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APPENDICES

Appendix A Calibration Curves

Table A1 Gas chromatograph's calibration curve for hydrogen (H₂)

Volume of hydrogen (ml)	Peak area
0.02	1,101,005
0.04	2,016,179
0.08	3,680,042
0.1	5,675,328
0.2	11,471,761
0.4	22,832,569

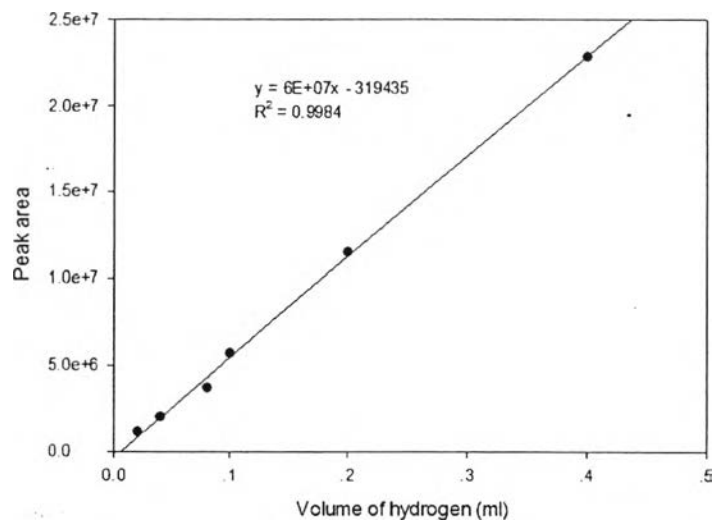


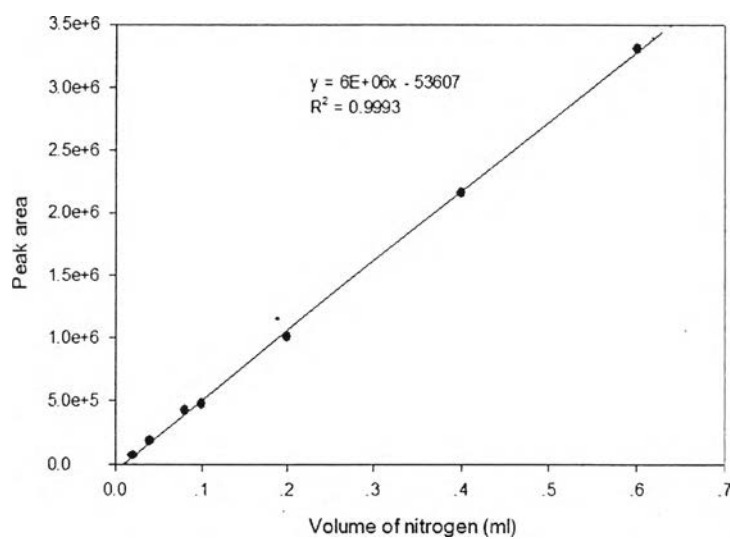
Figure A1 The relationship between amount of hydrogen (H₂) and peak area.

Equation

$$\text{Amount of hydrogen} = \frac{\text{Peak area} + 319,435}{6 \times 10^7}$$

Table A2 Gas chromatograph's calibration curve for nitrogen (N₂)

