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REVISED
Diastereocontrolled Synthesis of Carbon Glycosides of *N*-Acetylneuraminic Acid *via* Glycosyl Samarium(III) Intermediates

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SUPPORTING INFORMATION

General methods. *N*-Acetylneuraminic acid was purchased (Snow Brand Milk Products Company Ltd., Tokyo, Japan). All other reagents and solvents were of reagent grade and were dried using standard procedures. Optical rotations were measured with a Perkin Elmer 141 polarimeter at 22°C. ^{1}H NMR spectra were recorded at 25°C on a Varian Unity 500 MHz spectrometer and chemical shifts are given in ppm from tetramethylsilane as internal standard. All reactions were monitored by thin layer chromatography on aluminum sheets, silica gel 60 F_{254} (Merck); detection under short wavelength UV light (254 nm) and by dipping the plates into staining solution (1.0 g ceric ammonium sulfate and 24.0 g ammonium molybdate in 31 mL sulfuric acid 470 mL water) then heating. Flash chromatography was performed using 230-400 mesh silica gel 60 (Aldrich).

Synthesis and Analysis of New Compounds 10 and 11:

Methyl 5-acetamido-4,7,8,9-tetra-O-*acetyl-2,6-anhydro-3,5-dideoxy-2*-C-*{(S)-hydroxy-[3-(methyl 2,4,6-tri*-O-*benzyl-3-deoxy-a-D-galactopyranosidyl)]-methyl}-D*-erythro-*L*-manno-*nononate (10):* To a vigorously stirred neat mixture of 120 mg (0.2 mmol) [methyl (5-acetamido-4,7,8,9-tetra-*O*-acetyl-3,5-dideoxy-α-D-*glycero*-D-*galacto*-2-nonulopyranosyl)onate] 2-pyridyl sulfone (**8**) and 165 mg (0.3 mmol) methyl 2,4,6-tri-*O*-benzyl-3-deoxy-3-*C*-(formyl)-α-D-galactopyranoside (**9**) under argon a 0.1M solution of freshly prepared SmI_2 in THF (7 mL, 0.7 mmol) was added dropwise at 20°C. Stirring was continued for 45 min, than the reaction mixture was poured into an aqueous ammonium chloride solution and extracted twice with ethyl acetate. The combined organic

