# REFERENCES


Bhatnagar, R. (1993). A study of partial oxidition of methane under the influence of an AC electric discharge. M.Sc. Thesis, The University of Oklamoma.

Casey, P. S., McAllister, T., and Foger, K. (1944). Selective oxidation of methane to methanol at high pressures. Industrial Engineering Chemistry Research, 33, 1120-1125.

Eliasson, B., Hirth, M., and Kogelschatz, U. (1987). Ozone synthesis from oxygen in dielectric barrier discharge. Journal of Applied Physics, 20, 1421-1437.

Fraser, M., Fee, D., and Sheinson, R. (1985). Decomposition of methane in an AC discharge. Plasma Chemistry and Plasma Processing, 5, 163-173.

Gesser, H. D., Hunter, N. R., and Prakash, C. B. (1985). The Direct conversion of methane to methanol by controlled oxidation. Chemistry Revolutions, 85, 235-244.

Grill, A. (1994). Cold plasma in materials fabrication: From fundamentals to applications. IEEE Press: New York.

Hill, B. J., (1997). The oxidative coupling of methane using an AC electric gas discharge. M.Sc., Thesis, The University of Oklahoma.

Huang, J., Badani, M. V., Suib, S. L., Harrison, J. B., and Kablauoi, M. (1994). Partial oxidation of methane to methanol through microwave plasmas. Journal of Physical Chemistry, 98, 206-210.

Leethochawalit, K. (1998). Effect of carbon dioxide on methane conversion under electric discharge. M.Sc. Thesis, Chulalongkorn University, Bangkok.

Lui, C., Marafee, A., Hill, B., Xu, G., Mallinson, R., and Lobban, L. (1996). Oxidative coupling of methane with AC and DC corona discharges. Industrial & Engineering Chemistry Research, 35, 3295-3301.

Lui, C., Marafee, A., Hill, B., Xu, G., Mallinson, R., and Lobban, L. (1997). Oxidative coupling of methane in a DC corona discharges reactor over $Sr/La_2O_3$ catalyst. Industrial & Engineering Chemistry Research, 36, 632-637.

Mallinson, R. G., and Sliepecevich, C. M. (1986). Field effect catalysis program final report, University Technologist, Inc.

Mizuno, A., Chakrabari, A., and Okazaki, K. (1992). Application of corona technology in the reduction of greenhouse gases and other gaseous pollutants. Non-thermal Plasma Techniques for Pollution Control., NATO ASI series, 34, part B, 167-185.

Mizuno, A., Katsura, S., and Okumoto, M. (1998). Direct synthesis of methanol using non-thermal plasma, Japanese conference.

Morinaga, K., Suzuki, M. (1961). The chemical reaction in silent electric discharge I., Bullet Chemistry Society of Japan, 34, 157-161.

Morinaga, K., Suzuki, M. (1962). The chemical reaction in silent electric discharge II. , Bullet Chemistry Society of Japan, 35, 204-207.

Nasser, E. (1971). Fundamentals of gaseous ionization and plasma electronics, USA: John Wiley & Sons, Inc.

Nomoto, Y.,Ohkubo, T., Kanazawa, S., and Adachi, T. (1995). Improvement of ozone yield by a silent-surface hybrid discharge ozonizer. IEEE Transactions on Industry Applications, 31, 1458-1461.

Okumoto, M., Rajanikanth, B. S., Katsura, S., and Mizuno, A. (1998). Nonthermal plasma approach in direct methanol synthesis from methane. IEEE Transactions on Industry Applications, 34, 940-944.

Omata,K., Ogawa, K., Yamada, N., and Kishida, T. (1998). Direct synthesis of methanol from methane and water-vapor Mixture using plasma chemical reaction, Japanese conference.

Oumghar, A., Legrand, J. C., Diamy, A. M., and Turillon, N. (1995). Methane conversion by an air microwave plasma. Plasma Chemistry and Plasma Processing, 15, 87-107.