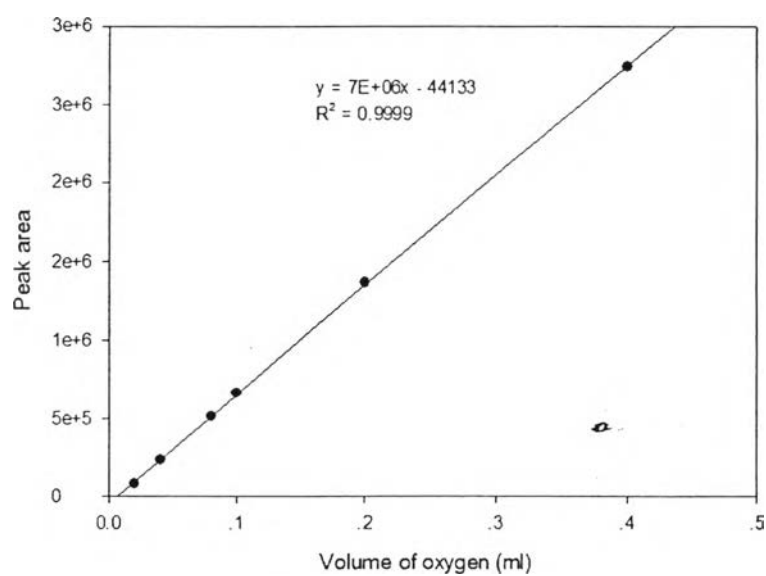
Volume of nitrogen (ml)	Peak area
0.02	69,431
0.04	188,161
0.08	426,068
0.1	478,146
0.2	1,008,515
0.4	2,155,800
0.6	3,309,337

**Figure A2** The relationship between amount of nitrogen (N₂) and peak area.**Equation**

$$\text{Amount of nitrogen} = \frac{\text{Peak area} + 53,607}{6 \times 10^6}$$

Table A3 Gas chromatograph's calibration curve for oxygen (O₂)

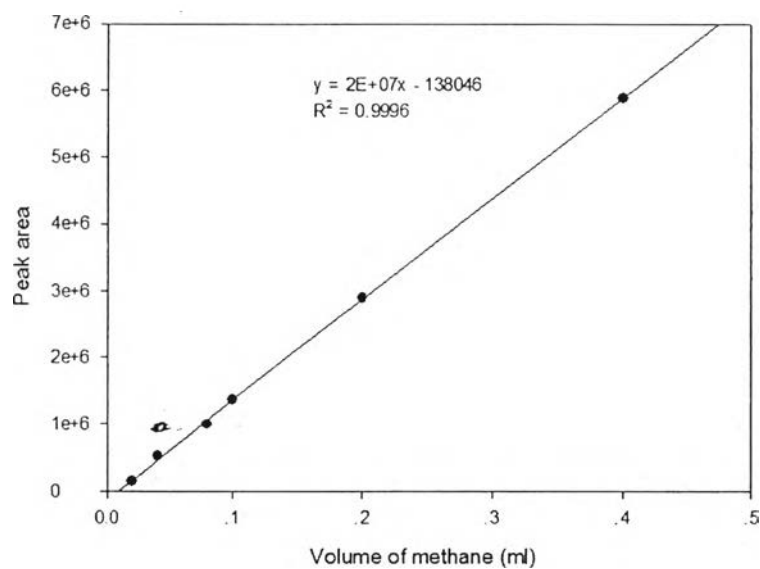
Volume of oxygen (ml)	Peak area
0.02	81,122
0.04	233,918
0.08	514,527
0.1	662,766
0.2	1,366,208
0.4	2,738,126

**Figure A3** The relationship between amount of oxygen (O₂) and peak area.**Equation**

$$\text{Amount of oxygen} = \frac{\text{Peak area} + 44,133}{7 \times 10^6}$$

Table A4 Gas chromatograph's calibration curve for methane (CH₄)

Volume of methane (ml)	Peak area
0.02	151,094
0.04	523,919
0.08	998,851
0.1	1,366,651
0.2	2,898,103
0.4	5,880,444

**Figure A4.** The relationship between amount of methane (CH₄) and peak area.**Equation**

$$\text{Amount of methane} = \frac{\text{Peak area} + 138,046}{2 \times 10^7}$$

Table A5 Gas chromatograph's calibration curve for carbon dioxide (CO₂)

Volume of carbon dioxide (ml)	Peak area
0.02	4,238
0.04	188,166
0.08	293,029
0.1	354,304
0.2	747,872
0.4	1,515,064

