REFERENCES

1. Rhoads, R.G., Proceedings of the US-Ducth International Symposium on " Air Pollution by Nitrogen Oxide ", May 24-28, 1982, Maastricht, The Netherlands, Eds. by Schneider, T. and Grant, L., Elsevier, Amsterdam, The Netherlands, p.989 (1982).
2. Nakajima, T., Proceedings of The US-Ducth International Symposium on " Air Pollution by Nitrogen Oxide ", May 24-28, 1982, Maastricht, The Netherlands, Eds. by Schneider, T. and Grant, L., Elsevier, Amsterdam, The Netherlands, p.951 (1982).
3. Masusaki, A., in " Chemistry of Atmosphere," Chemical Society of Japan, Tokyo, Japan, 1990, p.24.
4. Hakusho, K., Environmental Agency of Japan, 1992.
5. Brown, L.R., " State of the World , " Norten, W.W. & Company., USA, 1992.
6. Kim, E., J. Jpn. Inst. Energy, 71(1992) : 1150.
7. Osa, T., Sato, S., Koda, S., Yoshida, T., Takahashi, H., and Tominaga, H., in "Chemistry of NO_x ," Kyorisu, Tokyo, Japan.
8. Chiron, M., Stud. Surf. Sci. Catal., 30(1987) : 1.
9. Impens, R., Stud. Surf. Sci. Catal., 30(1987) : 11.
10. Bosch, and Janssen, F., Catal. Today, 2(1988) : 369.
11. Saito, K., and Ichihara, S., Cal. Today, 10(1991) : 45.
12. Yoshida, K., and Muramatsu, G., J. Jpn. Inst. Energy, 71(1992) : 1167.
13. Kanaoka, C., in " Chemistry of Atmosphere," Chemical Society of Japan, Tokyo, Japan, 1990, p.191.
14. Sato, K., and Ichihara, S., Shokubai, 31(1989) :572.

15. Kruithof, J., Proceedings of the US-Ducth International Symposium on " Air Pollution by Nitrogen Oxide ", May 24-28, 1982, Maastricht, The Netherlands, Eds. by Schneider, T. and Grant, L., Elsevier, Amsterdam, The Netherlands, p.885 (1982).

16. Oeting, H., and Shehweimer, G.W., Proceedings of the US-Ducth International Symposium on " Air Pollution by Nitrogen Oxide ", May 24-28, 1982, Maastricht, Eds. by Schneider, T. and Grant, L., Elsevier, Amsterdam, The Netherlands, p.897 (1982).

17. Truex,T.J., and Seales R.A., and Sun, D.C., Platinum Metals Rev., 36(1992) : 2.

18. Derouane, E.G., Lemos, F., Naccache, C., and Ribeiro, F.R.,(Eds.) "Zeolite Microporous Solid : Synthesis Structure, and Reactivity," Kluwer Acadamic Plublishers, Dortrecht, The Netherlands, 1991.

19. Flanigan, E.M., Stud. Surf. Sci. Catal., 58(1991) : 13.

20. Corma, A., in " Zeolite Microporous Solid : Synthesis, Structure, and Reactivity", Eds. by Derouane, E.G., Lemos, F., Naccache C., and Ribeiro, F.R., Kluwer Acadamic Plublishers, Dortrecht, The Netherlands, 1991 p. 373.

21. Hamada, H., Kintaichi, Y., Sasaki, M., and Ito, T., Appl. Catal., 64(1990) : L1.

22. Iwamoto, M., Yahiro, H., Yoshiota, T., and Mizuno, N., Chem. Lett.,11(1990) : 1967.

23. Inui, T., Kojo, S., Shibata, M., Yoshida, T., and Iwamoto, S., Stud. Surf. Sci., Catal., 69(1991) : 355.

24. Kikuchi, E., Yogo, K., Tanaka, S., and Abe, M., Chem. Lett., (1991) : 1063.

25. Held, W., and Koenig, A., Ger. Offen, DE 3642018 (1987).

26. _______, and Koenig, A., Richter, T., and Puppe, L., SEA paper 900496(1990).

27. Iwamoto, M., Proceedings of Meeting of Catalytic Technology for Removal of Nitrogen Oxides, January 25, 1990, Tokyo, Japan, Catalysis Society of Japan, p. 17(1990).

