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APPENDIX A

The obtained value from atomic absorption spectrophotometer was absorbance, then the concentration of lead can be obtained through the following calibration curve.

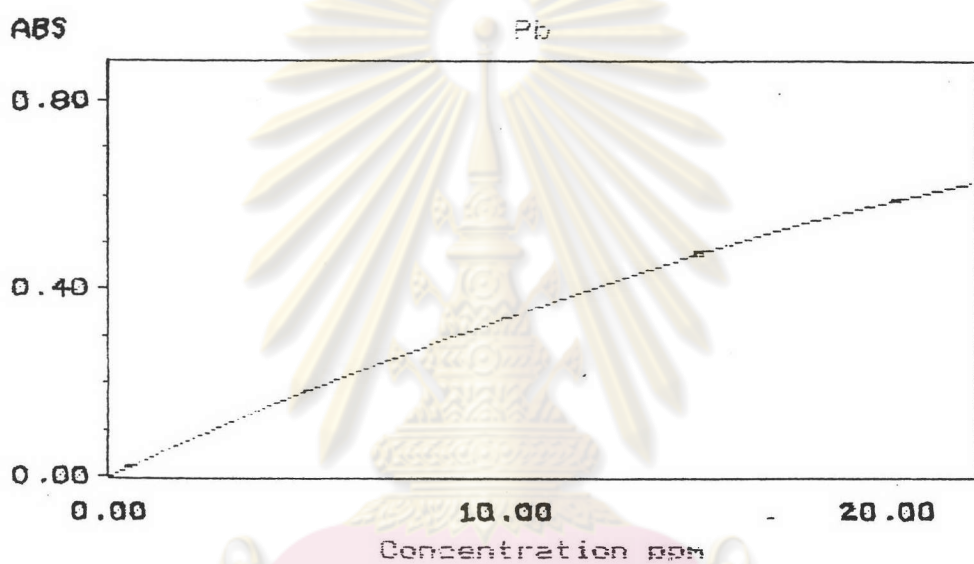


Figure A.1 The calibration curve of PE 17-001, PE 17-101, PP 16-001, PP 16-101, PP 17-001, PP 17-101, PP 17-002, PP 17-102, PS 18-001, and PS 18-101.

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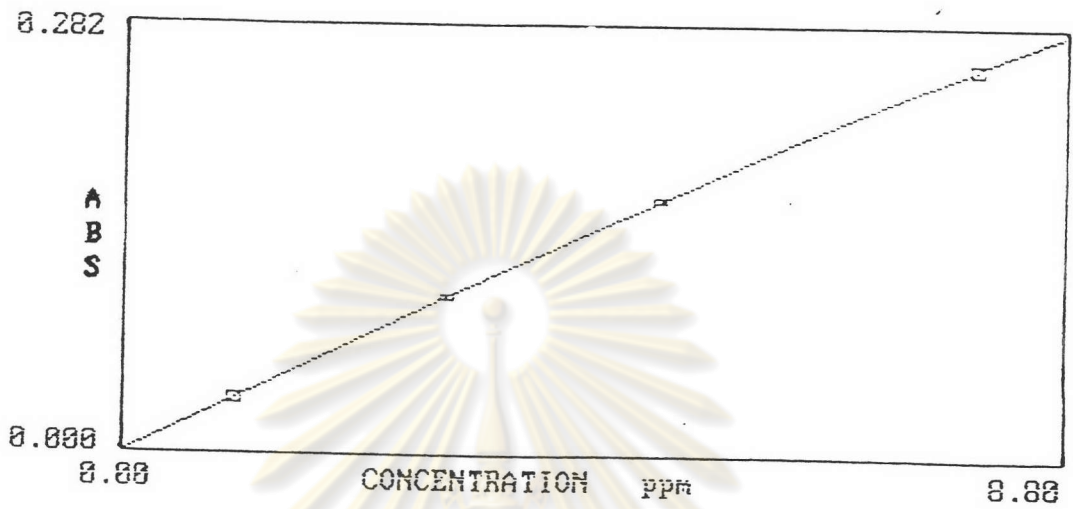


Figure A.2 The calibration curve of PE 14-001, PE 13-001, PE 13-101, PE 13-002, PE 13-102, PP 17-003, and PP 17-103.

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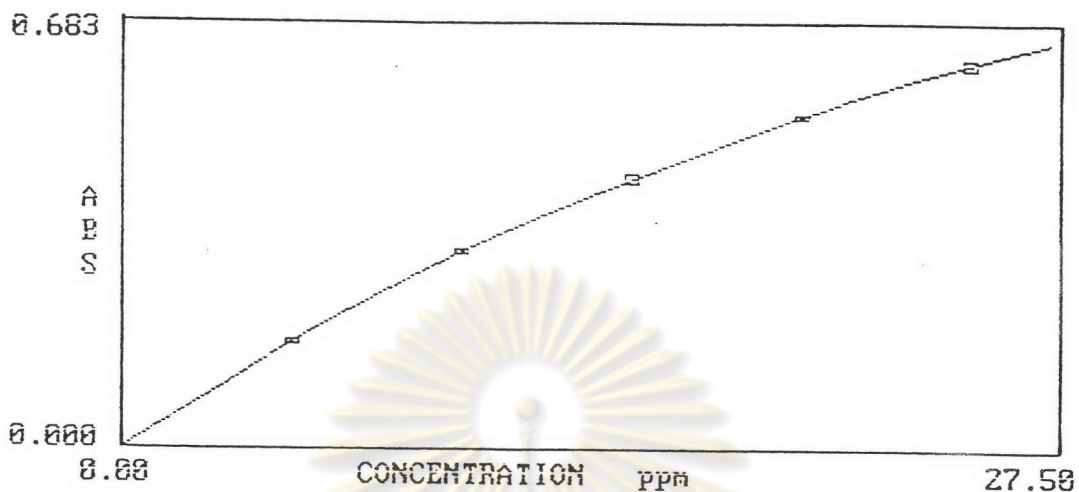


Figure A.3 The calibration curve of PE 17-002, PE 17-102, PE 22-001, PE 22-101, PE 14-002, PE 14-003, PE 35-001, PP 16-002, PP 16-102, PP15-001, PP 25-001, PS 11-002, PS 16-001, PS 16-101 ,PS 111-001, and PS 111-002.

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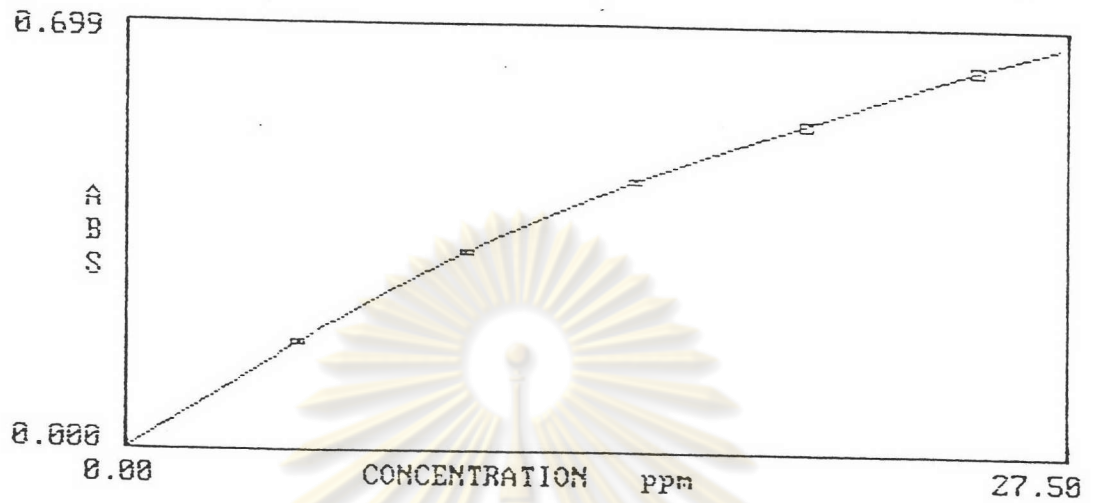


Figure A 4 The calibration curve PE 11-001, PE 11-101, PE 43-001, PE 63-001, PE 23-001, PE 53-001, PE 33-001, PP 13-001, PS 11-002, PS 11-102, and PS 11-001.

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Calculation of Lead Content

The amount of lead (mg/kg or ppm) is defined as

$$\text{lead content (ppm)} = CV/W$$

by

C = concentration of lead (mg/l) which obtained
from the calibration curve

V = volume of sample solution (ml)

W = weight of sample (g)

An example of calculation

The average lead content which received from the calibration curve for PE 17-001 is 24.38 ppm (mg/l). In this experiment, sample equal 50 ml and the weight of sample equal 2 g. so, C, V, and W are 24.38 mg/l, 50 ml, and 2 g., respectively. Then,

$$\begin{aligned} \text{lead content} &= CV/W \\ &= (24.38)(50)/(2) \\ &= 609.50 \text{ mg/kg} \end{aligned}$$

So, the amount of lead in PE 17-001 is 609.50 mg/kg.

Table A.1 Lead content of virgin resin.

Type of plastics	run no. 1	run no. 2	run no. 3	S.D.	average	concentration (mg/kg)
PE 35-001	0.00	0.00	0.00	0.00	0.00	0.00
PE 110-001	0.00	0.00	0.00	0.00	0.00	0.00
PS 111-001	0.00	0.00	0.00	0.00	0.00	0.00
PP 15-001	0.00	0.00	0.00	0.00	0.00	0.00
PP 25-001	0.00	0.00	0.00	0.00	0.00	0.00



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Table A.2 Lead content of recycled plastics.

Type of plastics	run no. 1	run no. 2	run no. 3	S.D.	average	concentration (mg/kg)
PE 12-001	9.98	10.16	10.12	0.09	10.09	252.25
PE 22-001	12.74	12.86	12.96	1.55	12.85	321.25
PE 14-001	0.05	0.05	0.05	0.00	0.05	1.25
PE 14-002	0.00	0.00	0.00	0.00	0.00	0.00
PE 14-003	0.00	0.00	0.00	0.00	0.00	0.00
PE 17-001	24.78	23.17	25.19	0.43	24.38	609.50
PE 17-002	9.41	9.93	9.07	0.02	9.47	236.75
PE 11-001	0.03	0.03	0.06	0.87	0.04	1.00
PE 23-001	14.66	12.98	13.45	1.96	13.70	342.50
PE 33-001	23.16	23.36	26.65	0.01	24.39	609.75
PE 43-001	0.01	0.01	0.02	0.63	0.01	0.25
PE 53-001	17.25	17.94	16.69	0.17	17.29	432.25
PE 63-001	0.55	0.72	0.88	1.07	0.72	18.00
PE 13-001	0.09	0.11	0.13	0.02	0.11	2.75
PE 13-002	0.00	0.00	0.00	0.00	0.00	0.00
PS 18-001	0.81	0.80	0.81	0.01	0.80	20.25
PS 11-001	0.00	0.00	0.00	0.00	0.00	0.00
PS 11-002	0.00	0.00	0.00	0.00	0.00	0.00
PS 16-001	0.94	1.10	1.13	0.10	1.06	26.50
PS 21-001	0.04	0.04	0.04	0.00	0.00	1.00
PP 16-001	3.04	2.81	2.75	0.15	2.87	71.75
PP 16-002	5.86	6.03	6.39	0.27	6.09	152.25
PP 17-001	17.16	15.79	16.87	0.72	16.61	415.25
PP 17-002	3.43	3.50	3.23	0.14	3.39	84.75
PP 17-003	4.48	4.57	4.60	0.06	4.68	117.00
PP 13-001	6.22	6.32	5.97	0.18	6.17	154.25

Table A.3 Lead content of ground waste plastics.

Type of plastics	run no. 1	run no.2	run no. 3	S.D.	average	concentration (mg/kg)
PE 13-101	0.26	0.20	0.26	0.03	0.24	6.00
PE 13-102	0.00	0.00	0.00	0.00	0.00	0.00
PE 11-101	0.06	0.06	0.06	0.00	0.06	1.50
PE 22-101	2.59	2.79	2.53	0.14	2.67	66.00
PE 17-101	3.46	3.67	3.04	0.32	3.39	84.75
PE 17-102	0.74	0.94	0.79	0.10	0.82	20.50
PS 11-102	0.00	0.00	0.00	0.00	0.00	0.00
PS 16-101	0.08	0.08	0.09	0.01	0.08	2.00
PS 18-101	0.05	0.06	0.05	0.01	0.05	1.25
PP 16-101	4.17	3.80	4.80	0.51	4.26	106.50
PP 16-102	3.05	3.44	3.96	0.46	3.48	87.00
PP 17-101	8.15	8.15	8.15	0.00	8.15	203.75
PP 17-102	8.67	8.85	8.57	0.14	8.70	217.50
PP17-103	5.24	5.17	5.14	0.05	5.18	129.50

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APPENDIX B

The calibration curve of cadmium content is shown in Figure B.

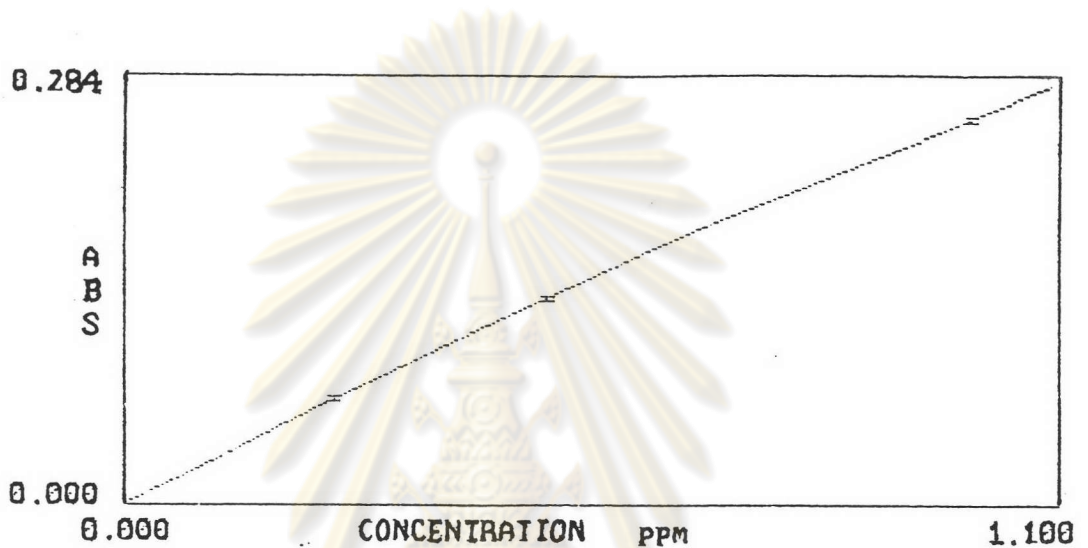


Figure B.1 The calibration curve of PE 17-001, PE 17-101, PE 13-001, PE 13-101, PE 17-002, PE 17-102, PS 18-001, PS 18-101, PS 11-001, PP 16-001, PP 16-101, PP 17-001, PP 17-101, PP17-002, and PP 17-102.