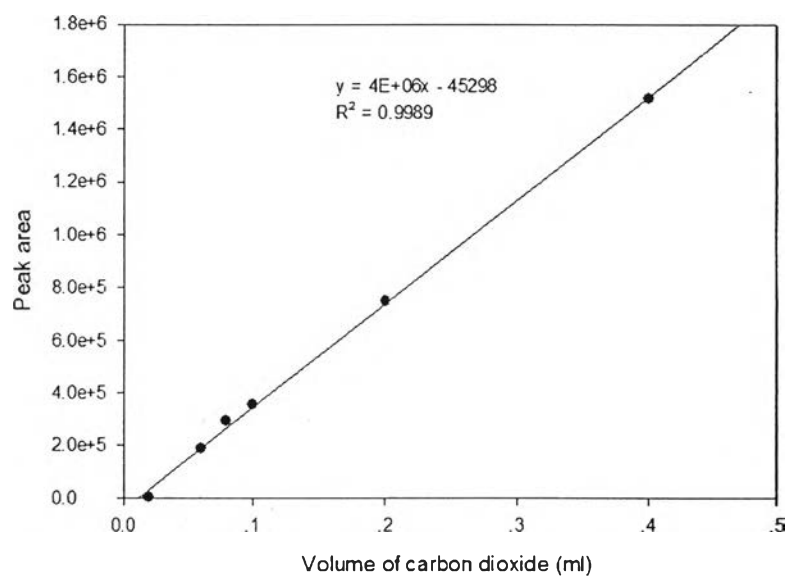


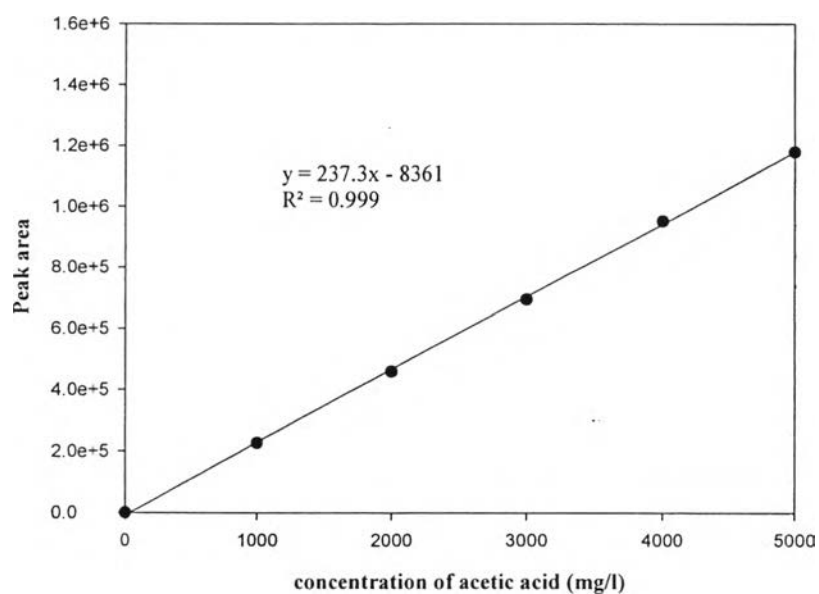
Figure A5 The relationship between amount of carbon dioxide (CO₂) and peak area.

Equation

$$\text{Amount of carbon dioxide} = \frac{\text{Peak area} + 45,298}{4 \times 10^6}$$

