REFERENCES

Thai

กองกีฏและสัตววิทยา. (2540). *เอกสารเผยแพร่การป้องกันและกำจัดหอยเชอรี่โดยวิธีผสมผสาน*.กรุงเทพมหานคร: กรมวิชาการเกษตร กระทรวงเกษตรและสหกรณ์.

ชมพูนุช จรรยาเพศ และทักษิณ อาชวาคม. (2541). *หอยเชอรี่*. เอกสารการประชุมสัมนากองกีฏและสัตว วิทยา กรมวิชาการเกษตร, ธันวาคม.

นันทิยา โพธิ์สวัสดิ์. (2543). *ศึกษาประสิทธิภาพของสารสกัดจากกากชาและโล่ติ๊นในการกำจัดหอยเชอรี่(Pomacea canaliculata)* วิทยานิพนธ์ปริญญามหาบัณฑิต, สาขาเทคโนโลยีบริหารสิ่งแวดล้อม บัณฑิตวิทยาลัย มหาวิทยาลัยมหิดล.

นันทวัน บุณยะประภัศร. (2542). *สมุนไพรพื้นบ้าน(3)*. กรุงเทพ: ประชาชน.

วิไลพร พรวิรุฬห์, วีณา ถือวิเศษสิน, วีณา จิรัจฉริยากูล และ รุ่งระวี เต็มศิริฤกษ์กุล. (2531). *ดัชนีการทำลายเซลล์เม็ดเลือดแดงในมาตรฐานสมุนไพรไทย*, รายงานโครงการพิเศษนักศึกษาคณะเภสัชศาสตร์ มหาวิทยาลัยมหิดล.

อุมาภัณฑ์ เอี่ยมศิลป์, อุษณีย์ อนุวรรตวรกุล และ อ้อมบุญ ล้วนรัตน์. (2539). *การสกัดมะคำดีควายเพื่อใช้ในแชมพูสระผม*. รายงานโครงการพิเศษนักศึกษาคณะเภสัชศาสตร์ มหาวิทยาลัยมหิดล.

English

Abbott, W. S. (1925). A method of computing the effectiveness of an insecticide. *J Econ. Entomol.* 18: 265-267.

Ahmed, B., and D. Garg. (1998). Antifertility activity of emarginatosides B and C of fruits of *Sapindus emarginatus*. *J. Med. Aro. Plant. Sci.* 20: 362-363.

Anon. (1965). Molluscicidal screening and evaluation. *WHO Bull.* 32: 507-581.

Calumpang, S. M. F. Medina, M. J. B.; Tejada, A. W.; Meedina, J.R. Environmental impact of two molluscicidal: niclosamide and metaldehyde in a rice paddy ecosystem. *Bull. Environ. Contam. Toxicol.* 1995, 55: 494-501.

Carmichael, J., De Grraff, W. G., Gazdar, A.F., Minna, J.D. (1987).and Mitchell, B. *Cancer Res.* 47: 936-942.

Chanyapate, C. and Archawacom, T. (1997). Golden apple snail In: A pest in rice fields. Report of Agriculture Zoology Research Group. Entomology and Zoology Division. Department of Agricuture, Thailand.

Chanyapate, C.and Archawacom, T. (1999). golden apple snail. Report of agriculture, Zoology Research Group. Entomology and Zoology Division. Department of Agriculture, Thailand.

Chao, D., C. Lin and Y. Chan. (1987). Studies on growth and distribution of *Angiostrongylus cantonensis* larvae in Ampullarium canaliculata. The Southeast Asia J.Trop. *Med. Pub. Hlth.* 18(2): 248-252.

Cowie, R. H. (2002) Apple snails (Ampullariidae as agricultural pests: Their biology, impacts, and management. *Molluscs as Crop Pests*, CABI Publishing: Oxfordshire, UK : p 145-192.

Domon, B. and Hostettmann, K. (1984). New saponins form *Phytolacca dodecandra* L'Herit. *Hev. Chim. Acta.* 67: 1310-1315.

Finney, D. J. (1971) *Probit analysis*, 3 rd ed. Cambridge University Press : London, UK : p 333.

Hostettmann, K., M. Hostettmann. And A. Marston. (1991). Saponin. pp. 435-471. In B.V. Charlwood and D.V. Banthorpe (ed.) vol.7 of

Methods in plant Biochemistry J.B. Harborne and P.M. Dey (ed.) Terpenoids. Academic Press. London.

Huang. H-C., S-C Liao, F-R. Chang, Y-H. Kuo, and Y-C. Wu. (2003). Molluscicidal saponins from *Sapindus mukorossi*, Inhibitory agents of golden apple snails, *Pomacea canaliculata. J. Agric. Food. Chem.* 51: 4916-4919.

Ireland, P. A. and Dziedzic, S. Z. (1987). Saponins and sapogenins of chickpea, harcot bean and red kidney bean. *Food Chem.* 23: 105-116.

Kanchanapoom. T ., R. Kasai, and K. Yamasaki. (2001). Acetylated triterpene saponins from the Thai medicinal plant, *Sapindus emarginatus. Chem. Pharm. Bull.* 49: 1195-1197.

Kasai, R., H. Fujino, T. Kuzuki, W. H. Wong, C. Goto, N. Yata, O. Tanaka, F. Yasuhara, and S. Yamaguchi. (1986). Acyclic sesquiterpene oligoglycosides from pericarps of *Sapindus mukurossi. Phytochemistry* 25: 871-876.

Keawjam, R.S. and Upatham, E.S. (1990). Shell morphology, reproductive anatomy and genetic patterns of three species of apple snails of the genus *Pomacea* in Thailand. *J.Med. Appl. Malacol.* 2: 45-57.

Kimata, H., T. Nakashima, S. Kokubun, K. Nakayama, Y. Mitoma, T. Kitahara, N. Yata, and O. Tanaka. (1983). Saponin of pericarps of *Sapindus mukurossi* Gaertn. And solubilization of monodesmosides by bisdesmosides. *Chem. Pharm. Bull.* 31: 1998-2005.

Lauhachinda, N., Senawong, C., Phongsmas, D., Udomchoke, V., Homchan, U., Makatan, N. (1996). Crop protection and

control from the golden apple snail *Pomacea canaliculata* (Orbingy) by physiological means and biocontrol. Research Report of Kasetsart University, Thailand.

Lemmich, E., Cornett, C., Furu, P. (1995). Molluscicidal saponins from *Catunaregam nilotica. Phytochemistry.* 39(1): 63-68.

Lemos, T. L. G., M. P. Sousa, A. L. Mendes, and R. Braz- Filho. (1994). Saponin from *Sapindus saponaria. Fitoterapia.* 65: 557.

Lum, K. A.; Kenny, J. S. (1989). The reproductive biology of the Ampullariid snail Pomacea canaliculata (Muller). *J. Moll. Stud.* 55: 53-66.

Marston, A. and Hostettmann, K. (1985). Review article number 6; plant molluscicides. *Phytochemistry* 24: 639-652.

Meeposom. C. (2004).The utilization of cashew nut shell crude extract for golden apple snail (*Pomacea canaliculata*) control. *M. Sc. Thesis*, Department of Technology for Resources and Environmental Development, Faculty of Graduate Studies, Mahidol University.

Murakami, T., Nakamura, J., Matsuda, H., Yoshikawa, M., (1999a). Bioactive saponins and glycosides. XV. Saponin constituents with gastroprotective effect from the seeds of Tea plant, *Camellia sinensis.* Assamsaponins A, B, C, D and E. *Chem. Pharm. Bull.* 47(12): 1759-1764.

Nakayama, k., H. Fujino, R. Kasai, O. Tanaka, and J. Zhou. (1986). Saponins of pericarps of Chinese *Sapindus delavayi*(pyi-shiau-tzu), a source of natural surfactants. *Chem. Pharm. Bull.* 34: 2209-2213.

Naylor, R. Invasions in agriculture: Assedding the cost of the golden apple snail in agriculture: Assessing the cost of the golden apple snail in Asia. *Ambio* 1996, 25: 443-448.

Smitinand, T. (2001). Thai Plant Names. Revised. Bangkok: The Forest Herbarium, Royal Forest Departments.

Somrudee, M. (2002). Toxicity of indigenous plant extracts to *Pomacea canaliculata. M. Sc. Thesis* in Environment Sanitation. Faculty of Graduate Studies, Mahidol University, Thailland.

Somkasettrin, A. (1999). Efficacy of neem extracts on golden apple snail (*Pomacea canaliculata*) M.S. Thesis in Biology. Faculty of Graduate Studies, Kasetsart University, Thailland.

Tamura, K., K. Mizutani, and S. Yamamoto. (1990). Isolation of monodesmoside saponins from rind of *Sapindus trifoliatus* or *mukorossi* fruits as skin fungicides. Patent: *Jpn. Kokai Tokkyo Koho*, 3 pp.

Toshiaki, M. (1989). Snail killing agents of Gastropoda. *Japan Patent 116095* esp@cenet database.

Twentyman, P.R. and Luscombe, M. (1987). Br. J. Cancer. 56: 279-285.

Wong, W-H., R. Kasai, W. Choshi, Y. Nakagama, K. Mizutani, K. Ohtani, and O. Tanaka. (1991). Acyclic sesquiterpene oligoglycosides from pericarps of *Sapindus delavayi. Phytochemistry* 30: 2699-2702.

Yoshikawa, M. (1994). *Chem. Pharm. Bull.* 42(3): 742-744.

Yoshikawa, M. Morikawa, T., Fujiwara, E., Ohgushi, T., Asao. Y., Matsuda, H. (2000). New Noroleanane-Type Triterpene Saponins with Gastroprotective effect and platelet aggregation activity from the flower of *Camellia japonica*: Revised

structures of Camellenodiol and Camelledionol. *Heterocycles* 55(9): 1653.

Zikova, N.Y., and P. E. Krivenchuk. (1965). Phytochemical investigation of *Sapindus mukorossi*. IV. Saponins. *Farm. Zhu.(Kiev)* 20 : 27-30.

APPENDICES

APPENDIX A

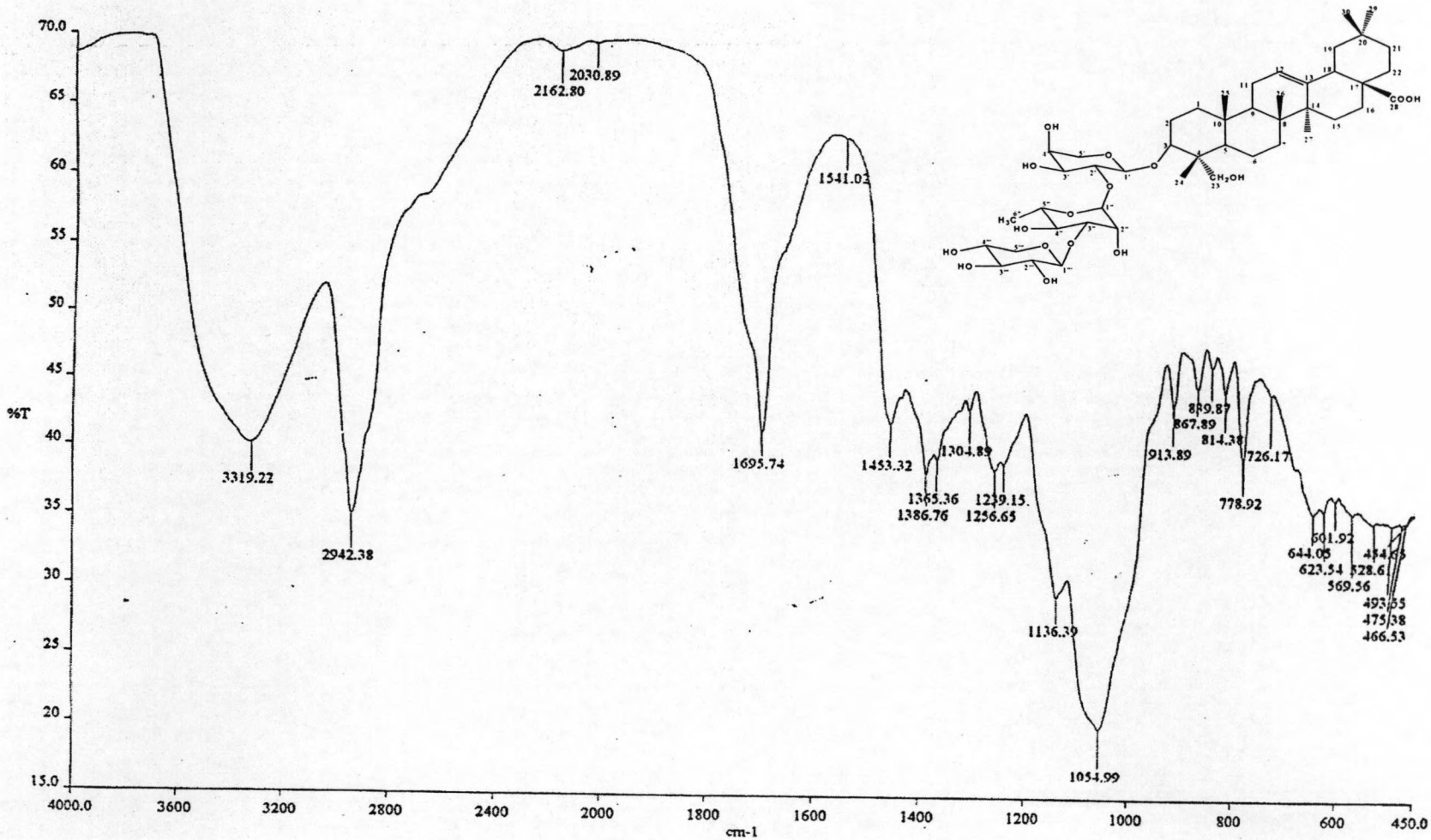

Figure 11 The IR spectrum of Compound Sp1 (KBr disc)