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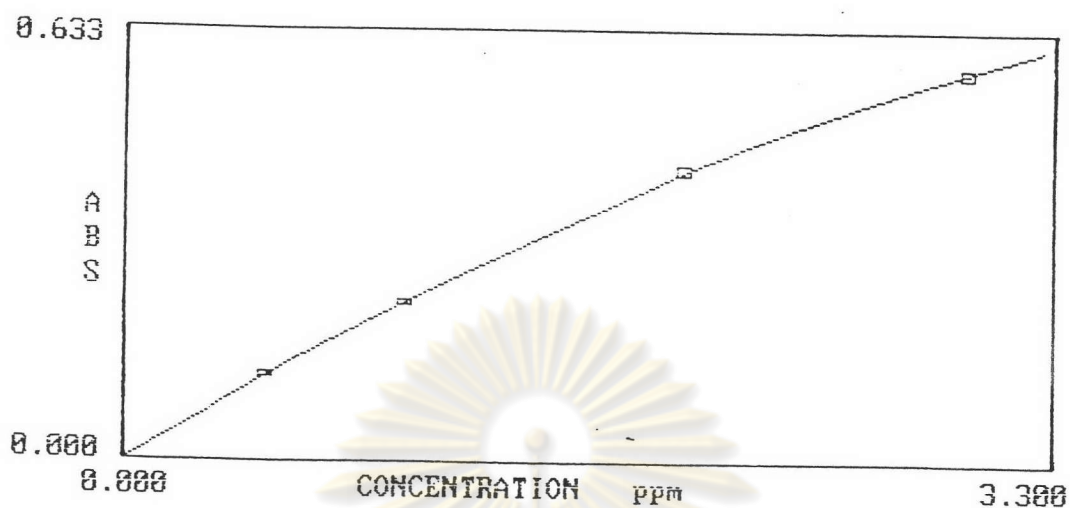


Figure B.2 The calibration curve of PE 14-001, PE 11-001, PE 11-101, PE 14-002, PE 14-003, PE 12-001, PE 35-001, PE 63-001, PE 53-001, PE 33-001, PS 11-002, PS 11-102, PS 16-001, PS 16-101, and PS 21-001.

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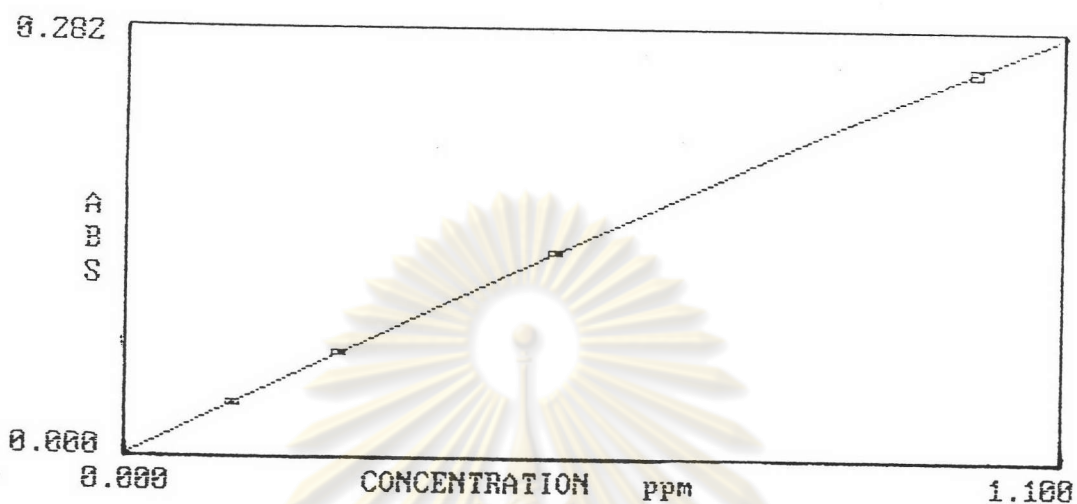


Figure B.3 The calibration curve of PE 22-001, PE 22-101, PE 14-003, PE 63-001, PE 23-001, PE 13-002, PE 13-102, PS 111-001, PS 111-002, PP 17-003, PP 17-103, PP 16-002, PP 16-102, PP 15-001, PP 13-001, and PP 25-001.

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An example of calculation

The calculation of cadmium (mg/kg or ppm) is similar to APPENDIX A

Table B.1 Cadmium content of virgin resin.

Type of plastics	run no.1	run no.2	run no.3	S.D.	average	concentration (mg/kg)
PE 35-001	0.00	0.00	0.00	0.00	0.00	0.00
PE 110-001	0.00	0.00	0.00	0.00	0.00	0.00
PE 111-001	0.00	0.00	0.00	0.00	0.00	0.00
PE 111-002	0.00	0.00	0.00	0.00	0.00	0.00
PP 15-001	0.00	0.00	0.00	0.00	0.00	0.00
PP 25-001	0.00	0.00	0.00	0.00	0.00	0.00

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Table B.2 Cadmium content in recycled plastics.

Type of plastics	run no. 1	run no. 2	run no. 3	S.D.	average	concentration (mg/kg)
PE 12-001	6.17	6.79	7.00	0.43	6.65	665.00
PE 22-001	1.03	1.03	1.05	0.01	1.04	104.00
PE 14-001	0.00	0.00	0.00	0.00	0.00	0.00
PE 14-002	0.00	0.00	0.00	0.00	0.00	0.00
PE 14-003	0.00	0.00	0.00	0.00	0.00	0.00
PE 17-001	1.93	1.92	1.93	0.01	1.93	193.00
PE 17-002	0.34	0.32	0.28	0.03	0.31	31.00
PE 11-001	0.00	0.00	0.00	0.00	0.00	0.00
PE 23-001	0.19	0.18	0.18	0.01	0.18	18.00
PE 33-001	0.95	0.98	0.84	0.07	0.92	92.00
PE 43-001	0.11	0.11	0.11	0.00	0.11	11.00
PE 53-001	0.00	0.00	0.00	0.00	0.00	0.00
PE 63-001	0.00	0.00	0.00	0.00	0.00	0.00
PE13-001	0.00	0.00	0.00	0.00	0.00	0.00
PE 13-002	0.00	0.00	0.00	0.00	0.00	0.00
PS 18-001	0.27	0.26	0.26	0.01	0.26	26.00
PS 11-001	0.07	0.08	0.08	0.01	0.08	8.00
PS 11-002	0.00	0.00	0.00	0.00	0.00	0.00
PS 16-001	0.48	0.46	0.47	0.01	0.47	47.00
PS 21-001	0.00	0.00	0.00	0.00	0.00	0.00
PP 16-001	0.66	0.65	0.66	0.01	0.66	66.00
PP 16-002	0.37	0.39	0.40	0.02	0.39	39.00
PP 17-001	0.63	0.67	0.52	0.08	0.61	61.00
PP 17-002	0.53	0.63	0.59	0.24	0.57	57.00
PP 17-003	0.22	0.20	0.24	0.02	0.22	22.00
PP 13-001	0.69	0.67	0.73	0.03	0.70	70.00

Table B.3 Cadmium content in ground waste plastics.

Type of plastics	run no. 1	run no. 2	run no. 3	S.D.	average	concentration (mg/kg)
PE 13-101	0.00	0.00	0.00	0.00	0.00	0.00
PE 13-102	0.00	0.00	0.00	0.00	0.00	0.00
PE 11-101	0.00	0.00	0.00	0.00	0.00	0.00
PE 22-101	0.34	0.26	0.27	0.04	0.29	29.00
PE 17-101	0.01	0.01	0.01	0.00	0.01	1.00
PE 17-102	0.10	0.14	0.10	0.02	0.11	11.00
PS 11-102	0.00	0.00	0.00	0.00	0.00	0.00
PS 16-101	0.49	0.47	0.50	0.02	0.49	49.00
PS 18-101	0.02	0.02	0.03	0.01	0.02	2.00
PP 16-101	0.74	0.68	0.90	0.11	0.77	77.00
PP 16-102	0.73	0.79	0.75	0.03	0.75	75.00
PP 17-101	1.00	1.02	1.03	0.02	1.02	102.00
PP 17-102	1.30	1.51	1.60	0.05	1.57	157.00
PP 17-103	1.23	1.13	1.01	0.11	1.12	112.00

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APPENDIX C

The calibration curve of mercury content is presented in Figure C.

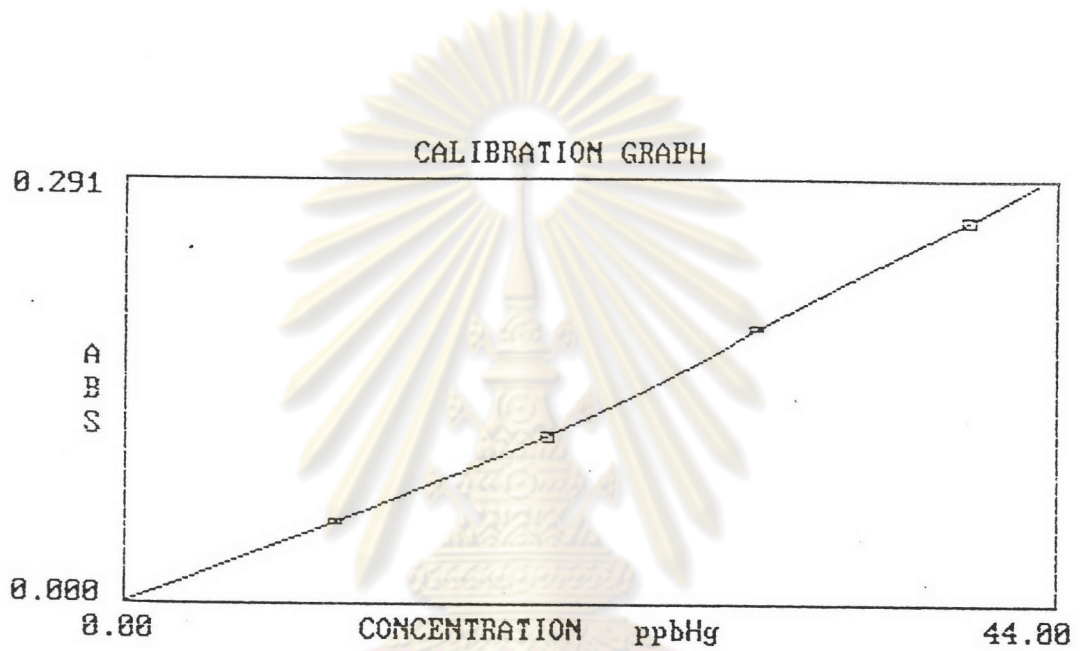


Figure C.1 The calibration curve of PE 13-001, PE 13-101, PE 22-001, PE 22-101, PE 11-001, PE 11-101, PE 14-002, PE 14-003, PE 12-001, PE 35-001, PE 43-001, PE 63-001, PE 23-001, PE 13-002, PE 13-102, PP 15-001, PP 13-001, PP 25-001, PP 17-002, PS 11-002, PS 11-102, PS 21-001, and PS 11-001.

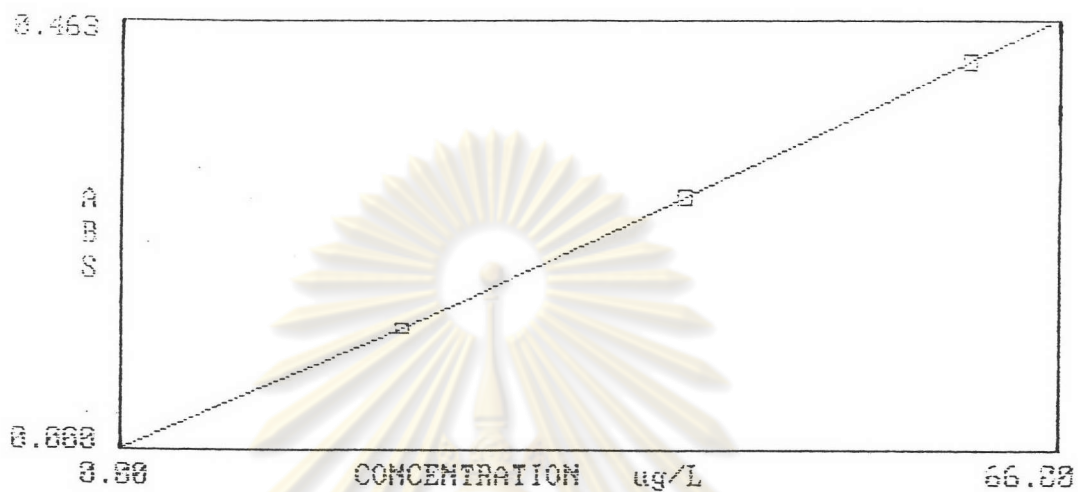


Figure C.2 The calibration curve of PE 17-001, PE 17-101, PE 17-002, PE 17-102, PE 53-001, PE 33-001, PP 16-001, PP 16-101, PP 17-001, PP 17-101, PP 17-003, PP 17-103, PP 16-002, PP 16-102, PS 18-001, PS 18-101, PS 16-001, PS 16-101, PS 111-001, and PS 111-002.

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An example of calculation

The calculation of mercury ($\mu\text{g}/\text{kg}$ or ppb) is similar to APPENDIX A

Table C.1 Mercury content of virgin resin.

Type of plastics	concentration($\mu\text{g}/\text{l}$)	concentration ($\mu\text{g}/\text{kg}$)
PE 35-001	0.00	0.00
PE 110-001	0.00	0.00
PS 111-001	0.00	0.00
PS 111-002	0.00	0.00
PP 15-001	0.00	0.00
PP 25-001	0.00	0.00

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Table C.2 Mercury content of recycled resin.

