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APPENDICES

Appendix A Calibration Curves

Table A1 Gas chromatograph's calibration curve for hydrogen (H_2)

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

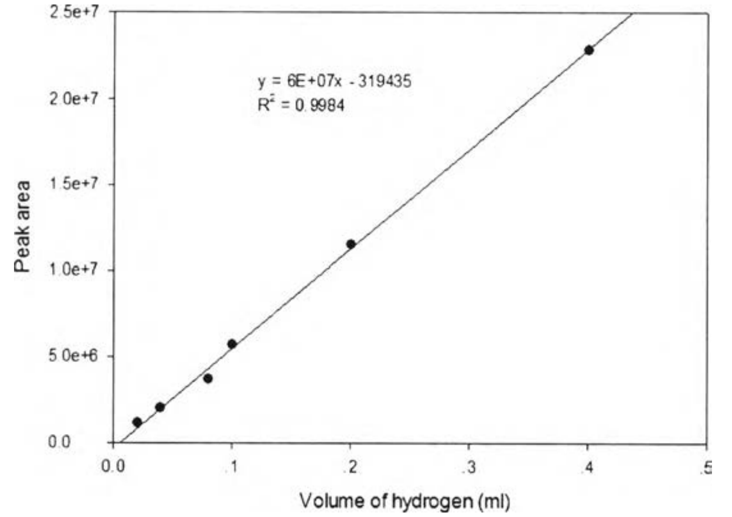

Figure A1 The relationship between amount of hydrogen (H_2) and peak area.

Equation

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

Table A2 Gas chromatograph's calibration curve for nitrogen (N_2)

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

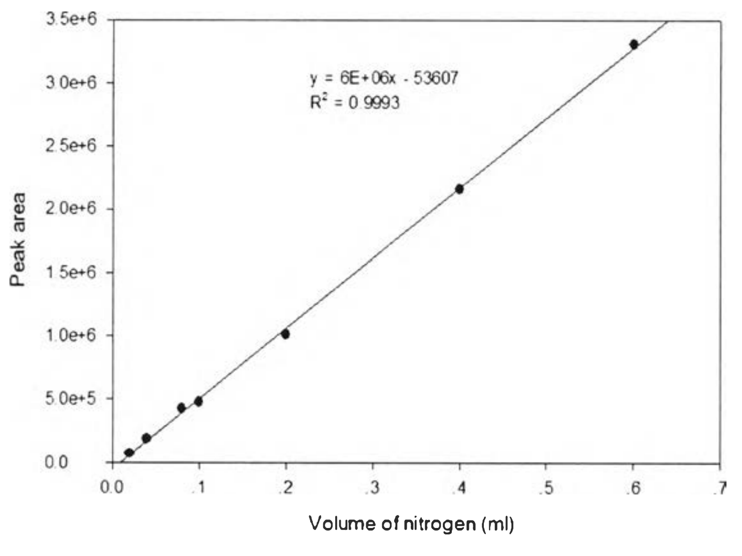

Figure A2 The relationship between amount of nitrogen (N_2) and peak area.

Equation

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

Table A3 Gas chromatograph's calibration curve for oxygen (O_2)

