Domino reactions of diazodicarbonyl compounds with α,β-unsaturated-δ-amino esters: convenient way towards 2-oxopiperidines, dihydropyridinones and isoquinolinediones

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Supporting Information:

1. Preparation of amides 4a-e:

a) (***E*)-Ethyl 5-(3-methoxy-*N*-(methoxyphenyl)-2-methyl-3-oxopropanamido)-5-phenylpent-2-enoate (4a)** was prepared according to the general procedure for preparation of amides **4a-e** from 161 mg (0.5 mmol) of amino ester **1a** and 154 mg (1 mmol, 2 eq.) of diazo compound **2a**. Mixture was refluxed in 30 ml of $PhCF_3$ during 35 h, after standard work-up procedure product **4a** was isolated in yield of 171 mg (84%).

b) **(*E*)-Ethyl 5-(3-ethoxy-*N*-(methoxyphenyl)-3-oxo-2-phenylpropanamido)-5-phenylpent-2-enoate (4b)** was prepared according to the general procedure for preparation of amides **4a-e** from 325 mg (1 mmol) of amino ester **1a** and 262 mg (1.2 mmol, 1.2 eq.) of diazo compound **2b**. Mixture was refluxed in 20 ml of $PhCF_3$ during 5 h, after standard work-up procedure product **4b** was isolated in yield of 469 mg (91%).

c) (***E*)-Ethyl 5-(*N*-(4-methoxyphenyl)-3-oxo-2,3-diphenylpropanamido)-5-phenylpent-2-enoate (4c)** was prepared according to the general procedure for preparation of amides **4a-e** from 200 mg (0.6 mmol) of amino ester **1a** and 195 mg (0.8 mmol, 1.3 eq.) of diazo compound **3a**. Mixture was refluxed in 5 ml of $PhCF_3$ during 2 h, after standard work-up procedure product **4c** was isolated in yield of 286 mg (84%).

d) **(*E*)-Ethyl 5-(2,3-bis(4-chlorophenyl)-*N*-(4-methoxyphenyl)-3-oxopropanamido)-5-phenylpent-2-enoate (4d)** was prepared according to the general procedure for preparation of amides **4a-e** from 325 mg (1 mmol) of amino ester **1a** and 344 mg (1.1 mmol, 1.1 eq.) of diazo compound **3b**. Mixture was refluxed in 10 ml of $PhCF_3$ during 2.5 h, after standard work-up procedure product **4c** was isolated in yield of 286 mg (84%).

e) (***E*)-Ethyl 5-(*N*-(4-methoxyphenyl)-2-methyl-3-oxobutanamido)-5-phenylpent-2-enoate (4e)** was prepared according to the general procedure for preparation of amides **4a-e** from 115 mg (0.35 mmol) of amino ester **1a** and 126 mg (0.46 mmol, 1.2 eq.) of diazo compound **3c**. Mixture was refluxed in 4 ml of $PhCF_3$ during 2 h, after standard work-up procedure product **4e** was isolated in yield of 127 mg (86%).

2. Reactions of amides 4b,c with NaH:

a) To a solution of amide **4b** (152 mg, 0.3 mmol, 1 eq) in 20 ml of THF, NaH (15 mg, 0.6 mmol, 2 eq) was added, system was stirred at room temperature during 15 h. The solvent was removed in vacuo, and then the residue was separated by silica gel flash chromatography (eluent: Hexan-Et_2O 5:1→1:1) to afford 2-oxopiperidine **5a** (71 mg, 46%) as a mixture of diastereomers. Major isomer was isolated by preparative TLC: (*3R*,4S*,6S**)-**5a** (21 mg).

b) To a solution of amide **4c** (190 mg, 0.35 mmol, 1 eq) in 20 ml of Et_2O, NaH (17 mg, 0.7 mmol, 2 eq) was added, system was stirred at room temperature during 20 h. The solvent was removed in vacuo, and then the residue was separated by silica gel flash chromatography (eluent: Hexan-Et_2O 10:1→1:1) to afford 5,6-dihedropyridin-2(1*H*)-one **6a** (82 mg, 66%).

3. Preparation of 2-oxopiperidines 5a-d:

a) **Ethyl 4-(2-ethoxy-2-oxoethyl)-1-(4-methoxyphenyl)-2-oxo-3,6-diphenylpiperidine-3-carboxylate (5a)** was prepared according to the general procedure for preparation of 2-oxopiperidines **5a-c** (*approach A*) from 152 mg of amine **1a** (0.47 mmol), 89 mg of diazo compound **2a** (0.63 mmol, 1.3 eq) and 40 mg of NaH (60% dispersion in mineral oil; 2 eq). Mixture was refluxed in 4 ml of $PhCF_3$ during 19 h, after standard work-up procedure products *anti*-**5a** (97 mg; 47%) and *anti*-**5a'** (17 mg; 8%) were isolated as major products (total yield - 55%; ratio *anti*-**5a**/*anti*-**5a'** - 5.9 : 1).

b) **Ethyl 4-(2-ethoxy-2-oxoethyl)-1-(4-methoxyphenyl)-2-oxo-3,6-diphenylpiperidine-3-carboxylate (5a)** was prepared according to the general procedure for preparation of 2-oxopiperidines **5a-c** (*approach B*) from 230 mg of amine **1a** (0.7 mmol), 121 mg of diazo compound **2a** (0.85 mmol, 1.2 eq) and 60 mg of NaH (60% dispersion in mineral oil; 2 eq). Mixture was refluxed in 8 ml of $PhCF_3$ during 16 h, and additional 5 h after addition of NaH, after standard work-up procedure products *anti*-**5a** (161 mg; 52%) and *anti*-**5a'** (31 mg; 10%) were isolated as major products (total yield - 62%, ratio *anti*-**5a**/*anti*-**5a'** - 5.2 : 1).

c) **Ethyl 4-(2-ethoxy-2-oxoethyl)-1-(4-methoxyphenyl)-2-oxo-3,6-diphenylpiperidine-3-carboxylate (5b)** was prepared according to the general procedure for preparation of 2-oxopiperidines **5a-c** (*approach A*) from 102 mg of amine **1a** (0.3 mmol), 75 mg of diazo compound **2b** (0.34 mmol, 1.1 eq) and 25 mg of NaH (60% dispersion in mineral oil; 2 eq).

Mixture was refluxed in 5 ml of toluene during 3 h, after standard work-up procedure products *anti*-**5b** (73 mg; 45%) and *anti*-**5b'** (29 mg; 18%) were isolated as major products (total yield - 63%; ratio *anti*-**5b**/*anti*-**5b'** - 2.5 : 1), also 24 mg of by-product **6a** was isolated (22%).

d) **Ethyl 2-(7-(4-methoxyphenyl)-1,6-dioxo-8-phenyl-7-azaspiro[4.5]decan-10-yl)acetate (5d)** was prepared according to the general procedure for preparation of 2-oxopiperidines **5a-c** (*approach A*) from 150 mg of amine **1a** (0.46 mmol), 76 mg of diazo compound **3e** (0.55 mmol, 1.2 eq) and 40 mg of NaH (60% dispersion in mineral oil; 2 eq). Mixture was refluxed in 10 ml of toluene during 6 h, after standard work-up procedure mixture of isomers **5d** were isolated (4 isomers: 157 mg (78.5%) as a mixture of *cis- [8S*,10R*]* and *trans- [8S*,10S*]* in ratio 1.3 : 1). Mixture was separated by preparative TLC to afford mixture of only two isomers, that was fully characterized.

e) **Ethyl 2-(7-(4-methoxyphenyl)-1,6-dioxo-8-phenyl-7-azaspiro[4.5]decan-10-yl)acetate (5d)** was prepared according to the general procedure for preparation of 2-oxopiperidines **5a-c** (*approach B*) from 56 mg of amine **1a** (0.17 mmol), 29 mg of diazo compound **3e** (0.21 mmol, 1.2 eq) and 15 mg of NaH (60% dispersion in mineral oil; 2 eq). Mixture was refluxed in 3 ml of toluene during 2 h, and additional 6 h after addition of NaH, after standard work-up procedure mixture of isomers **5d** were isolated (54 mg (73%) as a mixture of *cis- [8S*,10R*]* and *trans- [8S*,10S*]* in ratio 1.2 : 1).

4. Preparation of 5,6-dihedropyridin-2(1H)-ones 6a-e:

a) **1-(4-Methoxyphenyl)-3,6-diphenyl-5,6-dihydropyridin-2(1*H*)-one (6a)** was prepared according to the general procedure for preparation of 5,6-dihedropyridin-2(1*H*)-ones **6a-e** from 100 mg of amine **1a** (0.31 mmol), 85 mg of diazo compound **3a** (0.34 mmol, 1.1 eq) and 25 mg of NaH (60% dispersion in mineral oil; 2 eq). Mixture was refluxed in 5 ml of toluene during 2 h, after standard work-up procedure product **6a** was isolated in a yield of 75 mg (69%).

b) **3-(4-Chlorophenyl)-1-(4-methoxyphenyl)-6-phenyl-5,6-dihydropyridin-2(1*H*)-one (6b)** was prepared according to the general procedure for preparation of 5,6-dihedropyridin-2(1*H*)-ones **6a-e** from 100 mg of amine **1a** (0.31 mmol), 109 mg of diazo compound **3b** (0.34 mmol, 1.1 eq) and 25 mg of NaH (60% dispersion in mineral oil; 2 eq). Mixture was refluxed in 10 ml of toluene during 2.5 h, after standard work-up procedure product **6b** was isolated in a yield of 90 mg (75%).

c) **(*E*)-3-(4-chlorophenyl)-6-styryl-5,6-dihydropyridin-2(1*H*)-one (6c)** was prepared according to the general procedure for preparation of 5,6-dihedropyridin-2(1*H*)-ones **6a-e** from 69 mg of amine **1b** (0.2 mmol), 69 mg of diazo compound **3b** (0.22 mmol, 1.1 eq) and 20 mg of NaH (60% dispersion in mineral oil; 2 eq). Mixture was refluxed in 7 ml of toluene during 2 h, after standard work-up procedure product **6c** was isolated in a yield of 28 mg (34%).

d) **3-(4-Clorophenyl)-1-(4-mrthoxyphenyl)-6-(*o*-tolyl)-5,6-dihydropyridin-2(1*H*)-one (6d)** was prepared according to the general procedure for preparation of 5,6-dihedropyridin-2(1*H*)-ones **6a-e** from 84 mg of amine **1c** (0.25 mmol), 95 mg of diazo compound **3b** (0.3 mmol, 1.2 eq) and 20 mg of NaH (60% dispersion in mineral oil; 2 eq). Mixture was refluxed in 5 ml of toluene during 2.5 h, after standard work-up procedure product **6d** was isolated in a yield of 55 mg (54%).

e) **1-(Methoxyphenyl)-6-phenyl-3-(*p*-tolyl)-5,6-dihydropyridin-2(1*H*)-one (6e**) was prepared according to the general procedure for preparation of 5,6-dihedropyridin-2(1*H*)-ones **6a-e** from 162 mg of amine **1a** (0.5 mmol), 121 mg of diazo compound **3d** (0.6 mmol, 1.2 eq) and 40 mg of NaH (60% dispersion in mineral oil; 2 eq). Mixture was refluxed in 10 ml of toluene during 1 h, after standard work-up procedure product **6e** was isolated in a yield of 35 mg (19%).

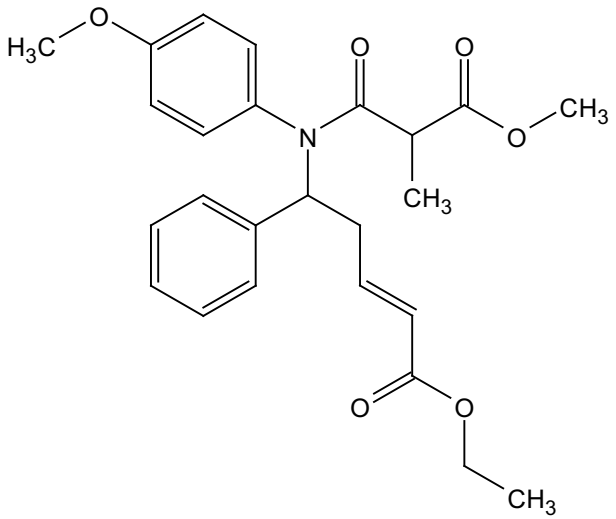
5. Attempt to perform intramolecular Claisen condensation with 2-oxopiperidine 5c

Solution of 45 mg (0.1 mmol) of compound **5c** in 5 ml of toluene with 16 mg of NaH (60% dispersion in mineral oil; 2 eq) was refluxed in toluene during 7h. Then reaction mixture was separated by silica gel flash chromatography (eluent: hexane-acetone 5:1→2:1) to afford 8.5 mg of isoquinolinedione **7b** (21%) and 30 mg of starting 2-oxopiperidine **5c**.

The 1H NMR spectra of **7b** was similar to the 1H spectra of **7a**.

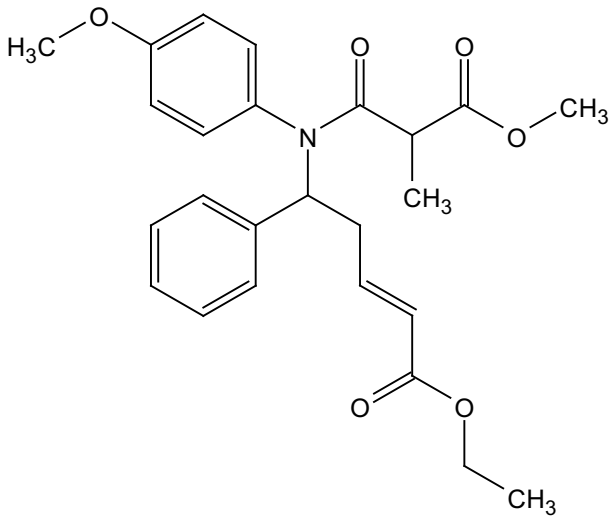
NMR (400 MHz, $CDCl_3$) δ 12.25 (s, 1H), 7.00-7.36 (m, 5H), 6.71 (d, J = 8.5 Hz, 1H), 6.52 (dd, J = 8.5, 2.3 Hz, 1H), 6.30 (d, J = 2.3 Hz, 1H), 5.50 (s, 1H), 4.86 (dd, J = 11.1, 6.4 Hz, 1H), 3.78 (s, 3H), 3.67 (s, 3H), 3.05-3.15 (m. 1H), 2.05-2.49 (m, 4H), 1.91 (s, 3H); HRMS (ESI) calcd for $C_{24}H_{25}NO_5$ $[M+H]^+$ 408.1805, found 408.1800.

