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APPENDICES

Appendix A Calibration Curves for Gas Chromatography (Temperature of 45 °C, Retention Time of 60 Minute)

Table A1 Calibration curve for hydrogen (H_2)

Volume of Hydrogen (ml)	Peak Area
0.02	16,313
0.04	58,770
0.08	180,674
0.1	226,743
0.2	427,198
0.4	778,509

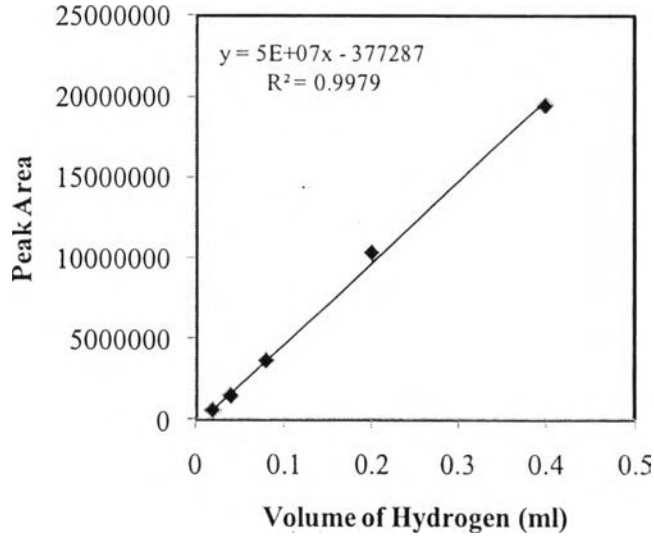

Figure A1 The relationship between volume of hydrogen (H_2) and peak area.

Equation

$$\text{Amount of hydrogen} = \frac{\text{Peak area} + 377287}{5 \times 10^7} \quad \text{(A1)}$$

Table A2 Calibration curve for nitrogen (N_2)

Volume of Nitrogen (ml)	Peak Area
0.02	34,210
0.04	128,767
0.08	305,287
0.1	393,916
0.2	809,433
0.4	1,602,475

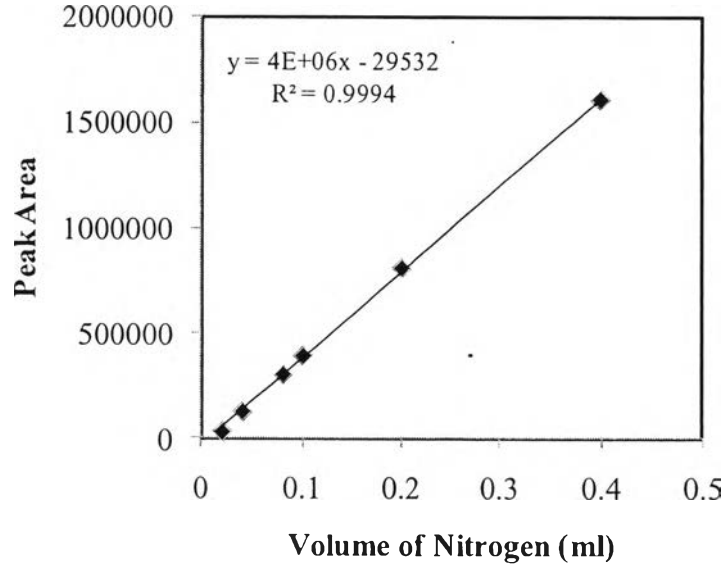

Figure A2 The relationship between volume of nitrogen (N_2) and peak area.

Equation

$$\text{Amount of nitrogen} = \frac{\text{Peak area} + 29532}{4 \times 10^6} \quad \text{(A2)}$$

Table A3 Calibration curve for oxygen (O_2)

Volume of Oxygen (ml)	Peak Area
0.02	12,286
0.04	43,995
0.08	104,342
0.1	135,546
0.2	280,220
0.4	562,001

