REFERENCES

1. Rideal, E.K. General properties of catalysts. In Concept in catalyst, pp. 4-5. London & New York: Academic Press, 1968.

2. Bond, G.C. Basic principles of catalysis. In P.W. Atkins, and A.K. Holliday (eds.), Heterogeneous catalysis : principles and applications, pp. 6-11. London: Oxford University Press, 1974.

3. Masters, C., ed. Homogeneous Transition-metal Catalysis. 1st ed. Cambridge: University Press, 1981.

4. Perrin, D.D., Armarego, W.L.F., and Perrin, D.R., eds. Purification of laboratory chemicals. 2nd ed. Oxford: Pergamon Press, 1980.

5. Grubbs, R.H. Hybrid-phase catalysts. CHEMTECH (August 1977): 512-518.

6. Bailey, D.C., and Langer, S.H. Immobilization transition-metal carbonyls and related catalysts. Chemical Reviews 81 (1981): 110-143.

7. Pittman, C.U., Jr., and Hanes, R.M. Unusual selectivities in hydroformylations catalyzed by polymer-attached $(PPh_3)_3RhH(CO)$. J.Amer.Chem.Soc. 98 (August 1976): 5402-5405.

8. Garrou, P.E., and Gates, B.C. Polymer-bound transition metal complexes catalysts. In D.C. Sherrington, and P. Hodge (eds.), Syntheses and separations using functional polymers, pp. 124-142. New York: Wiley Interscience, 1988.

9. Holy, N.L. Versatile polymer-bound hydrogenation catalysts. Rhodium(I)-catalyzed hydrogenation. J.Org.Chem. 44 (1979): 239-243.

10. _____. Who needs phosphines to tie down catalysts?. CHEMTECH (June 1980): 366-371.

11. Sherrington, D.C. Polymer-supported systems: Towards clean chemistry?. Chemistry & Industry (1991): 15-19.

12. Manassen, J. Chim.Ind. (Milan) 51 (1969).

13. Tamaru, K. Catal.Rew. 4 (1970): 160.

14. Hagg, W.O., et al. Belgian Patent 721 (1968): 686.

15. Grubbs, R.H., and Kroll, L.C. Catalytic reduction of olefins with a polymer-supported rhodium(I) catalyst. J.Amer.Chem.Soc. 93 (June 1971): 3062-3063.

16. Collman, J.P. and Reed, C.A. J.Amer.Chem.Soc. 95 (1973): 2048.

17. Dumont, W., Poulin, J.C., Dang, T.P., and Kagen, H.B. Asymmetric catalytic reduction with transition metal complexes. II. Asymmetric catalysis by a supported chiral rhodium complex. J.Amer.Chem.Soc. 95 (December 1973): 8295-8299.

18. Bonds, W.D., and others. Polystyrene attached titanocene species. Preparation and reactions. J.Amer.Chem.Soc. 97 (April 1975): 2128-2132.

19. Lang, W.H., Jurewicz, A.T., Hagg, W.O., Whitehurst, D.D., and Rollman, L.D. Rhodium elution from polymer-bonded hydroformylation catalysts. J.Organomet.Chem. 134 (1977): 85-94.

20. Card, R.J., and Neckers, D.C. Poly(styryl)bipyridine: Synthesis and formation of transition-metal complexes and some of their physical, chemical, and catalytic properties. Inorganic Chemistry 17 (1978): 2345-2349.

21. Pinna, F., Candilera, C., Strukul, G., Bonivento, M., and Graziani, M. Catalytic hydrogenation of propene over polymer supported rhodium complexes. J.Organomet.Chem. 159 (1978): 91-98.

22. Reed, J., Eisenberger, P., Teo, B.-K., and Kincaid, B.M. Structural effects of cross-linking in polymer-bound bromotris(triphenylphosphine)rhodium(I) catalyst by X-ray absorption studies. J.Amer.Chem.Soc. 100 (1978): 2375-2378.

23. Takaishi, N., Imai, H., Bertelo, C.A., and Stille, J.K. Transition metal catalyzed asymmetric organic syntheses via polymer-attached optically active phosphine ligands. Synthesis of *R* amino acids and hydratropic acid by hydrogenation. J.Amer.Chem.Soc. 100 (January 1978): 264-267.

24. Chang, B.-H., Grubbs, R.H., and Brubaker, C.H., JR. The preparation and some catalytic activity of polymer-supported ^{5}-cyclopentadienyl-rhodium and -cobalt dicarbonyls. J.Organomet.Chem. 172 (1979): 81-89.

