RSC Advances

Electronic Supplementary Information

Solvent free L-Proline-catalysed domino Knoevenagel/6π-electrocyclization for the synthesis of highly functionalised 2H-pyrans

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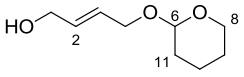
1. General

Unless otherwise stated, all chemicals were purchased as the highest purity commercially available and were used without further purification, except for **1a**,[1] 10-hydroxycitral **15**,[2] farnesal,[3] **18**[4] and **20**[5] which were synthesised according to the literature procedures. IR spectra were recorded on a BOMEM 100 FT-IR or an AVATAR 370 FT-IR Thermo Nicolet spectrophotometers. ^{1}H and ^{13}C NMR spectra were performed in $CDCl_3$ and referenced to the residual peak of $CHCl_3$ at δ 7.26 ppm and δ 77.0 ppm, for ^{1}H and ^{13}C, respectively, using Varian 200 VX and Bruker DRX 400 instruments. Chemical shifts are reported in δ ppm and coupling constants *(J)* are given in hertz. MS were performed at a VG-TS 250 spectrometer at 70 eV ionising voltage. Mass spectra are presented as *m/z* (% rel int.). HRMS were recorded on a VG Platform (Fisons) spectrometer using chemical ionisation (ammonia as gas) or Fast Atom Bombardment (FAB) technique. For some of the samples, QSTAR XL spectrometer was employed for electrospray ionisation (ESI). Optical rotations were determined on a Perkin-Elmer 241 polarimeter in 1 dm cell. HPLC analysis were carried out on a CHIRALCEL™ AD-H column [cellulose tris(3,5-dimethylphenycarbamate)] on silica gel using *n*-hexane/isopropyl alcohol. Column chromatography was performed using silica gel 60 (230-400 mesh), with solvent systems indicated in the relevant experimental procedures. Dichloromethane was distilled from calcium hydride; tetrahydrofuran and diethyl ether were distilled from sodium/benzophenone ketyl under argon atmosphere prior to use. Hexane was distilled prior to use.

2. Synthesis of the Nazarov reagents, 1b-1d.

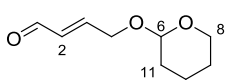


26

2.1 Monoprotection of (*E*)-1,4-butanediol with DHP: (*E*)-4-((tetrahydro-2*H*-pyran-2-yl)oxy)but-2-en-1-ol, 26.

(*E*)-1,4-butanediol (4 ml, 48.66 mmol) was dissolved in 194 ml of DCM under Ar at r.t. 3,4-Dihydro-2*H*-pyran (97%, 4.22g, 48.66 mmol) and *p*-toluenesulfonic acid monohydrate (93 mg, 0.486 mmol) were added and left to stir for 3 h. The reaction was quenched with a $NaHCO_3$ saturated solution, and extracted with DCM. The combined organics were washed with H_2O, brine, dried (Na_2SO_4), filtered and concentrated *in vacuo* to afford **26** (8.01 g, 96%). υ_{max} (liquid film) 3417, 2943, 2870, 1454, 1352, 1261, 1134; δ_H (200 MHz; $CDCl_3$) 5.88-5.33 (2H, m, H2 and H3), 4.67-4.60 (1H, m, H6), 4.32-3.99 (4H, m, H1 and H4), 3.92-3.71 (1H, m, $H8_a$), 3.57-3.40 (1H, m, $H8_b$), 1.91-1.36 (6H, m, H9, H10, and H11); δC (50 MHz; $CDCl_3$) 132.6, 127.3, 97.6, 62.6, 62.0, 57.9, 30.5, 25.4, 19.3; EIHRMS: Calcd for $C_9H_{16}O_3$ (M+Na): 195.0592; found: 195.0991 (M+Na).

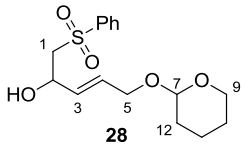
[1] J. Peña, A. B. Antón, R. F. Moro, I. S. Marcos, N. M. Garrido and D. Díez, *Tetrahedron* 2011, **67**, 8331.
[2] S. Xie,S. Uesato, T. Fujita and H. Inouye, *J. Nat. Prod.* 1989, **52**, 701.
[3] K. Ishihara, H. Ishibashi and H. Yamamoto, *J. Am. Chem. Soc.* 2002, **124**, 3647.
[4] J. G. Urones, J. De Pascual Teresa, I. S. Marcos, D. Díez, N. M. Garrido and R. A. Guerra, *Phytochemistry* 1987, **26**, 1077.
[5] P. Basabe, M. de Román, D. Díez, I. S. Marcos, O. Bodero, A. Blanco, F. Mollinedo and J. G. Urones, *Synlett* 2008, **8**, 1149.



27

2.2. Oxidation of 26 with PDC: (*E*)-4-((tetrahydro-2*H*-pyran-2-yl)oxy)but-2-enal, 27.

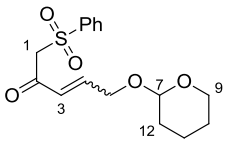
A mixture of monoprotected diol **26** (8.01 g, 46.5 mmol) and molecular sieves were dissolved in 232 ml of DCM under Ar and stirred at room temperature for 5 min. PDC (34.9 g, 93.02 mmol) was added and left to stir for 5 h. The mixture was filtered through a pad of Celite®/Silica/Celite®, and then extracted with EtOAc to afford **27** (7.19 g, 91%). υ_{max} (liquid film) 2945, 2870, 2853, 2727, 1693, 1454, 1352, 1261, 1201, 1120; δ_H (200 MHz; $CDCl_3$) 9.54 (1H, d, *J* = 8.0 Hz, CHO), 6.85 (1H, dt, *J* = 15.7, 4.0 Hz, H3), 6.34 (1H, ddt, *J* = 15.7, 8.0, 2.0, Hz, H2), 4.68-4.61 (1H, m, H6), 4.49 (1H, ddd, *J* = 17.3, 4.0, 2.0 Hz, $H4_a$), 4.21 (1H, ddd, *J* = 17.3, 4.0, 2.0 Hz, $H4_b$), 3.86-3.72 (1H, m, $H8_a$), 3.56-3.42 (1H, m, $H8_b$), 1.86-1.43 (6H, m, H9, H10, and H11); δC (50 MHz; $CDCl_3$) 193.5, 153.7, 131.5, 98.4, 65.6, 62.2, 30.4, 25.4, 19.2; EIHRMS: Calcd for $C_9H_{14}O_3$ (M+Na): 193.0835; found: 193.0835 (M+Na).



28

2.3. Addition of methylphenylsulfone to 27: (*E*)-1-(phenylsulfonyl)-5-((tetrahydro2*H*-pyran-2-yl)oxy)pent-3-em-2-ol, 28.

Methylphenylsulfone (3.64 g, 23.29 mmol) was dissolved in 100 ml of THF under Ar at -78 ºC. *n*-BuLi (1.6 M in hexanes, 14.9 ml, 23.29 mmol) was added and the mixture was stirred 15 min. Separately, **27** (4.40 g, 25.88 mmol) was dissolved in 30 ml of THF under Ar at r.t. This solution was added *via cannula* to the former one and the mixture was stirred at -78 ºC under Ar for 2h. Then the reaction was quenched with a NH_4Cl saturated solution and left to warm at room temperature. Then it was extracted with EtOAc and the combined organics were washed with H_2O, brine, dried (Na_2SO_4), filtered and concentrated in vacuo to leave a crude yellow oil. Flash chromatography (hexane:EtOAc, 6:4) afforded **28** (4.63 g, 61%). υ_{max} (liquid film) 3444, 2953, 2872, 2250, 1732, 1446, 1288, 1138 δ_H (200 MHz; $CDCl_3$) 7.97-7.83 (2H, m, ArH_{ortho}), 7.71-7.46 (3H, m, ArH_{meta}, ArH_{para}), 5.83 (1H, dt, *J* = 15.5, 5.2 Hz, H4), 5.62 (1H, dd, *J* = 15.5, 5.2 Hz, H3), 4.76-4.59 (1H, m, H7), 4.59-4.49 (1H, m, H2), 4.15 (1H, dd, *J* = 13.3, 4.6 Hz, $H5_a$), 3.95-3.69 (2H, m, $H1_a$ and $H5_a$), 3.55-3.41 (2H, m, H9), 3.30-3.19 (2H, m, $H1_b$ and 5_b), 1.84-1.37 (6H, m, H10, H11, and H12); δC (50 MHz; $CDCl_3$) 139.7, 134.1, 131.4, 129.5 (2C), 128.8, 128.1 (2C), 98.1, 66.6, 66.5, 62.2, 62.1, 30.6, 25.5, 19.5; EIHRMS: Calcd for $C_{16}H_{22}O_5S$ (M+Na): 349.1080; found: 349.1080 (M+Na).

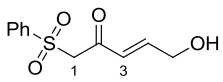


1b/1c

2.4. Oxidation of 28 with PDC: (*E*)-1-(phenylsulfonyl)-5-((tetrahydro-2*H*-pyran-2-yl)oxy)pent-3-en-2-one, 1b and 1c.

A mixture of **28** (537 g, 1.65 mmol) and molecular sieves were dissolved in 8 ml of DCM under Ar and stirred at r.t. for 5 min. PDC (1.24 g, 3.30 mmol) was added and left to stir for 4 h. The mixture was filtered through a pad of Celite®/Silica/Celite®, and then extracted with EtOAc to afford a crude brown oil. Flash chromatography (hexane:EtOAc, 6:4) afforded **1b** (304 mg, 57%) and **1c** (5 mg, 1%). **1b:** υ_{max} (liquid film) 2943, 2870, 2852, 1693, 1666, 1633, 1446, 1384, 1325, 1153; δ_H (200 MHz; $CDCl_3$) 7.89 (2H, d, *J* = 7.0 Hz, ArH_{ortho}), 7.74-7.50 (3H, m, ArH_{meta} and ArH_{para}), 6.98 (1H, dt, *J* = 15.8, 3.9 Hz, H4), 6.54 (1H, dt, *J* = 15.8, 1.9 Hz, H3), 4.65 (1H, t, *J* = 3.1 Hz, H7), 4.46 (1H, ddd, *J* = 17.6, 3.9, 1.9 Hz, $H5_a$), 4.32 (2H, s, H1), 4.18 (1H, ddd, *J* = 17.6, 3.9, 2.0 Hz, $H5_b$), 3.89-3.74 (1H, m, $H9_a$), 3.59-3.42 (1H, m, $H9_b$), 1.90-1.40 (6H, m, H10, H11, and H12); δC (50 MHz; $CDCl_3$) 187.3, 147.7, 138.9, 134.4, 129.4 (2C), 128.6 (2C), 128.0, 98.4, 65.6, 65.3, 62.2, 30.5, 25.5, 19.3; EIHRMS: Calcd for $C_{16}H_{20}O_5S$ (M+Na): 347.0924; found: 347.0924 (M+Na). **1c:** υ_{max} (liquid film) 2943, 2872, 2852, 1693, 1666, 1614, 1448, 1377, 1323, 1155; δ_H (200 MHz; $CDCl_3$) 8.01-7.80 (2H, m, ArH_{ortho}), 7.79-7.50 (3H, m, ArH_{meta} and ArH_{para}), 6.65-6.37 (2H, m, H3 and H4), 4.75-4.39 (3H, m, H5 and H7), 4.21 (2H, s, H1), 3.92-3.71 (1H, m, $H9_a$), 3.58-3.38 (1H, m, $H9_b$), 1.95-1.36 (6H, m, H10, H11, and H12); δC (50

MHz; $CDCl_3$) 187.4, 152.4, 138.8, 134.5, 129.6 (2C), 128.5 (2C), 124.7, 99.2, 68.1, 67.2, 62.8, 30.8, 25.6, 19.8; EIHRMS: Calcd for $C_{16}H_{20}O_5S$ (M+Na): 347.0924; found: 347.0924 (M+Na).



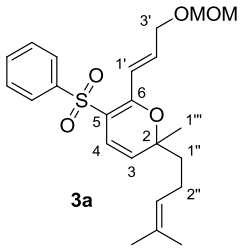
1d

2.5. Deprotection of 1b with *p*TsOH: (*E*)-5-hydroxy-1-(phenylsulfonyl)pent-3-en-2-one, 1d.

1b (203 mg, 0.62 mmol) and *p*-toluenesulfonic acid monohydrate (12 mg, 0.06 mmol) were dissolved in 6 ml of a 1/1 mixture of THF/H_2O, and the hole mixture was stirred for 5 days. The reaction was quenched with H_2O, extracted with EtOAc and the combined organics were washed with $NaHCO_3$ (5%), H_2O, brine, dried (Na_2SO_4), filtered and concentrated in vacuo to afford **1d** (130.2 mg, 88%). υ_{max} (liquid film) 3504, 2931, 1691, 1664, 1627, 1448, 1309, 1151; δ_H (200 MHz; $CDCl_3$) 7.93-7.82 (2H, m, ArH_{ortho}), 7.72-7.50 (3H, m, ArH_{meta} and ArH_{para}), 7.04 (1H, dt, *J* = 15.8, 3.6 Hz, H4), 6.58 (1H, dt, *J* = 15.8, 2.0 Hz, H3), 4.38 (2H, m, H5), 4.33 (2H, s, H1); δC (50 MHz; $CDCl_3$) 187.2, 150.4, 138.8, 134.6, 129.6 (2C), 128.6 (2C), 127.1, 65.8, 62.0; EIHRMS: Calcd for $C_{11}H_{12}O_4S$ (M+Na): 263.0349; found: 263.0349 (M+Na).

3. General procedure for the synthesis of 2*H*-pyrans, 3a-3c.

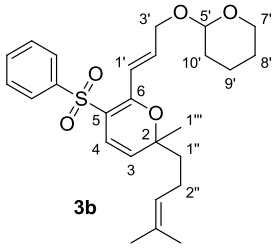
β-oxosulfone (**1a-1d)** (17.6 mmol) and *E/Z*-citral (8.7 mmol) were dissolved in 1 ml of the isopropyl alcohol. Next, *L*-Proline (20 mol%), and additive (20 mol%) if needed, was added and left stirring for the appropriate time. All products were purified by flash chromatography on silica gel using different mixtures of hexane/EtOAc.



3a

3.1 (*E*)-6-(3-(methoxymethoxy)prop-1-en-1-yl)-2-methyl-2-(4-methylpent-3-en-1-yl)-5-(phenylsulfonyl)-2*H*-pyran, 3a.

υ_{max} (liquid film) 2926, 1674, 1539, 1446, 1377, 1321, 1151; δ_H (400 MHz; $CDCl_3$) 7.84 (2H, d, *J* = 8.3 Hz, ArH_{ortho}), 7.59-7.41 (3H, m, ArH_{meta}, ArH_{para}), 7.42 (1H, dt, *J* = 15.4, 1.8 Hz, H1´), 6.56 (1H, dt, *J* = 15.4, 5.2 Hz, H2´), 6.36 (1H, d, *J* = 10.0 Hz, H4), 5.34 (1H, d, *J* = 10.0 Hz, H3), 5.05-4.93 (1H, m, H3´´), 4.67 (2H, s, O-CH_2-O), 4.25 (2H, dd, *J* = 5.2, 1.8 Hz, H3´), 3.39 (3H, s, O-CH_3), 2.06-1.86 (2H, m, H2´´), 1.63 (6H, s, $(CH_3)_2$-C4´´), 1,40 (2H, m, H1´´), 1.27 (3H, s, CH_3-C2); δC (101 MHz; $CDCl_3$) 156.0, 143.0, 136.1, 132.6, 132.0, 129.0 (2C), 126.4 (2C), 124.2, 123.4, 121.5, 119.1, 114.3, 96.0, 80.6, 66.9, 55.4, 40.8, 25.7, 22.2, 17.7 (2C); EIHRMS: Calcd for $C_{23}H_{30}O_5S$ (M+Na): 441.1712; found: 441.1706 (M+Na).

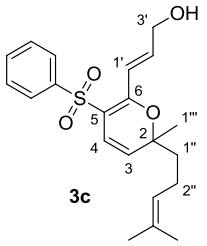


3b

3.2 (*E*)-2-methyl-2-(4-methylpent-3-en-1-yl)-5-(phenylsulfonyl)-6-(3-((tetrahydro-2*H*-pyran-2-yl)oxy)prop-1-en-1-yl)-2*H*-pyran, 3b.

υ_{max} (liquid film) 2926, 1647, 1537, 1446, 1377, 1321, 1153; δ_H (200 MHz; $CDCl_3$) 7.94-7.77 (2H, m, ArH_{ortho}), 7.60-7.45 (3H, m, ArH_{meta}, ArH_{para}), 7.45-7.32 (1H, m, H1´), 6.58 (1H, dt, *J* = 15.3, 5.0 Hz, H2´), 6.38 (1H, d, *J* = 10.0 Hz, H4), 5.33 (1H, d, *J* = 10.0 Hz, H3), 5.05-4.92 (1H, m, H3´´), 4.67 (1H, t, *J* = 3.2 Hz, O-CH-O), 4.50-4.33 (1H, m, $H3'_a$), 4.27-4.07 (1H, m, $H3'_b$), 3.94-3.76 (1H, m, $H7'_a$), 3.60-3.45 (1H, m, $H7'_b$), 2.06-1.86 (2H, m, H2´´), 1.64 (6H, s, $(CH_3)_2$-C4´´), 1.60-1.53 (4H, m, H10´ and H1´´), 1.53-1.44 (4H, m, H8´ and H9´), 1.27 (3H, s, CH_3-C2); δC (50 MHz; $CDCl_3$) 156.5, 143.4, 136.8, 132.8, 132.3, 129.2 (2C), 126.7 (2C), 124.3, 123.7, 121.3, 119.5, 114.3,

98.4, 80.8, 66.8, 62.3, 40.8, 30.7, 25.9, 25.8, 25.7, 22.5, 19.5, 17.8; EIHRMS: Calcd for $C_{26}H_{34}O_5S$ (M+Na): 481.2025; found: 481.2019 (M+Na).