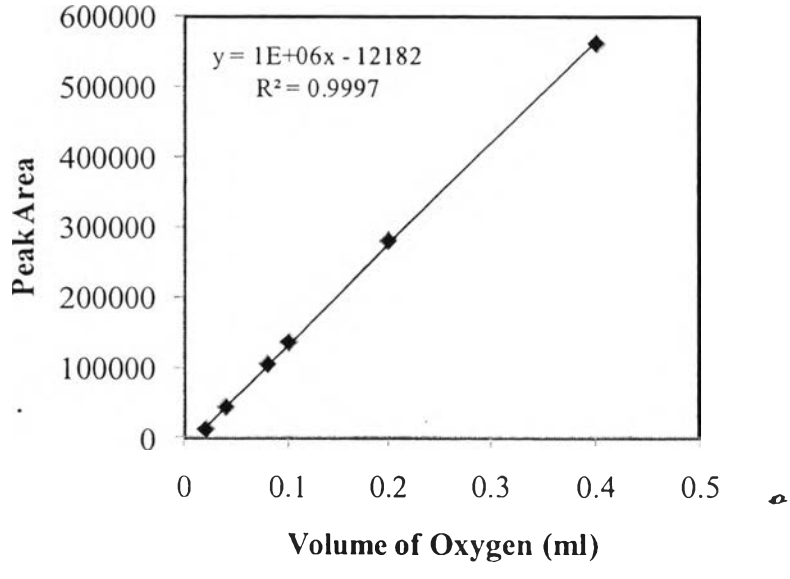

Figure A3 The relationship between volume of oxygen (O_2) and peak area.

Equation

$$\text{Amount of oxygen} = \frac{\text{Peak area} + 12182}{1 \times 10^6} \qquad \text{(A3)}$$

Table A4 Calibration curve for methane (CH_4)

Volume of Methane (ml)	Peak Area
0.02	92,517
0.04	381,106
0.1	1,293,552
0.2	2,674,654

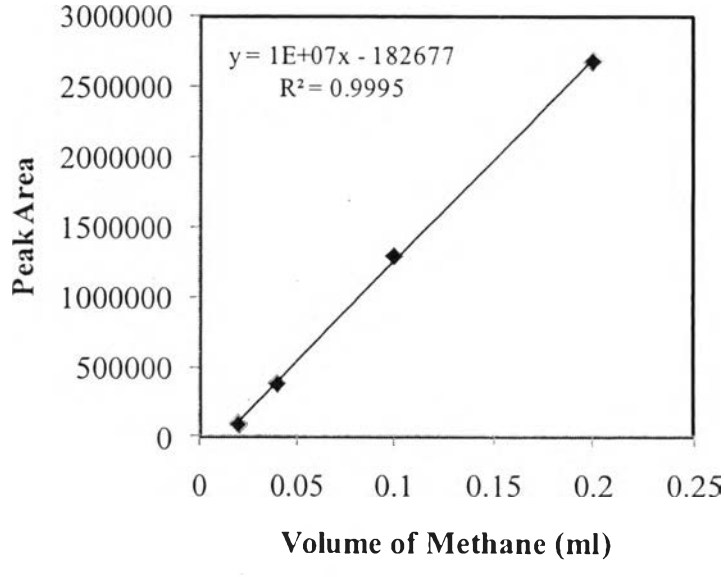

Figure A4 The relationship between volume of methane (CH_4) and peak area.

Equation

$$\text{Amount of methane} = \frac{\text{Peak area} + 182677}{1 \times 10^7} \quad \text{(A4)}$$

Table A5 Calibration curve for carbon dioxide (CO_2)

Volume of Carbon Dioxide (ml)	Peak Area
0.02	26,118
0.04	97,539
0.08	220,122
0.2	596,414
0.4	1,315,885

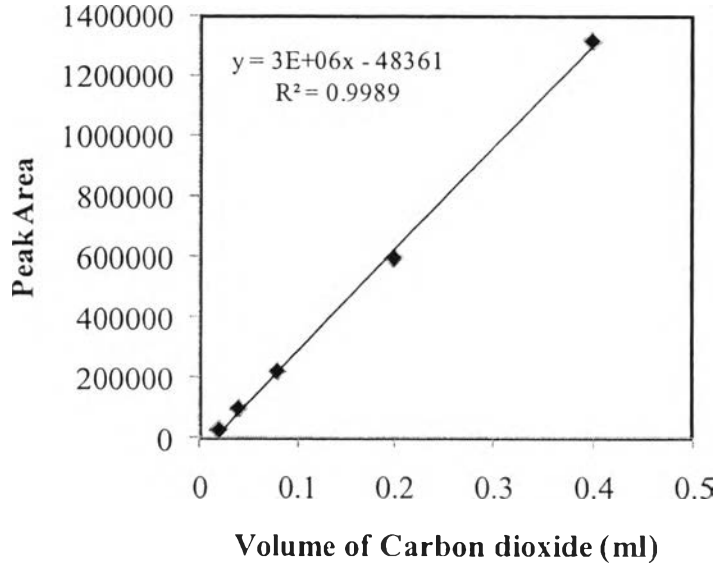

Figure A5 The relationship between volume of carbon dioxide (CO_2) and peak area.

