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APPENDIX A

Gas chromatogram and mass spectrum of standard PAHs



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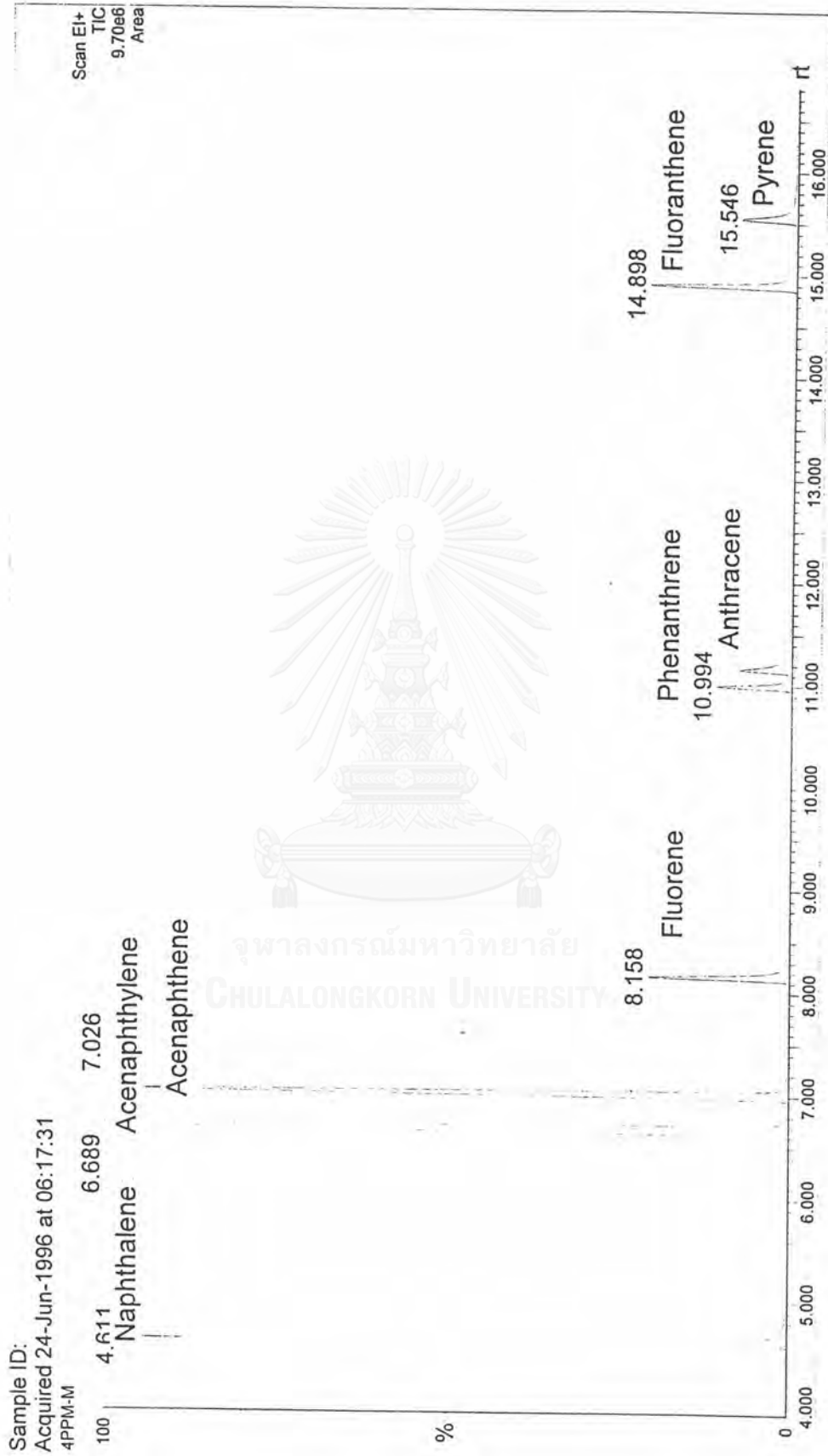


Figure A1 Gas Chromatogram of Standard PAHs

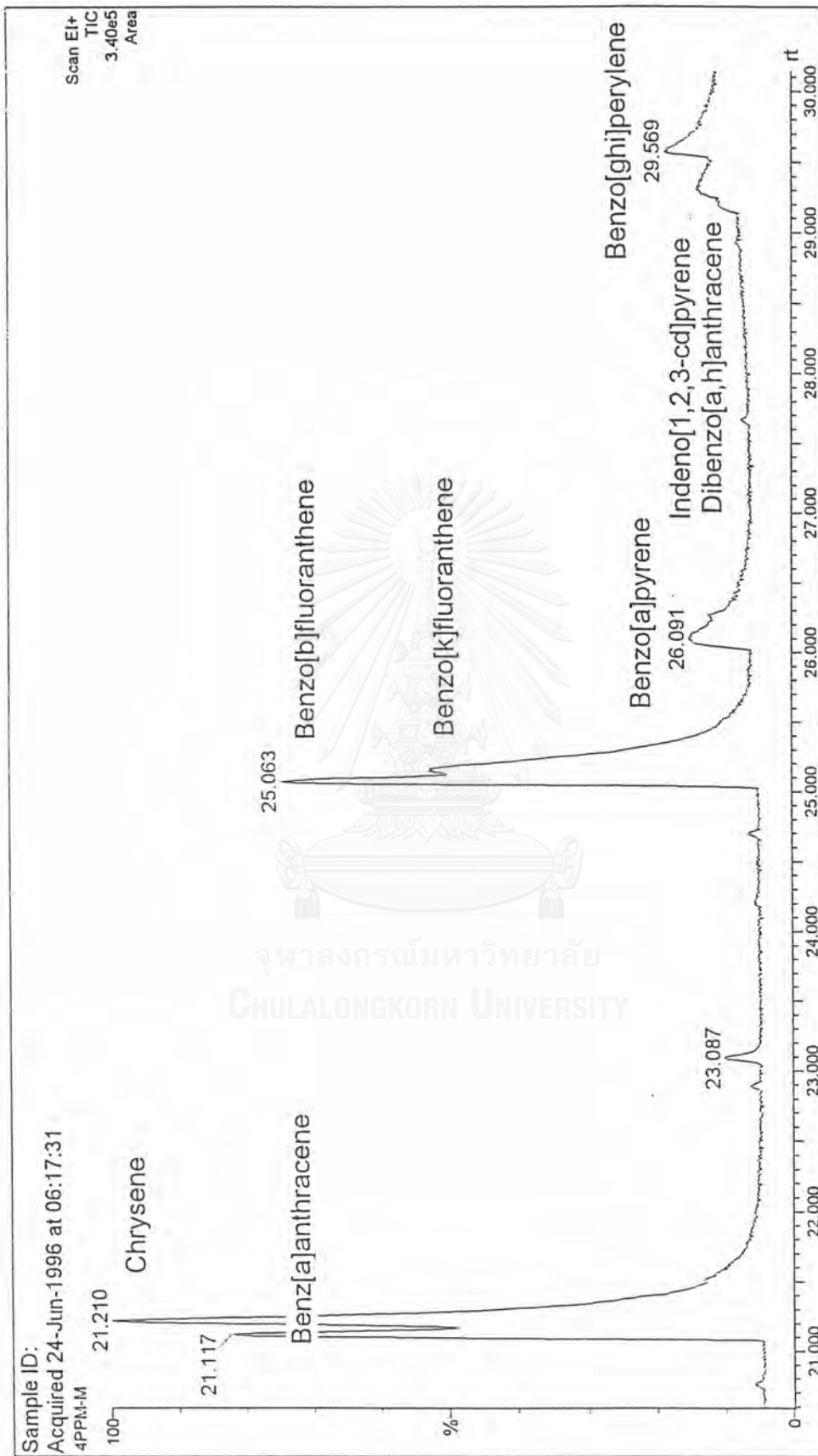


Figure A1 (continued) Gas Chromatogram of Standard PAHs

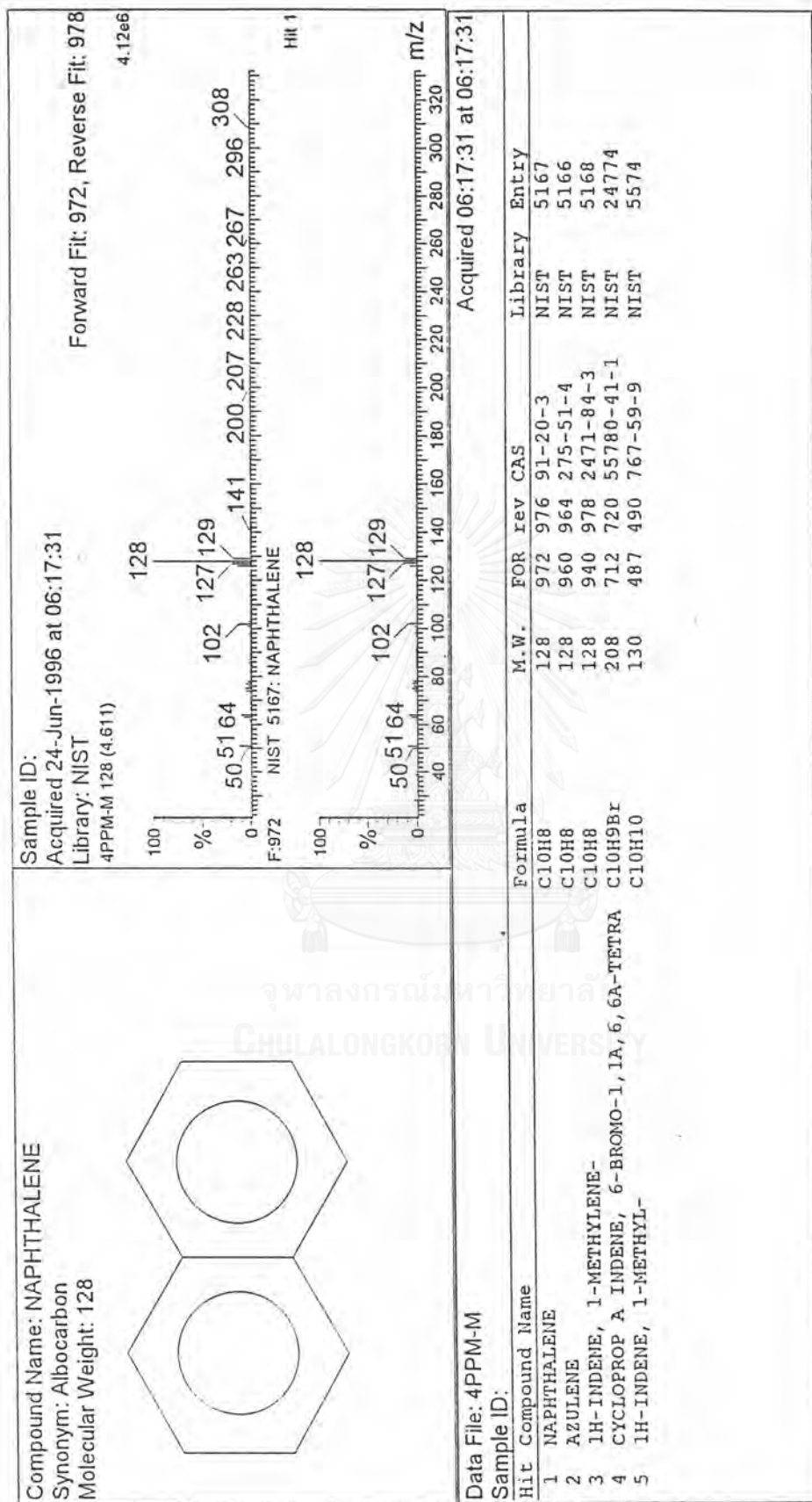


Figure A2 Comparison of Mass Spectra of Standard Naphthalene with Mass Spectra in NIST Library

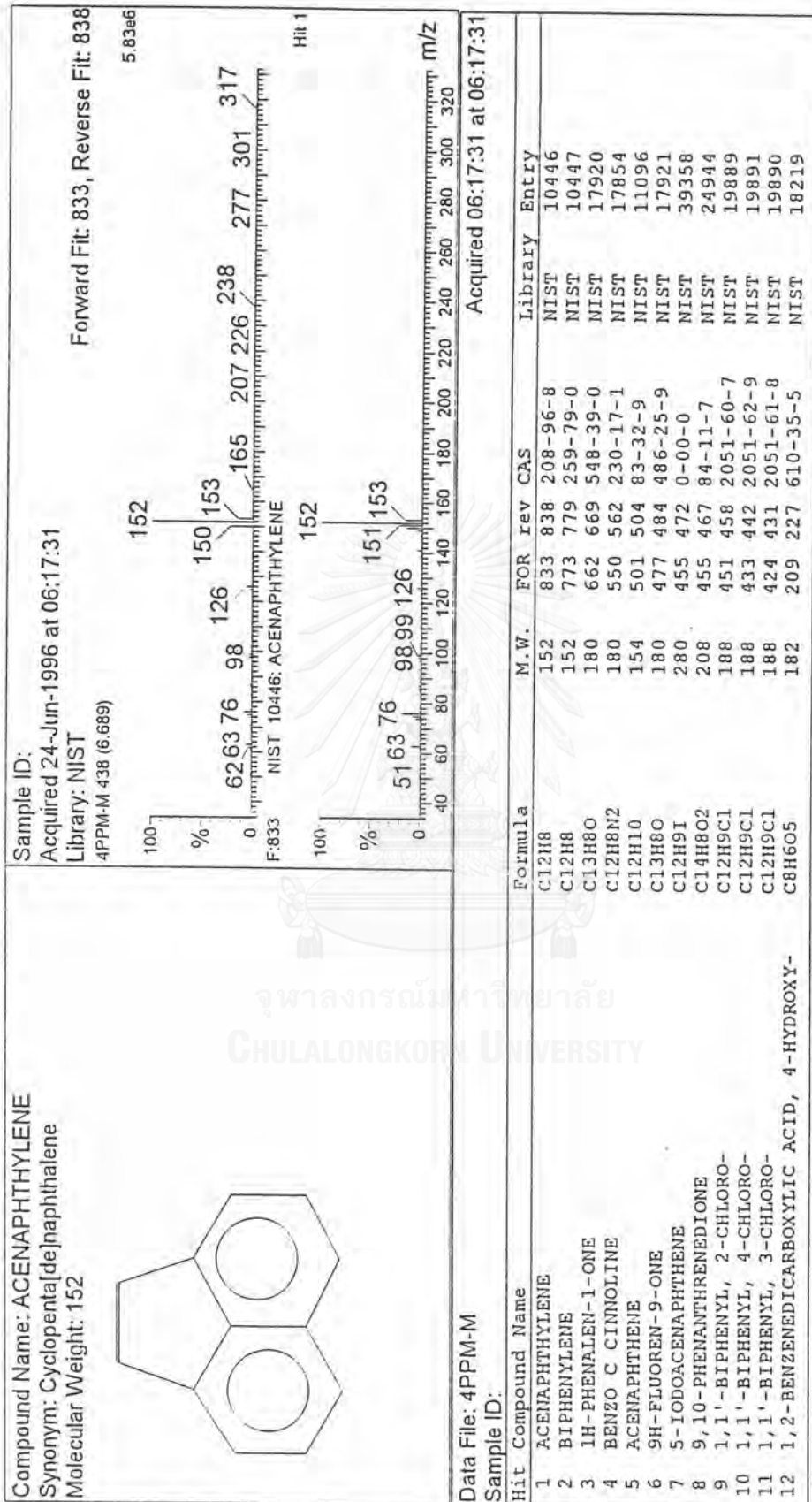
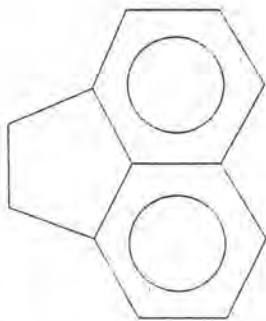


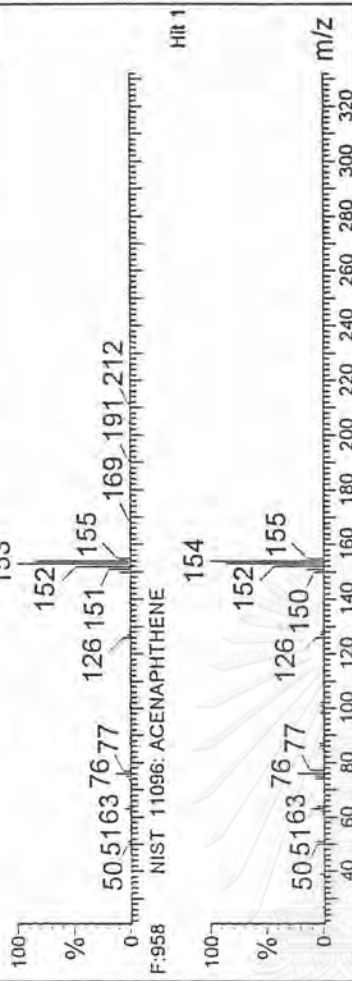
Figure A3 Comparison of Mass Spectra of Standard Acenaphthylene with Mass Spectra in NIST Library

Compound Name: ACENAPHTHENE
 Synonym: Acenaphthylene, 1,2-dihydro-
 Molecular Weight: 154



Sample ID:
 Acquired 24-Jun-1996 at 06:17:31
 Library: NIST
 4PPM-M 488 (7.026) Rf (6.3 000)

Forward Fit: 958, Reverse Fit: 960
 2.46e6



Data File: 4PPM-M
 Sample ID: Acquired 06:17:31 at 06:17:31

Hit	Compound Name	Formula	M.W.	FOR	rev	CAS	Library	Entry
1	ACENAPHTHENE	C12H10	154	958	960	83-32-9	NIST	11096
2	NAPHTHALENE, 2-ETHENYL-	C12H10	154	902	904	827-54-3	NIST	11097
3	1,4-ETHENONAPHTHALENE, 1,4-DIHYDRO-	C12H10	154	886	909	7322-47-6	NIST	11095
4	BIPHENYL	C12H10	154	859	865	92-52-4	NIST	11094
5	BENZENE, (2,4-CYCLOPENTADIEN-1-YLIDENEMETHY	C12H10	154	789	916	7338-50-3	NIST	11092
6	ACENAPHTHYLENE, 5-BROMO-1,2-DIHYDRO-	C12H9Br	232	689	696	2051-98-1	NIST	30279
7	5,10-METHANOBENZOCYCLOCTEN-11-ONE, 5-CHLOR	C13H9OCl	216	605	618	33655-73-1	NIST	26755
8	1,1'-BIPHENYL, 3-NITRO-	C12H9O2N	199	558	561	2113-58-8	NIST	22640
9	1,1'-BIPHENYL, 2-IODO-	C12H9I	280	458	464	2113-51-1	NIST	39360
10	5-IODOACENAPHTHENE	C12H9I	280	457	487	0-00-0	NIST	39358
11	1,4-ANTHRACENEDIONE	C14H8O2	208	350	362	635-12-1	NIST	24946