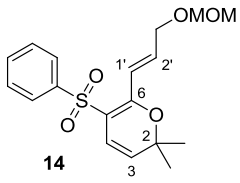
3c

3.3 (*E*)-3-(2-methyl-2-(4-methylpent-3-en-1-yl)-5-(phenylsulfonyl)-2*H*-pyran-6-yl)prop-2-en-1-ol, 3c.

υ_{max} (liquid film) 3493, 2968, 2916, 2850, 1645, 1621, 1537, 1446, 1317, 1155, ; δ_H (200 MHz; $CDCl_3$) 7.91-7.78 (2H, m, ArH_{ortho}), 7.60-7.47 (3H, m, ArH_{meta}, ArH_{para}), 7.41 (1H, dt, *J* = 15.3, 1.8 Hz, H1´), 6.64 (1H, dt, *J* = 15.3, 4.9 Hz, H2´), 6.36 (1H, d, *J* = 10.0 Hz, H4), 5.34 (1H, d, *J* = 10.0 Hz, H3), 5.07-4.94 (1H, m, H3´´), 4.43-4.30 (2H, m, H3´), 2.02-1.88 (2H, m, H2´´), 1.76-1.51 (8H, m, H1´´ and $(CH_3)_2$-C4´´), 1.27 (3H, s, CH_3-C2); δC (50 MHz; $CDCl_3$) 156.3, 143.2, 139.2, 132.9, 132.3, 129.3 (2C), 126.7 (2C), 124.4, 123.6, 120.6, 119.4, 114.5, 80.9, 63.2, 40.8, 25.9, 25.8, 22.5, 17.8; EIHRMS: Calcd for $C_{21}H_{26}O_4S$ (M+Na): 397.1444; found: 397.1444 (M+Na).

4. General procedure for the synthesis of 2*H*-pyrans and Knoevenagel adducts.

β-oxosulfone **1a** (50 mg, 17.6 mmol) and the corresponding aldehyde (8.7 mmol) were dissolved in 1 ml of isopropyl alcohol. Next, *L*-Proline (20 mol%), and additive (20 mol%) if needed was added and left stirring for the appropriate time. All products were purified by flash chromatography on silica gel using different mixtures of hexane:EtOAc.



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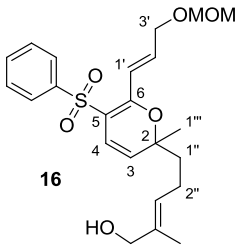
4.1 (*E*)-6-(3-(methoxymethoxy)prop-1-en-1-yl)-2,2-dimethyl-5-(phenylsulfonyl)-2*H*-pyran, 14.

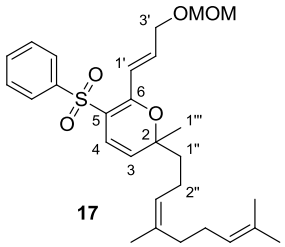
υ_{max} (liquid film) 2935, 1647, 1537, 1446, 1379, 1319, 1153; δ_H (200 MHz; $CDCl_3$) 7.85 (2H, dd, *J* = 7.9, 1.7 Hz, ArH_{ortho}), 7.59-7.41 (3H, m, ArH_{meta}, ArH_{para}), 7.39 (1H, dt, *J* = 15.4, 1.7 Hz, H1´), 6.57 (1H, dt, *J* = 15.4, 5.2 Hz, H2´), 6.33 (1H, d, *J* = 9.9 Hz, H4), 5.38 (1H, d, *J* = 9.9 Hz, H3), 4.68 (2H, s, O-CH_2-O), 4.25 (2H, dd, *J* = 5.2, 1.7 Hz, H3´), 3.39 (3H, s, O-CH_3), 1.31 (6H, s, $(CH_3)_2$-C2); δC (50 MHz; $CDCl_3$) 156.2, 143.3, 137.1, 132.9, 129.3 (2C), 126.7 (2C), 125.5, 121.9, 119.1, 114.9, 96.3, 78.3, 67.2, 55.6, 27.4 (2C); EIHRMS: Calcd for $C_{18}H_{22}O_5S$ (M+Na): 373.1086; found: 373.1080 (M+Na).



16

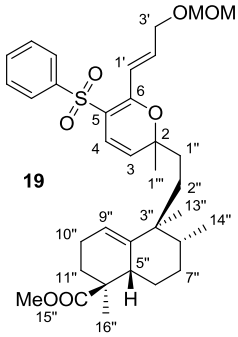
4.2 (*E*)-5-(6-((*E*)-3-(methoxymethoxy)prop-1-en-1-yl)-2-methyl-5-(phenylsulfonyl)-2*H*-pyran-2-yl)-2-methylpent-2-en-1-ol, 16.

υ_{max} (liquid film) 3469, 2934, 2889, 1649, 1537, 1446, 1307, 1213, 1151; δ_H (200 MHz; $CDCl_3$) 7.84 (2H, d, *J* = 7.9 Hz, ArH_{ortho}), 7.62-7.35 (4H, m, ArH_{meta}, ArH_{para} and H1´), 6.56 (1H, dt, *J* = 15.3, 5.4 Hz, H2´), 6.37 (1H, d, *J* = 10.1 Hz, H4), 5.39-5.22 (2H, m, H3 and H3´´), 4.67 (2H, s, O-CH_2-O), 4.25 (2H, d, J = 4.7 Hz, H3´), 3.94 (2H, s, CH_2-OH), 3.39 (3H, s, O-CH_3), 2.12-1.95 (2H, m, H2´´), 1.80-1.58 (2H, m, H1´´), 1.55 (3H, s, CH_3-C4´´), 1.25 (3H, s, CH_3-C2); δC (50 MHz; $CDCl_3$) 156.2, 143.2, 136.4, 135.5, 132.9, 129.3 (2C), 126.7 (2C), 125.0, 124.3, 121.8, 119.6, 114.5, 96.3, 80.9, 68.8, 67.2, 55.6, 40.5, 26.1, 22.2, 13.8; EIHRMS: Calcd for $C_{23}H_{30}O_6S$ (M+Na): 457.1655; found: 457.1655 (M+Na).



4.3 2-((*E*)-4,8-dimethylnona-3,7-dien-1-yl)-6-((*E*)-3-(methoxymethoxy)prop-1-en-1-yl)-2-methyl-5-(phenylsulfonyl)-2*H*-pyran, 17.

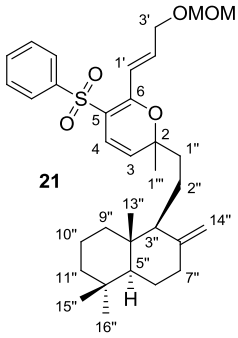
υ_{max} (liquid film) 2926, 1649, 1539, 1446, 1379, 1321, 1151; δ_H (200 MHz; $CDCl_3$) 7.85 (2H, dd, *J* = 7.9, 1.7 Hz, ArH_{ortho}), 7.59-7.44 (3H, m, ArH_{meta}, ArH_{para}), 7.40 (1H, dt, *J* = 15.3, 1.7 Hz, H1´), 6.57 (1H, dt, *J* = 15.3, 5.2 Hz, H2´), 6.36 (1H, d, *J* = 10.0 Hz, H4), 5.35 (1H, d, *J* = 10.0 Hz, H3), 5.13-4.91 (2H, m, H3´´ and H7´´), 4.68 (2H, s, O-CH_2-O), 4.25 (2H, dd, *J* = 5.2, 1.7 Hz, H3´), 3.40 (3H, s, O-CH_3), 2.11-1.85 (8H, m, H1´´, H2´´, H5´´ and H6´´), 1.67 (3H, s, CH_3-C4´´), 1.59 (3H, s, CH_{3a}-C8´´), 1.50 (3H, s, CH_{3b}-C8´´), 1.28 (3H, s, CH_3-C2); δC (50 MHz; $CDCl_3$) 156.3, 143.3, 136.4, 136.0, 132.8, 131.6, 129.5 (2C), 126.7 (2C), 124.5, 124.4, 123.5, 121.9, 119.4, 114.6, 96.3, 80.9, 67.2, 55.6, 40.8, 39.8, 26.8, 26.0 (2C), 22.4, 17.9, 16.1; EIHRMS: Calcd for $C_{28}H_{38}O_5S$ (M+Na): 509.2338; found: 509.2332 (M+Na).



4.4 (1S,5S,6R,8aS)-methyl 5-(3-(6-((*E*)-3-(methoxymethoxy)prop-1-en-1-yl)-2-methyl-5-phenylsulfonyl)-2*H*-pyran-2-yl)propyl)-1,5,6-trimethyl-1,2,3,5,6,7,8,8a-octahydronaphthalene-1-carboxylate, 19.

Caution: the name does not correspond to the numeration used.

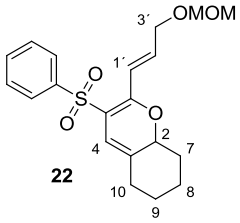
$[\alpha]_D^{25}$ = +35.4 (*c* 1.07, $CHCl_3$); υ_{max} (liquid film) 2932, 2874, 1726, 1539, 1446, 1321, 1157; δ_H (400 MHz; $CDCl_3$) 7.86 (2H, d, *J* = 7.3 Hz, ArH_{ortho}), 7.59-7.41 (3H, m, ArH_{meta}, ArH_{para}), 7.41 (1H, m, H1´), 6.59 (1H, m, H2´), 6.37 (1H, dd, *J* = 9.8, 3.0 Hz, H4), 5.33 (1H, d, *J* = 9.8 Hz, H3), 5.29-5.17 (1H, m, H9´´), 4.68 (2H, s, O-CH_2-O), 4.26 (2H, d, *J* = 5.2, Hz, H3´), 3.61 (3H, s, COO-CH_3), 3.40 (3H, s, O-CH_3), 2.65-2.50 (1H, m, H5´´), 1.97-0.65 (25H, m, H1´´, H2´´, H6´´, H7´´, H8´´, H10´´, H11´´, H13´´, H14´´, H16´´, H1´´´); δC (101 MHz; $CDCl_3$) 178.3, 156.3, 143.1, 141.1, 135.9, 132.5, 129.0 (2C), 126.4 (2C), 124.8, 121.5, 119.8, 119.1, 114.3, 96.0, 80.9, 67.1, 55.3, 51.6, 44.8, 42.7, 38.3(2C), 34.6, 31.4, 30.6, 28.6, 26.2, 22.9, 22.8, 22.3, 19.9, 15.4; EIHRMS: Calcd for $C_{34}H_{46}O_7S$ (M+Na): 621.2856; found: 621.2856 (M+Na).



4.5 6-((*E*)-3-(methoxymethoxy)prop-1-en-1-yl)-2-methyl-5-(phenylsulfonyl)-2-(2-((1S,4aS,8aS)-5,5,8a-trimethyl-2-methylenedecahydronaphthalen-1-yl)ethyl)-2*H*-pyran, 21.

Caution: the name does not correspond to the numeration used.

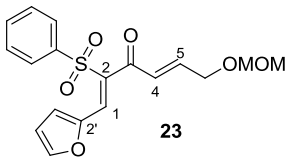
$[\alpha]_D^{25}$ = +4.58 (*c* 0.3, $CHCl_3$); υ_{max} (liquid film) 2918, 2848, 1539, 1446, 1321, 1153; δ_H (200 MHz; $CDCl_3$) 7.85 (2H, dd, *J* = 7.6, 1.6 Hz, ArH_{ortho}), 7.60-7.47 (3H, m, ArH_{meta}, ArH_{para}), 7.40 (1H, m, H1´), 6.56 (1H, dt, *J* = 10.1, 5.4 Hz, H2´), 6.36 (1H, dd, *J* = 10.1, 1.3 Hz, H4), 5.34 (1H, d, *J* = 10.1, H3), 4.74 (1H, s, $H29''_a$), 4.68 (2H, s, O-CH_2-O), 4.38 (1H, s, $H29''_b$), 4.25 (2H, d, *J* = 5.4, Hz, H3´), 3.40 (3H, s, O-CH_3), 2.44-0.87 (28H, m, H1´´, H2´´, H3´´, H5´´, H6´´, H7´´, H9´´, H10´´, H11´´, H13´´, H15´´, H16´´, H1´´´); δC (50 MHz; $CDCl_3$) 156.3, 148.5, 143.4, 136.4, 132.8, 129.3 (2C), 126.7 (2C), 124.6, 121.8, 119.5, 114.5, 106.6, 96.2, 81.3, 67.2, 57.3, 55.7, 55.6, 42.4, 40.1, 40.0, 39.1, 38.5, 33.8, 33.5, 26.2, 24.6, 21.9, 19.6, 19.2, 14.6; EIHRMS: Calcd for $C_{33}H_{46}O_5S$ (M+Na): 577.2958; found: 577.2958 (M+Na).



22

4.6 (*E*)-2-(3-(methoxymethoxy)prop-1-en-1-yl)-3-(phenylsulfonyl)-6,7,8,8a-tetrahydro-5*H*-chromene, 22.

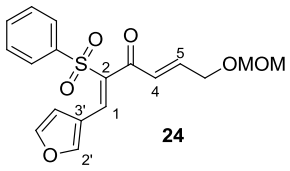
υ_{max} (liquid film) 2933, 1722, 1446, 1321, 1151; δ_H (200 MHz; $CDCl_3$) 7.86 (2H, dd, *J* = 7.8, 1.7 Hz, ArH_{ortho}), 7.64-7.44 (3H, m, ArH_{meta} and ArH_{para}), 7.36 (1H, dd, *J* = 14.9, 1.7 Hz, H1´), 6.48 (1H, dt, *J* = 14.9, 5.4 Hz, H2´), 5.98 (1H, s, H4), 4.91-4.73 (1H, m, H2), 4.66 (2H, s, O-CH_2-O), 4.23 (2H, d, *J* = 5.4 Hz, H3´), 3.39 (3H, s, O-CH_3), 2.45-1.18 (8H, m, H7, H8, H9, and H10); δC (50 MHz; $CDCl_3$) 155.0, 145.3, 134.7, 133.5, 132.8, 129.3 (2C), 126.8 (2C), 121.5, 116.9, 112.2, 96.2, 77.4, 67.2, 55.6, 34.5, 32.5, 26.3, 24.1; EIHRMS: Calcd for $C_{20}H_{24}O_5S$ (M+Na): 399.1237; found: 399.1237 (M+Na).



23

4.7 (1*Z*,4*E*)-1-(furan-2-yl)-6-(methoxymethoxy)-2-(phenylsulfonyl)hexa-1,4-dien-3-one, 23.

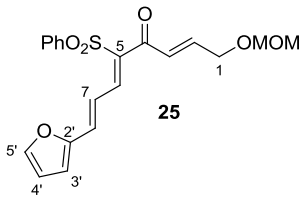
υ_{max} (liquid film) 2947, 2889, 1659, 1622, 1446, 1319, 1197, 1149; δ_H (400 MHz; $CDCl_3$) 7.86 (2H, dd, *J* = 8.4, 1.3 Hz, ArH_{ortho}), 7.64-7.57 (2H, m, H1 and ArH_{para}), 7.57-7.49 (2H, m, ArH_{meta}), 7.49-7,43 (1H, m, H5´), 6.84 (1H, dt, *J* = 16.0, 4.1 Hz, H5), 6.78 (1H, d, *J* = 3.5 Hz, H3´), 6.54 (1H, dt, J = 16.0, 2.0 Hz, H4), 6.46 (1H, dd, J = 3.5, 1.8 Hz, H4´), 4.60 (2H, s, O-CH_2-O), 4.21 (2H, dd, *J* = 4.1, 2.0 Hz, H6), 3.33 (3H, s, O-CH_3); δC (101 MHz; $CDCl_3$) 190.1, 147.9, 147.5, 146.9, 139.8, 135.7, 133.6), 129.8, 129.1 (2C), 128.3 (2C), 126.9, 119.3, 112.8, 96.0, 65.7, 55.4; EIHRMS: Calcd for $C_{18}H_{18}O_6S$ (M+Na): 385.0716; found: 385.0716 (M+Na).



24

4.8 (1*Z*,4*E*)-1-(furan-3-yl)-6-(methoxymethoxy)-2-(phenylsulfonyl)hexa-1,4-dien-3-one, 24.