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

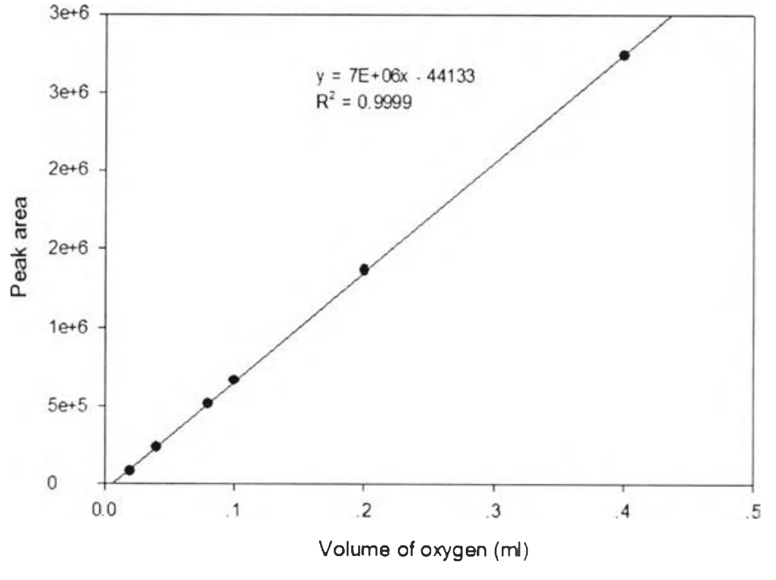

Figure A3 The relationship between amount of oxygen (O_2) and peak area.

Equation

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

Table A4 Gas chromatograph's calibration curve for methane (CH_4)

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

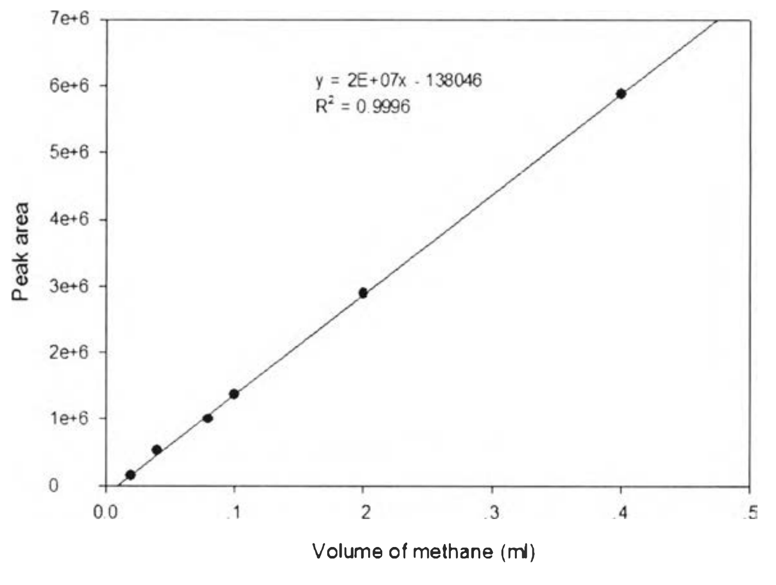

Figure A4 The relationship between amount of methane (CH_4) and peak area.

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 (CO_2)

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

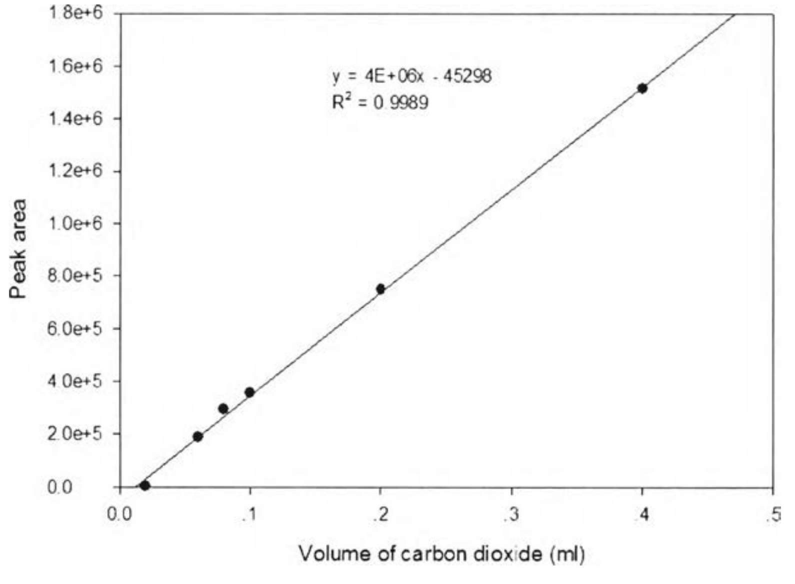

Figure A5 The relationship between amount of carbon dioxide (CO_2) and peak area.