Figure A4 Comparison of Mass Spectra of Standard Acenaphthene with Mass Spectra in NIST Library

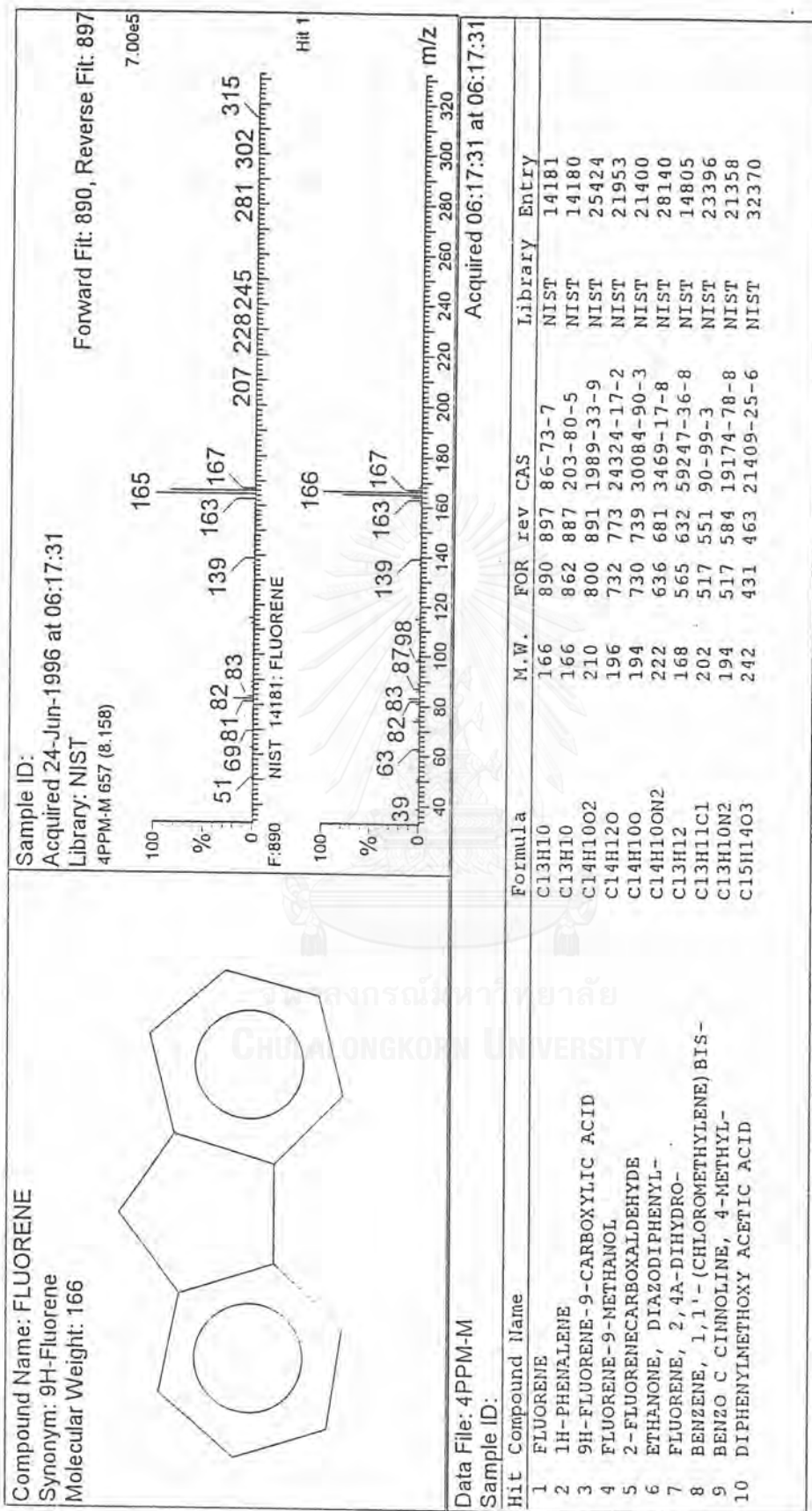


Figure A5 Comparison of Mass Spectra of Standard Fluorene with Mass Spectra in NIST Library

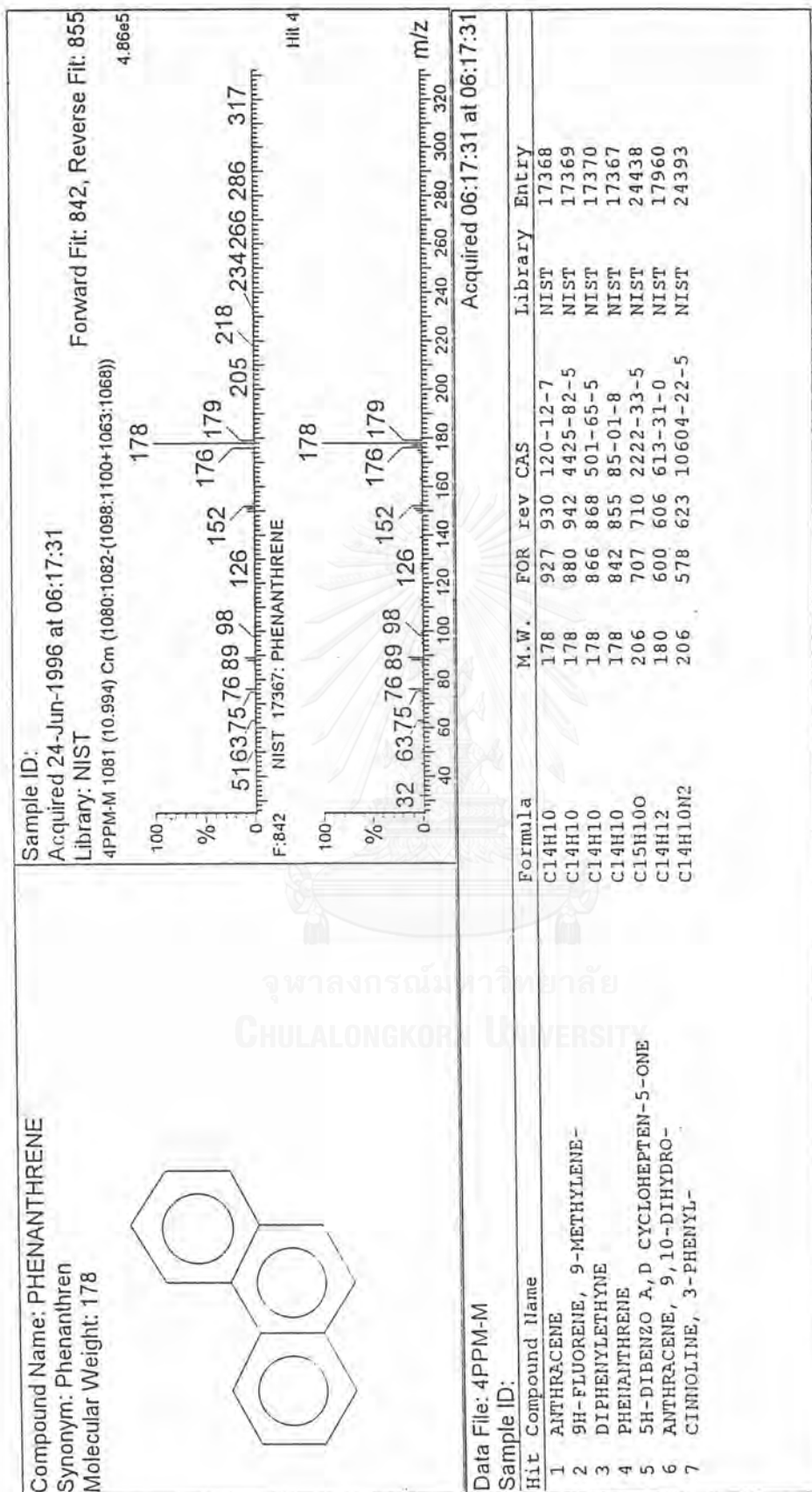


Figure A6 Comparison of Mass Spectra of Standard Phenanthrene with Mass Spectra in NIST Library

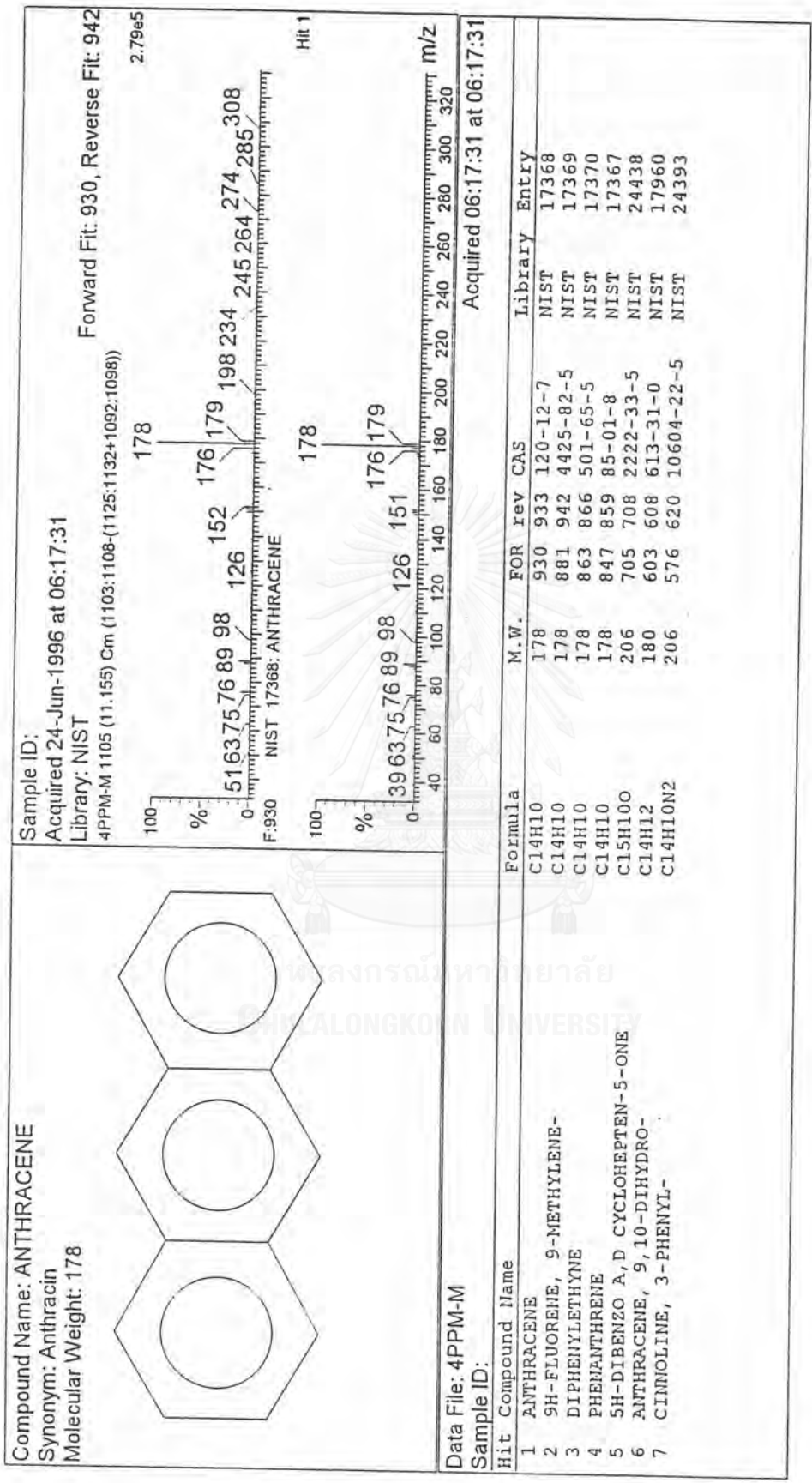


Figure A7 Comparison of Mass Spectra of Standard Anthracene with Mass Spectra in NIST Library

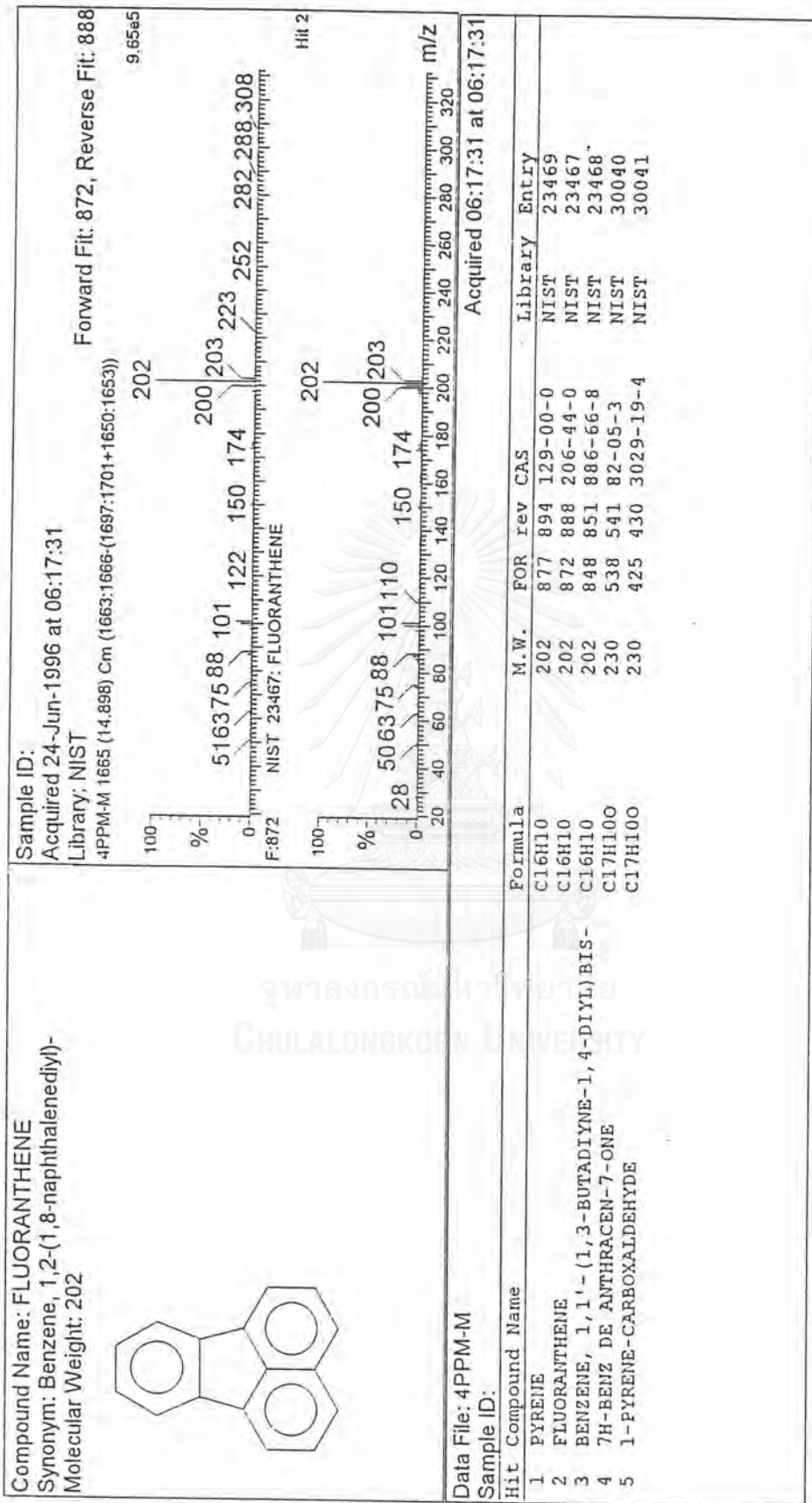


Figure A8 Comparison of Mass Spectra of Standard Fluoranthene with Mass Spectra in NIST Library

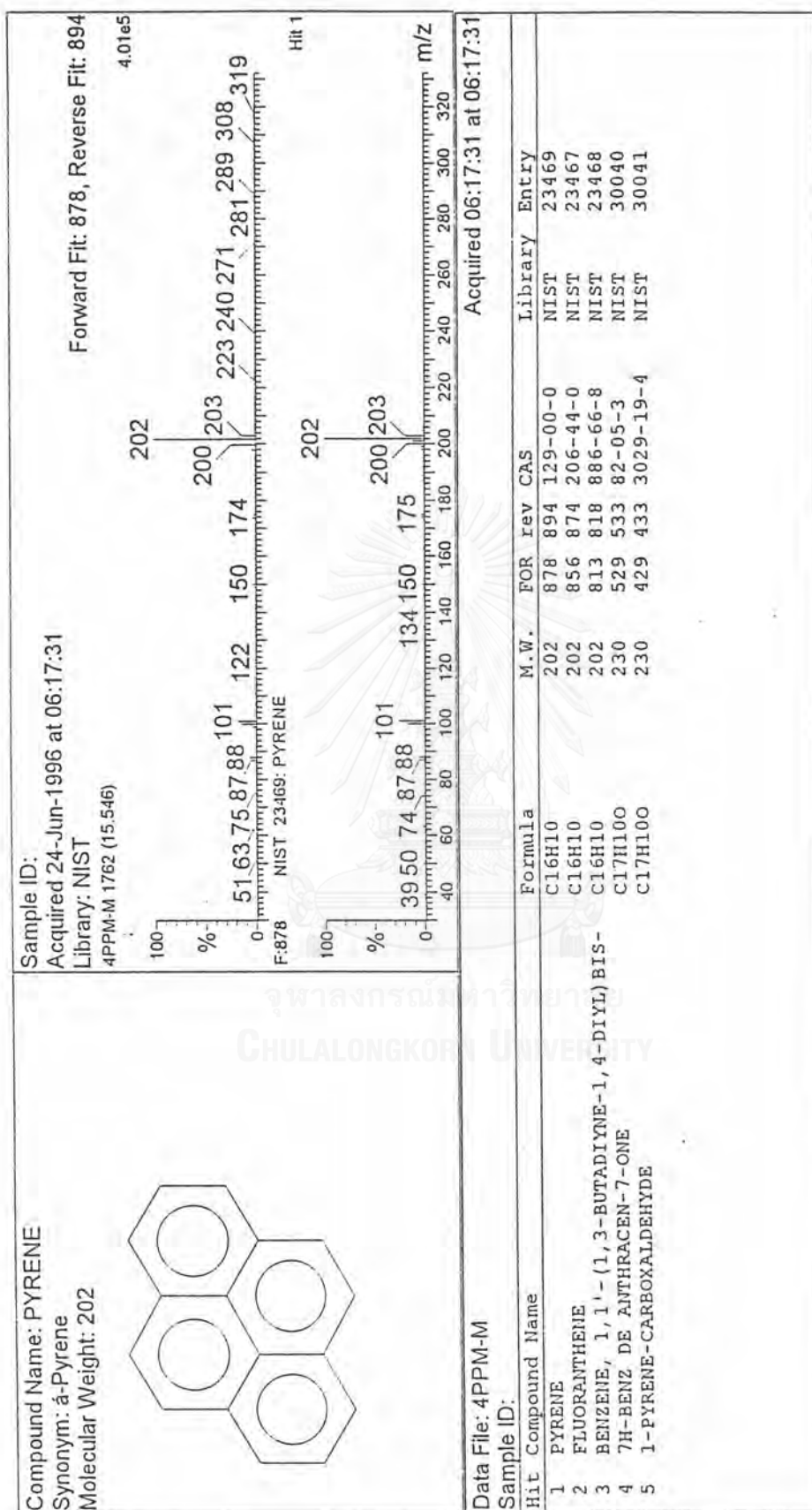


Figure A9 Comparison of Mass Spectra of Standard Pyrene with Mass Spectra in NIST Library