Equation

$$\text{Amount of carbon dioxide} = \frac{\text{Peak area} + 48361}{3 \times 10^6} \qquad \text{(A5)}$$

Appendix B Calibration Curves for High Performance Liquid Chromatography (Temperatureof 45 °C, RetentionTimeof 60 Minute, Mobile Phase of 4 mM H_2SO_4)

Table B1 Calibration curve for ethanol (C_2H_5OH)

Concentration of Ethanol (ppm)	Peak Area
1000	189,866
2000	377,275
3000	569,223
4000	765,786
5000	958,108

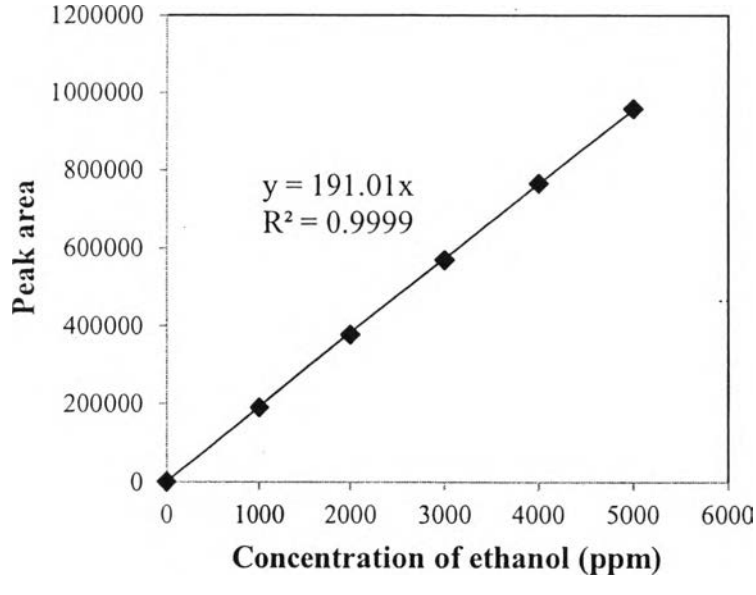

Figure B1 The relationship between concentration of ethanol (C_2H_5OH) and peak area.

Equation

$$\text{Concentration of ethanol} = \frac{\text{Peak area}}{191.01} \qquad \text{(B1)}$$

Table B2 Calibration curve for lactic acid ($C_3H_6O_3$)

Concentration of Lactic Acid (ppm)	Peak Area
1000	241,057
2000	513,754
3000	735,330
4000	1,047,749
5000	1,350,707

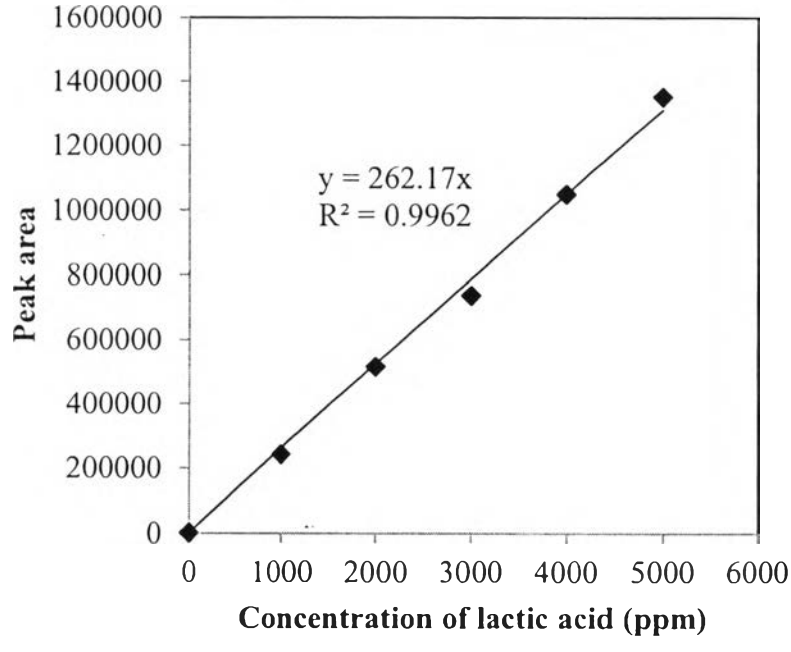

Figure B2 The relationship between concentrations of lactic acid ($C_3H_6O_3$) and peak area.