Perry R. H., Green D. W., and Maloney J. O., (1997). Perry' s Chemical Engineers' Handbook. 7 th, USA: McGraw-Hill, Inc.

Poonohatanapricha, P. (1998). Methane conversion in an AC electric discharge. M.Sc., Thesis, Chulalongkorn University, Bangkok.

Rosacha, L. A., Anderson, G. K., Bechtold, L. A., Coogan, J. J., Heck, H. G., Kang, M., McCulla, W. H., Tennant, R. A., and Wantuck, P. J. (1993). Treatment of hazardous organic wastes using silent discharge Plasmas. Non-Thermal Plasma Technique for Pollution Control., NATO ASI series, 34, part B, 128-139.

Siemens, W. (1857). Ozone generation with silent discharge. Applied Physics Chemistry, 102, 66-122.

Sutthiruangwong, S. (1999). Plasma catalytic production of methanol. M.Sc., Thesis, Chulalongkorn University, Bangkok.

Thayachotpaiboon, K. (1996). Direct conversion of methane to higher hydrocarbons under dielectric-barrier discharge influence. M.Sc., Thesis, Chulalongkorn University, Bangkok.

Zerger, R. P., Sui, S. L., and Zhang, Z. (1993). Preparation of oxygenates with methane/oxygen microwave plasmas. American Chemical Society, 37, 344-348.

Zhou, L.M., Xue, B., Kogelschatz, U., and Eliasson, B. (1998). Partial oxidation of methane to methanol with oxygen or air in a

# APPENDIX A
# ASSUMPTIONS, DEFINITIONS AND CALCULATION

To facilitate the calculations, some valid assumptions were made as follows:

1. All the gaseous behaviors obey the ideal gas law.
2. Pressure drop across the system is very small and can be negligible.
3. The pressure in the system equals atmospheric pressure (1 atm).
4. The temperature change due to the reactions is very small and can be negligible temperature.
5. The flow rate change across the reactor due to the variation in the gaseous composition during the reaction time is very small and is assumed to be negligible.

The total molar flow rate of the gaseous stream can be calculated from the following equation:

$$N = q \times \left( \frac{P}{R \times T} \right)$$

Where $q$ = total volumetric flow rate (determine by using soap bubble meter)

$P$ = total pressure of the system (1atm)

$R$ = gas constant (82.051 atm.ml.mol$^{-1}$.min$^{-1}$.K$^{-1}$)

$T$ = absolute ambient temperature (K)

With this, the molar flow rate of each component can also be determined by multiplying its percent volume derived from the GC analysis with the total molar flow rate.

The conversion is generally defined as:

$$\% \text{ Conversion} = \frac{(\text{Mole reactant in} - \text{Mole reactant out})}{\text{Mole reactant in}} \times 100$$

The selectivity of each product is, however, strictly defined on the basis of the amount of carbon converted from the reactant into any specified products. In this case, the product selectivity is defined as follows:

$$\% \ C_P \text{ Selectivity} = \frac{P \times \text{Mole of } C_P \text{ produced}}{R \times \text{Mole of } C_R \text{ converted}} \times 100$$

where P = number of carbon atom in product

R = number of carbon atom in reactant

$C_P$ = product that has carbon P atom

$C_R$ = reactant that has carbon R atom

$$\% \text{ Yield of hydrogen} = \frac{\text{Mole of } H_2 \text{ produced}}{\text{Mole of } CH_4 \text{ initially}} \times 100$$

$$\% \text{ Yield of CO} = \frac{\text{Mole of CO produced}}{\text{Mole of } CH_4 \text{ initially}} \times 100$$

# APPENDIX B

# EXPERIMENTAL DATA

## 1. In the Methane and Air System

### 1.1 Applied Voltage

**Table B.1** Applied voltage on conversion and yield at methane to air as ratio 3:4.8 at total flow rate 100 ml/min, gap width 0.9 cm and frequency 300 Hz

| Applied Voltage V | % Conv. | | % Yield | |
|---|---|---|---|---|
| | $O_2$ | $CH_4$ | $H_2$ | CO |
| 5,000 | 16.12 | 14.37 | 5.62 | 3.24 |
| 6,875 | 39.84 | 26.21 | 11.30 | 9.19 |
| 8,125 | 53.78 | 33.92 | 15.76 | 13.07 |
| 9,000 | 55.39 | 35.29 | 18.44 | 13.71 |