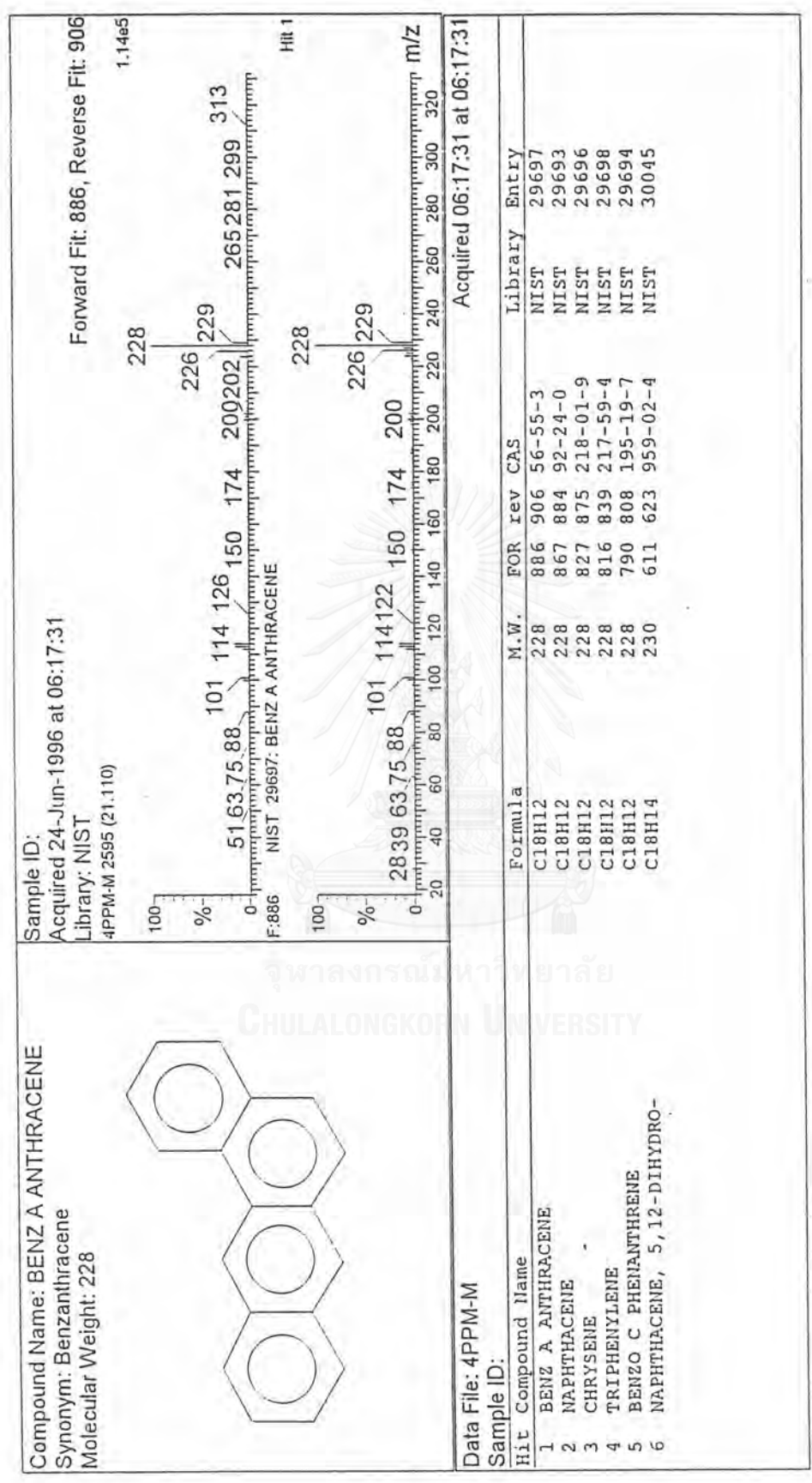


Figure A10 Comparison of Mass Spectra of Standard Benzo[a]anthracene with Mass Spectra in NIST Library

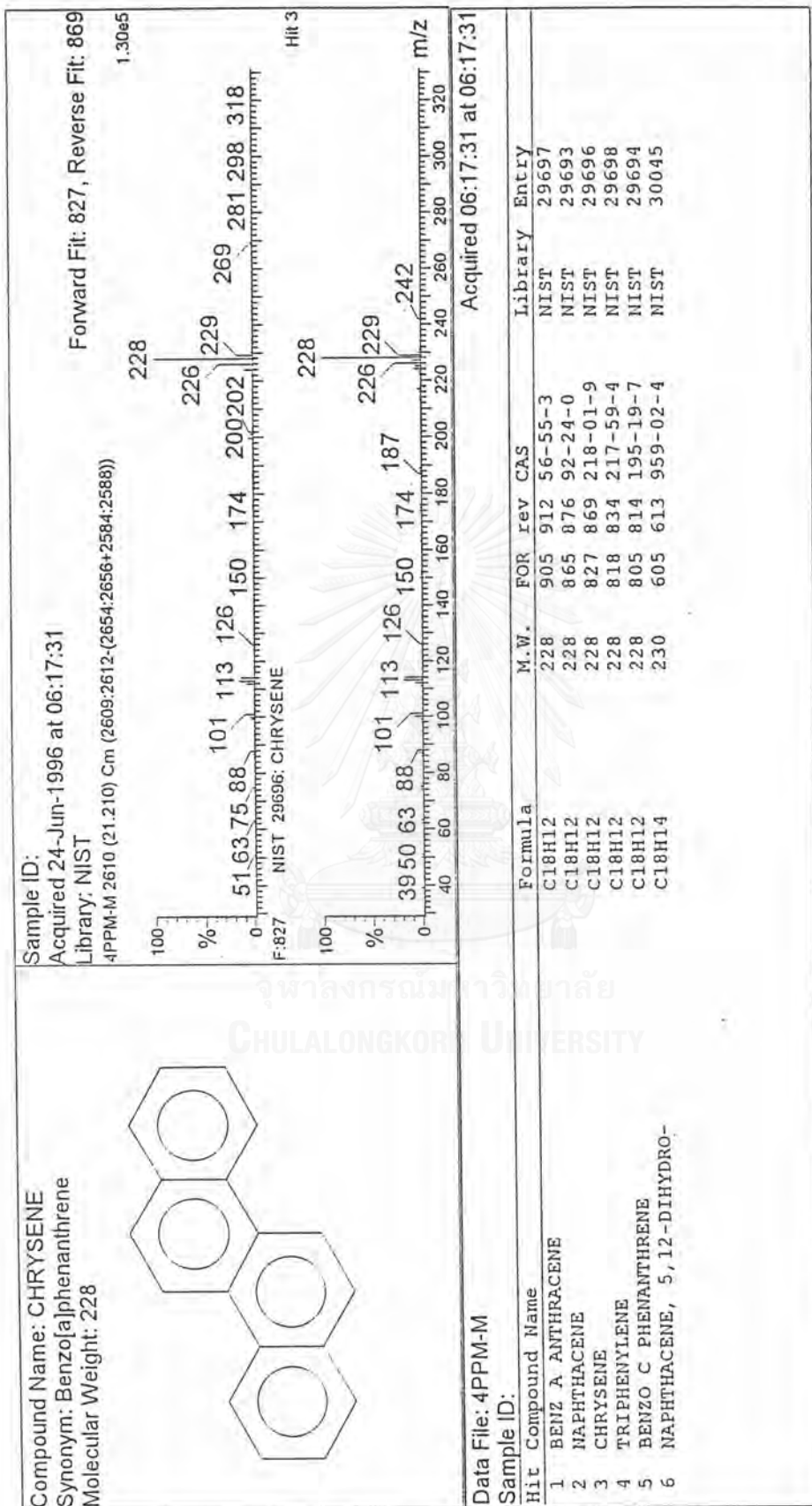


Figure A11 Comparison of Mass Spectra of Standard Chrysene and with Mass Spectra in NIST Library

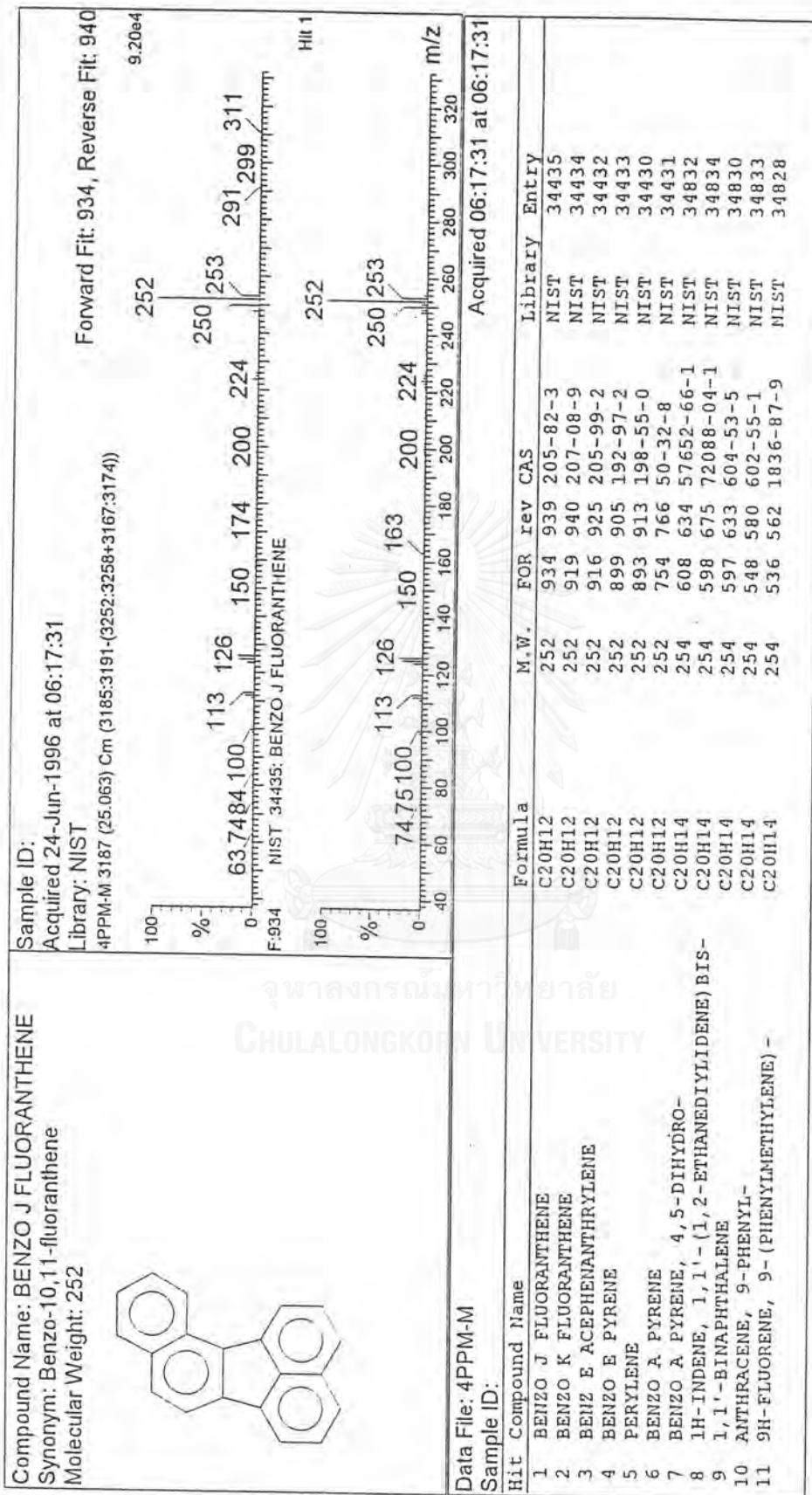


Figure A12 Comparison of Mass Spectra of Standard Benzo[b]fluoranthene with Mass Spectra in NIST Library

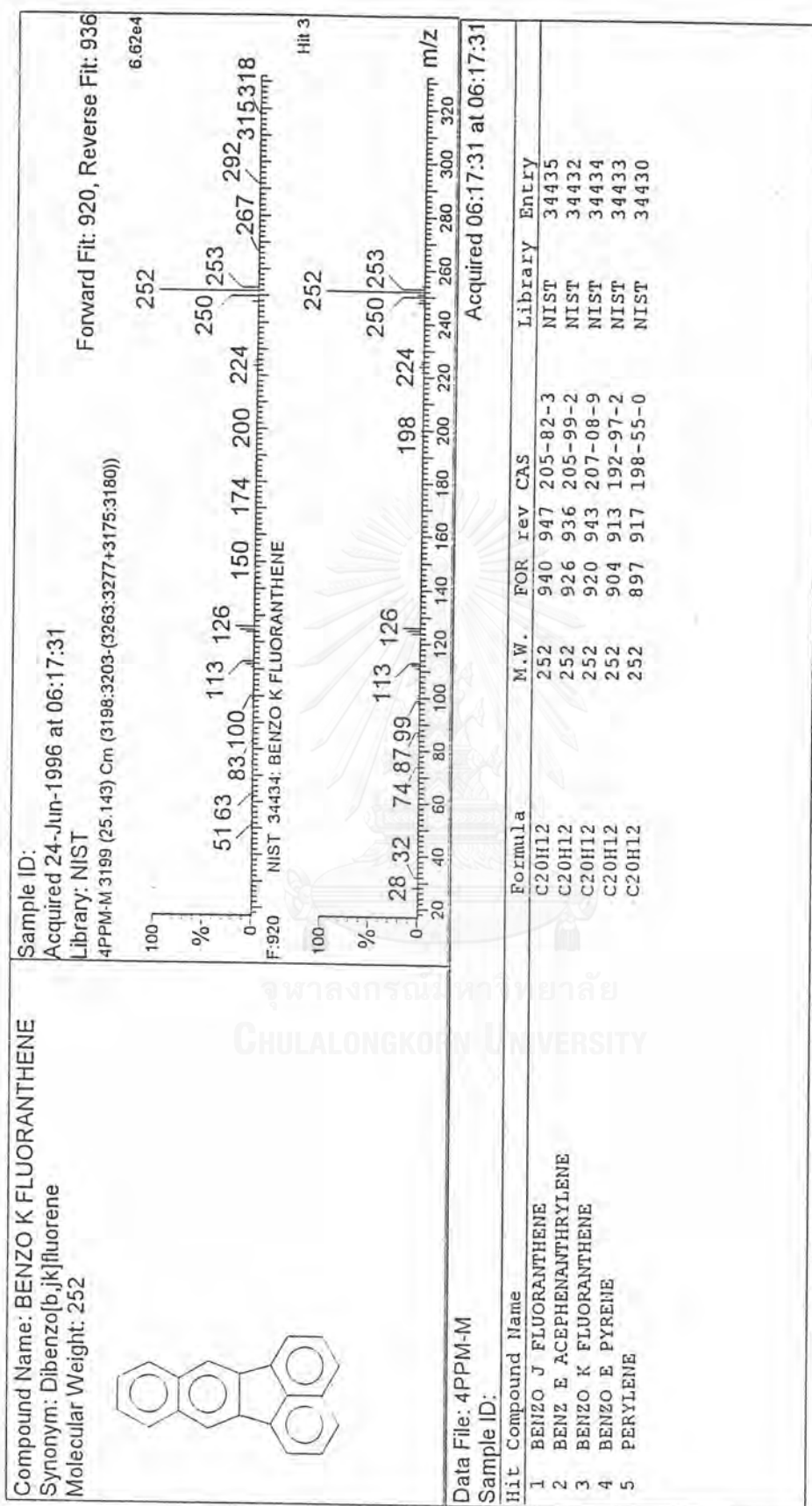


Figure A13 Comparison of Mass Spectra of Standard Benzo[k]fluoranthene with Mass Spectra in NIST Library