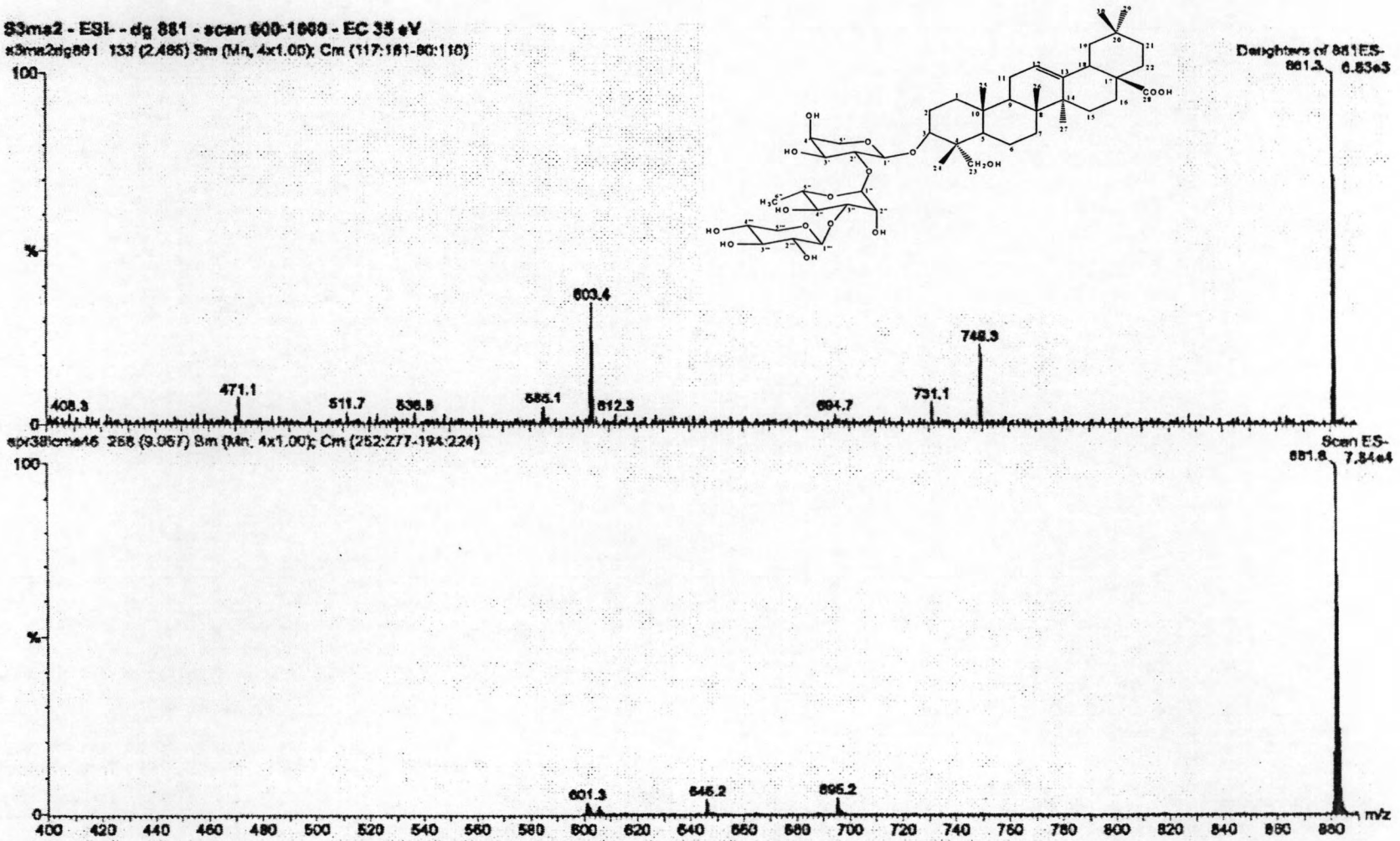

Figure 12 The EI-MS spectrum of Compound Sp1

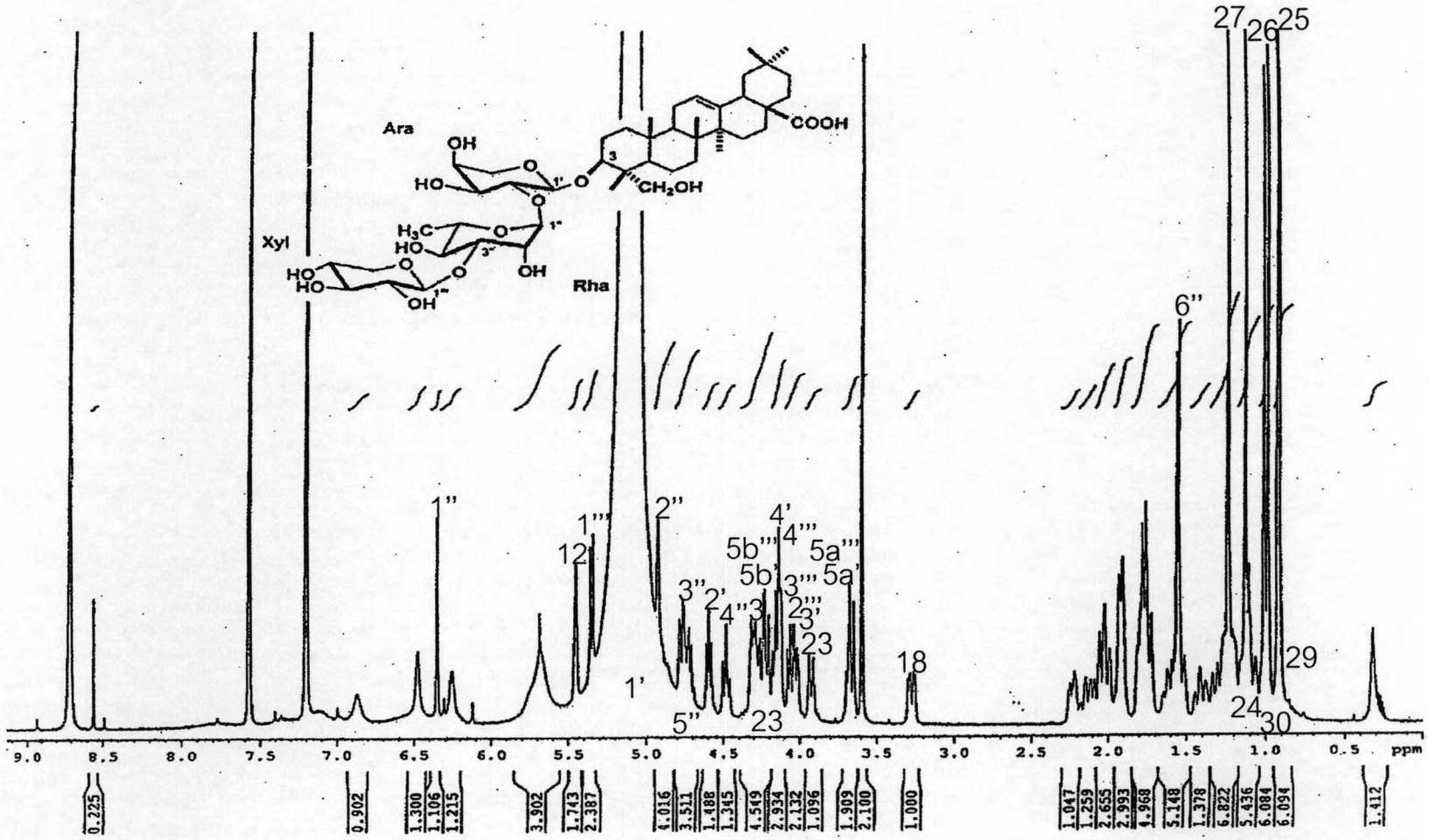

Figure 13 The 400 MHz ^{1}H-NMR spectrum of Compound Sp1 (in pyridine-d_5)

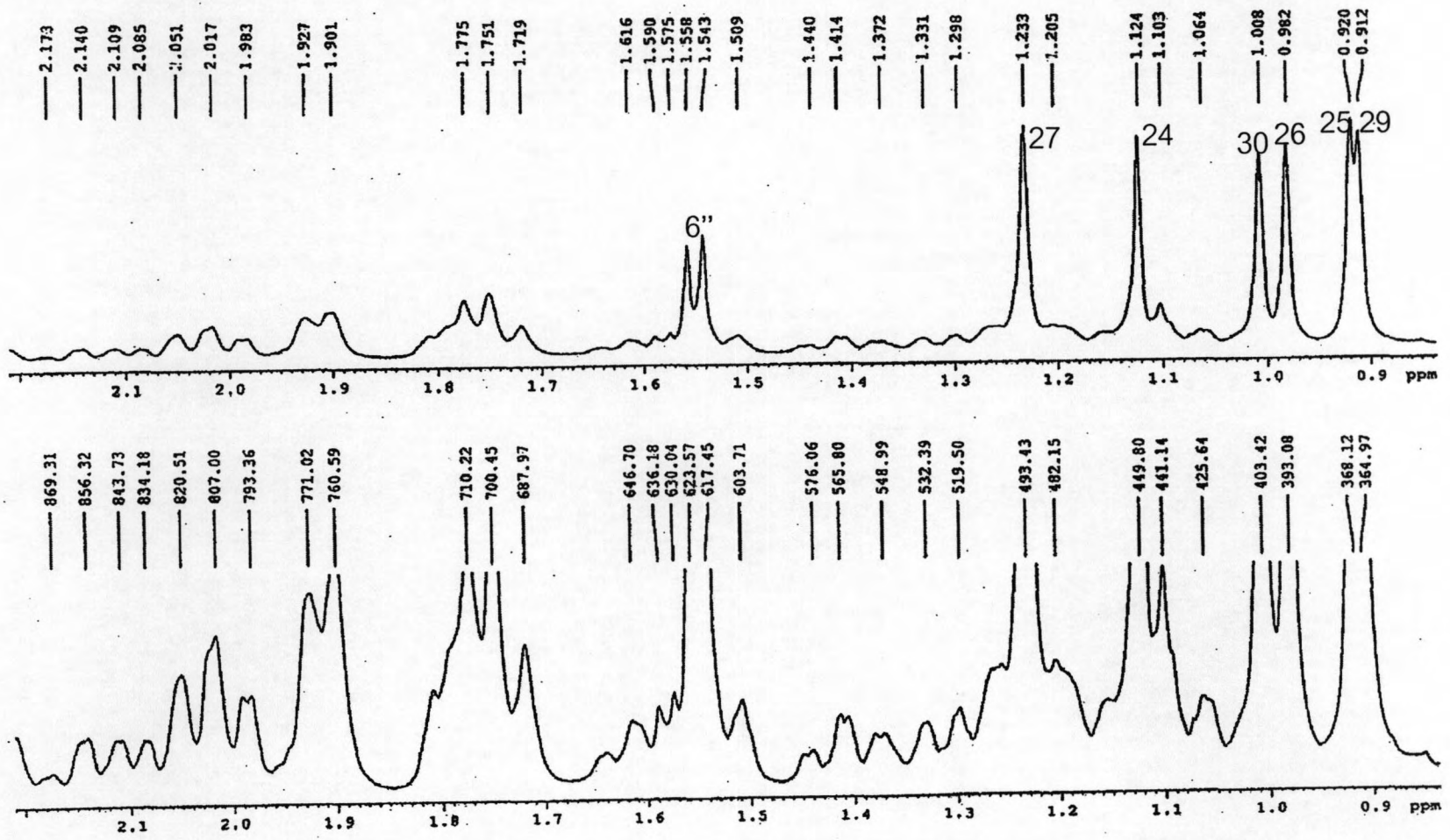

Figure 14 The expansion of ^{1}H-NMR spectrum of Compound Sp1 (in pyridine-d_5)

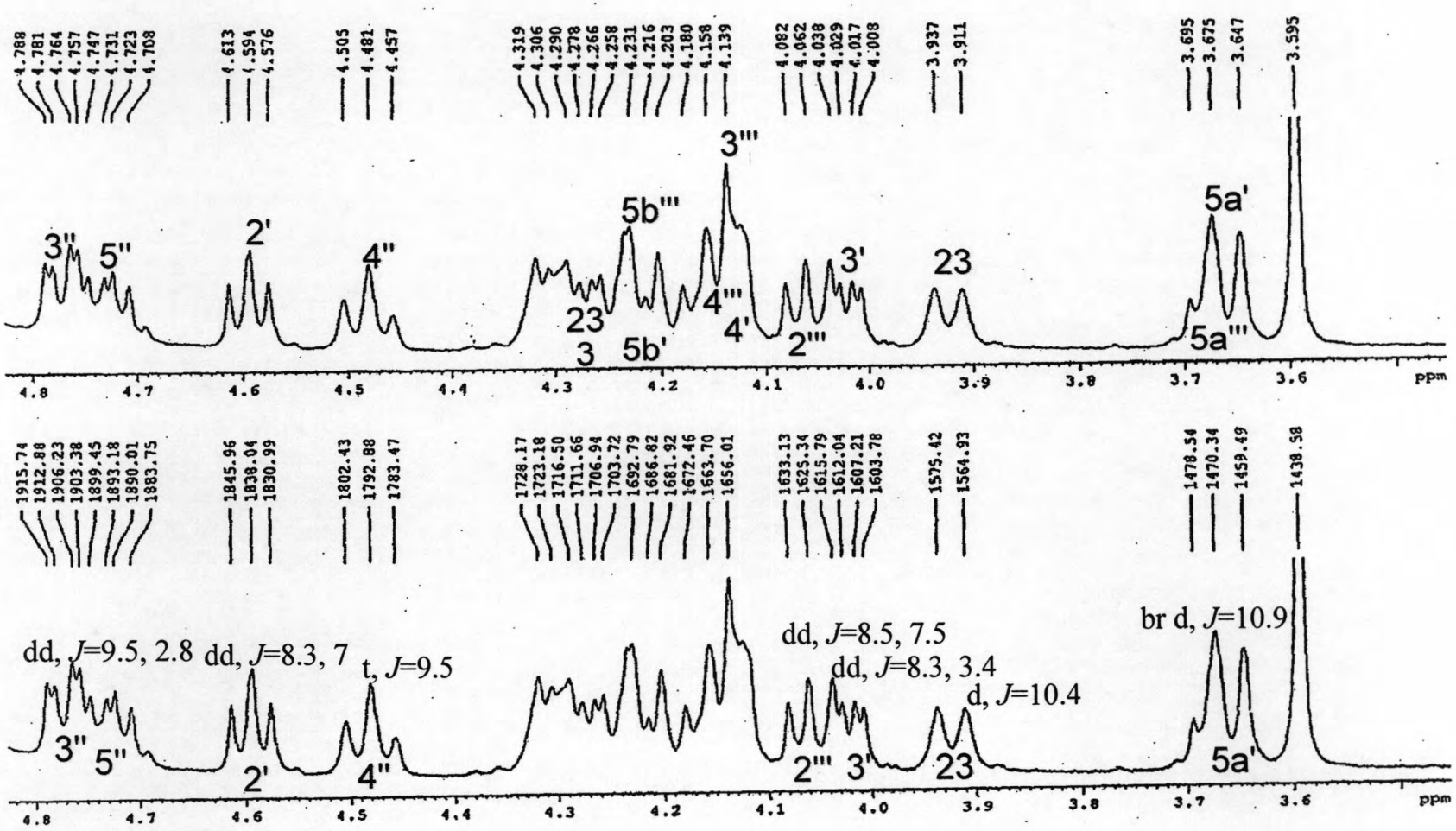

Figure 15 The expansion of ^{1}H-NMR spectrum of Compound Sp1 (in pyridine-d_5)