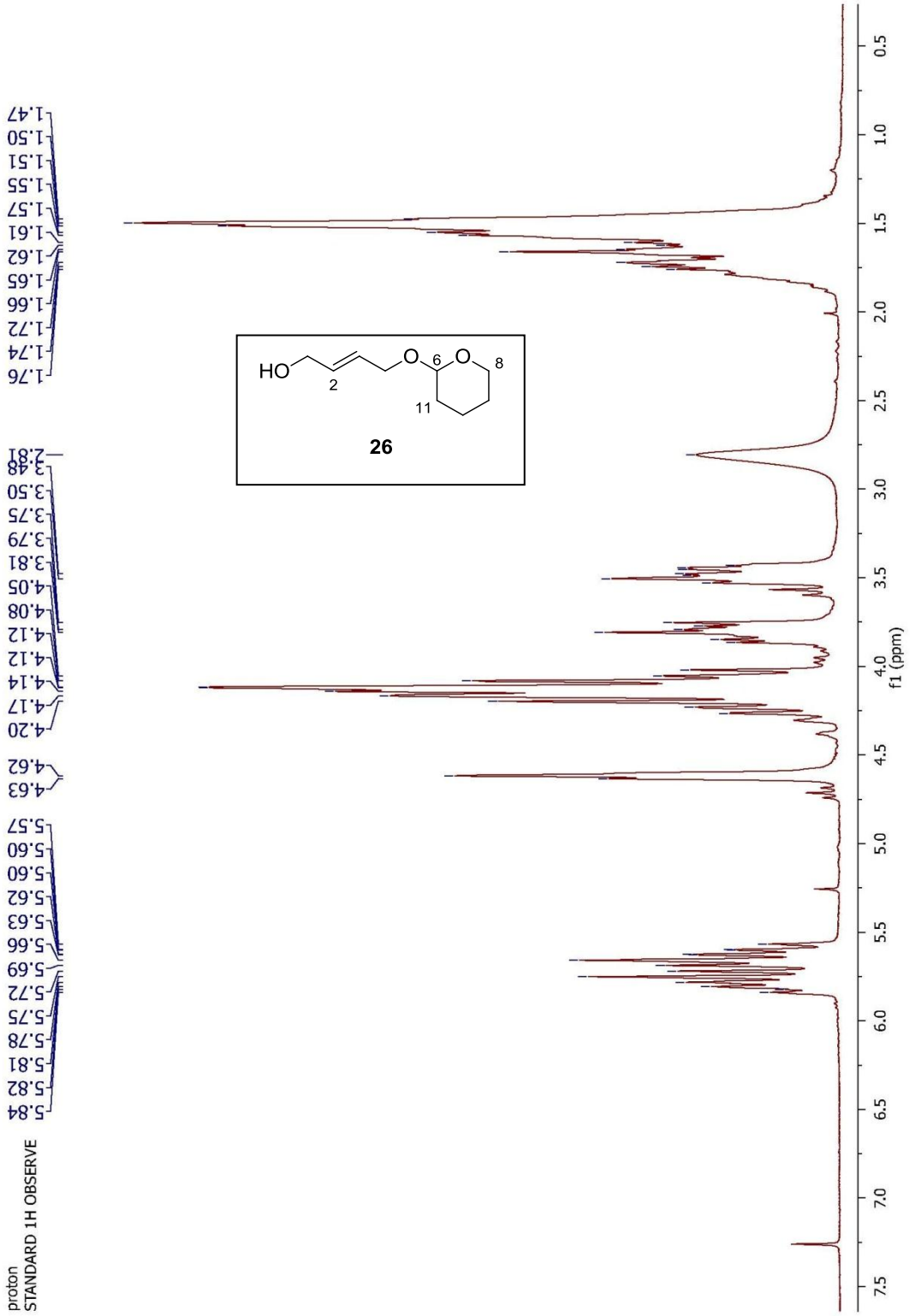
υ_{max} (liquid film) 2949, 2889, 1654, 1622, 1446, 1309, 1205, 1149; δ_H (400 MHz; $CDCl_3$) 7.85 (2H, dd, *J* = 8.5, 1.3 Hz, ArH_{ortho}), 7.74 (1H, dd, *J* = 1.1, 0.5 Hz, H1), 7.72-7.71 (1H, m, H2´), 7.63-7.58 (1H, m, ArH_{para}), 7.55-7.49 (2H, m, ArH_{meta}), 7.40-7.35 (1H, m, H5´), 6.92 (1H, dt, J = 15.9, 4.0 Hz, H5), 6.55 (1H, dt, J = 15.9, 2.1 Hz, H4), 6.29 (1H, dtd, J = 1.4, 0.9, 0.4 Hz, H4´), 4.60 (2H, s, O-CH_2-O), 4.22 (2H, dd, J = 4.0, 2.1 Hz, H6), 3.33 (3H, s, O-CH_3); δC (101 MHz; $CDCl_3$) 191.2, 149.5, 147.3, 144.7, 139.7, 138.1, 136.6, 131.6, 129.1 (2C), 129.0, 128.3 (2C), 119.0, 109.3, 96.0, 65.7, 55.4; EIHRMS: Calcd for $C_{18}H_{18}O_6S$ (M+Na): 385.0716; found: 385.0716 (M+Na).

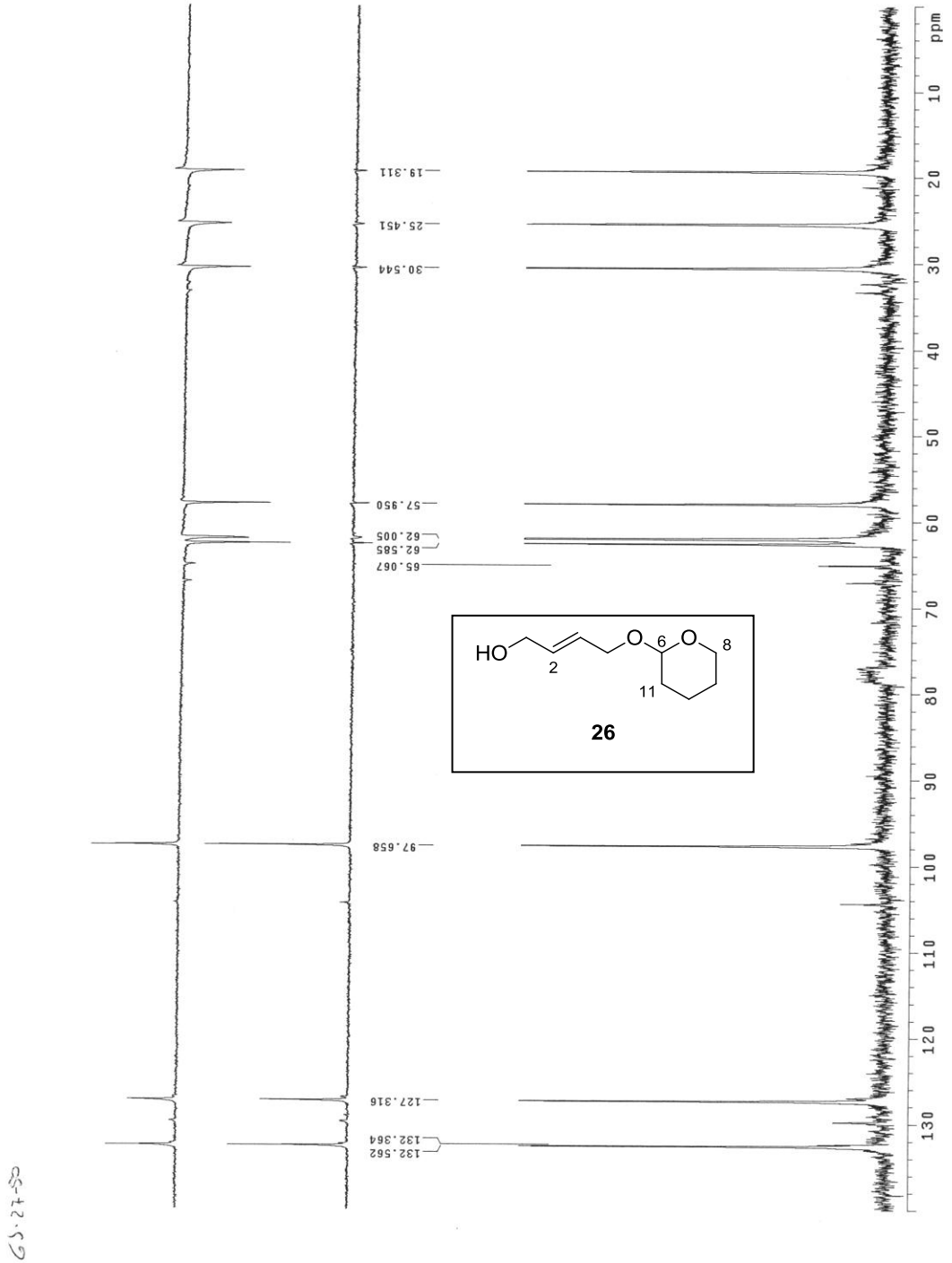


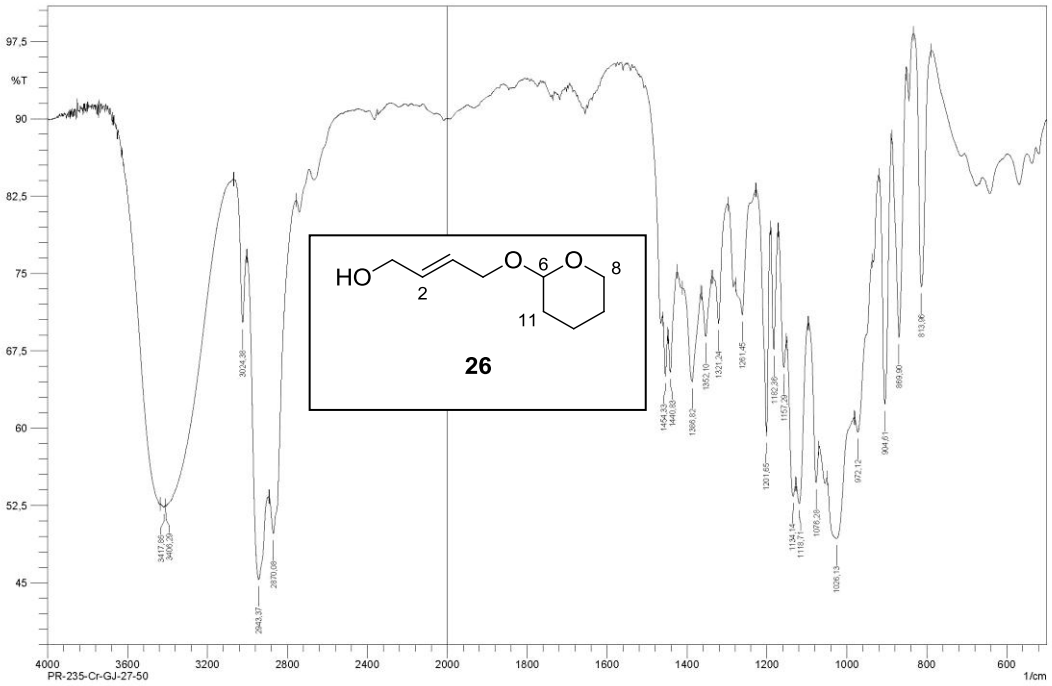
25

4.9 (2*E*,5*Z*,7*E*)-8-(furan-2-yl)-1-(methoxymethoxy)-5-(phenylsulfonyl)octa-2,5,7-trien-4-one, 25.

υ_{max} (liquid film) 2933, 2889, 1647, 1616, 1583, 1463, 1446, 1307, 1147; δ_H (400 MHz; $CDCl_3$) 7.88 (2H, d, *J* = 7.9 Hz, ArH_{ortho}), 7.72-7.43 (5H, m, H6, ArH_{meta}, ArH_{para} and H5´), 7.00-6.80 (3H, m, H2, H7 and H8), 6.71 (1H, d, *J* = 15.7 Hz, H3), 6.60 (1H, m, H3´), 6.48 (1H, m, H4´), 4.65 (2H, s, O-CH_2-O), 4.33-4.22 (2H, m, H1), 3.37 (3H, s, O-CH_3); δC (101 MHz; $CDCl_3$) 188.5, 151.5, 148.0, 145.1, 143.5, 140.5, 138.6, 133.4, 132.2, 129.0 (3C), 128.1 (2C), 119.9, 114.9, 112.6, 96.1, 65.9, 55.4; EIHRMS: Calcd for $C_{20}H_{20}O_6S$ (M+Na): 411.0873; found: 411.0873 (M+Na).


HO
2
O
6
O
8
11
26
f1 (ppm)
proton
STANDARD 1H OBSERVE





S. G. Espectrometria de Masas
Emitido por: César Raposo
(Responsable SGEM)

Plaza de los Caídos 1-5
37008 Salamanca

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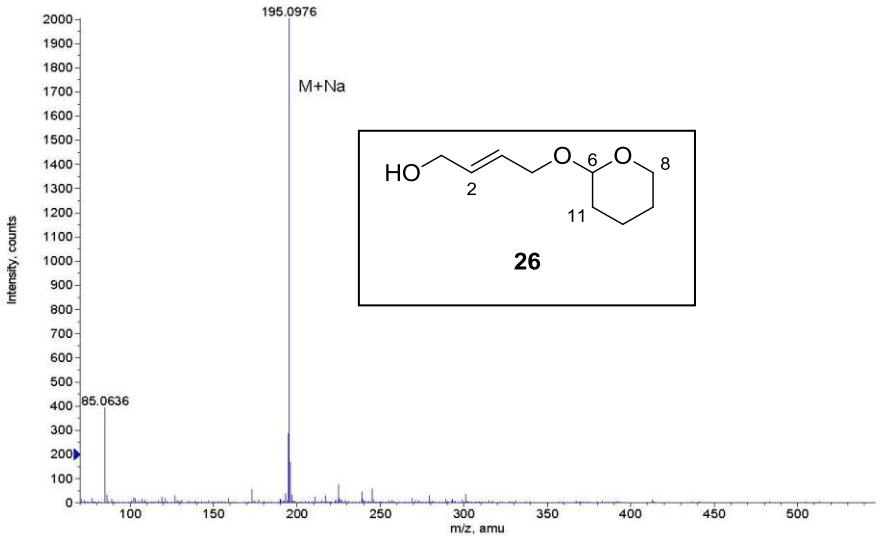
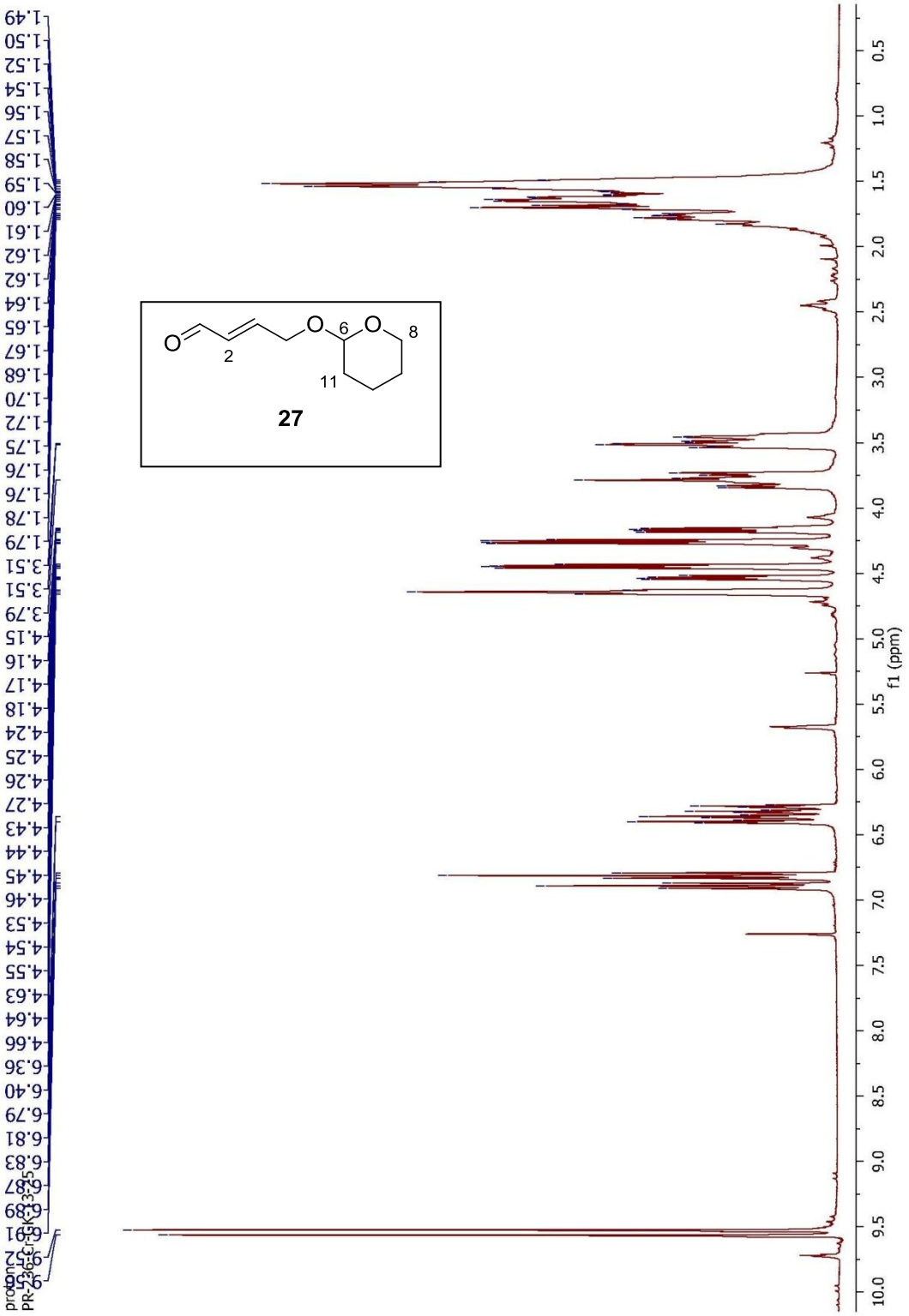
10/11/2011
Masa exacta