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	0.04
2,000	0.15
3,000	0.29
4,000	0.37
5,000	0.48

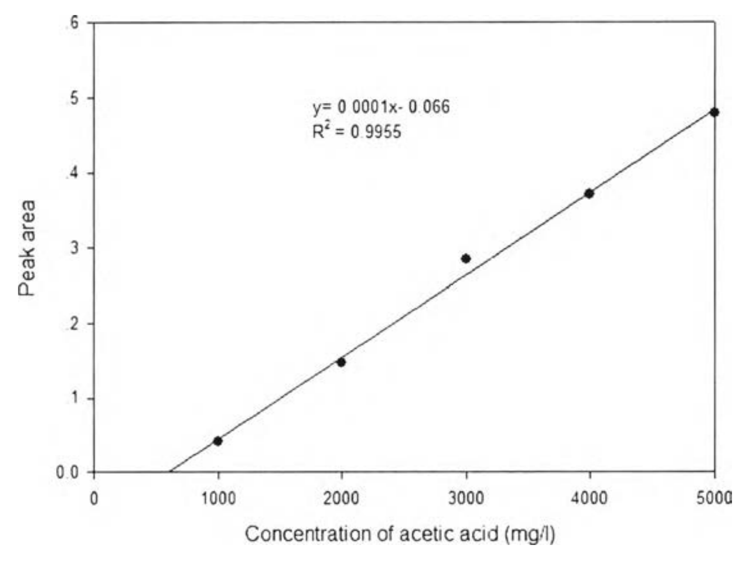

Figure A6 The relationship between concentration of acetic acid and peak area.

Equation

$$Amount\ of\ acetic\ acid = \frac{Peak\ area + 0.066}{0.0001}$$

Table A7 Liquid chromatograph's calibration curve for propionic acid

Concentration of propionic acid (mg/l)	Peak area
1,000	0.14
2,000	0.36
3,000	0.59
4,000	0.77
5,000	0.95

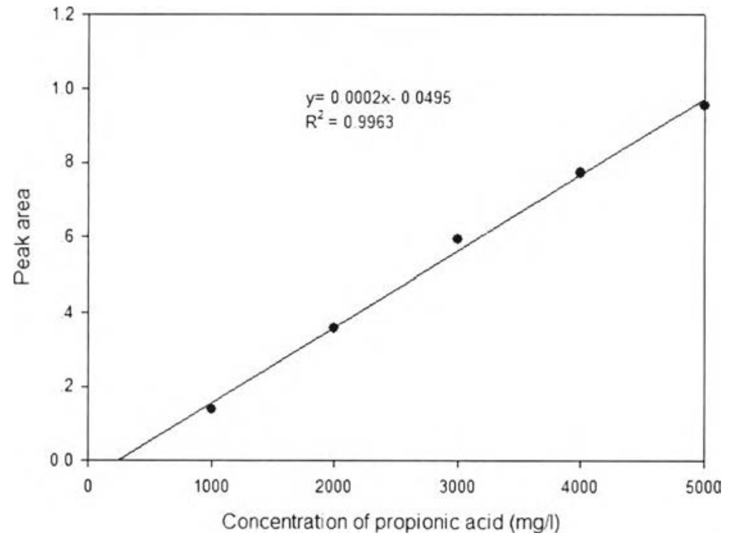

Figure A7 The relationship between concentration of propionic acid and peak area.

Equation

$$Amount\ of\ propionic\ acid = \frac{Peak\ area + 0.0495}{0.0002}$$

Table A8 Liquid chromatograph's calibration curve for butyric acid

Concentration of butyric acid (mg/l)	Peak area
1,000	0.23
2,000	0.48
3,000	0.83
4,000	1.11
5,000	1.31