28. _______, Yahiro, H., Shundo, S., Yu-u, Y., and Mizuno, N., Shokubai, 33(1990) : 430.

29. Inui, T., Iwamoto, S., Kojo, S., and Yoshida, T., Catal. Lett., 16(1992) : 223.

30. Yokoyama, C., and Misono, M., Chem. Lett., (1992) : 1669.

31. Ault, J.W., and Ayen, R.J., IChEJ., 17(1977) : 265.

32. Tzou,M.S., and Asukura, K.,Yamasaki, Y., and Kuroda, H., Catal. Lett., 11(1991) : 33.

33. Li, Y., and Armor, J.N., Appl. Catal. B, 1(1992) : L31.

34. Yogo, K., Tanaka, S., Ihara, M., Hishki, T., and Kikuchi, E., Chem. Lett., (1992) : 1025.

35. Ishihara, T., Kagawa, M., Mizuhara, Y., and Takita, Y., Chem Lett., (1992) : 2119.

36. Sato, S., Hirabayashi, H., Yahiro, H., Mizuno, N., and Iwamoto, M., Cattal. Lett., 12(1992) : 193.

37. Yogo, K., Ihara, M., Terasaki, I., and Kikuchi, E., Catal. Lett., 17(1993) : 303.

38. Hamada, H., Kintaichi, Y., Sasaki, M., Ito, T., and Tabata, M., Appl. Catal., 64(1990) : L1.

39. ________, Kintaichi, Y., Sasaki, M., Ito, T., and Tabata, M., Appl. Catal., 76(1990) : L15.

40. Inui, T., Kojo, S., Shibata, M., Yoshida, T., and Iwamoto, S., Zeolite Chemistry and Catalysis, in : Jacobs, P.A., et al.(Ed), Elsivier, Amsterdam, 1991, 335.

41. Kikuchi, E., Yogo, K., Tanaka, S. and Abe, M., Chem. Lett., (1991), 1063.

42. Spoto, G., Bordiga, S., Scarano, D., and Zecchina, A., Catal. Lett., 13(1992) : 39.

43. Inui, T., Kojo, S., Shibata, M., Yoshida, T., and Iwamoto, S., Stud. Surf. Sci. Catal., 69(1991) : 355.

44. ______, Nishiyama, H., Shimizu, S., and Iwamoto, S., Appl. Catal., to be submitted.

45. ______, Nishiyama, H., Shimizu, S., and Iwamoto, S., Appl. Catal., to be submitted.

46. ______, Nishiyama, H., Shimizu, S., and Iwamoto, S., Catal. Lett., to be submitted.

47. ______, Shimizu, S., and Iwamoto, S.,Proceedings from the 9 th International Zeolite Conference, July 5-10, 1992, Montreal, Canada, Eds.by von Ballmoos, R., Higgings, J.B., and Treacy, Buterworth-Heinemann, Stoneham, USA, Vol. II , p. 405, (1992).

48. _______, Hirabayashi, T., H., Shimizu, S., and Iwamoto, S., Catal. Lett., to be submitted.

49. _______, Okabe, M., H., Shimizu, S., and Iwamoto, S., Zeolites, to be submitted.

50. Iwamoto, M., Furukawa, H., Mine, Y.,Uemura, F., Mikuriya, S., and Kagawa, J. Chem. Soc. Commun., 1986, 1272.

51. _______, Yahiro, H., Kutsuno, T., Bunyu, S., and Kagawa, S., Bull. Chem. Soc. Jpn., 62(1989) : 583.

52. _______, Yahiro, H., Mine, Y., and Kagawa, S., Chem. Lett., (1989) : 213.

53. Kagawa, S., Ogawa, H., Furukawa, H., and Teraoka, Y., Chem. lett., (1991) : 407.

54. Sato, S., Yu-u, Y., Yahiro, Mizuno, N., and Iwamoto, M., Appl. Catal., 70(1991) : L1.

55. Iwamoto, M., Mizuno, N., Yahiro, H., Sekiyu Gakkaishi, Vol.34 ,No.5,(1991) : 375.

56. Teraoka, Y., Ogawa, H., Furakawa, H., and Kagawa, S., Catal. Lett., 12(1992) : 361.

57. Shelef, M., Catal. Lett., 15(1992) : 305.

58. Sasaki, M., Hamada, H., Kintaichi, Y., and Ito, T., Catal. Lett., 15(1992) : 297.

59. Hall, W.K., and Valyon, J., Catal. Lett., 15(1992) : 311.

60. d'Itri, J.L., and Sachtler, W.M.H., Catal. Lett., 15(1992) : 289.

