas to liquids: a technology for natural gas industrialization in Bolivia. Journal of Natural Gas Science and Engineering, 2(5), 222-228.

Wang, W.J. and Chen, Y.W. (1991) Influence of metal loading on the reducibility and hydrogenation activity of cobalt/alumina catalysts. Applied Catalysis, 77(2), 223-233.

Weaver, J.F., Chen, J.J., and Gerrard, A.L. (2005) Oxidation of Pt(111) by gas-phase oxygen atoms. Surface Science, 592(1-3), 83-103.

Wikipedia. (2014a) "Fischer-Tropsch process." Wikipedia. 30 December 2013. 21 Febuary 2014. <http://en.wikipedia.org/wiki/Fischer-Tropsch_process>.

Wikipedia. (2014b) "Methane." Wikipedia. 16 February 2014. 21 February 2014. <http://en.wikipedia.org/wiki/methane>.

Wikipedia. (2014c) "Syngas." Wikipedia. 14 February 2014. 19 February 2014 <http://en.wikipedia.org/wiki/Syngas>.

Wood, D.A. (2005) LNG risk profile-1. Where we are: relationships, contracts evolve along supply chain. Oil & Gas Journal, 24th ed., 54-59.

Wood, D.A., Nwaoha, C., and Towler, B.F. (2012) Gas-to-liquids (GTL): A review of an industry offering several routes for monetizing natural gas. Journal of Natural Gas Science and Engineering, 9, 196-208.

Zayat, M. and Levy, D. (2000) Blue $CoAl_2O_4$ particles prepared by the sol-gel and citrate-gel methods. Chemistry of Materials, 12(9), 2763-2769.

APPENDIX

Calibration Data

The calibration curve and regression equation of raw materials and some products is shown below. The response factors used for calculate the products amount that derived from the slope of calibration curve is also shown.

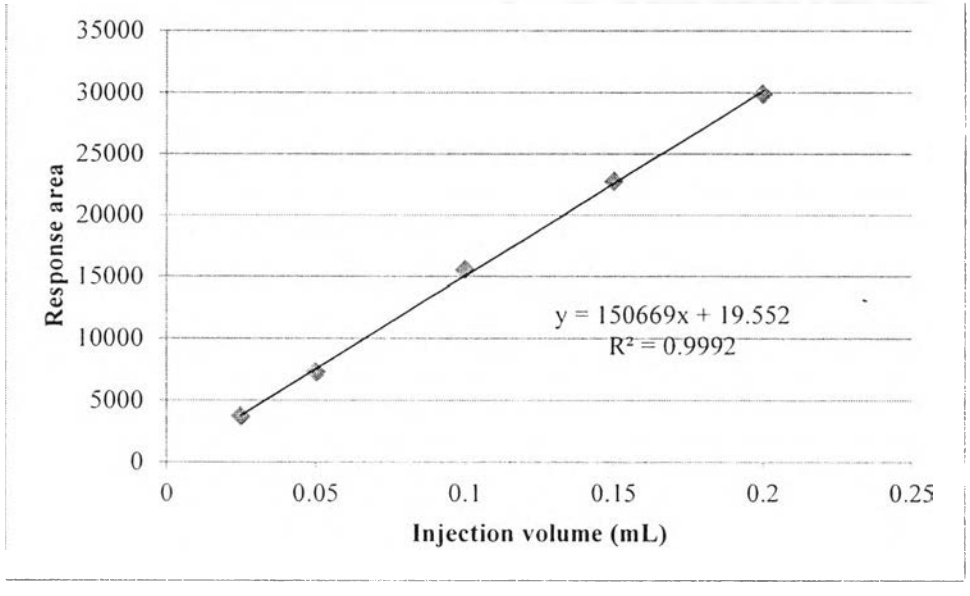

Figure A1 Response area from GC FID as a function of injection volume of methane.