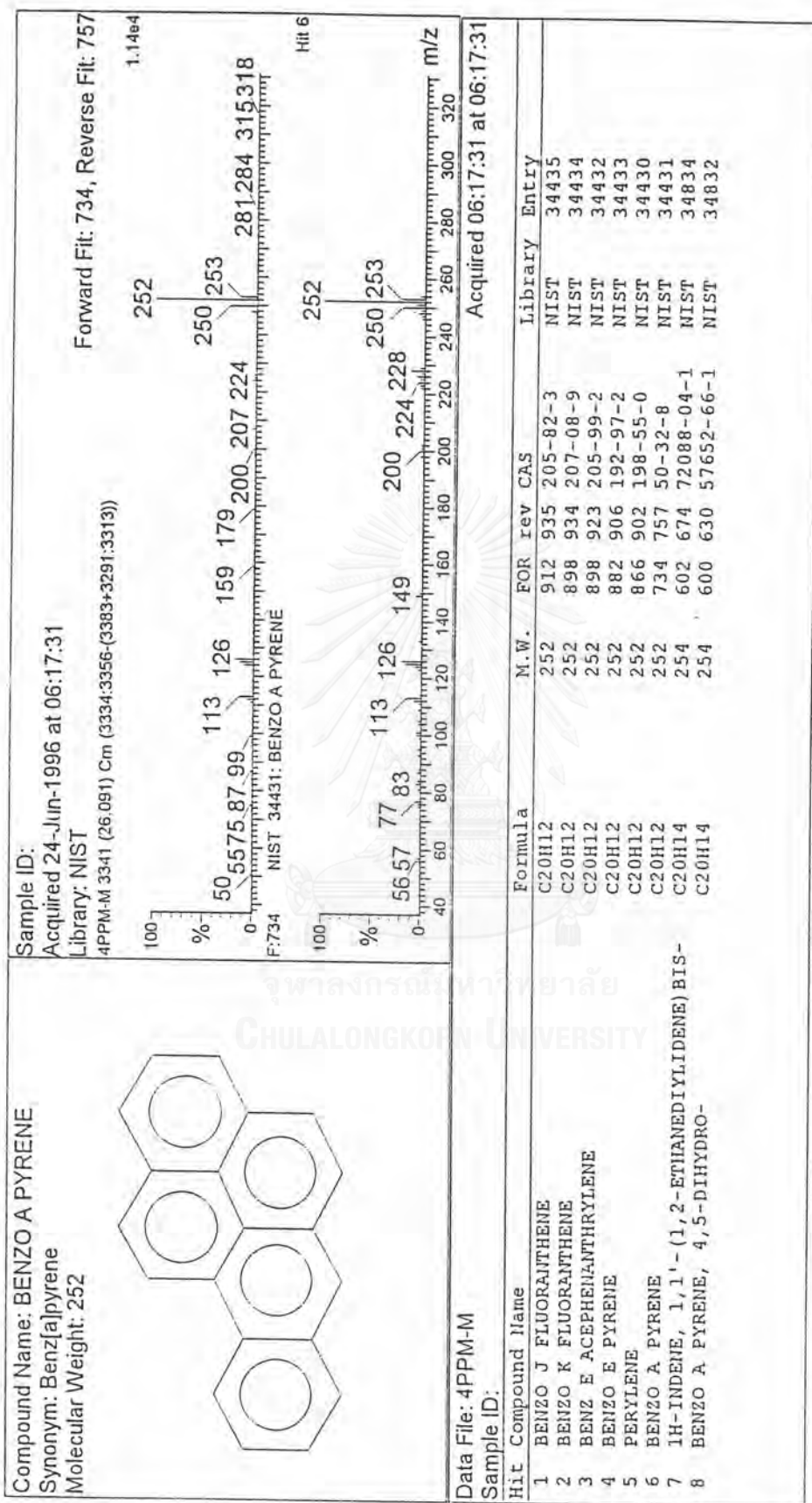


Figure A14 Comparison of Mass Spectra of Standard Benzo[a]pyrene with Mass Spectra in NIST Library

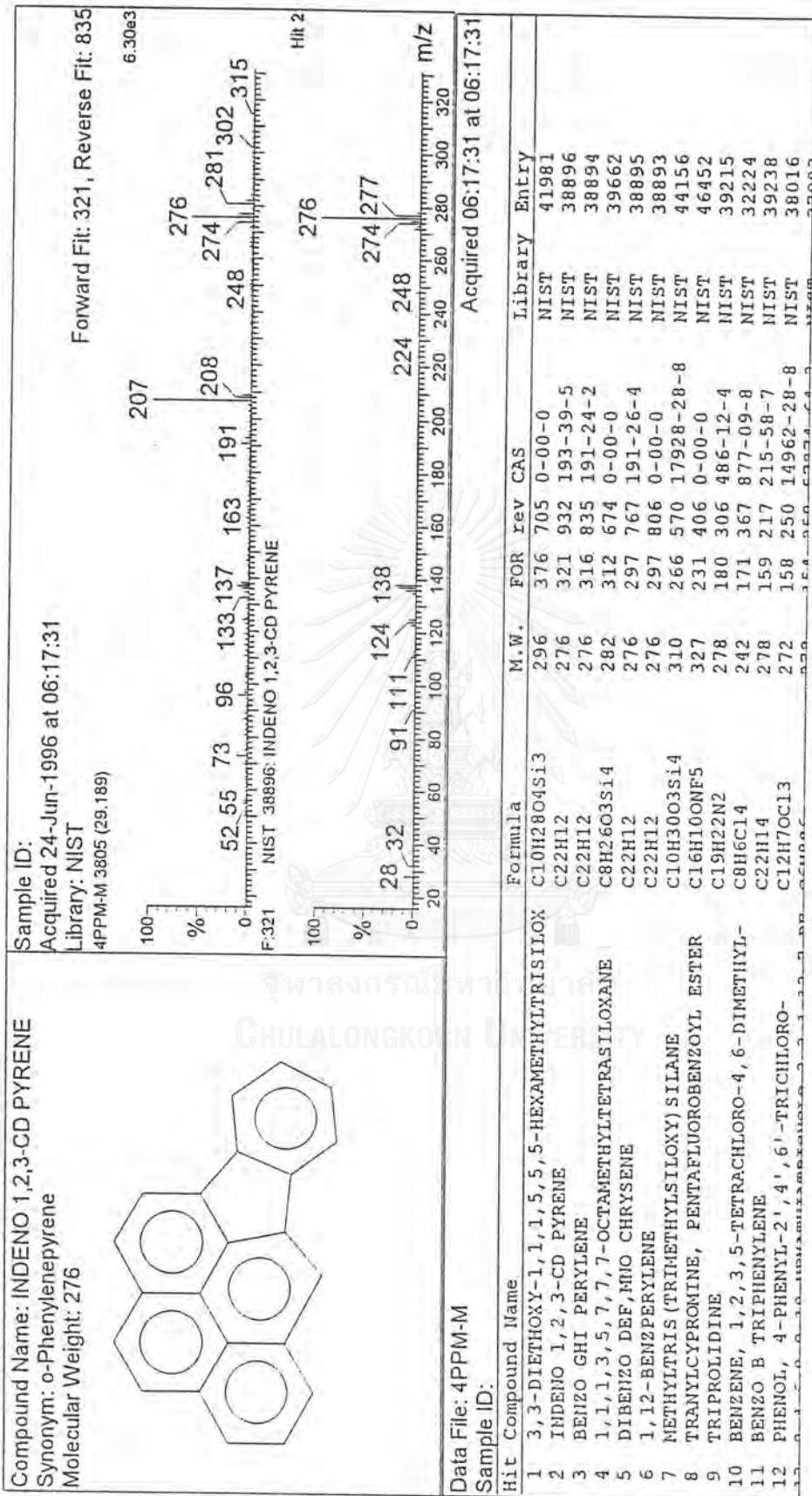


Figure A15 Comparison of Mass Spectra of Standard Indeno[1,2,3-cd]pyrene with Mass Spectra in NIST Library

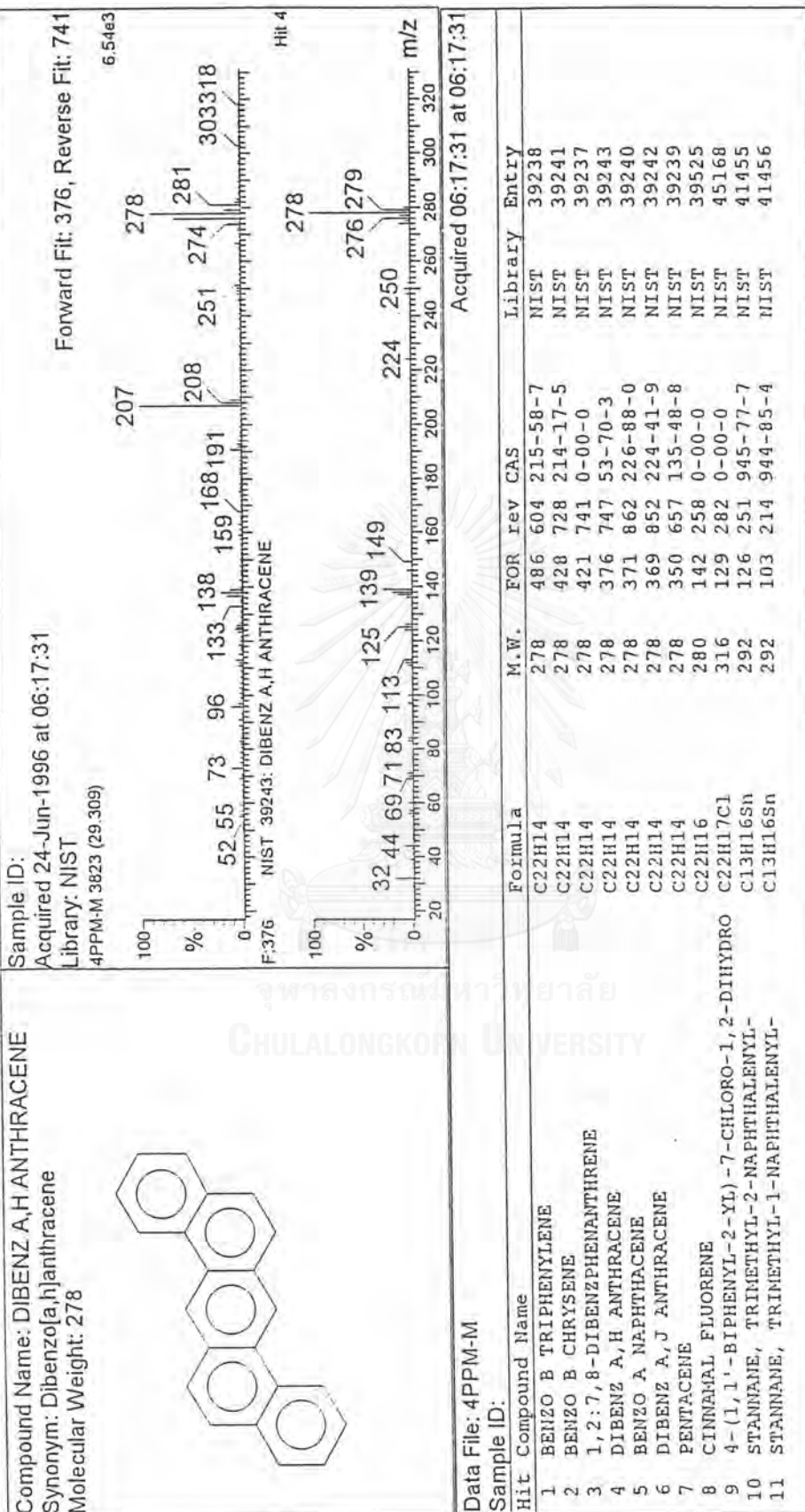
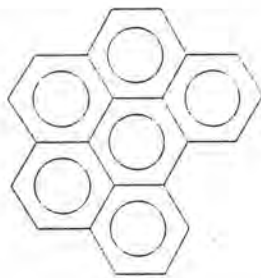


Figure A16 Comparison of Mass Spectra of Standard Dibenzo[a,h]anthracene with Mass Spectra in NIST Library

Compound Name: BENZO GHI PERYLENE
 Synonym: Benzo-1,12-perylene
 Molecular Weight: 276



Acquired 06:17:31 at 06:17:31

Data File: 4PPM-M

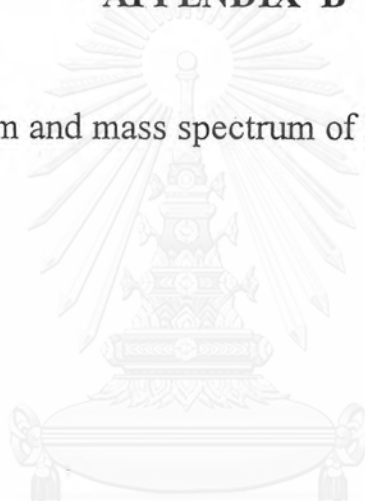
Sample ID:

Hit	Compound Name	Formula	M.W.	FOR	rev	CAS	Library	Entry
1	INDEHO 1,2,3-CD PYRENE	C22H12	276	490	866	193-39-5	NIST	38896
2	BENZO GHI PERYLENE	C22H12	276	489	820	191-24-2	NIST	38894
3	1,12-BENZPERYLENE	C22H12	276	454	769	0-00-0	NIST	38893
4	DIBENZO DEF,MNO CHRYSENE	C22H12	276	429	726	191-26-4	NIST	38895
5	BENZO B TRIPHENYLENE	C22H14	278	383	475	215-58-7	NIST	39238
6	1,2:7,8-DIBENZPHENANTHRENE	C22H14	278	355	562	0-00-0	NIST	39237
7	DIBENZ A,H ANTHRACENE	C22H14	278	296	527	53-70-3	NIST	39243
8	DIBENZ A,J ANTHRACENE	C22H14	278	268	540	224-41-9	NIST	39242
9	BENZO A NAPHTHACENE	C22H14	278	264	532	226-88-0	NIST	39240

Figure A17 Comparison of Mass Spectra of Standard Benzo[ghi]perylene with Mass Spectra in NIST Library

APPENDIX B

Gas chromatogram and mass spectrum of PAHs in diesel exhaust



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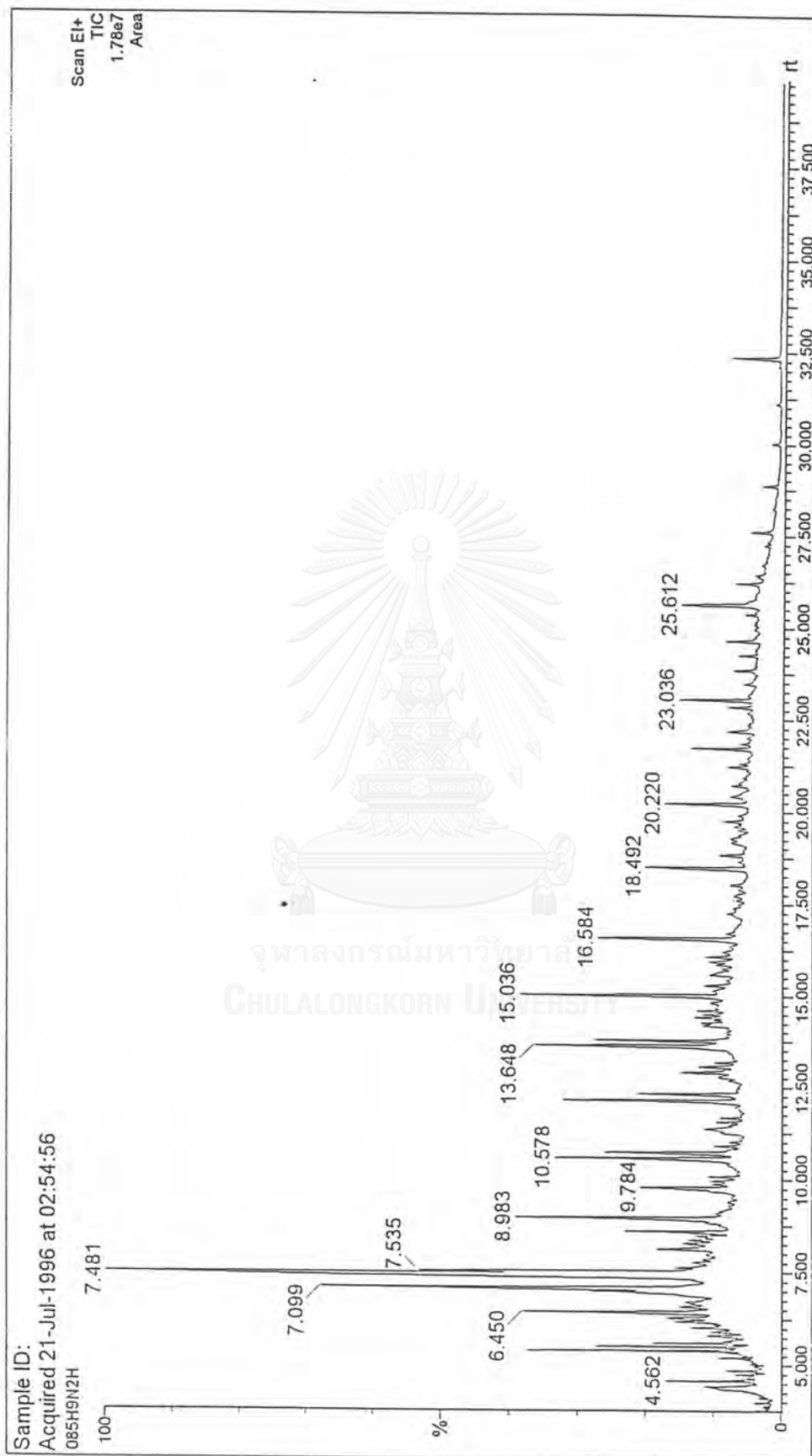


Figure B 1 Gas Chromatogram of Hydrocarbon Fraction of Diesel Exhaust

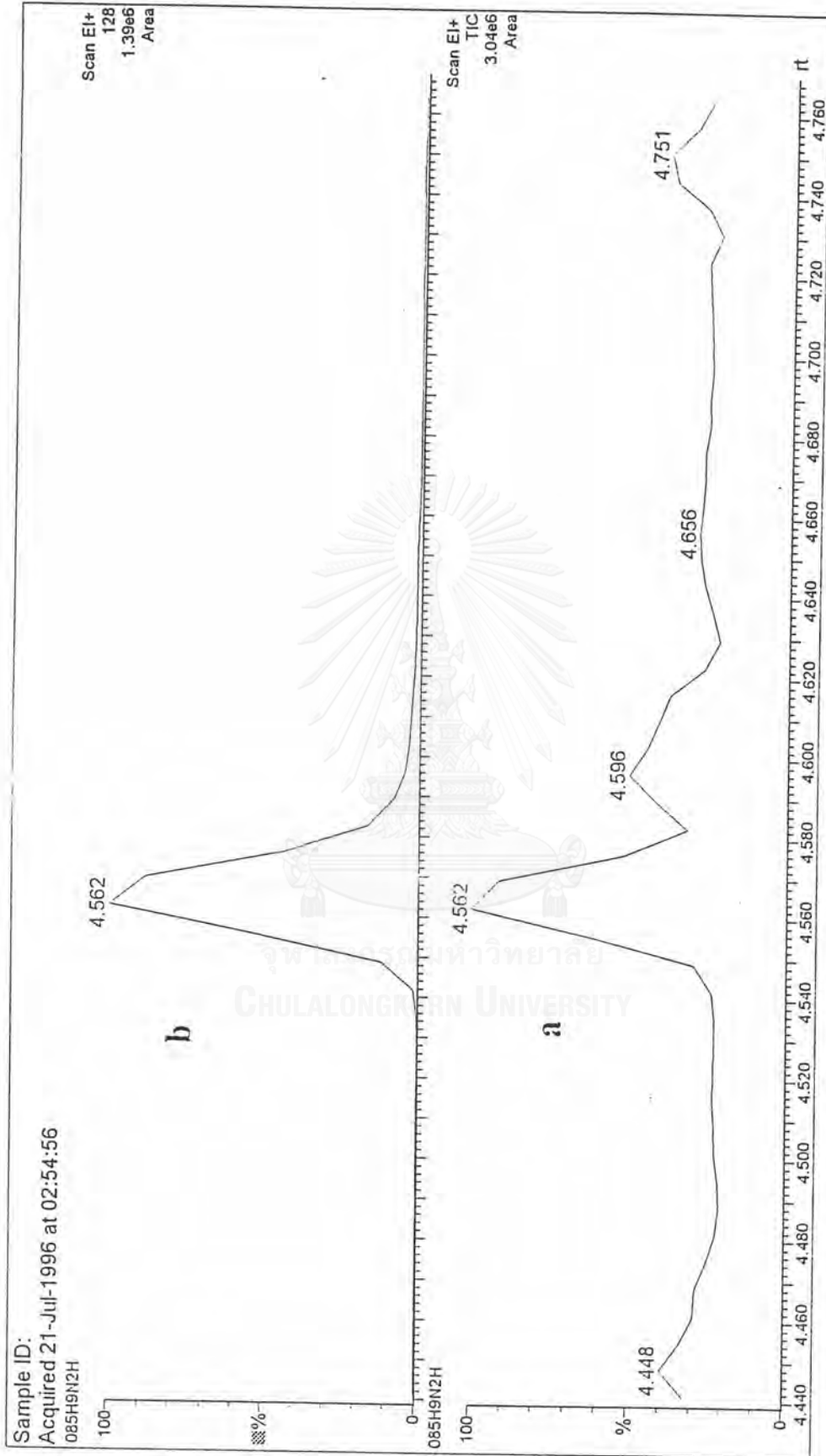


Figure B 2 (a) Gas Chromatogram of Naphthalene Fraction and (b) Selected Ion Chromatograms of m/z 128