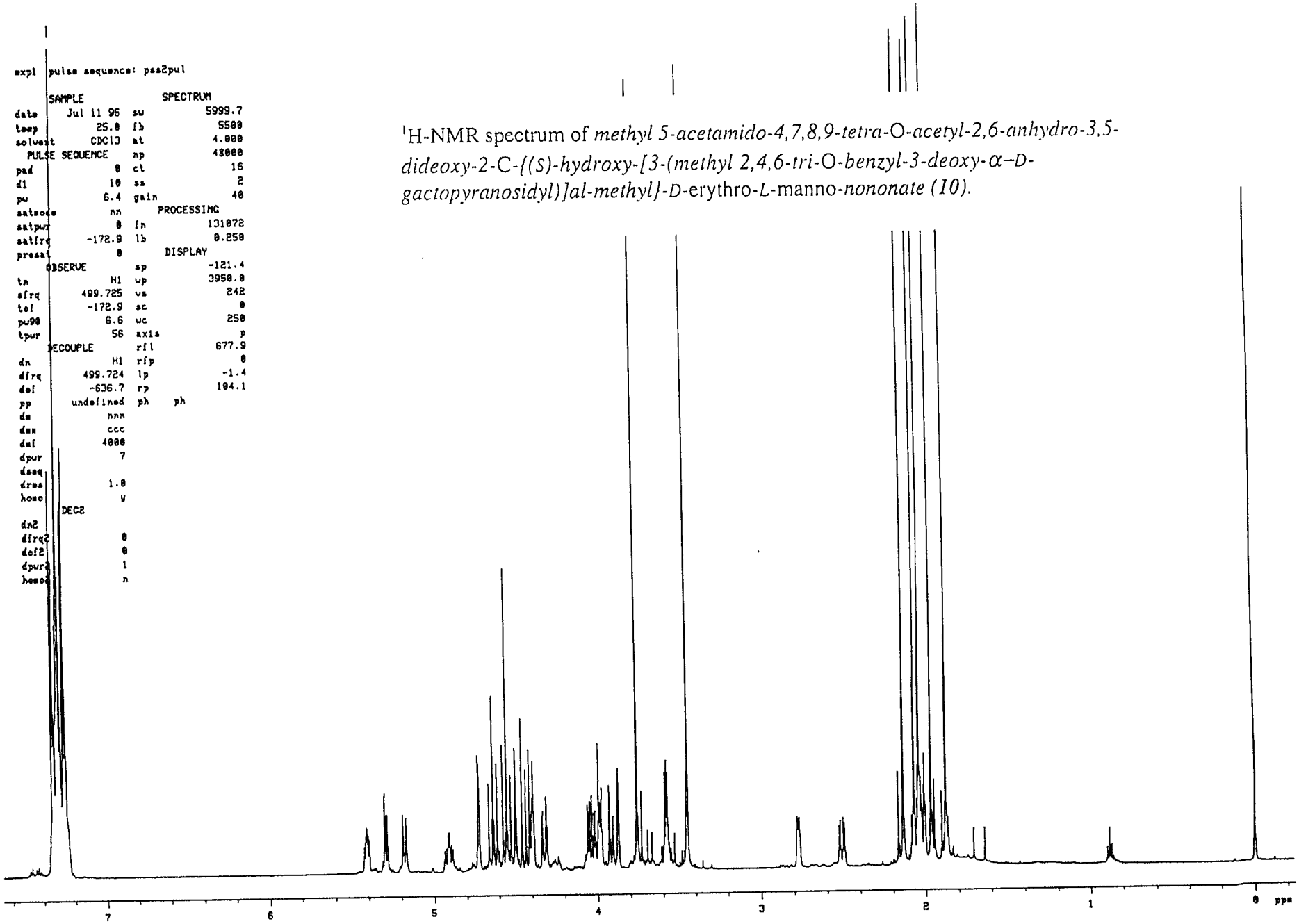
layers were dried ($MgSO_4$) and concentrated *in vacuo*. The residue was purified by flash chromatography with light petroleum / ethyl acetate (1:3) to yield 167 mg (88%) of **10** as a colorless foam. TLC (light petroleum / ethyl acetate, 1:3): R_f=0.32. $[\alpha]_D^{22}$=-18 (c=1, chloroform). ^{1}H-NMR: δ = 1.89-2.14 (5s, 15H, 5 COCH_3), 2.03 (under an $COCH_3$ signal is 1H, H-3'$_{ax}$), 2.51 (dd, $J_{3'ax,3'eq}$ = 12.9 Hz, $J_{3'eq,4'}$ = 4.6 Hz, 1H, H-3'$_{eq}$), 2.79 (bd, $J_{2,3}$ = 6.3 Hz, $J_{3,4}$ and $J_{3,3''}$ < 0.5 Hz, 1H, H-3), 3.45 (s, 3H, OCH_3), 3.57 - 3.58 (m, 2H, 2 H-6), 3.87 (bs, $J_{3'',OH} = J_{3'',3}$ < 0.5 Hz, 1H, H-3"), 3.90 (dd, $J_{5',6'}$ = 10.7 Hz, $J_{6',7'}$ = 2.1 Hz, 1H, H-6'), 3.97 - 4.01 (m, 2H, H-2 and H-5'), 4.05 (dd, $J_{8',9'A}$ = 6.1 Hz, $J_{9'A,9'B}$ = 12.3 Hz, 1H, H-9'$_A$), 4.31 (dd, $J_{8',9'B}$ = 3.9 Hz, 1H, H-9'$_B$), 4.39 (m, 2H, H-5 and O*H*), 4.41 - 4.66 (m, 7H, 3 CH_2Ph and H-4 at δ = 4.55), 4.90 (ddd, $J_{3'ax,4'} = J_{4',5'}$ =11.6 Hz, 1H, H-4'), 5.15 (bd, $J_{NH,5'}$ = 9.8 Hz, 1H, N*H*), 5.28 (dd, $J_{7',8'}$ = 7.7 Hz, 1H, H-7'), 5.42 (ddd, 1H, H-8'), 7.12 - 7.42 (m, 15H, 3 Ph).