MM82H
M. Meleshina



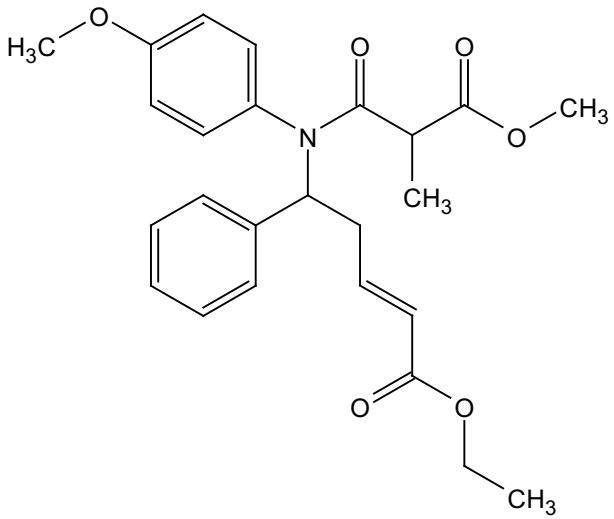
4a (*mixture of diastereomers in ratio 1 : 1*)

MM82C
M. Meleshina



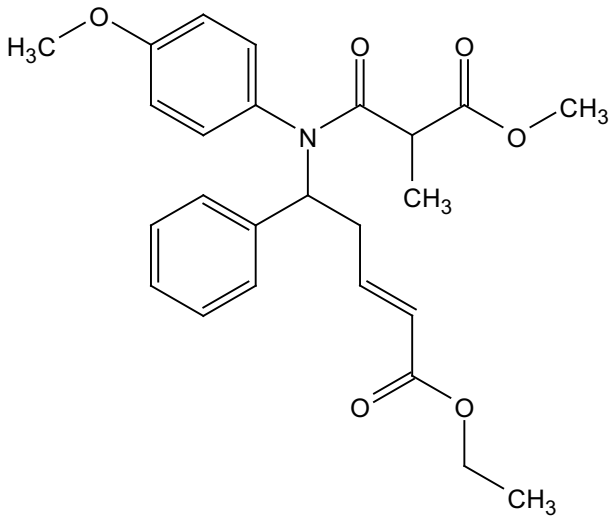
4a (*mixture of diastereomers in ratio 1 : 1*)

MM801H
M. Meleshina



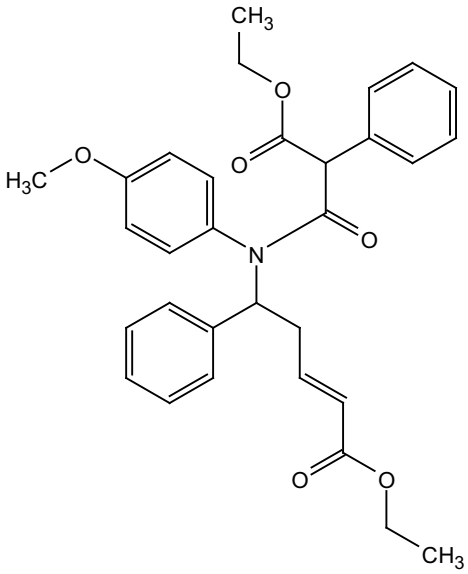
4a (diastereomer B)

MM801C
M. Meleshina



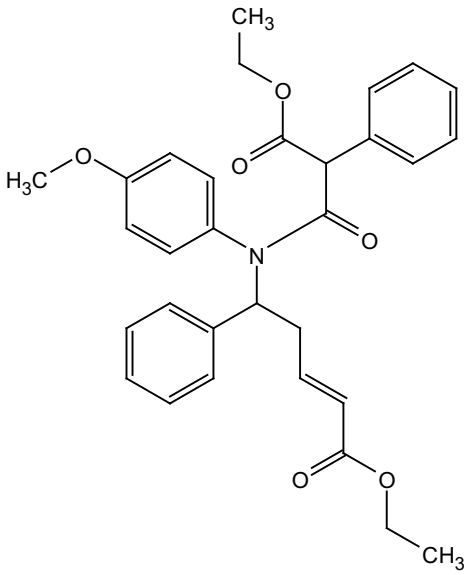
4a (diastereomer B)

MM303H
M. Meleshina

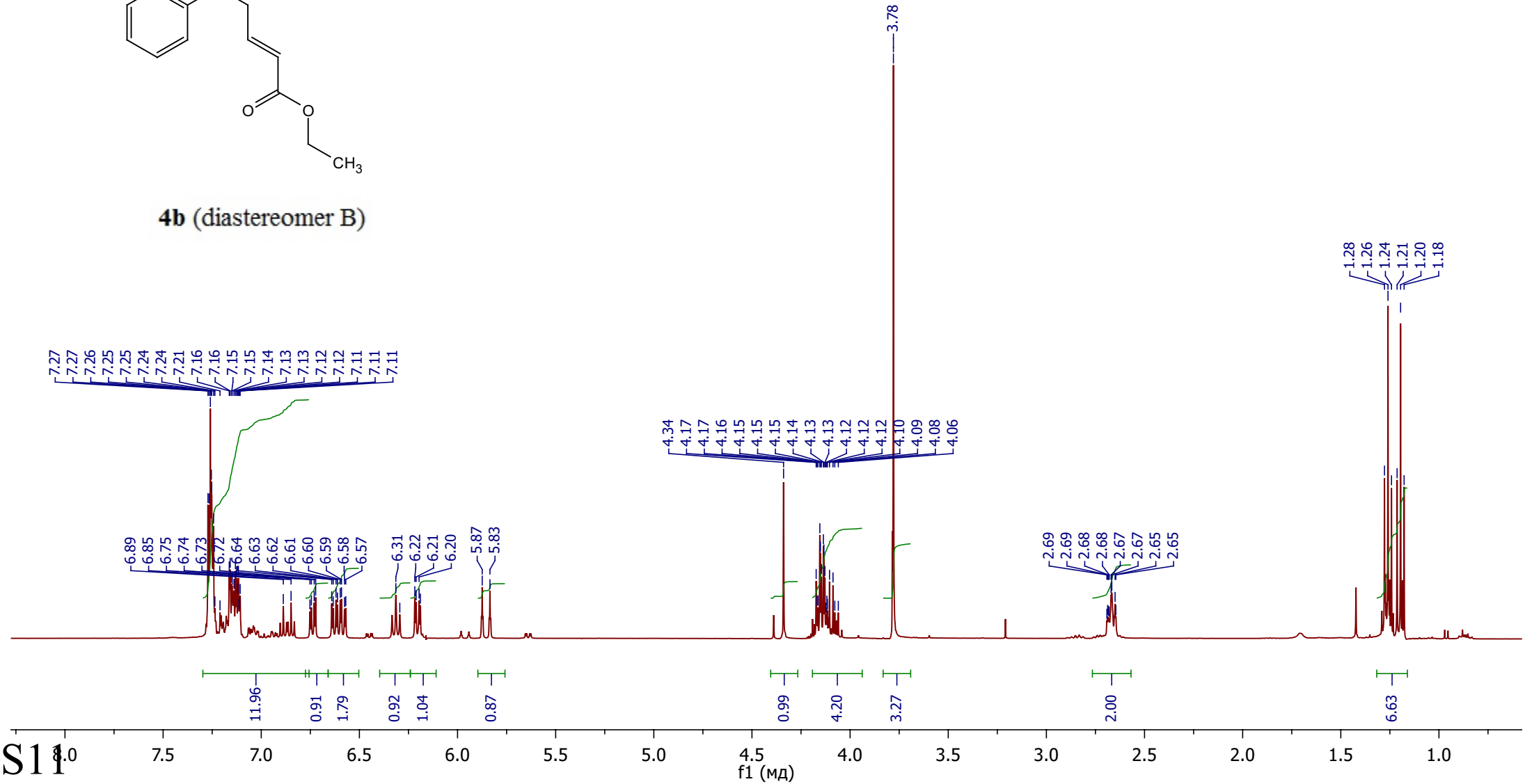


4b (*mixture of diastereomers in ratio 1 : 1*)

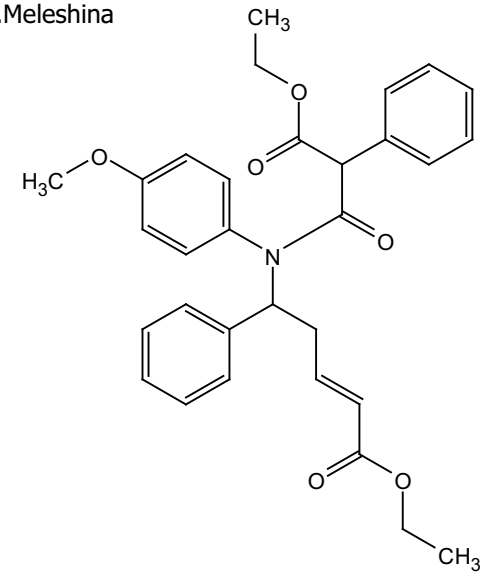
MM301H
M.Meleshina



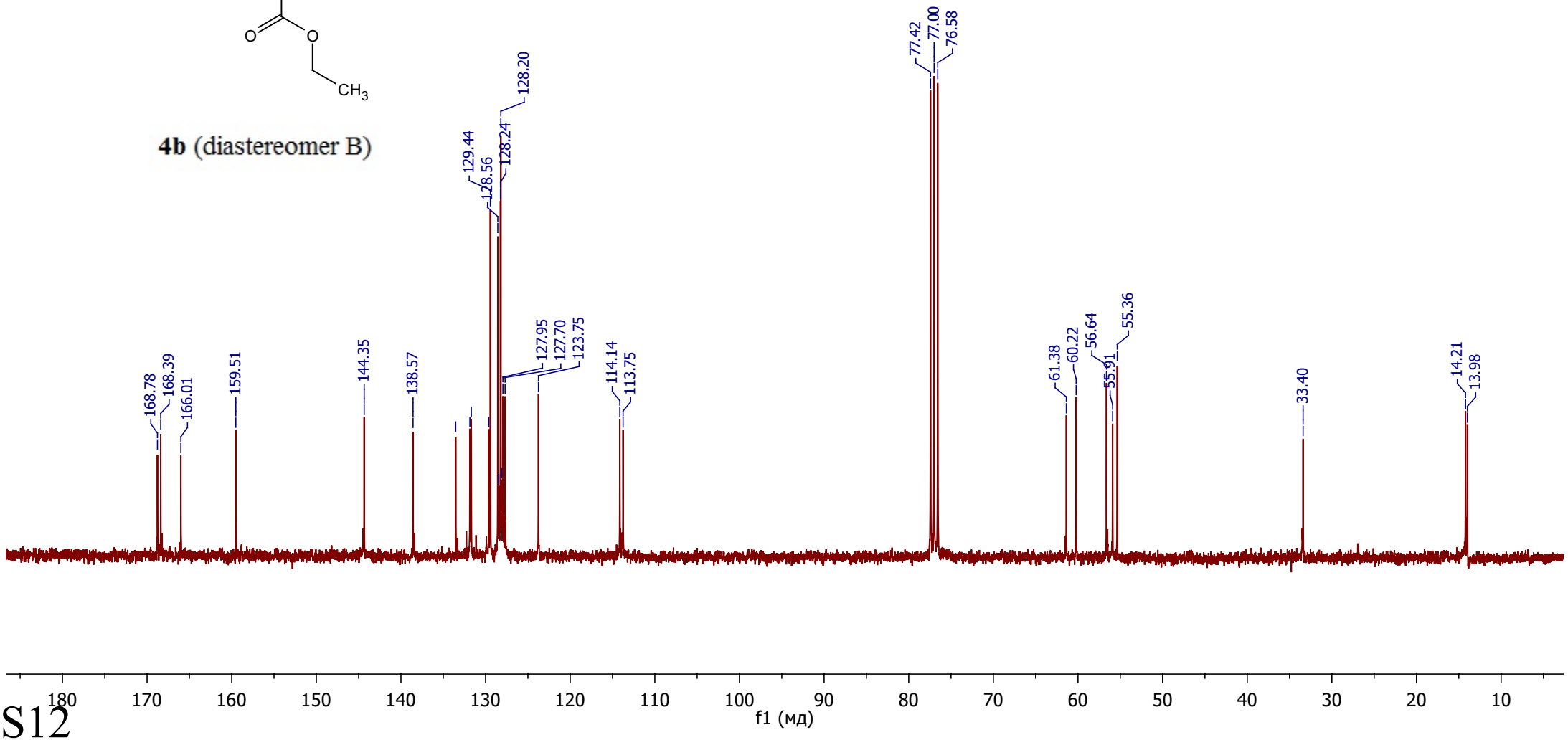
4b (diastereomer B)



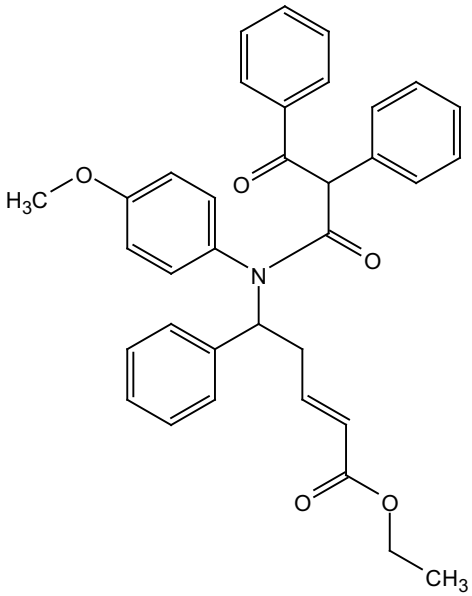
MM301C
Std Carbon experiment
M.Meleshina



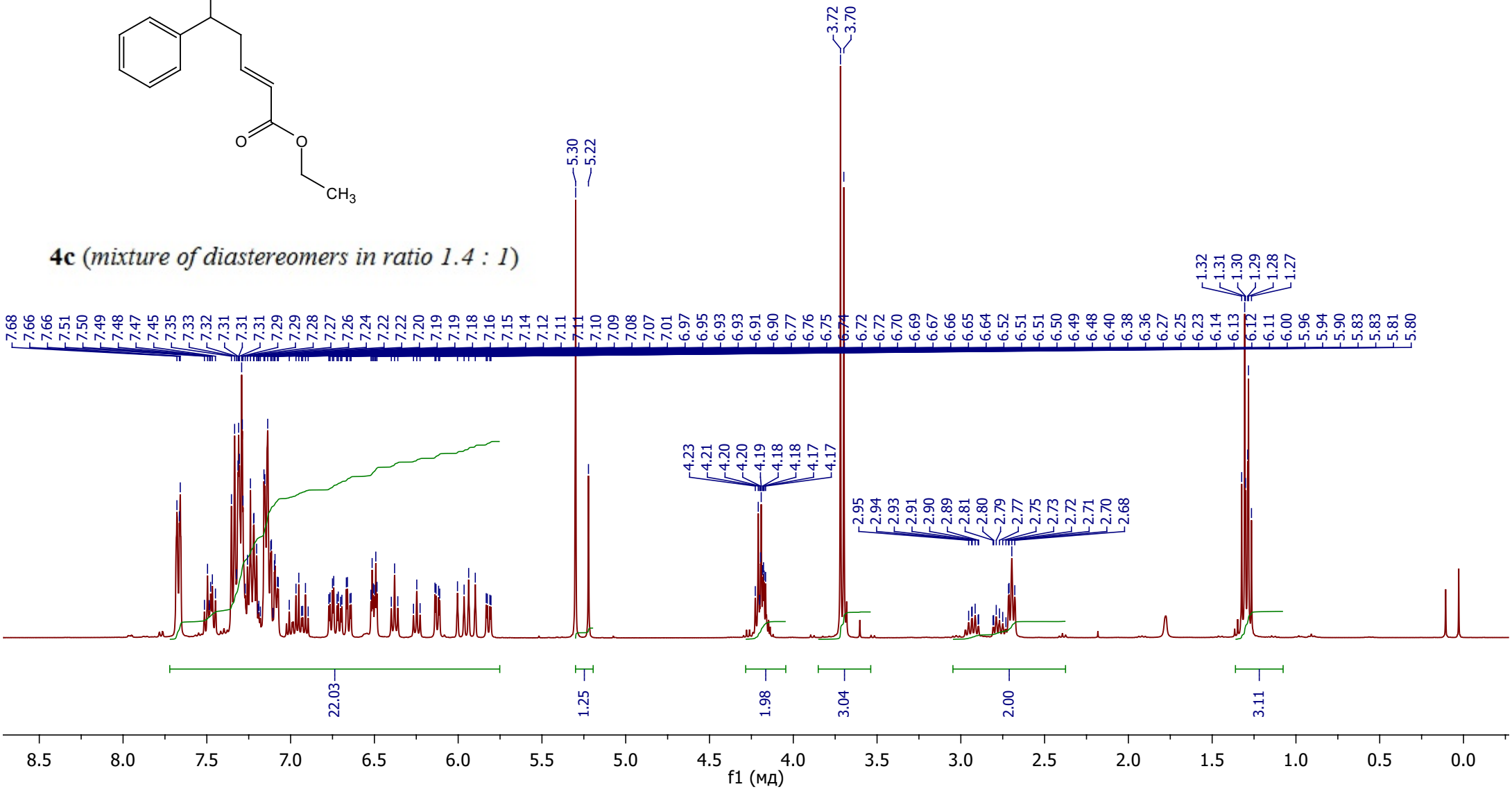
4b (diastereomer B)