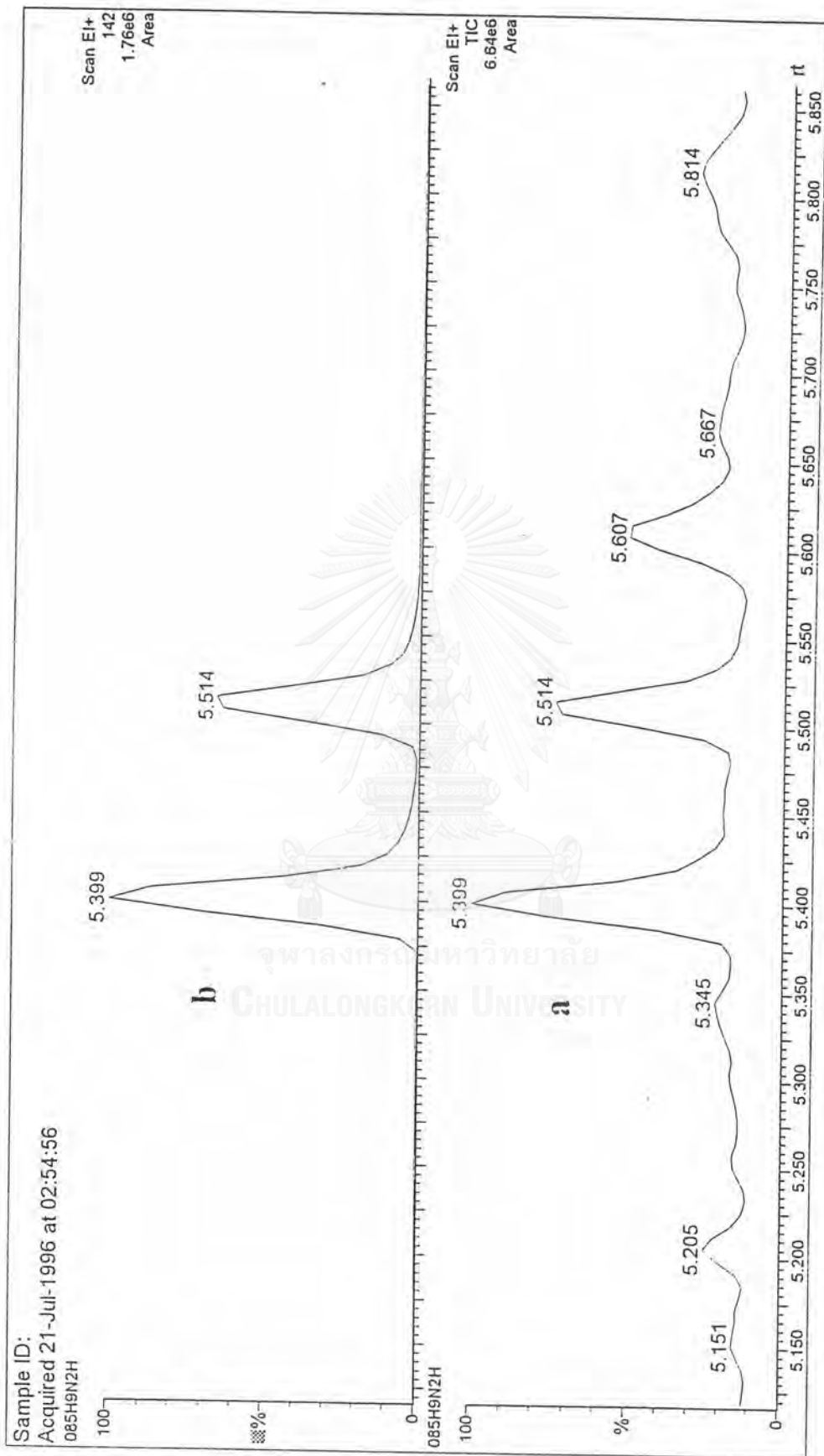


Figure B 3 (a) Gas Chromatogram of Methyl-naphthalene Fraction and (b) Selected Ion Chromatograms of m/z 142

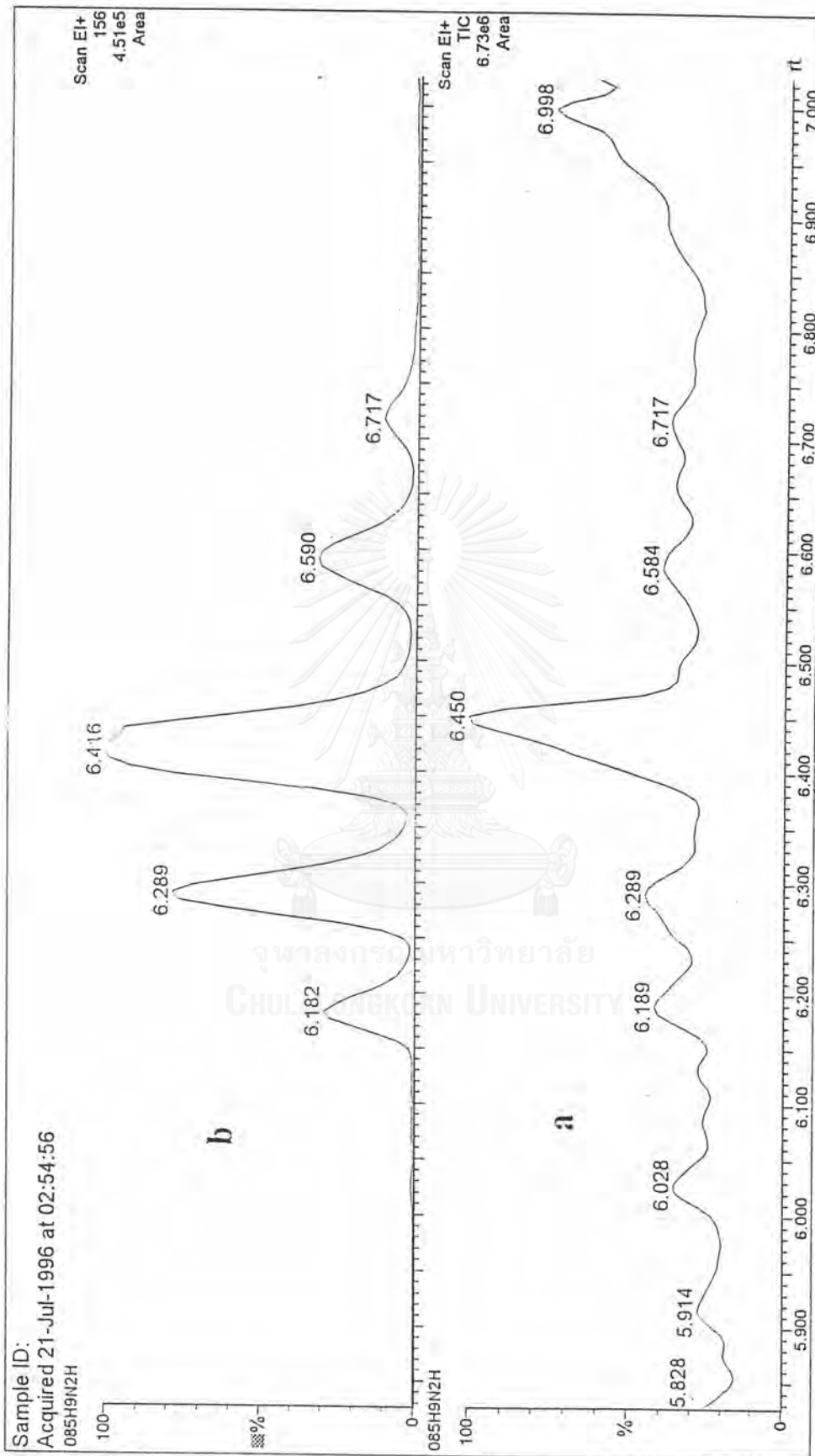


Figure B 4 (a) Gas Chromatogram of Dimethylnaphthalene Fraction and (b) Selected Ion Chromatograms of m/z 156

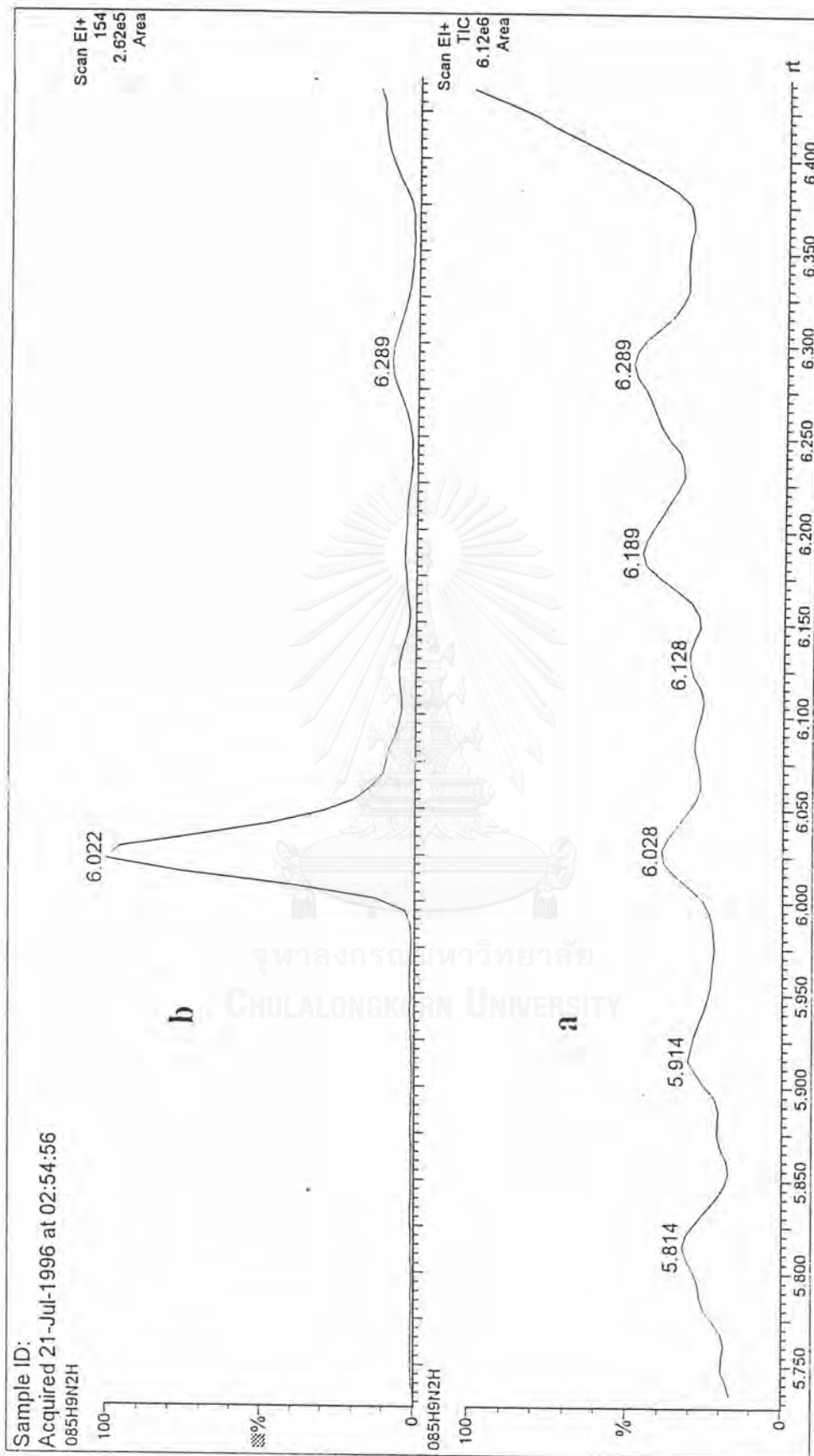


Figure B 5 (a) Gas Chromatogram of Acenaphthene Fraction and (b) Selected Ion Chromatograms of m/z 154

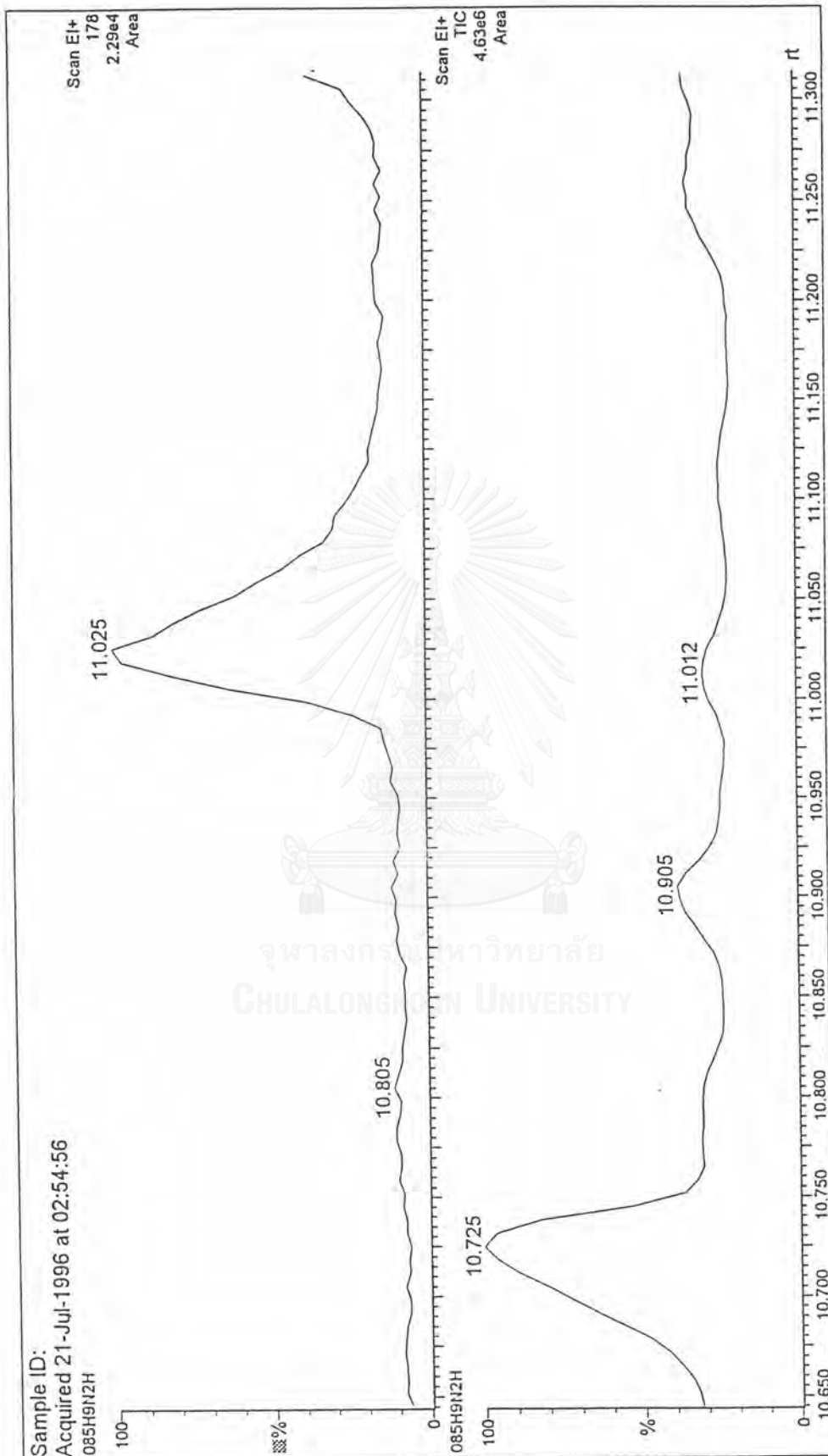
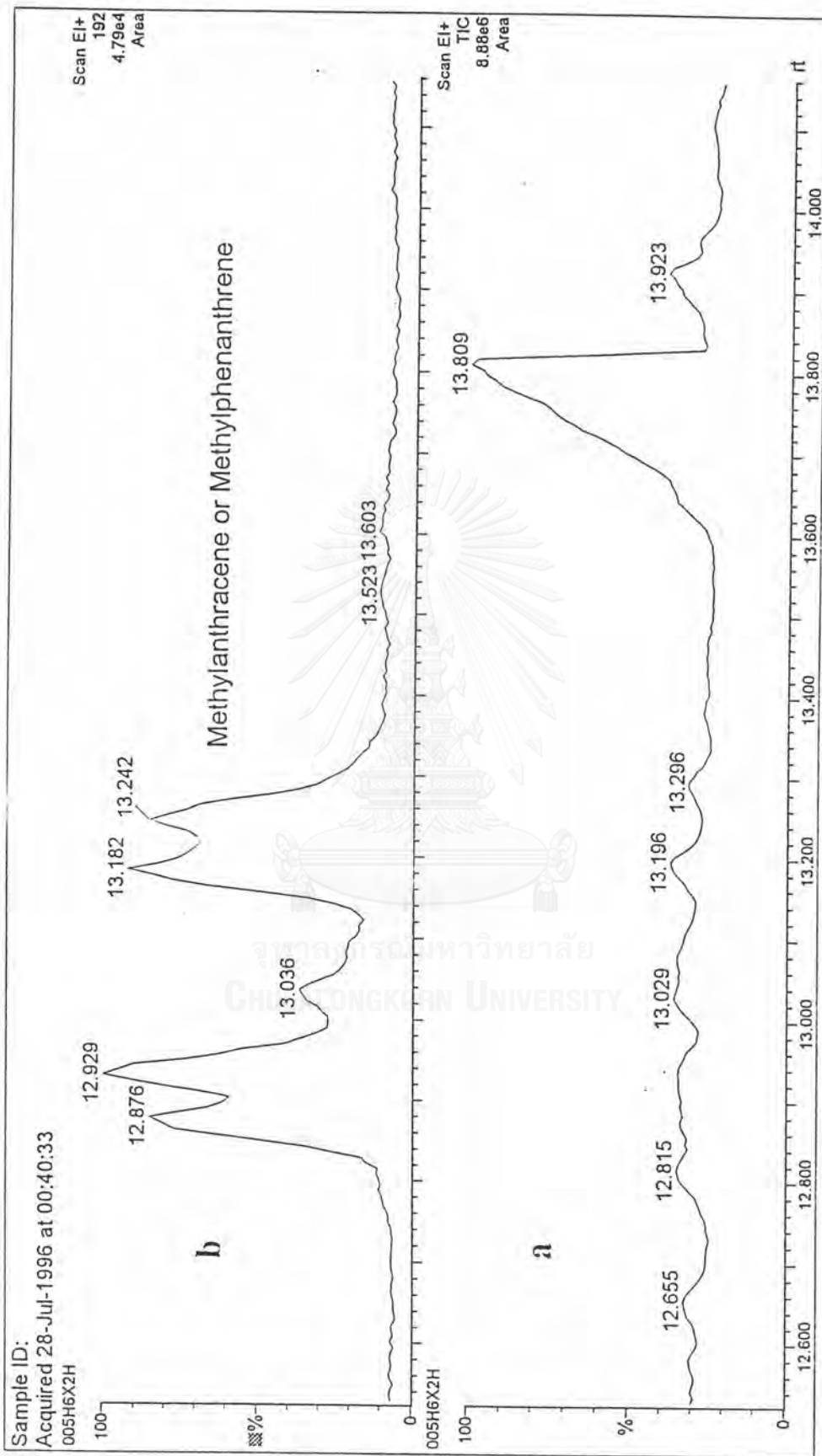