Anal. Calcd for $C_{49}H_{61}N_1O_{18}$ (952.02): C, 61.82; H, 6.46; N, 1.47. Found: C, 61.47; H, 6.53; N, 1.26.

Synthesis of Methyl 5-acetamido-4,7,8,9-tetra-O-*acetyl-2,6-anhydro-3,5-dideoxy-2*-C [*hydroxy-4-(*tert-*butylcyclohexyl)] -D*-erythro-*L*-manno-*nononate (11).*

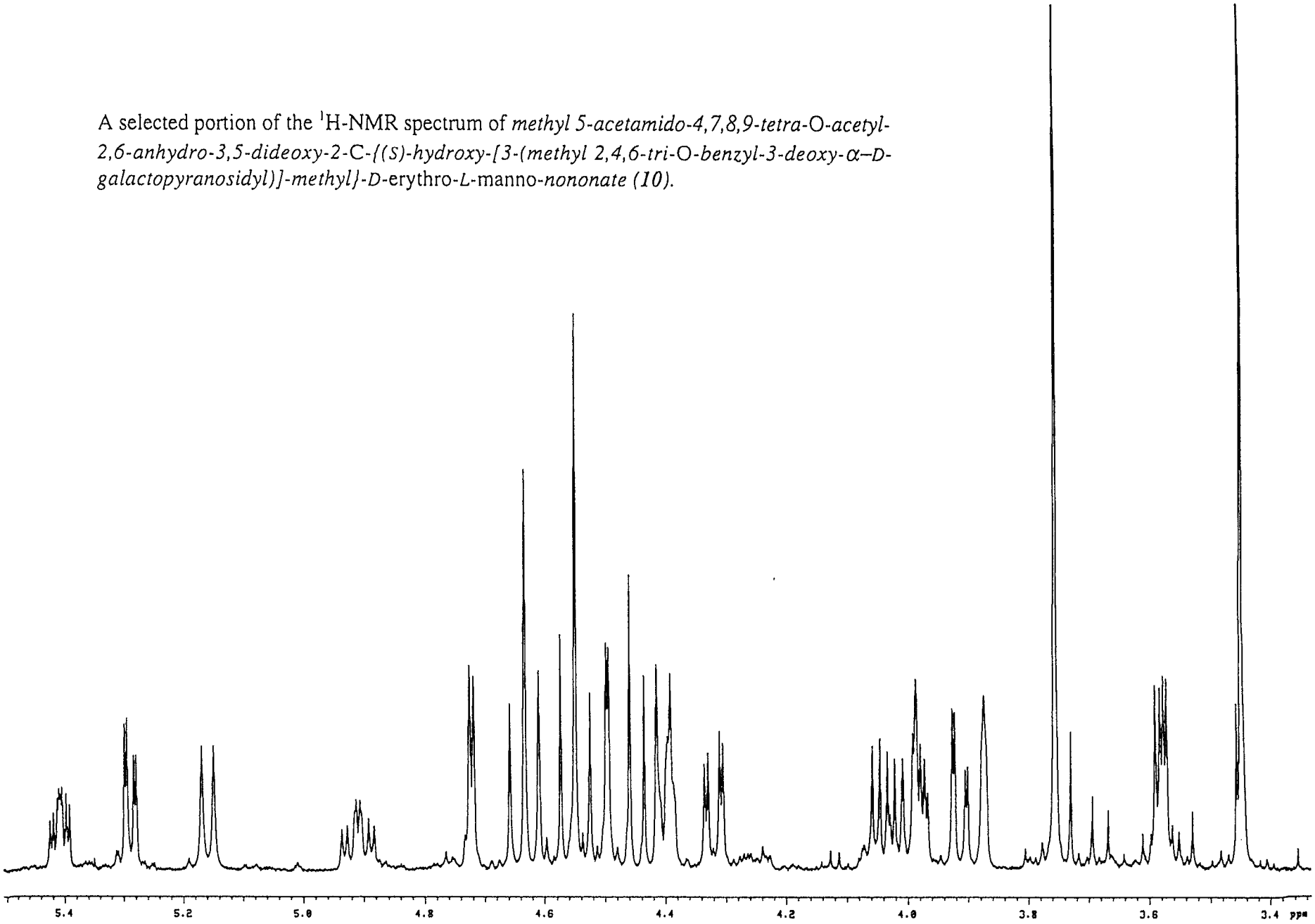
To a vigorously stirred neat mixture of 120 mg (0.2 mmol) [methyl (5-acetamido-4,7,8,9-tetra-*O*-acetyl-3,5-dideoxy-α-D-*glycero*-D-*galacto*-2-nonulopyranosyl)onate] 2-pyridyl sulfone (**8**) and and 83.0 mg (0.6 mmol) 4-*tert*-butylcyclohexanone under argon a 0.1M solution of freshly prepared SmI_2 in THF (7 mL, 0.7 mmol) was added dropwise at 20°C. Stirring was continued for 45 min, than the reaction mixture was poured into an aqueous ammonium chloride solution and extracted twice with ethyl acetate. The combined organic layers were dried ($MgSO_4$) and concentrated *in vacuo*. The residue was purified by flash chromatography with light petroleum / ethyl acetate (1:3) to yield 167 mg (90%) of **11** as a colorless oil. TLC (light petroleum / ethyl acetate, 1:3): R_f=0.6. $[\alpha]_D^{22}$= -12 (c=1, chloroform). ^{1}H-NMR: δ = 0.88 (s, 9H), 1.19 (dt, *J*=13.1 Hz, *J*=3,3 Hz), 1.42 (m, 3H), 1.60 (m, 3H), 1.78 (m, 1H), 1.85 (m, 3H), 1.87 (s, 3H), 1.96 (t, *J*=12.4 Hz), 2.02 (s,