Type of plastics	concentration($\mu\text{g/l}$)	concentration ($\mu\text{g/kg}$)
PE 12-001	0.00	0.00
PE 22-001	12.50	2.50
PE 14-001	0.00	0.00
PE 14-002	0.00	0.00
PE 14-003	0.00	0.00
PE 17-001	50.19	1003.80
PE 17-002	0.00	0.00
PE 11-001	0.00	0.00
PE 23-001	39.60	792.00
PE 33-001	41.10	822.00
PE 43-001	7.41	148.20
PE 53-001	75.80	1516.00
PE 63-001	64.50	1290.00
PE 13-001	0.98	19.60
PE 13-002	0.00	0.00
PS 18-001	1.70	34.00
PS 11-001	17.9	358.00
PS 11-002	0.00	0.00
PS 16-001	43.80	876.00
PS 21-001	15.60	312.00
PP 16-001	25.46	509.20
PP 16-002	47.60	952.00
PP 17-001	22.84	456.00
PP17-002	20.85	417.00
PP 17-003	30.10	602.00

Table C.3 Mercury content of ground waste plastics.

Type of plastics	concentration (mg/l)	concentration (mg/kg)
PE 13-101	1.70	34.00
PE 13-102	0.00	0.00
PE 11-101	0.00	0.00
PE 22-101	31.00	620.00
PE 17-101	1.80	36.00
PE 17-102	0.00	0.00
PS 11-102	25.30	506.00
PS 16-101	59.90	1198.00
PS 18-101	2.40	48.00
PP 16-101	1.70	34.00
PP 16-102	64.00	1280.00
PP 17-101	29.27	585.40
PP 17-102	10.10	202.00
PP 17-103	51.30	1026.00

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APPENDIX D

The result of quantitative measurement of styrene monomer is shown in Figure D.1 to Figure D.30.

Calibration Curve

The calibration graph is drawn by plotting the ratio of peak area, A'_a/A'_s , against the respective concentrations in milligram per litre. The calibration graph is shown in Figure D 31 and Figure D 32 . With the corresponding ratios determined from the sample solution, A_a/A_s , the concentration of substance to be determined in sample solution, C_a , may be taken from the calibration graph. From the calibration graph. From C_a , the concentration of styrene monomer (mg/kg) in the polystyrene sample , P_a , is calculated according to the relation :

$$P_a(\text{mg/kg}) = 1.5C_aV/M_p$$

By

A'_a is the peak area of styrene monomer to be determined in the calibration solution

A'_s is the peak area of internal standard (n-butylbenzene) in the calibration solution

A_a is the peak area of styrene to be determined in sample solution

A_s is the peak area of internal standard (m-butylbenzene) in sample solution

C_a is the concentration of styrene monomer in sample solution, expressed in milligrams per litre

M_p is the mass of polymer sample, expressed in grams

V is the volume of sample solution

P_a is the content of styrene monomer in polystyrene expressed in milligrams per kilogram.

An example of calculation

The concentration of styrene monomer which obtained from the calibration graph for PS 18-001 is 57.29 ppm (mg/l). In this experiment, the volume of sample solution equal 15 ml and weight of polystyrene as 1.5 g. so, V and M_p are 15 and 1.5, respectively. The calculation as following:

$$P_a = 1.5 C_a V / M_p$$

$$= 1.5(57.29)(15) / 1.5$$

$$P_a = 859.35 \text{ mg/kg}$$

For sample of PS 18-001 has styrene monomer 859.35 mg/kg.

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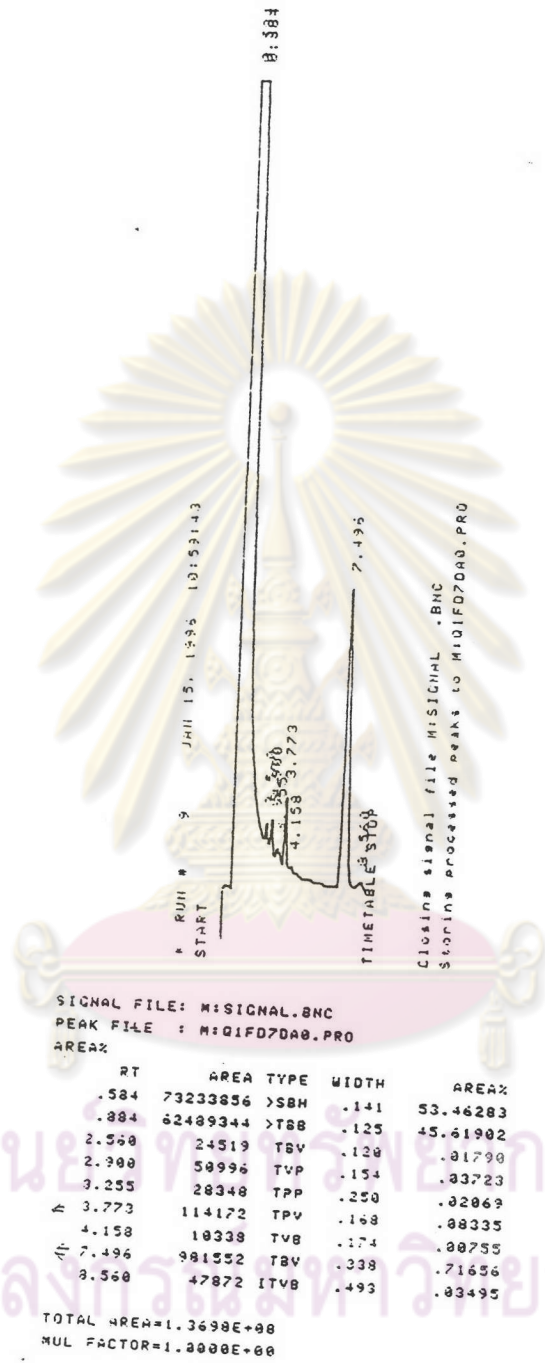


Figure D.1 GC chromatogram of PS 111-001 (1).

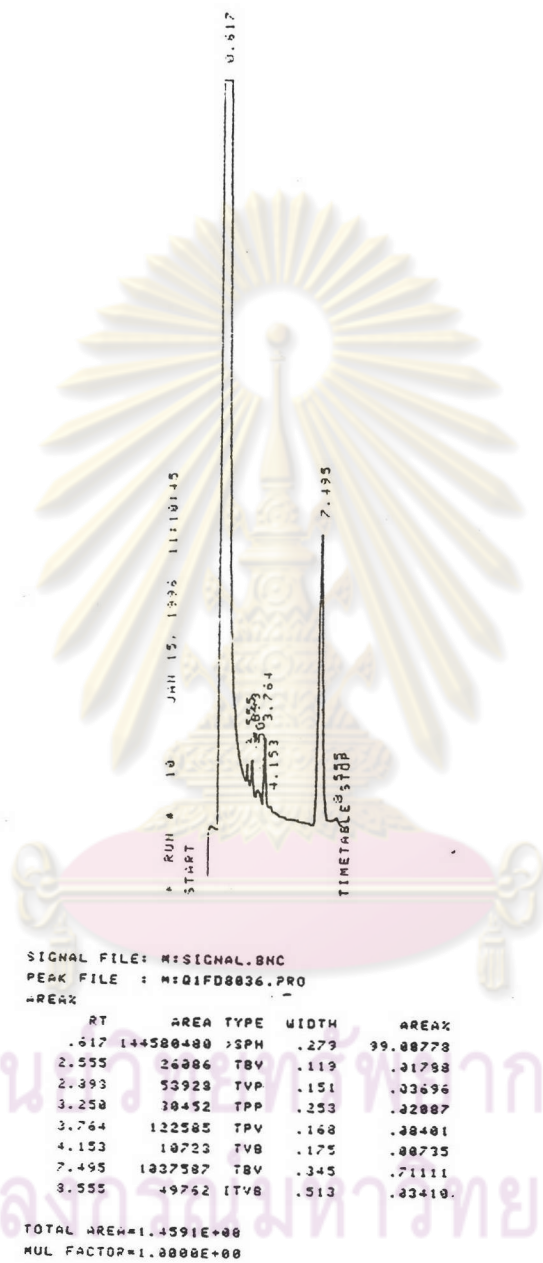


Figure D.2 GC chromatogram of PS 111-001 (2).

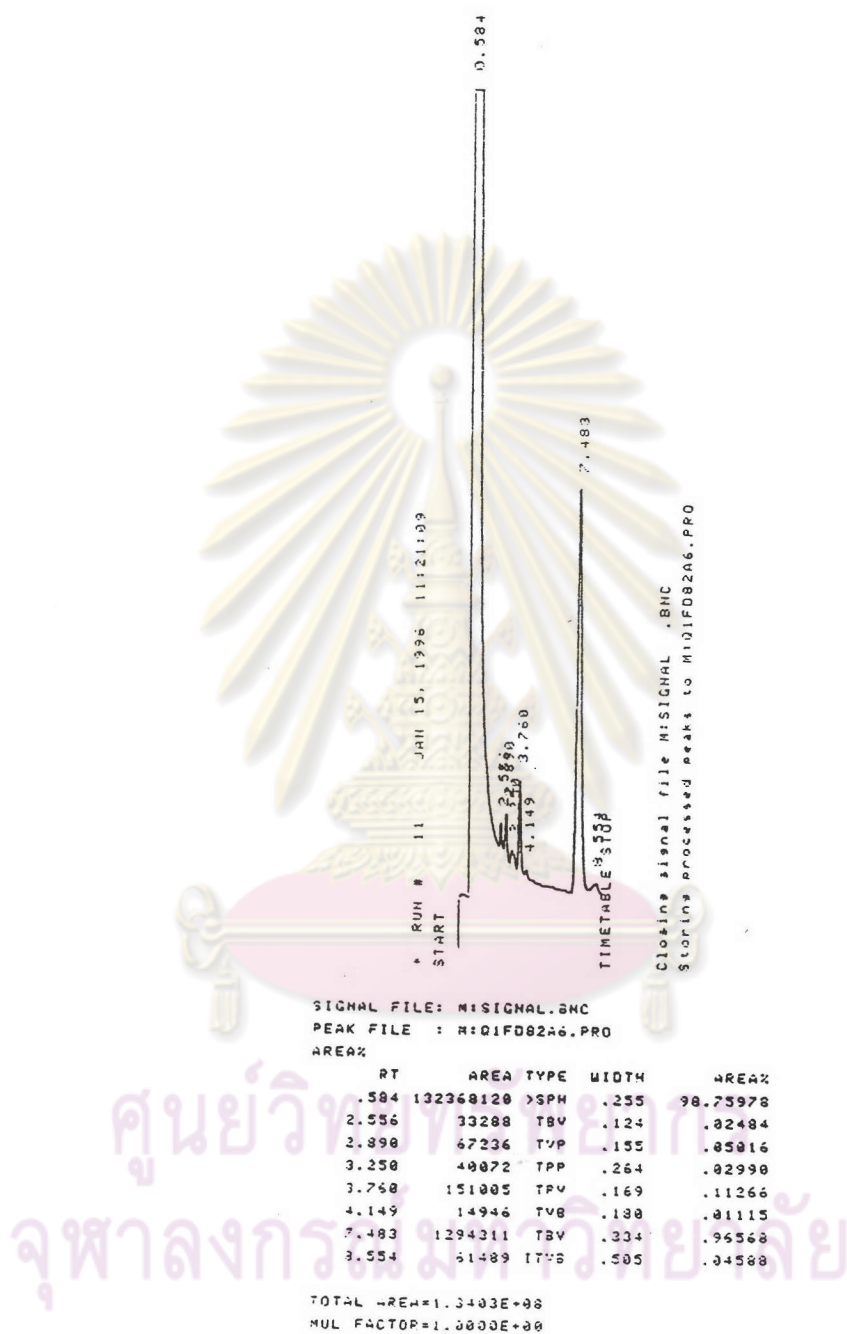


Figure D.3 GC chromatogram of PS 111-001 (3).

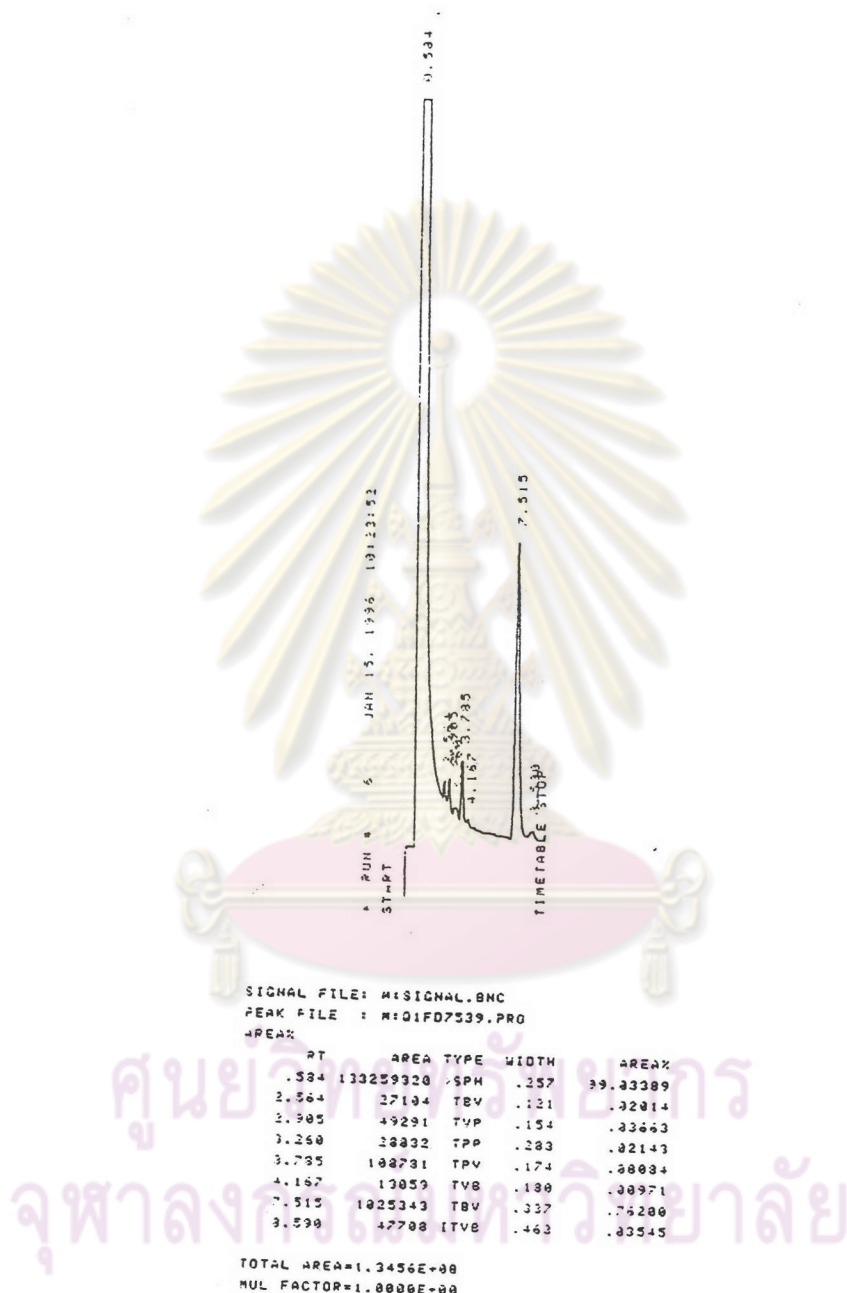


Figure D.4 GC chromatogram of PS 111-002 (1).