Figure B 6 (a) Gas Chromatogram of Phenanthrene Fraction and (b) Selected Ion Chromatograms of m/z 178



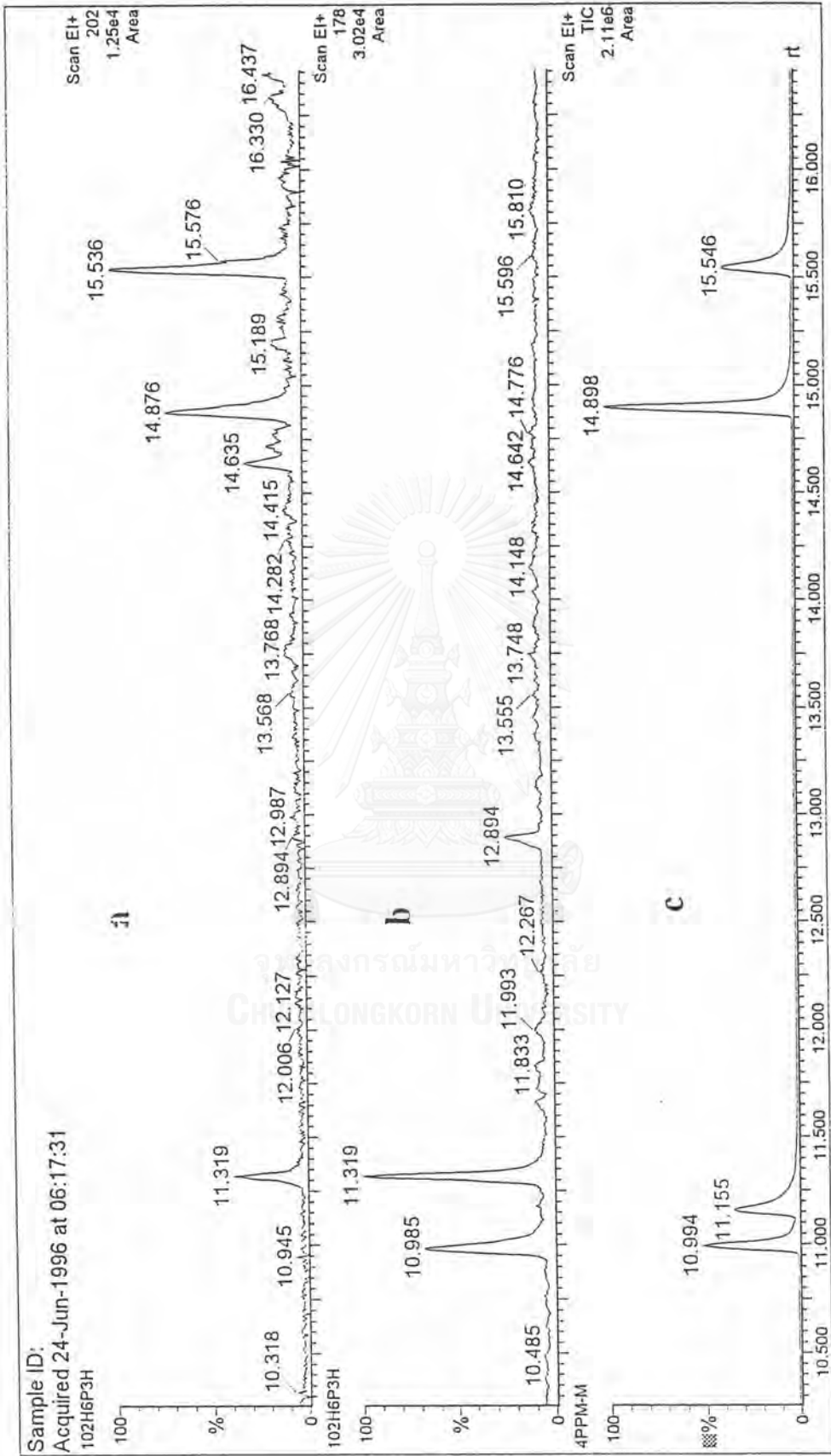


Figure B 8 (a) Selected Ion Chromatograms of m/z 202, (b) Selected Ion Chromatograms of m/z 178 and (c) Gas Chromatogram of Standard Phenanthrene, Fluoranthene, and Pyrene

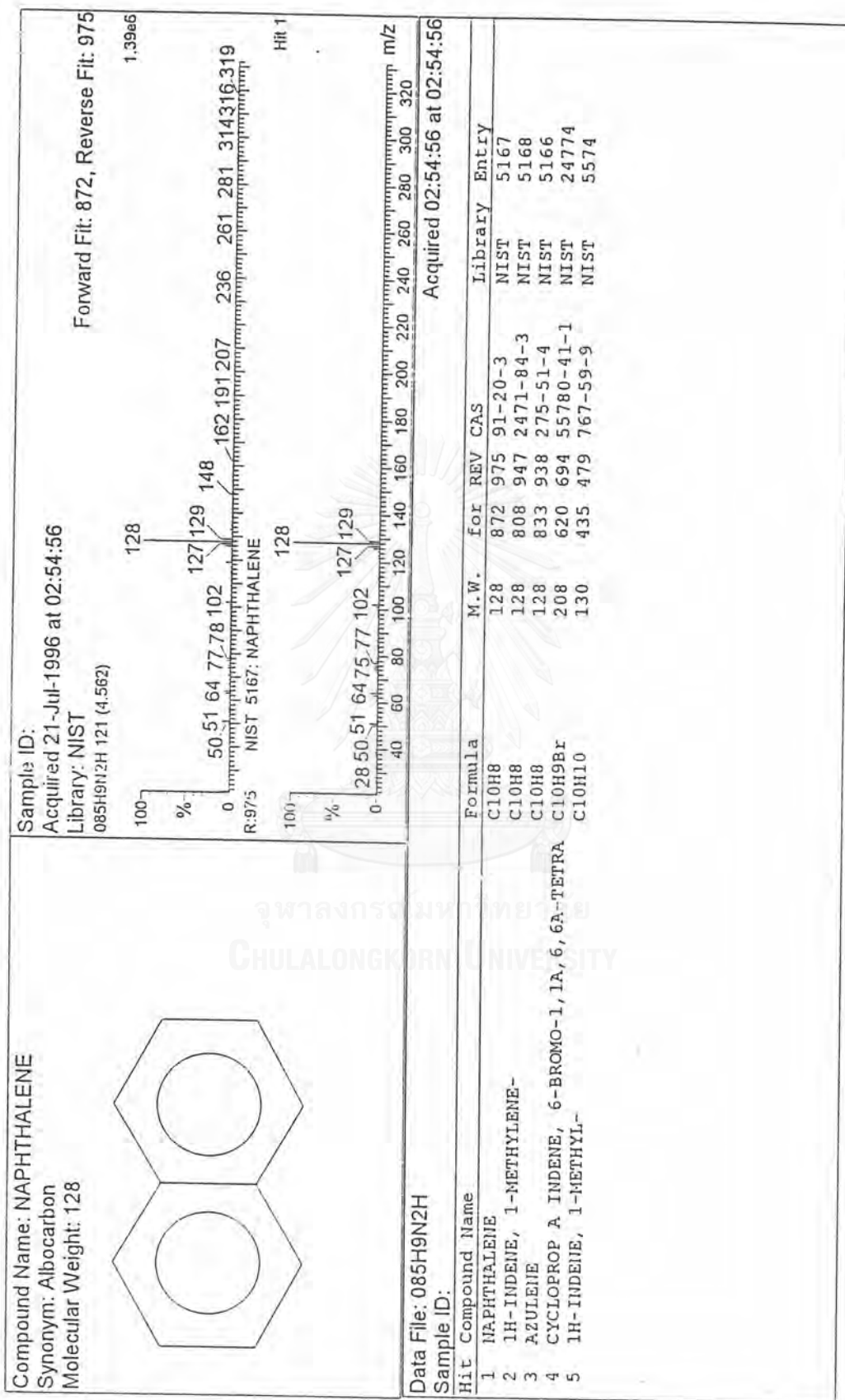


Figure B9 Comparison of Mass Spectra of Naphthalene with Mass Spectra in NIST Library

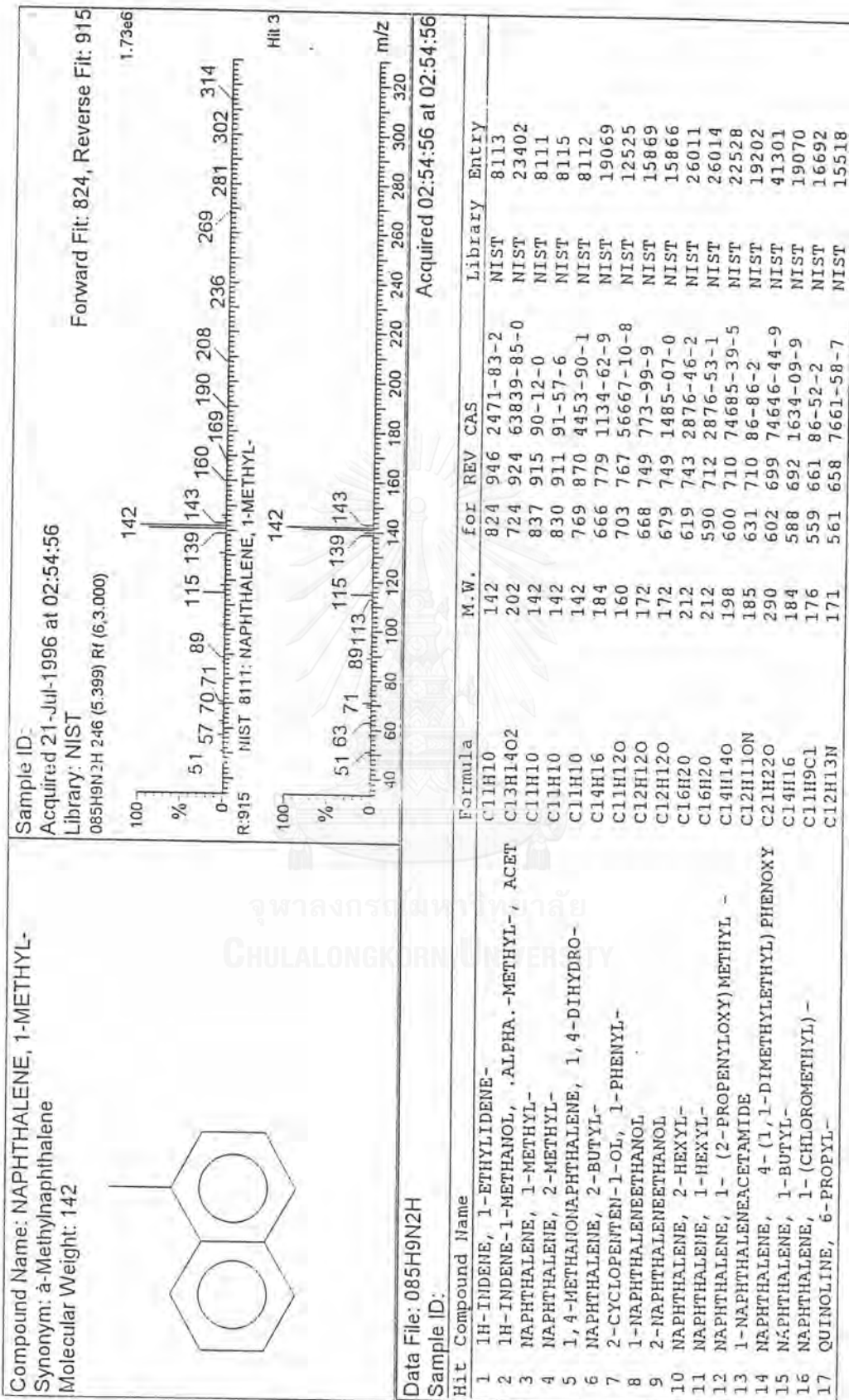


Figure B10 Comparison of Mass Spectra of Methylnaphthalene with Mass Spectra in NIST Library

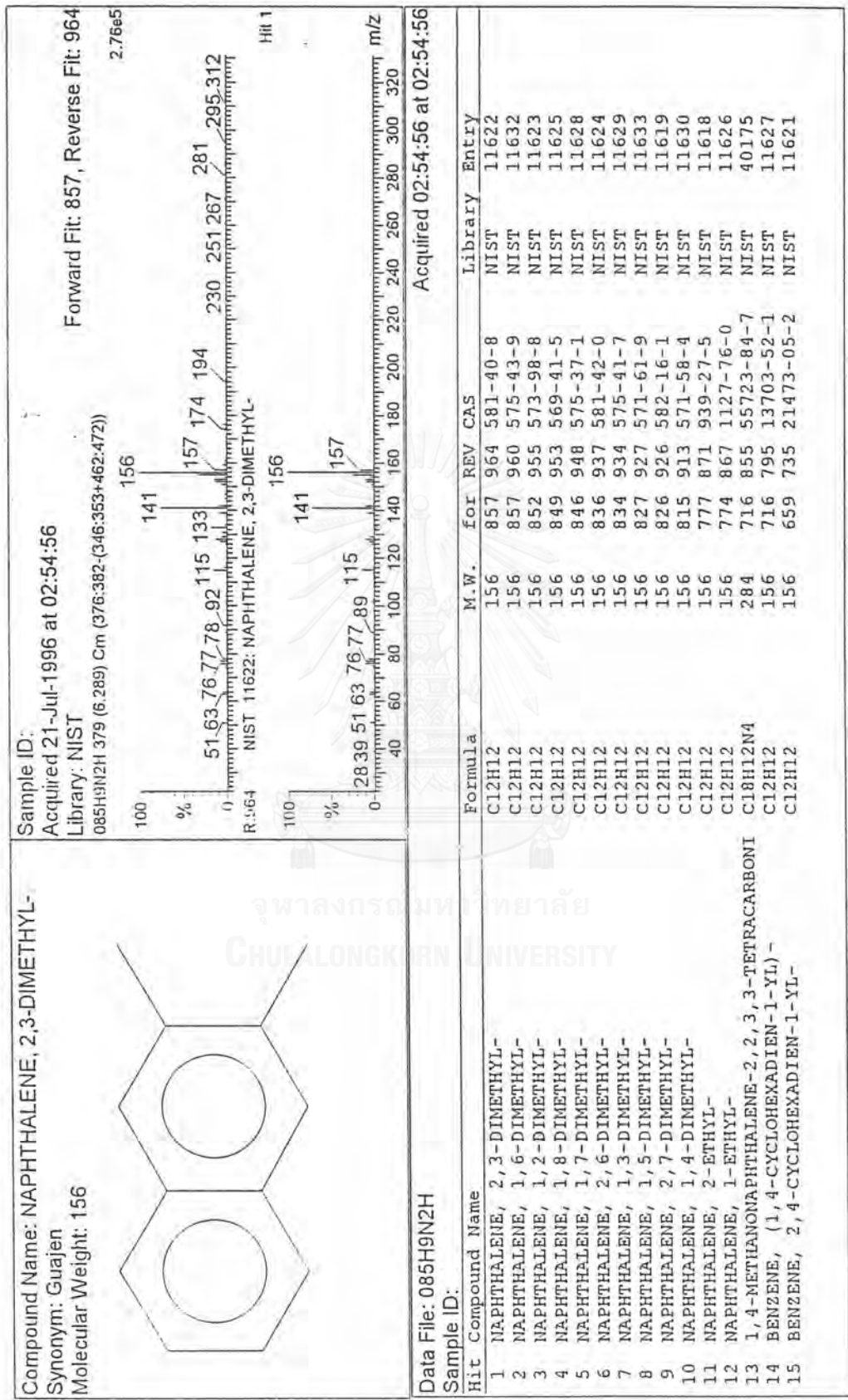


Figure B11 Comparison of Mass Spectra of Dimethylnaphthalene with Mass Spectra in NIST Library