3H), 2.05 (s, 3H), 2.12 (s, 3H), 2.16 (s, 3H), 2.46 (dd, *J*=12.4 Hz, *J*=4.5 Hz), 2.57 (s, 1H), 3.79 (s, 3H), 3.99 (m, 2H), 4.07 (dd, 1H, *J*=12.3 Hz, *J*=6.2 Hz), 4.32 (dd, 1H, *J*=12.3 Hz, *J*=2.5 Hz), 4.76 (m, 1H), 5.16 (bd, 1H, *J*=8.8 Hz), 5.30 (d, 1H, *J*=6.1 Hz), 5.42 (dt, *J*=6.1 Hz, *J*=2.4 Hz). Anal. Calcd for $C_{30}H_{47}N_1O_{13}$ (629.70): C, 57.22; H, 7.52; n, 2.22. Found: C, 56.94; H, 7.63; N, 1.94.



^{1}H-NMR spectrum of *methyl 5-acetamido-4,7,8,9-tetra*-O-*acetyl-2,6-anhydro-3,5-dideoxy-2-C-{(S)-hydroxy-[3-(methyl 2,4,6-tri*-O-*benzyl-3-deoxy-α–D-gactopyranosidyl)]al-methyl}-D*-erythro-*L*-manno-*nononate (10)*.

A selected portion of the ^{1}H-NMR spectrum of *methyl 5-acetamido-4,7,8,9-tetra*-O-*acetyl-2,6-anhydro-3,5-dideoxy-2*-C-*{(S)-hydroxy-[3-(methyl 2,4,6-tri*-O-*benzyl-3-deoxy-α–D-galactopyranosidyl)]-methyl}-D*-erythro-*L*-manno-*nononate (10)*.