Table A6 Liquid chromatograph's calibration curve for acetic acid

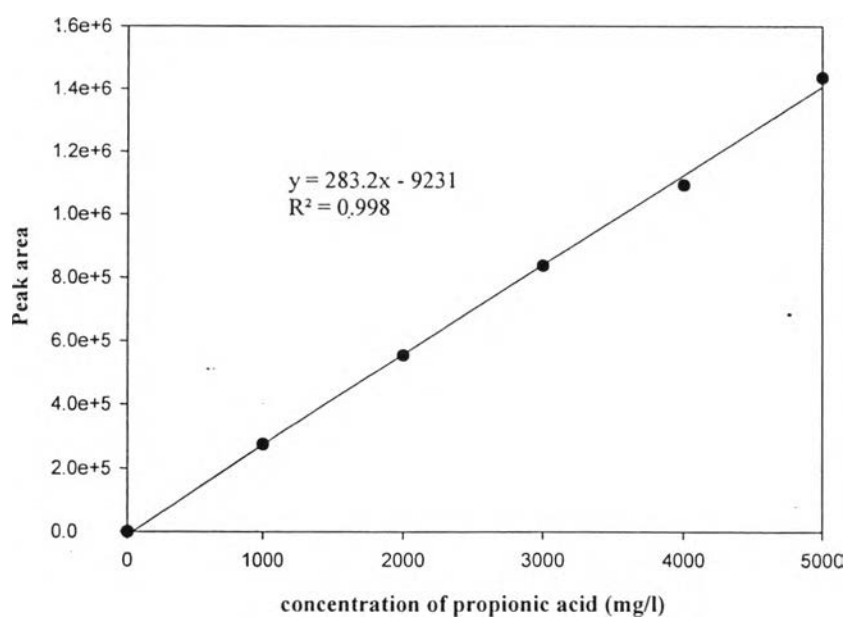
Concentration of acetic acid (mg/l)	Peak area
1,000	226,593
2,000	458,639
3,000	693,445
4,000	951,778
5,000	1,179,161

**Figure A6** The relationship between concentration of acetic acid and peak area.**Equation**

$$\text{Amount of acetic acid} = \frac{\text{Peak area} + 8361}{237.3}$$

Table A7 Liquid chromatograph's calibration curve for propionic acid

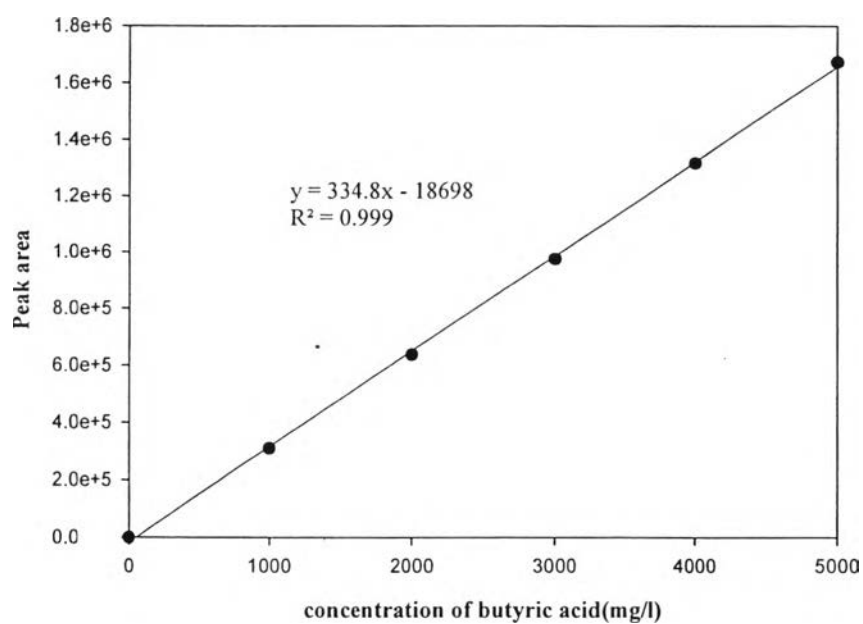
Concentration of propionic acid (mg/l)	Peak area
1,000	274,670
2,000	553,990
3,000	836,683
4,000	1,091,859
5,000	1,435,669

