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# APPENDICES

## Appendix A Effect of Operating Conditions on Ethylene Epoxidation Performance

**Table A1** Effect of applied voltage on ethylene and nitrous oxide conversion, EO selectivity, and EO yield

| Applied Voltage (kV) | Conversion (%) | | EO Selectivity (%) | EO Yield (%) |
|---|---|---|---|---|
| | $C_2H_4$ | $N_2O$ | | |
| 15 | 13.87 | 4.73 | 45.53 | 6.31 |
| 17 | 18.65 | 13.93 | 47.66 | 8.89 |
| 19 | 17.68 | 13.37 | 48.87 | 8.64 |
| 21 | 21.52 | 14.98 | 46.43 | 9.99 |

**Table A2** Effect of applied voltage on by products selectivity and power consumption

| Applied Voltage (kV) | Selectivity (%) | | | | | | | Power Consumption (Ws × $10^{16}$) | |
|---|---|---|---|---|---|---|---|---|---|
| | $CH_4$ | $C_2H_2$ | $C_2H_6$ | $C_3H_8$ | $H_2$ | $CO_2$ | CO | per molecule of $C_2H_4$ converted | per molecule of EO produced |
| 15 | 1.89 | 16.32 | 3.70 | 6.60 | 23.77 | - | 2.19 | 1.50 | 1.42 |
| 17 | 1.98 | 11.41 | 3.55 | 8.31 | 24.07 | - | 2.04 | 1.07 | 1.09 |
| 19 | 2.08 | 13.31 | 3.62 | 7.52 | 22.58 | - | 2.04 | 1.13 | 1.00 |
| 21 | 2.30 | 12.79 | 3.87 | 7.50 | 24.16 | - | 2.96 | 0.96 | 1.11 |

**Table A3** Effect of input frequency on ethylene and nitrous oxide conversion, EO selectivity, and EO yield

| Input Frequency (Hz) | Conversion (%) | | EO Selectivity (%) | EO Yield (%) |
|---|---|---|---|---|
| | $C_2H_4$ | $N_2O$ | | |
| 450 | 21.87 | 18.51 | 45.10 | 9.88 |
| 500 | 17.68 | 13.37 | 48.87 | 8.64 |
| 550 | 13.64 | 12.49 | 47.58 | 6.49 |
| 600 | 13.00 | 6.91 | 46.17 | 6.00 |

**Table A4** Effect of input frequency on by products selectivity

| Input Frequency (Hz) | Selectivity (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| | $CH_4$ | $C_2H_2$ | $C_2H_6$ | $C_3H_8$ | $H_2$ | $CO_2$ | CO |
| 450 | 2.33 | 15.68 | 3.81 | 6.65 | 23.57 | - | 2.85 |
| 500 | 2.08 | 13.31 | 3.62 | 7.52 | 22.58 | - | 2.03 |
| 550 | 1.56 | 16.42 | 3.20 | 8.30 | 21.14 | - | 1.80 |
| 600 | 1.81 | 14.89 | 3.75 | 8.34 | 22.57 | - | 2.48 |

**Table A5** Effect of input frequency on power consumption and current

| Input Frequency (Hz) | Power Consumption ($Ws \times 10^{16}$) | | Current (A) |
|---|---|---|---|
| | per molecule of $C_2H_4$ converted | per molecule of EO produced | |
| 450 | 0.91 | 1.12 | 0.83 |
| 500 | 1.13 | 1.0 | 0.82 |
| 550 | 1.46 | 1.12 | 0.8 |
| 600 | 1.36 | 1.12 | 0.75 |

**Table A6** Effect of total feed flow rate on ethylene and nitrous oxide conversion, EO selectivity, and EO yield

| Total Feed Flow Rate ($cm^3$/min) | Conversion (%) | | EO Selectivity (%) | EO Yield (%) |
|---|---|---|---|---|
| | $C_2H_4$ | $N_2O$ | | |
| 30 | 33.16 | 37.1 | 40.24 | 11.13 |
| 40 | 19.4 | 20.72 | 43.3 | 8.288 |
| 50 | 17.68 | 13.37 | 48.87 - | 6.685 |
| 60 | 14.18 | 11.70 | 44.55 | 7.01917 |

**Table A7** Effect of total feed flow rate on by products selectivity and power consumption

| Total Feed Flow Rate ($cm^3$/min) | Selectivity (%) | | | | | | | Power Consumption (Ws × $10^{16}$) | |
|---|---|---|---|---|---|---|---|---|---|
| | $CH_4$ | $C_2H_2$ | $C_2H_6$ | $C_3H_8$ | $H_2$ | $CO_2$ | CO | per molecule of $C_2H_4$ converted | per molecule of EO produced |
| 30 | 3.29 | 15.15 | 4.06 | 4.72 | 27.58 | - | 4.96 | 0.92 | 2.24 |
| 40 | 1.72 | 28.56 | 3.10 | 2.93 | 17.78 | - | 1.51 | 1.03 | 0.93 |
| 50 | 2.08 | 13.31 | 3.62 | 7.52 | 22.58 | - | 2.03 | 1.17 | 1.00 |
| 60 | 0.00 | 17.49 | 5.83 | 5.94 | 24.42 | - | 1.76 | 1.15 | 1.17 |