25. Ohkubo, K., Fujimori, K., and Yoxhinaga, K. Asymmetric hydrogenation of prochiral unsaturated acids by soluble and insoluble polymer-supported rhodium(I) chiral diphosphine complexes. Inorg.Nucl.Chem.Letters 15 (1979): 231-234.

26. Awl, R.A., Frankel, E.N., Friedrich, J.P., and Swanson, C.L. Tricarbonylchromium-complexed phenylsiloxane polymers as stereoselective hydrogenation catalysts: Preparation and properties. J.Polym.Sci.Polym.Chem.Ed. 18 (1980): 2663-2676.

27. Gordon, B., III, Butler, J.S., and Harrison, I.R. Preparation and hydrogenation studies of rhodium(I) catalyst supported on polymer crystal surfaces. J.Polym. Sci. : Polym.Chem.Ed. 23 (1985): 19-26.

28. Montelatici, S., Vander Int, A., Osborn, J.A., and Wilkinson, G. Further studies on the homogeneous hydrogenation of olefins by use of tris(tertiary phosphine) chlororhodium(I) complexes. J.Amer.Chem.Soc. (A) (1986): 1054-1058.

29. Yamaguchi, S., Inove, M., and Enomoto, S. Pd(II) ion fixed on sulfonated polystyrene-type resin catalysts for the oxidation of 2-methylnaphthalene to 2-methyl-1,4-naphthoquinone with hydrogen peroxide. Chemical & Pharmaceutical Bulletin 34 (February 1986): 445-449.

30. Bergbreiter,D.E., and Chandran, R. Polyethylene-bound rhodium(I) hydrogenation catalysts. J.Amer.Chem.Soc. 109 (1987): 174-179.

31. Trumbo, D.L., and Marvel, C.S. Synthesis of acetylene-terminat polymers using supported palladium(II) catalysts. J.Polym.Sci.Polym.Chem. 25 (1987): 847-856.

32. Bergbreiter, D.E., and Weatherford, D.A. Polyethylene-bound soluble recoverable palladium(o) catalysts. J.Org.Chem. 54 (1989): 2726-2730.

33. Lieto, J., Milstein, D., Albright, R.L., Minkiewicz, J.V., and Gates, B.C. Polymeric supports for catalysts. CHEMTECH (January 1983): 46-53.

34. Frechet, J.M.J., and Farrall, M.J. Functionalization of crosslinked polystyrene resins by chemical modification: A REVIEW. In Chemistry and properties of crosslinked polymers, pp. 59-83. New York: Academic Press, 1979.

35. Braun, D., Cherdron, H., and Kern, W. General methods of polymer chemistry. In Techniques of polymer synthesis and characterization, pp. 57-58. New York: Wiley Interscience, 1979.

36. Michalska, Z.M., and Webster, D.E. Supported homogeneous catalysts. CHEMTECH (February 1975): 117-122.

37. Akelah, A. Heterogeneous organic synthesis using functionalise polymers. Synthesis (1981): 413-438.

38. Pittman, C.U., JR. Polymer supported catalysts. Complehensive organometallic chemistry. (1982): 553-610.

39. Kondo, F., Ohtsuka, T., and Tsuda, K., Convenient synthesis and free radical copolymerization of para-chloromethylstyrene. J.Macromol.Sci.Chem. 6 (1979): 767-775.

40. George, A.O., Simon, H.Y. Protonated Chloromethyl alcohol and chloromethyl ether. Proof for intermediacy of the elusive chloromethyl alcohol. J.Am.Chem.Soc. 97 (April 1975): 2293-2295.

41. Ogata, Y., and Okano, M. Kinetics of the condensation of dimethylaniline with formaldehyde. J.Am.Chem.Soc. 78 (1956): 5423.

42. Tseng, C.M., Lu, Y.Y., EL-AASSER, M.S., and Vanderhoff, J.W. Uniform polymer particles by dispersion polymerization in alcohol. J.Polym.Sci.Polym.Chem.Ed. 24 (1986): 2995-3007.

43. Ihara, H., Furusawa, H., Li, x., and Hirayama, C. Polypeptide Spheres. VII. Macroreticulation of Spherical Poly(gamma-methyl-L-glutamate) Beads. J.Appl.Polym.Sci. 42 (1991): 347-350.