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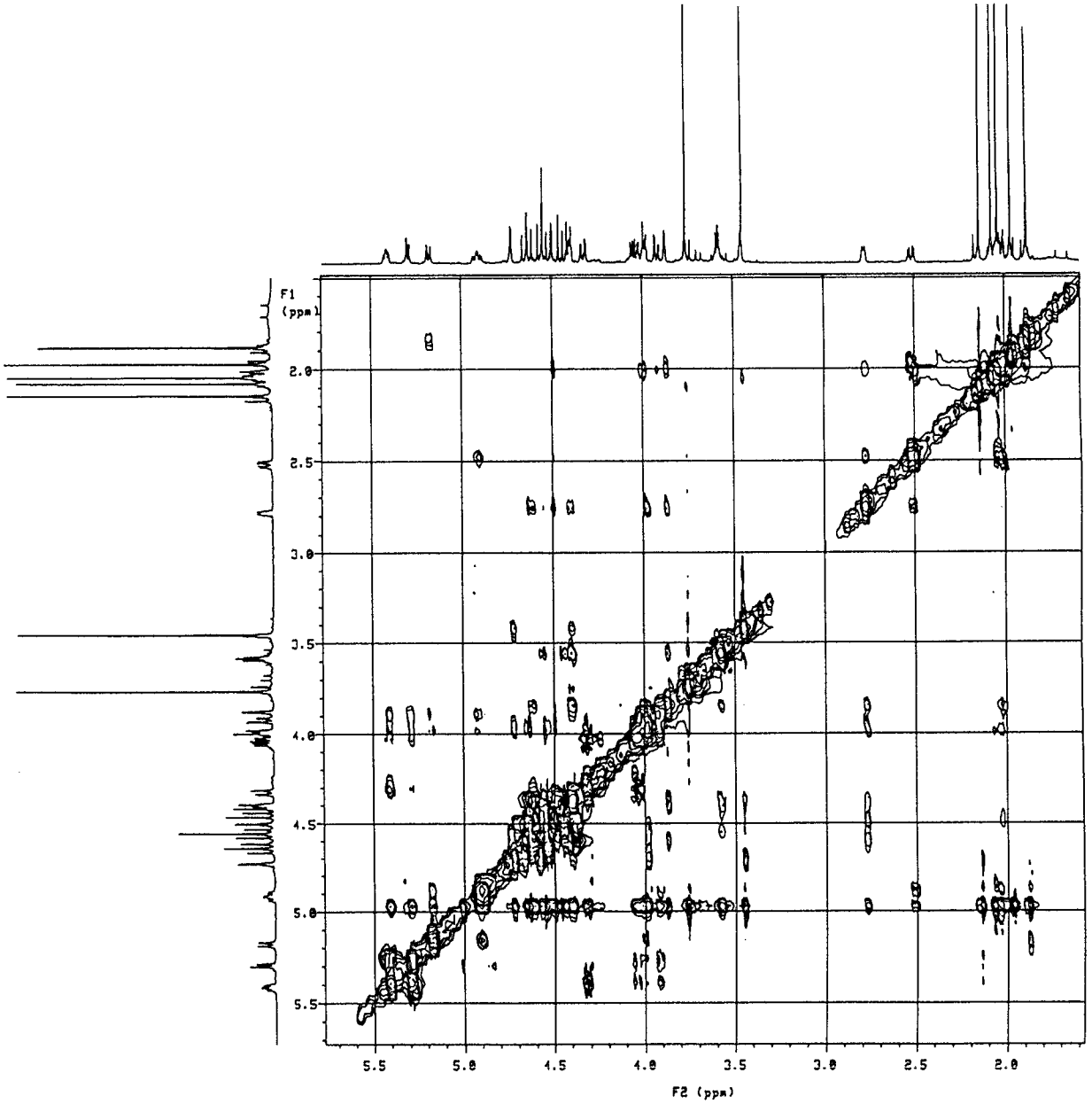
new experiment