**Table B.2** Applied voltage on conversion and yield at methane to air as ratio 3:4.8 at total flow rate 100 ml/min., gap width 0.9 cm and frequency 400 Hz

| Applied Voltage V | % Conv. | | % Yield | |
|---|---|---|---|---|
| | $O_2$ | $CH_4$ | $H_2$ | CO |
| 5,000 | 11.36 | 9.84 | 3.82 | 2.62 |
| 6,875 | 16.56 | 12.74 | 5.01 | 3.88 |
| 8,125 | 21 | 16.83 | 8.01 | 5.63 |
| 9,000 | 24.63 | 17.49 | 9.00 | 6.02 |

**Table B.3** Applied voltage on partial pressure at methane to air as ratio 3:4.8 at total flow rate 100 ml/min, gap width 0.9 cm and frequency 300 Hz

| Applied voltage (V) | Partial pressure at atmosphere (atm) | | | |
|---|---|---|---|---|
| | $CH_4$ | $O_2$ | $H_2$ | CO |
| 5,000 | 0.355 | 0.115 | 0.046 | 0.013 |
| 6,875 | 0.305 | 0.083 | 0.093 | 0.038 |
| 8,125 | 0.273 | 0.064 | 0.130 | 0.054 |
| 9,000 | 0.267 | 0.061 | 0.152 | 0.057 |

**Table B.4** Applied voltage on partial pressure at methane to air as ratio 3:4.8 at total flow rate 100 ml/min, gap width 0.9 cm and frequency 400 Hz

| Applied voltage (V) | Partial pressure at atmosphere (atm) | | | |
|---|---|---|---|---|
| | $CH_4$ | $O_2$ | $H_2$ | CO |
| 5,000 | 0.348 | 0.117 | 0.030 | 0.010 |
| 6,875 | 0.337 | 0.110 | 0.039 | 0.011 |
| 8,125 | 0.321 | 0.102 | 0.062 | 0.022 |
| 9,000 | 0.319 | 0.099 | 0.069 | 0.023 |

**Table B.5** Applied voltage on current at methane to air as ratio 3:4.8, total flow rate 100 ml/min, gap width 0.9 cm. and frequency of 300 and 400 Hz

| Voltage (Vac) | (mA) 400 Hz. | (mA) 300 Hz. |
|---|---|---|
| 5,000 | 1.2 | 1.6 |
| 6,875 | 1.7 | 2.5 |
| 8,125 | 1.9 | 2.9 |
| 9,000 | 2.0 | 3.2 |

**Table B.6** Applied voltage on temperature at methane to air as ratio 3:4.8, total flow rate 100 ml/min, gap width 0.9 cm. and frequency 300 Hz

| Applied Voltage (V) | Temperature C° |
|---|---|
| 5,000 | 180 |
| 6,875 | 225 |
| 8,125 | 262 |
| 9,000 | 280 |

**Table B.7** Applied voltage on selectivity at methane to air as ratio 3:4.8, total flow rate 100 ml/min, gap width 0.9 cm. and frequency 300 Hz

| Applied Voltage | % Selectivity | | | | | | |
|---|---|---|---|---|---|---|---|
| V | $H_2$ | CO | $C_2H_2$ | $CO_2$ | $C_2H_4$ | $C_2H_6$ | $CH_3OH$ |
| 5,000 | 39.08 | 22.53 | 0.92 | 1.65 | 1.74 | 0.62 | 0.12 |
| 6,875 | 43.11 | 35.05 | 12.33 | 3.45 | 13.97 | 0 | 0.13 |
| 8,125 | 46.47 | 38.52 | 14.43 | 2.99 | 12.5 | 0 | 0.14 |
| 9,000 | 52.25 | 38.85 | 15.44 | 2.61 | 15.44 | 0.44 | 0.13 |