YME
YME, 36, BF = 400.13 MHz, Solvent - CDCl3, 06 Jun 2013 T=300 K



4c (*mixture of diastereomers in ratio 1.4 : 1*)



YMEc
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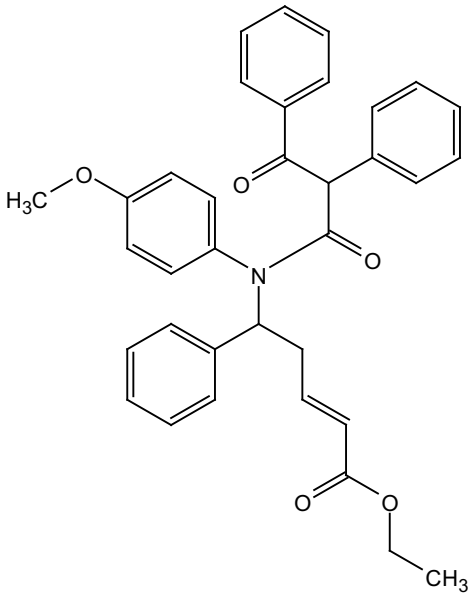

4c (*mixture of diastereomers in ratio 1.4 : 1*)

SEM
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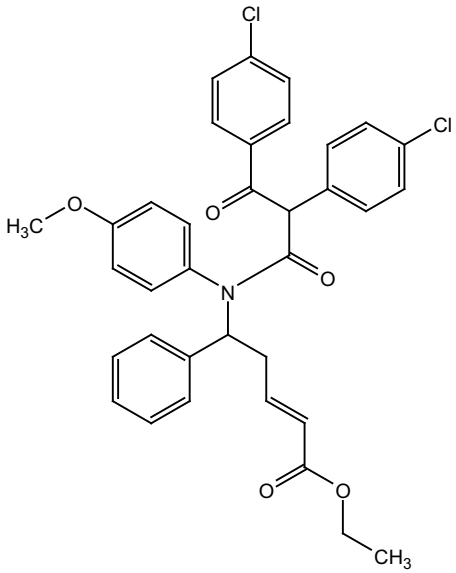
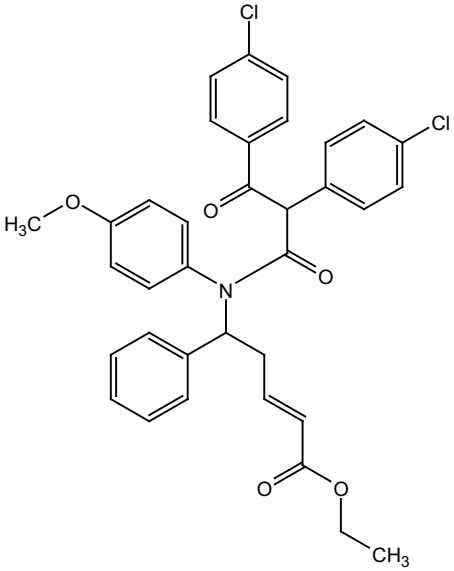


4d *(mixture of diastereomers in ratio 2 : 1)*



4d *(mixture of diastereomers in ratio 2 : 1)*

YME
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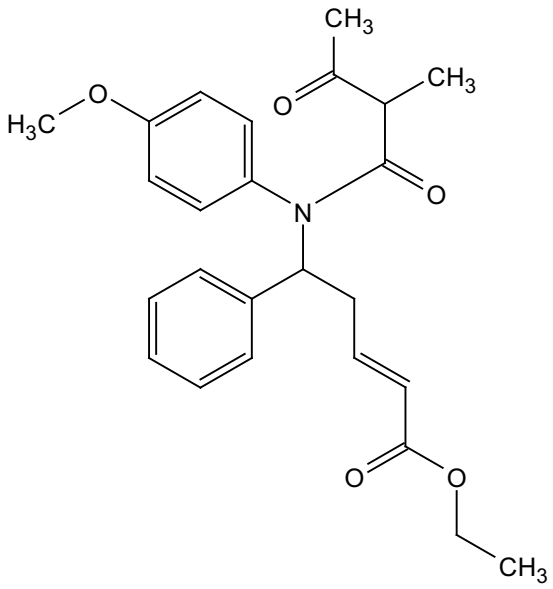
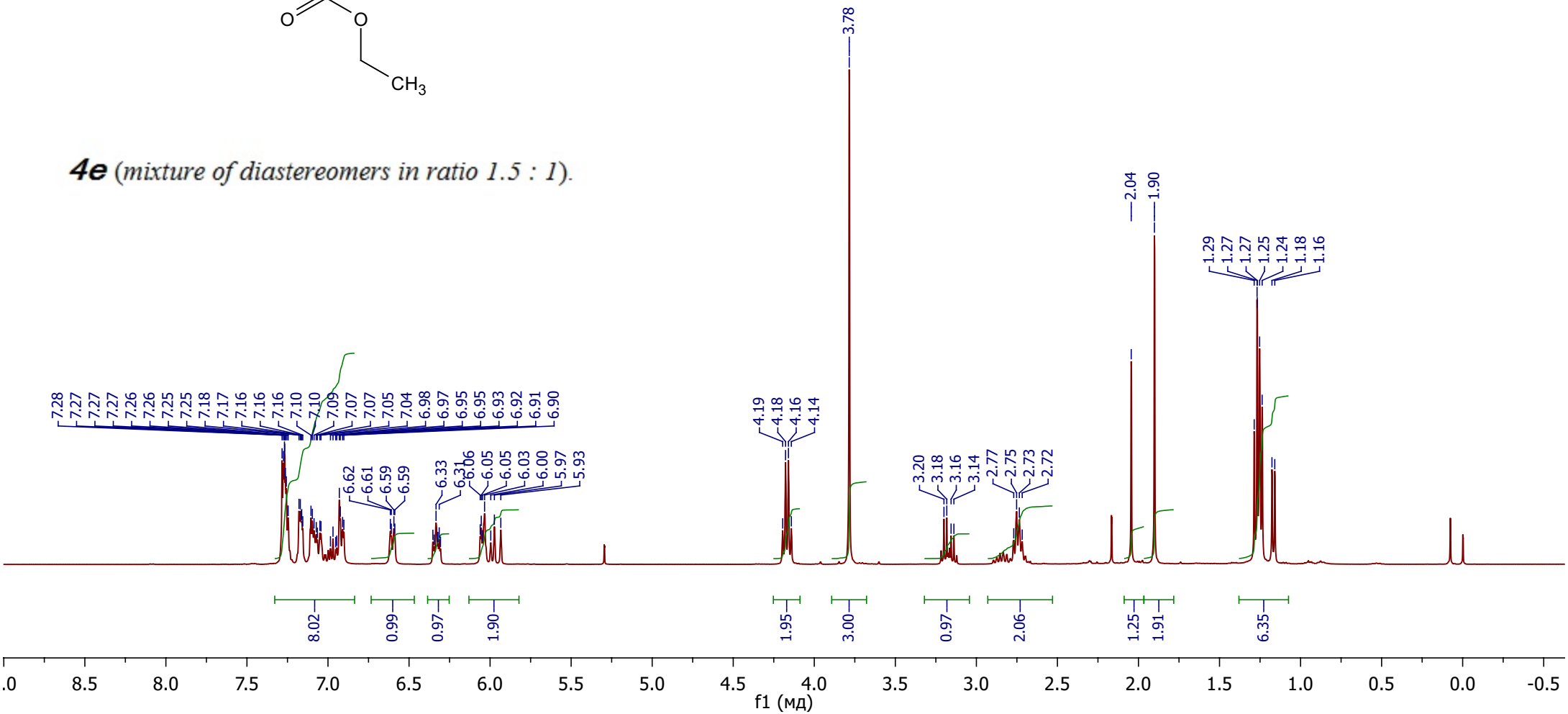


4e *(mixture of diastereomers in ratio 1.5 : 1).*



YMEc
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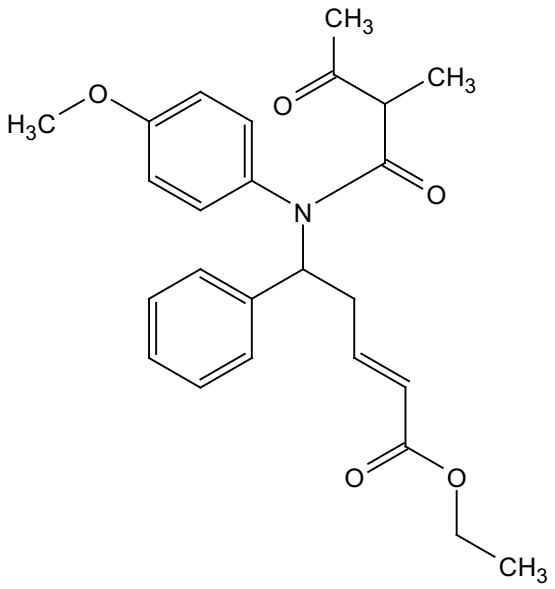
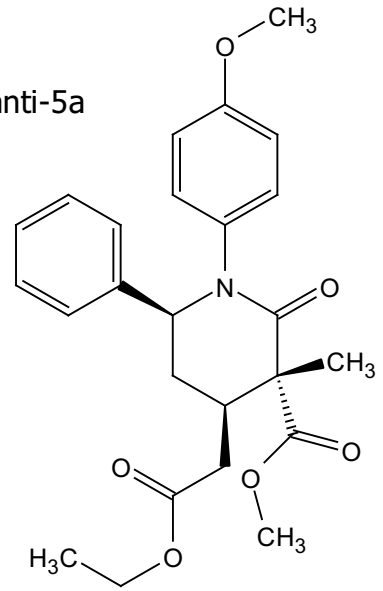


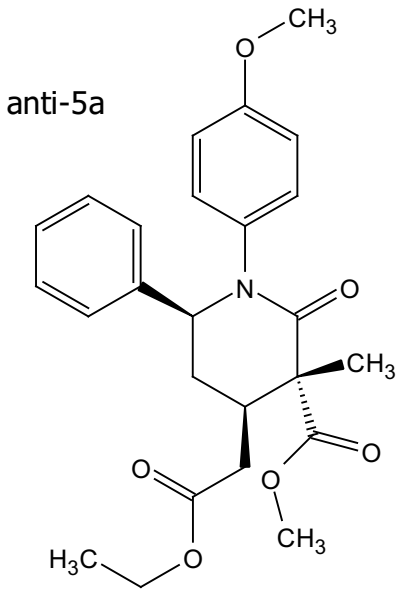
4e *(mixture of diastereomers in ratio 1.5 : 1).*

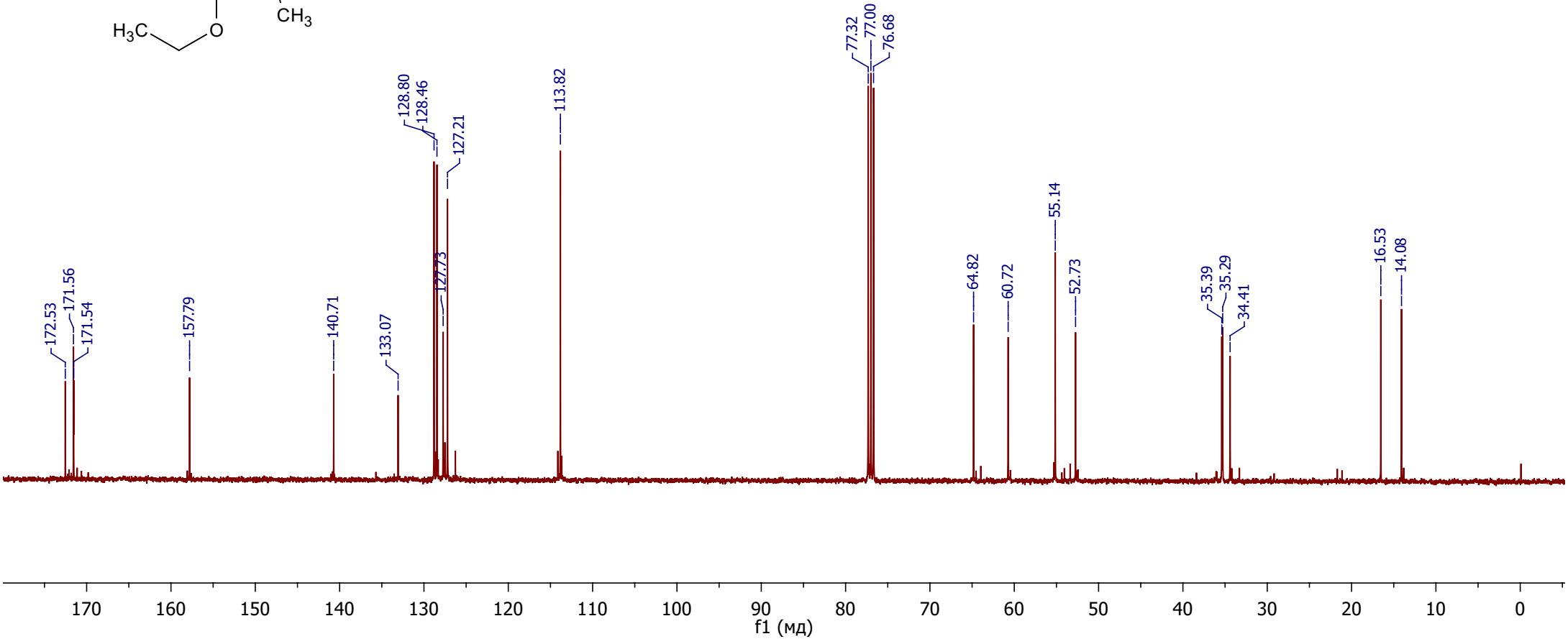
1H
YME, 66, BF = 400.13 MHz, Solvent - CDCl3, 18 Jul 2013 T=296 K

anti-5a

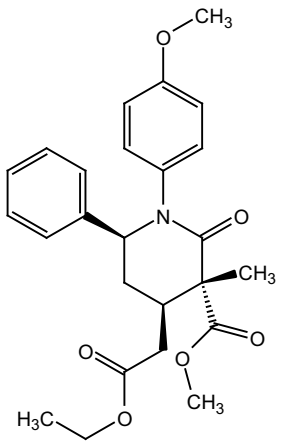


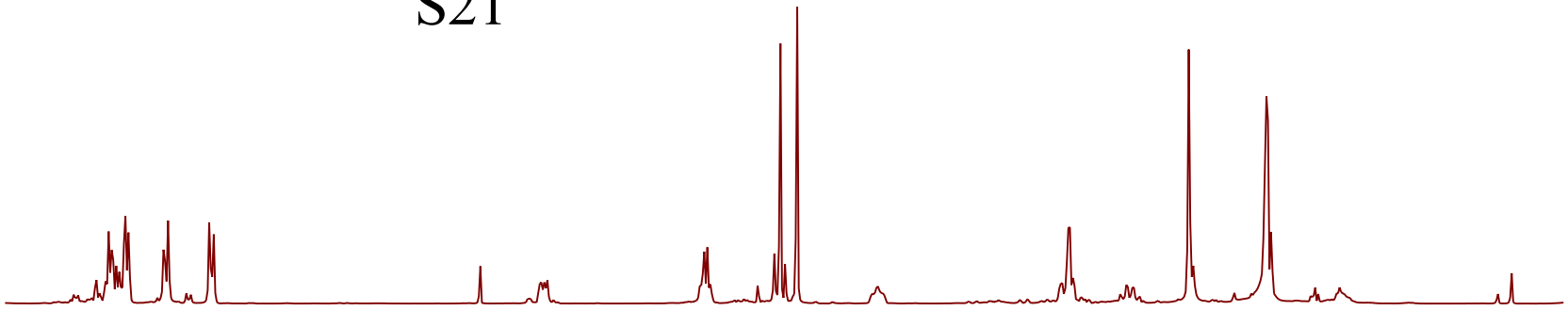
13C
YMEc, 66, BF = 100.612769 MHz, Solvent - CDCl3, 18 Jul 2013 T=297 K

