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APPENDICES

Appendix A Assumptions, Definitions, and Calculations

In this work, the following assumptions were made:

1. All the gaseous behaviors obey the ideal gas law
2. The change in the system, pressure is very small and negligible.
3. The pressure in the system equals the atmospheric pressure (1 atm)

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

$$N = q \times (P/RT) \qquad \text{(B.1)}$$

where

q = total volumetric flow rate

P = total pressure of the system

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

T = absolute ambient temperature (K)

The molar flow rate of each component can be obtained by multiplying its fraction derived from the gas chromatography analysis by the total molar flow rate.

The conversion is defined as:

$$\%\ \text{Conversion} = \frac{\text{Mole reactant in} - \text{Mole reactant out}}{\text{Mole reactant in}} \times 100 \qquad \text{(B.2)}$$

The first selectivity is defined as:

$$\%\ \text{Selectivity} = \frac{P \times \text{Mole of } C_p \text{ produced}}{R \times \text{Mole of } C_R \text{ converted}} \times 100 \qquad \text{(B.3)}$$

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

The second selectivity is defined as:

$$\% \text{ Selectivity} = \frac{\text{Mole of product}}{\text{Total mole of all products}} \times 100 \qquad \text{(B.4)}$$

To determine the energy efficiency of corona discharge system, the specific energy consumption was calculated in a unit of electron-volt per molecule of converted carbon (eV/m_c) from the following equation:

$$\text{Specific energy consumption} = \frac{P \times 60}{(1.602 \times 10^{-19}) \times \tilde{N} \times M_C} \text{ eV/ mol } C_2H_4$$

Where P = Power (W)

$\tilde{N}$ = Avogadro's number = $6.02 \text{ X } 10^{23}$ molecules.g-mole^{-1}

M_C = Rate of carbon in feed gas converted (g-mole.min^{-1})

1 eV = $1.602 \text{ X } 10^{-19}$ Ws

To determine the UV light intensity of corona discharge system, the intensity was calculated in a unit of μW. In this work, the following assumption was that the UV light spread out in all direction.

$$\text{Intensity } (\mu W) = \frac{\text{Intensity measured from UV meter } (\mu W/cm^2)}{\text{Area of sphere } (cm^2)}$$

Where Area of sphere = $4¶r^2$

r = 1.5 cm

Appendix B Experimental data

Table B.1 Effect of total feed flow rate at 11,000, 200 Hz, a gap distance of 10 mm. and O_2: C_2H_4 ratio of 5:1

Feed flow rate (ml/min)	Stage (s)	% Conversion		% Selectivity				
		C_2H_4	O_2	CO	CO_2	CH_4	C_2H_2	C_2H_6
40	1	100	57.32	38.33	54.59	u	u	u
	2	100	68.03	20.22	78.65	u	u	u
	3	100	69.53	10.59	90.92	u	u	u
	4	100	71.11	5.86	99.58	u	u	u
80	1	85.37	50.89	52.74	45.83	0.22	0.39	0.39
	2	99.77	62.49	39.18	62.94	0.03	0.1	0.38
	3	99.88	65.82	27.32	76.57	0.05	0.19	0.18
	4	99.90	69.54	16.81	83.04	0.17	u	0.19
160	1	72.26	34.58	53.31	47.68	0.65	0.26	0.78
	2	96.15	49.19	45.59	55.67	u	0.13	0.11
	3	99.39	54.62	36.24	66.97	0.19	0.11	0.34
	4	99.56	55.45	28.15	75.49	u	0.48	0.25
200	1	65.45	30.89	51.45	43.74	0.65	0.45	0.24
	2	90.23	44.91	49.43	51.02	0.05	0.13	0.07
	3	100	53.07	41.10	59.50	u	0.19	0.51
	4	99.81	56.72	34.90	66.99	u	0.05	0.02
240	1	62.10	27.67	48.86	40.18	0.19	u	0.25
	2	90.27	40.89	46.87	42.82	0.38	0.19	0.39
	3	100	48.82	42.98	52.54	0.03	0.28	0.27
	4	99.96	53.00	38.29	61.38	0.09	u	0.18

u = below the GC detecting limit

Table B.2 Effect of frequency at 11,000, feed flow rate 160 ml/min, a gap distance of 10 mm, and O_2: C_2H_4 ratio of 5:1