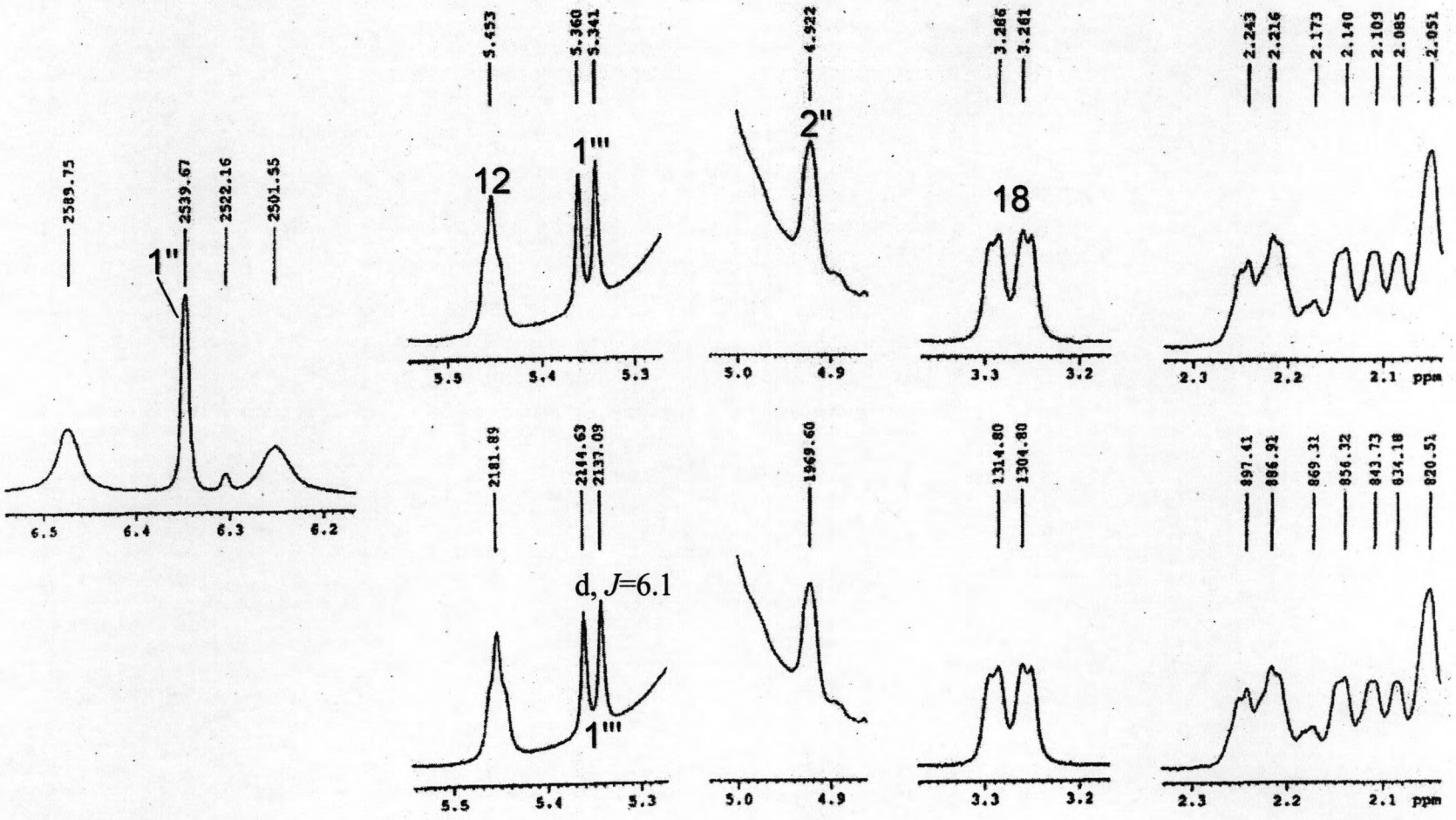

Figure 16 The expansion of ^{1}H-NMR spectrum of Compound Sp1 (in pyridine-d_5)

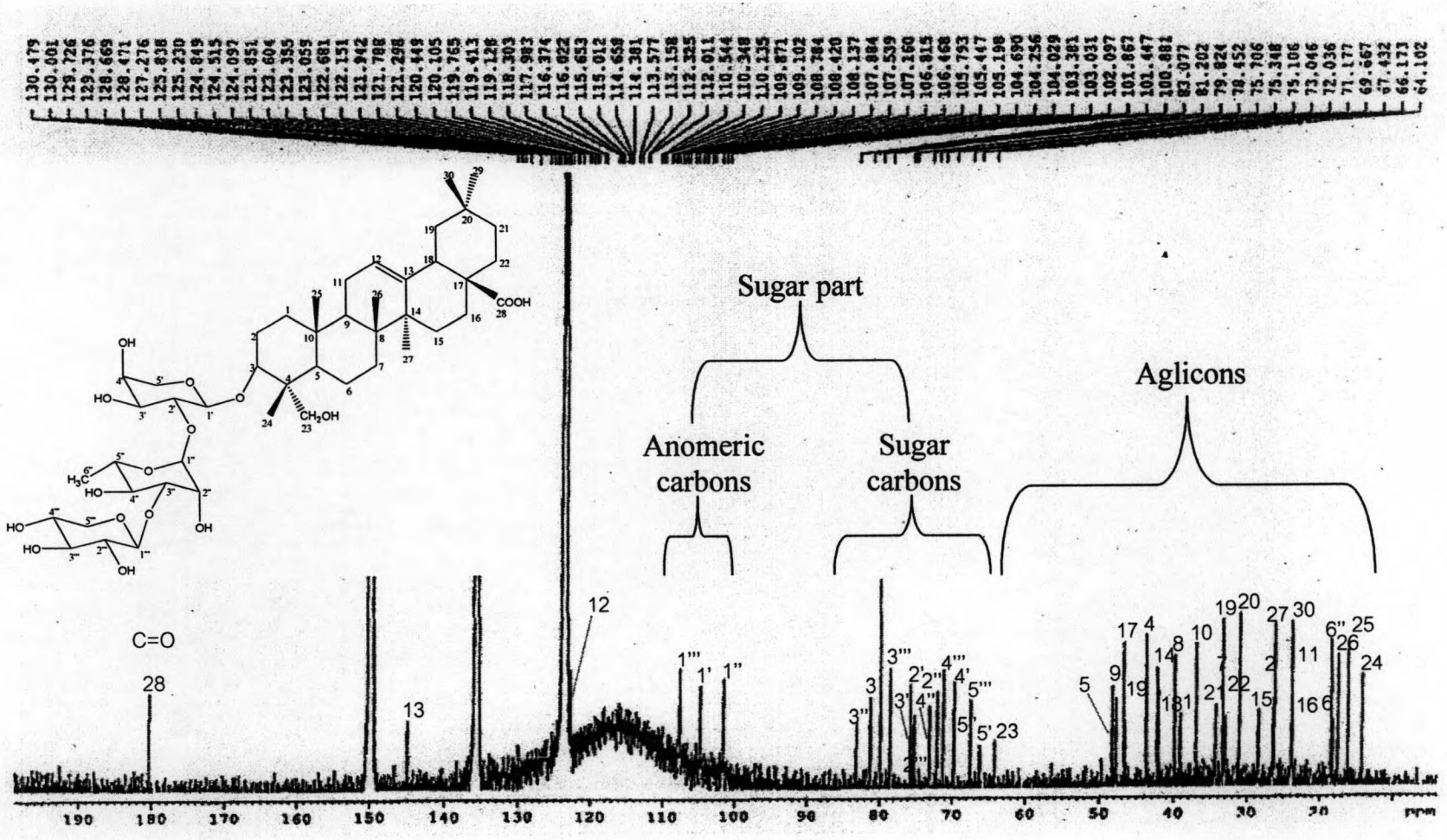

Figure 17 The 100 MHz ^{13}C-NMR spectrum of Compound Sp1(in pyridine-d_5)

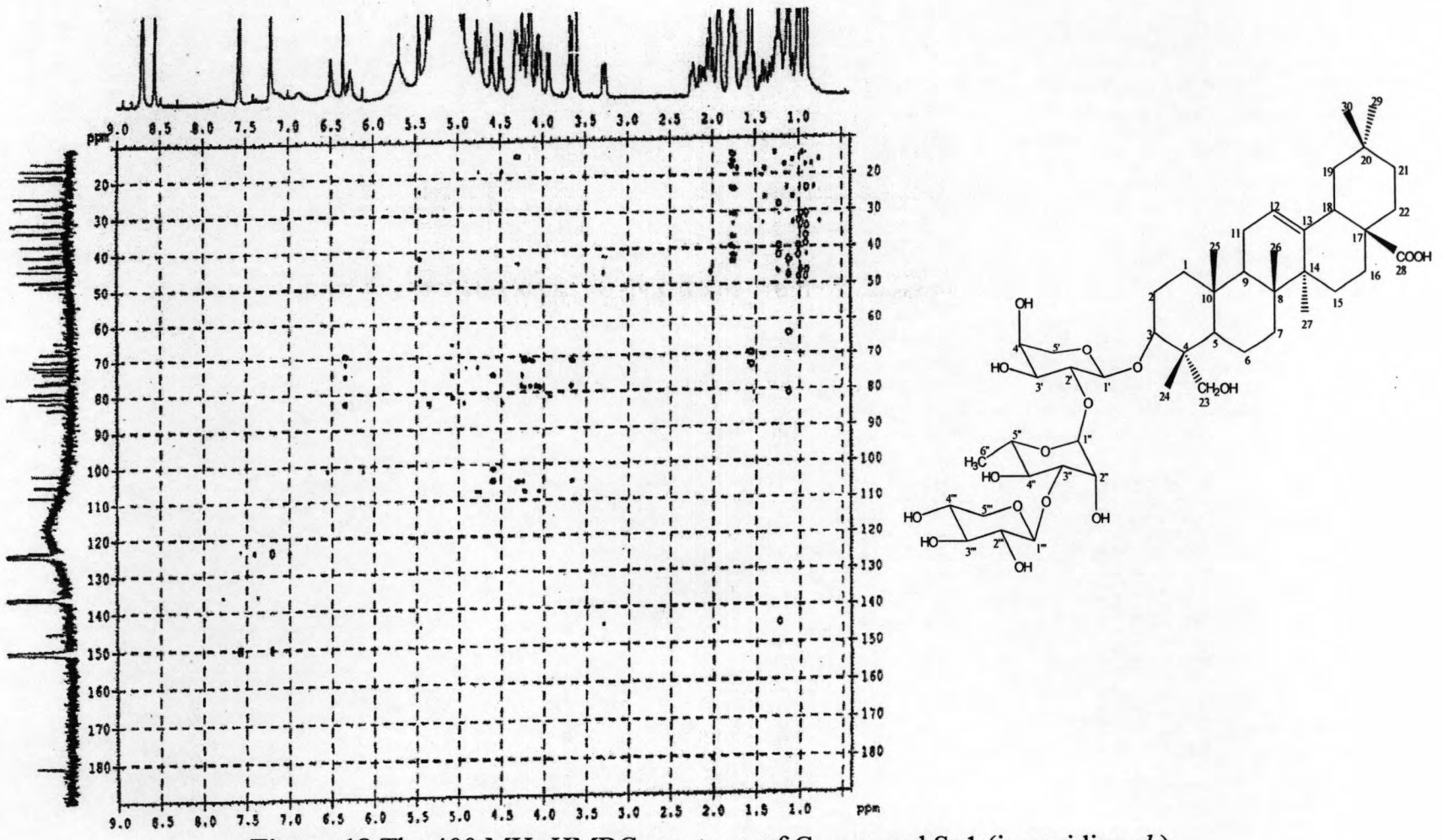

Figure 18 The 400 MHz HMBC spectrum of Compound Sp1 (in pyridine-d_5)

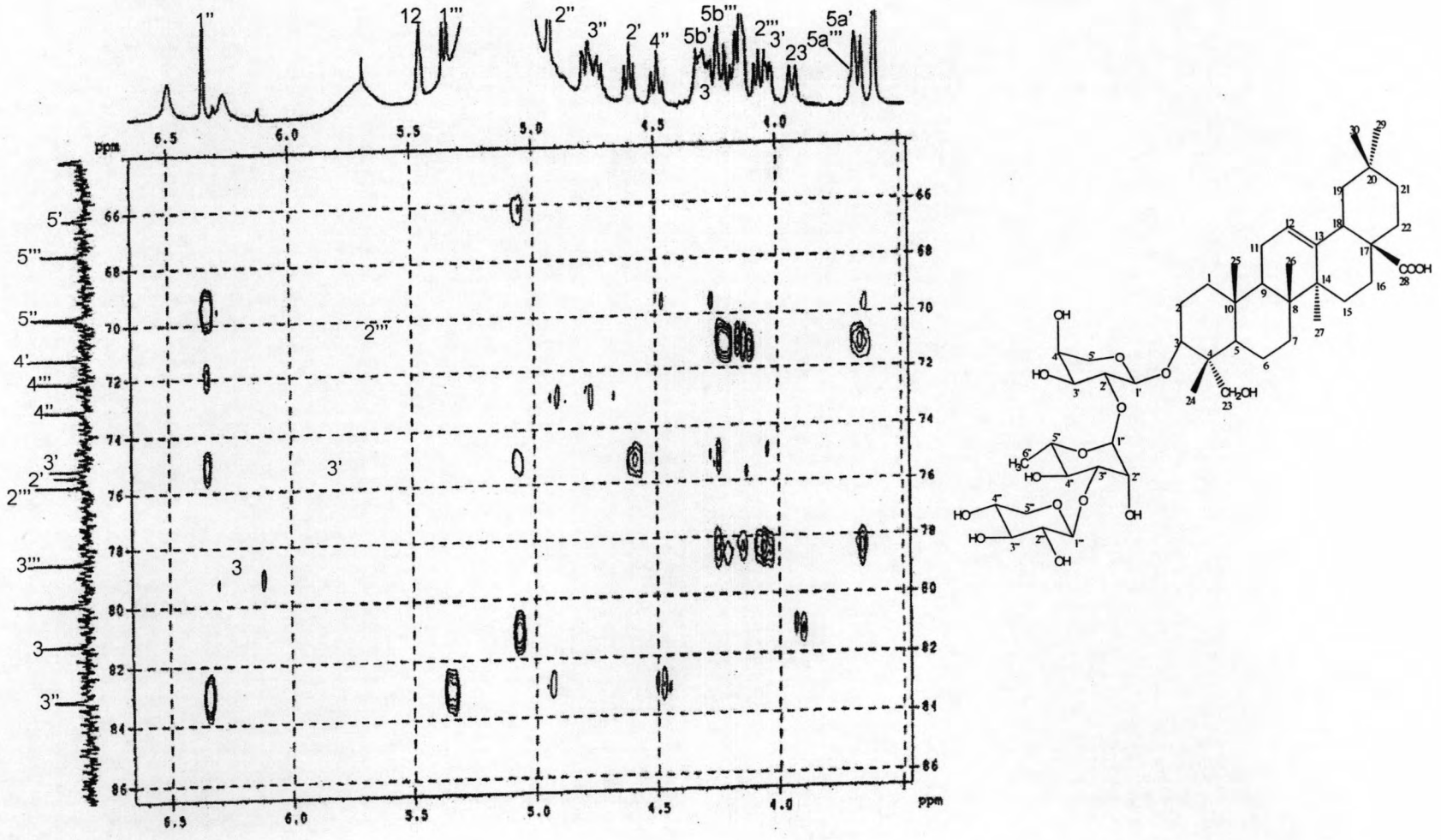

Figure 19 The expansion of HMBC spectrum of Compound Sp1 (in pyridine-d_5)