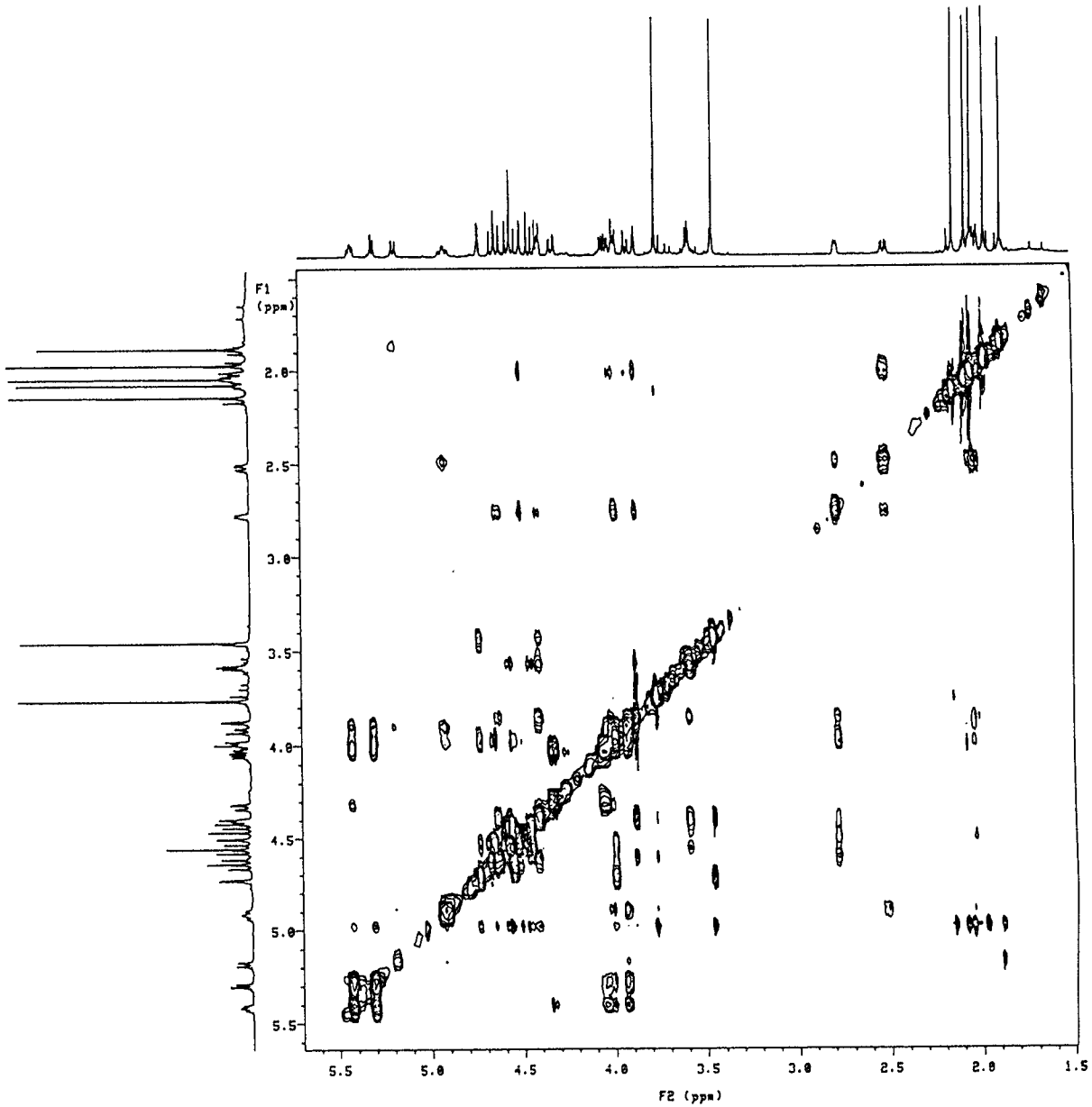
exp2  pulse sequence: roesy

      SAMPLE           2D SPECTRUM      ACQUISITION ARRAYS
date      Jul 16 96  sw1          5999.7  array          phase
temp          25.0   ni              256  arraydim       512
solvent       CDCl3  phase       arrayed
  PULSE SEQUENCE         PROCESSING       1              phase
d1                3   fn             2048  1                1
p1              6.5   gf           0.079   2                2
plvl             56   gfs       not used
pw              4.3     2D PROCESSING
mix           0.100   fn1             512
ratio         2.000   gf1           0.020
rocomp            n   gfs1      not used
sspul             n       DISPLAY
hs               nn   sp            785.3
satmode           n   wp           2099.6
     OBSERVE          vs              100
tn               H1   sc               10
sfrq        499.725   wc              115
tof               0   axis             pp
pw90            6.6   rf1           505.8
tpwr             44   rfp               0
     DECOUPLE         lp             28.8
dn               H1   rp            720.7
dfrq        499.724   ai  cdc  ph
dof            -788.9     2D DISPLAY
dpwr              7   sp1           742.8
home              y   wp1          2117.5
       DEC2           th                8
dn2                   sc2               0
dfrq2             0   wc2             115
dof2              0   rf11          505.8
dpwr2             1   rfp1              0
home2             n   lp1             2.0