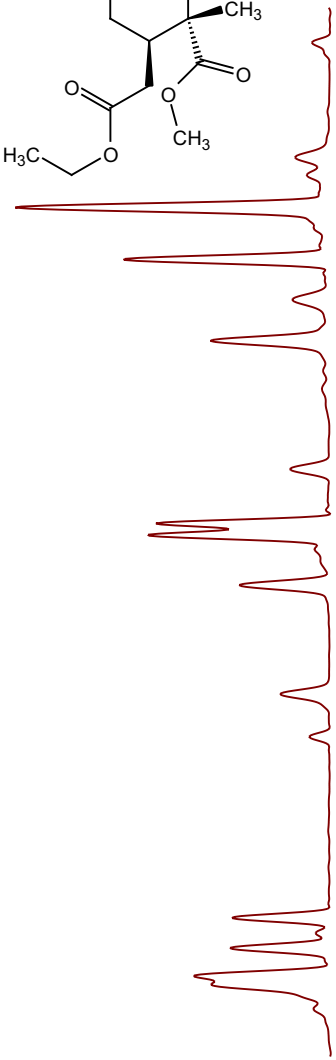


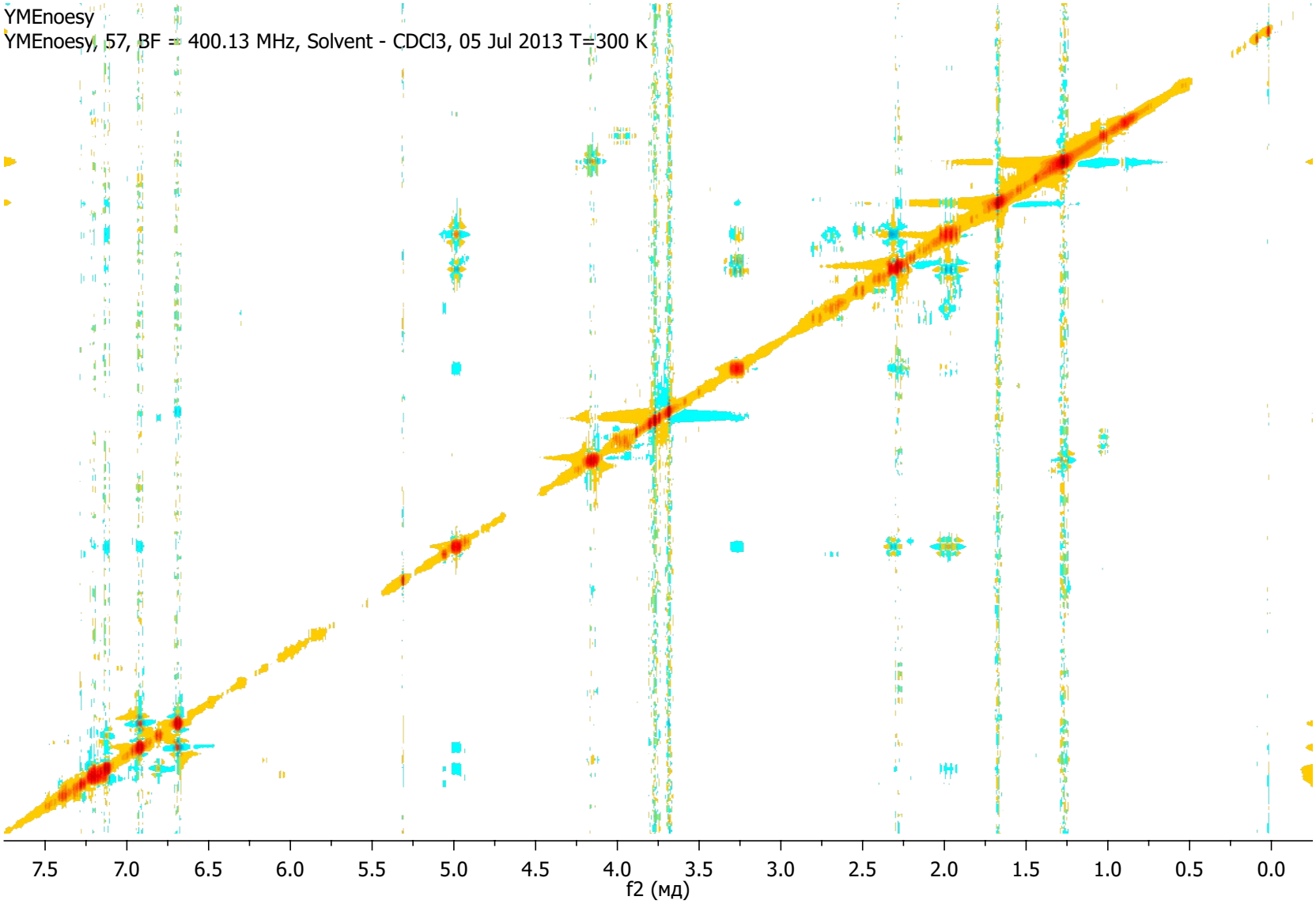


anti-5a

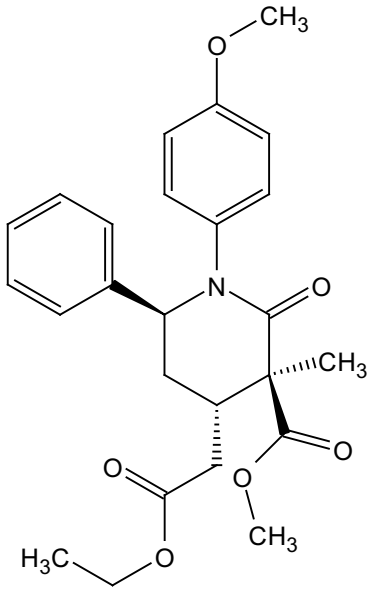







YMEnoesy
YMEnoesy, 57, BF = 400.13 MHz, Solvent - CDCl3, 05 Jul 2013 T=300 K
f2 (мд)
f1 (мд)

1H
YME, 61, BF = 400.13 MHz, Solvent - CDCl3, 10 Jul 2013 T=298 K



anti-5'a

SEM
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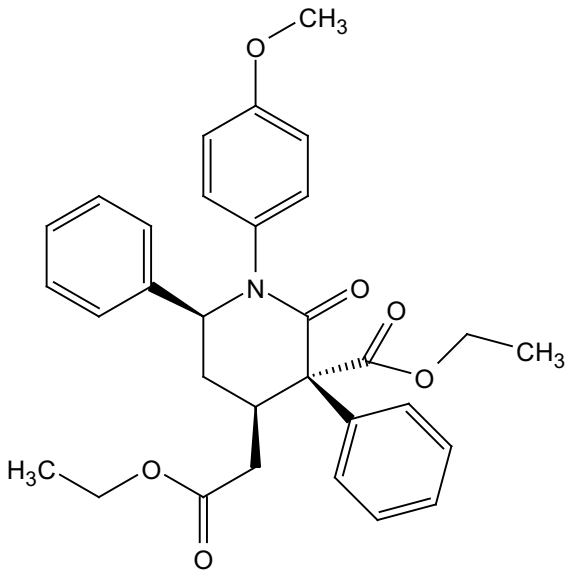
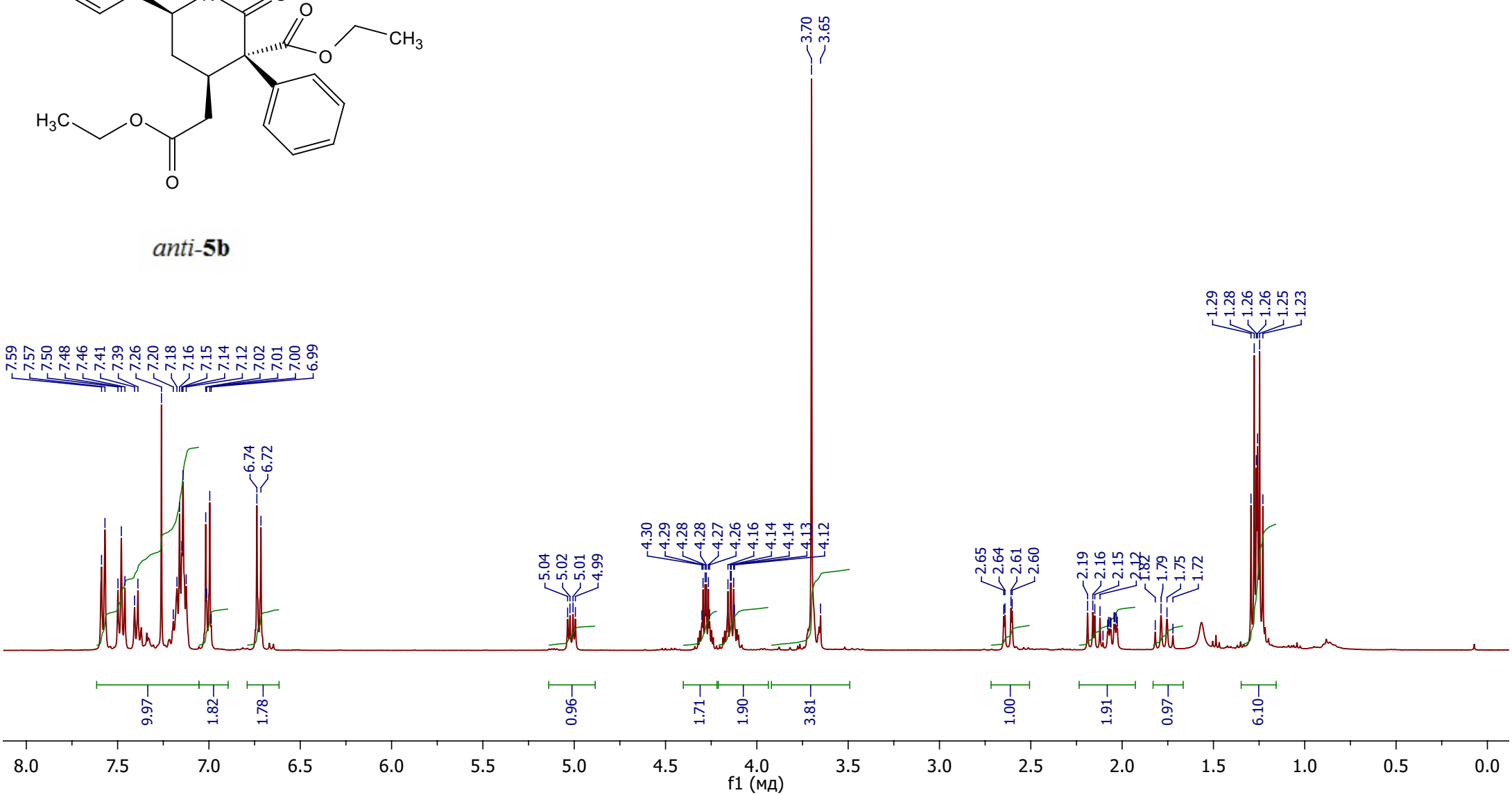


anti-**5b**



SEMc
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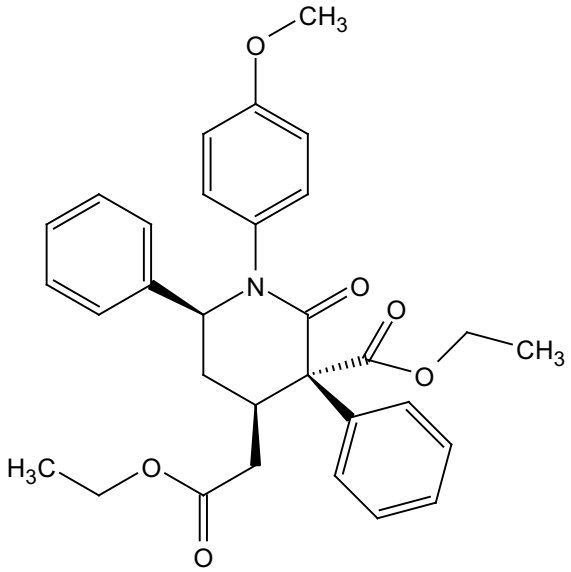
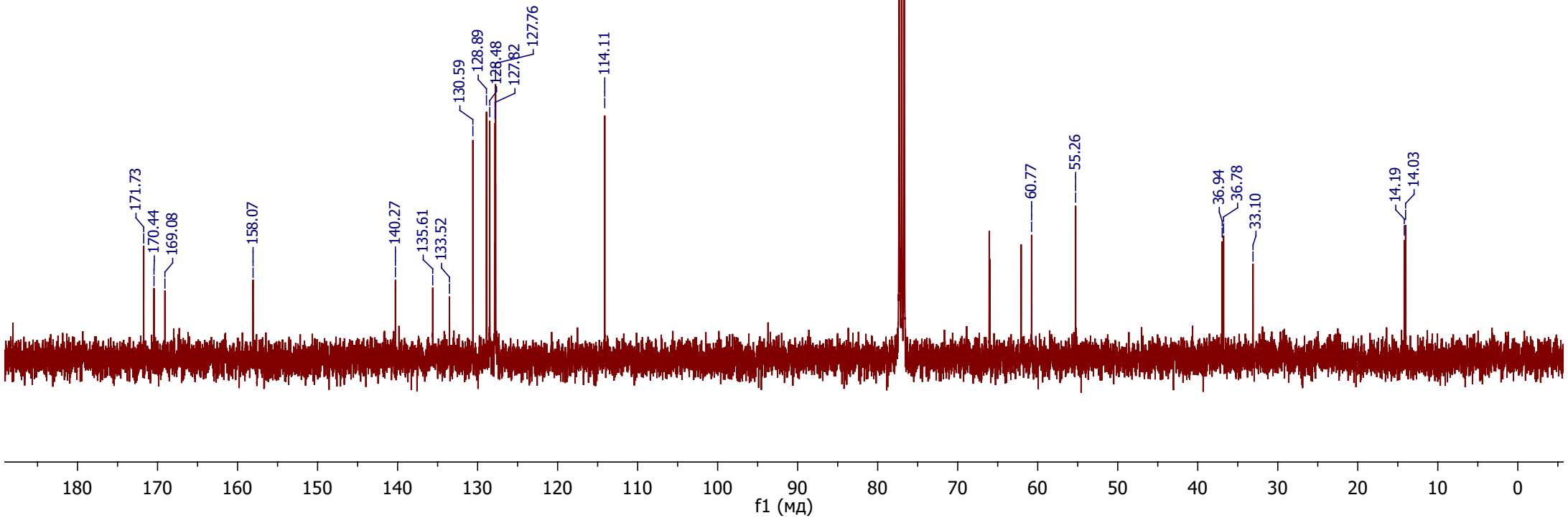
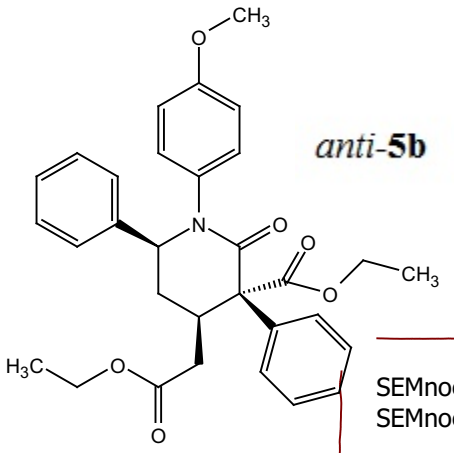