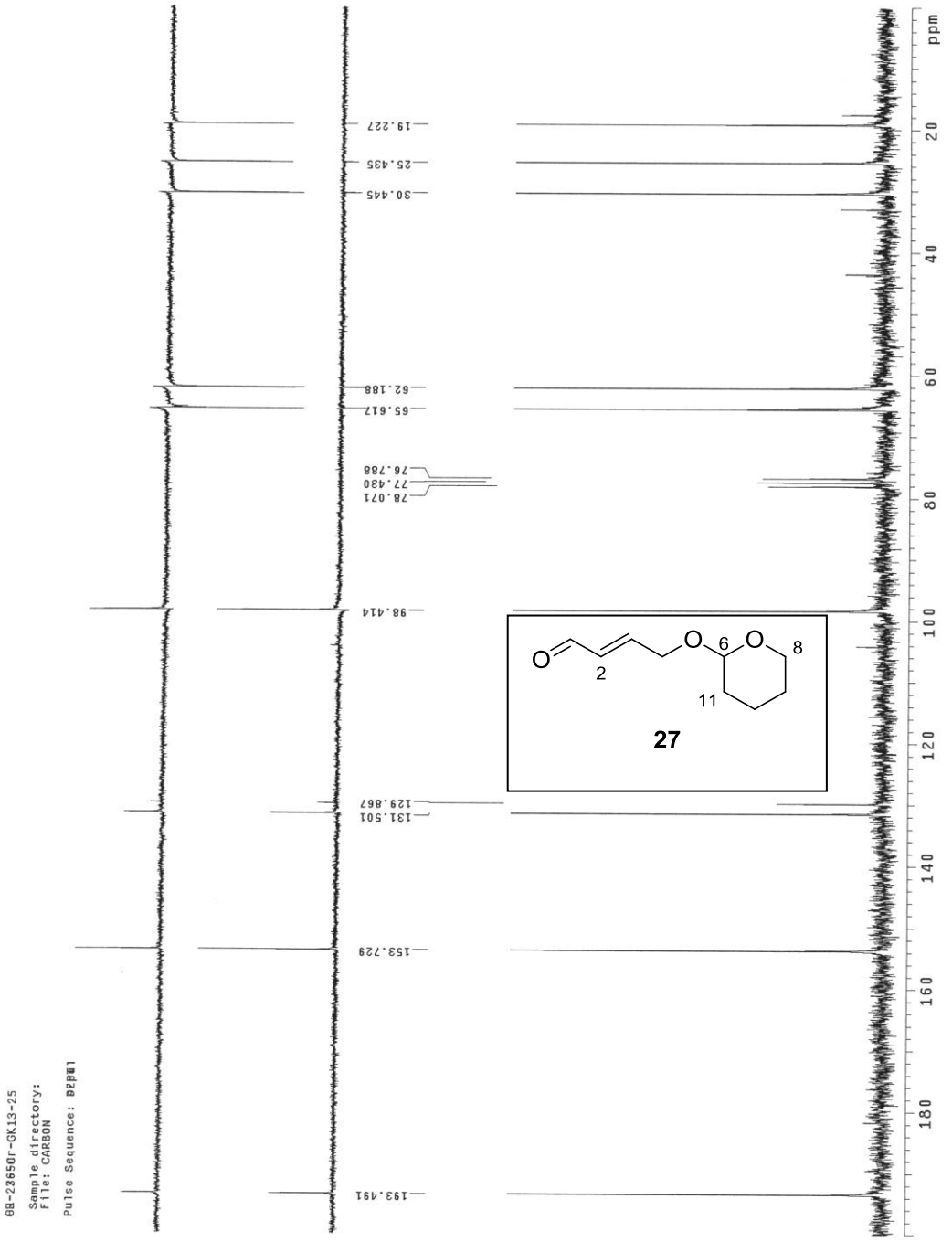
+TOF MS: 0.934 min from Sample 5 (Cr-GJ-27-50) of oct1011l13.wiff
a=3.56671390090838620e-004, t0=-3.50372002432777660e+001 R;

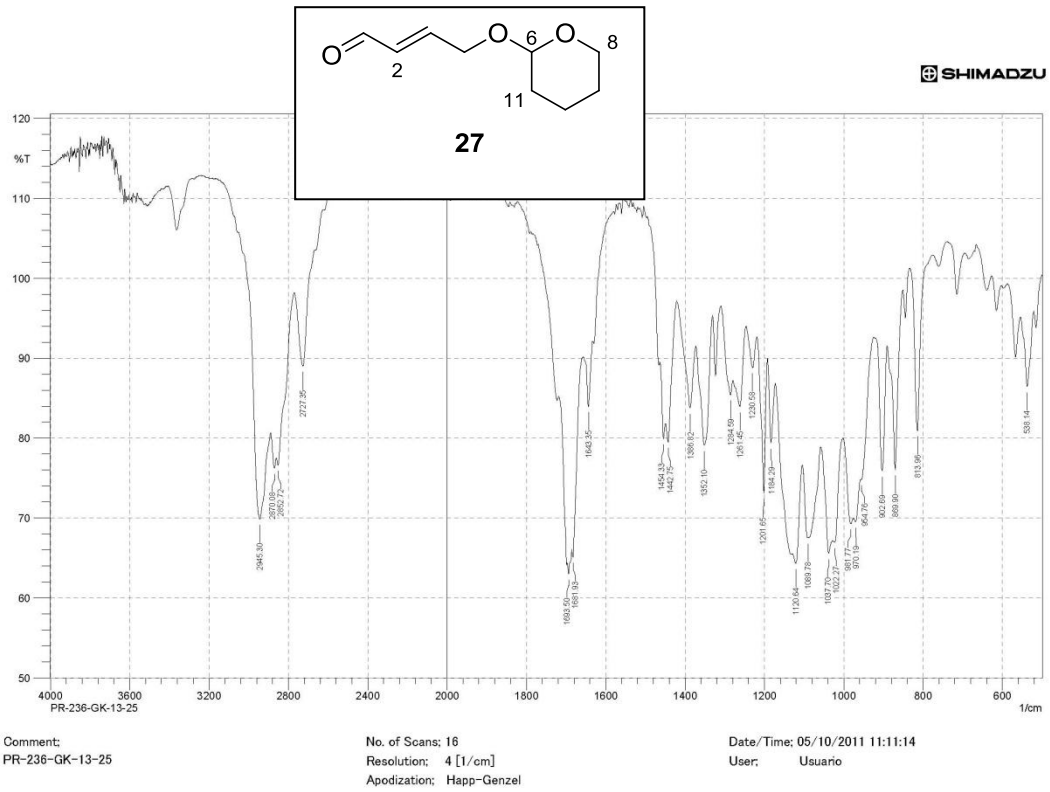
Max. 2005.0 counts.



Formula	CalculatedMass	mDaError	ppmError	RDB
C6 H15 N2 O5	195.097548	0.051764	0.265323	0.5
C5 H12 N6 O Na	195.09648	1.119712	5.739224	2.5
C7 H11 N6 O	195.098886	-1.285548	-6.589237	5.5
C9 H16 O3 Na	195.099166	-1.56568	-8.025089	1.5


O
2
O
6
O
8
11
27
f1 (ppm)





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37008 Salamanca

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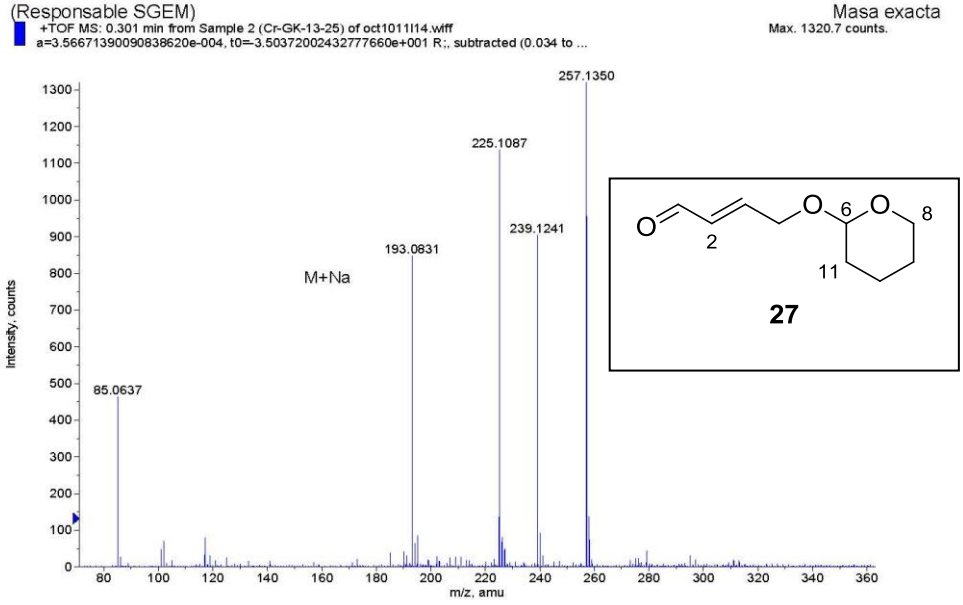
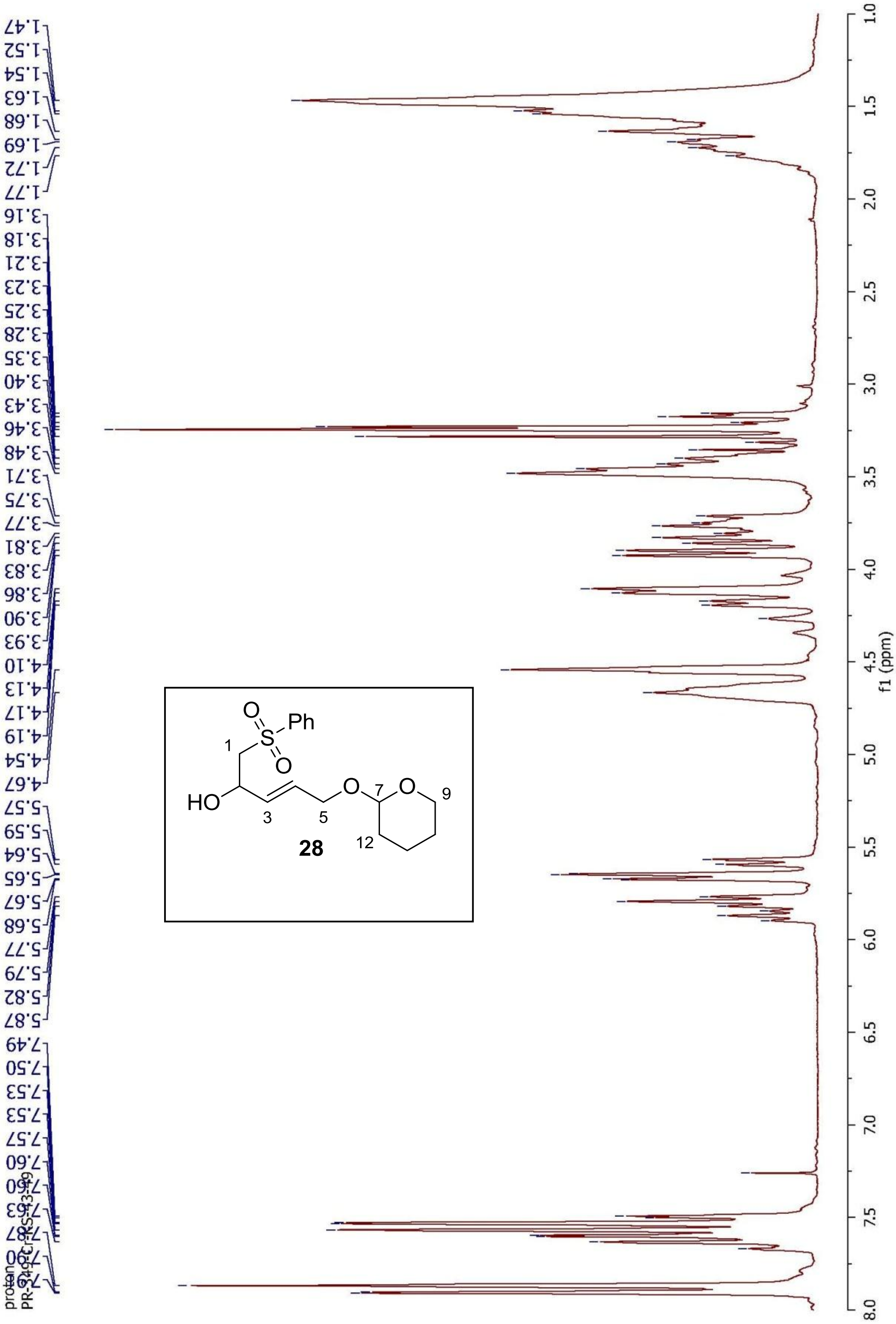
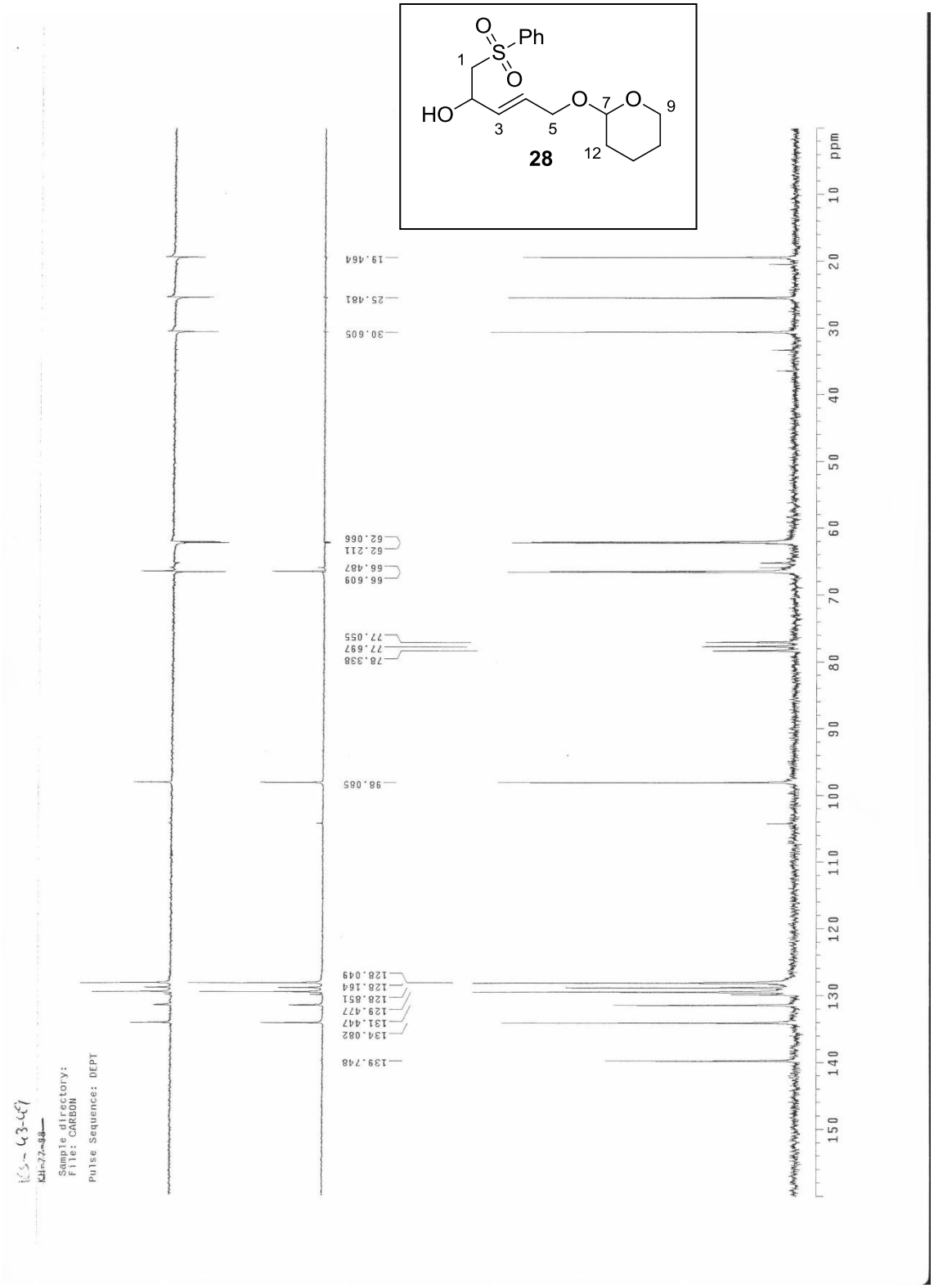
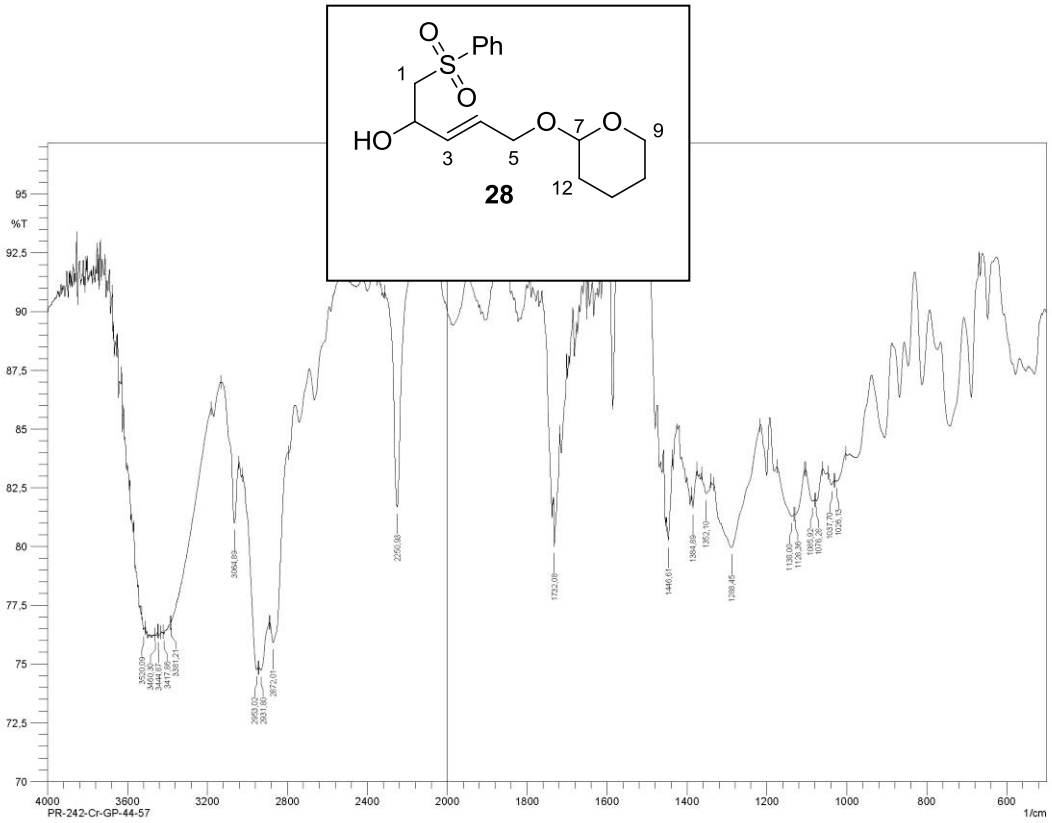
10/11/2011
Masa exacta