Frequency (Hz)	Stage (s)	% Conversion		% Selectivity				
		C_2H_4	O_2	CO	CO_2	CH_4	C_2H_2	C_2H_6
50	1	96.55	55.92	18.12	84.60	0.16	0.13	0.06
	2	99.90	60.85	10.53	92.98	u	0.06	0.20
	3	100	62.25	5.85	98.29	0.09	u	0.59
	4	100	63.07	4.99	99.53	u	u	u
100	1	92.75	47.36	34.21	63.87	u	u	u
	2	100	55.34	26.64	75.94	u	u	u
	3	100	58.58	18.15	86.74	u	0.08	u
	4	100	59.47	14.04	92.12	0.03	0.04	0.10
200	1	72.26	34.58	53.31	47.68	0.65	0.26	0.78
	2	96.15	49.19	45.59	55.67	u	0.13	0.11
	3	99.39	54.62	36.24	66.97	0.19	0.11	0.34
	4	99.56	55.45	28.15	75.49	u	0.48	0.25
300	1	47.23	20.96	71.71	21.54	0.27	u	u
	2	84.63	37.15	63.83	28.22	0.94	0.06	0.05
	3	95.96	47.29	57.08	40.77	0.16	0.12	u
	4	100	51.53	48.38	49.30	u	u	u
400	1	40.11	13.92	69.18	12.78	1.24	0.16	u
	2	69.62	25.91	67.96	16.30	1.62	u	0.13
	3	88.35	36.92	65.21	24.46	1.43	0.02	1.41
	4	95.98	43.59	60.03	32.40	0.98	u	u
500	1	30.51	11.14	73.31	10.86	1.54	0.47	1.01
	2	61.19	21.66	67.86	13.30	2.42	0.23	u
	3	81.38	31.82	68.35	16.89	2.26	0.11	u
	4	91.14	37.71	66.64	22.97	1.63	u	u
700	1	25.15	8.40	59.54	7.59	2.45	0.16	0.15
	2	46.68	15.00	61.77	9.68	2.61	u	u
	3	65.55	20.75	63.36	12.46	2.69	0.09	u
	4	77.74	26.82	64.35	13.73	1.12	0.14	0.12

Table B.3 Effect of frequency on current and power consumption at 11,000, feed flow rate 160 ml/min, a gap distance of 10 mm, and O_2: C_2H_4 ratio of 5:1

Frequency (Hz)	Stage (s)	Current (A)	Power Consumption (eV/ C_2H_4 Molecule)
50	1	1.528	730
	2	2.300	1168
	3	3.710	1838
	4	4.610	2318
100	1	1.076	506
	2	1.518	700
	3	2.460	1163
	4	2.910	1399
200	1	0.860	466
	2	1.063	474
	3	1.859	775
	4	1.980	883
300	1	0.776	599
	2	0.915	443
	3	1.645	674
	4	1.798	739
400	1	0.744	642
	2	0.844	464
	3	1.524	665
	4	1.678	679
500	1	0.734	781
	2	0.799	474
	3	1.442	639
	4	1.529	634
700	1	0.686	850
	2	0.771	577
	3	1.405	751
	4	1.501	710

Table B.4 Effect of voltage at feed flow rate 160 ml/min, 200 Hz, a gap distance of 10 mm, and O_2: C_2H_4 ratio of 5:1

Voltage (V)	Stage (s)	% Conversion		% Selectivity				
		C_2H_4	O_2	CO	CO_2	CH_4	C_2H_2	C_2H_6
9000	1	67.88	33.12	58.02	38.93	u	u	u
	2	92.9	47.07	54.32	43.95	0.36	u	u
	3	99.31	53.90	46.78	55.07	0.08	u	u
	4	99.80	56.56	39.59	64.42	0.14	u	u
11,000	1	72.26	34.58	53.31	47.68	0.65	0.26	0.78
	2	96.15	49.19	45.59	55.67	u	0.13	0.11
	3	99.39	54.62	36.24	66.97	0.19	0.11	0.34
	4	99.56	55.45	28.15	75.49	u	0.48	0.25
13,000	1	71.25	40.73	51.35	52.29	0.29	0.09	u
	2	98.80	56.52	40.24	58.40	0.10	0.52	0.65
	3	99.89	61.17	33.72	71.00	u	0.01	0.08
	4	100	63.10	25.52	79.04	u	0.23	0.08
15,000	1	78.64	41.43	47.05	55.32	u	0.25	0.15
	2	96.03	53.89	40.38	64.89	u	u	0.06
	3	99.81	59.71	29.99	76.06	u	0.09	0.03
	4	100	61.34	23.05	82.70	u	u	0.08

Table B.5 Effect of voltage on current at feed flow rate 160 ml/min, 200 Hz, a gap distance of 10 mm, and O_2: C_2H_4 ratio of 5:1

Voltage (V)	Stage (s)	Current
9000	1	0.803
	2	0.972
	3	1.741
	4	1.907
11,000	1	0.860
	2	1.063
	3	1.859
	4	1.980
13,000	1	0.907
	2	1.173
	3	1.972
	4	2.180
15,000	1	0.942
	2	1.232
	3	2.040
	4	2.370

Table B.6 Effect of stage number of reactor with different residence time at 11,000, 200 Hz, a gap distance of 10 mm, and O_2: C_2H_4 ratio of 5:1

Residence time (s)	Stage (s)	% Conversion		% Selectivity				
		C_2H_4	O_2	CO	CO_2	CH_4	C_2H_2	C_2H_6
0.38	1	85.37	50.89	52.74	45.83	u	u	u
	2	96.15	49.19	45.59	55.67	u	u	u
	3	100	48.82	42.98	52.54	u	u	u
0.75	1	100	57.32	38.33	54.59	u	u	u
	2	99.77	62.49	39.18	62.94	u	u	u
	3	99.00	62.00	30.00	72.00	u	u	u
	4	99.56	55.45	28.15	75.49	u	u	u
1.00	1	100	58.56	36.71	63.97	u	u	u
	2	99.86	61.47	32.86	73.77	u	u	u
	3	99.88	59.75	25.66	78.13	u	u	u
	4	99.95	62.55	24.82	80.31	u	u	u