anti-**5b**





anti-**5b**

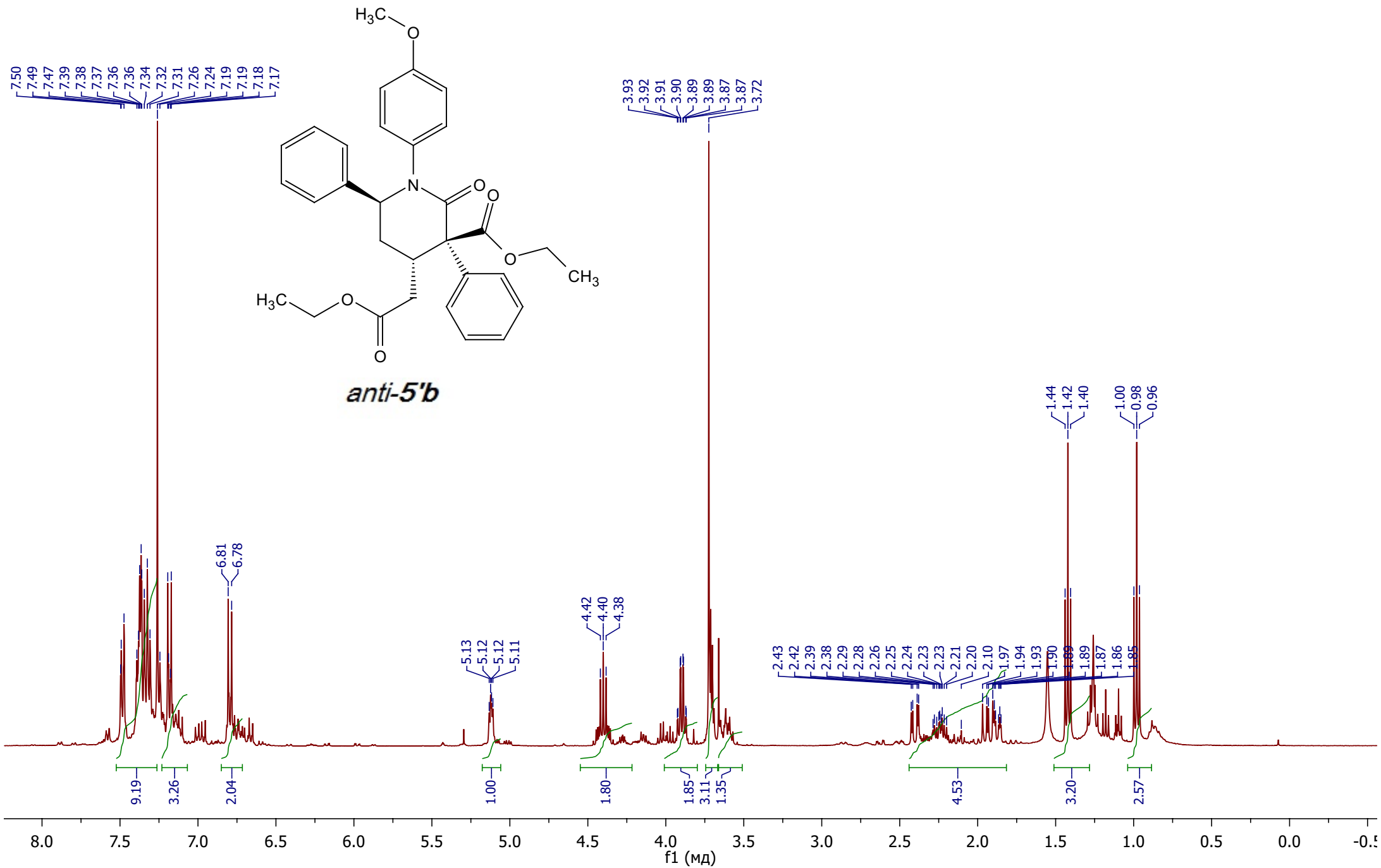
SEMnoesy

SEMnoesy, 692, BF = 400.13 MHz, Solvent - CDCl3, 03 Mar 2015 T=296 K

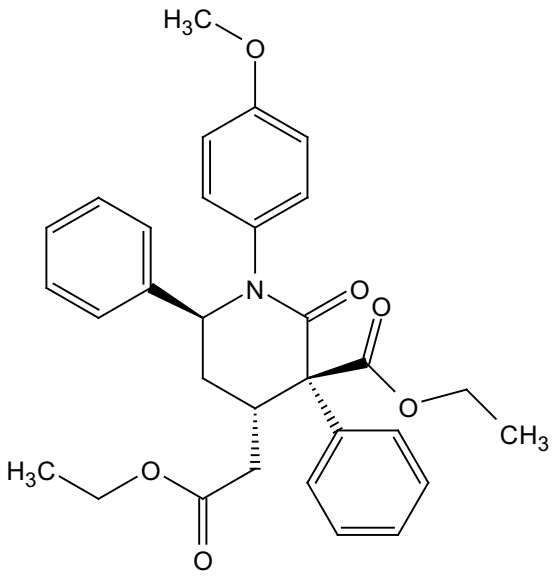
f2 (мд)

f1 (мд)

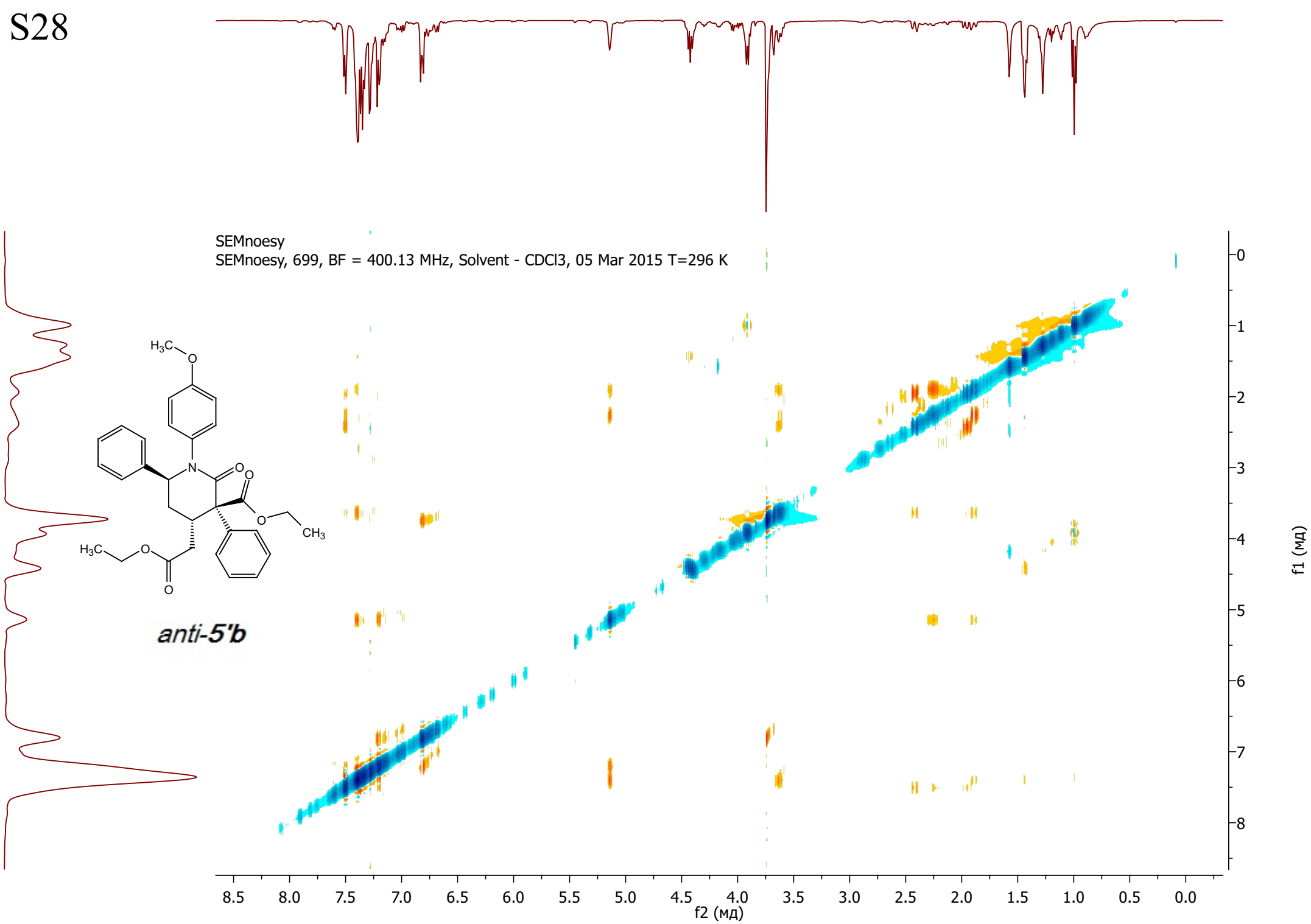
SEM
SEM, 699, BF = 400.13 MHz, Solvent - CDCl3, 04 Mar 2015 T=296 K



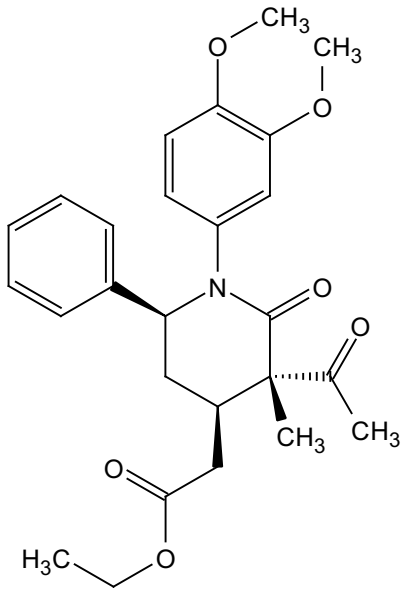
SEMc
SEMc, 699, BF = 100.612769 MHz, Solvent - CDCl3, 04 Mar 2015 T=297 K



anti-5'b

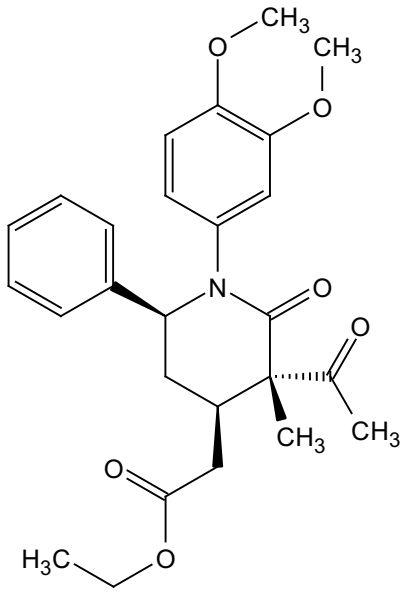

SEMnoesy
SEMnoesy, 699, BF = 400.13 MHz, Solvent - CDCl3, 05 Mar 2015 T=296 K
anti-5'b
f2 (мд)
f1 (мд)