Formula	CalculatedMass	mDaError	ppmError	RDB
C7 H9 N6 O	193.083235	-0.135468	-0.701603	6.5
C9 H14 O3 Na	193.083516	-0.4156	-2.152435	2.5
C6 H13 N2 O5	193.081898	1.201844	6.224473	1.5


f1 (ppm)
HO
Ph
28





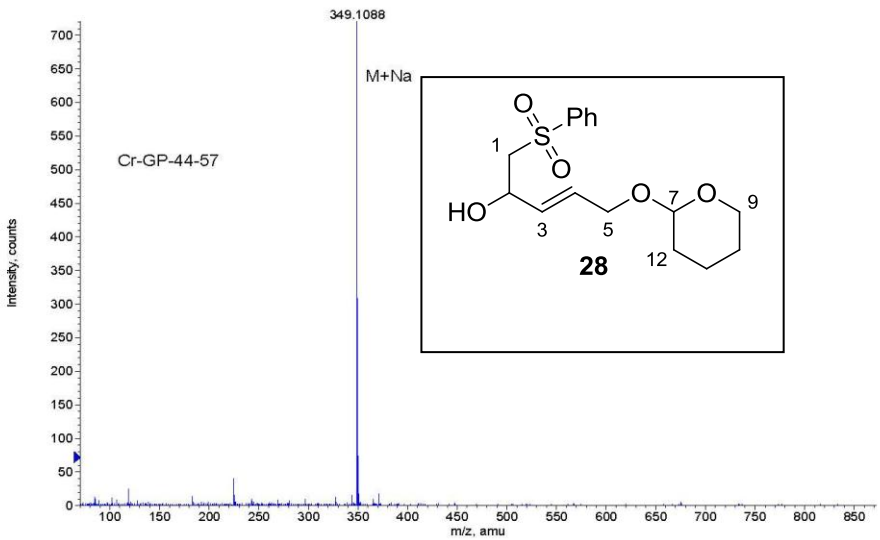
S. G. Espectrometria de Masas
Emitido por: César Raposo
(Responsable SGEM)

Plaza de los Caídos 1-5
37008 Salamanca

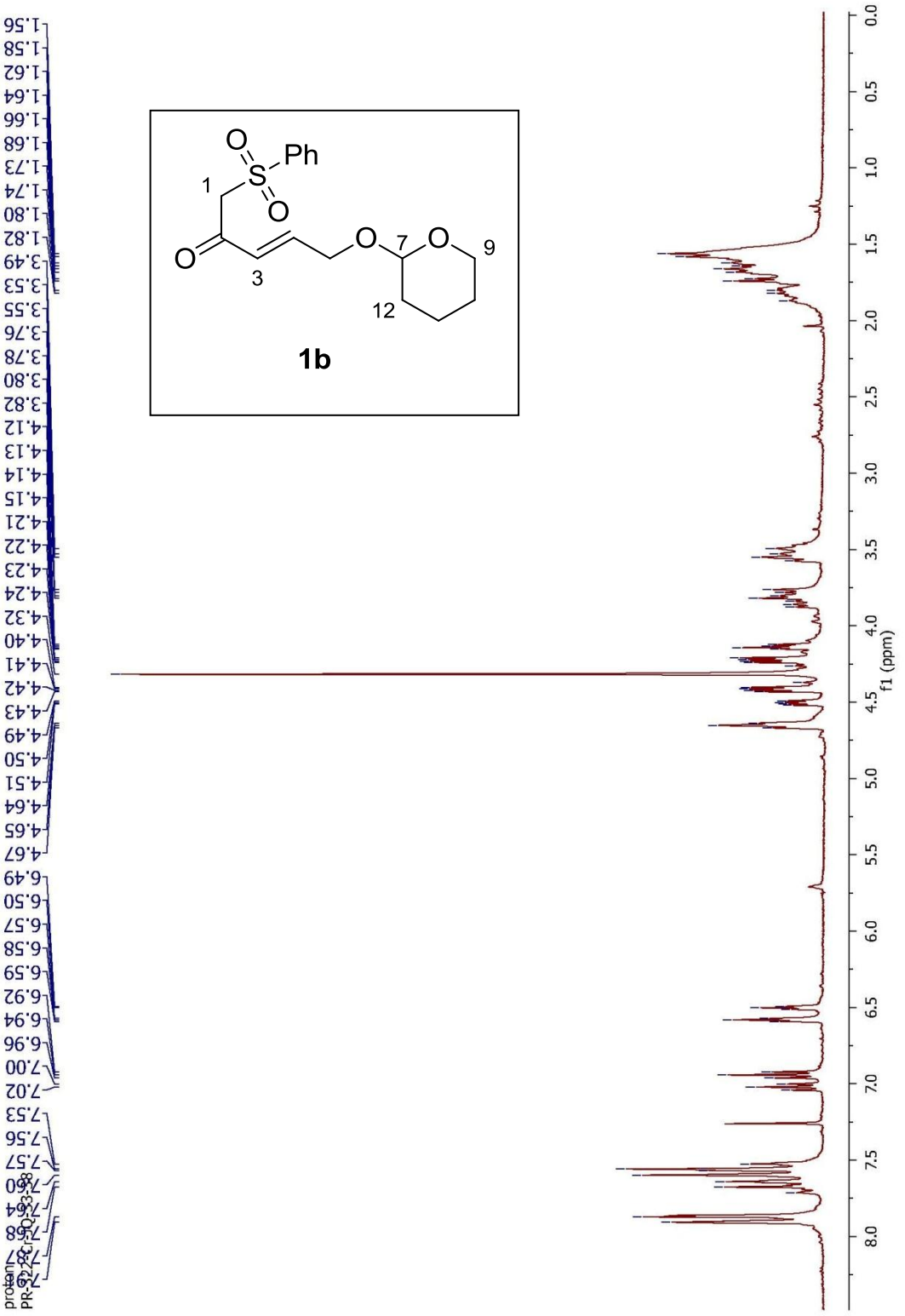
página 1 de 1
10/18/2011
Masa exacta

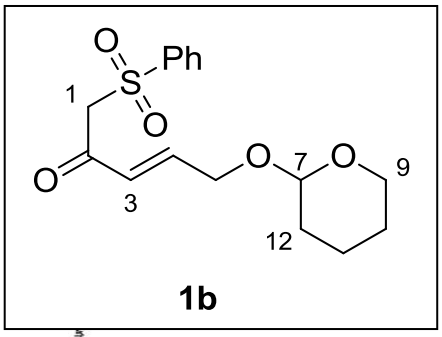
+TOF MS: 0.750 min from Sample 3 (Cr-GP-44-57) of oct1811l1.wiff
a=3.56675914938910860e-004, t0=-3.50739020320907000e+001 R:, subtracted (0.034 to 0...

Max. 721.0 counts.

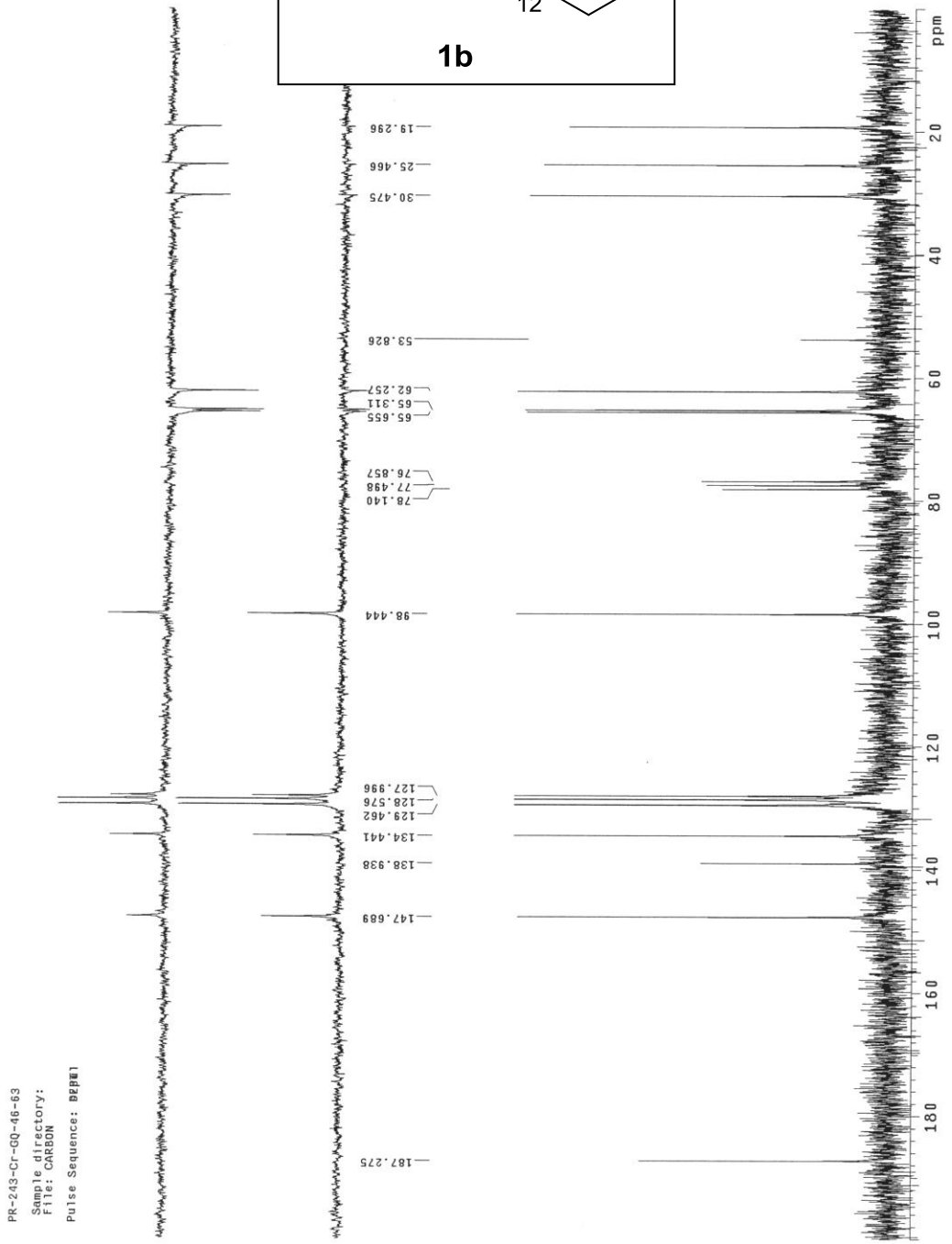


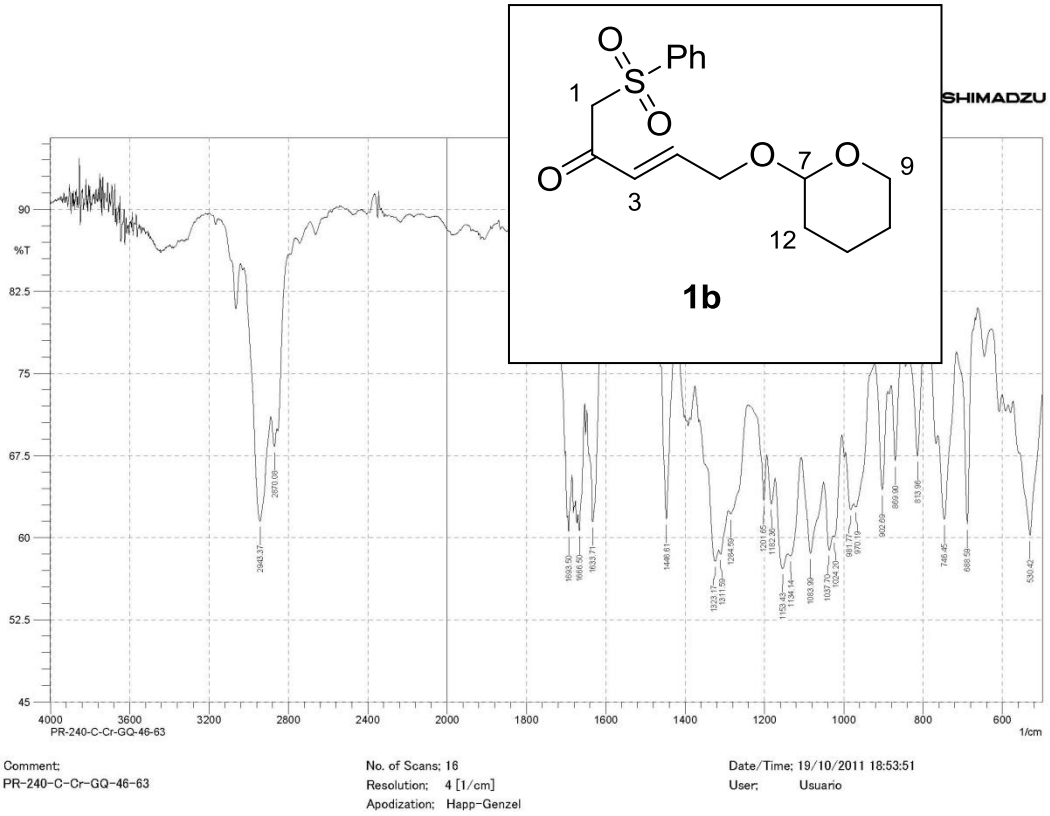
Formula	CalculatedMass	mDaError	ppmError	RDB
C17 H18 N4 O Na S	349.109354	-0.554312	-1.587789	10.5
C16 H22 O5 Na S	349.108017	0.783	2.24285	5.5
C14 H17 N6 O3 S	349.107737	1.063132	3.045269	9.5
C18 H21 O5 S	349.110422	-1.62226	-4.646854	8.5
C3 H17 N12 O6 S	349.110925	-2.124836	-6.086448	1.5
C13 H21 N2 O7 S	349.1064	2.400444	6.875909	4.5
C19 H17 N4 O S	349.11176	-2.959572	-8.477493	13.5
C12 H18 N6 O3 Na S	349.105332	3.468392	9.934973	6.5


O
Ph
S
1
O
O
O
7
O
9
3
12
1b
f1 (ppm)