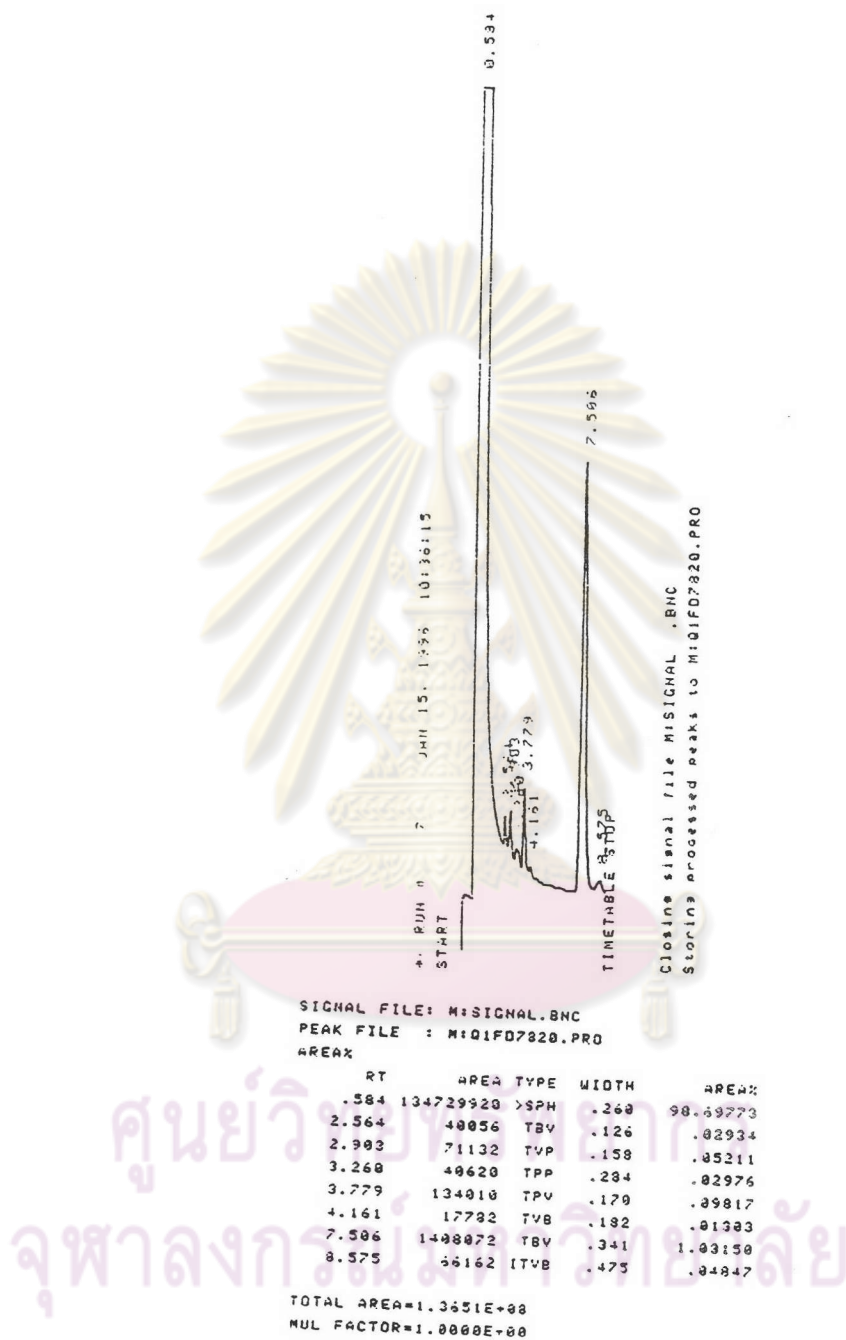


Figure D.5 GC chromatogram of PS 111-002 (2).

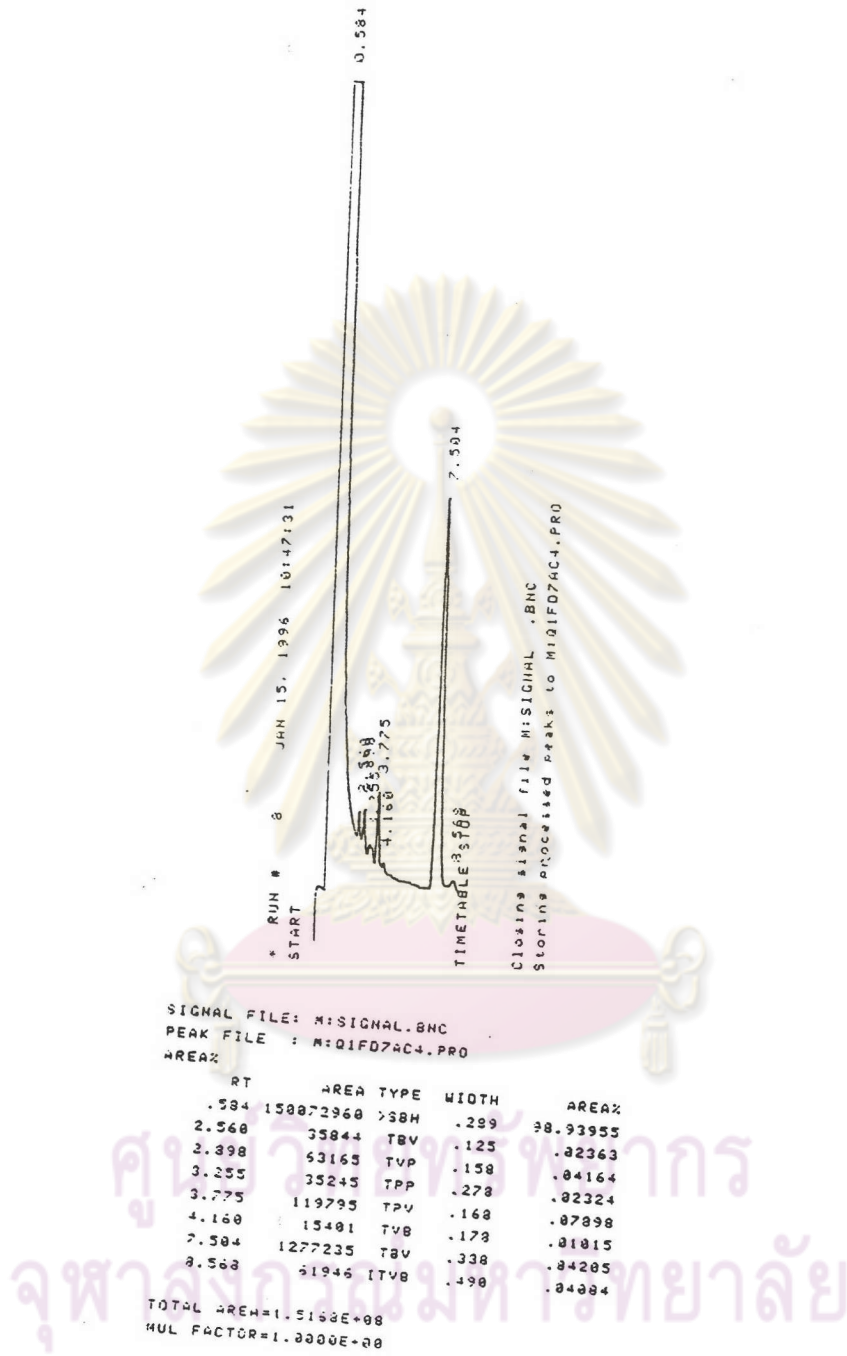


Figure D.6 GC chromatogram of PS 111-002 (3).

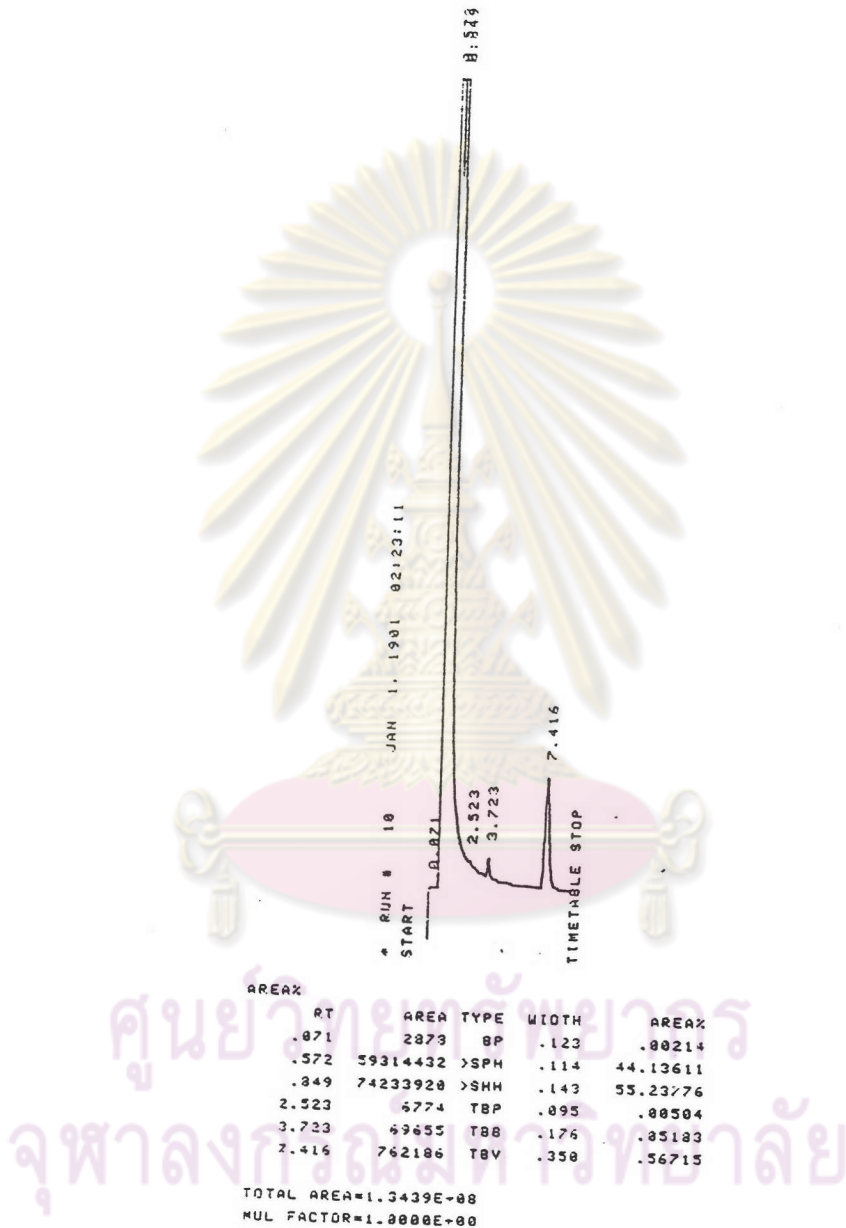


Figure D.7 GC chromatogram of PS 18-001 (1).

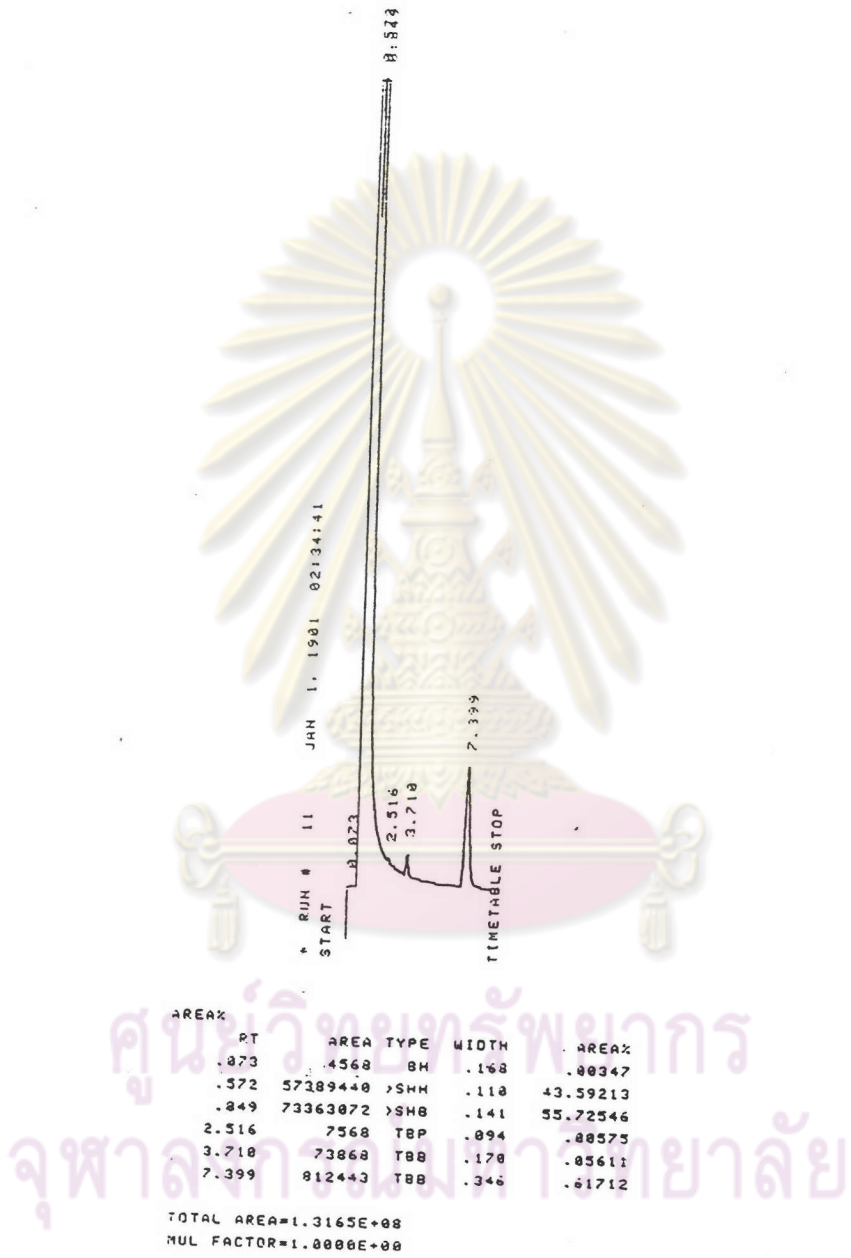


Figure D.8 GC chromatogram of PS 18-001 (2).