SEM
SEM, 732, BF = 400.13 MHz, Solvent - CDCl3, 30 Mar 2015 T=294 K

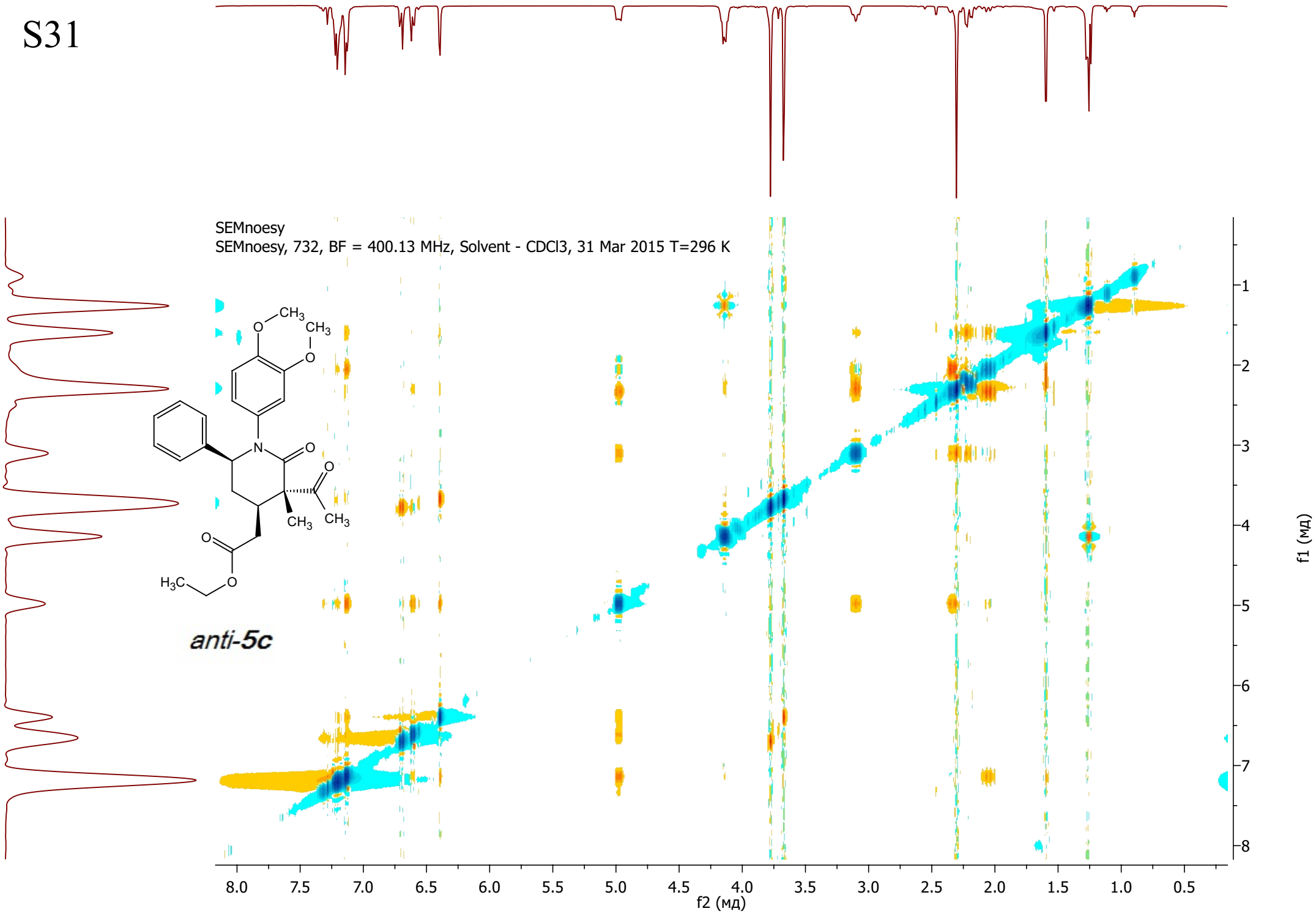


anti-5c

SEMc
SEMc, 732, BF = 100.612769 MHz, Solvent - CDCl3, 31 Mar 2015 T=295 K

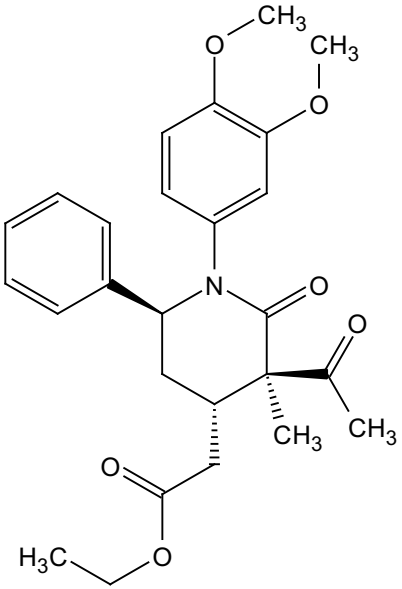


anti-5c

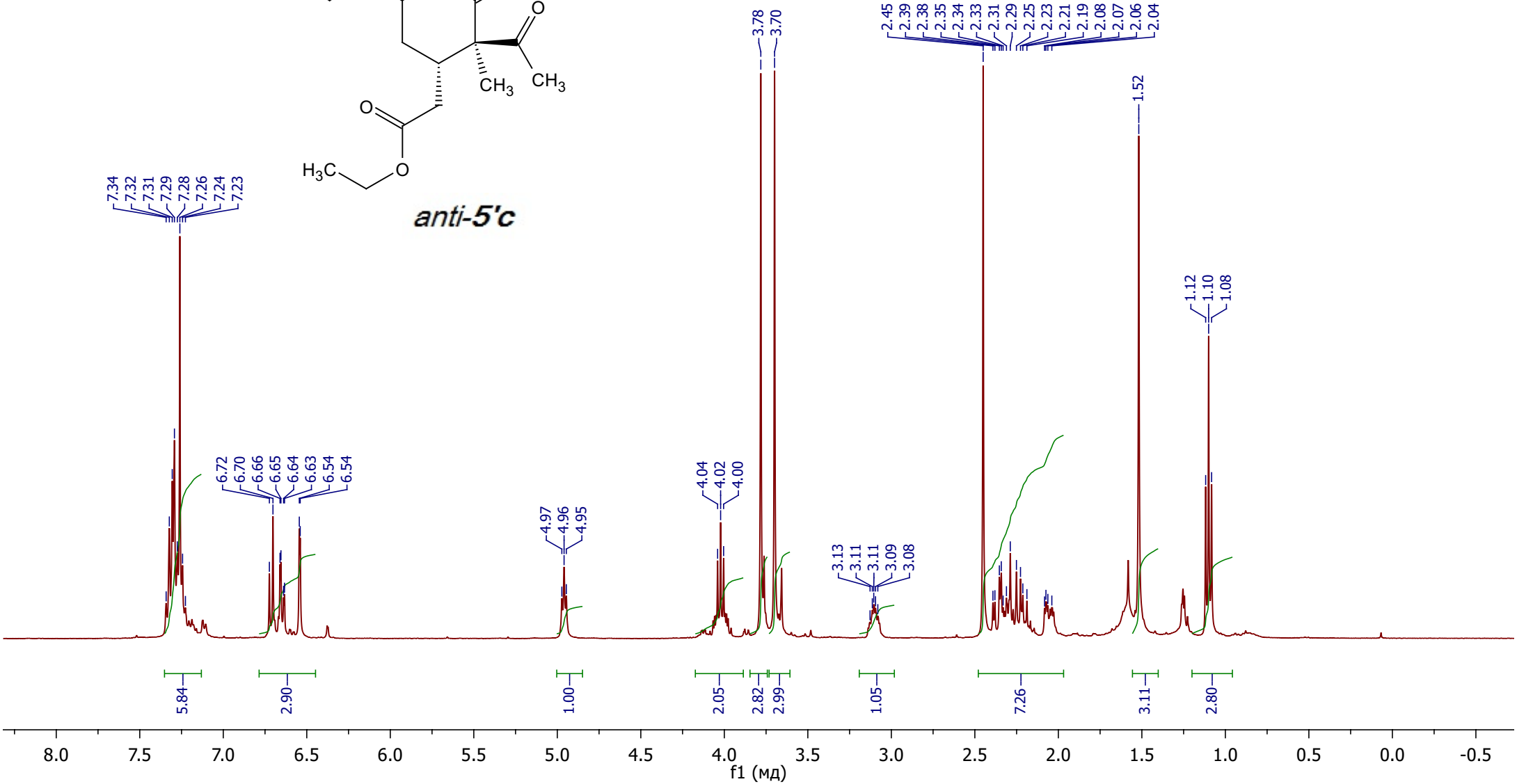

SEMnoesy
SEMnoesy, 732, BF = 400.13 MHz, Solvent - CDCl3, 31 Mar 2015 T=296 K
anti-5c
f2 (мд)
f1 (мд)

SEM

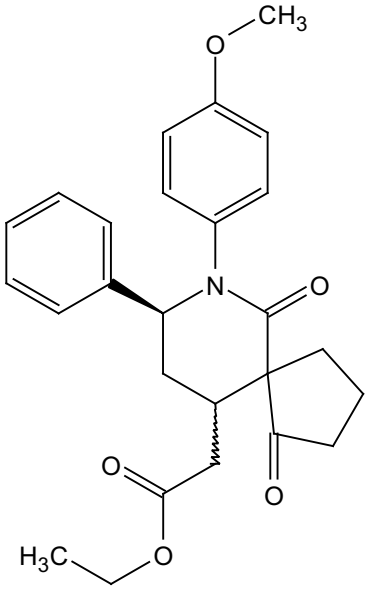
SEM, 736, BF = 400.13 MHz, Solvent - CDCl3, 02 Apr 2015 T=296 K



anti-5'c

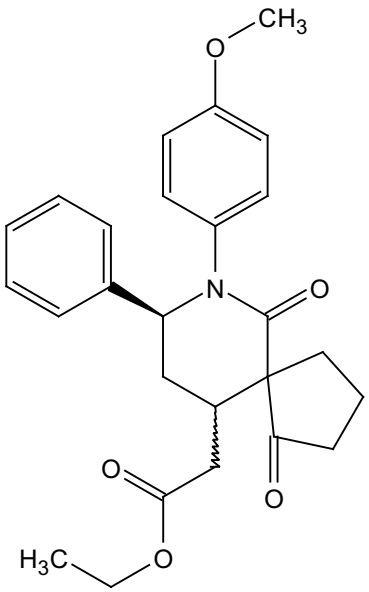


SEM
SEM, 706, BF = 400.13 MHz, Solvent - CDCl3, 12 Mar 2015 T=296 K

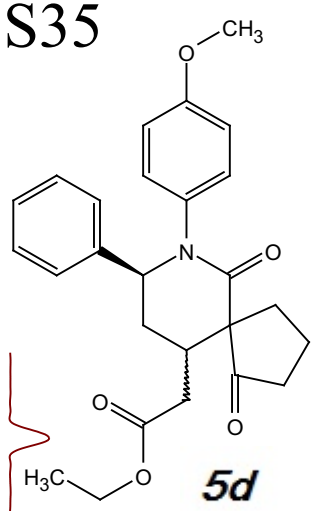


5d

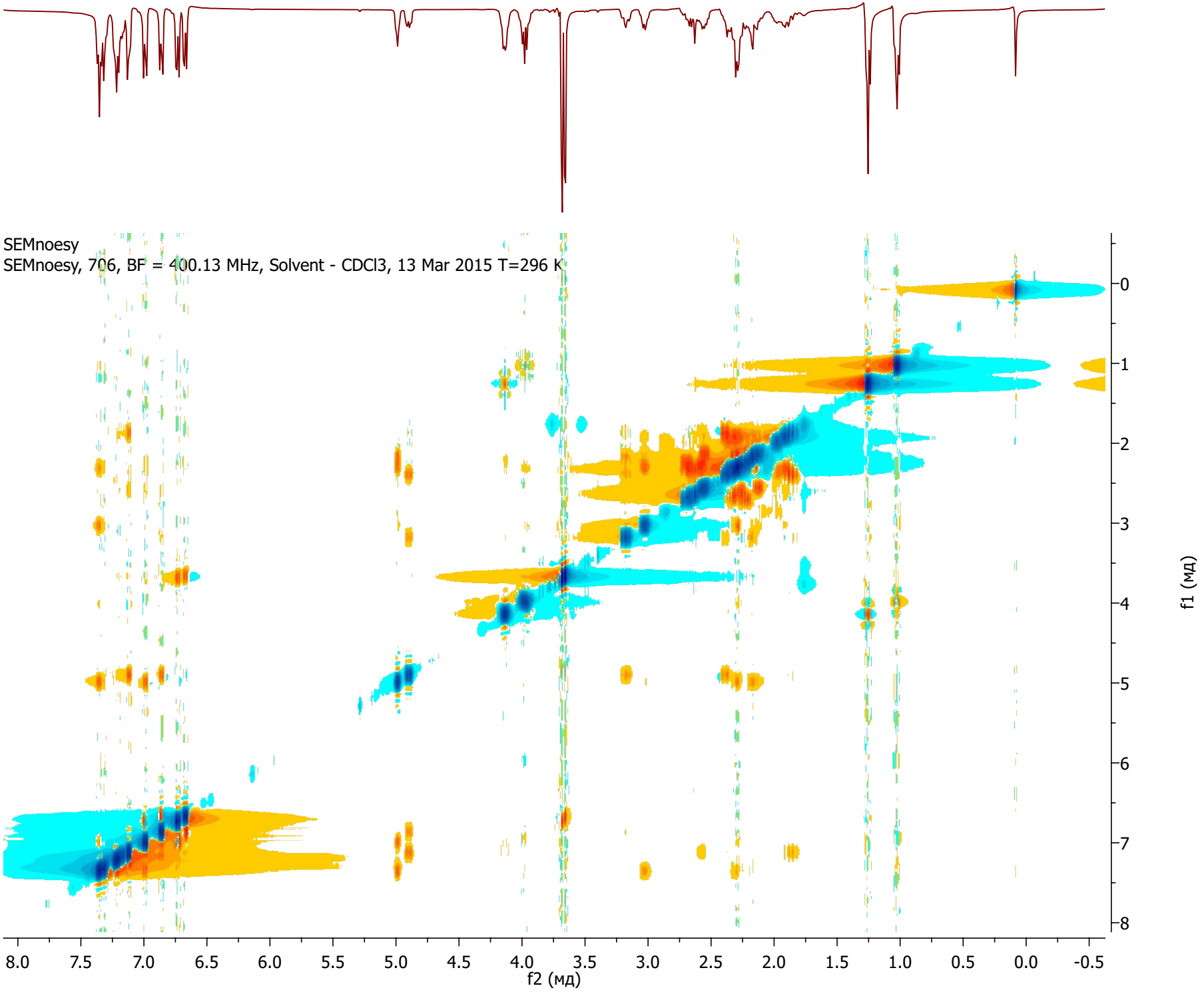
SEMc
SEMc, 706, BF = 100.612769 MHz, Solvent - CDCl3, 12 Mar 2015 T=296 K



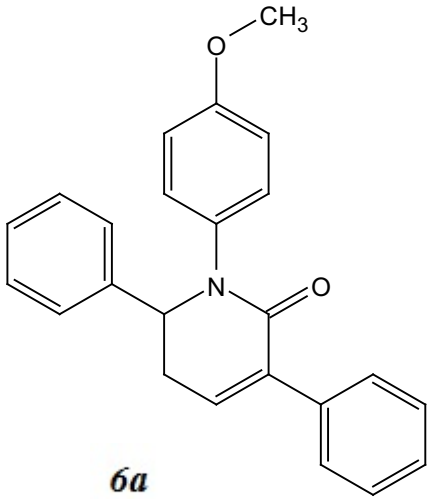
5d


O
CH3
N
O
O
O
O
H3C
O

5d

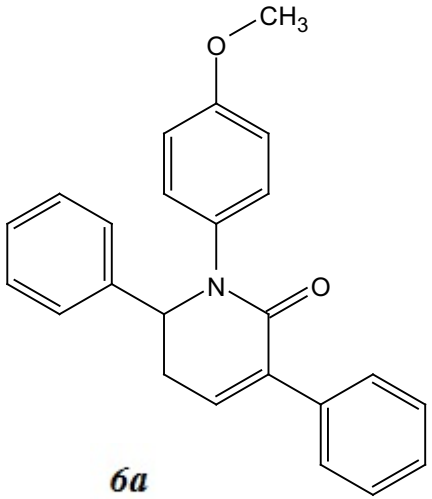

SEMnoesy
SEMnoesy, 706, BF = 400.13 MHz, Solvent - CDCl3, 13 Mar 2015 T=296 K
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f2 (мд)
0
1
2
3
4
5
6
7
8
f1 (мд)

1H
YME, 70, BF = 400.13 MHz, Solvent - CDCl3, 18 Jul 2013 T=298 K



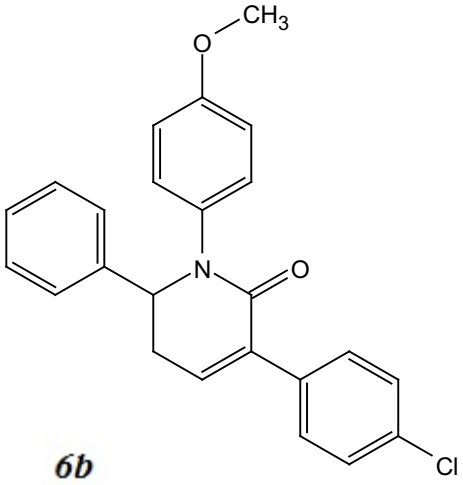
6a

13C
YMEc, 70, BF = 100.612769 MHz, Solvent - CDCl3, 18 Jul 2013 T=298 K



6a

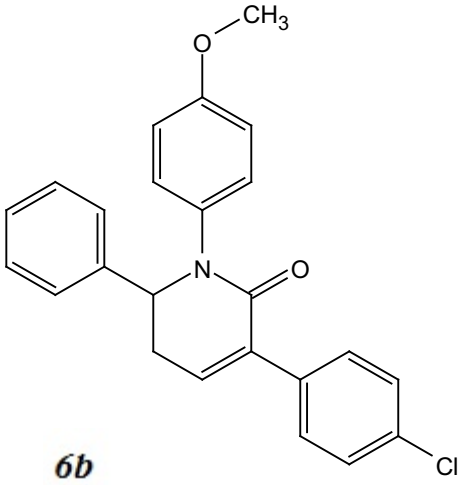
SEM
SEM, 710, BF = 400.13 MHz, Solvent - CDCl3, 13 Mar 2015 T=296 K