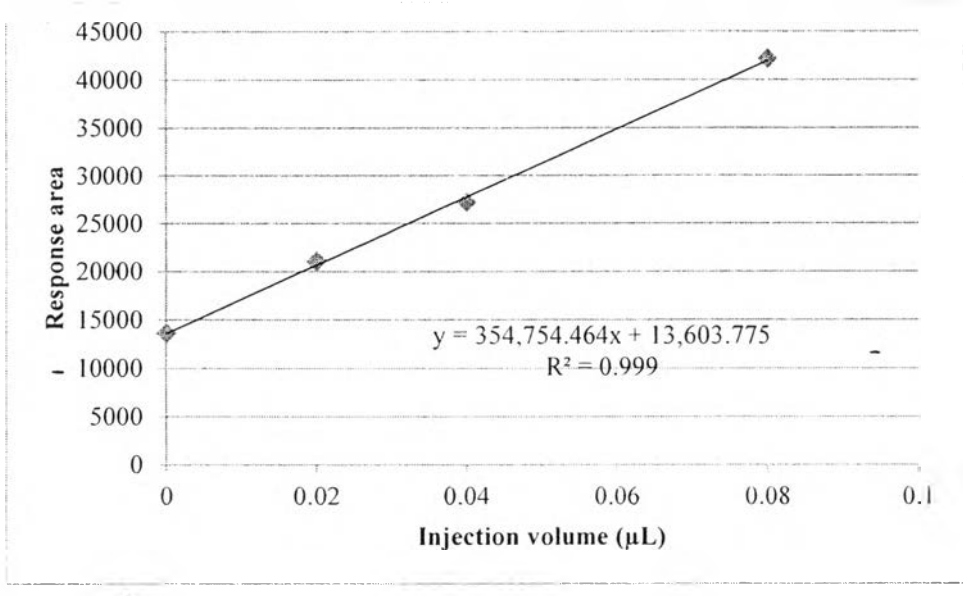

Figure A2 Response area from GC FID as a function of injection volume of benzene.

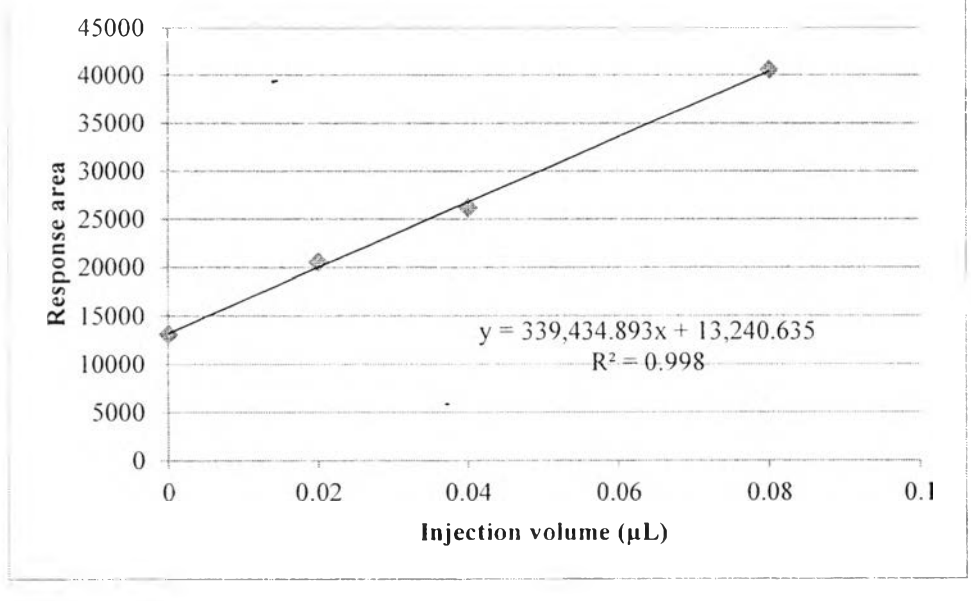

Figure A3 Response area from GC FID as a function of injection volume of toluene.

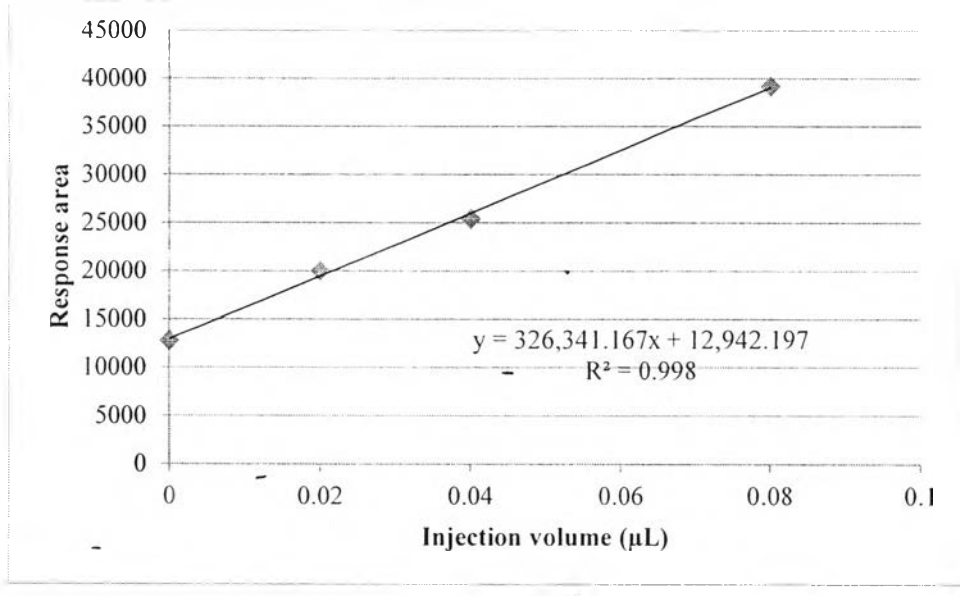

Figure A4 Response area from GC FID as a function of injection volume of *p*-xylene.