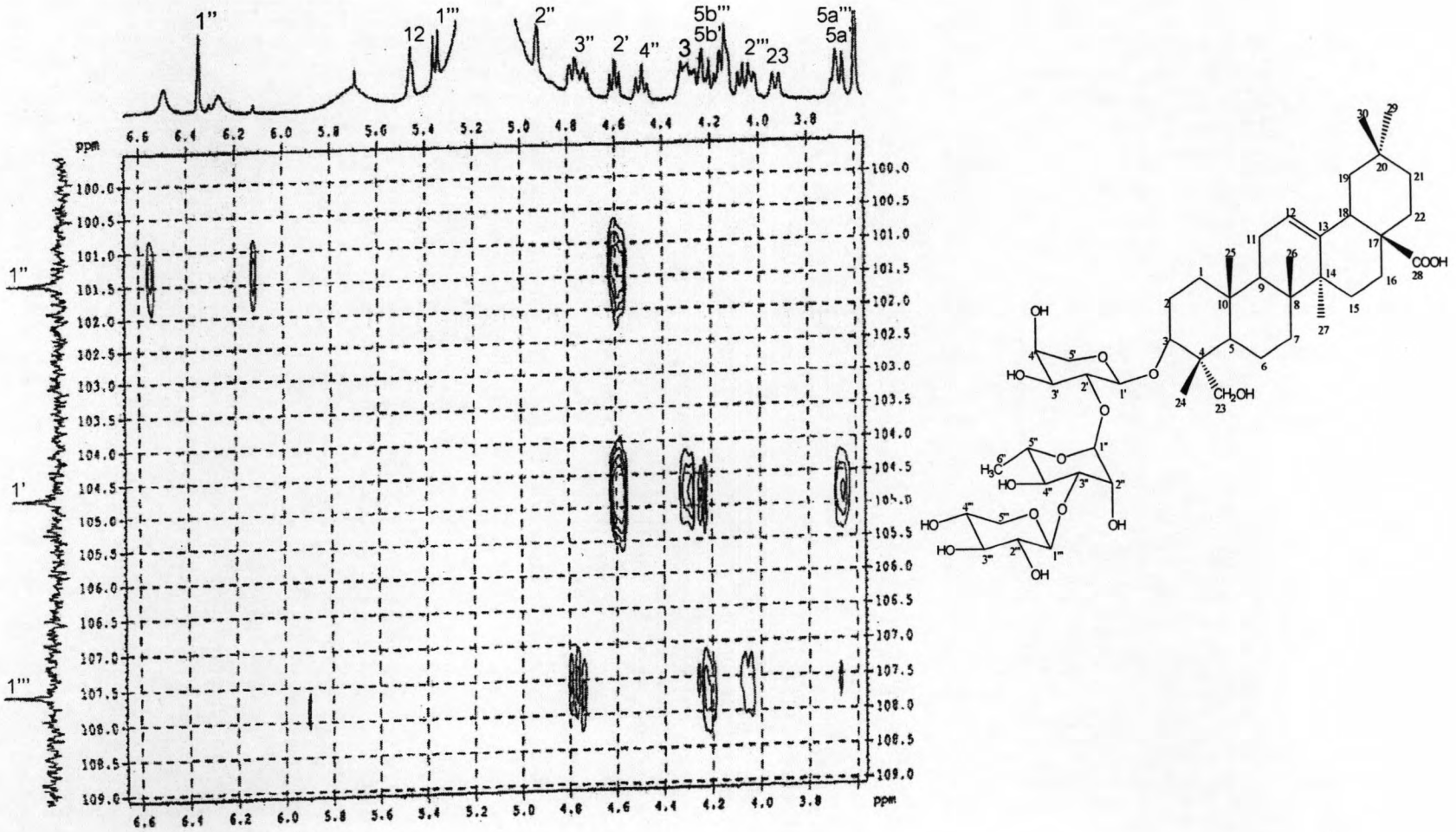

Figure 20 The expansion of HMBC spectrum of Compound Sp1 (in pyridine-d_5)

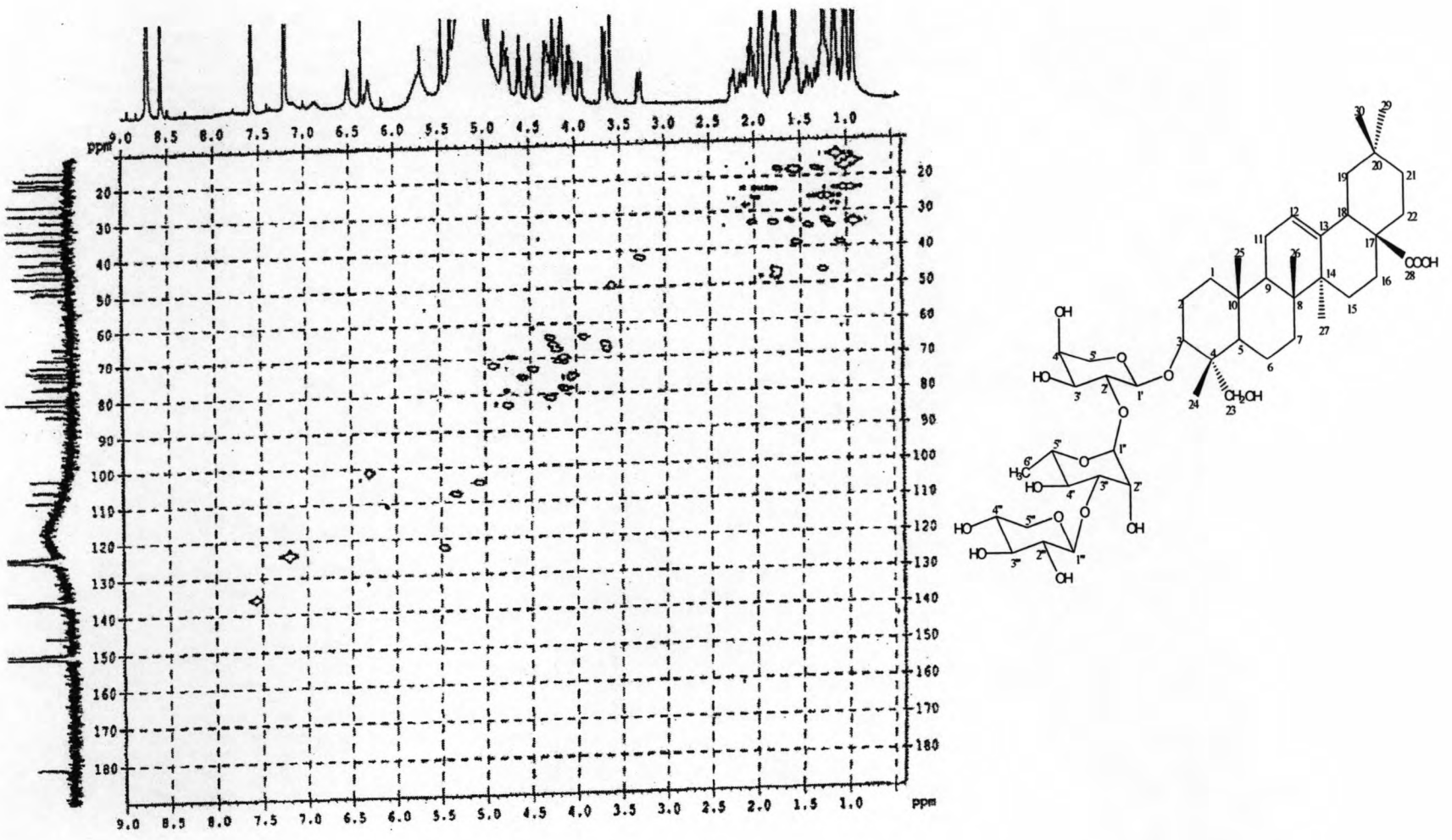

Figure 21 The 400 MHz HMQC spectrum of Compound Sp1 (in pyridine-d_5)

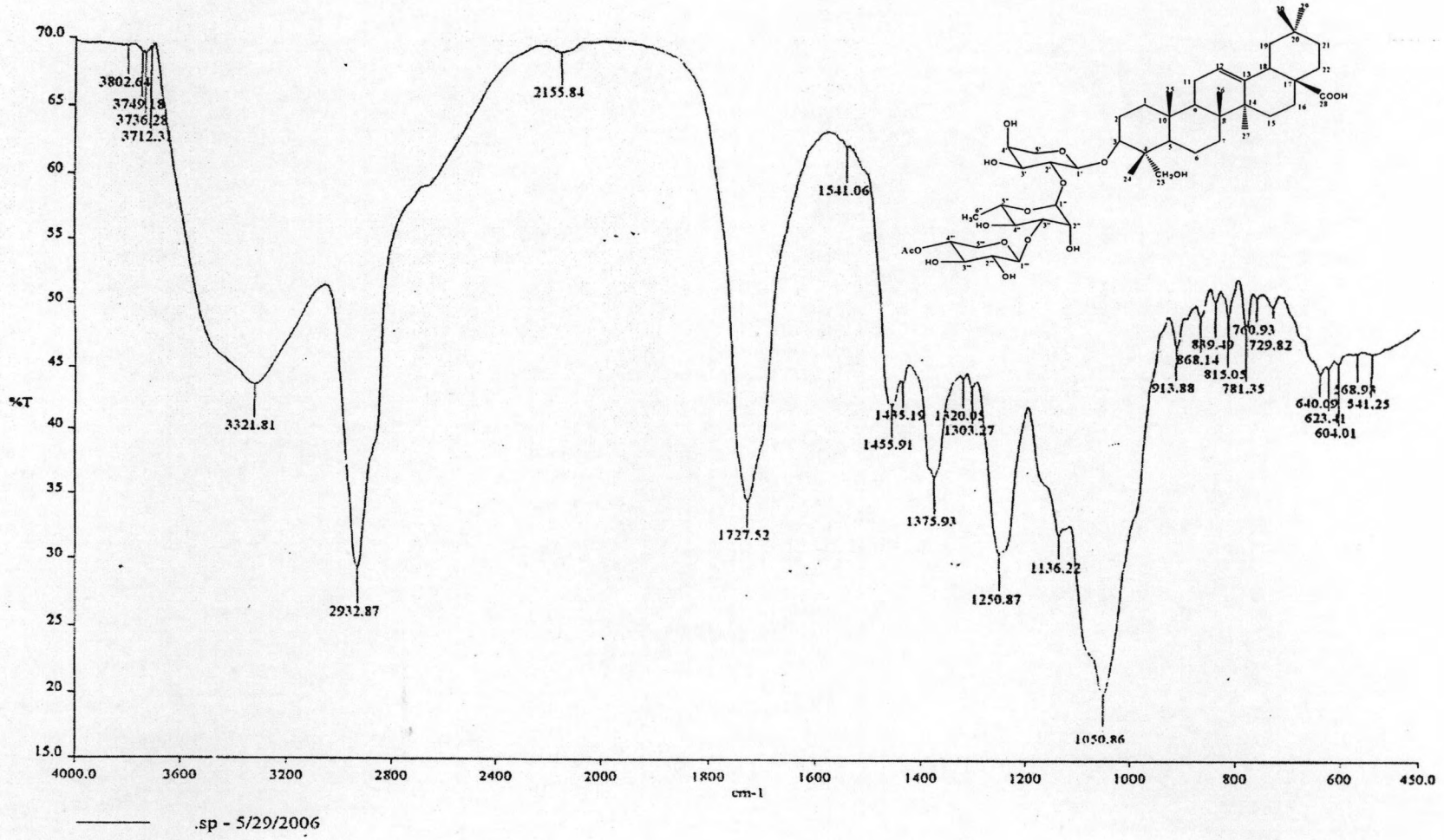

Figure 22 The IR spectrum of Compound Sp2 (KBr disc)

