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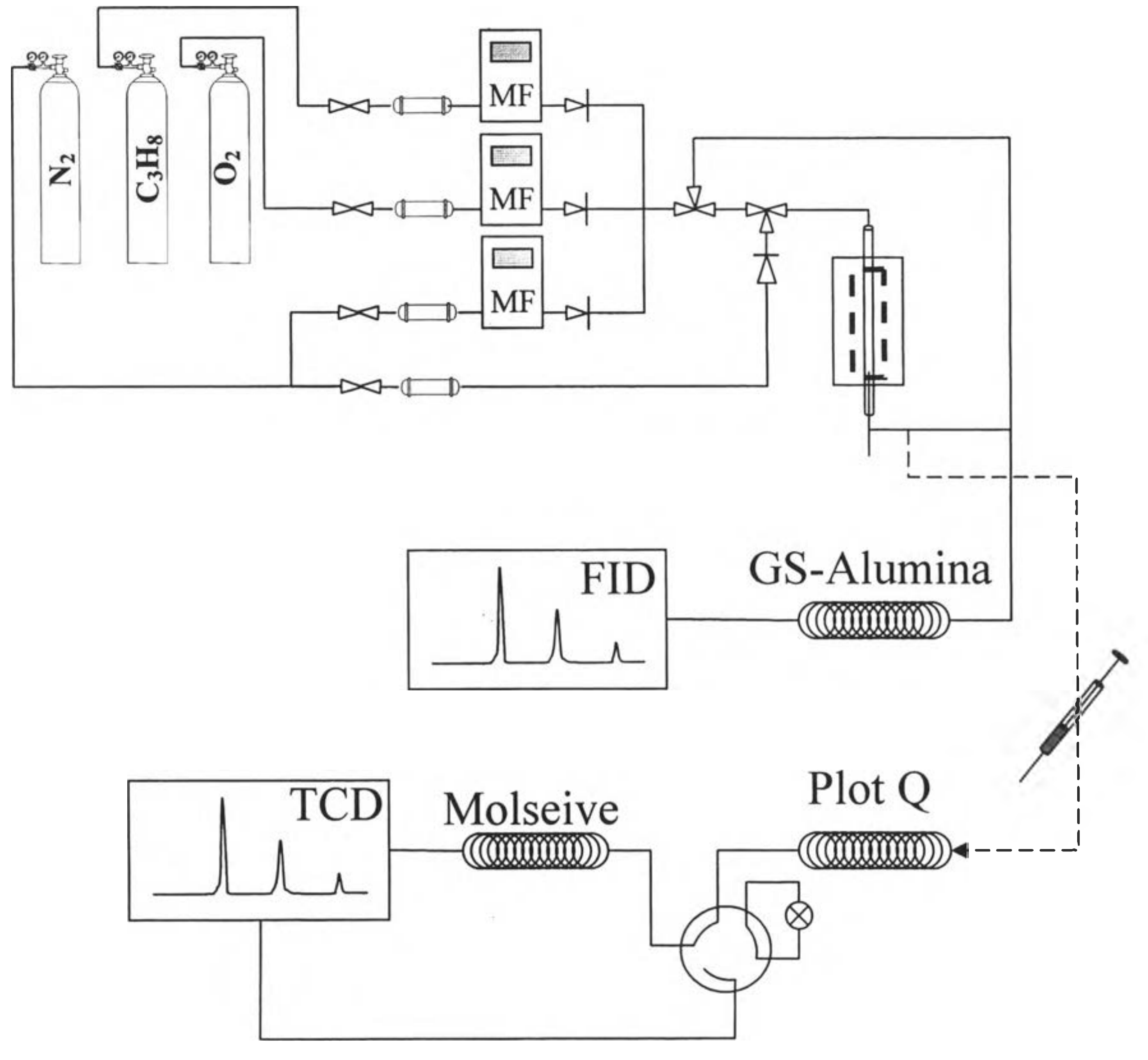
# APPENDICES