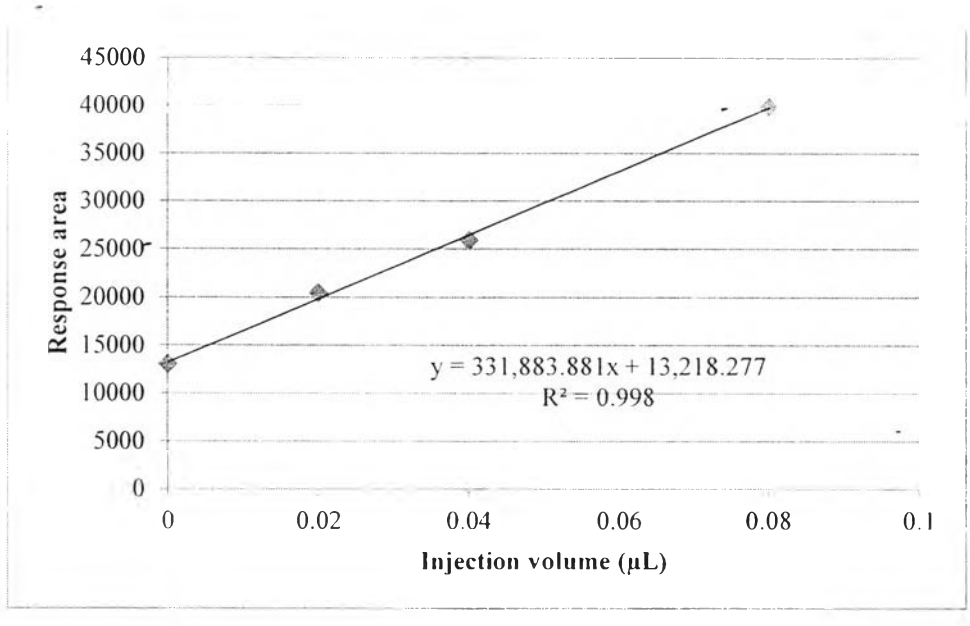

Figure A5 Response area from GC FID as a function of injection volume of *m*-xylene.

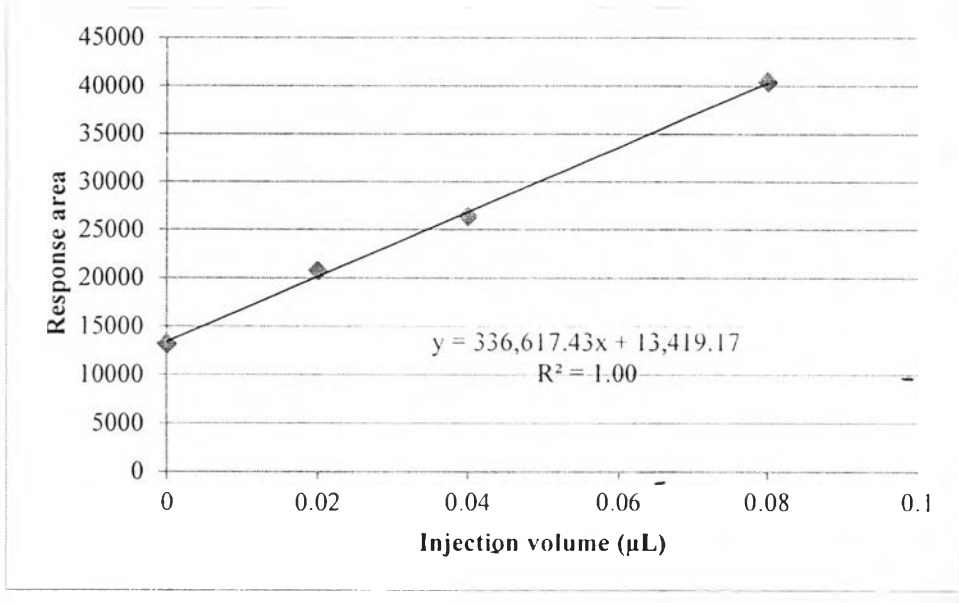

Figure A6 Response area from GC FID as a function of injection volume of *o*-xylene.