61. Burch, R., and Millington, P.J., Appl. Catal.B, 2(1993) : 101.

62. Ansell, G.P., Diwell, A. F., Golunski, S. E., Hayes, J. W., Rajaram, R. R. , Truex, T. J., and Walker, A. P., Appl. Catal.B, 2(1993) : 81.

63. Petunchi, J.O., Sill, G., and Hall, W. K., Appl. Catal.B, 2(1993) : 303.

64. Liu, D., and Robota, H. J., Catal. Lett., 21(1993) : 291.

65. Valyon, J., and Hall, W. K., Catal. Lett., 19(1993) : 109.

66. Szostak, R., Molecular Sieve Principle of Synthesis and Identification, p.1-2, 283-316, Van Nostrand Reinhold, New York, 1989.

67. Tanabe, K., Misona, M., Ona, Y., and Hattori,H., New Solid Acids and Bases (Delman, B., and Yates, J.T., eds.), Studies in Surface Science and Catalysis, 51, p. 142-161, Elsevier,Tokyo, 1989.

68. Barthoment, D., " Acidic Catalysis Zeolites," Zeolites Science and Technology (Rebeiro F.R. et al.), p. 317- 346, Martinus Nijhoff Publishers, The Hugue, 1984.

69. Chang,C.D., " Hydrocarbons from Methanal," Catal. Rev.-Sci. Eng., 25(1), p. 9, 1983.

70. Ashton, A. G., Batmanian, S., Dwyer,J., " Acidity in Zeolites ," Catalysis by Acids and Bases (Imelik, B. et al.), p. 101-109, Elsevier,Amsterdam,1985.

71. Sano, T., Fujisawa, K., and Higiwara, H., " High Steam Stability of HZSM-5 Type Zeolite Containing alkaline earth metals," Catalyst Deactivation 1987 (Delmin, B., and Fromant, G. F. eds.), Studies in Surface Science and Catalysis, 34 ; p. 613- 624, Elsevier, Amsterdam,1987.

72. Derouane, E. G., "New aspects of molecular shape Selectivity," Catalysis by Zeolites (Imelik, B. et al.), p. 5 - 27, Elsevier, Amsterdam, 1980.

73. ________, " Molecular Shape Selectivity Catalysis by Zeolites, " Zeolites Science and Technology (Rebeiro, F. R. et al.) p. 347 - 371, Martinus Nijhoff Publishers, The Hague, 1984.

74. Satterfield, C.N., Heterogeneous Catalysis in Practice, p. 42 - 67, 151 - 179, McGraw - Hill Book Company, New York, 1980.

75. Breck, D. W., Zeolite Melecular Sieves, p. 529-530 , Robert E. Krieger Publishing Company, Malabar, Florida, 1984.

76. Cotton, F. A., and Wilkinson, G., Advanced Inorganic Chemistry, p. 422 - 428, John & Sons, New York, 1980.

77. Inui, T., Vamase, O., Fukuda, K., Itoh, A., Tarmuto, J., Morina, N., Hagiwara, T., and

Takegami, Y.," Proceedings, 8th International Congress on Catalysis, Berlin, 1984, " vol.3, p. 569, Dechema, Frankfult-am-Main, 1984.

78. Argauer, R.J., and Landolt, G.R., " Crystalline zeolite ZSM-5 and method of preparing the same, " U.S. Pat. 3,702,886 , November 14, 1972.

79. _______, and Landolt, G.R., " Crystalline zeolite ZSM-5 and method of preparing the same, " U.S. Pat. 3,702,886 , November 14, 1972.

80. Anderson, J.R., Foger, K.,Mole, R., Rajadhyaksha, R.A., and Sanders, J.V., J. Catal., 58, 114, 1979.

81. Dejaifve, P., Auroux, A., Gravelle, P.C., and Ve'drin, J.C., and Giabelica, Z., and Derouane, E.G., J. Catal., 70, 123, 1981.