**Table B.8** Applied voltage on selectivity at methane to air as ratio 3:4.8, total flow rate 100 ml/min, gap width 0.9 cm. and frequency 400 Hz

| Applied Voltage | % Selectivity | | | | | | |
|---|---|---|---|---|---|---|---|
| V | $H_2$ | CO | $C_2H_2$ | $CO_2$ | $C_2H_4$ | $C_2H_6$ | $CH_3OH$ |
| 5,000 | 38.76 | 26.58 | 7.27 | 0.16 | 0.38 | 2.42 | 0.19 |
| 6,875 | 39.63 | 30.48 | 1.63 | 1.77 | 2.74 | 8.66 | 0.14 |
| 8,125 | 47.62 | 33.43 | 6.32 | 2.22 | 1.66 | 14.07 | 0.17 |
| 9,000 | 51.75 | 34.65 | 3.11 | 2.40 | 2.51 | 0.68 | 0.18 |

1.2 Frequency

**Table B.9** Frequency on conversion and yield at methane to air ratio as 3:4.8, total flow rate 100 ml/min., gap width 0.9 cm. and voltage 6,500 V

| Frequency | % Conv. | | % Yield | |
|---|---|---|---|---|
| Hz | $O_2$ | $CH_4$ | $H_2$ | CO |
| 300 | 24.08 | 19.39 | 7.59 | 5.47 |
| 400 | 15.13 | 18.22 | 5.20 | 3.22 |
| 550 | 10.96 | 15.64 | 3.56 | 2.28 |
| 700 | 9.55 | 14.36 | 3.07 | 2.00 |

**Table B.10** Frequency on conversion and yield at methane to air ratio as 3:4.8, total flow rate 100 ml/min., gap width 0.9 cm and voltage 9,000 V

| Frequency | % Conv. | | % Yield | |
|---|---|---|---|---|
| Hz | $O_2$ | $CH_4$ | $H_2$ | CO |
| 300 | 55.40 | 35.29 | 18.44 | 13.71 |
| 400 | 22.94 | 16.30 | 7.73 | 5.41 |
| 550 | 16.58 | 12.91 | 6.09 | 3.75 |
| 700 | 9.62 | 8.74 | 3.35 | 2.11 |

**Table B.11** Frequency on partial pressure at methane to air as ratio 3:4.8, total flow rate 100 ml/min, gap width 0.9 cm and voltage 6,500 V

| Frequency | Partial pressure at atmosphere (atm) | | | |
|---|---|---|---|---|
| (Hz) | $CH_4$ | $O_2$ | $H_2$ | CO |
| 300 | 0.335 | 0.098 | 0.063 | 0.023 |
| 400 | 0.34 | 0.109 | 0.043 | 0.013 |
| 550 | 0.351 | 0.115 | 0.029 | 0.01 |
| 700 | 0.356 | 0.117 | 0.026 | 0.008 |

**Table B.12** Frequency on partial pressure at methane to air as ratio 3:4.8, total flow rate 100 ml/min, gap width 0.9 cm and voltage 9,000 V

| Frequency (Hz) | Partial pressure at atmosphere (atm) | | | |
|---|---|---|---|---|
| | $CH_4$ | $O_2$ | $H_2$ | CO |
| 300 | 0.267 | 0.061 | 0.152 | 0.057 |
| 400 | 0.340 | 0.102 | 0.064 | 0.022 |
| 550 | 0.351 | 0.111 | 0.052 | 0.015 |
| 700 | 0.367 | 0.120 | 0.027 | 0.085 |

**Table B.13** Frequency on current at methane to air as ratio 3:4.8, total flow rate 100 ml/min, gap width 0.9 cm and voltage 6,500 and 9,000 V

| Frequency (Hz) | (mA) 6,500Vac | (mA) 9,000Vac |
|---|---|---|
| 300 | 2.24 | 3.20 |
| 400 | 1.65 | 2.19 |
| 550 | 1.38 | 1.55 |
| 700 | 0.75 | 1.29 |