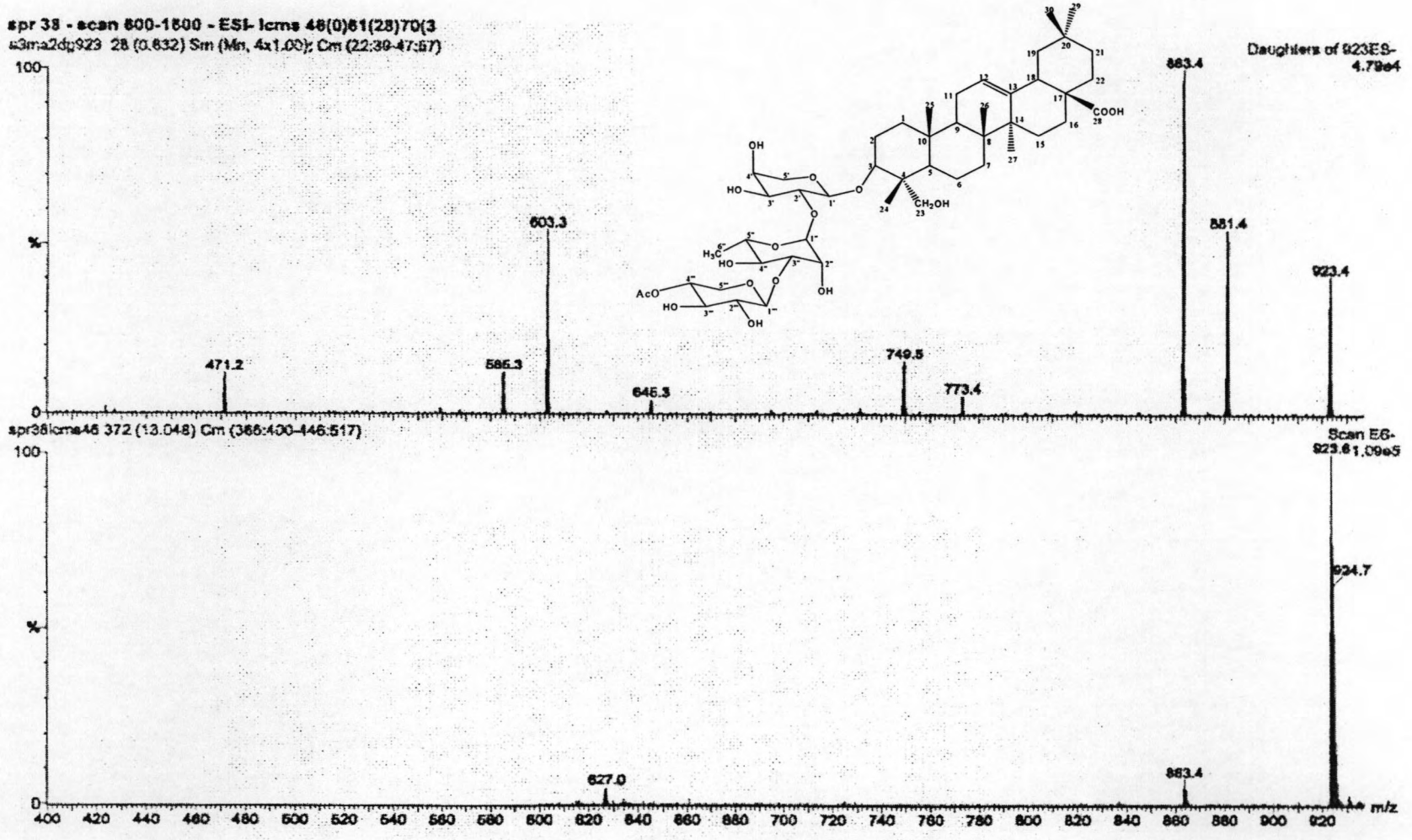

Figure 23 The EI-MS spectrum of Compound Sp2

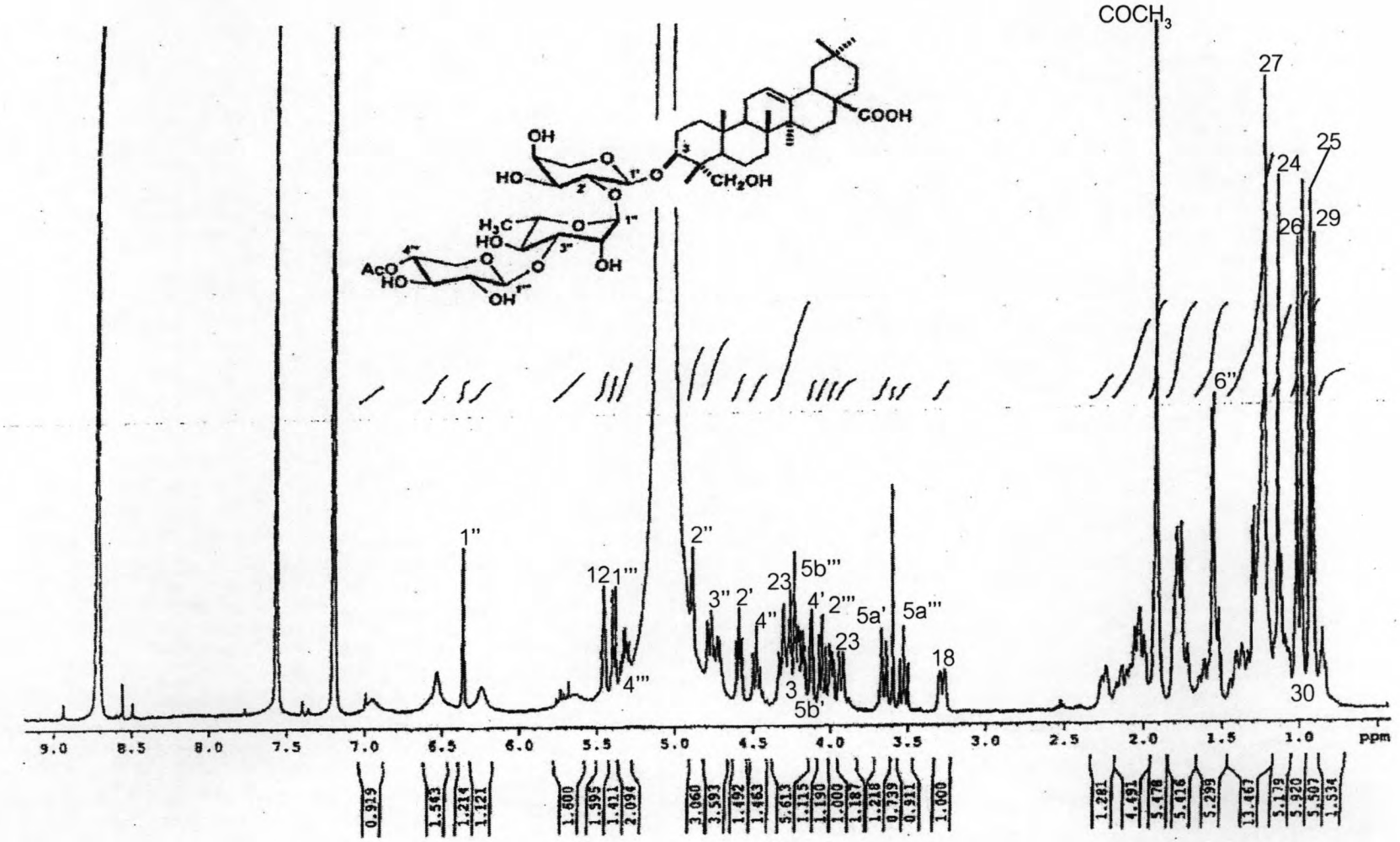

Figure 24 The 400 MHz ^{1}H-NMR spectrum of Compound Sp2 (in pyridine-d_5)

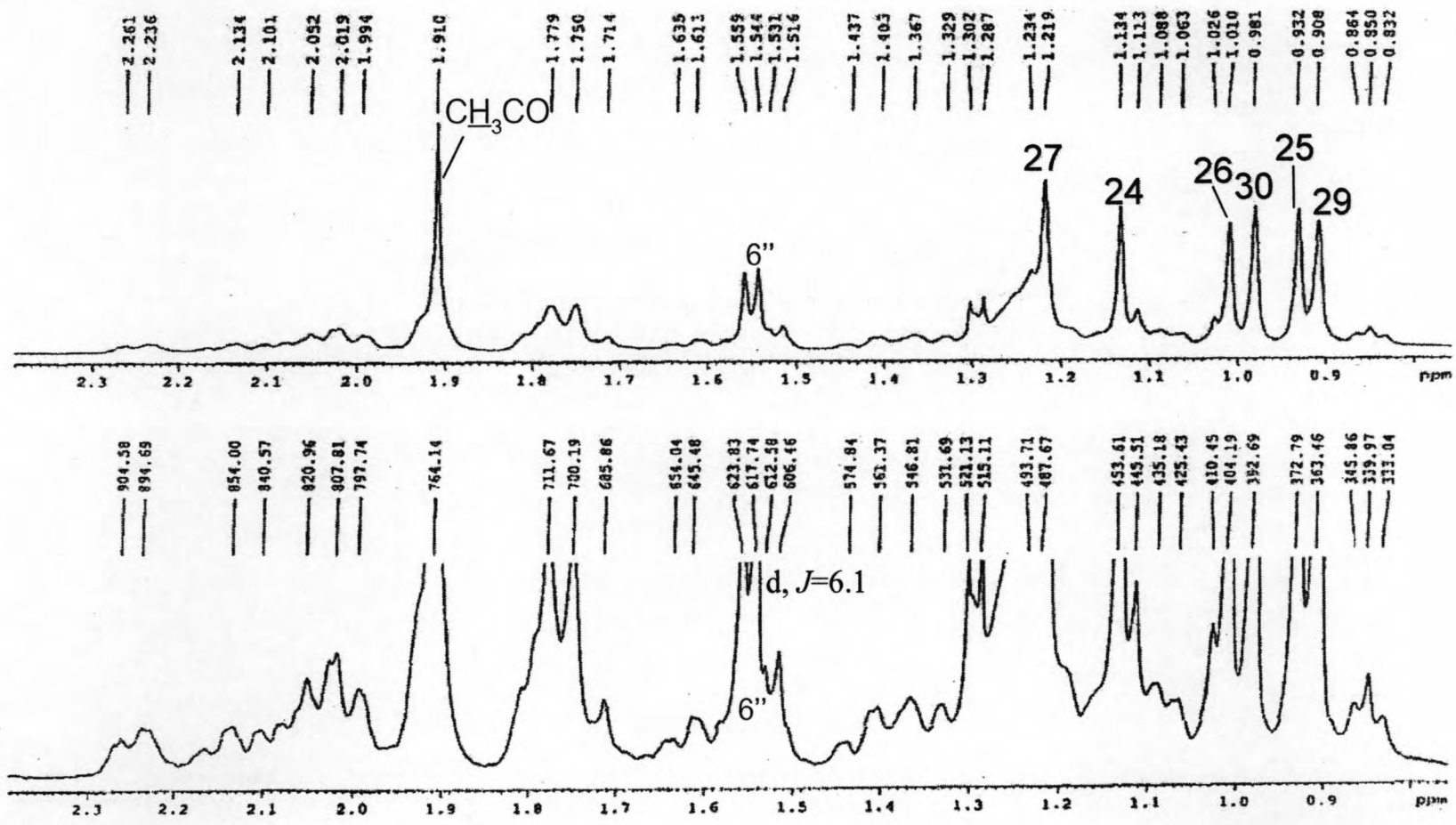

Figure 25 The expansion of ^{1}H-NMR spectrum of Compound Sp2 (in pyridine-d_5)

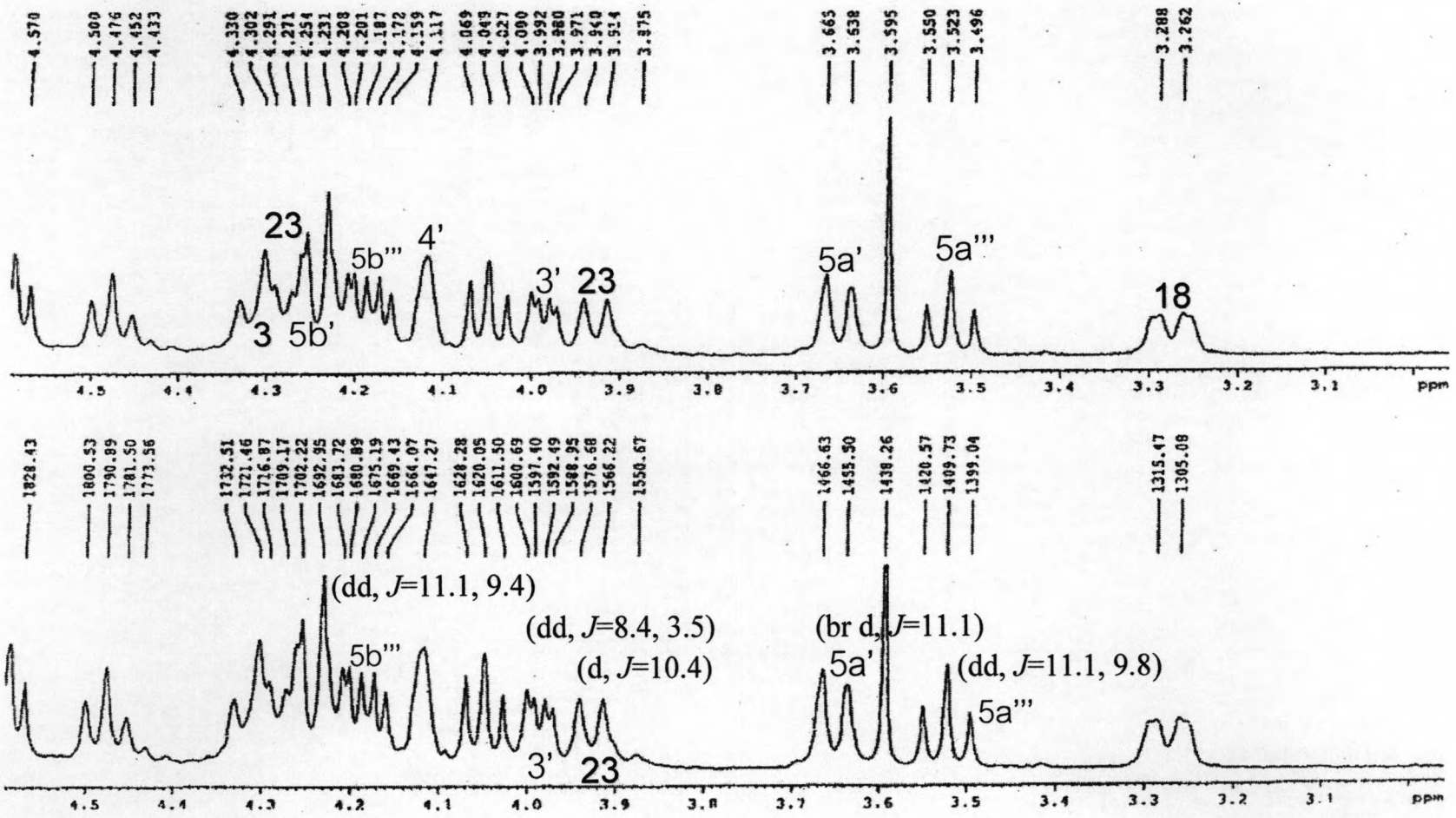

Figure 26 The expansion of ^{1}H-NMR spectrum of Compound Sp2 (in pyridine-d_5)