82. Topse, N.Y., Pederson, K., and Derouane, E.G., J. Catal., 70, 41, 1981.

83. Inui, T., Suzuki, T., Inoue, M., Murakami, Y., and Takegami, Y., " structure and Reactivity of Modified Zeolites," (Jacobs, P. A. et al. eds.), p.201, Elsevier, Amsterdam, 1984.

84. Yogo, K. Ihara, M., Terasaki, I., and Kikuchi, E., Catal. Lett., 17(1993) : 303.

85. Tzou, M. S., Asukura, K., Yamazaki, Y., and Kuroda, H., Catal. Lett., 11(1991) : 33.

86. Inui, T., Nishiyama, H., Shimizu, S., and Iwamoto, S., Appl. Catal., to be submitted.

APPENDIX A

SAMPLE OF CALCULATIONS

A-1 Calculation of Si/Metal Atomic Ratio for ZSM-5, Fe-silicate, and Cu-silicate

The calculation is based on weight of Sodium Silicate ($Na_2O \cdot SiO_2 \cdot H_2O$) in B1 and B2 solutions.

M.W. of Si = 28.0855

M.W. of SiO_2 = 60.0843

Weight percent of SiO_2 in Sodium Silicate = 28.5

M.W. of Al = 26.9815

M.W. of $AlCl_3$ = 133.3405

Weight percent purity of $AlCl_3$ = 97

M.W. of Fe = 55.847

M.W. of $Fe(NO_3) \cdot 9H_2O$ = 404.00

Weight percent purity of $Fe(NO_3)_3 \cdot 9H_2O$ = 99

M.W. of Cu = 63.54

M.W. of $Cu(NO_3)_2 \cdot 3H_2O$ = 241.60

Weight percent purity of $Cu(NO_3)_2 \cdot 3H_2O$ = 99.5

For example, to prepare ZSM-5 at Si/Al atomic ratio of 50. Using Sodium Silicate 69 g with 45 g of water as B1 solution.

$$\text{mole of Si used} = \frac{\text{wt.(\%)}}{100} \cdot \frac{\text{(M.W. of Si)}}{\text{(M.W. of SiO}_2\text{)}} \cdot \frac{\text{(1 mole)}}{\text{(M.W. of Si)}} \qquad \text{(A-1.1)}$$

$= 69 \cdot (28.5/100) \cdot (1/60.0843)$

$= 0.3273$

Si/Al atomic ratio = 50

mole of $AlCl_3$ required $= 0.3273/50 = 6.5458 \cdot 10^{-3}$ mole

amount of $AlCl_3$ $= 6.5458 \cdot 10^{-3} \cdot 133.34\ (100/97)$

$= 0.8998$ g

This is the amount of $AlCl_3$ used in A1 and A2 solutions

Si/Fe = 50

mole of $Fe(NO_3)_3 \cdot 9H_2O$ required $= 0.3273/50 = 6.5458 \cdot 10^{-3}$ mole

amount of $Fe(NO_3)_3 \cdot 9H_2O$ $= 6.5458 \cdot 10^{-3} \cdot 404.00 \cdot (100/99)$

$= 2.6712$ g

This is the amount of $Fe(NO_3)_3 \cdot 9H_2O$ used in A1 and A2 solutions.

Si/Cu = 50

mole of $Cu(NO_3)_2 \cdot 3H_2O$ required $= 0.3273/50 = 6.5458 \cdot 10^{-3}$ mole

amount of $Cu(NO_3)_2 \cdot 3H_2O$ $= 6.5458 \cdot 10^{-3} \cdot 241.60 \cdot (100/99.5)$

$= 1.5894$ g

This is the amount of $Cu(NO_3)_2 \cdot 3H_2O$ used in A1 and A2 solutions.

A-2 Calculation of Metal Ion-exchanged ZSM-5 and Metallosilicate

Pt ion-exchange

Determine the amount of Pt into catalyst = 0.5 wt.%

The catalyst use = x g

So that: from the equation

$$Pt/(x+Pt) = 0.5/100 \qquad (A\text{-}2.1)$$

$$100 \cdot Pt = 0.5 \cdot (x+Pt)$$

$$(100-0.5) \cdot Pt = 0.5 \cdot x$$

thus $Pt = 0.5 \cdot x/(100-0.5)$ g

use $Pt(NH_3)_4Cl_2 \cdot H_2O$ (M.W. 352.13, 55% Pt)

$$\text{weight of } Pt(NH_3)_4Cl_2 \cdot H_2O = [0.5 \cdot x/(100-0.5)] \cdot [100/55] \text{ g}$$