**Table B.14** Frequency on selectivity at methane to air as ratio 3:4.8, total flow rate 100 ml/min, gap width 0.9 cm and voltage 6,500 V

| Frequency Hz | % Selectivity | | | | | | |
|---|---|---|---|---|---|---|---|
| | $H_2$ | CO | $C_2H_2$ | $CO_2$ | $C_2H_4$ | $C_2H_6$ | $CH_3OH$ |
| 300 | 39.12 | 28.18 | 8.31 | 1.77 | 1.53 | 1.83 | 0.17 |
| 400 | 28.51 | 17.65 | 2.59 | 0.92 | 1.58 | 4.68 | 0.07 |
| 550 | 22.78 | 14.59 | 0.48 | 0.64 | 0.09 | 1.44 | 0.10 |
| 700 | 21.41 | 13.95 | 0.65 | 0.65 | 0.05 | 3.73 | 0.13 |

**Table B.15** Frequency on selectivity at methane to air as ratio 3:4.8, total flow rate 100 ml/min, gap width 0.9 cm and voltage 9,000 V

| Frequency | % Selectivity | | | | | | |
|---|---|---|---|---|---|---|---|
| Hz | $H_2$ | CO | $C_2H_2$ | $CO_2$ | $C_2H_4$ | $C_2H_6$ | $CH_3OH$ |
| 300 | 52.25 | 38.85 | 15.44 | 2.61 | 1.50 | 0.50 | 0.13 |
| 400 | 47.46 | 33.18 | 10.38 | 1.34 | 2.40 | 3.00 | 0.17 |
| 550 | 47.12 | 29.06 | 6.93 | 0.59 | 2.76 | 0.76 | 0.11 |
| 700 | 38.37 | 24.09 | 0 | 0.73 | 0.62 | 4.60 | 0.17 |

**Table B.16** Frequency on temperature at methane to air as ratio 3:4.8, total flow rate 100 ml/min, gap width 0.9 cm and voltage 9,000V

| Frequency (Hz) | Temperature C° |
|---|---|
| 300 | 280 |
| 400 | 200 |
| 550 | 165 |
| 700 | 145 |

1.2 Ratio of Methane Over Air

**Table B.17** Ratio of methane to air (4.8) on conversion and yield, total flow rate 100 ml/min., gap width 0.9 cm at voltage 9,000 V and frequency 300 Hz

| $CH_4$:Air | % Conv. | | % Yield | |
|---|---|---|---|---|
| | $O_2$ | $CH_4$ | $H_2$ | CO |
| 2:4.8 | 72.68 | 51.72 | 26.31 | 27.04 |
| 3:4.8 | 55.39 | 35.30 | 18.44 | 13.71 |
| 4:4.8 | 28.59 | 13.64 | 8.17 | 5.2 |

**Table B.18** Ratio of methane to air (4.8) on partial pressure at methane to air as ratio 3:4.8, total flow rate 100 ml/min., gap width 0.9 cm and frequency 300 Hz

| $CH_4$:Air | Partial pressure at atmosphere (atm) | | | |
|---|---|---|---|---|
| | $CH_4$ | $O_2$ | $H_2$ | CO |
| 2:4.8 | 0.148 | 0.043 | 0.16 | 0.083 |
| 3:4.8 | 0.267 | 0.061 | 0.152 | 0.057 |
| 4:4.8 | 0.399 | 0.082 | 0.076 | 0.022 |

**Table B.19** Ratio of methane to air (4.8) on current at total flow rate 100 ml/min, gap width 0.9 cm, voltage 9,000 V and frequency 300 Hz

| $CH_4$:Air | (mA)9,000 V |
|---|---|
| 2:4.8 | 3.14 |
| 3:4.8 | 3.20 |
| 4:4.8 | 3.22 |