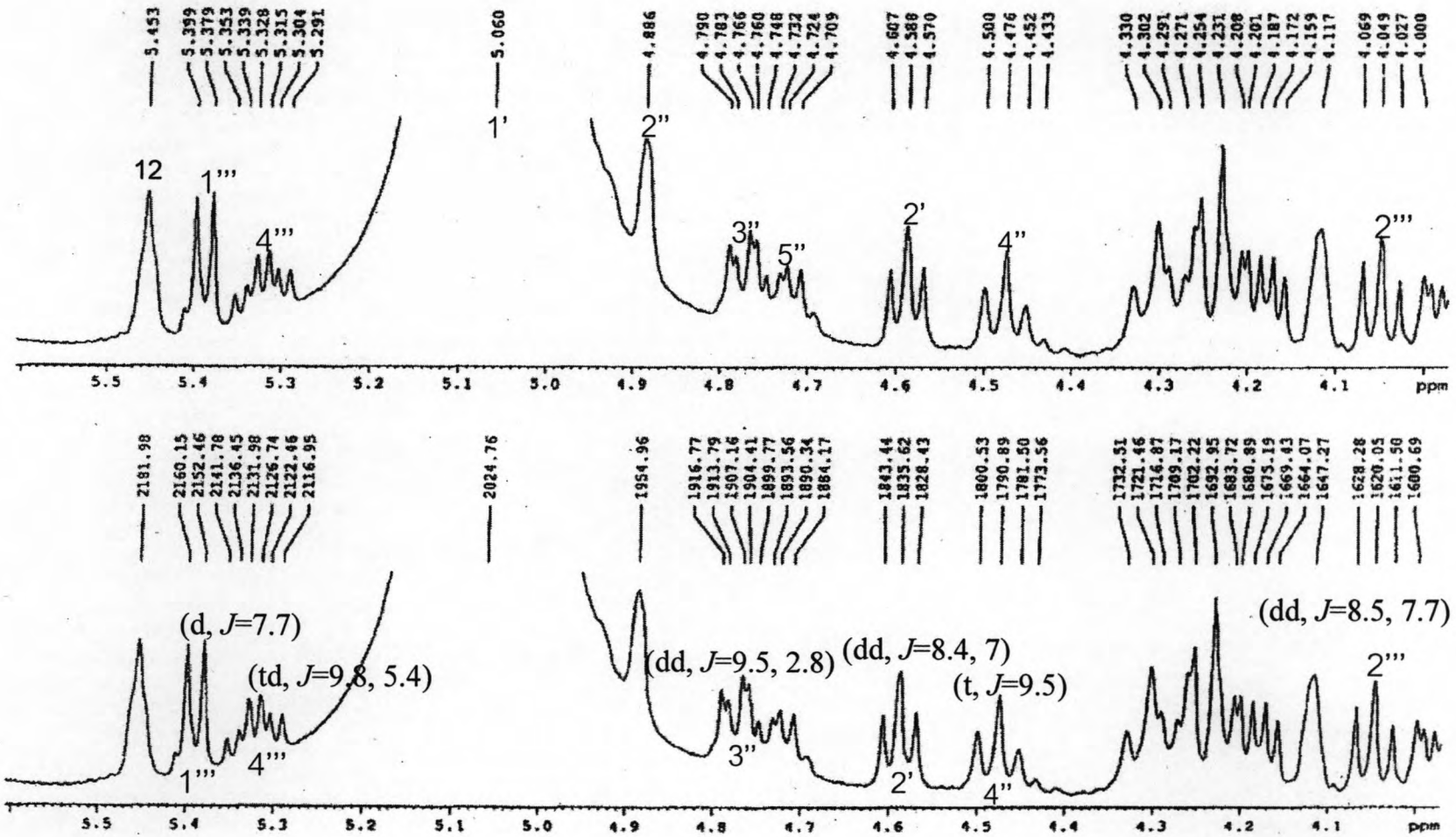

Figure 27 The expansion of ^{1}H-NMR spectrum of Compound Sp2 (in pyridine-d_5)

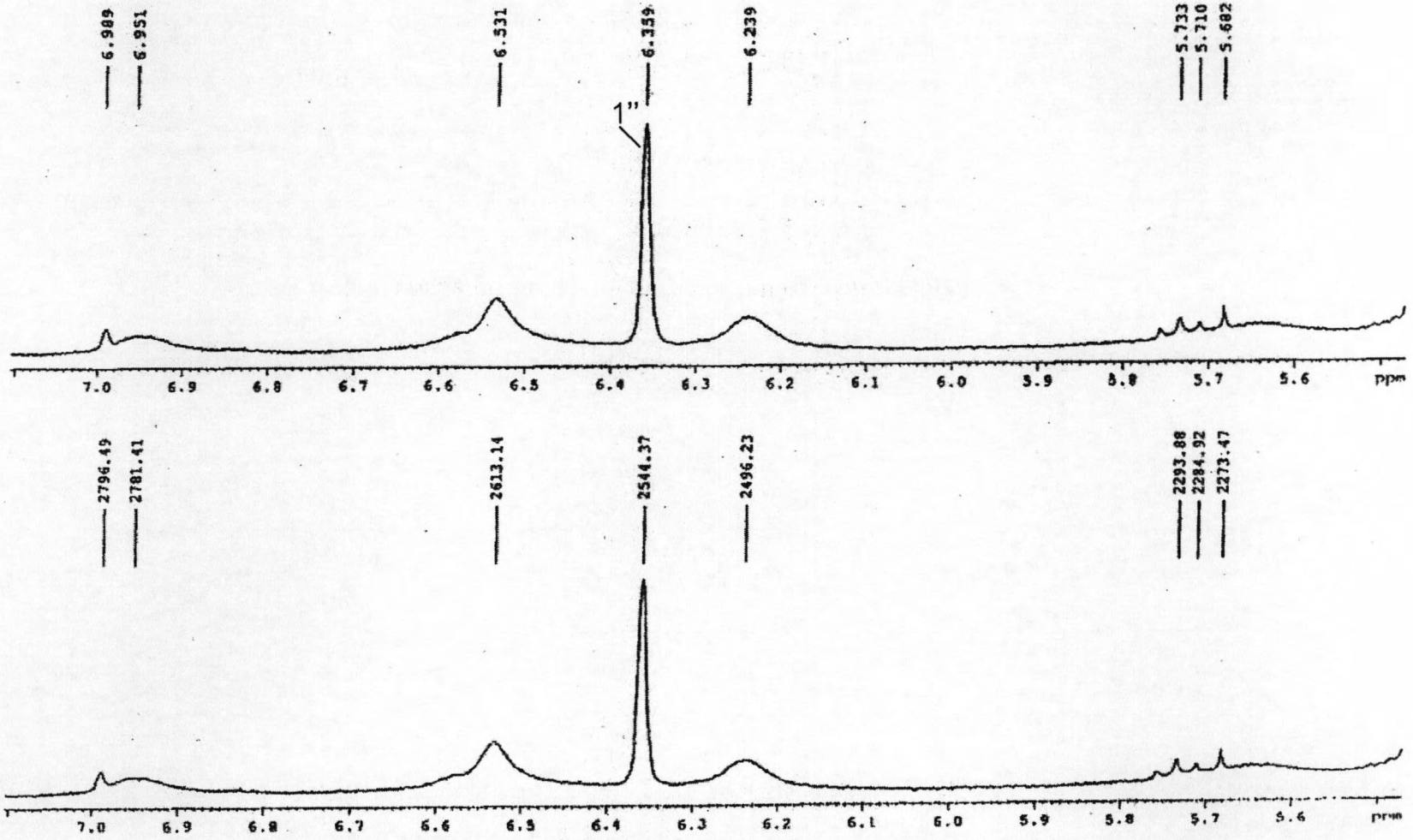

Figure 28 The expansion of ^{1}H-NMR spectrum of Compound Sp2 (in pyridine-d_5)

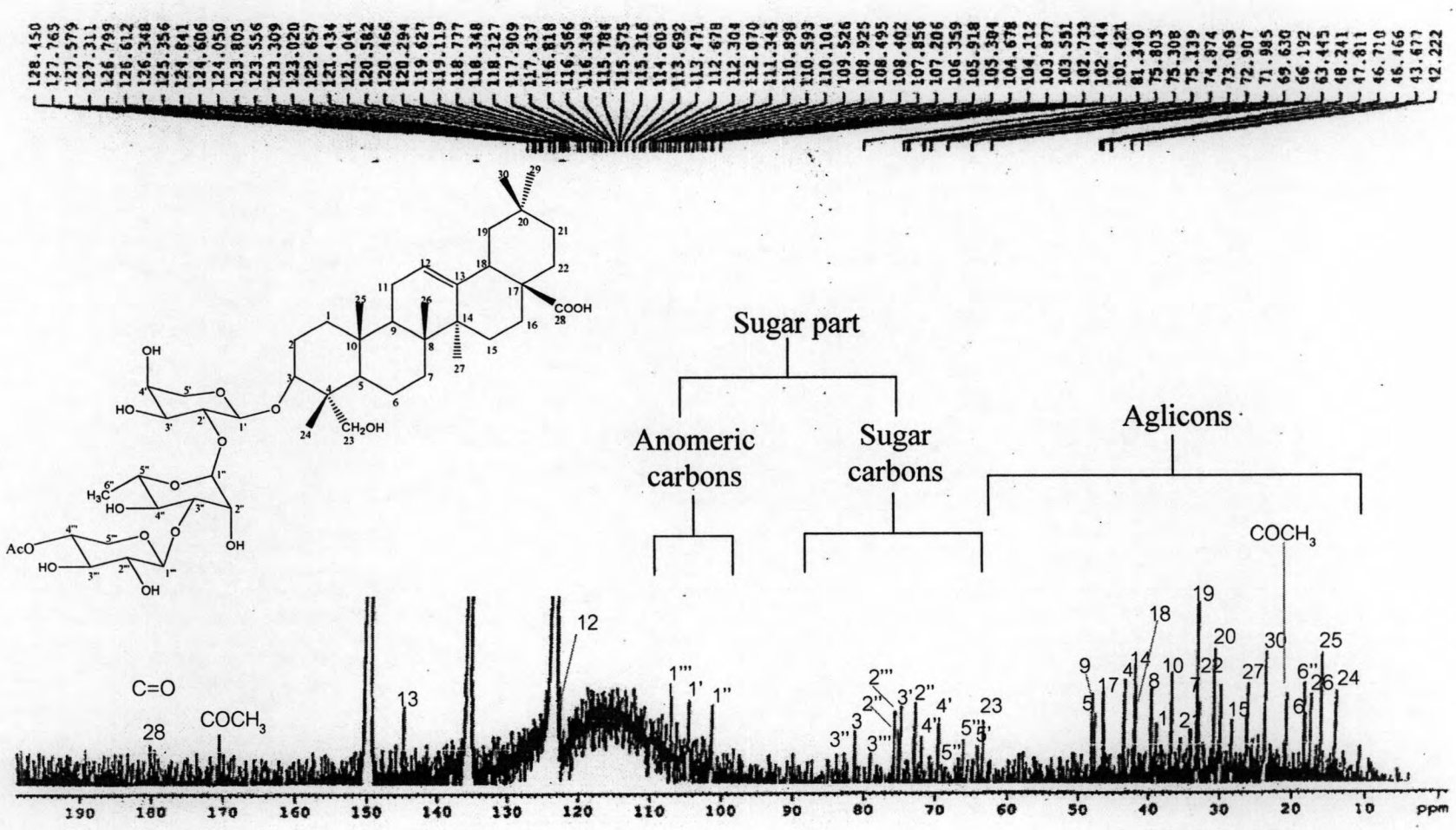

Figure 29 The 100 MHz ^{13}C-NMR spectrum of Compound Sp2 (in pyridine-d_5)

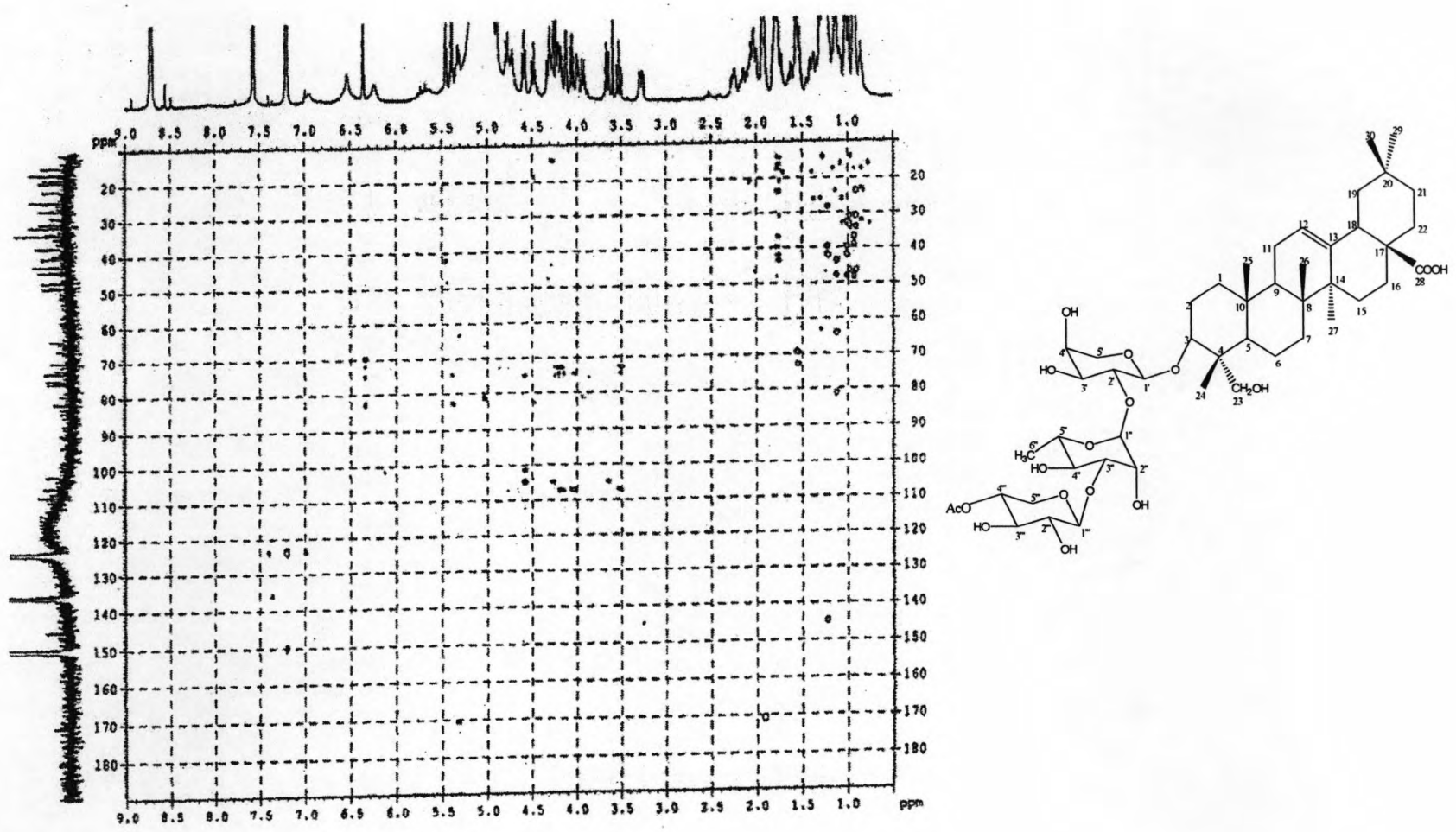

Figure 30 The 400 MHz HMBC spectrum of Compound Sp2 (in pyridine-d_5)