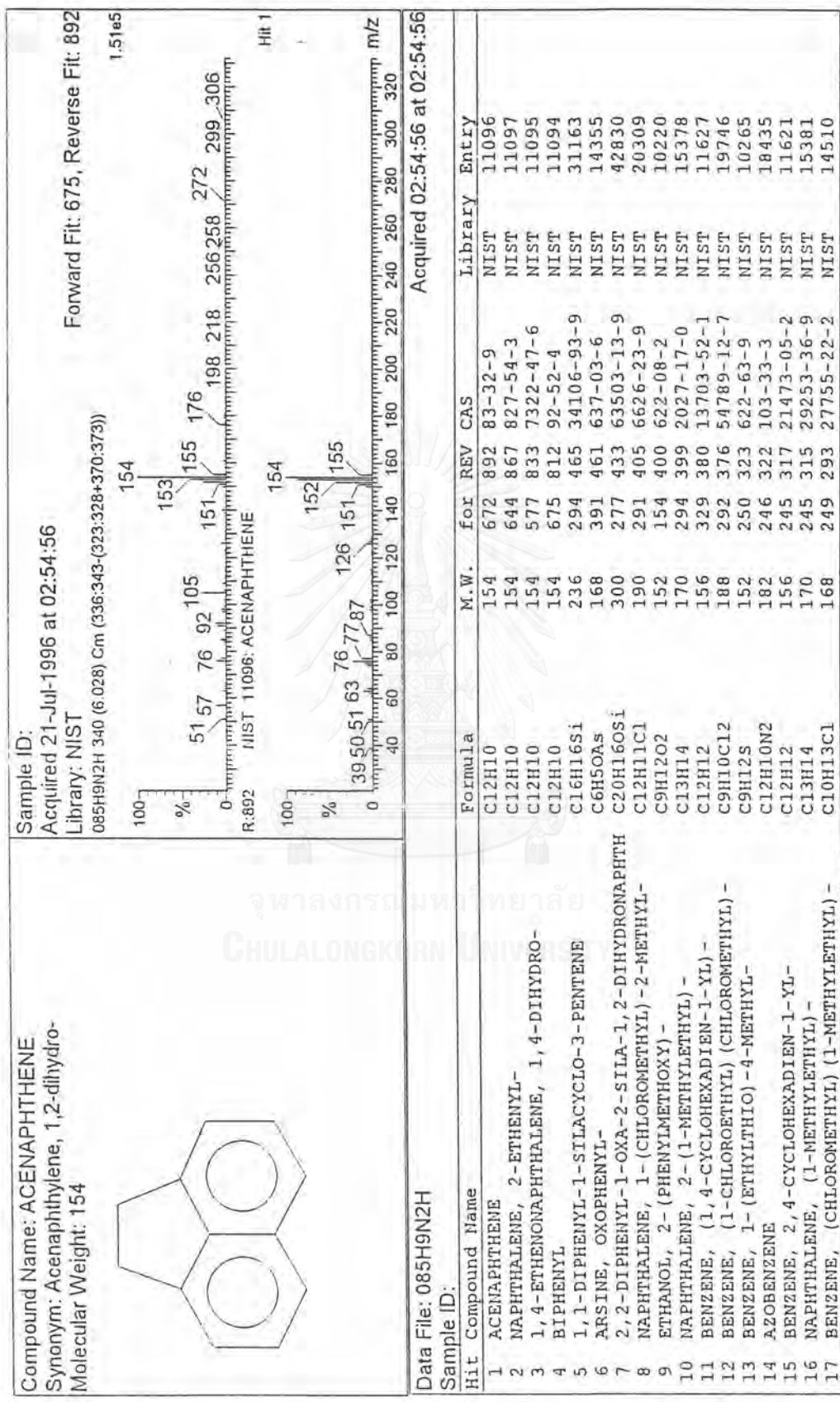


Figure B12 Comparison of Mass Spectra of Acenaphthene with Mass Spectra in NIST Library

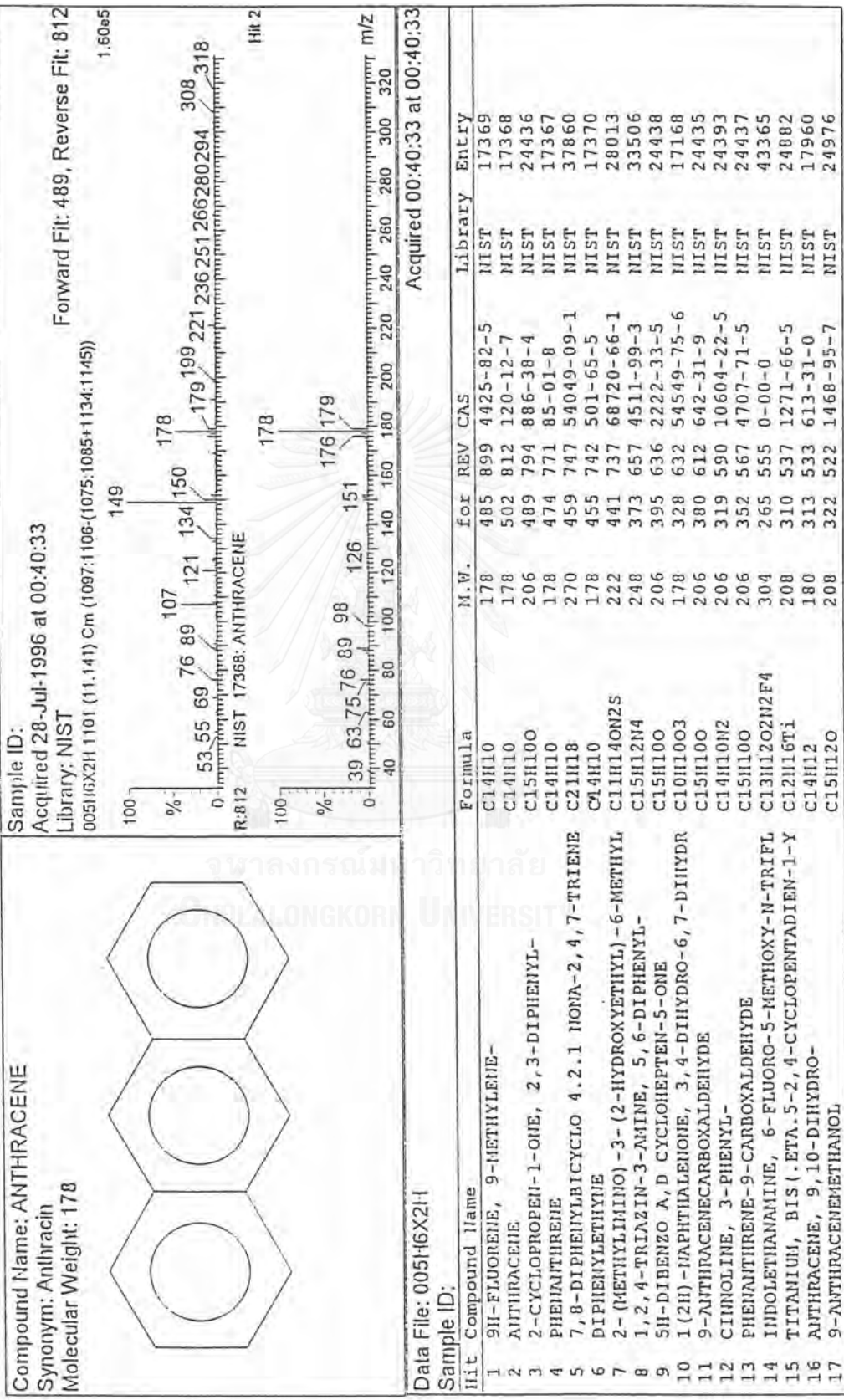


Figure B13 Comparison of Mass Spectra of Phenanthrene with Mass Spectra in NIST Library

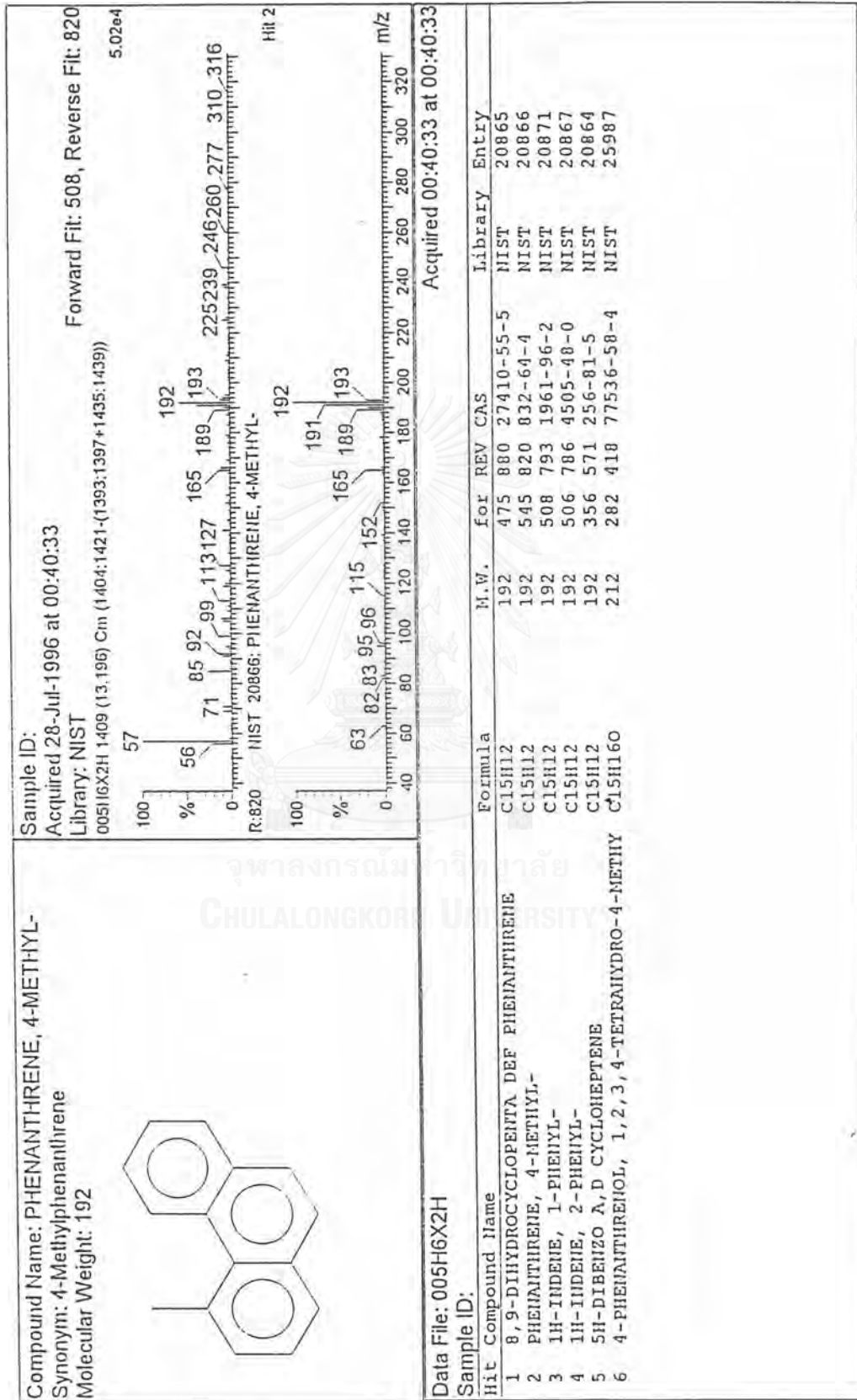


Figure B14 Comparison of Mass Spectra of Methylphenanthrene with Mass Spectra in NIST Library

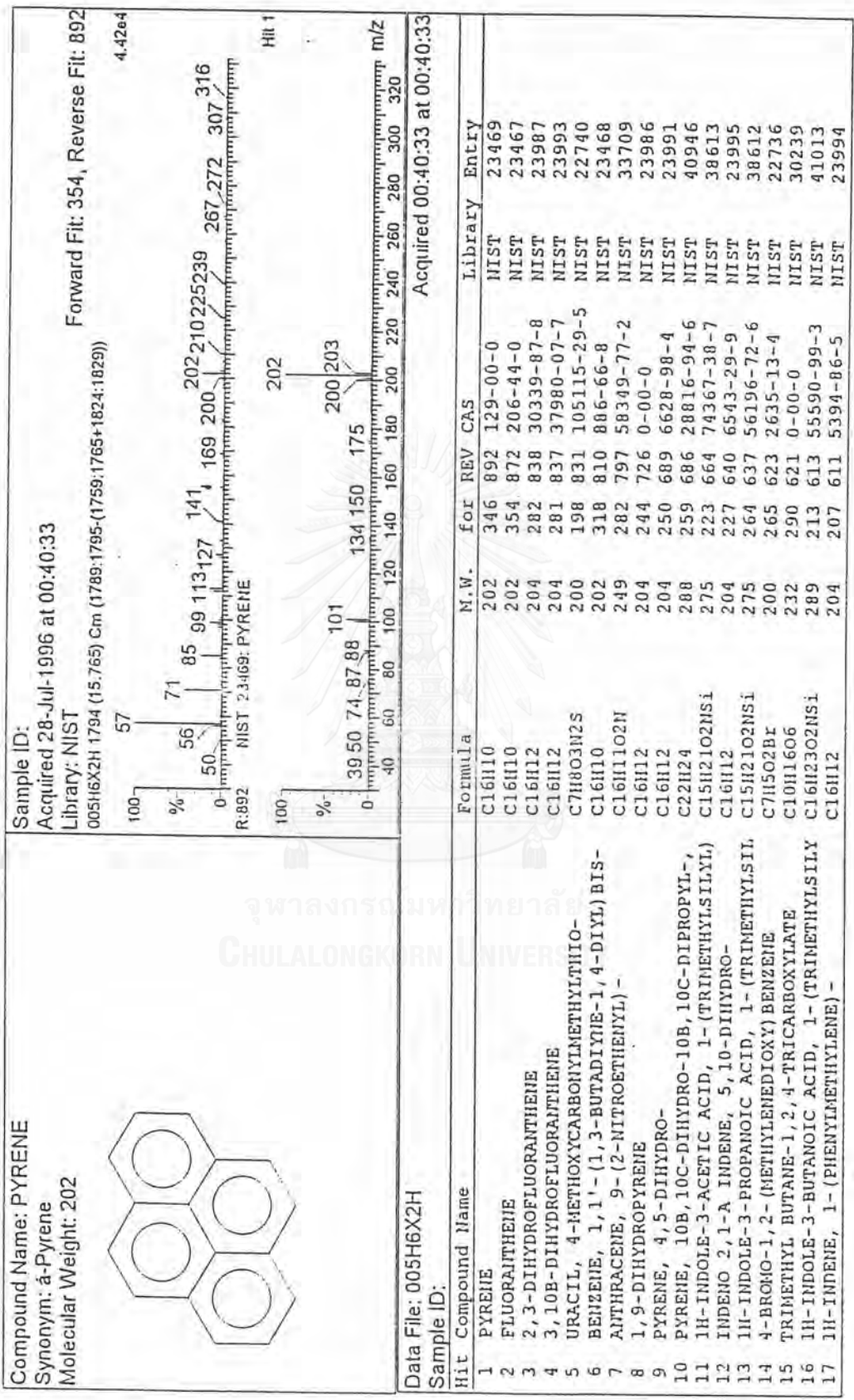


Figure B15 Comparison of Mass Spectra of Pyrene with Mass Spectra in NIST Library

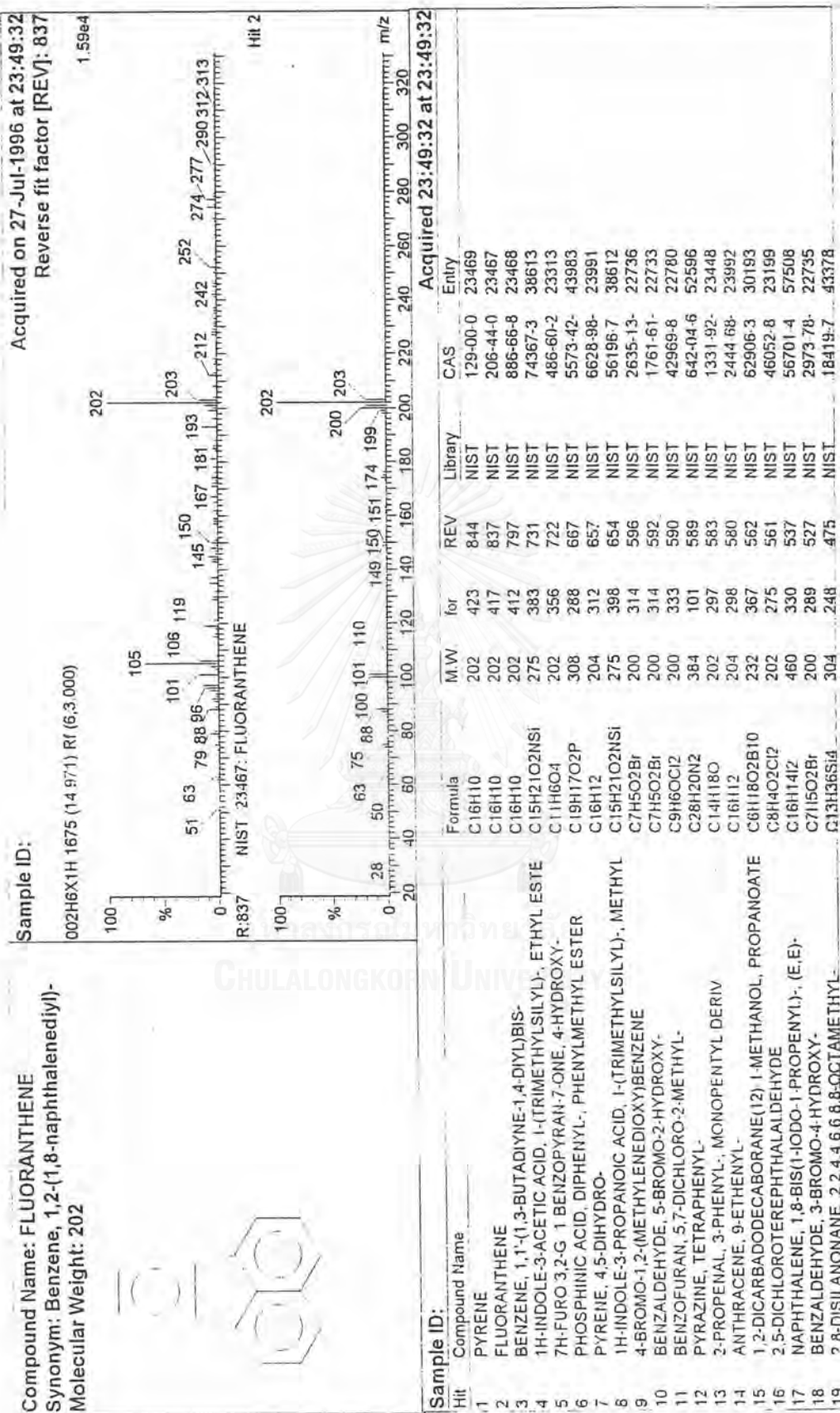


Figure B16 Comparison of Mass Spectra of Fluoranthene with Mass Spectra in NIST Library