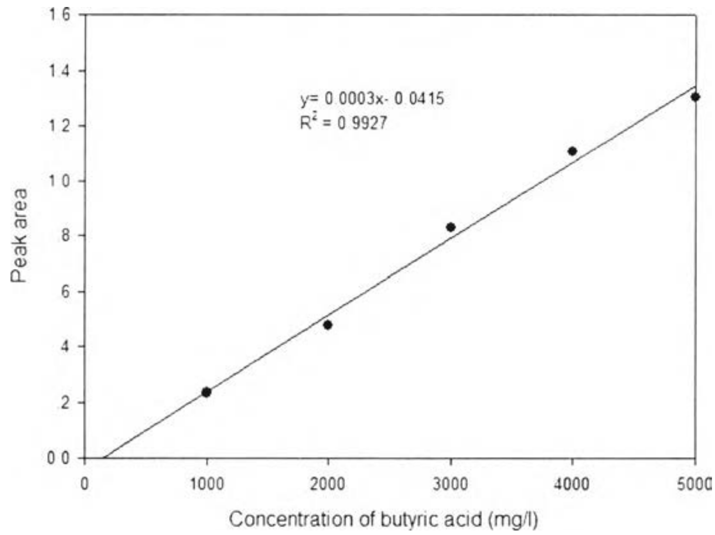

Figure A8 The relationship between concentration of butyric acid and peak area.

Equation

$$Amount\ of\ butyric\ acid = \frac{Peak\ area + 0.0415}{0.0003}$$

Table A9 Liquid chromatograph's calibration curve for valeric acid

Concentration of valeric acid (mg/l)	Peak area
1,000	0.21
2,000	0.51
3,000	0.80
4,000	1.19
5,000	1.36

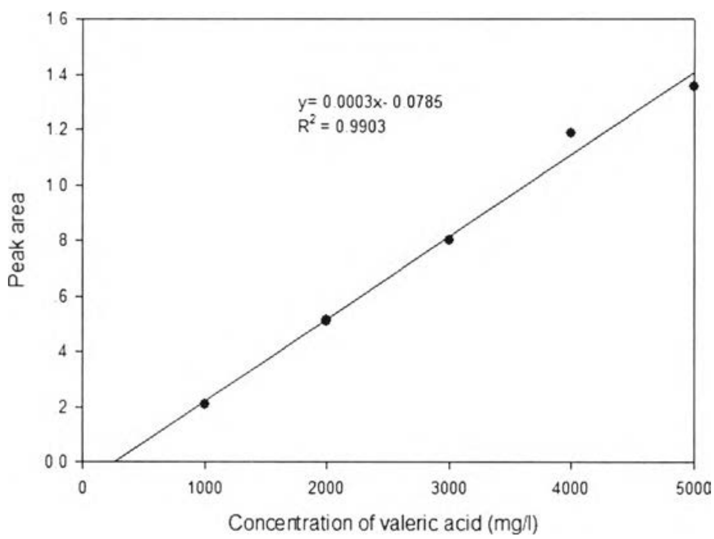

Figure A9 The relationship between concentration of valeric acid and peak area.

Equation

$$Amount\ of\ valeric\ acid = \frac{Peak\ area + 0.0785}{0.0003}$$

Table A10 Liquid chromatograph's calibration curve for ethanol

Concentration of ethanol (mg/l)	Peak area
1,000	0.21
2,000	0.53
3,000	0.78
4,000	1.05
5,000	1.35

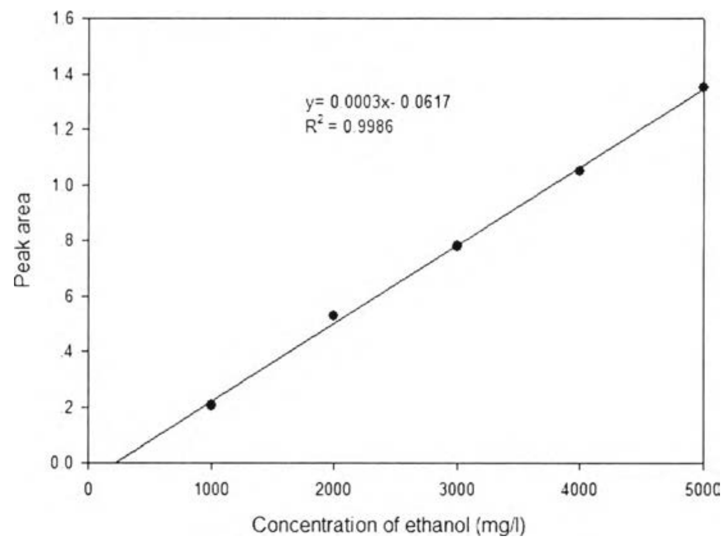

Figure A10 The relationship between concentration of ethanol and peak area.