## Appendix A Reactor diagram for testing VS-1 zeolite by oxidative dehydrogenation reaction



**Appendix B Constructing calibration of hydrocarbon compound with FID detector. (GS-Alumina Column)**

From
$$f_i = \frac{A_{STD} \times G_i \times f_{STD}}{A_i \times G_{STD}}$$

And
$$m_i = \frac{f_i \times A_i}{\sum f_i \times A_i}$$

When $f_i$ = response factor of component

$f_{STD}$ = response factor of standard component

$A_i$ = GC peak area of component

$A_{STD}$ = GC peak area of standard component

$G_i$ = mass of component

$G_{STD}$ = mass of standard component

$m_i$ = unknown mass of component

Propane was selected as a standard component ($f_{STD} = 1$)

| Component | $f_i$ |
|---|---|
| Methane | 1.03532 |
| Ethane | 1.02381 |
| Ethylene | 0.93305 |
| Propane | 1 |
| Propylene | 0.95951 |

**Appendix C Constructing calibration of gas carrier, reactance and carbon oxide product with TCD detector. (PlotQ and Molseive column)**

From
$$(RMR)_i = \frac{A_i}{A_{STD}} \frac{n_{STD}}{n_i} (RMR)_{STD}$$

And
$$y_i = \frac{A_i/(RMR)_i}{\sum A_i/(RMR)_i}$$

When
$(RMR)_i$ = relative molar response factor of component

$(RMR)_{STD}$ = relative molar response factor of standard component

$A_i$ = GC peak area of component

$A_{STD}$ = GC peak area of standard component

$n_i$ = mole of component

$n_{STD}$ = mole of standard component

$y_i$ = unknown mole of component

Propane was selected as a standard component ($(RMR)_{STD} = 1$)

| Component | $(RMR)_i$ |
|---|---|
| Propane | 1 |
| Nitrogen | 0.57415 |
| Oxygen | 0.62457 |
| Carbon monoxide | 0.37439 |
| Carbon dioxide | 0.57889 |

## Appendix D Sample calculation of conversion, selectivity and carbon balance.

GC data calculation from GS-Alumina column equipped with FID detector

| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Component | f | M.W. | | | VW24_311 | VW24_312 | VW24_313 | VW24_314 | Sample Code or Name |
| 2 | Methane | 1.03532 | 16.04303 | 1 | 2.548 | 3002.389 | 2543.629 | 3119.546 | 3011.838 | |
| 3 | Ethane | 1.02381 | 30.07012 | 2 | 2.680 | 312.356 | 271.747 | 321.912 | 312.518 | |
| 4 | Ethlene | 0.93305 | 28.05418 | 3 | 2.853 | 6932.419 | 5919.348 | 7190.448 | 6976.691 | GC area peak of raw data |
| 5 | Propane | 1 | 44.09721 | 4 | 3.145 | 11826.061 | 9039.662 | 11115.327 | 11357.844 | |
| 6 | Propylene | 0.95951 | 42.08127 | 5 | 4.155 | 5330.349 | 4410.696 | 5348.109 | 5275.590 | |
| 7 | | | | | | | | | | |
| 8 | Methane | See Appendix B | | | Wi/Wc3h8 | 0.282844 | 0.29132 | 0.290565 | 0.274542 | |
| 9 | Ethane | | | | | 0.027041 | 0.03078 | 0.029651 | 0.028171 | Relative weight to propane |
| 10 | Ethlene | | | | | 0.546953 | 0.61098 | 0.603586 | 0.573138 | For Eample |
| 11 | Propane | | | | | 1 | 1 | 1 | 1 | F8=F2*$B2/(F$5*$B$5) |
| 12 | Propylene | | | | | 0.432481 | 0.46817 | 0.461668 | 0.445683 | |
| 13 | | | | | | | | | | |
| 14 | | | | | | | | | | |
| 15 | | | | | | | $k_{i,FID}$ | | | |
| 16 | Methane | | | | ni/n c3h8 | 0.722474 | 0.80076 | 0.79867 | 0.75463 | |
| 17 | Ethane | | | | | 0.039656 | 0.04513 | 0.043482 | 0.041312 | Mole relative to propane |
| 18 | Ethlene | | | | | 0.859733 | 0.96037 | 0.948752 | 0.900892 | For Eample |
| 19 | Propane | | | | | 1 | 1 | 1 | 1 | F16=F8*$C$5/$C2 |
| 20 | Propylene | | | | | 0.453199 | 0.4906 | 0.483784 | 0.467034 | |
| 21 | | | | | | | | | | |