APPENDIX C

Calibration curve of standard PAHs



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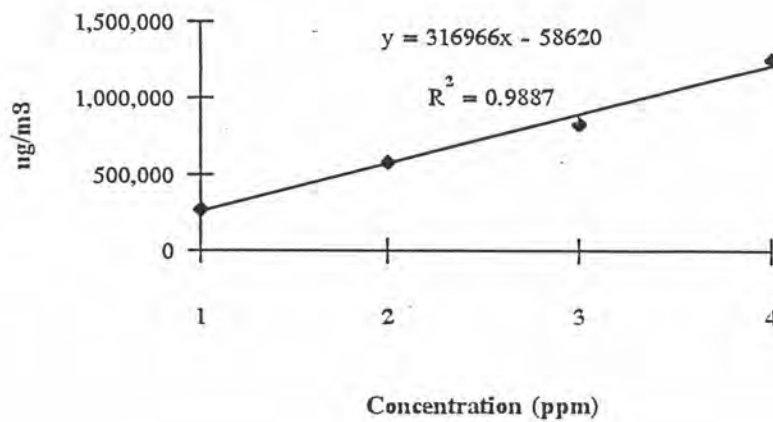


Figure C1 Calibration Curve for Naphthalene

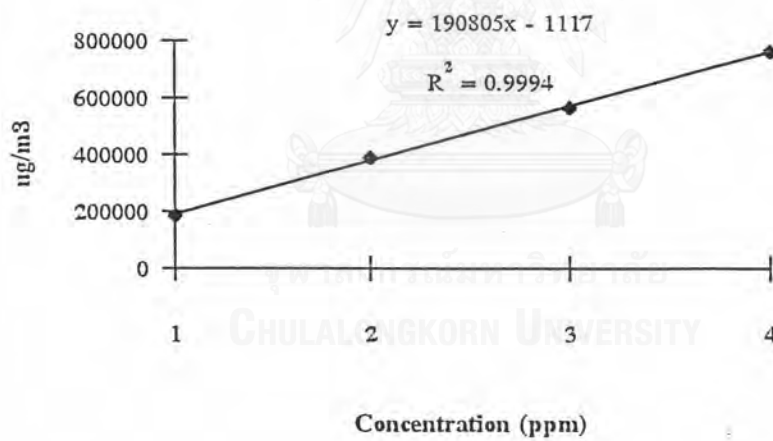


Figure C2 Calibration Curve for Acenaphthene

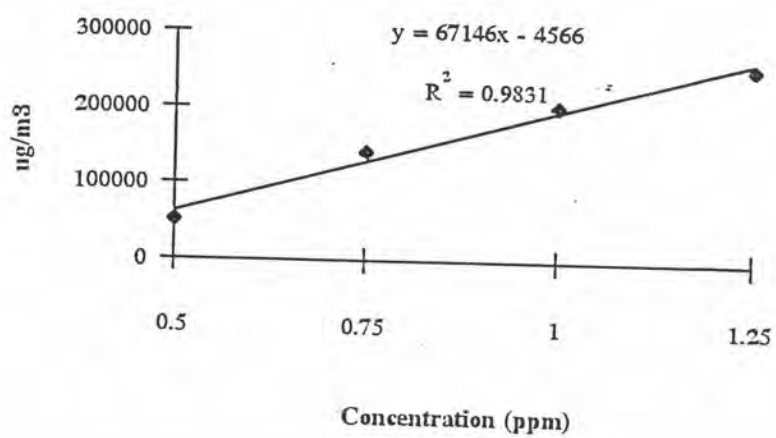


Figure C3 Calibration Curve for Phenanthrene

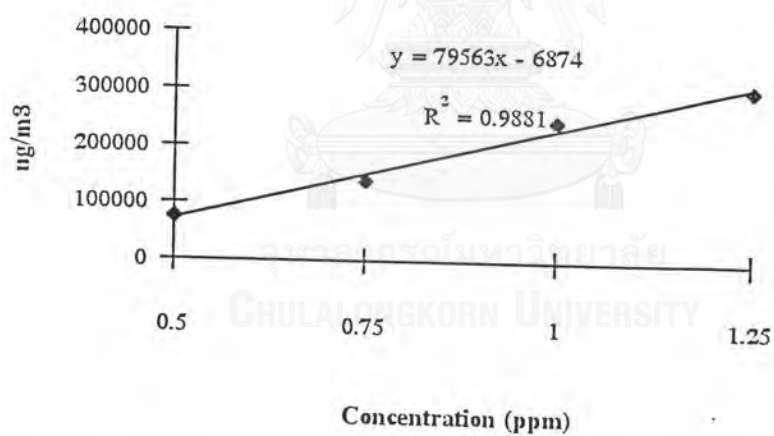


Figure C4 Calibration Curve for Fluoranthene

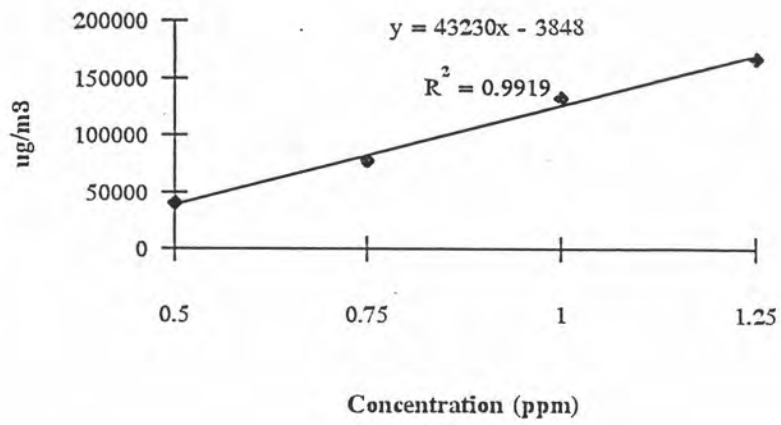
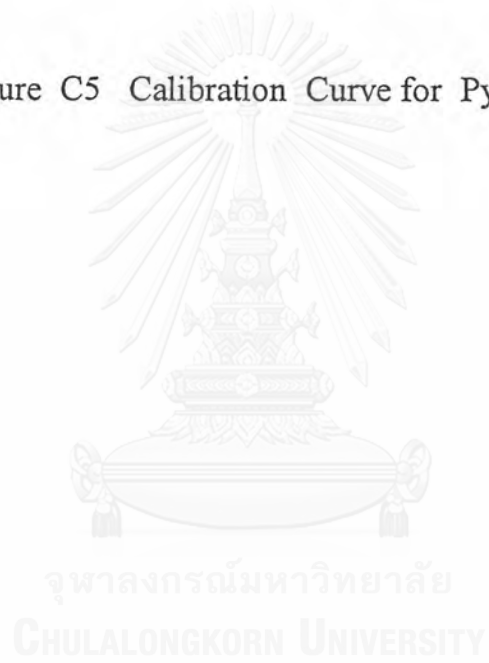


Figure C5 Calibration Curve for Pyrene



APPENDIX D

Concentration of PAHs in diesel exhaust, Exhaust temperature, and Air : fuel ratio



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Table D1 (continued) Concentration of PAHs in Diesel Exhaust

Fuel	speed and load	Nap.	Menap.	Dimena	Ace.	Phe.	Mephe.	Flu.	Pyr.	PAHs
	(r.p.m. and load)	ug/m ³	ug/m ³	ug/m ³	ug/m ³	ug/m ³	ug/m ³	ug/m ³	ug/m ³	ug/m ³
DTH56P	1500 r.p.m. 80%load	57.904	105.972	84.249	66.693	9.4624	18.571	3.518	6.0719	19.052
	2500 r.p.m. no load	85.253	106.870	76.638	62.913	10.095	24.256	2.7715	4.6989	17.565
	2500 r.p.m. 80%load	56.191	123.785	85.980	71.070	11.755	38.539	5.1972	9.1618	26.114
	2500 r.p.m. 50%load	104.757	196.350	118.272	107.572	7.5125	13.893	2.8813	4.9008	15.295
	3500 r.p.m. 80%load	62.635	131.360	99.946	81.630	7.6214	16.699	3.2825	5.6382	16.542
DTH59P	1500 r.p.m. 80%load	59.683	114.061	90.580	69.082	11.686	24.439	4.4743	7.8322	23.993
	2500 r.p.m. no load	87.767	107.941	67.690	50.174	9.5895	19.103	2.4532	4.113	16.156
	2500 r.p.m. 80%load	71.465	188.026	126.669	106.654	9.3601	26.221	4.0411	7.0349	20.436
	2500 r.p.m. 50%load	60.360	108.520	72.948	59.750	5.7541	6.1089	1.6944	2.7163	10.165
	3500 r.p.m. 80%load	63.907	117.406	83.724	66.033	9.8975	19.681	4.2707	7.4564	21.625
DTH62P	1500 r.p.m. 80%load	53.589	89.273	67.334	55.019	7.1154	10.694	3.1168	5.3336	15.566
	2500 r.p.m. no load	45.077	65.449	51.966	37.292	6.9974	18.785	2.4444	4.0967	13.538
	2500 r.p.m. 80%load	64.748	132.953	98.034	78.084	13.937	33.283	4.1045	7.1511	25.193
	2500 r.p.m. 50%load	62.412	90.991	57.645	47.021	4.1958	5.3707	1.7334	2.7882	8.717
	3500 r.p.m. 80%load	63.926	118.702	84.382	68.858	7.6483	17.731	4.0594	7.0681	18.776
DTL52X	1500 r.p.m. 80%load	34.506	85.731	88.018	74.022	2.9163	16.569	3.0714	5.2501	11.238
	2500 r.p.m. no load	42.571	80.673	73.868	60.567	11.073	31.162	3.3051	5.6808	20.059
	2500 r.p.m. 80%load	30.330	87.544	120.195	99.899	21.532	52.287	6.7572	12.034	40.323
	2500 r.p.m. 50%load	24.881	68.512	101.839	89.039	8.8594	8.4541	1.5376	2.4278	12.825
	3500 r.p.m. 80%load	29.278	81.186	113.742	101.454	19.777	33.56	3.9458	6.8591	30.582
DTH53X	1500 r.p.m. 80%load	70.324	141.678	123.003	70.062	12.221	18.468	7.8365	14.02	34.077
	2500 r.p.m. no load	123.972	138.654	70.848	57.121	8.0949	17.914	2.3087	3.847	14.251
	2500 r.p.m. 80%load	83.396	216.259	160.266	107.021	17.174	34.853	4.0846	7.1152	28.374
	2500 r.p.m. 50%load	115.283	277.679	198.034	139.370	12.547	6.2343	1.5158	2.3874	16.451
	3500 r.p.m. 80%load	75.502	205.338	151.505	111.531	16.971	25.308	3.7068	6.4191	27.097
DTH52X	1500 r.p.m. 80%load	39.319	104.073	96.986	59.463	9.2048	14.509	2.3876	3.9915	15.584
	2500 r.p.m. no load	52.485	91.964	65.315	55.755	9.1788	15.246	2.5636	4.3161	16.058
	2500 r.p.m. 80%load	35.699	100.249	95.188	63.149	10.568	25.938	4.3039	7.5185	22.390
	2500 r.p.m. 50%load	37.039	90.570	94.206	75.046	4.1358	1.5622	0.7652	1.0063	5.907
	3500 r.p.m. 80%load	31.588	84.605	85.145	60.386	11.225	15.087	2.3613	3.9423	17.528

Table D1 (continued) Concentration of PAHs in Diesel Exhaust

Fuel	speed and load	Nap.	Menap.	Dimena	Ace.	Phe.	Mephe.	Flu.	Pyr.	PAHs
	(r.p.m. and load)	ug/m ³	ug/m ³	ug/m ³	ug/m ³	ug/m ³	ug/m ³	ug/m ³	ug/m ³	ug/m ³
DTL56N	1500 r.p.m. 80%load	56.153	128.021	96.625	85.927	24.905	81.505	8.4037	15.064	48.373
	2500 r.p.m. no load	54.715	111.186	93.466	80.976	6.4544	15.844	2.4074	4.0287	12.891
	2500 r.p.m. 80%load	35.509	119.119	124.530	109.486	17.417	46.134	6.5077	11.575	35.499
	2500 r.p.m. 50%load	35.048	93.247	96.810	88.400	4.333	5.6554	1.2287	1.8592	7.421
	3500 r.p.m. 80%load	15.588	83.613	107.030	96.563	16.262	28.936	3.2583	5.5927	25.113
DTL58N	1500 r.p.m. 80%load	35.590	75.237	62.626	54.021	8.8167	25.635	3.5354	6.104	18.456
	2500 r.p.m. no load	46.476	80.147	55.829	51.775	6.7043	12.764	2.1351	3.5275	12.367
	2500 r.p.m. 80%load	43.131	139.401	144.618	135.562	22.061	52.241	6.377	11.333	39.771
	2500 r.p.m. 50%load	50.331	105.065	86.600	80.721	5.4556	6.6138	1.3662	2.1124	8.934
	3500 r.p.m. 80%load	39.397	119.672	115.759	108.456	14.301	29.042	3.0027	5.1222	22.425
DTL60N	1500 r.p.m. 80%load	31.820	93.501	103.284	90.876	14.968	33.117	4.6898	8.2287	27.887
	2500 r.p.m. no load	49.018	85.643	63.780	65.011	4.9026	6.7512	0.8319	1.129	6.863
	2500 r.p.m. 80%load	37.101	110.237	118.352	116.929	17.013	34.23	4.097	7.1373	28.247
	2500 r.p.m. 50%load	38.831	101.439	109.526	109.104	6.1055	6.6138	1.4523	2.2707	9.828
	3500 r.p.m. 80%load	8.157	56.954	67.972	58.634	17.097	31.966	3.9163	6.8015	27.815
	Mean	46.94	100.651	90.4103	70.379	10.419	21.829	3.2641	5.6182	19.301

PAHs = Fluoranthene+Phenanthrene+ Pyrene

Table D2 Temperature of Exhaust Emission

Condition\Fuel	DTH 55X	DTH 58X	DTH 57X	DTH 59N	DTH 61N	DTH 62N	DTH 56P	DTH 59P	DTH 62P	DTL 52X	DTH 53X	DTH 52X	DTL 56N	DTL 58N	DTL 60N
1500 r.p.m. 80% load	299	302	293	323	322	322	318	319	312	302	321	321	297	295	301
2500 r.p.m. no load	132	140	141	137	137	138	134	136	135	139	138	136	137	135	136
2500 r.p.m. 50% load	293	310	293	312	309	311	306	302	302	298	313	312	297	294	294
2500 r.p.m. 80% load	398	406	405	432	431	432	412	421	420	413	434	429	413	404	407
3500 r.p.m. 80% load	435	447	448	470	475	474	466	462	463	450	478	471	453	444	449

Table D3 Air to Fuel Ratio of Diesel Engine

Condition\Fuel	DTH 55X	DTH 58X	DTH 57X	DTH 59N	DTH 61N	DTH 62N	DTH 56P	DTH 59P	DTH 62P	DTL 52X	DTH 53X	DTH 52X	DTL 56N	DTL 58N	DTL 60N
1500 r.p.m. 80% load	33.25	34.60	34.73	33.78	32.46	32.72	33.15	33.80	33.60	34.87	34.87	34.87	34.053	34.053	34.053
2500 r.p.m. no load	118.98	118.22	120.77	123.10	123.72	118.92	117.16	117.55	116.06	123.73	123.73	123.73	121.41	121.41	121.41
2500 r.p.m. 50% load	39.93	42.08	42.45	39.42	40.13	38.63	39.86	40.01	40.75	40.17	40.17	40.17	40.34	40.34	40.34
2500 r.p.m. 80% load	27.52	29.00	28.86	26.78	27.98	25.63	27.35	27.62	27.70	27.95	27.95	27.95	27.68	27.68	27.68
3500 r.p.m. 80% load	26.88	28.45	28.39	26.28	26.45	26.40	27.09	26.89	28.00	27.03	27.03	27.03	27.43	27.43	27.43

Table D3 (continued) Air to Fuel Ratio of Diesel Engine

Condition\Fuel	DTL 56N	DTL 58N	DTL 60N
1500 r.p.m. 80% load	32.68	33.54	34.32
2500 r.p.m. no load	111.75	112.08	113.33
2500 r.p.m. 50% load	40.12	39.47	39.88
2500 r.p.m. 80% load	26.44	27.10	27.10
3500 r.p.m. 80% load	26.26	26.04	25.77

Table D4 Volume of Diesel Exhaust Sampling (m³)

Condition\Fuel	DTH 55X	DTH 58X	DTH 57X	DTH 59N	DTH 61N	DTH 62N	DTH 56P	DTH 59P	DTH 62P	DTL 52X	DTH 53X	DTH 52X
1500 r.p.m. 80% load	1.7383	1.7397	1.7338	1.7382	1.7385	1.7375	1.7378	1.7390	1.7380	1.7385	1.7387	1.7383
2500 r.p.m. no load	1.7413	1.7413	1.7413	1.7413	1.7413	1.7413	1.7413	1.7413	1.7413	1.7413	1.7413	1.7413
2500 r.p.m. 50% load	1.7413	1.7410	1.7410	1.7423	1.7413	1.7413	1.7413	1.7413	1.7413	1.7413	1.7413	1.7405
2500 r.p.m. 80% load	1.7315	1.7392	1.7382	1.7367	1.7377	1.7375	1.7352	1.7388	1.7370	1.7382	1.7387	1.7400
3500 r.p.m. 80% load	1.7345	1.7302	1.7375	1.7272	1.7368	1.7375	1.7363	1.7345	1.7368	1.7372	1.7345	1.7368

Table D4 (continued) Volume of Diesel Exhaust Sampling (m³)

Condition\Fuel	DTL 56N	DTL 58N	DTL 60N
1500 r.p.m. 80% load	1.7393	1.7388	1.7380
2500 r.p.m. no load	1.7413	1.7413	1.7413
2500 r.p.m. 50% load	1.7413	1.7380	1.7410
2500 r.p.m. 80% load	1.7393	1.7357	1.7373
3500 r.p.m. 80% load	1.7325	1.7327	1.7228

VITA

Mr. Opart Septhum was born on April 18, 1971 in Nakorn Si Thamarat. He received his Bachelor's Degree of Science in Chemistry from Department of Chemistry, Faculty of Science, Prince of Songkla University in 1994. He began his Master study at Multidisciplinary of Petrochemistry and Polymer, Graduate School, Chulalongkorn University, in 1994 and completed the program in 1997.