     SPECTRUM         rp1             5.4
sw            5999.7
fb              3300
at             0.171
np              2048
nt                 4
ss                 8
gain              48
```

A selected portion of the ^{1}H-^{1}H ROESY (τ_m=100 ms) spectrum of *methyl 5-acetamido-4,7,8,9-tetra*-O-*acetyl-2,6-anhydro-3,5-dideoxy-2*-C-*[(S)-hydroxy-[3-(methyl 2,4,6-tri*-O-*benzyl-3-deoxy-α–D-galactopyranosidyl)]-methyl]*-*D*-erythro-*L*-manno-*nononate (10)*.



A selected portion of the ^{1}H-^{1}H ROESY (τ_m=700 ms) spectrum of *methyl 5-acetamido-4,7,8,9-tetra*-O-*acetyl-2,6-anhydro-3,5-dideoxy-2*-C-*{(S)-hydroxy-[3-(methyl 2,4,6-tri*-O-*benzyl-3-deoxy-α–D-galactopyranosidyl)]-methyl}-D*-erythro-*L*-manno-*nononate (10).*



exp7 pulse sequence: roesy

SAMPLE		2D SPECTRUM		ACQUISITION ARRAYS	
date	Jul 16 96	sw1	5999.7	array	phase
temp	25.0	ni	256	arraydim	512
solvent	CDCl3	phase	arrayed		
PULSE SEQUENCE		PROCESSING		1	phase
d1	3	fn	2048	1	1
p1	6.5	gf	0.079	2	2
plvl	56	gfs	not used		
pw	4.3	2D PROCESSING			
mix	0.700	fn1	512		
ratio	2.000	gf1	0.020		
rocomp	n	gfs1	not used		
sspul	n	DISPLAY			
hs	nn	sp	746.8		
satmode	n	wp	2899.6		
OBSERVE		vs	111		
tn	H1	sc	10		
sfrq	499.725	wc	115		
tof	0	axis	pp		
pw90	6.6	rfl	496.6		
tpwr	44	rfp	0		
DECOUPLE		lp	26.5		
dn	H1	rp	1.3		
dfrq	499.724	ai cdc ph			
dof	-788.9	2D DISPLAY			
dpwr	7	sp1	723.5		
homo	y	wp1	2894.0		
DEC2		th	1		
dn2		sc2	0		
dfrq2	0	wc2	115		
dof2	0	rfl1	500.0		
dpwr2	1	rfp1	0		
homo2	n	lp1	-1.2		
SPECTRUM		rp1	6.5		
sw	5999.7				
fb	3380				
at	0.171				
np	2048				
ct	4				
ss	8				
gain	40				