**Appendix B Effect of Calcination Temperature on Ethylene Epoxidation Performance**

**Table B1** Effect of calcinations temperature on ethylene and nitrous oxide conversion, EO selectivity, and EO yield

| Calcination Temperature (°C) | Conversion (%) | | EO Selectivity (%) | EO Yield (%) |
|---|---|---|---|---|
| | $C_2H_4$ | $N_2O$ | | |
| 450 | 17.21 | 12.10 | 44.55 | 7.67 |
| 500 | 18.71 | 22.00 | 45.36 | 8.49 |
| 550 | 17.68 | 13.37 | 48.87 | 8.58 |
| 600 | 18.18 | 19.70 | 43.39 | 7.89 |
| 650 | 18.49 | 12.68 | 42.97 | 7.95 |

## Appendix C Effect of Different Oxygen Source Types on Ethylene Epoxidation Performance

**Table C1** Effects of oxygen/ethylene feed molar ratio on ethylene and nitrous oxide conversion, EO selectivity, and EO yield

| $O_2$:$C_2H_4$ | Conversion (%) | | EO Selectivity (%) | EO Yield (%) |
|---|---|---|---|---|
| | $C_2H_4$ | $O_2$ | | |
| 0.10 | 15.86 | 99.63 | 38.86 | 6.16 |
| 0.20 | 14.87 | 96.77 | 13.38 | 1.99 |
| 0.50 | 18.18 | 6.64 | 0.82 | 0.15 |
| 1.00 | 15.46 | 17.62 | 0.67 | 0.10 |

**Table C2** Effects of oxygen/ethylene feed molar ratio on by product selectivities

| $O_2$:$C_2H_4$ | Selectivity (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| | $CH_4$ | $C_2H_2$ | $C_2H_6$ | $C_3H_8$ | $H_2$ | $CO_2$ | CO |
| 0.10 | 2.24 | 14.77 | 3.10 | 6.51 | 25.33 | 1.24 | 7.95 |
| 0.20 | 2.20 | 13.81 | 1.43 | 5.74 | 24.34 | 13.21 | 25.90 |
| 0.50 | 2.54 | 14.94 | 0.19 | 4.31 | 20.95 | 11.40 | 44.85 |
| 1.00 | 2.52 | 17.67 | 0.27 | 3.79 | 22.98 | 9.12 | 42.98 |

**Table C3** Effects of nitrous oxide/ethylene feed molar on ethylene and nitrous oxide conversion, EO selectivity, and EO yield

| $N_2O:C_2H_4$ | Conversion (%) | | EO Selectivity (%) | EO Yield (%) |
|---|---|---|---|---|
| | $C_2H_4$ | $N_2O$ | | |
| 0.10 | 17.60 | 31.97 | 45.51 | 8.01 |
| 0.17 | 17.68 | 13.37 | 48.87 | 8.64 |
| 0.50 | 20.09 | 16.72 | 35.50 | 7.13 |
| 1.00 | 21.78 | 13.90 | 28.86 | 6.17 |

**Table C4** Effects of nitrous oxide/ethylene feed molar ratio on by products selectivity

| $N_2O:C_2H_4$ | Selectivity (%) | | | | | | |
|---|---|---|---|---|---|---|---|
| | $CH_4$ | $C_2H_2$ | $C_2H_6$ | $C_3H_8$ | $H_2$ | $CO_2$ | CO |
| 0.10 | 1.88 | 16.84 | 3.26 | 5.82 | 24.99 | - | 1.70 |
| 0.17 | 2.08 | 13.31 | 3.62 | 7.52 | 22.58 | - | 2.03 |
| 0.50 | 3.04 | 20.10 | 4.34 | 5.14 | 24.32 | - | 7.55 |
| 1.00 | 4.39 | 19.66 | 4.35 | 3.90 | 25.58 | - | 13.26 |

**Table C5** Comparison of ethylene epoxidation performance

| | Sole Plasma System | | | Catalytic System | | |
|---|---|---|---|---|---|---|
| Oxygen Source | $C_2H_4$ Conversion (%) | EO Selectivity (%) | EO Yield (%) | EO Conversion (%) | EO Selectivity (%) | EO Yield (%) |
| Oxygen | 20.79 | 33.90 | 7.05 | 15.86 | 38.86 | 6.16 |
| Nitrous Oxide | 18.37 | 45.75 | 8.40 | 17.68 | 48.87 | 8.64 |

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