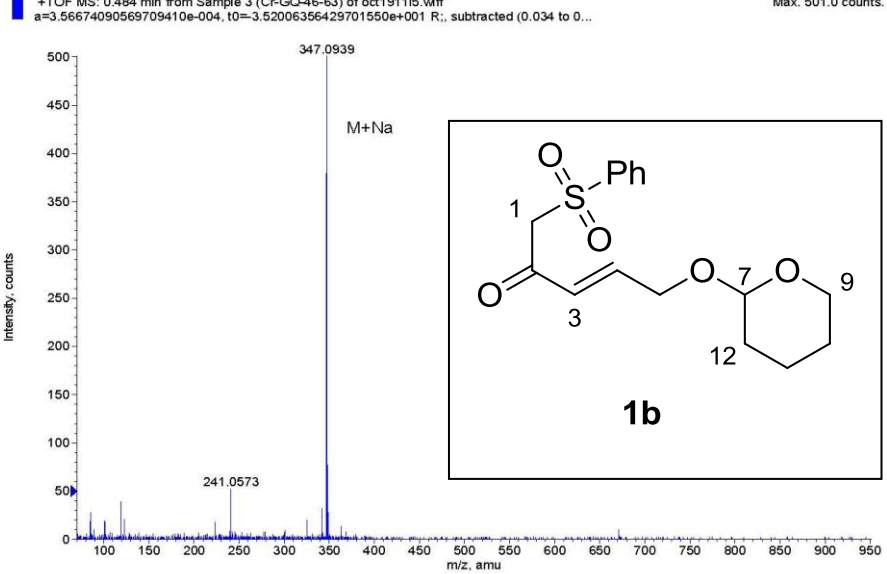


1b

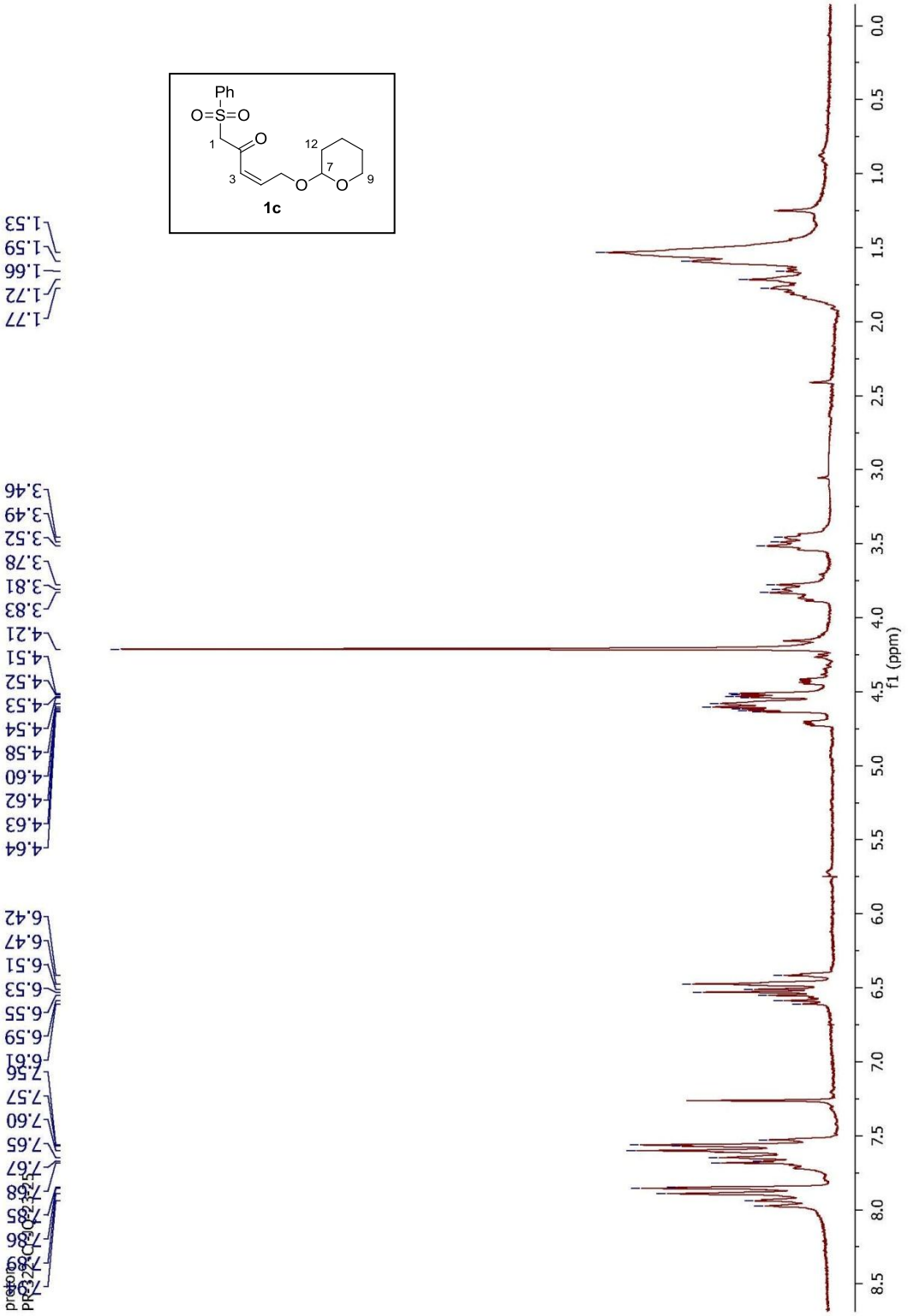


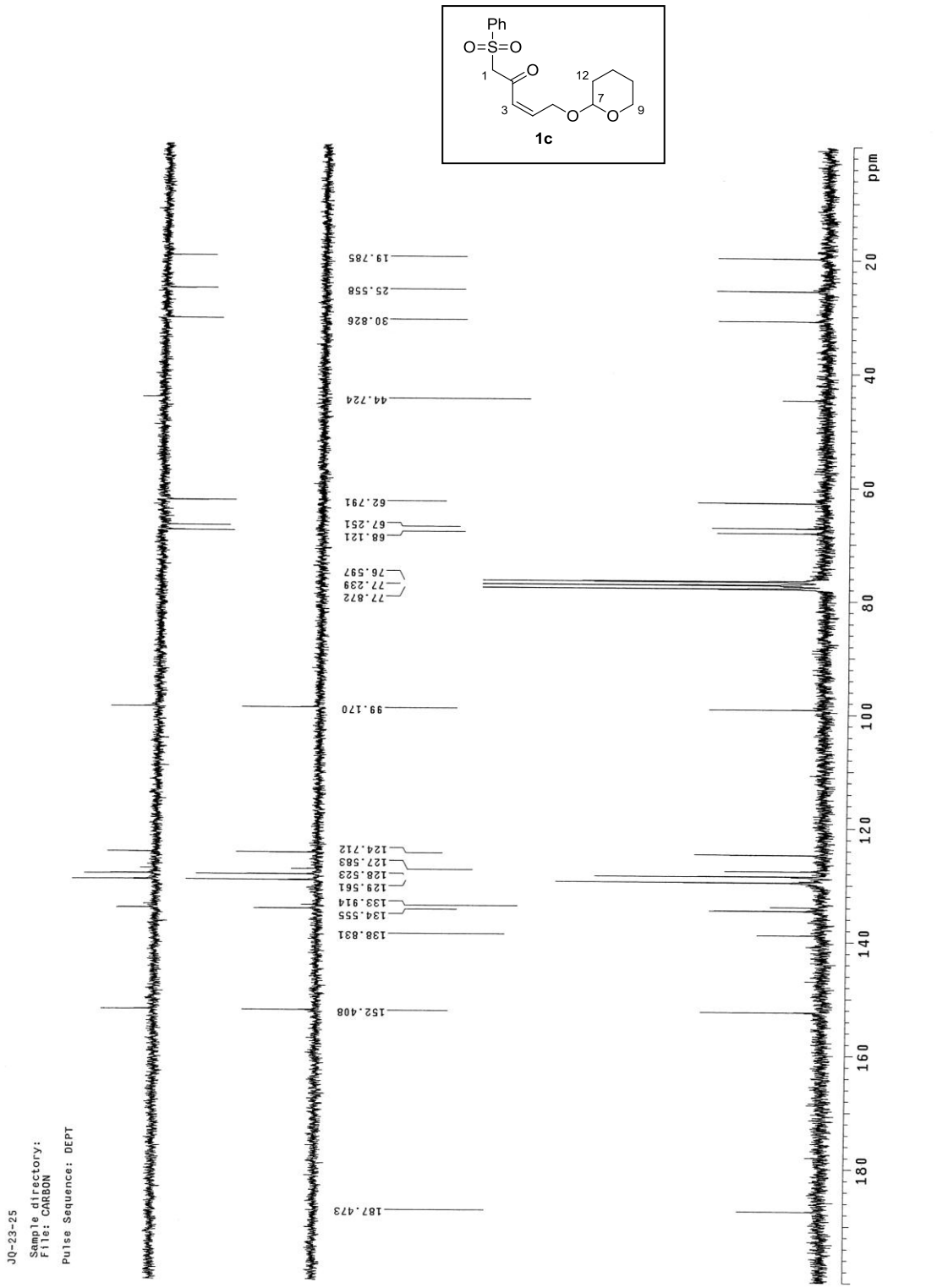


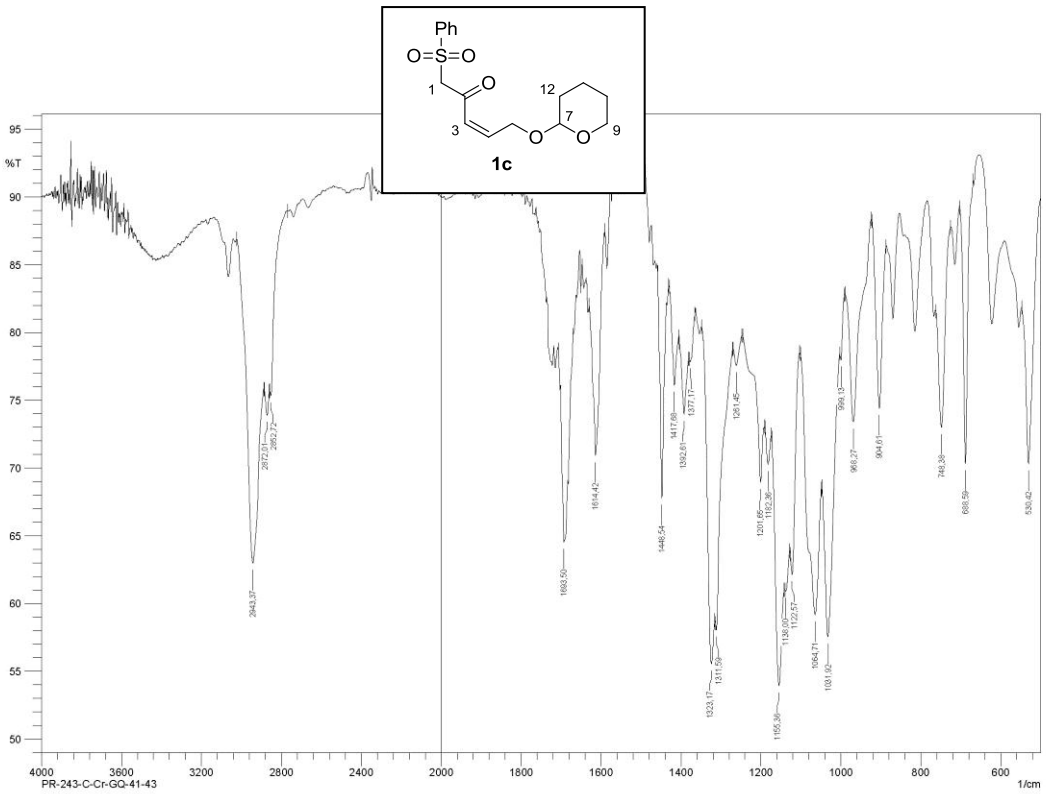
S. G. Espectrometria de Masas — Plaza de los Caídos 1-5 — página 1 de 1
Emitido por: César Raposo — 37008 Salamanca — 10/19/2011
(Responsable SGEM) — Masa exacta

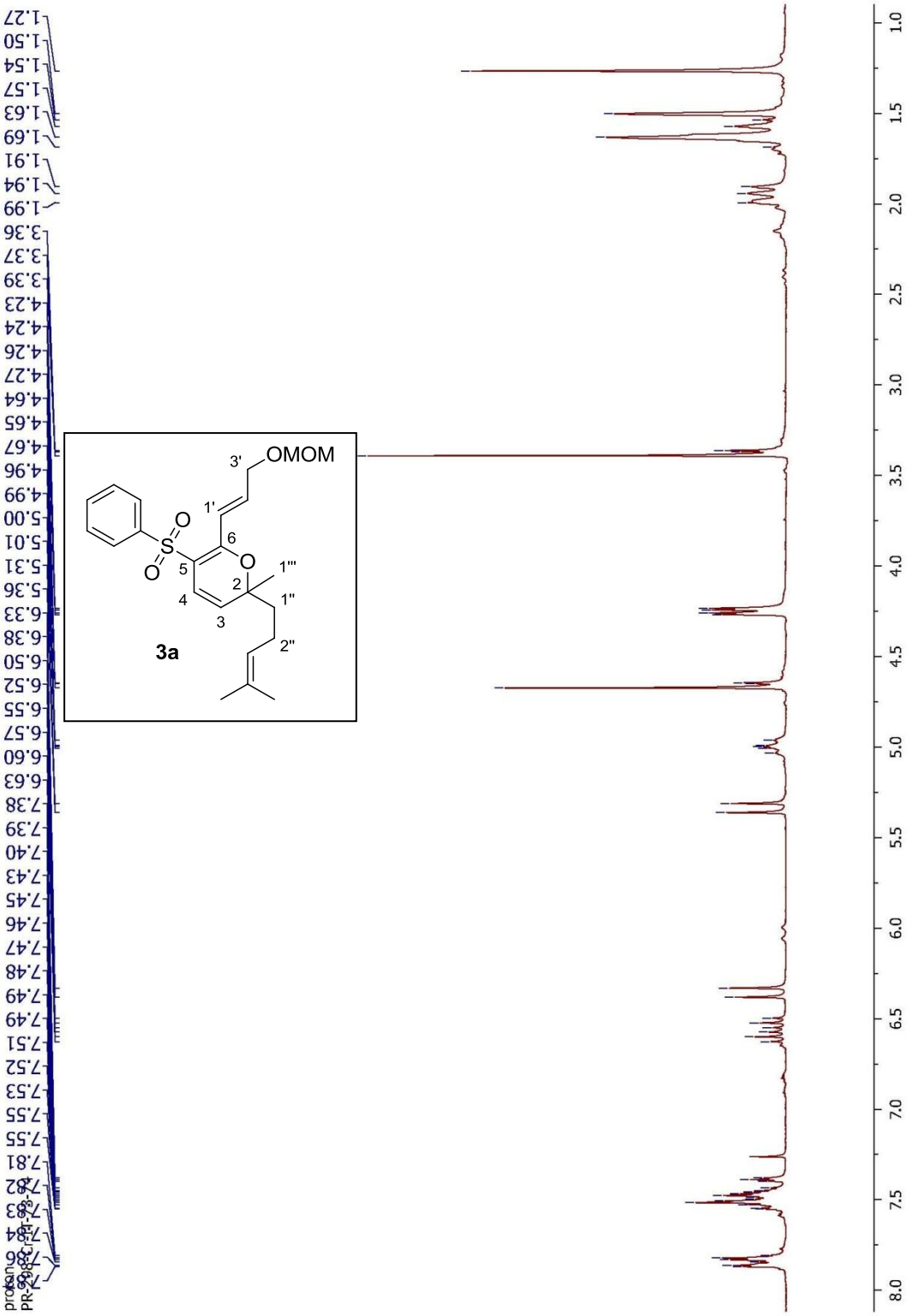


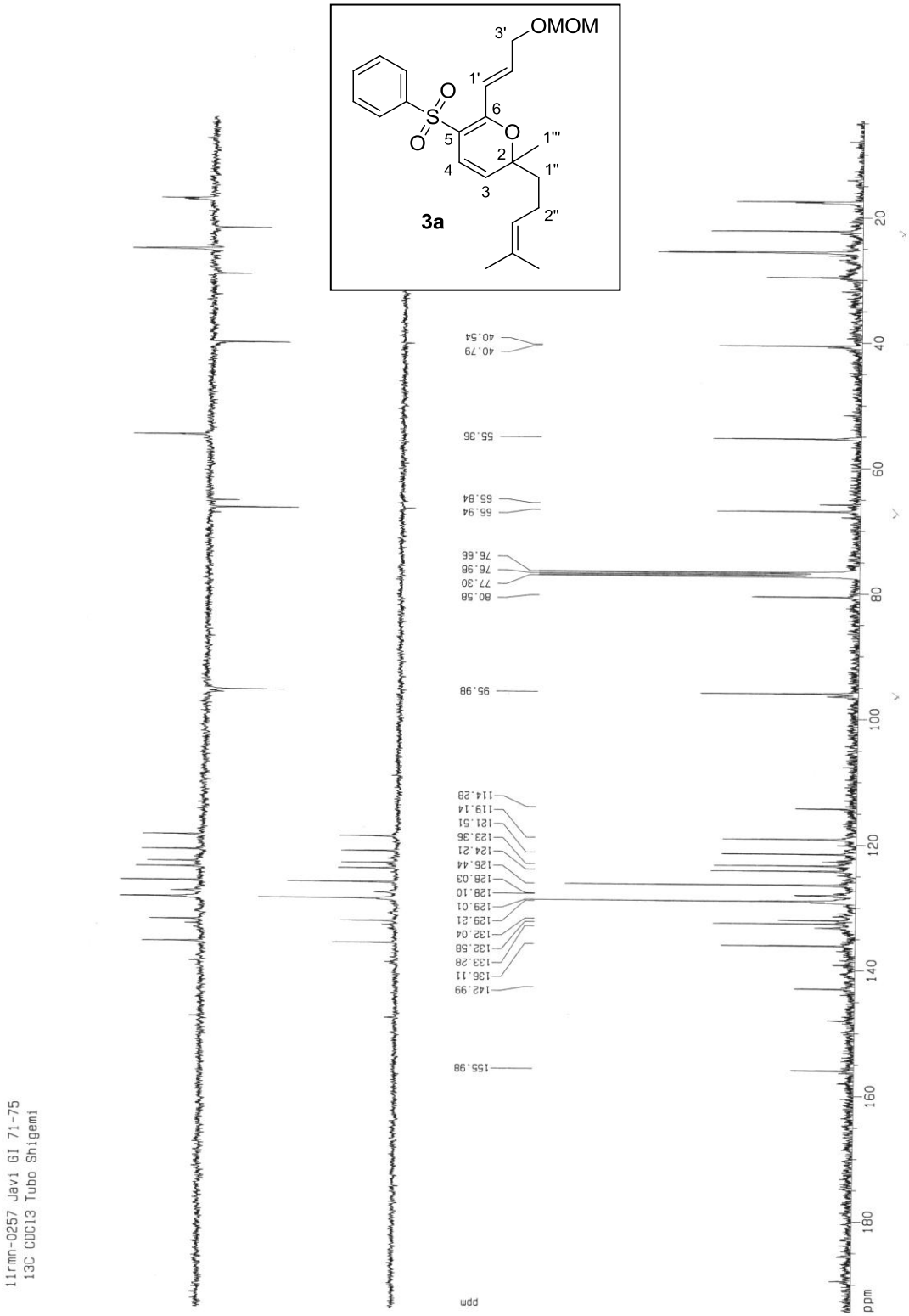
Formula	CalculatedMass	mDaError	ppmError	RDB
C17 H16 N4 O Na S	347.093704	0.195768	0.564019	11.5
C9 H12 N10 O4 Na	347.09352	0.37976	1.094111	8.5
C9 H19 N2 O12	347.093251	0.649124	1.870165	1.5
C10 H15 N6 O8	347.094588	-0.688188	-1.982711	6.5
C18 H19 O5 S	347.094772	-0.87218	-2.512803	9.5
C10 H8 N14 Na	347.094858	-0.957552	-2.758765	13.5
C12 H20 O10 Na	347.094868	-0.96832	-2.789788	2.5
C H16 N12 O6 Na S	347.092869	1.030504	2.968944	-0.5
C22 H11 N4 O	347.092738	1.162468	3.34914	19.5
C3 H15 N12 O6 S	347.095275	-1.374756	-3.960755	2.5
C16 H20 O5 Na S	347.092367	1.53308	4.416896	6.5