Equation

$$\text{Concentration of lactic acid} = \frac{\text{Peak area}}{262.17} \qquad \text{(B2)}$$

Table B3 Calibration curve for valeric acid ($C_5H_{10}O_2$)

Concentration of Valeric Acid (ppm)	Peak Area
1000	346,808
2000	707,645
3000	108,2011
4000	1,470,955
5000	1,844,040

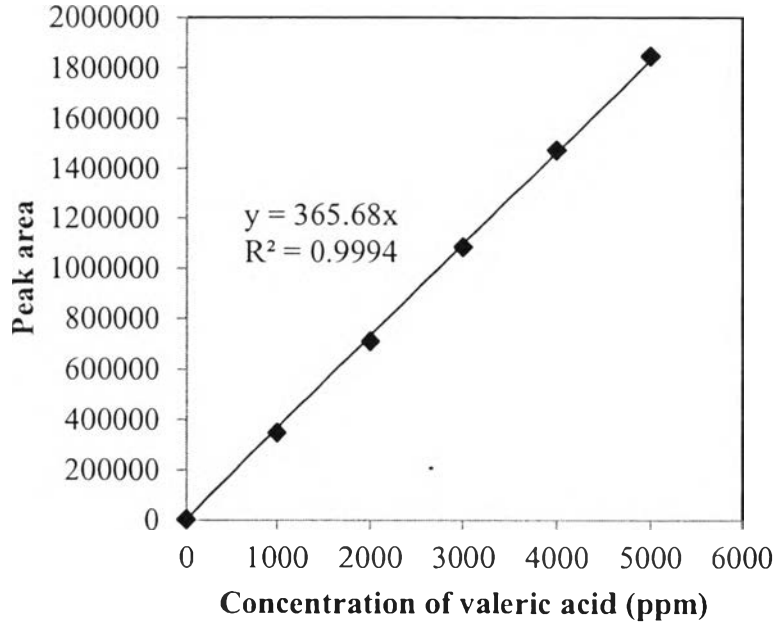

Figure B3 The relationship between concentrations of valeric acid ($C_5H_{10}O_2$) and peak area.

Equation

$$\text{Concentration of valeric acid} = \frac{\text{Peak area}}{365.68} \qquad \text{(B3)}$$

Table B4 Calibration curve for propionic acid ($C_3H_6O_2$)

Concentration of Propionic Acid (ppm)	Peak Area
1000	274,670
2000	553,990
3000	836,683
4000	1,091,859
5000	1,435,669

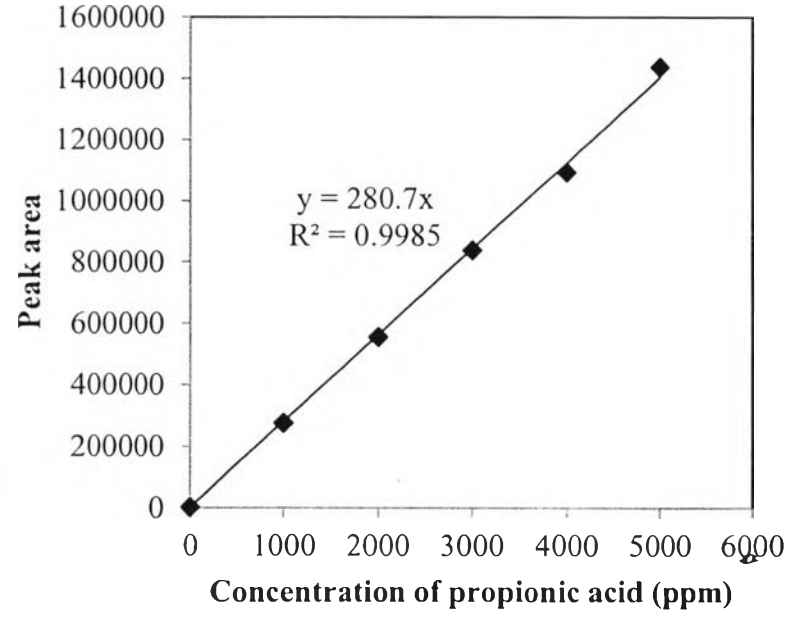

Figure B4 The relationship between concentrations of propionic acid ($C_3H_6O_2$) and peak area.