Table A1 The response factor calculated from calibration curve of each substances

Chemicals	Slope(Area/ml)	Density(g/ml)	(Area/g)	MW(g/mol)	Response factor (Area/mol)
Methane	150669	-	-	-	3685027598
Benzene	354754464	0.88	403130073	78	31444145673
Toluene	339434893	0.87	390155049	92	35894264547
p-Xylene	326341167	0.86	379466473	106	40223446165
m-Xylene	331883881	0.86	385911490	106	40906617891
o-Xylene	336617430	0.88	382519807	106	40547099523

The value of response factors calculated from the calibration curve that shown in Table A1 is further used in the products quantification for each chemical. For the non-calibrated chemicals found during the analysis, the response factor of *p*-xylene was applied.

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Publications:

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2. Jermwongratanachai, T.; Jacobs, G.; Shafer, W.D.; Ma, W.; Pendyala, V.R.R.; Davis, B.D.; Kitiyanan, B.; Khalid, S.; Cronauer, D.; Kropf, A.J.; and Marshall, C.L. (2014) Fischer–Tropsch synthesis: Oxidation of a fraction of cobalt crystallites in research catalysts at the onset of FT at partial pressures mimicking 50 %CO conversion. Topics in Catalysis, 57(6-9), 479-490.
3. Jermwongratanachai, T.; Jacobs, G.; Ma, W.; Shafer, W.D.; Gnanamani, M.K., Gao, P.; Kitiyanan, B.; Davis, B.H.; Klettlinger, J.L.S.; Yen, C.H.; Cronauer, D.C.; Kropf, A.J.; and Marshall, C.L. (2013) Fischer–Tropsch synthesis: Comparisons between Pt and Ag promoted Co/Al_2O_3 catalysts for reducibility, local atomic structure, catalytic activity, and oxidation–reduction (OR) cycles. Applied Catalysis A: General, 464–465, 165-180

Presentations:

1. Jermwongratanachai, T.; Jacobs, G.; Kitiyanan, B.; Ma, W.; and Davis, B.H. (2014, January 30-31) Investigation of metal promoters (Pt, Ru, Re, Ag, Au, Rh, Ir) in facilitating the reduction Co oxide in Fischer-Tropsch Co/Al_2O_3 catalyst after reduction-oxidation cycles. Paper presented at Molecular Catalysis as Basis in Green Sustainable Chemistry for Environmentally Benign Urban Life, Tokyo, Japan.
2. Jermwongratanachai, T.; Jacobs, G.; Ma, W.; Gao, P.; Kitiyanan, B.; Davis, B.H.; Cronauer, D.C.; Kropf, A.J.; and Marshall, C.L. (2013, April 7-11) Fischer-Tropsch synthesis: investigation of the impact of Pt and Ag promoter loading on the local atomic structure of Co/alumina catalysts using an in-situ EXAFS. Paper presented at 245th ACS National Meeting & Exposition, New Orleans, Louisiana, USA.

3. Jermwongratanachai, T.; Jacobs, G.; Kitiyanan, B.; Ma, W.; and Davis, B.H. (2013, December 1-5) Study of Ag as a metal promoter for Co/Al_2O_3 Fischer-Tropsch synthesis catalyst. Paper presented at International Symposium on Catalysis and Fine Chemicals 2013 (C&FC 2013), Beijing, China.
4. Jermwongratanachai, T.; Jacobs, G.; Ma, W.; Shafer, W.D.; Gnanamani, M.K.; Gao, P.; Kitiyanan, B.; Davis, B.H.; Cronauer, D.C.; Kropf, A.J.; and Marshall, C.L. (2013, June 2-7) Fischer-Tropsch synthesis: examination of the coordination environment and simulated regeneration of Pt promoted Co/Al_2O_3 using oxidation-reduction cycles. Paper presented at 23rd North American Catalysis Society Meeting, Louisville, Kentucky, USA.
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6. Jermwongratanachai, T.; Srisayan, T.; and Kitiyanan, B. (2012, July 1-6) Methylation of benzene by methane using Ag/ZSM-5 catalyst. Paper presented at 15th International Congress on Catalysis (ICC 2012), Munich, Germany.
7. Jermwongratanachai, T.; and Kitiyanan, B. (2012, April 22) Investigation of Ag species in Ag-exchanged HZSM-5 and its application for direct methylation of benzene with methane. Paper presented at The 3rd Research Symposium on Petrochemical and Materials Technology and The 18th PPC Symposium on Petroleum, Petrochemicals, and Polymers, Bangkok, Thailand.
8. Jermwongratanachai, T.; and Kitiyanan, B. (2011, June 26-July 1) Synthesis and characterization of silver substituted ZSM-5 zeolite: Effect of NH_4OH. Paper presented at International Conference on Materials for Advanced Technologies (ICMAT 2011), Singapore City, Singapore.