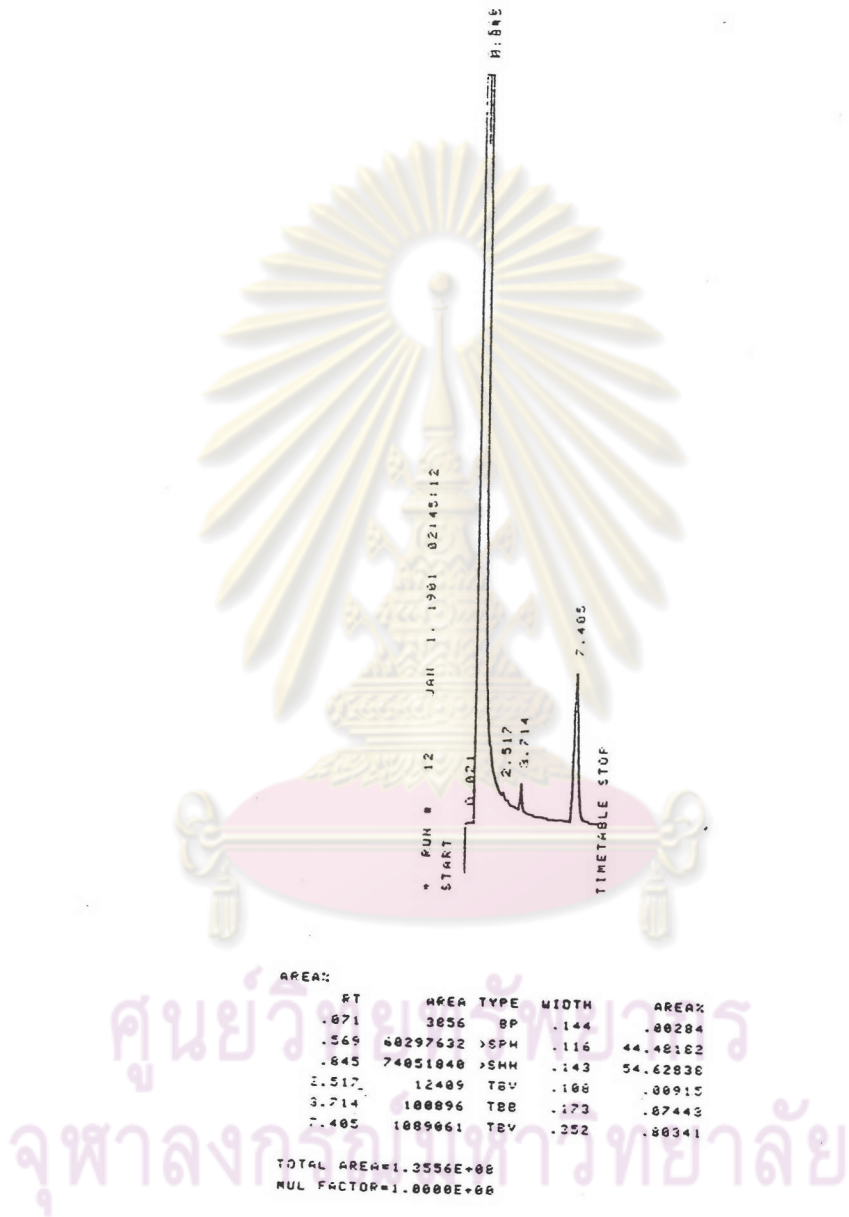


Figure D.9 GC chromatogram of PS 18-001 (3).

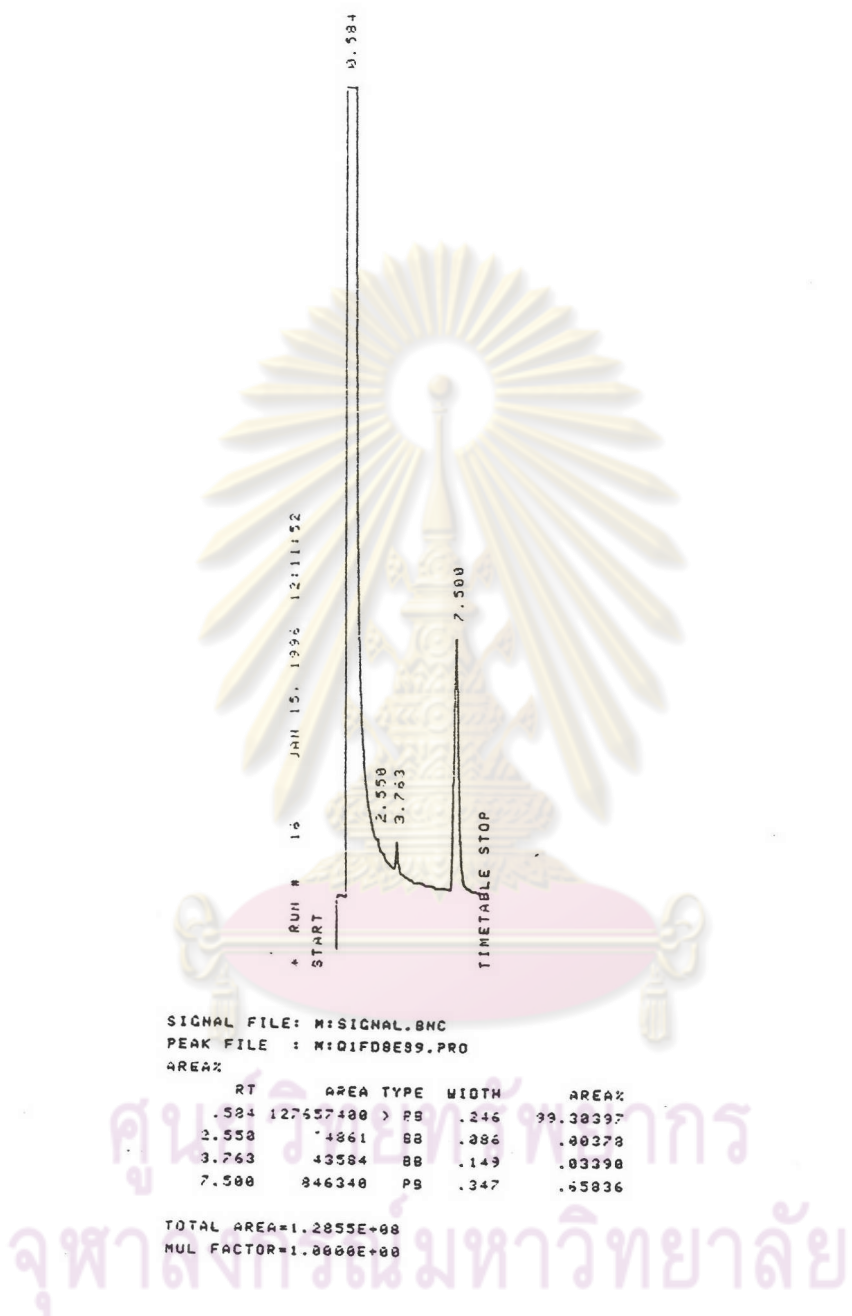
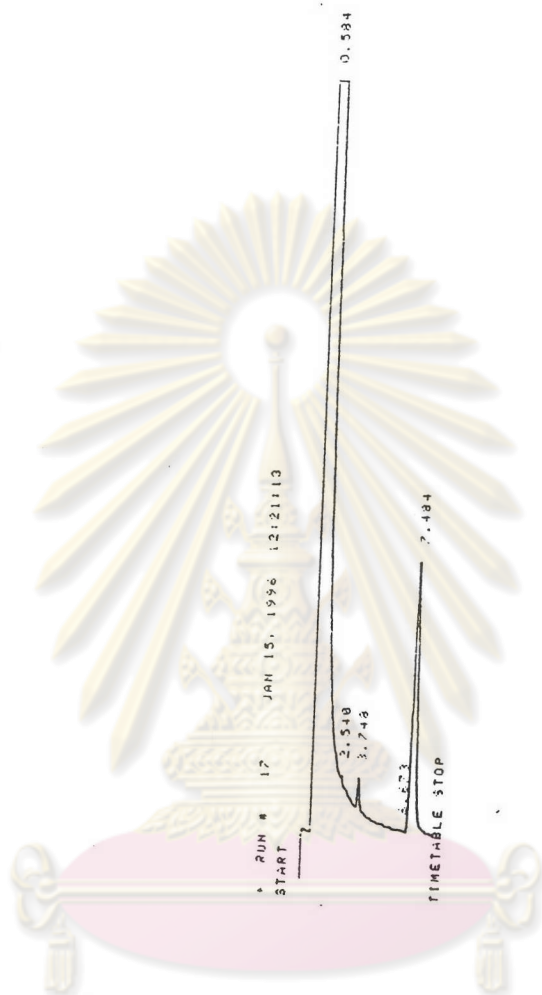


Figure D.10 GC chromatogram of PS 11-002 (1).



SIGNAL FILE: M:SIGNAL.BNC
PEAK FILE : M:DIFD908A.PRO
BREAK

RT	AREA	TYPE	WIDTH	AREA%
0.584	141674648	PS	.274	99.28477
2.540	4987	SB	.088	.00349
3.748	51616	SB	.155	.03617
5.673	6933	SP	.273	.00423
7.484	558017	PS	.345	.67137

TOTAL AREA=1.4279E+09
MUL FACTOR=1.0000E-08

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Figure D.11 GC chromatogram of PS 11-002 (2).

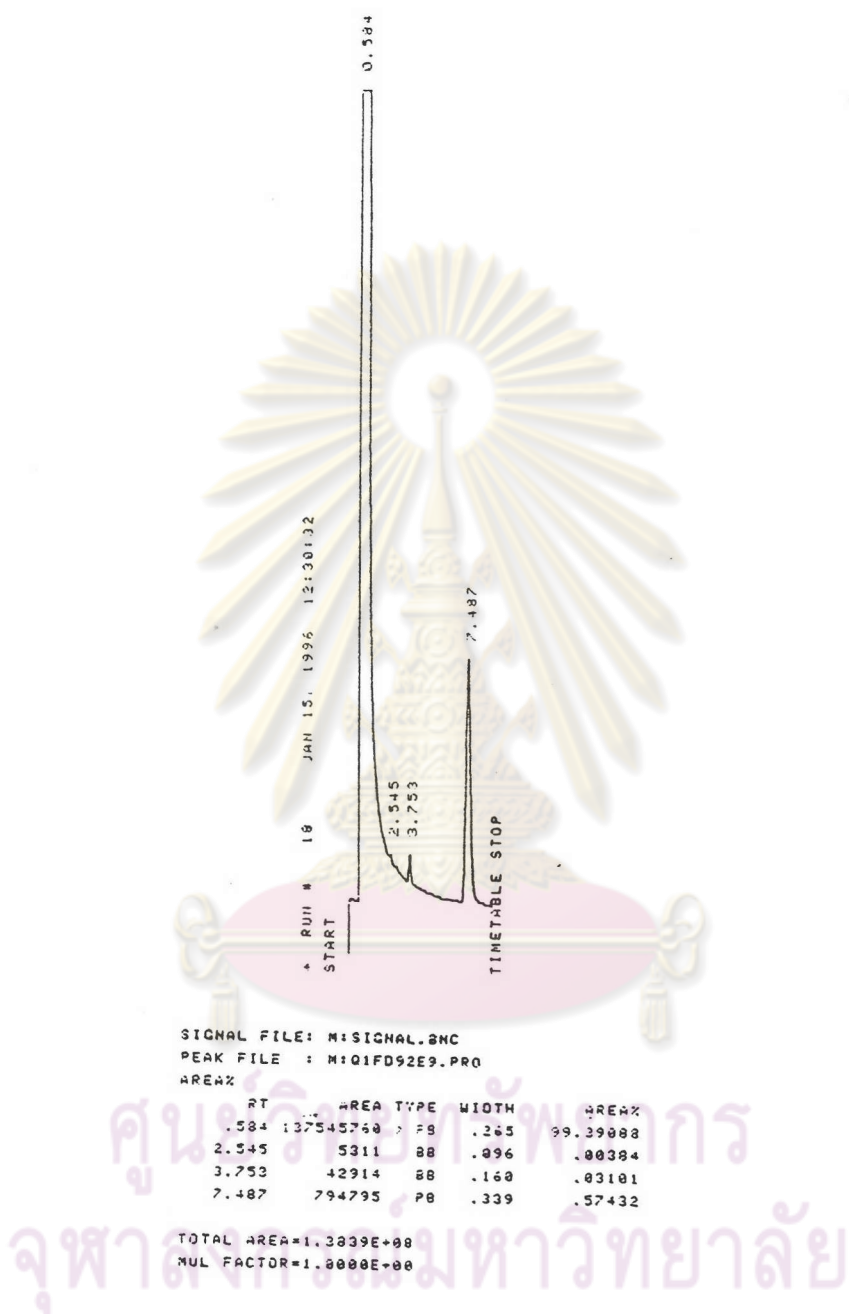


Figure D.12 GC chromatogram of PS 11-002 (3).