GC data calculation from Plot Q and Molseive column equipped with TCD detector

| | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | RMR | M.W. | | | VW24_311 | VW24_312 | VW24_313 | VW24_314 | Sample Code or Name |
| 2 | CO2 | 0.57889 | 44.00995 | 1 | 2.501 | 49.063 | 49.369 | 51.384 | 49.252 | |
| 3 | C2= | | 28.05418 | 2 | 2.750 | 981.977 | 1007.434 | 1018.491 | 989.785 | |
| 4 | C2 | | 30.07012 | 3 | 2.981 | 52.501 | 53.920 | 54.495 | 51.060 | |
| 5 | C3= | | 42.08127 | 4 | 6.044 | 646.462 | 640.504 | 656.196 | 656.133 | |
| 6 | C3 | 1 | 44.09721 | 5 | 6.477 | 1561.704 | 1451.928 | 1493.013 | 1523.107 | GC area peak of raw data (TCD detector) |
| 7 | Oxy | 0.62457 | 31.99880 | 6 | 9.777 | 599.438 | 610.271 | 593.679 | 626.078 | |
| 8 | Nitrogen | 0.57415 | 28.01340 | 7 | 10.226 | 18328.686 | 18346.320 | 18319.379 | 18374.301 | |
| 9 | C1 | | 16.04303 | 8 | 10.970 | 29.352 | 32.112 | 33.932 | 33.206 | |
| 10 | CO | 0.37439 | 28.01055 | 9 | 12.975 | 227.359 | 239.590 | 243.196 | 231.188 | |
| 11 | | | | | | | $k_{i,TCD}$ | | | |
| 12 | | See Appendix C | | | | | | | | |
| 13 | CO2 | | | | | 0.05427 | 0.058737 | 0.059452 | 0.055859 | |
| 14 | C3 | | | | | 1 | 1 | 1 | 1 | Mole relative to propane |
| 15 | Oxy | | | | | 0.614564 | 0.672976 | 0.636664 | 0.658142 | For Eample |
| 16 | Nitrogen | | | | | 20.44119 | 22.00784 | 21.37079 | 21.01135 | F13=(F2/$B2)/(F6/$B6) |
| 17 | CO | | | | | 0.388857 | 0.440758 | 0.43508 | 0.405426 | |
| 18 | | | | | | | | | | |
| 19 | | | | | | | $k_i$ | | | |
| 20 | Methane | | | | | 0.722474 | 0.800756 | 0.79867 | 0.75463 | |
| 21 | Ethane | | | | | 0.039656 | 0.045135 | 0.043482 | 0.041312 | |
| 22 | Ethlene | | | | | 0.859733 | 0.960374 | 0.948752 | 0.900892 | |
| 23 | Propane | | | | | 1 | 1 | 1 | 1 | Mole relative to propane |
| 24 | Propylene | | | | | 0.453199 | 0.490601 | 0.483784 | 0.467034 | from TCD and FID detector |
| 25 | Cabondioxide | | | | | 0.05427 | 0.058737 | 0.059452 | 0.055859 | |
| 26 | Oxygen | | | | | 0.614564 | 0.672976 | 0.636664 | 0.658142 | |
| 27 | Nitrogen | | | | | 20.44119 | 22.00784 | 21.37079 | 21.01135 | |
| 28 | Cabonmonoxide | | | | | 0.388857 | 0.440758 | 0.43508 | 0.405426 | |
| 29 | | | | | | | | | | |

| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | | | | | | | | | | | | | | | | |
| 19 | | | | | | | $k_i$ | | | | | | | | | |
| 20 | Methane | | | | | 0.722474 | 0.800756 | 0.79867 | 0.75463 | | | | | | | |
| 21 | Ethane | | | | | 0.039656 | 0.045135 | 0.043482 | 0.041312 | | | | | | | |
| 22 | Ethlene | | | | | 0.859733 | 0.960374 | 0.948752 | 0.900892 | | | | | | | |
| 23 | Propane | | | | | 1 | 1 | 1 | 1 | | Mole relative to propane | | | | | |
| 24 | Propylene | | | | | 0.453199 | 0.490601 | 0.483784 | 0.467034 | | from TCD and FID detector | | | | | |
| 25 | Cabondioxide | | | | | 0.05427 | 0.058737 | 0.059452 | 0.055859 | | | | | | | |
| 26 | Oxygen | | | | | 0.614564 | 0.672976 | 0.636664 | 0.658142 | | | | | | | |
| 27 | Nitrogen | | | | | 20.44119 | 22.00784 | 21.37079 | 21.01135 | | | | | | | |
| 28 | Cabonmonoxide | | | | | 0.388857 | 0.440758 | 0.43508 | 0.405426 | | | | | | | |
| 29 | | | | | | | | | | | | | | | | |
| 30 | Mole fraction of feed nitrogen | | | 0.84703 | | | | | | | | | | | | |
| 31 | Mole fraction of feed oxygen | | | 0.05008 | | | | | | Mole fraction | | | | | | |
| 32 | Mole fraction of feed propane | | | 0.10289 | | | | $y_i$ | | for example | | 0.30866 | L32=3*D32 | | | |
| 33 | | | | | | | | | | F34=F20/SUM(F$20:F$28) | | | | | | |
| 34 | Methane | | | | | 0.0294 | 0.030243 | 0.030984 | 0.029834 | | ==> | 0.0294 | 0.03024 | 0.03098 | 0.02983 | |
| 35 | Ethane | | | | | 0.001614 | 0.001705 | 0.001687 | 0.001633 | | ==> X2 | 0.00323 | 0.00341 | 0.00337 | 0.00327 | |
| 36 | Ethlene | | | | | 0.034986 | 0.036272 | 0.036807 | 0.035616 | | ==> X2 | 0.06997 | 0.07254 | 0.07361 | 0.07123 | |
| 37 | Propane | | | | | 0.040694 | 0.037768 | 0.038795 | 0.039534 | | ==> X3 | 0.12208 | 0.11331 | 0.11638 | 0.1186 | Carbon |
| 38 | Propylene | | | | | 0.018442 | 0.018529 | 0.018768 | 0.018464 | | ==> X3 | 0.05533 | 0.05559 | 0.0563 | 0.05539 | Balance |
| 39 | Carbondioxide | | | | | 0.002208 | 0.002218 | 0.002306 | 0.002208 | | ==> | 0.00221 | 0.00222 | 0.00231 | 0.00221 | |
| 40 | Oxygen | | | | | 0.025009 | 0.025417 | 0.024699 | 0.026019 | | | | | | | |
| 41 | Nitrogen | | | | | 0.831824 | 0.8312 | 0.829075 | 0.830664 | | | | | | | |
| 42 | Carbonmonoxide | | | | | 0.015824 | 0.016647 | 0.016879 | 0.016028 | | ==> | 0.01582 | 0.01665 | 0.01688 | 0.01603 | |
| 43 | | | | | | 1 | 1 | 1 | 1 | | Summation | 0.29804 | 0.29395 | 0.29985 | 0.29656 | |
| 44 | | | | | | | | | | Average | | | | | | Average |
| 45 | % Propane Conversion | | | | | 61.16 | 63.98 | 63.09 | 62.32 | 62.64 | | 0.96558 | 0.95234 | 0.97143 | 0.96079 | 0.96254 |
| 46 | % Oxygen Conversion | | | | | 50.96 | 50.20 | 51.73 | 49.05 | 50.49 | | | | | | |
| 47 | % Propylene Selectivity | | | ===> | | 18.00 | 17.54 | 17.47 | 17.79 | 17.70 | | | | | | |
| 48 | % Cabonmonoxide Selectivity | | | | | 15.44 | 15.76 | 15.71 | 15.44 | 15.59 | | | | | | |
| 49 | % Cabondioxide Selectivity | | | | | 2.16 | 2.10 | 2.15 | 2.13 | 2.13 | | | | | | |
| 50 | % Ethane | | | | | 1.57 | 1.61 | 1.57 | 1.57 | 1.58 | | | | | | |
| 51 | % Ethylene | | | | | 34.14 | 34.34 | 34.26 | 34.32 | 34.27 | | | | | | |
| 52 | % Methane | | | | | 28.69 | 28.64 | 28.84 | 28.75 | 28.73 | | | | | | |
| 53 | | | | | | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 | | | | | | |