Cu ion-exchange

Determine the amount of Cu into catalyst = 0.5 wt.%

the catalyst use = x g

So that : from the equation

$$Cu/(x+Cu) = 0.5/100$$

$$100 \cdot Cu = 0.5 \cdot (x+Cu)$$

$$(100-0.5) \cdot Cu = 0.5 \cdot x$$

thus $Cu = 0.5 \cdot x/(100-0.5)$ g

use $Cu(NO_3)_2 \cdot 3H_2O$ (M.W. 241.60, 26.30%Cu, purity 99.5%)

weight of $Cu(NO_3)_2 \cdot 3H_2O$ = [0.5∗x/(100-0.5)]∗[(100/26.30)∗(100/99.5)]

Various copper salts used for ion exchange

copper salt	%purity	M.W.	%Cu	weight of copper salt (g)
$Cu(NO_3)_2 \cdot 3H_2O$	99.5	241.60	26.30	[0.5∗x/(100-0.5)]∗[(100/26.30)∗(100/99.5)]
$Cu(CH_3COO)_2 \cdot H_2O$	99.0	199.65	31.83	[0.5∗x/(100-0.5)]∗[(100/31.83)∗(100/99)]
CuCl	95	98.993	64.19	[0.5∗x/(100-0.5)]∗[(100/64.19)∗(100/95)]
$CuCl_2 \cdot 2H_2O$	97	170.48	37.27	[0.5∗x/(100-0.5)]∗[(100/37.27)∗(100/97)]
$CuSO_4 \cdot 5H_2O$	99.5	249.68	25.45	[0.5∗x(100-0.5)]∗[(100/25.45)∗(100/99.5)]

A-3 Calculation of Reaction Flow Rate

The catalyst used = 0.5000 g

packed catalyst into quartz reactor (diameter = 0.6 cm)

determine the average high of catalyst bed = x cm

So that, volume of catalyst bed = $\pi * (0.3)^2 * x$ cc-catalyst

used GHSV(Gas Hourly Space Velocity) = 2,000 h^{-1}

$$GHSV = \frac{\text{Volumetric flow rate}}{\text{Volume of Catalyst}} = 4{,}000 \ h^{-1}$$

Volumetric flow rate = 4,000 ∗ Volume of catalyst

$$= 4{,}000 \cdot \pi (0.3)^2 \cdot x \quad cc./h$$

$$= 4{,}000 \cdot \pi (0.3)^2 \cdot x / 60 \quad cc./\ min.$$

at STP : Volumetric flow rate = Volumetric flow rate = Volume flow rate $\cdot \frac{(273.15+t)}{273.15}$

where : t = room temperature, ^{o}C

A-4. BET Surface Area Calculation

From BET equation :

$$x / v(1-x) = (1/ v_mC) + (C-1) \cdot x / v_mC \qquad \text{(A-4.1)}$$

where : x = ratio of partial pressure P/ P_o

P_o = saturated vapor pressure of N_2 (or adsorbed gas)

P = equilibrium vapor pressure of N_2

v = amount of adsorption to cover the surface, c.c. at the NTP/gm of sample

$$C = \exp (E_1-E_2 / RT) \qquad \text{(A-4.2)}$$

where : E_1 = heat of adsorption of the first layer

E_2 = heat of condensation of adsorbed gas assume $C \rightarrow \propto$, then

$$x / (v \cdot (1-x)) = (1 / v_m C) \cdot x \qquad \text{(A-5.3)}$$

let : $v_m = v'_m$

v_m = maen amount of adsorption to form the N_2 complete monolayer

v = amount of adsorption measuring by G.C.