**Figure A7** The relationship between concentration of propionic acid and peak area.**Equation**

$$\text{Amount of propionic acid} = \frac{\text{Peak area} + 9231}{283.2}$$

Table A8 Liquid chromatograph's calibration curve for butyric acid

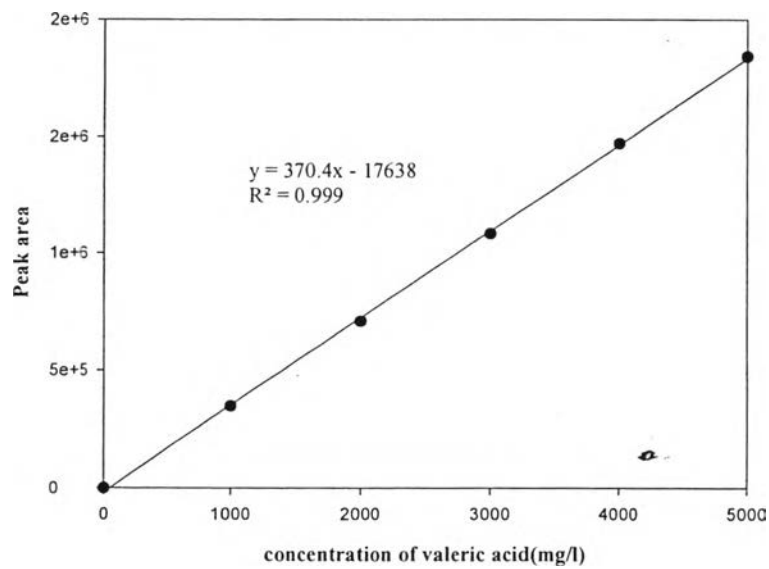
Concentration of butyric acid (mg/l)	Peak area
1,000	310,185
2,000	636,623
3,000	974,830
4,000	1,315,752
5,000	1,672,791

**Figure A8** The relationship between concentration of butyric acid and peak area.**Equation**

$$\text{Amount of butyric acid} = \frac{\text{Peak area} + 18698}{334.8}$$

Table A9 Liquid chromatograph's calibration curve for valeric acid

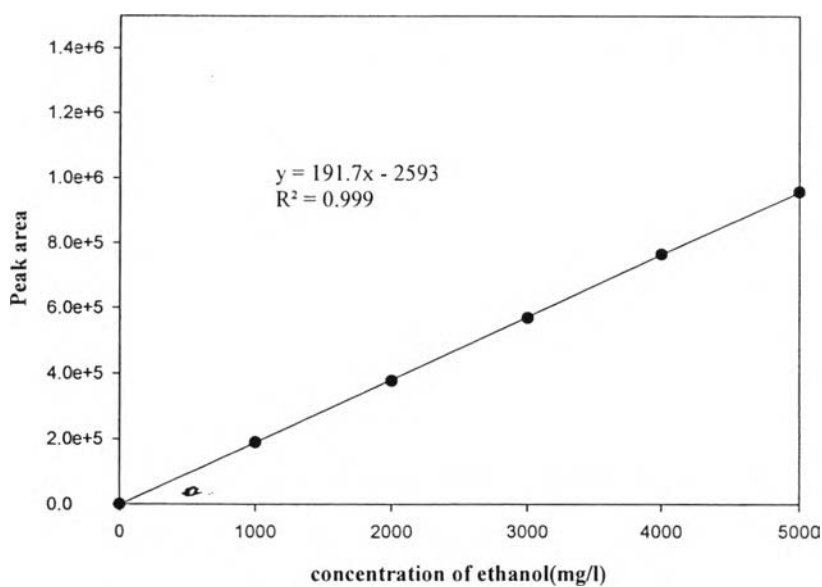
Concentration of valeric acid (mg/l)	Peak area
1,000	346,808
2,000	707,645
3,000	1,082,011
4,000	1,470,955
5,000	1,844,040