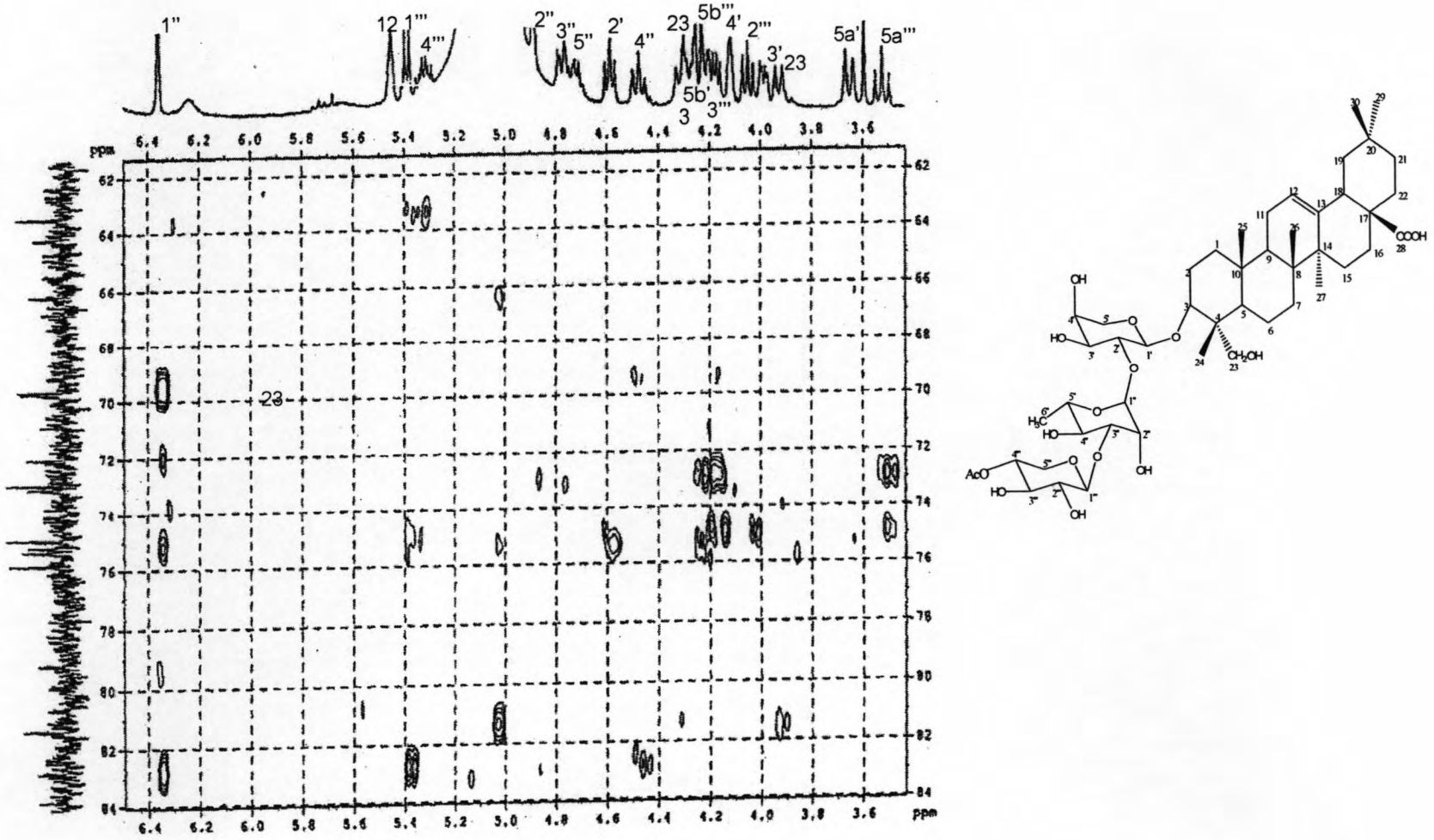

Figure 31 The expansion of HMBC spectrum of Compound Sp2 (in pyridine-d_5)

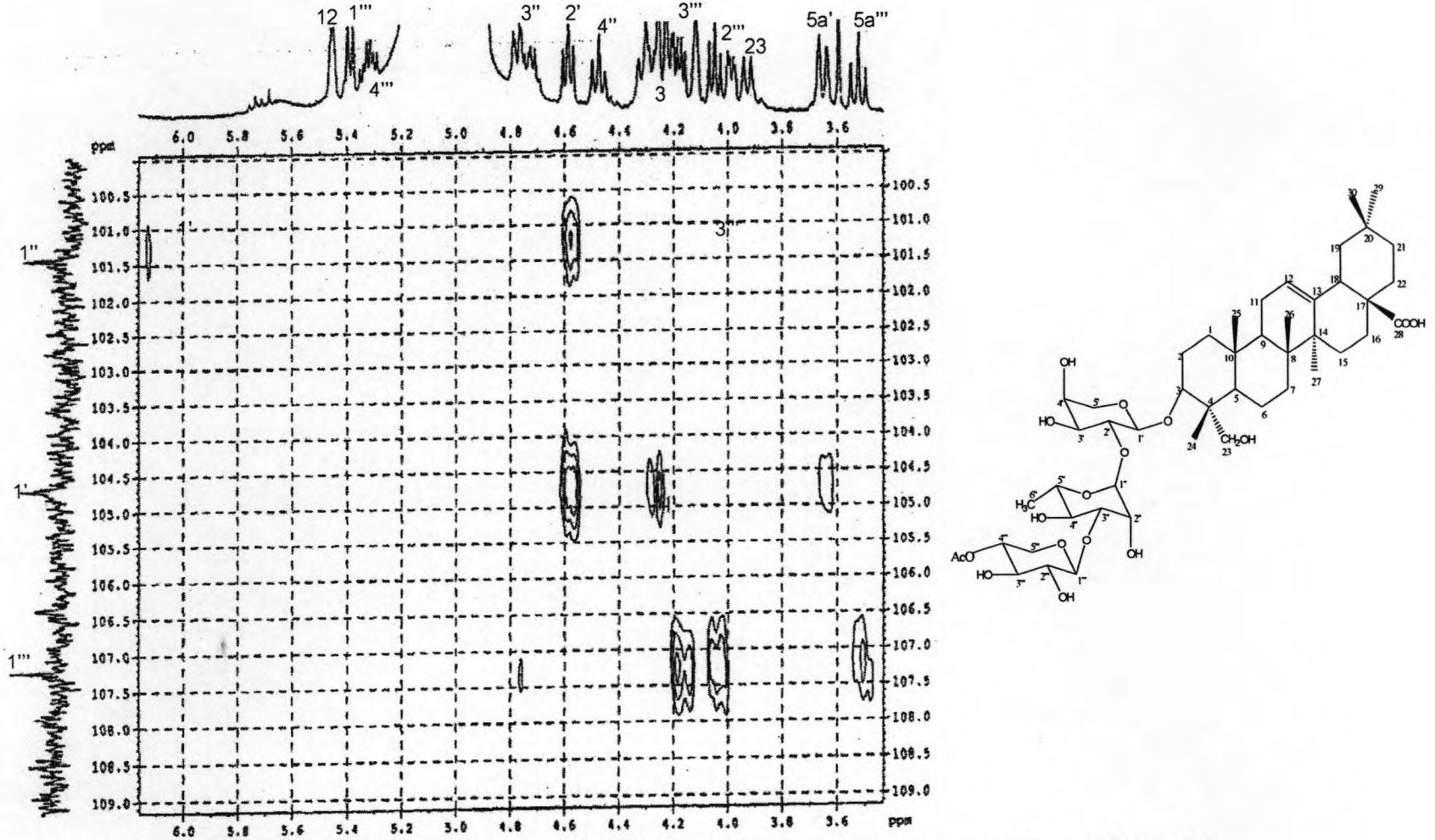

Figure 32 The expansion of HMBC spectrum of Compound Sp2 (in pyridine-d_5)

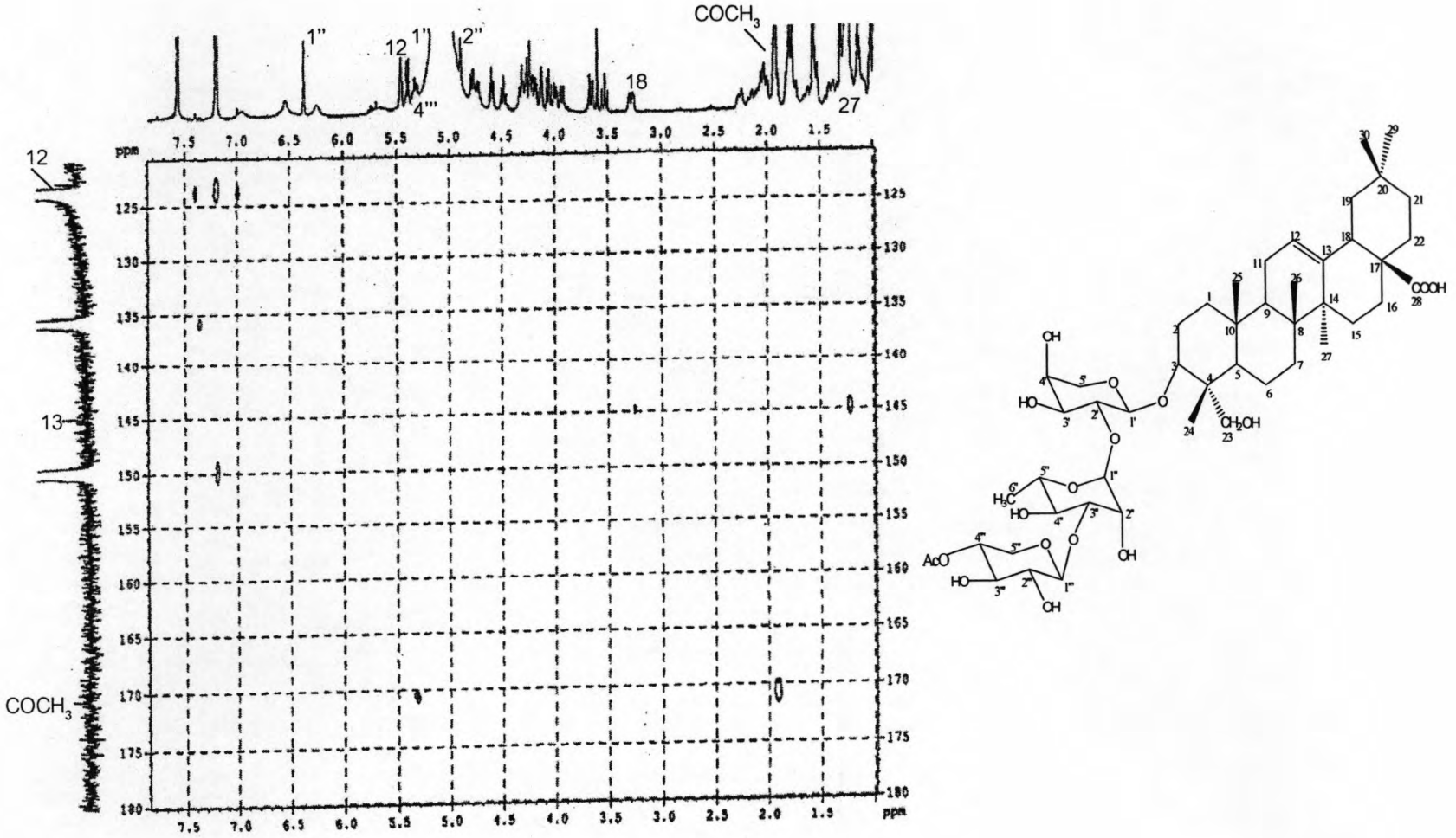

Figure 33 The expansion of HMBC spectrum of Compound Sp2 (in pyridine-d_5)

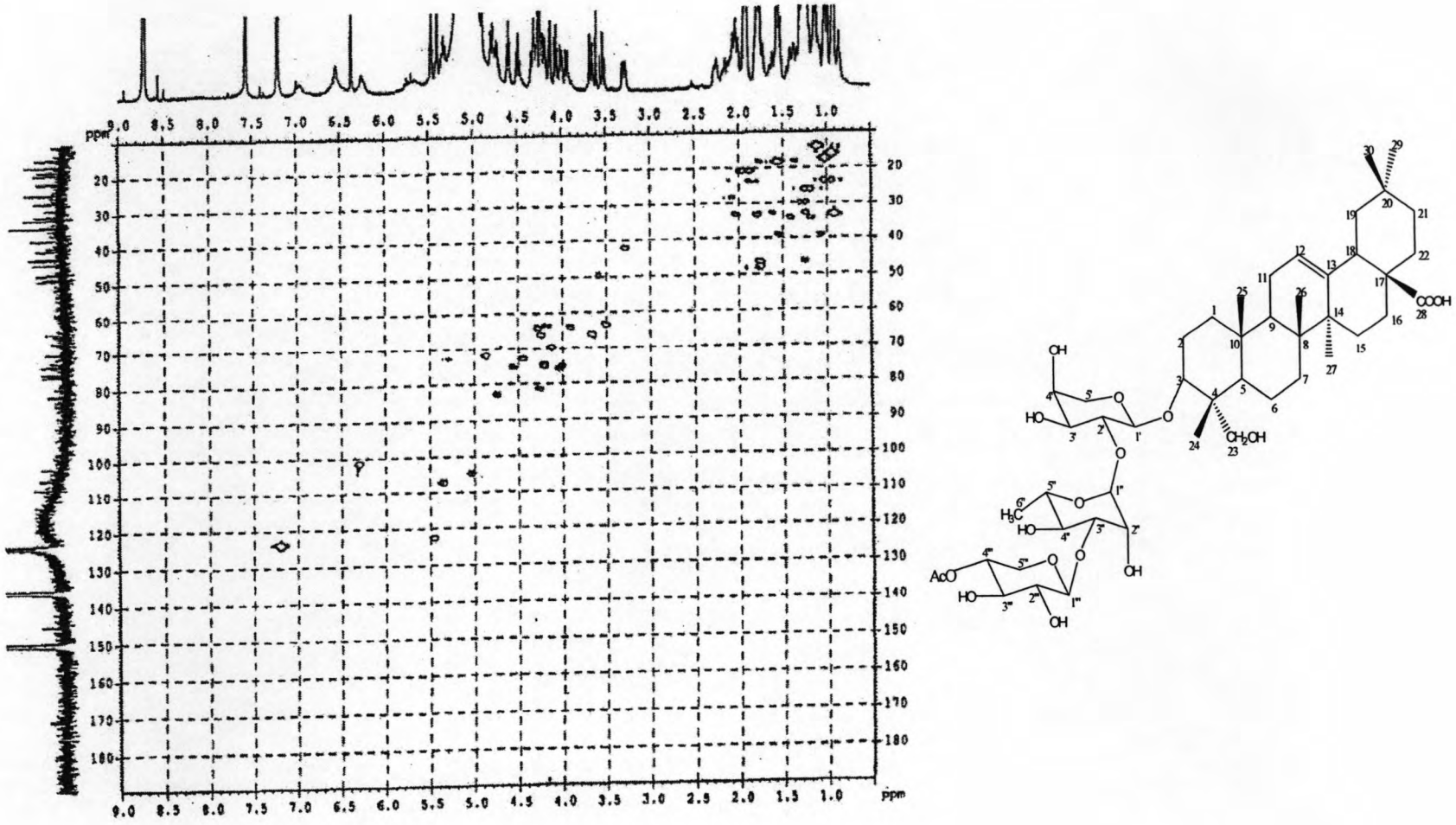

Figure 34 The 400 MHz HMQC spectrum of Compound Sp2 (in pyridine-d_5)