Equation

$$Amount\ of\ et\square anol = \frac{Peak\ area + 0.0617}{0.0003}$$

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)

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

$$= 40\frac{g}{l}$$

Appendix C Volatile Fatty Acids (VFA) Quantification by Distillation Method

C 1. Acetic Acids Stock Solution Preparation for Recovery Factor (f) Determination

Concentration of fresh acetic acid (liquid)	=	99.7%
Density of acetic acid	=	1.07 g/ml
Molecular weight of acetic acid	=	60

Determination of fresh acetic acids concentration in term of molar

$$= \frac{0.997 \text{ L of acetic acid}}{\text{L of solution}} \times \frac{1.07 \text{ g of acetic acid}}{\text{mL of acetic acid}} \times \frac{1 \text{ mol of acetic acid}}{60 \text{ g of acetic acid}}$$

= 17.78 M

Preparation of acetic acid at concentration of 2,000 mg/L

$$= 2{,}000 \frac{\text{mg of acetic acid}}{\text{L of solution}} \times \frac{1 \text{ mole of acetic acid}}{60 \text{ g of acetic acid}}$$

= 0.0333 M

Dilution of acetic acid

$$N_1V_1 = N_2V_2$$

$$V_1 = N_2V_2/N_1$$

$$= (0.0333 \times 1)/17.78$$

$$= 1.873 \times 10^{-3} \text{ L}$$

C 2. Standard Sodium Hydroxide (0.1 M) Preparation

Concentration of fresh NaOH (solid)	=	99%
Molecular weight of acetic acid	=	40

Preparation of acetic acid at concentration of 0.1 M

$$= \frac{0.1 \text{ mol}}{1 \text{ L}} \times \frac{40 \text{ g}}{1 \text{ mol}} \times \frac{100}{99}$$

= 4.04 g

C 3. Recovery Factor (f) Determination

Distill 150 ml of 0.0333 M of acetic acid in distillation apparatus

Calculate the recovery factor

$$f = \frac{a}{b}$$

where

a = volatile acid concentration recovered in distillate, mg/L

b = volatile acid concentration in standard solution used, mg/L

Find volatile acid concentration recovered in distillate by titration with 0.1 M of NaOH (MW of acetic acid = 60.5)

1) Distillate 50 ml NaOH 11.7 ml

Used NaOH	=	$11.7\text{x}10^{-3}\text{x}0.1$
	=	$1.17\text{x}10^{-3}$ mol
Acetic acid in distillate	=	$1.17\text{x}10^{-3}$ mol
	=	$1.17\text{x}10^{-3}$ x 60.5
	=	0.07 g
Concentration of acetic acid in distillate		
	=	0.07/50
	=	$1.405\text{x}10^{-3}$ g/ml
	=	1,405 mg/l

2) Distillate 25 ml NaOH 5.7 ml

Used NaOH	=	$5.7\text{x}10^{-3}\text{x}0.1$
	=	$5.7\text{x}10^{-4}$ mol
Acetic acid in distillate	=	$5.7\text{x}10^{-4}$ mol
	=	$5.7\text{x}10^{-4}$ x 60.5
	=	0.034 g
Concentration of acetic acid in distillate		
	=	0.034/25
	=	$1.368\text{x}10^{-3}$ g/ml
	=	1,368 mg/l
Average	=	1,387 mg/l
Recovery factor (f)	=	1,387/2,000
	=	0.693

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Proceedings:

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Presentation:

1. Wangmor, T.; Intanoo, P.; Rangsunvigit, P.; and Chavadej, S. (2014,May 7-8) Optimization of two-stage UASB system for H_2 and CH_4 production from cassava wastewater with added cassava residue. Paper presented at 2014 International Conference on Environment and Renewable Energy, Paris, France.