Table B.7 The UV light intensity measure by UV meter at feed flow rate 160 ml/min, 200 Hz, 9,000 V, a gap distance of 10 mm, and O_2: C_2H_4 ratio of 5:1.

min	Intensity (μW/cm^2)	min	Intensity (μW/cm^2)	min	Intensity (μW/cm^2)	min	Intensity (μW/cm^2)
1	0.01470	26	0.01212	51	0.01314	76	0.01300
2	0.01301	27	0.01281	52	0.01252	77	0.01112
3	0.01281	28	0.01180	53	0.01302	78	0.01234
4	0.01062	29	0.01090	54	0.01130	79	0.01080
5	0.01180	30	0.01290	55	0.01252	80	0.01121
6	0.01283	31	0.01194	56	0.01052	81	0.01272
7	0.01180	32	0.01180	57	0.01193	82	0.00829
8	0.01310	33	0.01280	58	0.01210	83	0.01162
9	0.01200	34	0.01260	59	0.01180	84	0.01170
10	0.01050	35	0.01250	60	0.01333	85	0.01220
11	0.01161	36	0.01312	61	0.01240	86	0.01230
12	0.01160	37	0.01360	62	0.01184	87	0.01190
13	0.01150	38	0.01221	63	0.01241	88	0.01240
14	0.01273	39	0.01260	64	0.00969	89	0.01270
15	0.01210	40	0.01190	65	0.01140	90	0.01340
16	0.01060	41	0.01192	66	0.01390	91	0.01174
17	0.01200	42	0.01120	67	0.01173	92	0.01270
18	0.01261	43	0.01224	68	0.01230	93	0.01193
19	0.01252	44	0.01330	69	0.01190	94	0.01160
20	0.01180	45	0.01050	70	0.01324	95	0.01230
21	0.01200	46	0.01220	71	0.01143	96	0.01200
22	0.01213	47	0.01150	72	0.01124	97	0.01340
23	0.01150	48	0.01073	73	0.01230	98	0.01110
24	0.01151	49	0.01261	74	0.01232	99	0.01232
25	0.01081	50	0.01213	75	0.01320	100	0.01171

Table B.7 The UV light intensity measure by UV meter at feed flow rate 160 ml/min, 200 Hz, 9,000 V, a gap distance of 10 mm, and O_2: C_2H_4 ratio of 5:1.

min	Intensity (μW/cm^2)	min	Intensity (μW/cm^2)	min	Intensity (μW/cm^2)
101	0.01251	124	0.01122	147	0.01151
102	0.01230	125	0.01080	148	0.01240
103	0.01320	126	0.01292	149	0.01340
104	0.01160	127	0.01250	150	0.01160
105	0.01182	128	0.01152	151	0.01330
106	0.01203	129	0.01190	152	0.01162
107	0.01130	130	0.01251	153	0.01130
108	0.01070	131	0.01260	154	0.01260
109	0.01120	132	0.01190	155	0.01154
110	0.01120	133	0.01100	156	0.01180
111	0.01100	134	0.01313	157	0.01262
112	0.01191	135	0.01180	158	0.01220
113	0.01220	136	0.01140	159	0.01170
114	0.01080	137	0.01053	160	0.01241
115	0.01144	138	0.01040	161	0.01350
116	0.01120	139	0.01213	162	0.01370
117	0.01290	140	0.01230	163	0.01333
118	0.01293	141	0.01271	164	0.01323
119	0.01143	142	0.01192	165	0.01490
120	0.01221	143	0.01160	166	0.01480
121	0.01280	144	0.01093	167	0.01400
122	0.01110	145	0.01264	168	0.01421
123	0.01170	146	0.01350	169	0.01220

Table B.8 Comparative results of different selectivity calculation.

Product	% Selectivity					
	Degussa P25		Sol-Gel TiO_2		1%Pt/ Sol-Gel TiO_2	
	First	Second	First	Second	First	Second
4 Stages						
CO	41	40	41	41	35	33
CO_2	60	60	60	59	70	67
3 Stages						
CO	48	49	48	49	46	45
CO_2	51	51	51	51	56	55
2 Stages						
CO	56	57	55	56	55	52
CO_2	42	43	43	44	46	44
1 Stage						
CO	58	62	57	55	56	55
CO_2	36	38	38	37	46	45

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2. **Saktrakool, K.**, Chavadej, S., Rangsunvigit, P., and Lobban, L. L. (2003) "Ethylene Oxidation in a Multistage Plasma Reactor in The Presence of TiO_2" *The 8th International Conference on Atmospheric Sciences and Applications to Air Quality*, Tsukuba, Japan 11 – 13 March.