**Table B.20** Ratio of methane to air (4.8) on selectivity at total flow rate 100 ml/min., gap width 0.9 cm at voltage 9,000 V and frequency 300 Hz

| $CH_4$:Air | % Selectivity | | | | | | |
|---|---|---|---|---|---|---|---|
| | $H_2$ | CO | $C_2H_2$ | $CO_2$ | $C_2H_4$ | $C_2H_6$ | $CH_3OH$ |
| 2:4.8 | 50.29 | 52.29 | 18.18 | 4.24 | 0.37 | 0.68 | 0.08 |
| 3:4.8 | 52.75 | 38.85 | 15.44 | 2.61 | 1.50 | 0.44 | 0.13 |
| 4:4.8 | 59.87 | 34.88 | 15.27 | 0.69 | 4.41 | 5.53 | 0.25 |

1.3 Flow Rate

**Table B.21** Flow rate on conversion and yield at methane to air as ratio 3:4.8, gap width 0.9 cm, voltage 9,000 V and frequency 300 Hz

| Flow rate ml/ min | % Conv. | | % Yield | |
|---|---|---|---|---|
| | $O_2$ | $CH_4$ | $H_2$ | CO |
| 50 | 63.25 | 37.26 | 19.83 | 16.47 |
| 75 | 56.19 | 35.00 | 17.00 | 14.22 |
| 100 | 55.40 | 35.30 | 18.44 | 13.71 |
| 125 | 38.29 | 25.17 | 12.51 | 9.35 |

**Table B.22** Flow rate on partial pressure at methane to air as ratio 3:4.8, gap width 0.9 cm, voltage 9,000 V and frequency 300 Hz

| Flow rate ml/ min | Partial pressure at atmosphere (atm) | | | |
|---|---|---|---|---|
| | $CH_4$ | $O_2$ | $H_2$ | CO |
| 50 | 0.250 | 0.048 | 0.160 | 0.066 |
| 75 | 0.259 | 0.059 | 0.140 | 0.057 |
| 100 | 0.267 | 0.061 | 0.152 | 0.056 |
| 125 | 0.303 | 0.083 | 0.101 | 0.038 |

**Table B.23** Flow rate on current at methane to air as ratio 3:4.8, gap width 0.9 cm, voltage 9,000 V and frequency 300 Hz

| Flow rate (ml/ min) | (mA) 9,000 V |
|---|---|
| 50 | 3.17 |
| 75 | 3.20 |
| 100 | 3.20 |
| 125 | 3.21 |

**Table B.24** Flow rate on selectivity at methane to air as ratio 3:4.8, gap width 0.9 cm, voltage 9,000 V and frequency 300 Hz

| Flow rate | % Selectivity | | | | | | |
|---|---|---|---|---|---|---|---|
| ml/ min | $H_2$ | CO | $C_2H_2$ | $CO_2$ | $C_2H_4$ | $C_2H_6$ | $CH_3OH$ |
| 50 | 53.23 | 44.20 | 15.64 | 2.72 | 13.94 | 0.61 | 0.12 |
| 75 | 49.27 | 41.20 | 14.23 | 2.56 | 13.63 | 0.00 | 0.14 |
| 100 | 52.25 | 38.85 | 14.98 | 2.61 | 1.50 | 0.44 | 0.13 |
| 125 | 49.70 | 37.14 | 15.85 | 2.50 | 1.56 | 0 | 0.18 |

1.4 Gap Width

**Table B.25** Gap width on conversion and yield at methane to air as ratio 3:4.8, total flow rate 100 ml/min, voltage 9,000 V and frequency 300 Hz

| Gap width | % Conv. | | % Yield | |
|---|---|---|---|---|
| cm. | $O_2$ | $CH_4$ | $H_2$ | CO |
| 0.7 | 54.74 | 33.94 | 19.70 | 14.42 |
| 0.9 | 55.40 | 35.29 | 18.44 | 13.71 |
| 1.5 | 56.36 | 37.36 | 15.58 | 13.12 |
| 1.9 | 60.4 | 37.89 | 12.3 | 11.40 |