APPENDIX

Appendix I

Calculation of Chloride content in poly(styrene-co-divinyl benzene-co-vinylbenzyl chloride) by modified volhard method

This method is used for determination of halide content by precipitating with silver nitrate solution which is called argentimetry method. By adding silver nitrate solution excessively and exactly known content. Then titration the remaining of silver nitrate solution is carried out with standardized thiocyanate solution as ferric alum indicator. At the end point the red solution of ferric thiocyanate $(FeSCN)^{2+}$ is considered.

$$Ag^{+}(aq) + SCN^{-}(aq) \longrightarrow AgSCN(s)$$

$$Fe^{3+}(aq) + SCN^{-}(aq) \longrightarrow Fe(SCN)^{2+}(aq)$$

The concentration of standardized $AgNO_3$ solution	0.10	N
The concentration of standardized KSCN solution	0.0991	N
The weight of polymer beads	0.2005	g
The volume of standardized $AgNO_3$ solution added in polymer beads mixture	10.0	ml
The volume of standardized KSCN solution titrated with polymer beads mixture	8.86	ml

So, the mole of chloride in polymer beads

= (mole of total $AgNO_3$) - (mole of remaining $AgNO_3$)

= (0.1/1000)10 - (0.0991/1000)8.86 mol

= 0.1220 mmole/0.2005 g of polymer beads

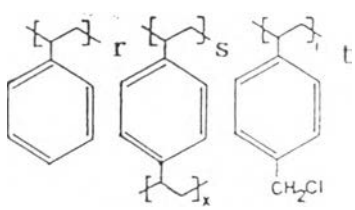
= 0.6085 mmole/g of polymer beads = 2.15 % of Cl.

APPENDIX II

Calculation of percentage element

1. Polymeric supports

Structure



Formular weight of polymeric support

atom	atomic weight	number	atomic weight * number
C	12.011	8r+10s+9t	12.011(8r+10s+9t)
H	1.008	8r+10s+9t	1.008(8r+10s+9t)
Cl	35.453	t	35.453(t)

Formular weight for polymeric support 104.152r+130.19s+152.624t

For 3 percentages of DVB

Let r = 0.87, s = 0.03, and t = 0.10

So C = 89.28 % ,H = 7.49 % ,Cl = 3.23 %

For 10 percentages of DVB

Let r = 0.80, s = 0.10, and t = 0.10

So C = 89.33 % ,H = 7.50 % ,Cl = 3.18 %

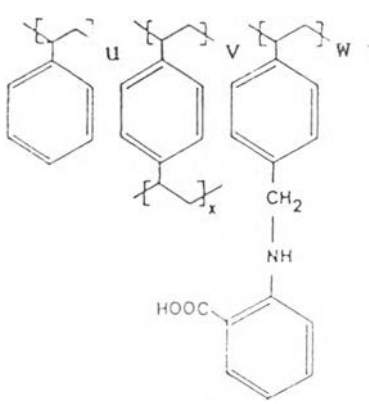
For 20 percentages of DVB

Let r = 0.70, s = 0.20, and t = 0.10

So C = 89.39 % ,H = 7.50 % ,Cl = 3.10 %

2. Polymeric ligands

Structure



Formular weight of polymeric ligand

atom	atomic weight	number	atomic weight * number
C	12.011	8u+10v+16w	12.011(8u+10v+16w)
H	1.008	8u+10v+15w	1.008(8u+10v+15w)
N	14.0067	w	14.0067(w)
O	15.9994	2w	15.9994(2w)