6b

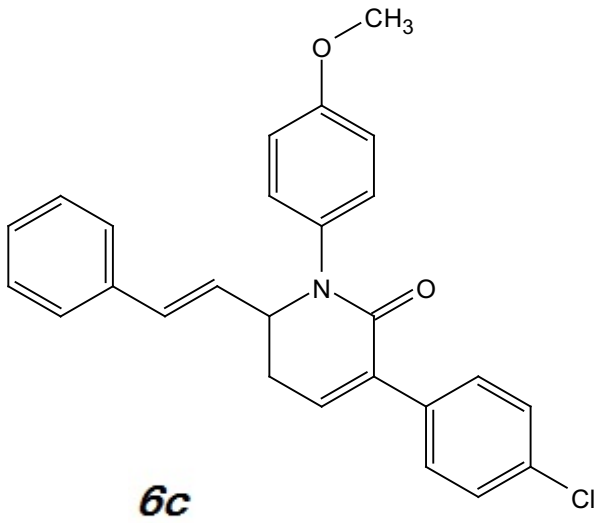
SEMc

SEMc, 710, BF = 100.612769 MHz, Solvent - CDCl3, 13 Mar 2015 T=296 K



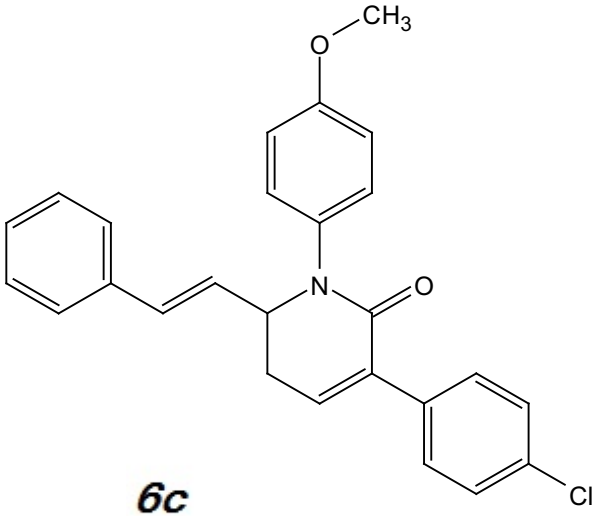
6b

SEM
SEM, 714, BF = 400.13 MHz, Solvent - CDCl3, 17 Mar 2015 T=297 K



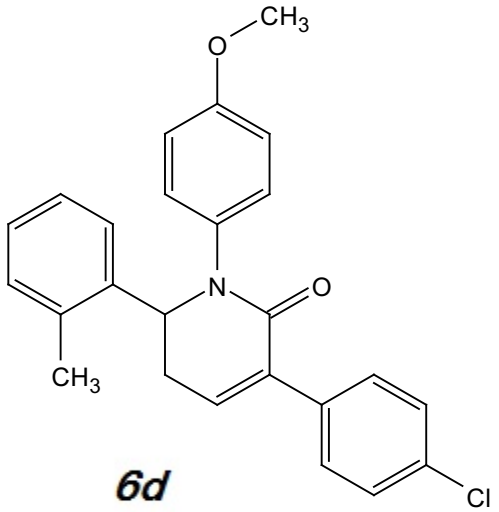
6c

SEMc
SEMc, 714, BF = 100.612769 MHz, Solvent - CDCl3, 17 Mar 2015 T=297 K

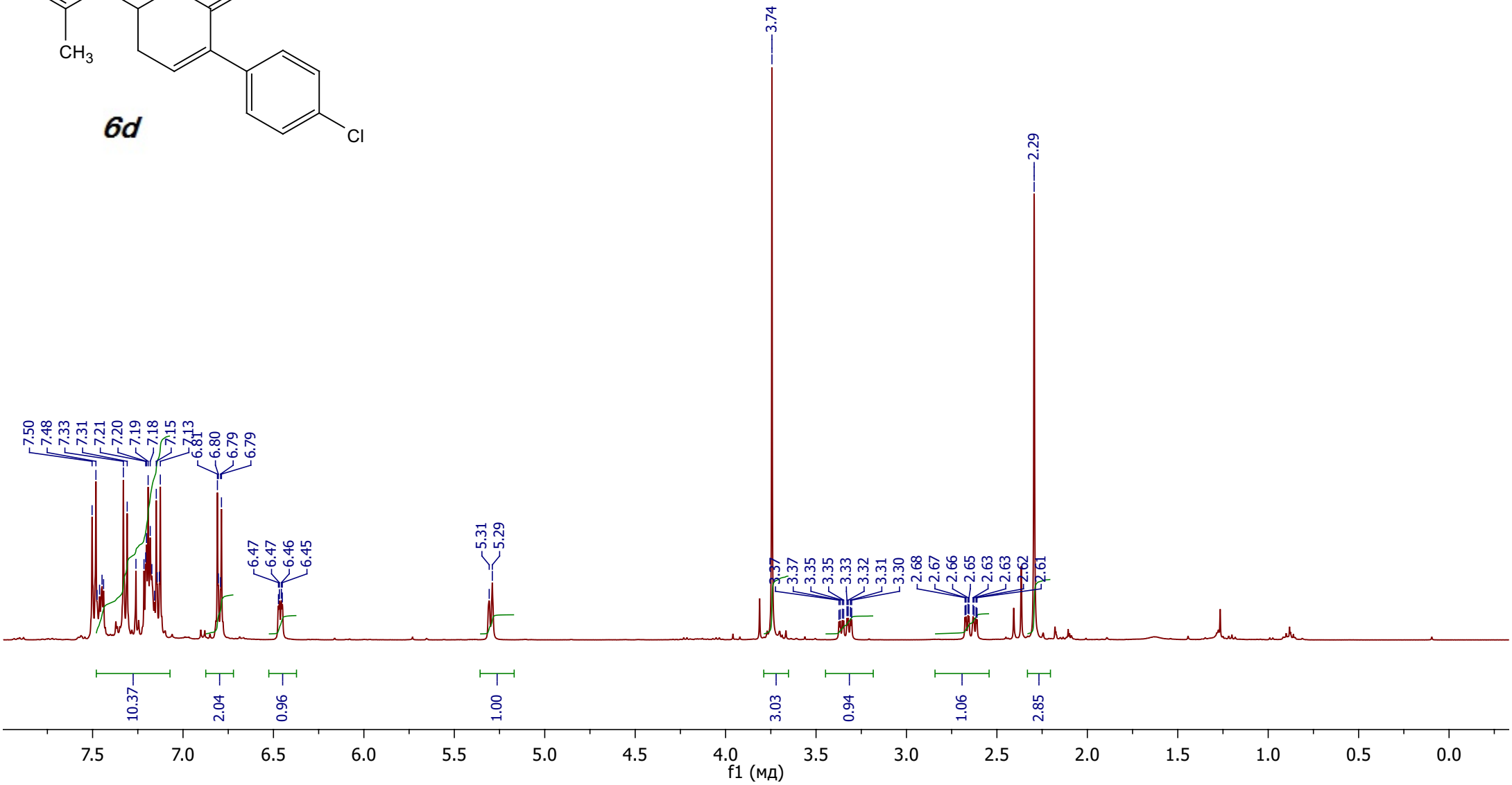


6c

SEM
SEM, 724, BF = 400.13 MHz, Solvent - CDCl3, 23 Mar 2015 T=295 K

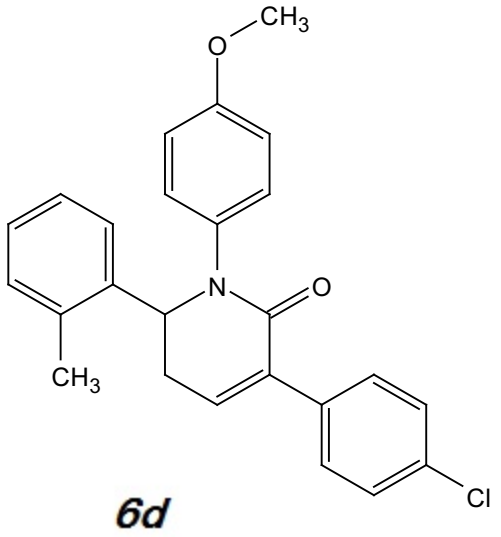


6d



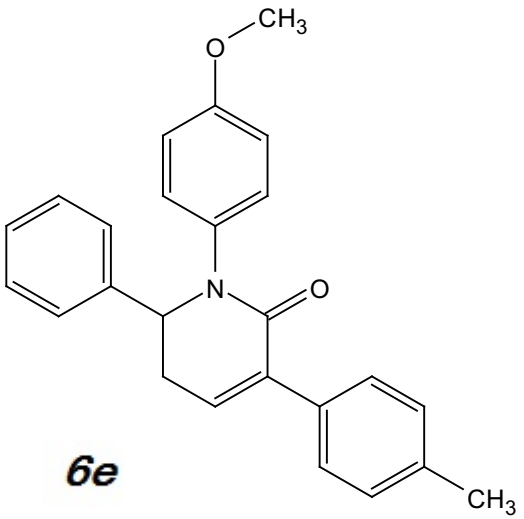
SEMc

SEMc, 724, BF = 100.612769 MHz, Solvent - CDCl3, 24 Mar 2015 T=296 K



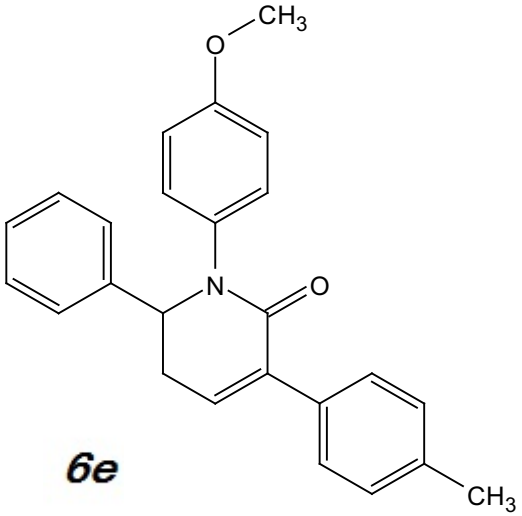
6d

SEM
SEM, 726, BF = 400.13 MHz, Solvent - CDCl3, 24 Mar 2015 T=295 K



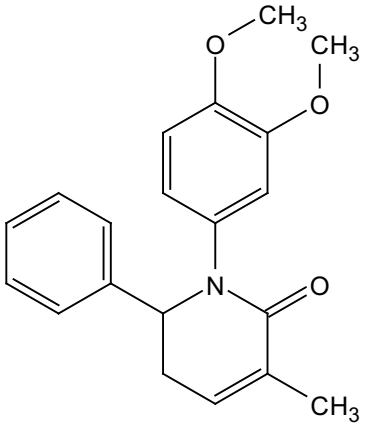
6e

SEMc
SEMc, 726, BF = 100.612769 MHz, Solvent - CDCl3, 24 Mar 2015 T=296 K

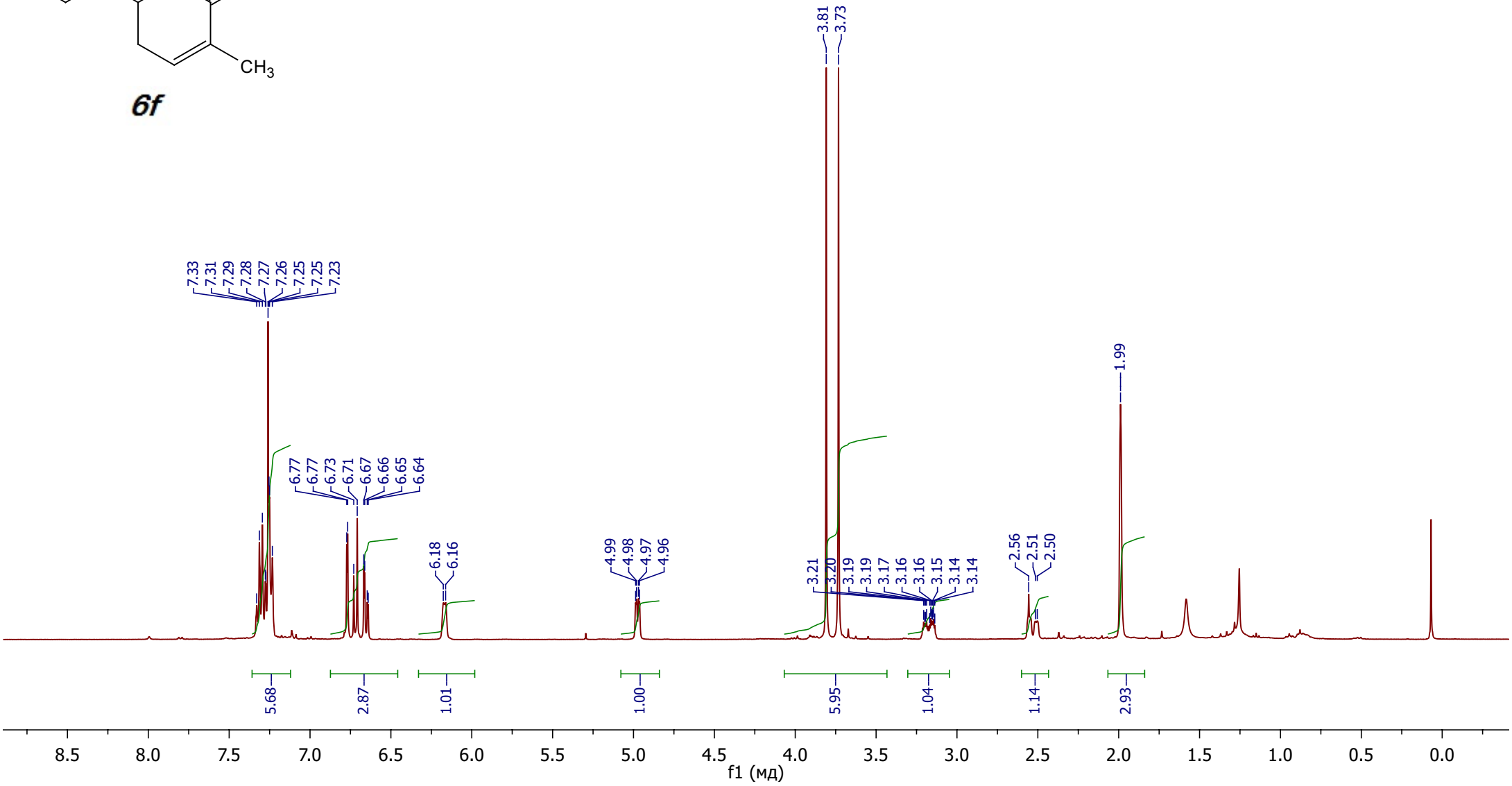


6e

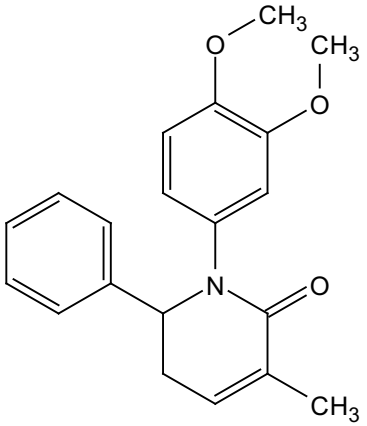
SEM
SEM, 734, BF = 400.13 MHz, Solvent - CDCl3, 02 Apr 2015 T=296 K