**Figure A9** The relationship between concentration of valeric acid and peak area.**Equation**

$$\text{Amount of valeric acid} = \frac{\text{Peak area} + 17638}{370.4}$$

Table A10 Liquid chromatograph's calibration curve for ethanol

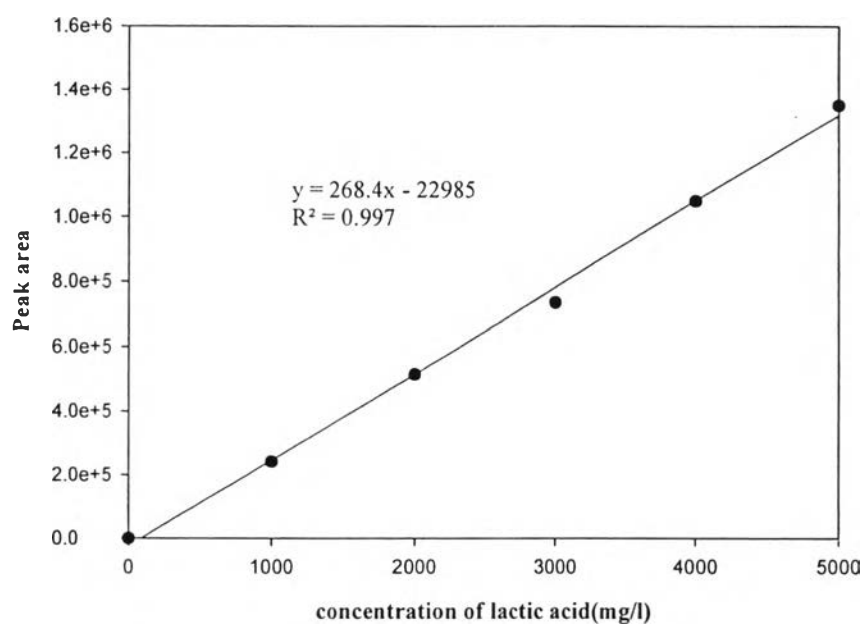
Concentration of ethanol (mg/l)	Peak area
1,000	189,866
2,000	377,275
3,000	569,223
4,000	765,786
5,000	958,108

**Figure A10** The relationship between concentration of ethanol and peak area.**Equation**

$$\text{Amount of ethanol} = \frac{\text{Peak area} + 2593}{191.7}$$

Table A11 Liquid chromatograph's calibration curve for lactic acid

Concentration of ethanol (mg/l)	Peak area
1,000	241,057
2,000	513,754
3,000	735,330
4,000	1,047,749
5,000	1,350,707

**Figure A11** The relationship between concentration of lactic acid and peak area.**Equation**

$$\text{Amount of ethanol} = \frac{\text{Peak area} + 22985}{268.4}$$

Appendix B Preparation of 1 M NaOH Solution for pH-controlled System

Preparation of NaOH at concentration of 1 M
(Molecular weight of acetic acid = 60)

$$= \frac{1 \text{ mol}}{1 \text{ l}} \times \frac{40 \text{ g}}{1 \text{ mol}}$$
$$= 40 \frac{\text{g}}{\text{l}}$$

Appendix C Volatile Fatty Acids (VFA) Quantification by using High-Performance Liquid Chromatography

C 1. Mobile phase solution preparation

Concentration of fresh sulfuric acid (liquid) = 98%v/v

Density of sulfuric acid = 1.84 g/ml

Molecular weight of sulfuric acid = 98.08

Determination of fresh acetic acids concentration in term of molar

$$\frac{0.98 \text{ mL of sulfuric acid}}{\text{mL of solution}} \times \frac{1.84 \text{ g of sulfuric acid}}{\text{mL of sulfuric acid}} \times \frac{1 \text{ mol of sulfuric acid}}{98.08 \text{ g of sulfuric acid}} \times \frac{1000 \text{ mL}}{1 \text{ L}}$$

$$= 18.38 \text{ M}$$

Sulfuric acid are required at concentration of 0.004M

Dilution of sulfuric acid

$$N_1 V_1 = N_2 V_2$$

$$V_1 = \frac{N_2 V_2}{N_1}$$

$$= \frac{(0.004 \times 2)}{18.38}$$

$$= 4.352 \times 10^{-4} \text{ L}$$

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1. Tuntiwichayanon, P.; and Chavadej, S. (2015, April 21) Effects of Microaeration on Hydrogen and Methane Production from Cassava Wastewater using a Two-stage UASB System. Proceedings of The 6th Research Symposium on Petroleum, Petrochemicals, and Advanced Materials and The 21th PPC Symposium on Petroleum, Petrochemicals, and Polymers, Bangkok, Thailand.