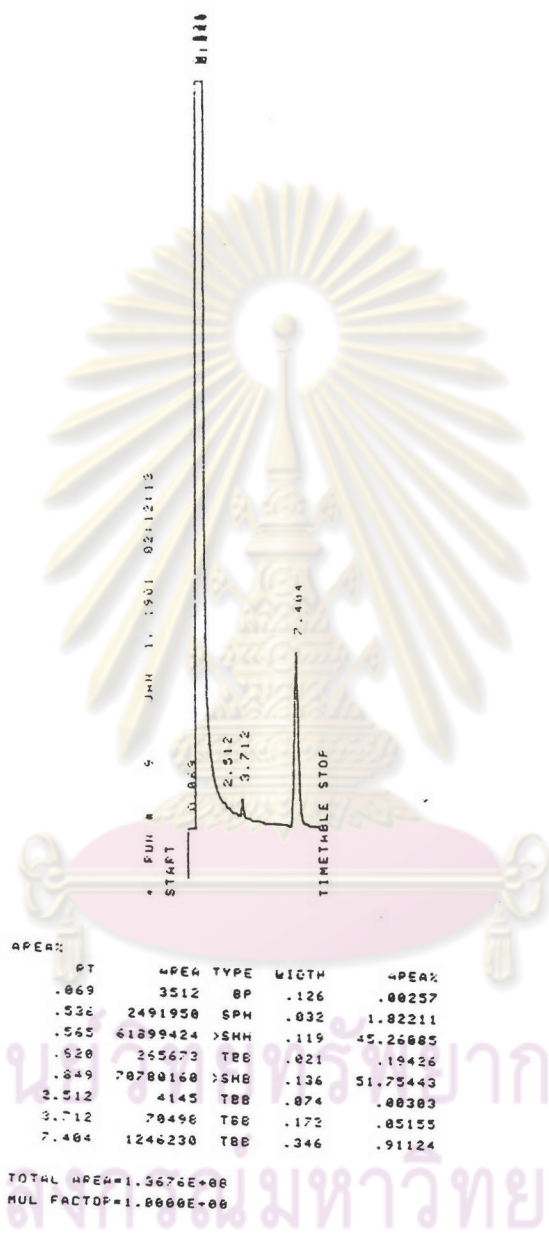


Figure D.13 GC chromatogram of PS 16-001 (1).

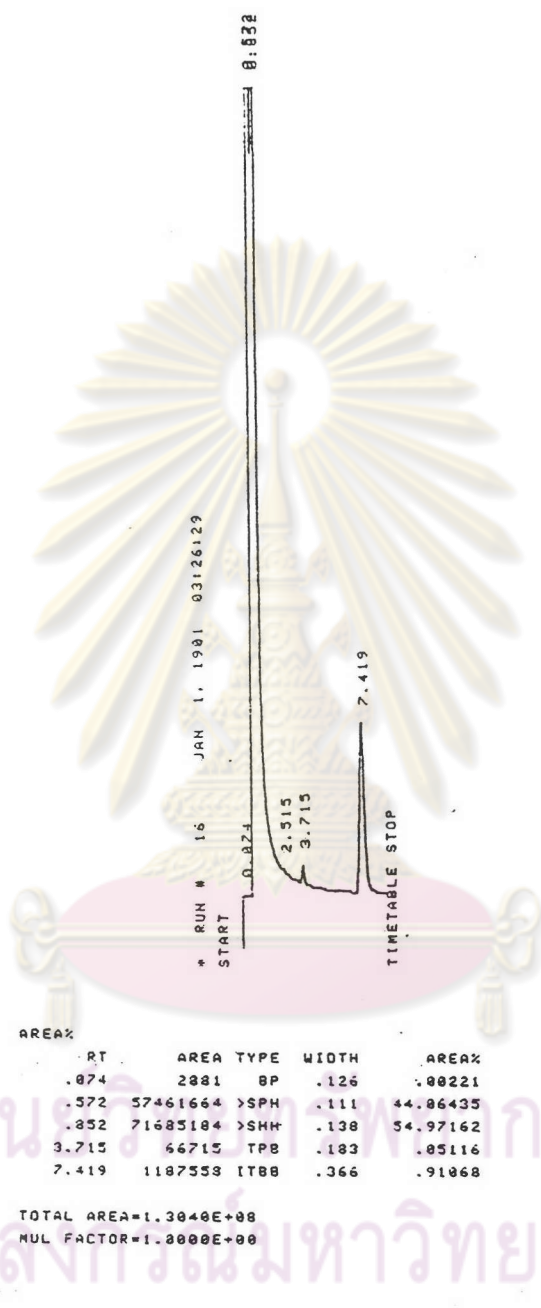


Figure D.14 GC chromatogram of PS 16-001 (2).

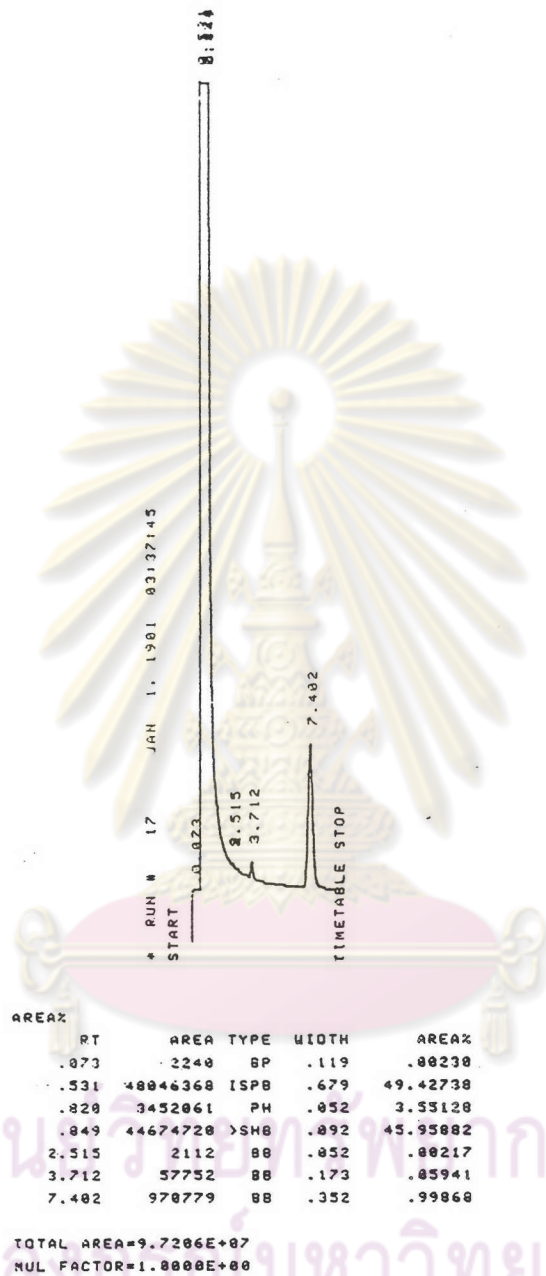


Figure D.15 GC chromatogram of PS 16-001 (3).

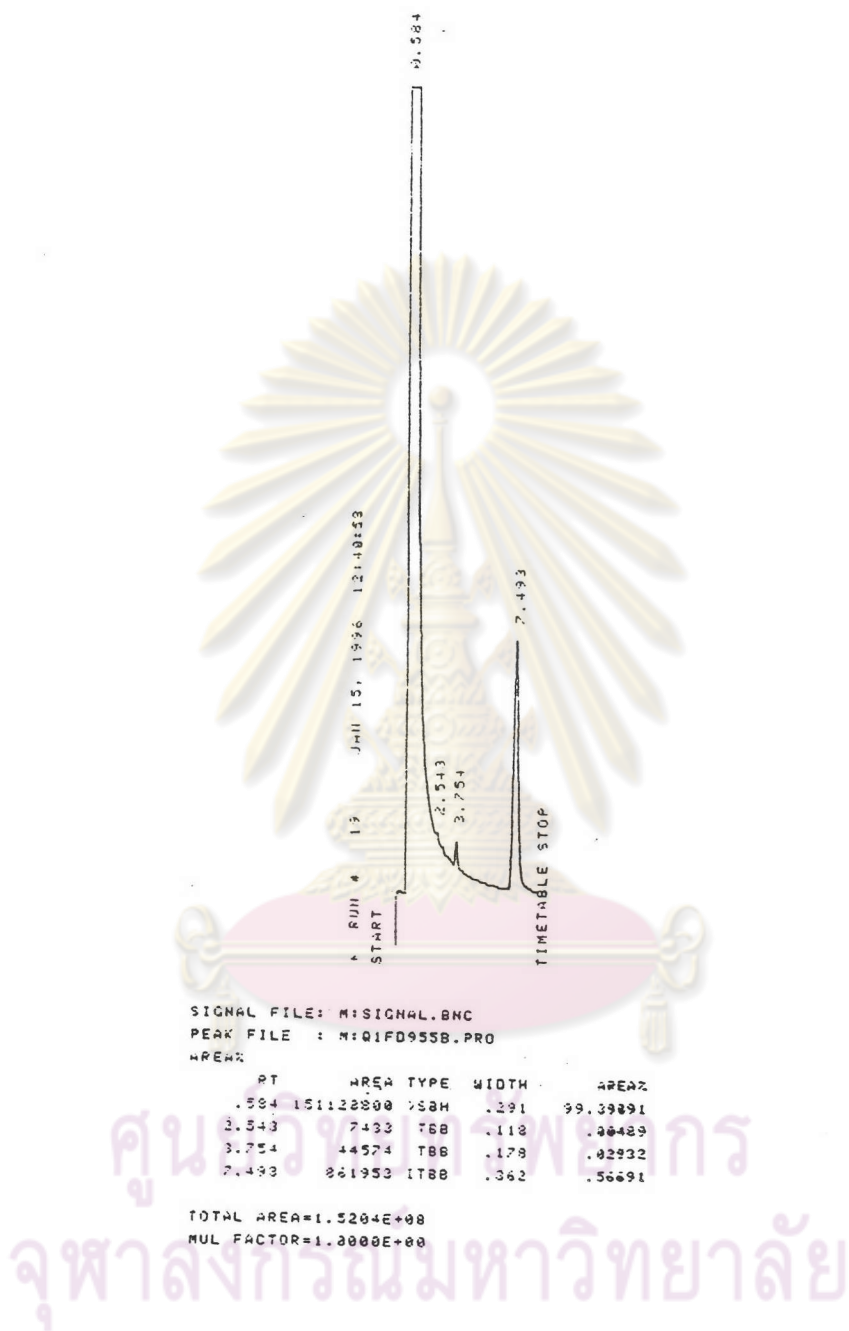
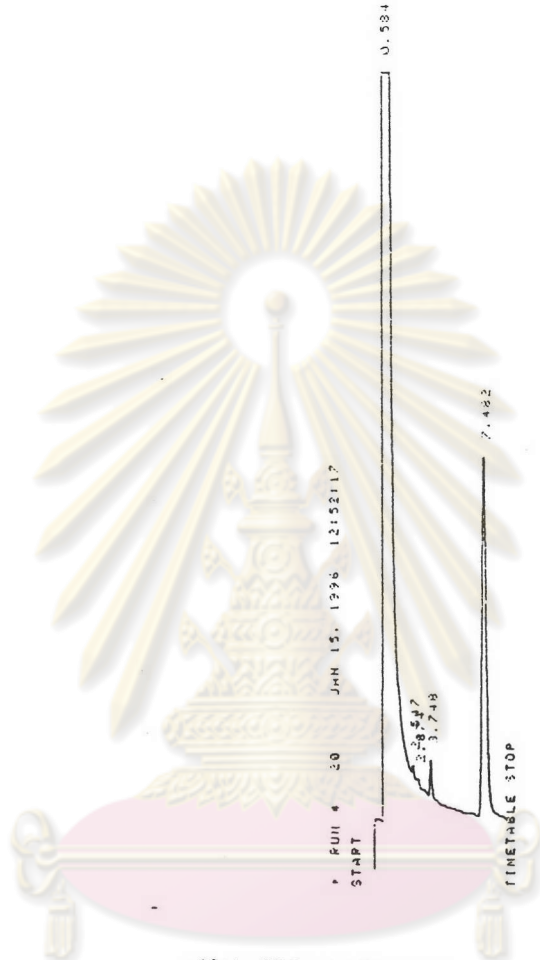


Figure D.16 GC chromatogram of PS 11-001 (1).



SIGNAL FILE: H:\SIGNAL.BNC
 PEAK FILE : M:\01FD9882.PRO
 #PEAK

RT	AREA	TYPE	WIDTH	%PEAK
0.534	143194328	SBM	.276	99.83891
2.547	12255	TBP	.114	.00917
2.374	7914	TV8	.134	.00547
3.748	49634	TBB	.171	.04816
7.482	1298886	ITBB	.349	.09931

TOTAL AREA=1.4459E+08
 MUL FACTOR=1.0600E-08

Figure D.17 GC chromatogram of PS 11-001 (2).