6f

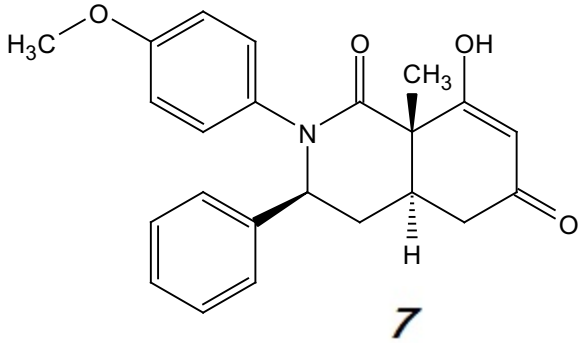


SEMc
SEMc, 734, BF = 100.612769 MHz, Solvent - CDCl3, 02 Apr 2015 T=296 K



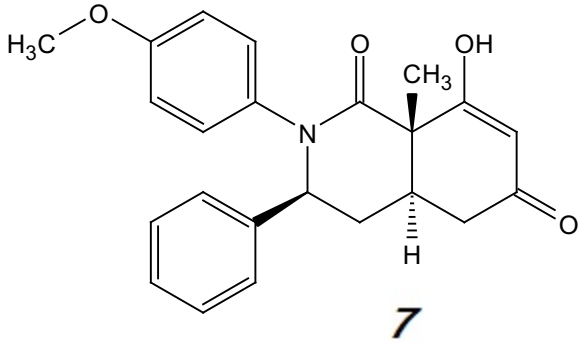
6f

SEM
SEM, 719, BF = 400.13 MHz, Solvent - CDCl3, 20 Mar 2015 T=295 K



7

SEMc
SEMc, 719, BF = 100.612769 MHz, Solvent - CDCl3, 20 Mar 2015 T=296 K



7

Crystallographic data for compound (3*S,4a*R**,8a*S**)-7a**

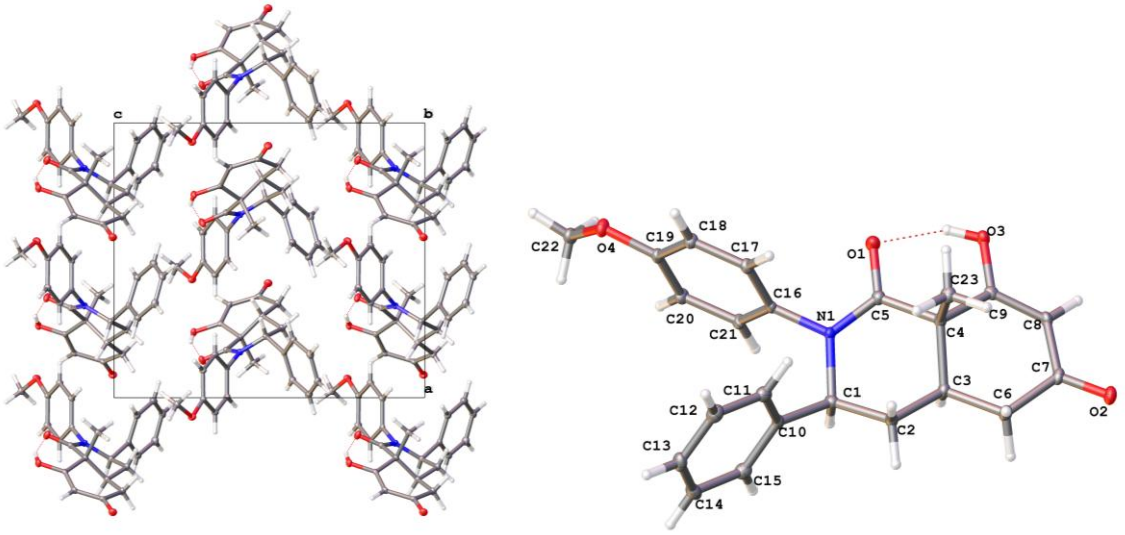


Table 1 Crystal data and structure refinement for compound (3*S,4a*R**,8a*S**)-7a.**

Identification code	Sem-720
Empirical formula	$C_{92}H_{92}N_4O_{16}$
Formula weight	1509.70
Temperature/K	293(2)
Crystal system	orthorhombic
Space group	$Pca2_1$
a/Å	13.1515(8)
b/Å	9.4791(4)
c/Å	14.8569(8)
α/°	90.00
β/°	90.00
γ/°	90.00
Volume/Å^3	1852.13(17)
Z	1
ρ_{calc}g/cm^3	1.354
μ/mm^{-1}	0.093
F(000)	800.0
Crystal size/mm^3	? × ? × ?
Radiation	Mo Kα (λ = 0.7107)
2Θ range for data collection/°	5.96 to 54.98
Index ranges	$-16 \le h \le 16$, $-12 \le k \le 11$, $-19 \le l \le 18$
Reflections collected	6087
Independent reflections	3623 [R_{int} = 0.0251, R_{sigma} = 0.0477]
Data/restraints/parameters	3623/1/255
Goodness-of-fit on F^2	1.064

Final R indexes [I>=2σ (I)]	R_1 = 0.0446, wR_2 = 0.1060
Final R indexes [all data]	R_1 = 0.0518, wR_2 = 0.1129
Largest diff. peak/hole / e Å^{-3}	0.36/-0.20
Flack parameter	-1.5(12)

Table 2 Fractional Atomic Coordinates (×10^4) and Equivalent Isotropic Displacement Parameters (Å^2×10^3) for 7a. U_{eq} is defined as 1/3 of of the trace of the orthogonalised U_{IJ} tensor.

Atom	*x*	*y*	*z*	U(eq)
O3	-2614.4(13)	-4928.2(17)	2428.7(11)	20.4(4)
O4	-5704.1(12)	2902.7(17)	2484.6(12)	22.0(4)
O2	-833.0(13)	-6948.6(17)	39.7(12)	24.9(4)
O1	-3638.4(13)	-2735.1(18)	2157.6(12)	26.3(4)
N1	-3339.9(14)	-1371(2)	944.7(13)	15.7(4)
C16	-3913.2(16)	-243(2)	1363.6(15)	15.9(5)
C1	-2766.8(17)	-1008(2)	104.2(16)	19.5(5)
C12	-4882(2)	672(3)	-1272.6(18)	26.4(6)
C18	-5539.4(18)	741(3)	1743.9(17)	19.4(5)
C19	-5061.7(17)	1909(2)	2128.6(17)	17.5(5)
C9	-2298.5(16)	-4904(2)	1573.2(16)	16.6(5)
C5	-3261.6(17)	-2595(2)	1390.2(16)	17.8(5)
C10	-3372.4(17)	12(2)	-478.3(16)	18.1(5)
C22	-5244.7(19)	4030(2)	2975.3(16)	21.7(5)
C7	-1312.7(17)	-5935(2)	345.5(17)	19.3(5)
C21	-3437.7(18)	899(2)	1748.9(17)	18.9(5)
C20	-4003.3(17)	1992(3)	2138.1(17)	20.3(5)
C3	-2021.0(17)	-3430(2)	221.1(16)	18.3(5)
C15	-2897.6(19)	1247(3)	-767.8(16)	24.1(5)
C11	-4361.1(18)	-267(3)	-747.8(17)	23.1(5)
C14	-3429(2)	2201(3)	-1316.6(18)	26.2(6)
C8	-1624.7(17)	-5867(2)	1273.6(16)	18.5(5)
C17	-4973.6(17)	-327(2)	1363.3(16)	18.0(5)
C13	-4420(2)	1906(3)	-1555.6(17)	26.5(6)
C4	-2807.2(17)	-3879(2)	921.8(16)	18.0(5)
C2	-2478(2)	-2344(2)	-414.4(17)	20.5(5)
C23	-3727.6(18)	-4692(3)	509.9(17)	22.5(5)
C6	-1589.3(19)	-4723(3)	-274.5(16)	22.0(5)

Table 3 Anisotropic Displacement Parameters (Å^2×10^3) for 7a. The Anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2a^{*2}U_{11}+2hka^*b^*U_{12}+\ldots]$.

Atom	U_{11}	U_{22}	U_{33}	U_{23}	U_{13}	U_{12}
O3	26.7(9)	17.4(8)	17.3(8)	2.0(7)	-0.3(7)	4.9(7)
O4	21.0(9)	17.5(9)	27.5(9)	-7.3(8)	-2.0(7)	2.0(6)
O2	24.4(9)	20.5(8)	29.7(10)	-0.5(8)	0.0(7)	7.5(7)
O1	32.7(10)	23.9(9)	22.3(9)	4.8(8)	7.1(8)	7.8(7)
N1	18.2(9)	13.3(9)	15.5(9)	0.1(8)	2.6(8)	2.6(7)
C16	19.3(11)	14.2(11)	14.2(11)	3.1(9)	1.8(9)	3.0(9)
C1	19.6(12)	19.7(11)	19.0(12)	4(1)	0.6(9)	-0.8(9)
C12	23.0(13)	31.3(14)	25.0(13)	-4.4(11)	-2.8(10)	2.1(11)
C18	17.1(11)	19.5(12)	21.7(12)	-1.2(11)	-1.3(9)	0.0(9)
C19	20.3(12)	14.8(10)	17.5(11)	-1.2(10)	-0.4(9)	1.2(9)
C9	16.7(11)	16.4(11)	16.9(11)	0.3(10)	-3.3(9)	-3.4(9)
C5	16.6(11)	18.7(11)	18.1(12)	-0.5(10)	-1.3(9)	1.2(9)
C10	23.2(12)	16.4(10)	14.7(11)	0.3(10)	0.6(9)	5.2(9)
C22	26.2(13)	17.4(12)	21.5(13)	-3.9(11)	-0.4(10)	1.1(9)
C7	14.4(11)	17.1(11)	26.5(12)	-3.5(10)	-2.5(9)	3.1(9)
C21	14.7(11)	18.0(11)	23.9(12)	1.6(11)	-1.3(9)	2.1(9)
C20	20.9(12)	17.0(11)	22.9(12)	-3.8(11)	-0.7(10)	-2.5(9)
C3	18.5(11)	16.6(11)	19.7(11)	-0.3(10)	-1.4(9)	3.1(9)
C15	21.2(13)	29.3(13)	21.8(13)	-3.2(11)	-1.2(10)	-1(1)
C11	24.8(13)	22.2(13)	22.3(13)	-2.0(11)	1.4(10)	-1.7(10)
C14	35.2(15)	18.9(13)	24.5(13)	2.2(11)	2.7(11)	-1.6(10)
C8	19.8(11)	15.7(11)	20.0(12)	2.4(10)	-4.2(9)	2.9(9)
C17	19.7(11)	14.8(11)	19.5(12)	-1.4(10)	-2.6(9)	-1.5(9)
C13	32.9(14)	24.0(14)	22.6(13)	1.6(11)	-4.1(11)	8.8(11)
C4	19.9(12)	17.1(11)	16.9(11)	1.5(10)	-1.2(9)	3.4(9)
C2	25.8(12)	18.3(11)	17.3(11)	2.5(10)	1.8(9)	5.5(10)
C23	19.8(12)	24.1(12)	23.6(13)	-0.9(11)	-3.2(10)	0.3(10)
C6	25.6(13)	20.7(12)	19.6(12)	0.1(10)	2.6(10)	7.3(10)

Table 4 Bond Lengths for 7a.

Atom	Atom	Length/Å	Atom	Atom	Length/Å
O3	C9	1.337(3)	C19	C20	1.394(3)
O4	C19	1.372(3)	C9	C8	1.348(3)
O4	C22	1.427(3)	C9	C4	1.525(3)
O2	C7	1.236(3)	C5	C4	1.525(3)
O1	C5	1.250(3)	C10	C15	1.395(3)
N1	C16	1.448(3)	C10	C11	1.386(3)
N1	C1	1.499(3)	C7	C8	1.440(3)
N1	C5	1.340(3)	C7	C6	1.517(3)
C16	C21	1.375(3)	C21	C20	1.400(3)
C16	C17	1.397(3)	C3	C4	1.528(3)
C1	C10	1.522(3)	C3	C2	1.521(3)

C1	C2	1.531(3)	C3	C6	1.538(3)
C12	C11	1.367(4)	C15	C14	1.404(4)
C12	C13	1.384(4)	C14	C13	1.379(4)
C18	C19	1.395(3)	C4	C23	1.560(3)
C18	C17	1.378(3)			

Table 5 Bond Angles for 7a.

Atom	Atom	Atom	Angle/°	Atom	Atom	Atom	Angle/°
C19	O4	C22	116.76(17)	C11	C10	C15	119.4(2)
C16	N1	C1	116.77(17)	O2	C7	C8	122.2(2)
C5	N1	C16	117.82(19)	O2	C7	C6	119.2(2)
C5	N1	C1	124.88(18)	C8	C7	C6	118.6(2)
C21	C16	N1	121.54(19)	C16	C21	C20	120.9(2)
C21	C16	C17	119.9(2)	C19	C20	C21	119.0(2)
C17	C16	N1	118.5(2)	C4	C3	C6	110.74(19)
N1	C1	C10	110.87(18)	C2	C3	C4	110.14(19)
N1	C1	C2	110.74(19)	C2	C3	C6	112.82(19)
C10	C1	C2	111.66(19)	C10	C15	C14	119.8(2)
C11	C12	C13	120.3(2)	C12	C11	C10	120.7(2)
C17	C18	C19	120.5(2)	C13	C14	C15	119.3(2)
O4	C19	C18	115.2(2)	C9	C8	C7	122.3(2)
O4	C19	C20	124.9(2)	C18	C17	C16	119.8(2)
C20	C19	C18	119.9(2)	C14	C13	C12	120.5(2)
O3	C9	C8	120.4(2)	C9	C4	C3	108.23(18)
O3	C9	C4	118.54(19)	C9	C4	C23	105.96(18)
C8	C9	C4	120.7(2)	C5	C4	C9	113.00(19)
O1	C5	N1	120.8(2)	C5	C4	C3	110.72(19)
O1	C5	C4	119.1(2)	C5	C4	C23	105.62(18)
N1	C5	C4	119.8(2)	C3	C4	C23	113.3(2)
C15	C10	C1	118.3(2)	C3	C2	C1	110.2(2)
C11	C10	C1	122.3(2)	C7	C6	C3	113.7(2)

Table 6 Hydrogen Atom Coordinates (Å×10^4) and Isotropic Displacement Parameters (Å^2×10^3) for 7a.

Atom	*x*	*y*	*z*	U(eq)
H3	-2962	-4228	2530	31
H1	-2136	-533	283	23
H12	-5549	481	-1440	32
H18	-6245	684	1744	23
H22A	-4813	4563	2581	33
H22B	-4848	3650	3460	33
H22C	-5765	4633	3214	33

H21	-2731	946	1751	23
H20	-3678	2762	2399	24
H3A	-1458	-2977	541	22
H15	-2231	1438	-598	29
H11	-4674	-1102	-570	28
H14	-3116	3023	-1517	31
H8	-1352	-6510	1680	22
H17	-5297	-1102	1107	22
H13	-4780	2542	-1910	32
H2A	-3077	-2735	-701	25
H2B	-1989	-2112	-881	25
H23A	-4076	-4093	90	34
H23B	-4186	-4963	982	34
H23C	-3487	-5520	205	34
H6A	-2088	-5050	-708	26
H6B	-988	-4438	-606	26

Experimental

The crystal was kept at 293(2) K during data collection. Using Olex2 [1], the structure was solved with the ShelXS [2] structure solution program using Direct Methods and refined with the XH [3] refinement package using Least Squares minimisation.

1. Dolomanov, O.V., Bourhis, L.J., Gildea, R.J, Howard, J.A.K. & Puschmann, H. (2009), J. Appl. Cryst. 42, 339-341.
2. Sheldrick, G.M. (2008). Acta Cryst. A64, 112-122.
3. Sheldrick, G.M. (2008). Acta Cryst. A64, 112-122.

Crystal structure determination of 7a

Crystal Data for $C_{92}H_{92}N_4O_{16}$ (*M* =1509.70 g/mol): orthorhombic, space group $Pca2_1$ (no. 29), *a* = 13.1515(8) Å, *b* = 9.4791(4) Å, *c* = 14.8569(8) Å, *V* = 1852.13(17) $Å^3$, *Z* = 1, *T* = 293(2) K, μ(Mo Kα) = 0.093 mm^{-1}, *Dcalc* = 1.354 g/cm^3, 6087 reflections measured ($5.96° \leq 2\Theta \leq 54.98°$), 3623 unique ($R_{int}$ = 0.0251, R_{sigma} = 0.0477) which were used in all calculations. The final R_1 was 0.0446 (>2sigma(I)) and wR_2 was 0.1129 (all data).