x = P/P_o

$$P_b \cdot V / 273 = Pt\ V/ T \qquad \text{(A-4.4)}$$

where : V = constant volume

P_b = pressure at 0 °C

P_t = pressure at t °C

T = 273.15 + t, K

P_b = $(273.15 / T) \cdot P_t$ = 1 atm

partial pressure

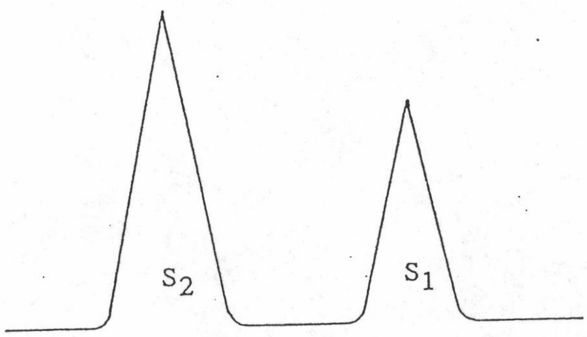
$$P = \frac{((\text{Flow of } (He + N_2)) - \text{Flow of } He)}{\text{Flow of } (He + N_2)) \cdot Pb} \qquad \text{(A-4.5)}$$

$$= 0.3 \text{ atm}$$

N_2 saturated vapor pressure , P_o = 1.1 atm = 836 mm. Hg

$$X = P / P_o = P / 1.1$$

How to measure v



1 ml /1 atm at room temperature

desorption of N_2 area — N_2 calibration area

$$V = (s_2 / s_1) \cdot (1 / w) \cdot (273.15 / T) \cdot V \quad \text{c.c. / g of catalyst} \qquad \text{(A-4.6)}$$

where : w = weight of sample

$$v'_m = \frac{v \cdot [\,1 - ((\text{flow of He} + N_2 - \text{flow of He}) / 1.1\,]}{\text{flow of He} + N_2} \quad \text{c.c. NTP /g of catalyst} \qquad \text{(A-4.7)}$$

$$s_b = s \cdot v'_m \qquad \text{(A-4.8)}$$

where : s = surface area from literature of N_2

= 4.373 m^2/c.c of N_2

so that : s_b = 4.373 v'_m m^2 / g of catalyst

A-5 TPD calculation

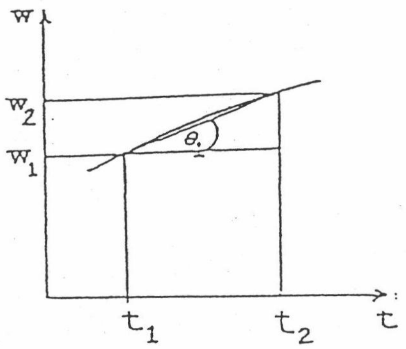


Figure A-5.1 Plot of weight loss vs. time

From figure A-5.1:

$$(dw/dt) = (w_2-w_1) \ / \ (t_2-t_1) + \tan\theta \qquad \text{(A-5.1)}$$

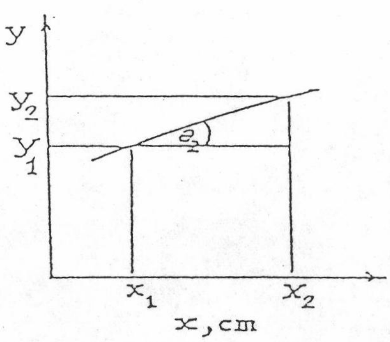


Figure A-5.2 Plot of full scale chart relating weight loss to speed chart which is related to time.

From figure A-5.2 :

The recorder condition was adjust follows :

$$25 \text{ cm} = a \text{ mg}$$

$$y_1 \text{ cm} = (a * y_1)/25 \text{ mg}$$

$$\text{and } y_2 \text{ cm} = (a * y_2)/25 \text{ mg}$$

chart speed $\quad b \text{ cm} = 60 \text{ sec}$

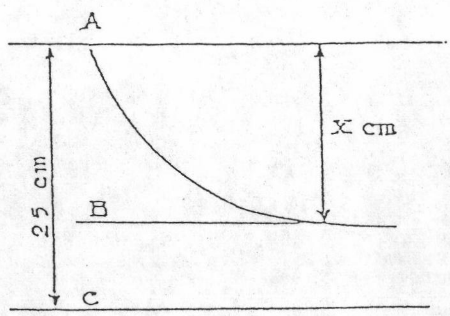
$$x_1 \text{ cm} = (60 * x_1)/b \text{ sec}$$

$$x_2 \text{ cm} = (60 * x_2)/b \text{ sec}$$

$$dw/dt = \frac{(a/25) * (y_2 - y_1)}{(60/b) * (x_2 - x_1)} = \frac{ab}{(25 * 60)} \tan\theta \qquad \text{(A-5.2)}$$