%Propane conversion
e.g. F45=100*($D32*$D30-F37*F41)/($D32*$D30)
%Oxygen conversion
e.g. F46=100*($D31*$D30-F40*F41)/($D31*$D30)
%Propene selectivity
e.g. F47=100*F38/SUM(F34:F36,F38,F39,F42)

# CURRICULUM VITAE

**Name:** Mr. Phairat Phiriyawirut

**Date of Birth:** January 31, 1975

**Nationality:** Thai

**University Education:**

1997-1999 Master Degree of Polymer Science, Petroleum and Petrochemical College, Chulalongkorn University, Bangkok, Thailand.

1993-1997 Bachelor Degree of Chemical Science, Faculty of Science, King Mongkut University of Technology Thonburi, Bangkok, Thailand.

**Working Experience:**

1999-2001 Position: Technical Sale Engineer

Company name: Chemical Innovation Co. Ltd.

**Publications:**

1. Phiriyawirut, P., Ishida, H., and Magaraphan, R., (2001) Preparation and characterization of polybenzoxazine-clay immiscible nanocomposite. Material Research Innovation, 4, 187-196
2. Phiriyawirut, P., Magaraphan, R., Jamieson, A. M., and Wongkasemjit, S. (2003) MFI zeolite synthesis directly from silatrane via sol-gel process and microwave technique. Materials Science and Engineering A, 361, 147-154
3. Phiriyawirut, P., Magaraphan, R., Jamieson, A. M., and Wongkasemjit, S. (2003) Morphology study of MFI zeolite synthesized directly from silatrane and alumatrane via the sol-gel process and microwave heating. Microporous and Mesoporous Materials 64, 83-93
4. Phiriyawirut, P., Jamieson, A. M., and Wongkasemjit, S. (2005) VS-1 Zeolite synthesized directly from silatrane. Microporous and Mesoporous Materials, 77, 203-213

**Presentations:**

1. Phiriyawirut, P., Magaraphan, R., Jamieson, A. M., and Wongkasemjit, S. (2003, September) Effect of Reaction Parameters on Morphology of Synthesized MFI. Paper presented at 1st International Meeting on Applied Physics, Badajoz, Spain.

2. Phiriyawirut, P., Magaraphan, R., Jamieson, A. M., and Wongkasemjit, S. (2002, April) Silica Based Zeolite Synthesis Directly from Silatrane via Sol-Gel Process and Microwave Technique. Paper presented at RGJ-Ph.D. Congress III, Pattaya, Chonburi, Thailand.