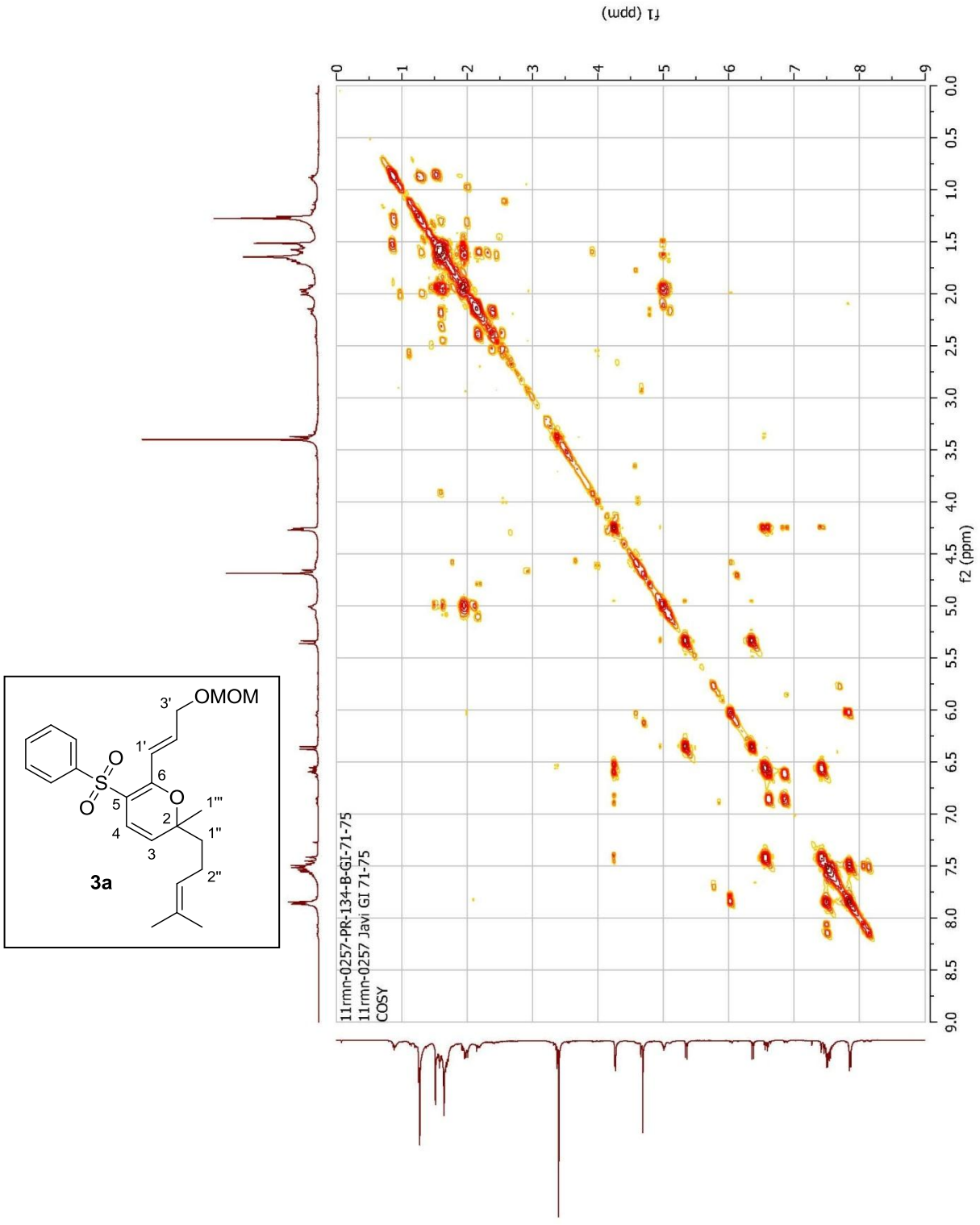

Ph
O=S=O
1
O
3
O
12
7
O
9
1c
1.53
1.59
1.66
1.72
1.77
3.46
3.49
3.52
3.78
3.81
3.83
4.21
4.51
4.52
4.53
4.54
4.58
4.60
4.62
4.63
4.64
6.42
6.47
6.51
6.53
6.55
6.59
6.61
7.56
7.57
7.60
7.65
7.67
7.68
7.85
7.86
7.89
7.91
f1 (ppm)

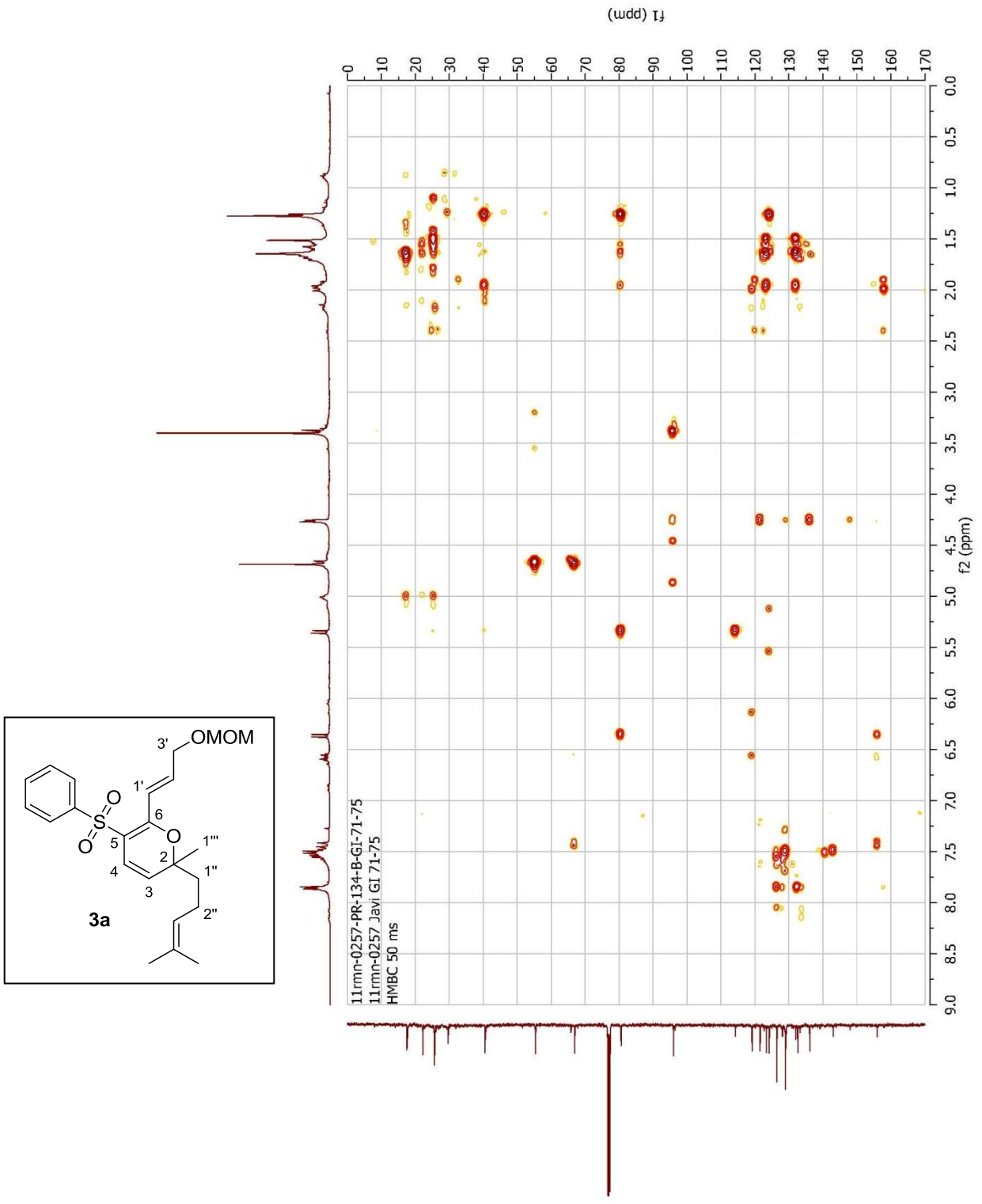


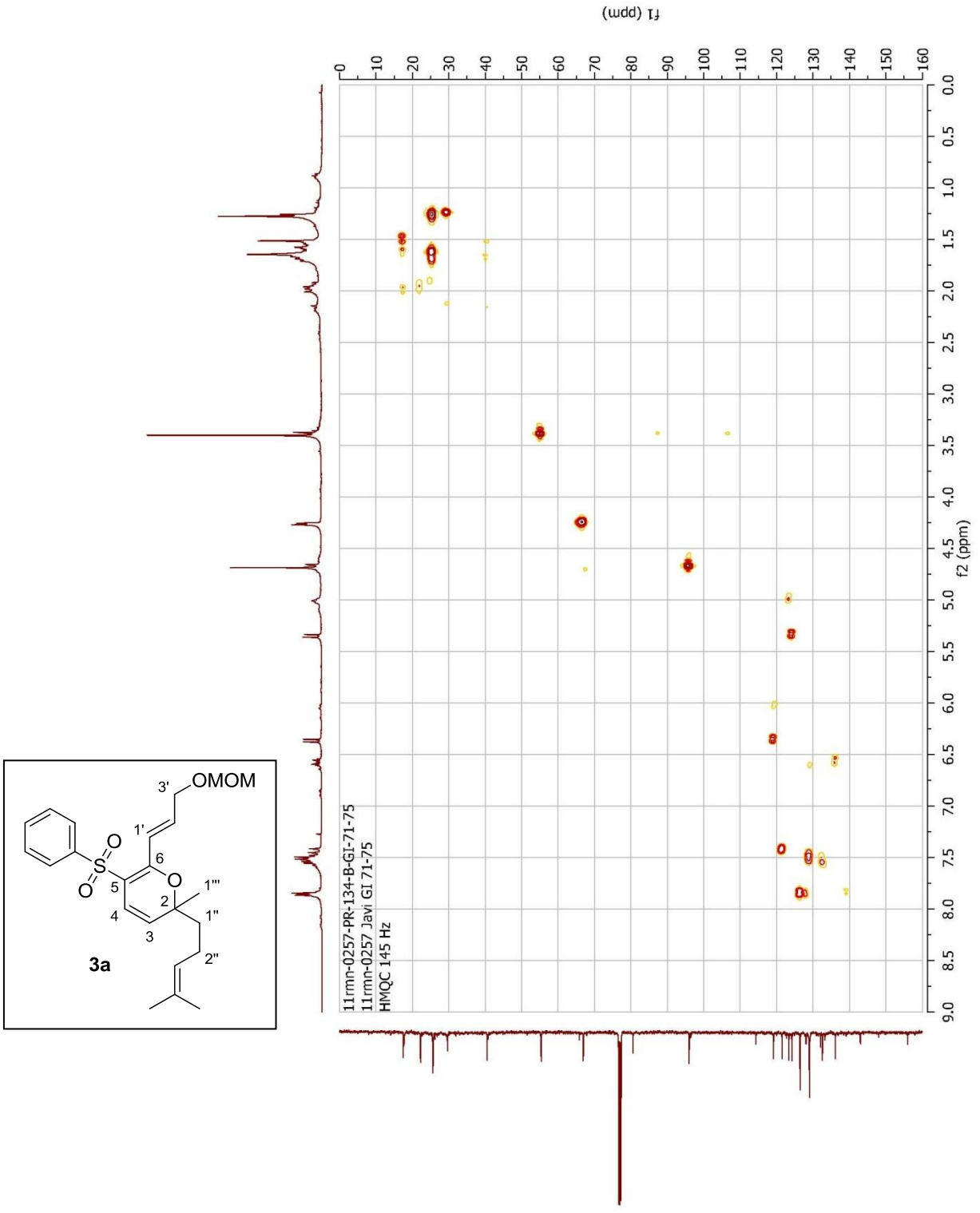

Ph
O=S=O
1
O
3
O
12
7
O
9
1c
%T
95
90
85
80
75
70
65
60
55
50
4000
3600
3200
2800
2400
2000
1800
1600
1400
1200
1000
800
600
1/cm
PR-243-C-Cr-GQ-41-43
2943.37
2872.01
2852.72
1693.59
1644.42
1446.54
1417.68
1392.61
1377.17
1311.59
1261.45
1223.17
1201.65
1162.36
1155.36
1138.00
1122.57
1064.71
1031.92
998.13
966.27
934.01
748.38
688.59
530.42

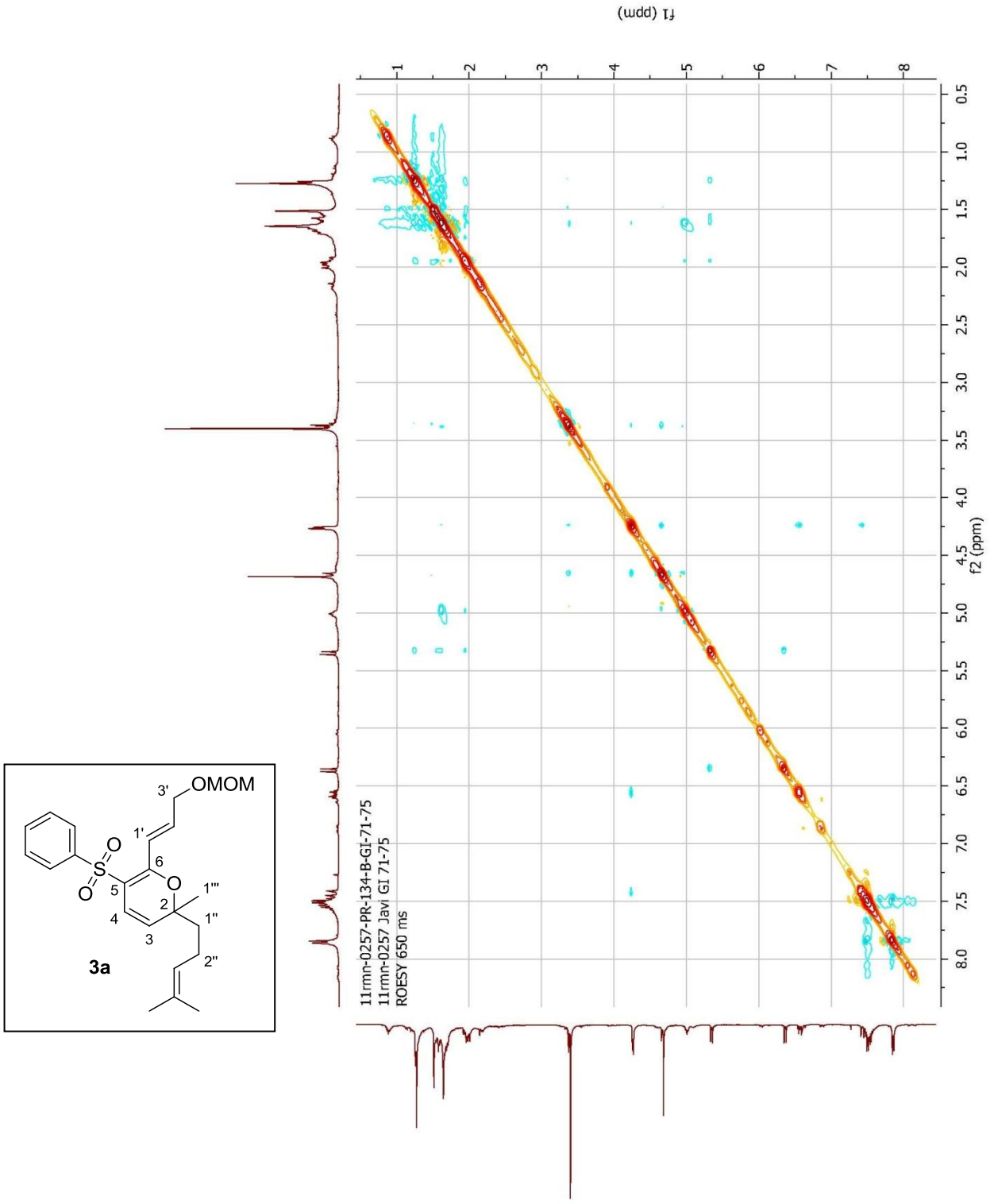

OMOM
3'
1'
6
O
S
O
O
5
4
3
2
1'''
1''
2''
3a

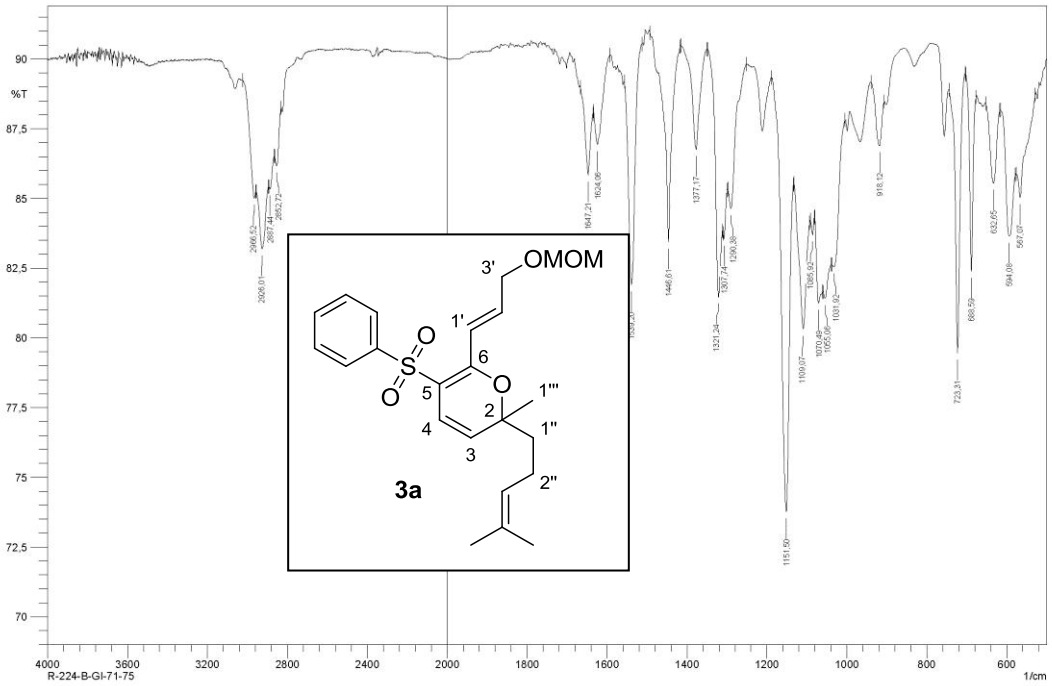



f1 (ppm)
f2 (ppm)
11rmn-0257-PR-134-B-GI-71-75
11rmn-0257 Javi GI 71-75
COSY
OMOM
3'
1'
6
5
O
2
1'''
4
1''
3
2''
3a


f1 (ppm)
f2 (ppm)
11rmn-0257-PR-134-B-GI-71-75
11rmn-0257 Javi GI 71-75
HMBC 50 ms
OMOM
3'
1'
6
O
S
O
O
5
4
3
2
1'''
1''
2''
3a


f1 (ppm)
f2 (ppm)
11rmn-0257-PR-134-B-GI-71-75
11rmn-0257 Javi GI 71-75
HMQC 145 Hz
OMOM
3'
1'
6
O
5
S
O
O
2
1'''
4
3
1''
2''
3a