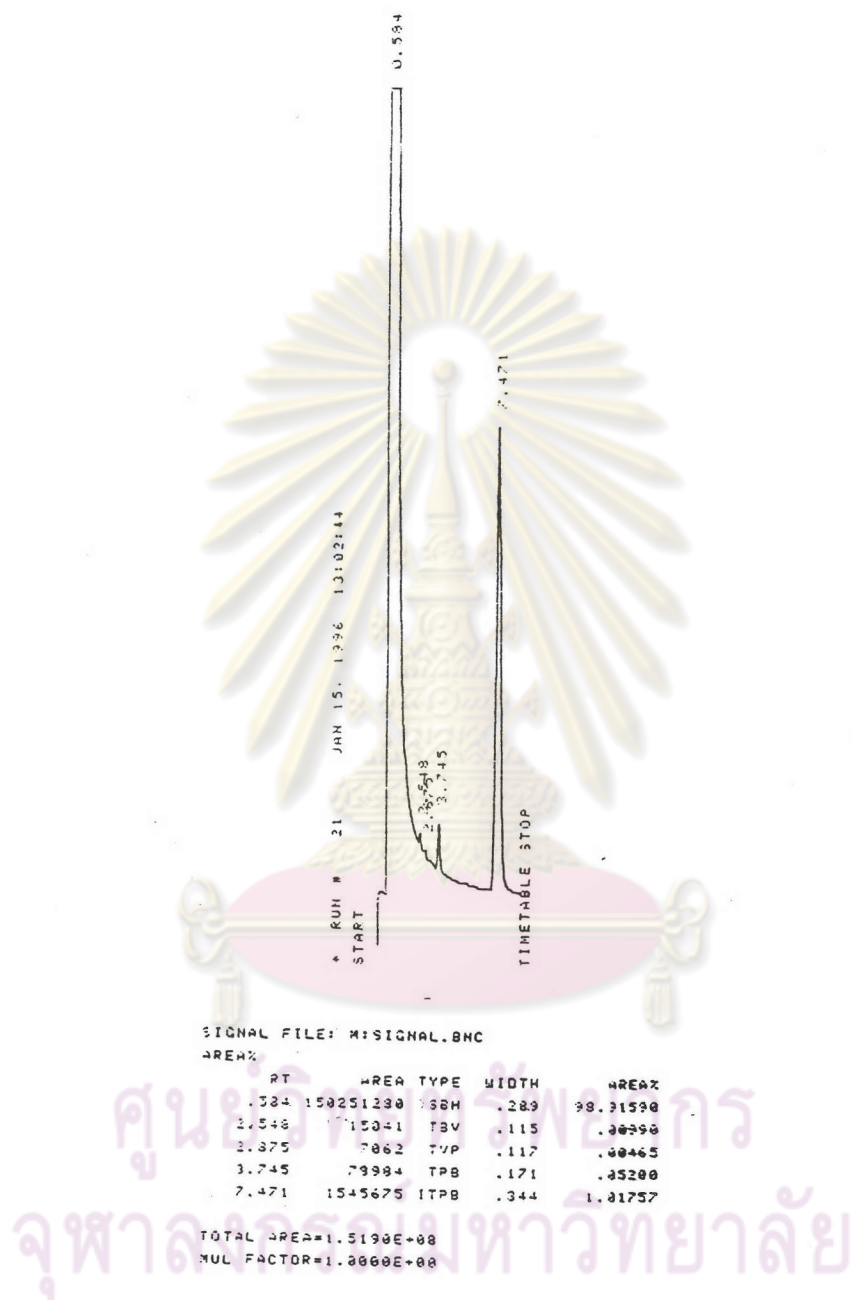
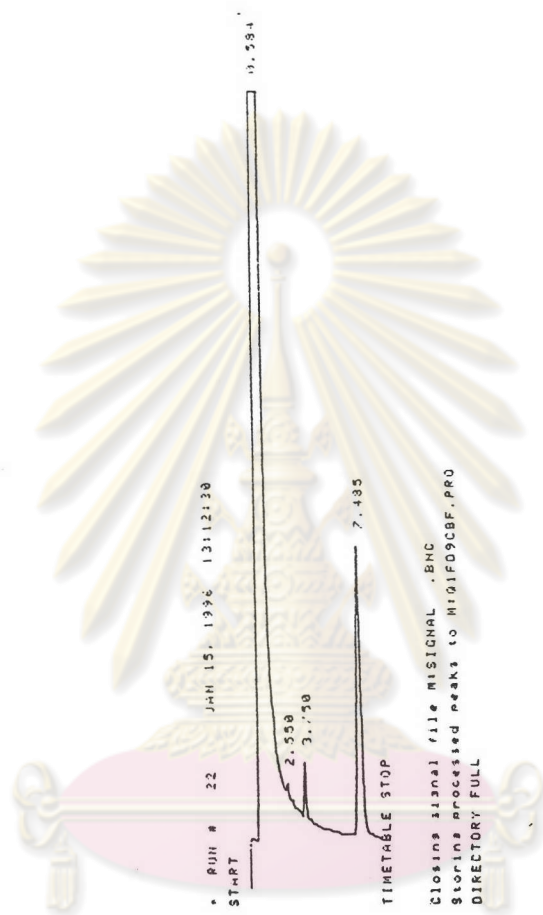


Figure D.18 GC chromatogram of PS 11-001 (3).



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SIGNAL FILE: M SIGNAL.BMC
 -REAX

RT	AREA	TYPE	WIDTH	AREAX
2.558	146326248	SBB	.232	33.22720
3.750	149222	TBY	.123	.01005
7.485	99435	TBB	.172	.06743
	1225396	FB	.247	.59534

TOTAL AREA=1.4747E+08
 MUL FACTOR=1.0000E+00

Figure D.19 GC chromatogram of PS 21-001 (1).

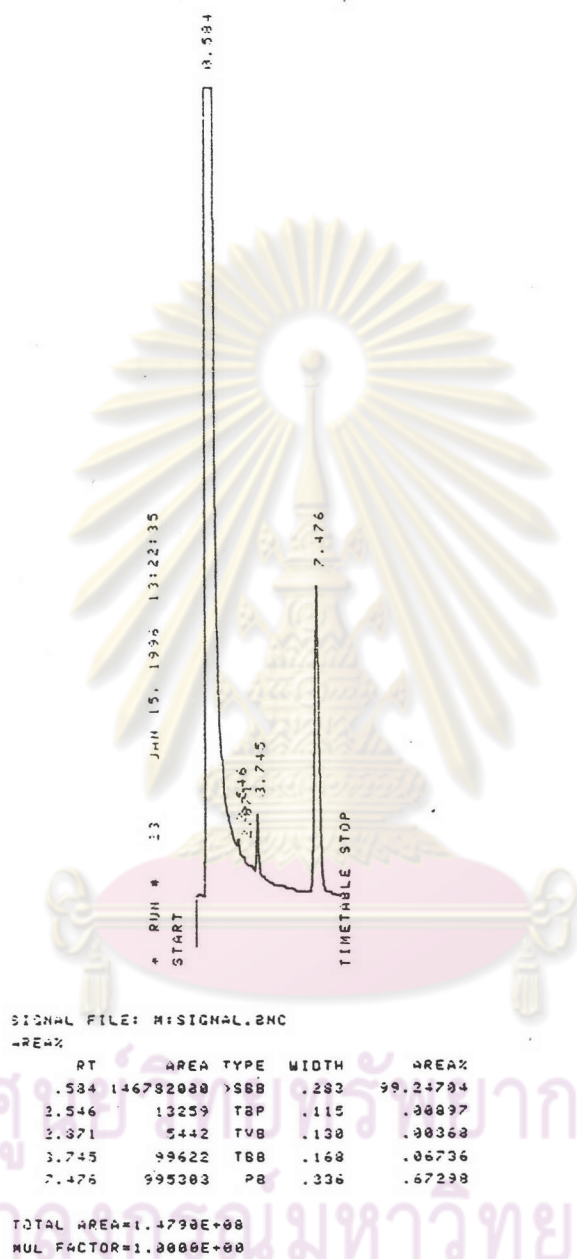


Figure D.20 GC chromatogram of PS 21-001 (2).

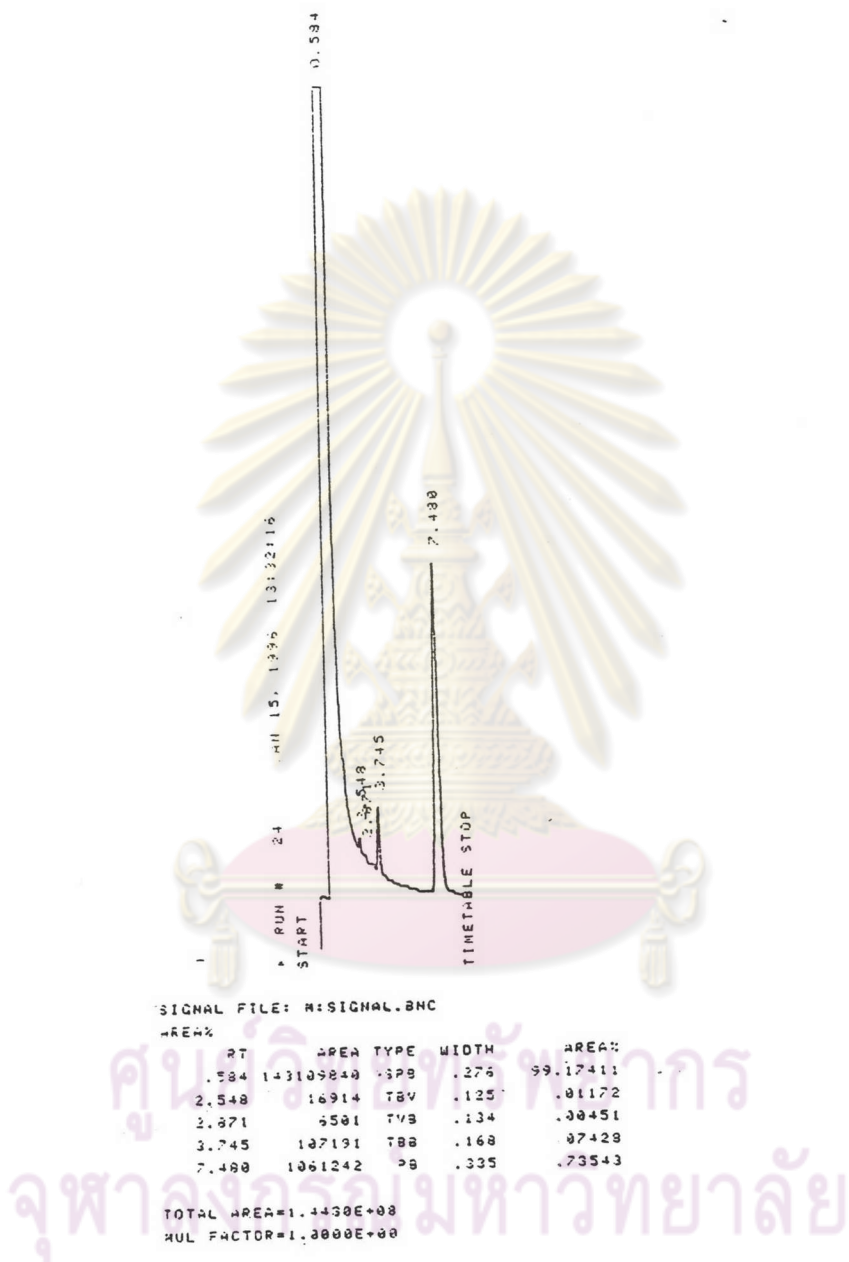


Figure D.21 GC chromatogram of PS 21-001 (3).

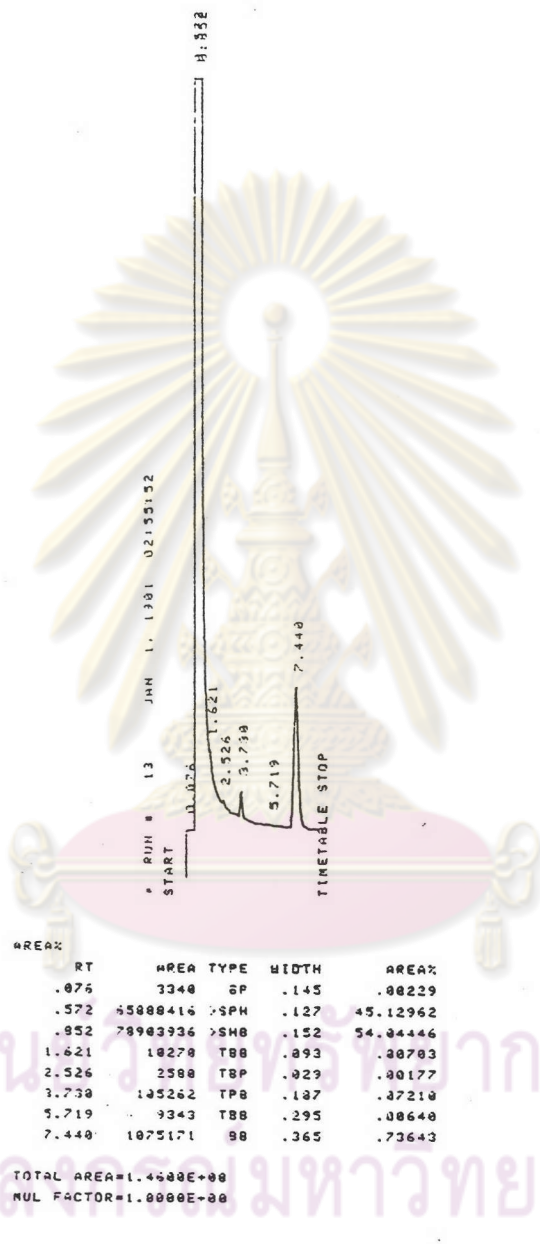


Figure D.22 GC chromatogram of PS 18-101 (1).

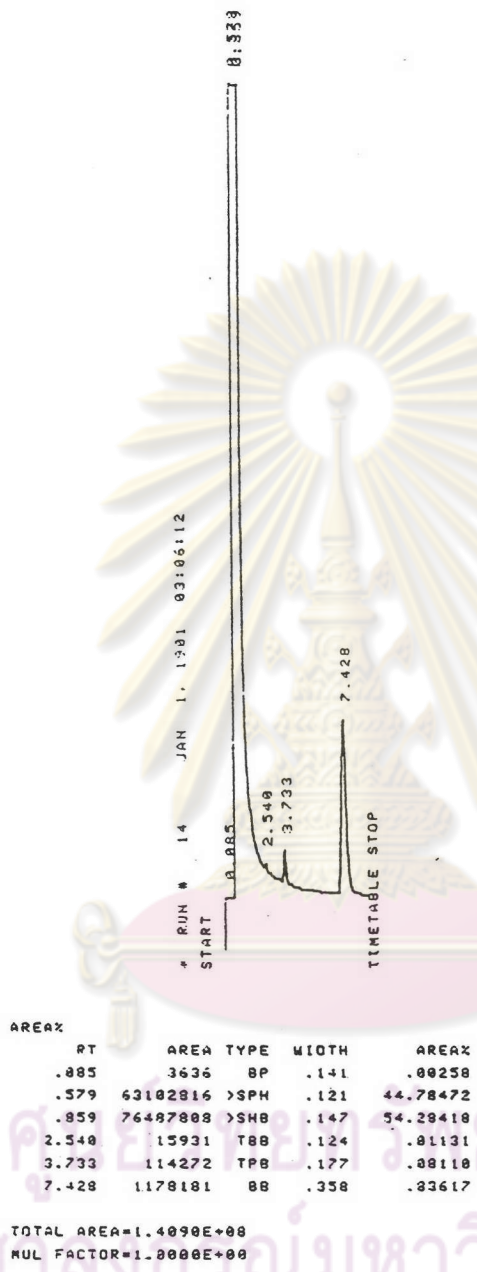


Figure D.23 GC chromatogram of PS 18-101 (2).