**Table B.26** Gap width on partial pressure at methane to air as ratio 3:4.8, total flow rate 100 ml/min, voltage 9,000 V and frequency 300 Hz

| Gap width | Partial pressure at atmosphere (atm) | | | |
|---|---|---|---|---|
| cm. | $CH_4$ | $O_2$ | $H_2$ | CO |
| 0.7 | 0.257 | 0.062 | 0.153 | 0.06 |
| 0.9 | 0.267 | 0.061 | 0.152 | 0.057 |
| 1.5 | 0.243 | 0.060 | 0.12 | 0.05 |
| 1.9 | 0.241 | 0.057 | 0.096 | 0.044 |

**Table B.27** Gap width on current at methane to air as ratio 3:4.8, total flow rate 100 ml/min, voltage 9,000 V and frequency 300 Hz

| Gap width (cm) | (mA) 9,000 V |
|---|---|
| 0.7 | 3.30 |
| 0.9 | 3.20 |
| 1.5 | 1.94 |
| 1.9 | 1.80 |

**Table B.28** Gap width on selectivity at methane to air as ratio 3:4.8, total flow rate 100 ml/min, voltage 9,000 V and frequency 300 Hz

| Gap width | % Selectivity | | | | | | |
|---|---|---|---|---|---|---|---|
| cm. | $H_2$ | CO | $C_2H_2$ | $CO_2$ | $C_2H_4$ | $C_2H_6$ | $CH_3OH$ |
| 0.7 | 58.04 | 42.48 | 24.91 | 0 | 0.50 | 1.23 | 0.12 |
| 0.9 | 52.25 | 38.85 | 15.44 | 1.52 | 1.5 | 0.44 | 0.13 |
| 1.5 | 41.70 | 35.12 | 9.36 | 1.84 | 10.60 | 0 | 0.08 |
| 1.9 | 32.63 | 30.25 | 6.63 | 1.26 | 9.73 | 0 | 0.06 |

## 2 In the Methane/Ethane/Air System

### 2.1 Applied Voltage

**Table B.29** Applied voltage on conversion at methane/ethane/air as ratio 2:1:4.8, total flow rate 100 ml/min, gap width 0.9 cm and frequency 300 Hz

| Applied Volatge | % Conv. | | |
|---|---|---|---|
| (V) | $O_2$ | $CH_4$ | $C_2H_6$ |
| 5,000 | 28.21 | 11.52 | 39.21 |
| 6,875 | 55.45 | 22.3 | 67.23 |
| 7,250 | 57.76 | 21.76 | 68.74 |

**Table B.30** Applied voltage on yield at methane/ethane/air as ratio 2:1:4.8, total flow rate 100 ml/min, gap width 0.9 cm and frequency 300 Hz

| Applied Volatge (V) | % Yield | | |
|---|---|---|---|
| | $C_2H_4$ | $H_2$ | CO |
| 5,000 | 13.61 | 9.00 | 5.77 |
| 6,875 | 15.10 | 18.22 | 12.60 |
| 7,250 | 15.14 | 19.58 | 13.7 |

**Table B.31** Applied voltage on partial pressure at methane/ethane/air as ratio 2:1:4.8, total flow rate 100 ml/min, gap width 0.9 cm and frequency 300 Hz

| Applied voltage (V) | Partial pressure at atmosphere (atm) | | | | | |
|---|---|---|---|---|---|---|
| | $C_2H_6$ | $CH_4$ | $O_2$ | $C_2H_4$ | $H_2$ | CO |
| 5,000 | 0.07 | 0.217 | 0.096 | 0.033 | 0.076 | 0.028 |
| 6,875 | 0.039 | 0.19 | 0.059 | 0.037 | 0.155 | 0.061 |
| 7,250 | 0.037 | 0.189 | 0.057 | 0.037 | 0.166 | 0.064 |

**Table B.32** Applied voltage on current at methane/ethane/air as ratio 2:1:4.8, total flow rate100 ml/min, gap width 0.9 cm and frequency 300 Hz

| Applied voltage(V) | (mA) 300 Hz |
|---|---|
| 5,000 | 1.87 |
| 6,875 | 2.30 |
| 7,250 | 2.43 |