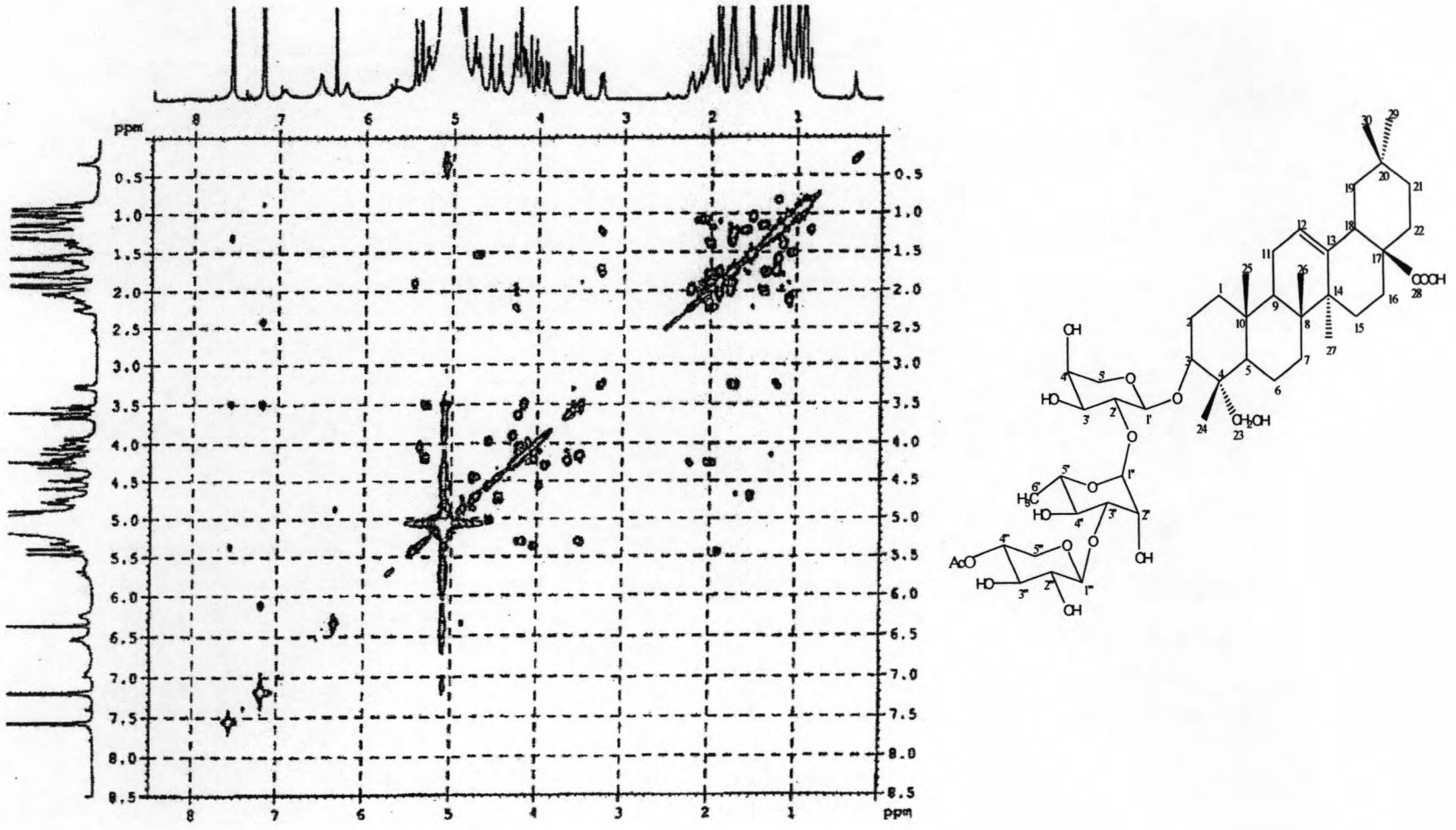

Figure 35 The 400 MHz ^{1}H-^{1}H COSY spectrum of Compound Sp2 (in pyridine-d_5)

APPENDIX B

Molluscicidal activity test

Table 38 The results of molluscicidal activity testing of methanol extract against *P. canaliculata* at 24 hours intervals.

Concentration (ppm)	Total snails	Death snails	Mean of mortality	LC_{50} (ppm)	LC_{90} (ppm)
1.00	60	0.00	0.00±0.00	11.19 (9.71-12.72)	19.82 (17.72-22.79)
5.00	60	19.00	6.33±1.53		
10.00	60	32.00	10.67±3.51		
15.00	60	40.00	13.33±1.53		
20.00	60	50.00	16.67±1.15		
25.00	60	60.00	20.00±0.00		
0 (control)	60	0.00	0.00		

95 % confidence Limits of LC_{50} and LC_{90}

Mean±S.E., calculated from Triplicate (each per 20 snails)

Table 39 The results of molluscicidal activity testing of aqueous layer against *P.canaliculata* at 24 hours intervals.

Concentration (ppm)	Total snails	Death snails	Mean of mortality	LC_{50} (ppm)	LC_{90} (ppm)
1	60	0.00	0.00±0.00	9.62 (7.49-11.76)	18.80 (16.11-23.46)
5	60	32.00	10.67±1.53		
10	60	37.00	12.33±2.08		
15	60	44.00	14.67±1.53		
20	60	54.00	16.67±2.08		
25	60	60.00	20.00±0.00		
0 (control)	60	0.00	0.00		

95 % confidence Limits of LC_{50} and LC_{90}

Mean±S.E., calculated from Triplicate (each per 20 snails)

Table 40 The results of molluscicidal activity testing of fraction A-1 against *P. canaliculata* at 24 hours intervals.

Concentration (ppm)	Total snails	Death snails	Mean of mortality	LC_{50} (ppm)	LC_{90} (ppm)
1	60	0.00	0.00±0.00	8.47 (6.24-10.69)	16.86 (14.08-21.61)
5	60	37.00	12.33±1.20		
10	60	40.00	13.33±1.20		
15	60	46.00	15.33±1.20		
20	60	55.00	18.33±1.20		
25	60	60.00	20.00±0.00		
0 (control)	60	0.00	0.00		

95 % confidence Limits of LC_{50} and LC_{90}

Mean±S.E., calculated from Triplicate (each per 20 snails)

Table 41 The results of molluscicidal activity testing of fraction B-6 against *P.canaliculata* at 24 hours intervals.

Concentration (ppm)	Total snails	Death snails	Mean of mortality	LC_{50} (ppm)	LC_{90} (ppm)
1	60	0.00	0.00±0.00	6.21 (5.67-6.79)	10.59 (9.73-11.73)
3	60	20.00	6±0.57		
5	60	26.00	9±0.57		
8	60	38.00	12.67±0.33		
10	60	48.00	16.67±0.88		
15	60	60.00	20.00±0.00		
0 (control)	60	0.00	0.00		

95 % confidence Limits of LC_{50} and LC_{90}

Mean±S.E., calculated from Triplicate (each per 20 snails)

Table 42 The results of molluscicidal activity testing of fraction C-1 against *P.canaliculata* at 24 hours intervals.

Concentration (ppm)	Total snails	Death snails	Mean of mortality	LC_{50} (ppm)	LC_{90} (ppm)
1	60	0.00	0.00±0.00	5.54 (4.66-6.46)	9.56 (8.35-11.44)
3	60	14.00	4.67±1.20		
5	60	41.00	13.67±1.45		
8	60	46.00	15.33±1.45		
10	60	50.00	16.67±1.45		
15	60	60.00	20.00±0.00		
0 (control)	60	0.00	0.00		

95 % confidence Limits of LC_{50} and LC_{90}

Mean±S.E., calculated from Triplicate (each per 20 snails)

Table 43 The results of molluscicidal activity testing of fraction D-4 against *P.canaliculata* at 24 hours intervals.

Concentration (ppm)	Total snails	Death snails	Mean of mortality	LC_{50} (ppm)	LC_{90} (ppm)
1	60	0.00	0.00±0.00	4.44 (3.85-5.00)	7.24 (6.53-8.23)
3	60	19.00	6.33±1.20		
5	60	44.00	14.67±1.86		
7	60	53.00	17.67±0.88		
9	60	55.00	18.33±0.33		
10	60	60.00	20.00±0.00		
0 (control)	60	0.00	0.00		

95 % confidence Limits of LC_{50} and LC_{90}

Mean±S.E., calculated from Triplicate (each per 20 snails)

Table 44 The results of % mortality of compound Sp1 at 24, 48 and 72 h. against *P. canaliculata*.

Concentration(ppm)	% mortality at 24 h.	% mortality at 48 h.	% mortality at 72 h.
1	0.00	3.33	13.33
3	31.67	53.33	73.33
5	76.67	86.67	91.67
7	83.33	96.67	100
9	98.33	100	-
10	100	-	-
0 (control)	0.00	0.00	0.00

calculated from Triplicate (each per 20 snails)

Table 45 The results of molluscicidal activity testing of compound Sp1 against *P.canaliculata* at 24 hours intervals.

Concentration (ppm)	Total snails	Death snails	Mean of mortality	LC_{50} (ppm)	LC_{90} (ppm)
1	60	0.00	0.00±0.00	4.34 (3.78-4.88)	7.21 (6.52-8.15)
3	60	23.00	7.67±0.67		
5	60	44.00	14.67±0.88		
7	60	51.00	17.00±0.58		
9	60	56.00	18.67±0.67		
10	60	60.00	20.00±0.00		
0 (control)	60	0.00	0.00		

95 % confidence Limits of LC_{50} and LC_{90}

Mean±S.E., calculated from Triplicate (each per 20 snails)

Table 46 The results of % mortality of compound Sp2 at 24, 48 and 72 h. against *P. canaliculata*.

Concentration(ppm)	% mortality at 24 h.	% mortality at 48 h.	% mortality at 72 h.
1	0.00	6.67	18.33
3	36.67	56.67	83.33
5	76.67	93.33	96.67
7	86.67	96.67	100
9	93.33	100	-
10	100	-	-
0 (control)	0.00	0.00	0.00

calculated from Triplicate (each per 20 snails)

Table 47 The results of molluscicidal activity testing of compound Sp2 against *P. canaliculata* at 24 hours intervals.

Concentration (ppm)	Total snails	Death snails	Mean of mortality	LC_{50} (ppm)	LC_{90} (ppm)
1	60	0.00	0.00±0.00	4.28 (3.62-4.92)	7.08 (6.30-8.22)
3	60	22.00	7.33±1.45		
5	60	46.00	15.33±0.88		
7	60	52.00	17.33±0.33		
9	60	56.00	18.67±0.88		
10	60	60.00	20.00±0.00		
0 (control)	60	0.00	0.00		

95 % confidence Limits of LC_{50} and LC_{90}

Mean±S.E., calculated from Triplicate (each per 20 snails)

PROBIT ANALYSIS

The LC_{50} value was determined by Probit Analysis using SPSS version 15 for window at 95% confidence interval. This is the example of the result from probit analysis for LC_{50} value (24 hours) of saponin crude extract from *Sapindus rarak* fruits in small snails (2.0-2.5 cm.)

********** PROBIT ANALYSIS**********

DATA Information

21 unweighted cases accepted.

0 cases rejected because of missing data.

3 cases are in the control group.

MODEL Information

ONLY Normal Sigmoid is requested.

********** PROBIT ANALYSIS**********

Parameter Estimates (PROBIT model: (Probit(p)) = Intercept +BX):

	Regression Coeff	Standard Error	Coeff./ S.E.
CONC	.153	.012	12.357
Intercept		Standard Error	Intercept/ S.E.
	- 1.294	.132	- 9.779

Pearson Goodness- of -Fit Chi Square = 70.297 DF = 19 P = .000

Since Goodness-of-Fit Chi square is significant, a heterogeity Factor is used in the calculation of confidence limits.

********** PROBIT ANALYSIS**********

Observed and Expected Frequencies

Cell Counts and Residuals

	Number	Concen	Number of Subjects	Observed Responses	Expected Responses	Residual	Probability
PROBIT	1	.000	20	0	1.957	-1.957	.098
	2	.000	20	0	1.957	-1.957	.098
	3	.000	20	0	1.957	-1.957	.098
	4	1.000	20	0	2.538	-2.538	.127
	5	1.000	20	0	2.538	-2.538	.127
	6	1.000	20	0	2.538	-2.538	.127
	7	5.000	20	13	5.961	7.039	.298
	8	5.000	20	14	5.961	8.039	.298
	9	5.000	20	10	5.961	4.039	.298
	10	10.000	20	15	11.849	3.151	.592
	11	10.000	20	14	11.849	2.151	.592
	12	10.000	20	11	11.849	-.849	.592
	13	15.000	20	16	16.816	-.816	.841
	14	15.000	20	17	16.816	.184	.841
	15	15.000	20	13	16.816	-3.816	.841
	16	20.000	20	19	19.219	-.219	.961
	17	20.000	20	20	19.219	.781	.961
	18	20.000	20	16	19.219	-3.219	.961
	19	25.000	20	20	19.884	.116	.994
	20	25.000	20	20	19.884	.116	.994
	21	25.000	20	20	19.884	.116	.994

********** PROBIT ANALYSIS**********

Confidence Limits for Effective Concen

Confidence Limits

	Probability	95% Confidence Limits for Concen		
		Estimate	Lower Bound	Upper Bound
PROBIT[a]	.010	-6.759	-14.576	-2.573
	.020	-4.974	-11.981	-1.175
	.030	-3.842	-10.341	-.282
	.040	-2.991	-9.112	.394
	.050	-2.298	-8.116	.948
	.060	-1.708	-7.270	1.422
	.070	-1.191	-6.531	1.839
	.080	-.728	-5.871	2.215
	.090	-.307	-5.273	2.559
	.100	.080	-4.724	2.877
	.150	1.685	-2.472	4.216
	.200	2.960	-.715	5.312
	.250	4.054	.762	6.283
	.300	5.036	2.057	7.186
	.350	5.947	3.223	8.057
	.400	6.811	4.294	8.919
	.450	7.647	5.292	9.791
	.500	8.469	6.235	10.688
	.550	9.292	7.138	11.626
	.600	10.127	8.016	12.618
	.650	10.991	8.883	13.684
	.700	11.902	9.759	14.845
	.750	12.884	10.667	16.135
	.800	13.978	11.642	17.608
	.850	15.253	12.741	19.363
	.900	16.858	14.083	21.611
	.910	17.245	14.401	22.159
	.920	17.666	14.746	22.757
	.930	18.129	15.122	23.416
	.940	18.646	15.541	24.155
	.950	19.236	16.015	25.000
	.960	19.929	16.569	25.996
	.970	20.780	17.246	27.225
	.980	21.913	18.140	28.864
	.990	23.697	19.538	31.458

a. A heterogeneity factor is used.

VITA

Miss Tatsaneewan Faysoon was born on Tueday 28th August, 1979, in Burirum, Thailand. She received her Bachelor's degree of Science in Pharmacy in 2003 from the Faculty of Pharmaceutical Sciences, Rungsit University, Thailand.