Formular weight for polymeric ligand 104.152u+130.19v+253.3015w

For 3 percentages of DVB

Let u = 0.87, v = 0.03, and w = 0.10

So C = 88.84 % ,H = 7.37 % ,N = 1.15 % and O = 2.63%

For 10 percentages of DVB

Let u = 0.80, v = 0.10, and w = 0.10

So C = 88.79 % ,H = 7.37 % ,N = 1.17 % and O = 2.67%

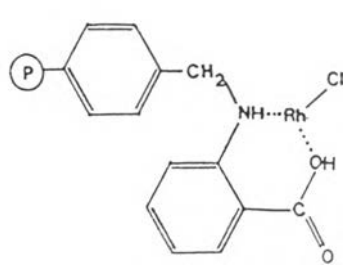
For 20 percentages of DVB

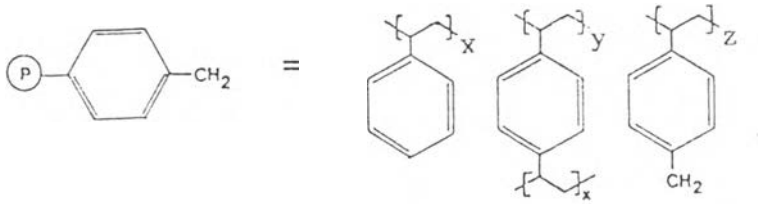
Let u = 0.70, v = 0.20, and w = 0.10

So C = 88.92 % ,H = 7.38 % ,N = 1.13 % and O = 2.57%

3. Polymeric catalysts

Structure





Formular weight of polymeric catalyst

atom	atomic weight	number	atomic weight * number
C	12.011	8x+10y+16z	12.011(8x+10y+16z)
H	1.008	8x+10y+14z	1.008(8x+10y+14z)
N	14.0067	z	14.0067(z)
O	15.9994	2z	15.9994(2z)
Rh	102.9055	z	102.9055(z)
Cl	35.453	z	35.453(z)

Formular weight for polymeric catalyst **104.152x+130.19y+390.652z**

For 3 percentages of DVB

Let x = 0.87, y = 0.03, and z = 0.10

So C = 79.66 % ,H = 6.53 % ,N = 1.05 % ,O = 2.40 %,

Rh = 7.70 % and Cl = 2.65 %

For 10 percentages of DVB

Let x = 0.80, y = 0.10, and z = 0.10

So C = 79.83 % ,H = 6.55 % ,N = 1.03 % ,O = 2.36 %,

Rh = 7.60 % and Cl = 2.62 %

For 20 percentages of DVB

Let x = 0.70, y = 0.20, and z = 0.10

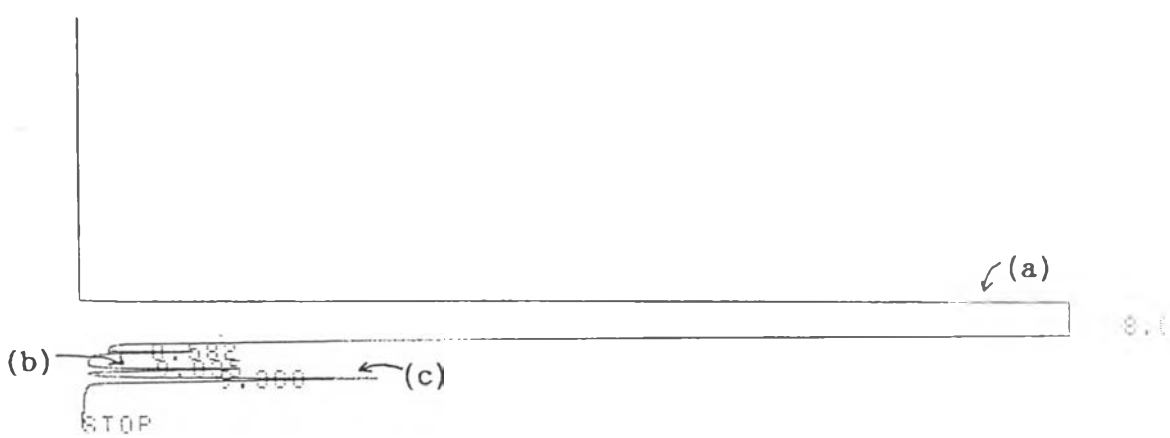
So C = 80.07 % ,H = 6.57 % ,N = 1.01 % ,O = 2.32 %,

Rh = 7.46 % and Cl = 2.57 %

APPENDIX III

The gas-liquid chromatogram

WIDTH	3	SLOPE	43.2059
DRIFT	0	MIN.AREA	30000
T.DBL	0	STOP.TM	20
ATTEN	7	SPEED	5
METHOD$	41	FORMAT$	0
SPL.WT	100	IS.WT	1



PKNO	TIME	AREA	MK	IDNO	CONC
1	8.026	19246466	S		98.4326
2	8.582	30013	T		0.1535
3	9.035	76311	T		0.3903
4	9.308	200143	TW		1.0236
					100

The GC chromatogram of (a) Hexane

(b) Cyclohexane

(c) Cyclohexene

VITA

Miss Rungravee Thawornpanich was born on August 26,1967 in Bangkok, Thailand. She graduated with a Bachelor Degree of Science in Chemistry from Khonkaen University in 1988. She has been a graduate student in Petrochemistry-Polymer multidisciplinary Program, Chulalongkorn University since 1989. During the study towards the Master's degree of science, the financial support was from The National metal and Materials Technology center. (National Science and Technology Development Agency)