**Table B.33** Applied voltage on selectivity at methane/ethane/air as ratio 2:1:4.8, total flow rate 100 ml/min, gap width 0.9 cm and frequency 300 Hz

| Applied voltage (V) | %Selectivity | | | | | |
|---|---|---|---|---|---|---|
| | $C_2H_4$ | $H_2$ | CO | $C_2H_2$ | $CO_2$ | $CH_3OH$ |
| 5,000 | 53.94 | 38.65 | 22.89 | 9.51 | 0.95 | 0.23 |
| 6,875 | 45.64 | 45.05 | 28.26 | 15.27 | 1.51 | 0.18 |
| 7,250 | 34.17 | 47.67 | 29.71 | 15.03 | 1.4 | 0.18 |

2.2 Frequency

**Table B.34** Frequency on conversion at methane/ethane/air as ratio 2:1:4.8, total flow rate 100 ml/min, gap width 0.9 cm and voltage 7,250 V

| Frequency Hz | % Conversion | | |
|---|---|---|---|
| | $O_2$ | $CH_4$ | $C_2H_6$ |
| 300 | 57.76 | 21.76 | 68.74 |
| 400 | 38.69 | 15.56 | 51.08 |
| 550 | 22.67 | 9.33 | 39.08 |
| 700 | 14.63 | 5.42 | 20.42 |

**Table B.35** Frequency on yield at methane/ethane/air as ratio 2:1:4.8, total flow rate 100 ml/min, gap width 0.9 cm and voltage 7,250 V

| Frequency Hz | % Yield | | |
|---|---|---|---|
| | $C_2H_4$ | $H_2$ | CO |
| 300 | 15.14 | 19.58 | 13.17 |
| 400 | 15.43 | 12.25 | 8.13 |
| 550 | 11.82 | 10.15 | 6.39 |
| 700 | 6.96 | 6.04 | 3.56 |

**Table B.36** Frequency on partial pressure at methane/ethane/air as ratio 2:1:4.8, total flow rate 100 ml/min, gap width 0.9 cm and voltage 7,250 V

| Frequency | Partial pressure at atmosphere(atm) | | | | | |
|---|---|---|---|---|---|---|
| (Hz) | $C_2H_6$ | $CH_4$ | $O_2$ | $C_2H_4$ | $H_2$ | CO |
| 300 | 0.04 | 0.189 | 0.057 | 0.033 | 0.166 | 0.064 |
| 400 | 0.058 | 0.207 | 0.082 | 0.037 | 0.103 | 0.039 |
| 550 | 0.072 | 0.222 | 0.104 | 0.028 | 0.06 | 0.02 |
| 700 | 0.094 | 0.232 | 0.115 | 0.017 | 0.037 | 0.012 |

**Table B.37** Frequency on selectivity at methane/ethane/air as ratio 2:1:4.8, total flow rate 100 ml/min, gap width 0.9 cm and voltage 7,250 V

| Frequency | % Selectivity | | | | | |
|---|---|---|---|---|---|---|
| (Hz) | $C_2H_4$ | $H_2$ | CO | $C_2H_2$ | $CO_2$ | $CH_3OH$ |
| 300 | 34.17 | 47.67 | 29.71 | 15.03 | 1.40 | 0.18 |
| 400 | 46.84 | 40.27 | 24.69 | 5.82 | 1.20 | 0.23 |
| 550 | 54.81 | 38.47 | 20.84 | 6.57 | 0.83 | 0.22 |
| 700 | 54.53 | 37.19 | 18.72 | 6.26 | 0.72 | 0.33 |

**Table B.38** Frequency on current at methane/ethane/air as ratio 2:1:4.8, total flow rate 100 ml/min, gap width 0.9 cm and voltage 7,250 V

| Frequency (Hz) | (mA) 7,250 V |
|---|---|
| 300 | 2.43 |
| 400 | 2.32 |
| 550 | 1.57 |
| 700 | 1.02 |

# CURRICULUM VITAE

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