Equation

$$\text{Concentration of propionic acid} = \frac{\text{Peak area}}{280.7} \qquad \text{(B4)}$$

Table B5 Calibration curve for acetic acid (CH_3COOH)

Concentration of Acetic Acid (ppm)	Peak Area
1000	226,593
2000	458,639
3000	693,445
4000	951,778
5000	1,179,161

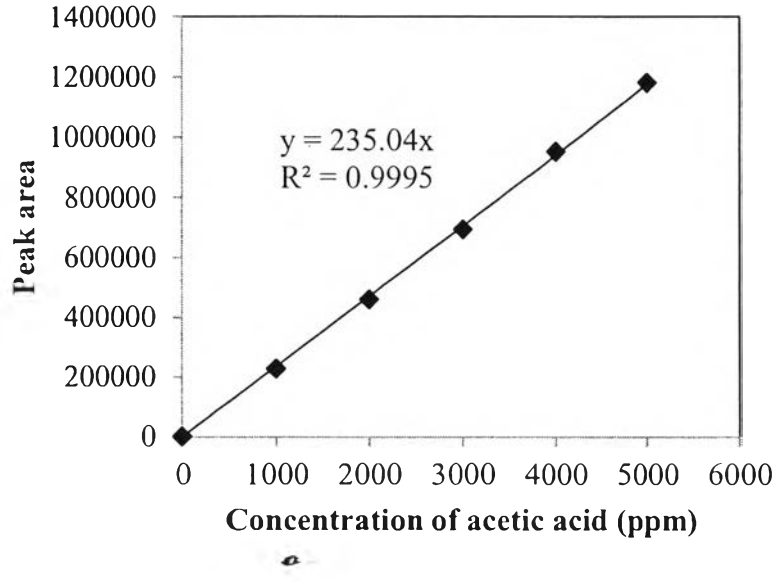

Figure B5 The relationship between concentration of acetic acid (CH_3COOH) and peak area.

Equation

$$\text{Concentration of acetic acid} = \frac{\text{Peak area}}{235.04} \qquad \text{(B5)}$$

Table B6 Calibration curve for butyric acid ($C_3H_6O_3$)

Concentration of Butyric Acid (ppm)	Peak Area
1000	310,185
2000	636,623
3000	974,830
4000	1,315,752
5000	1,672,791

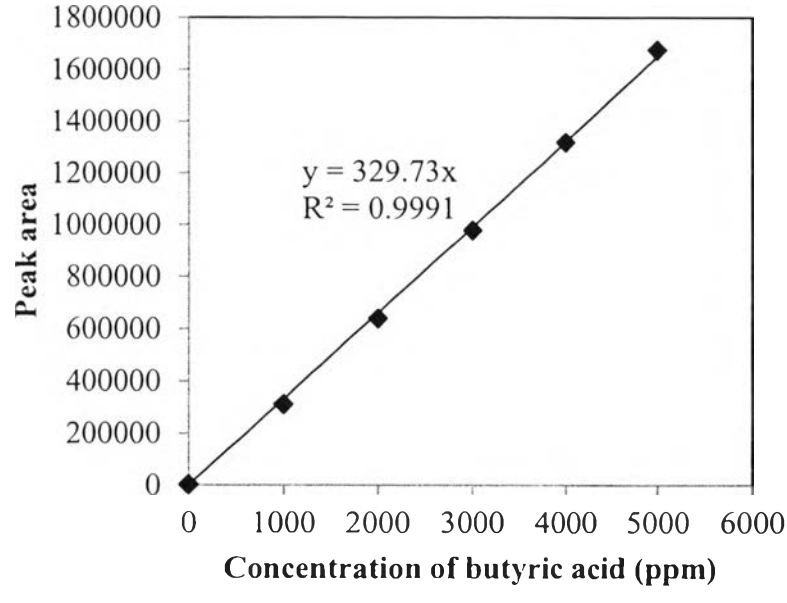

Figure B6 The relationship between concentrations of butyric acid ($C_3H_6O_3$) and peak area.

Equation

$$\text{Concentration of butyric acid} = \frac{\text{Peak area}}{329.73} \qquad \text{(B6)}$$

Appendix C Preparation of 1 M NaOH Solution for pH-Controlled System

Preparation of NaOH at concentration of 1 M NaOH

$$= \frac{40 \text{ g NaOH}}{1 \text{ litter } H_2O} \tag{C1}$$

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Proceedings

1. Sri-ubon, N.; Chavadej, S.; and Intanoo, P. (2015, April 21) Enhancement of separate hydrogen and methane production from ethanol wastewater in a two-stage UASB unit by microaeration. Proceeding of The 6th Research Symposium on Petrochemical and Materials Technology and the 21st PPC Symposium on Petroleum, Petrochemicals and Polymers, Bangkok, Thailand.
2. Sri-ubon, N.; Chavadej, S.; and Intanoo, P. (2015, July 20-22) Optimization of separate hydrogen and methane production from alcohol wastewater in a two-stage UASB system. Proceeding of The International Conference on Chemical and Biochemical Engineering 2015, Paris, France.