For TPD curve plot between $(dw/dt)/w_o$ vs. temperature

where : w = dry weight of catalyst and calculated as follows



we set full chart scale = a mg

at A position weight of catalyst = a mg

B position weight of catalyst = ax/25 mg weight loss = ax/25 mg (A-5.3)

dry wt. of catalyst = wt. of sample before drying - wt. loss (A-5.4)

A-6 Calculation of NO and C_3H_8 conversion

The effluent gas was analyzed by gas chromatography, the NO reduction activity was evaluated in terms of the conversion of NO into N_2.

$$\text{NO Conversion(\%)} = (2[N_2]_{out} / [NO]_{in}) \cdot 100$$

The C_3H_8 oxidation activity was evaluated in terms of the conversion of C_3H_8 into CO and CO_2.

$$C_3H_8\ \text{Conversion(\%)} = \frac{([C_3H_8]_{in} - [C_3H_8]_{out}) \cdot 100}{[C_3H_8]_{in}}$$

APPENDIX B

Physical Properties of Nitric Oxide

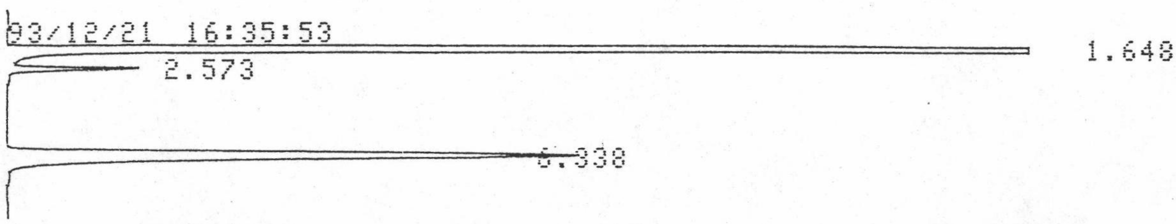
Property	Value
mol. wt.	30.1
m.p., °C	-161
b.p., °C	151.18
heat of fusion, kcal./mole	0.550
heat of vaporization, kcal./mole	3.293
heat of formation, kcal./mole	21.50
density[0 °C, 1 atm], g/L	1.2536
sp. gr., gas, [0 °C, 1 atm], (air = 1)	-93
critical temperature, °C	1.018
critical pressure, atm	64
color	colorless gas, blue liquid and solid

Ambient Air Quality Standard of Thailand(1981)

Pollutants	average value (mg/m^3)				methods of
	1 h	8 h	24 h	1 year	measurement
Carbon Monoxide (CO)	50	20	-	-	Non Dispersive Infrared Detection
Nitrogen Dioxide (NO_2)	0.32	-	-	-	Gas Phase Chemiluminescence
Sulfur Dioxide (SO_2)	-	- 0.3	1*		Pararosanniline
Suspended Particulate Matter (SPM)	-	-	0.33	0.1*	Gravimetric
Photochemical Oxidant (O_3)	0.20	-	-	-	Chemiluminescence
Lead (Pb)	-	-	0.01	-	Wet Ashing

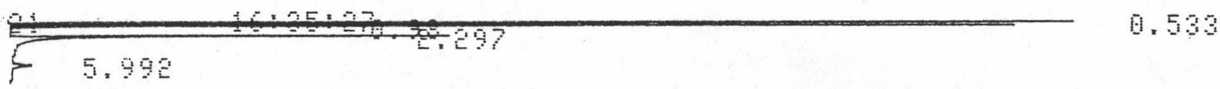
Note : * = Geometric mean

Sample of Chromatogram



COLUMN MS-5A

PKNO	TIME	AREA	CONC.	NAME
1	1.648	221521	94.4088	O_2
2	2.573	1252	0.5336	N_2
3	6.338	11867	5.0576	CO



COLUMN PORAPAK-Q

PKNO	TIME	AREA	CONC.	NAME
1	0.533	52711	85.2217	AIR
2	0.98	4111	6.6467	CO_2
3	2.297	4598	7.4345	H_2O
4	5.992	431	0.6971	C_3H_8

VITA

Mr. Wittaya Engopasanan was born in Chaiyaphum, Thailand, on February 26, 1967. He received his Bachelor Degree of Science from the Department of Chemistry, Faculty of Science, Chiangmai University in 1989.