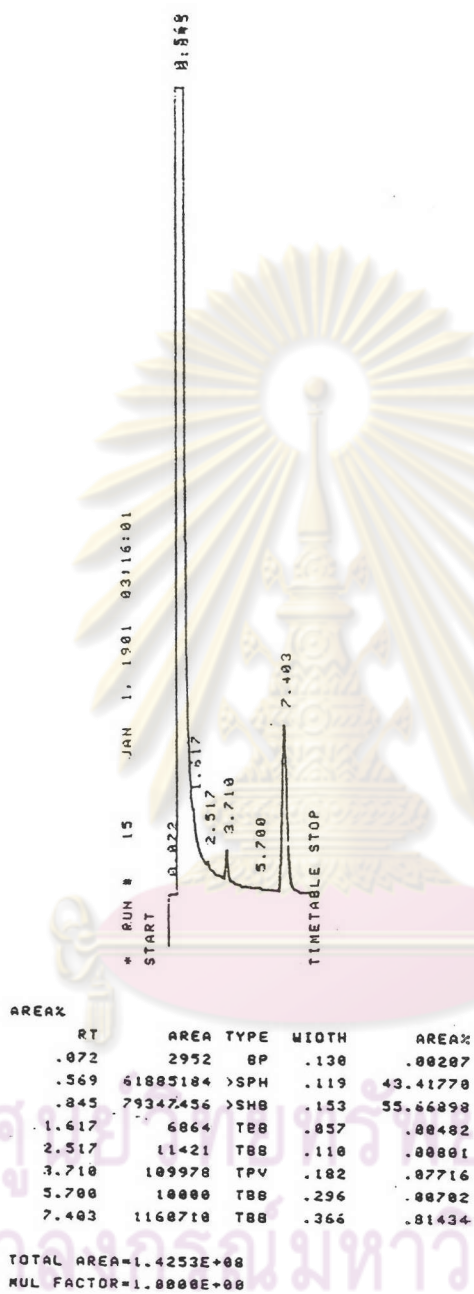


Figure D.24 GC chromatogram of PS 18-101 (3).



Figure D. 27 GC chromatogram of PS 11-102 (3).

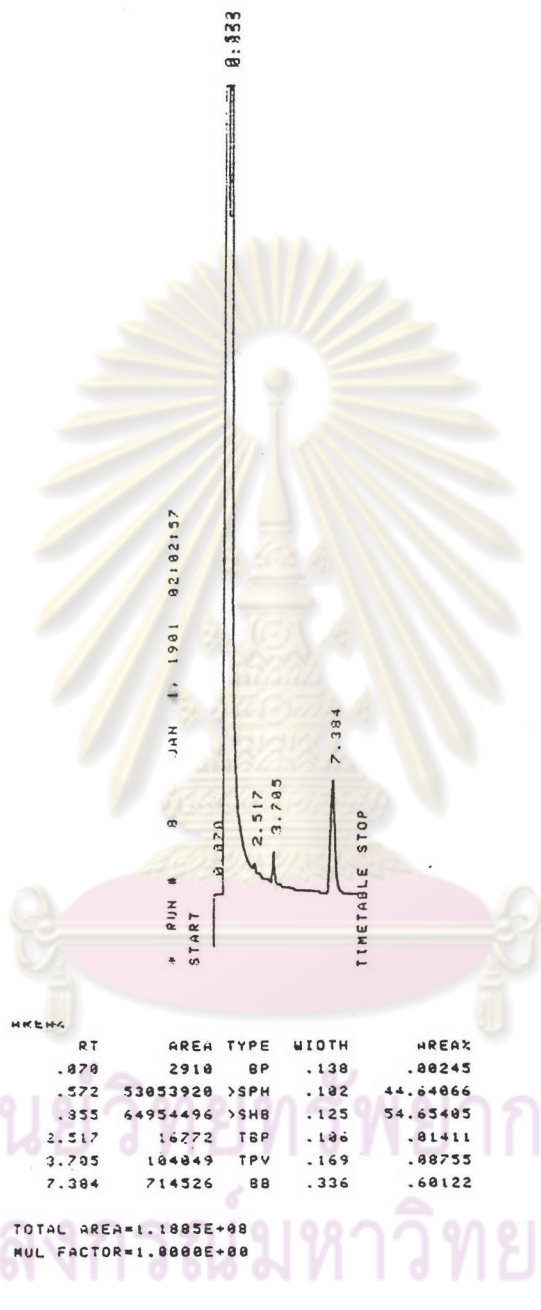


Figure D.28 GC chromatogram of PS 16-101 (1).

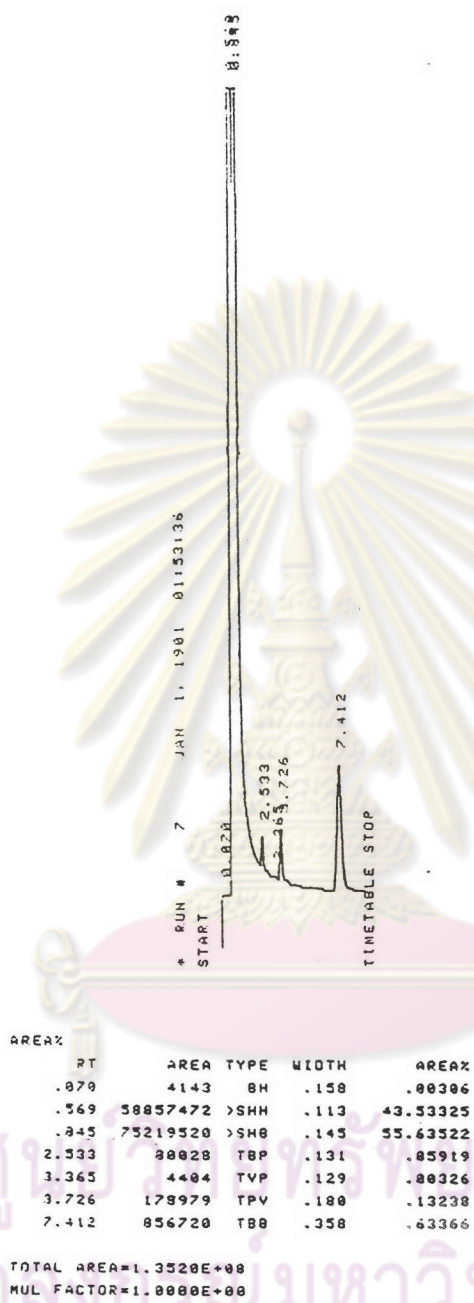


Figure D.29 GC chromatogram of PS 16-101 (2).

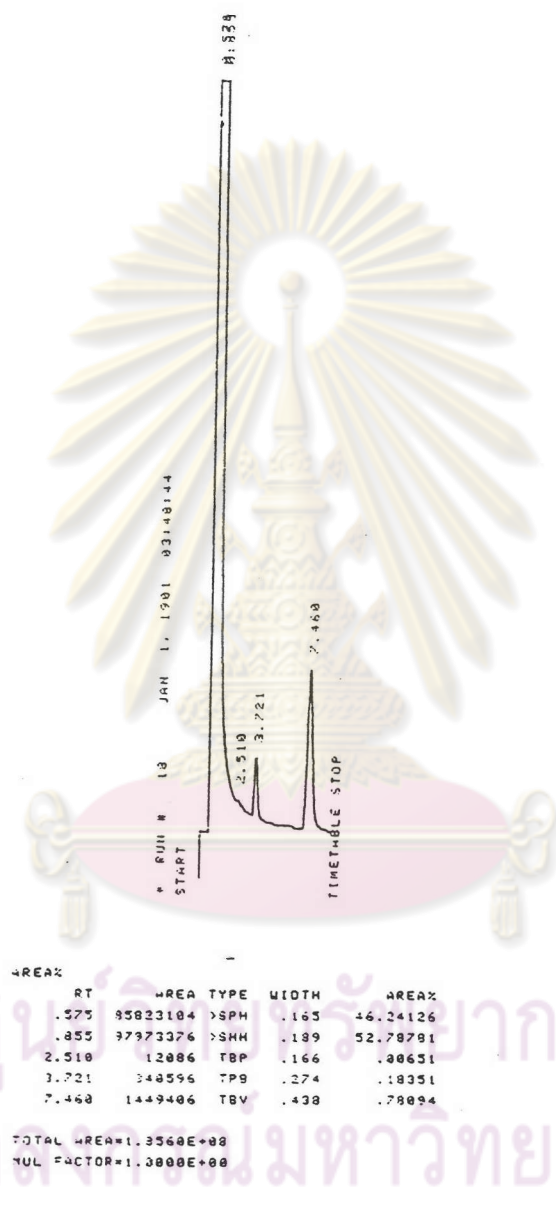


Figure D.30 GC chromatogram of PS 16-101 (3).

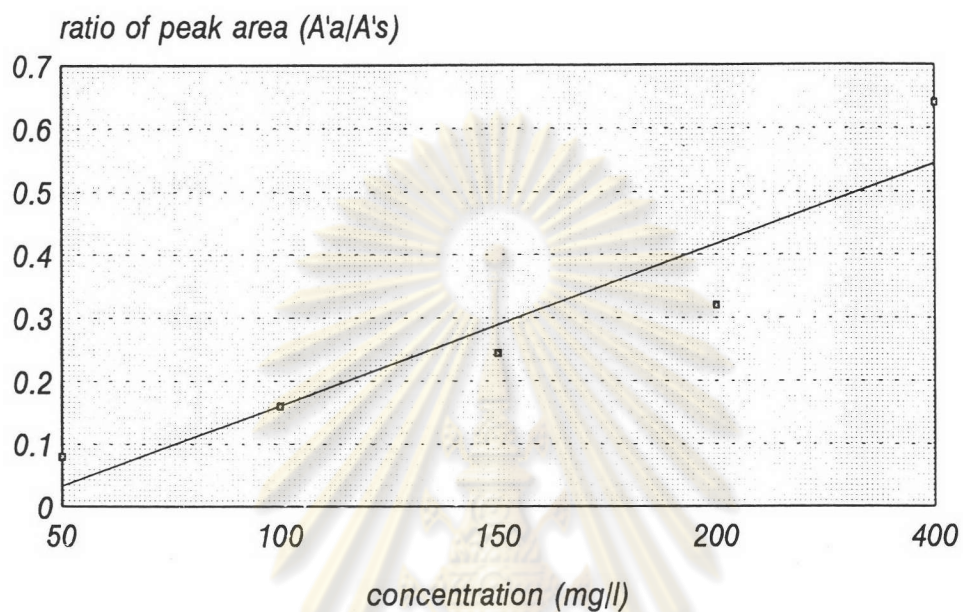


Figure D.31 The calibration curve for PS 111-001, PS 111-002, PS 11-002, PS 11-001, PS 21-001, and PS 11-102.

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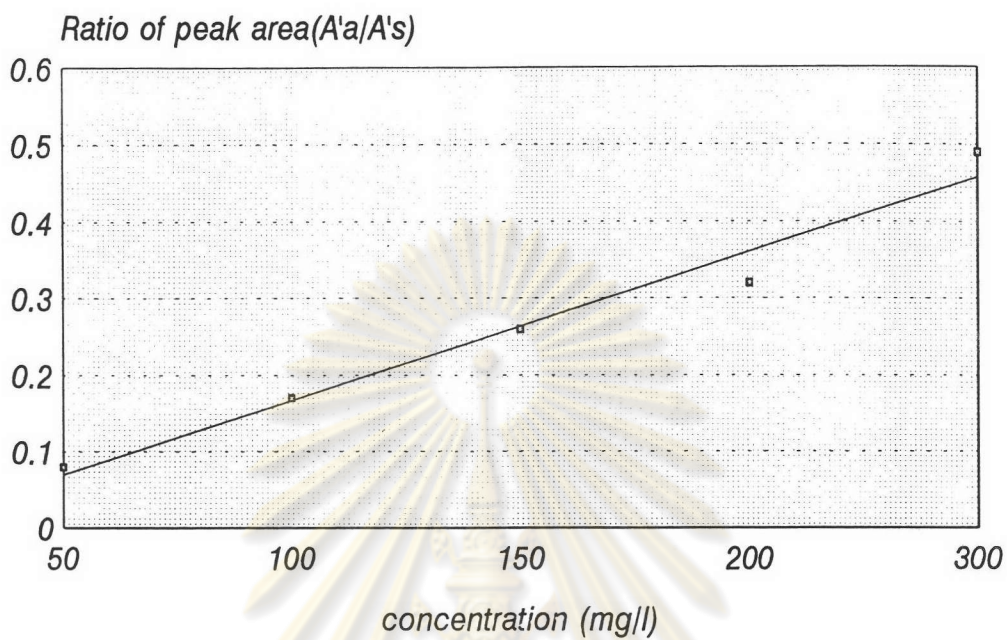


Figure D.32 The calibration curve for PS 18-001, PS 16-001, PS 18-101, and PS 16-101.

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Table D.1 Styrene monomer content obtained from calibration graph for virgin resins, recycled plastics, and ground waste plastics.

Type of plastics	run no.1	run no.2	run no.3
PS 111-001	0.116	0.118	0.116
PS 111-002	0.106	0.095	0.94
PS 18-001	0.091	0.091	0.093
PS 11-002	0.051	0.054	0.054
PS 16-001	0.057	0.056	0.059
PS 11-001	0.051	0.054	0.051
PS 21-001	0.097	0.100	0.101
PS 18-101	0.098	0.097	0.097
PS 11-102	0.051	0.045	0.040
PS 16-101	0.145	0.209	0.235

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Table D.2 Styrene monomer content (mg/kg) of polystyrene.

Type of plastics	run no. 1	run no. 2	run no. 3	S.D.	average	concentration (mg/kg)
PS 111-001	72.50	73.75	72.50	0.72	72.92	1093.76
PS 111-002	66.25	59.38	58.375	4.16	61.46	921.90
PS 18-001	56.88	56.88	58.12	0.72	52.29	859.35
PS 11-002	31.88	33.75	33.75	1.08	33.13	496.95
PS 16-001	35.63	35.00	36.87	0.78	35.83	537.45
PS 11-001	31.88	33.76	31.88	1.09	32.51	487.65
PS 21-001	60.43	62.50	63.12	1.30	62.08	931.20
PS 18-101	61.25	60.63	60.63	0.00	60.83	912.45
PS 11-102	31.88	28.12	25.00	3.48	28.33	424.95
PS 16-101	90.63	130.63	146.88	25.89	122.71	1840.65

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VITA

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