S. G. Espectrometria de Masas
Emitido por: César Raposo
(Responsable SGEM)

Plaza de los Caídos 1-5
37008 Salamanca

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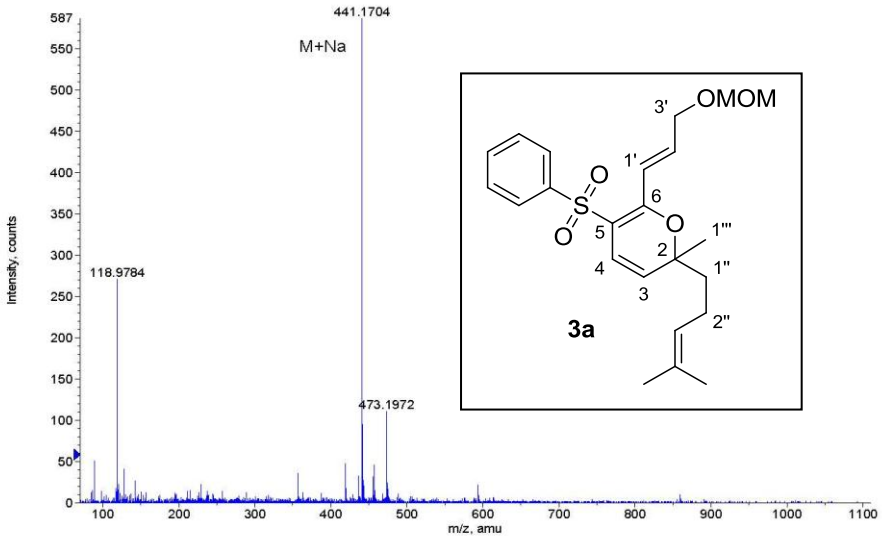
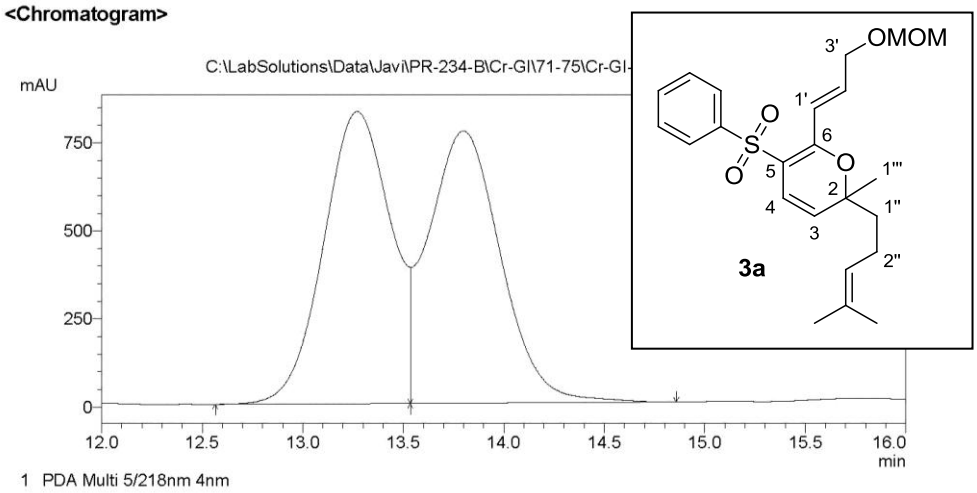
10/11/2011
Masa exacta

+TOF MS: 0.284 min from Sample 5 (Cr-GI-71-75) of oct1011l14.wiff
a=3.56671390090838620e-004, t0=-3.50372002432777660e+001 R:, subtracted (0.034 to 0...

Max. 587.0 counts.



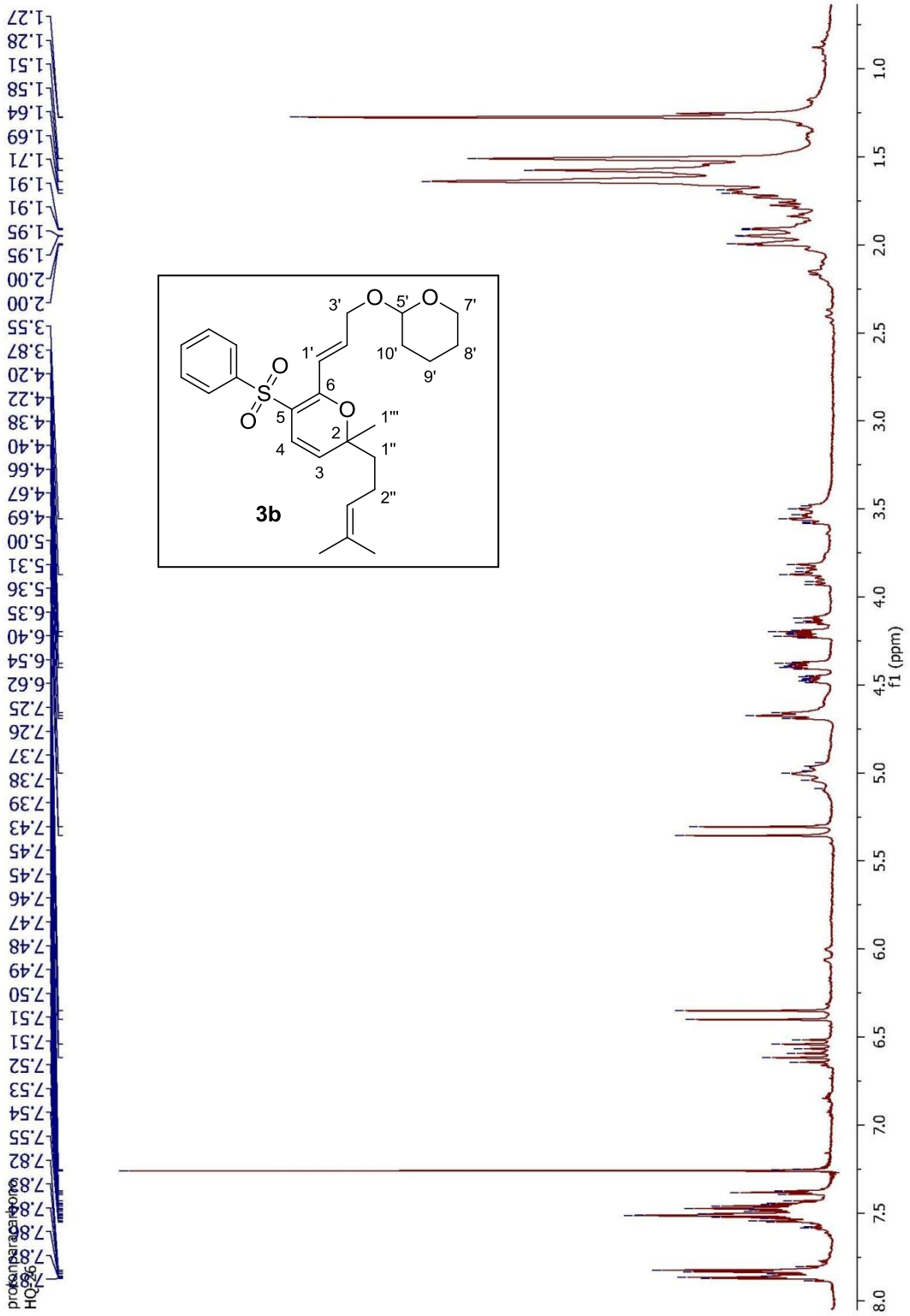
Formula	CalculatedMass	mDaError	ppmError	RDB
C21 H25 N6 O3 S	441.170337	0.062812	0.142376	12.5
C23 H30 O5 Na S	441.170617	-0.21732	-0.492598	8.5

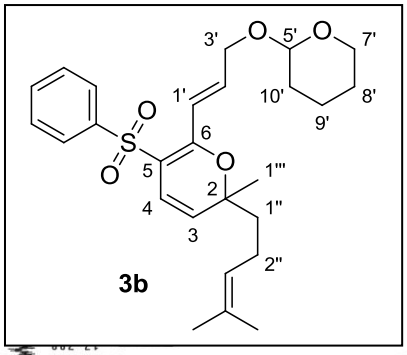


PeakTable

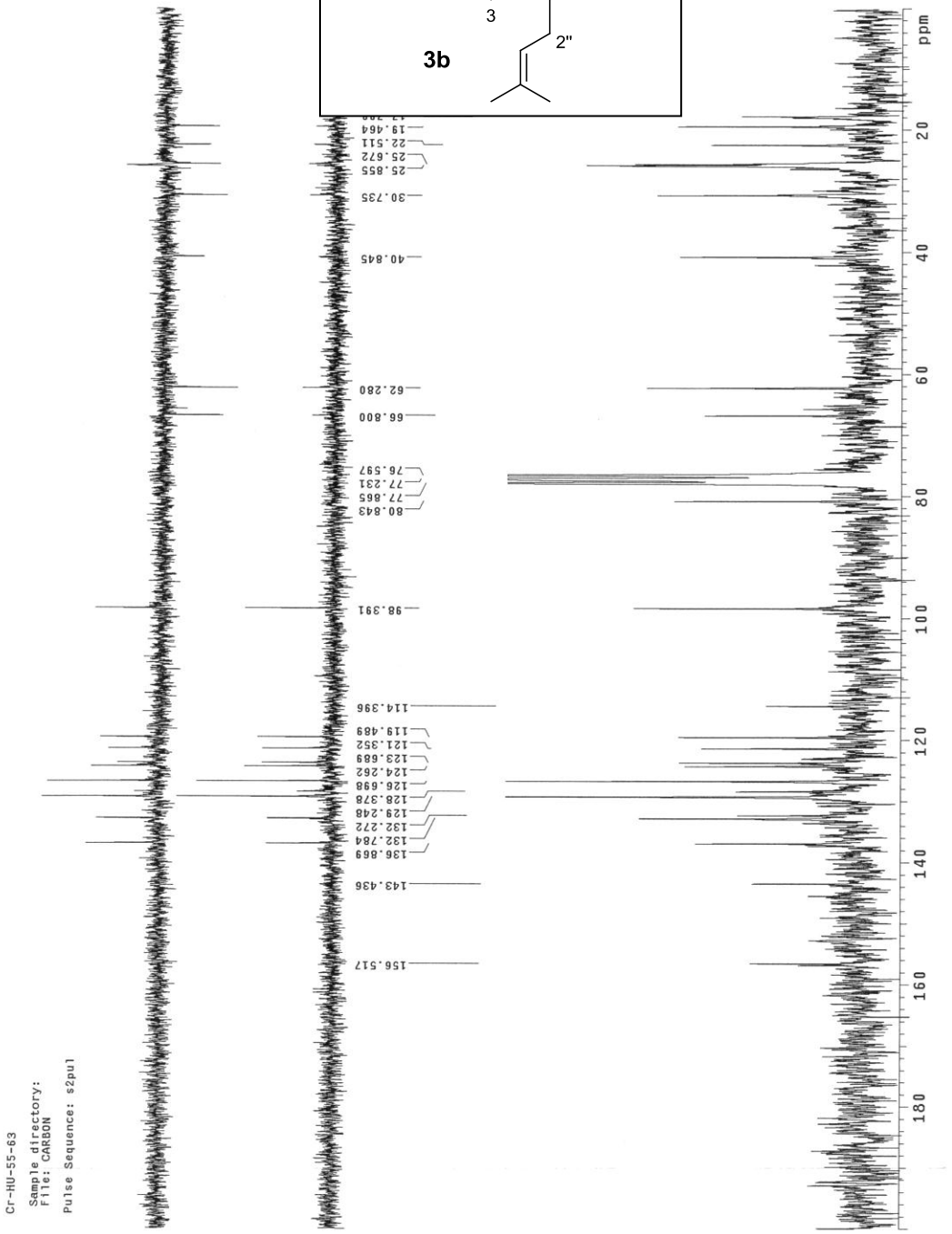
PDA Ch5 218nm 4nm

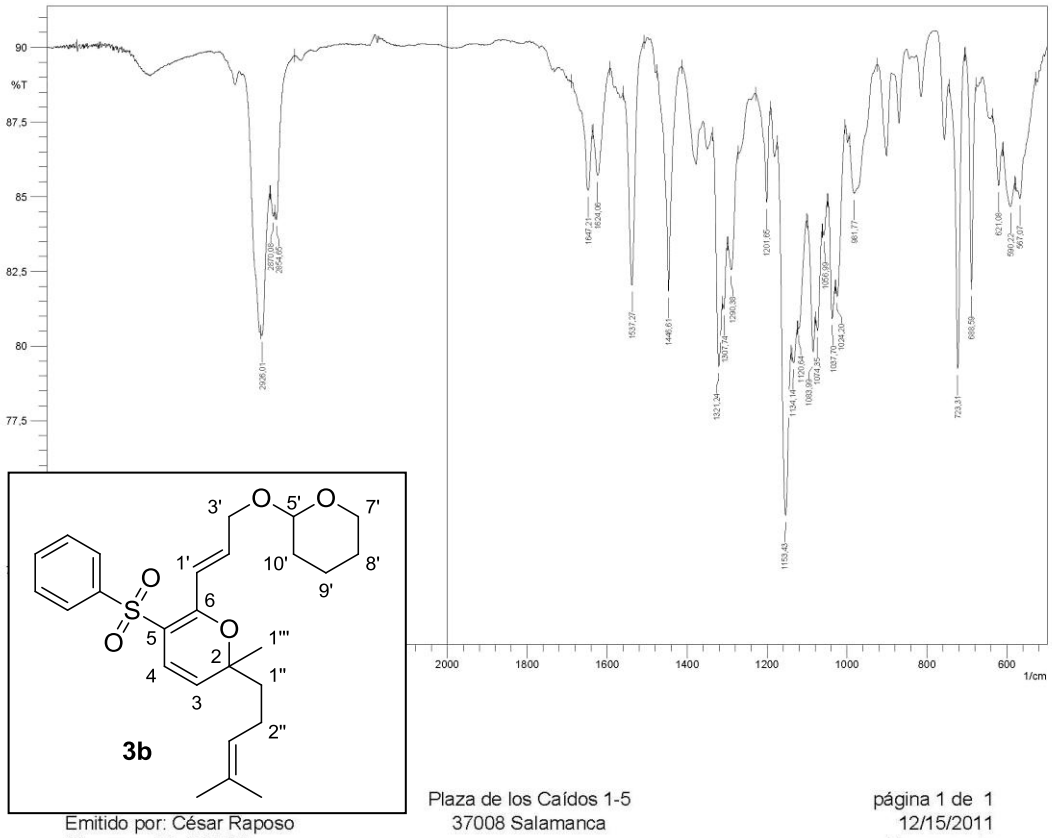
Peak#	Ret. Time	Area %
1	13.265	50.162
2	13.794	49.838
Total		100.000


3'
O
5'
O
7'
1'
10'
8'
9'
6
O
S
O
O
5
2
1'''
4
1''
3
2''
3b
f1 (ppm)



3b

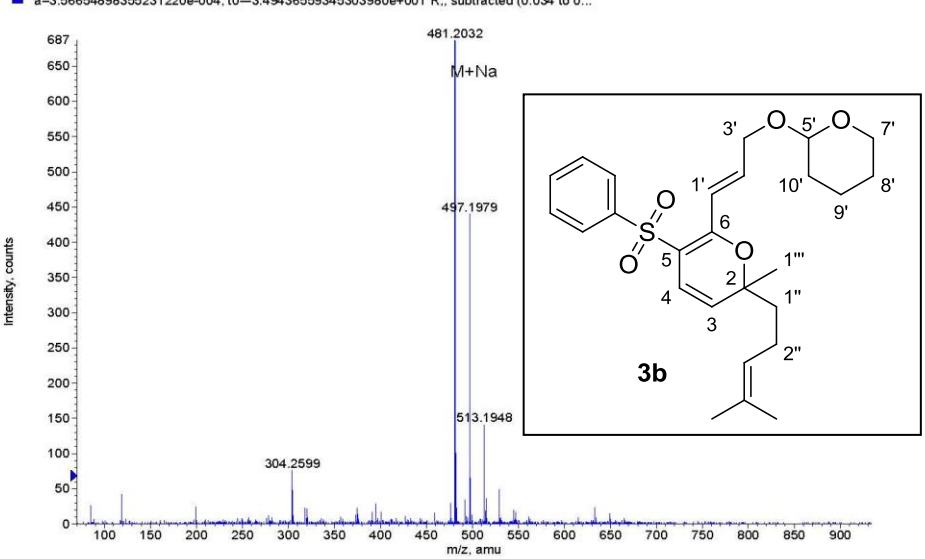




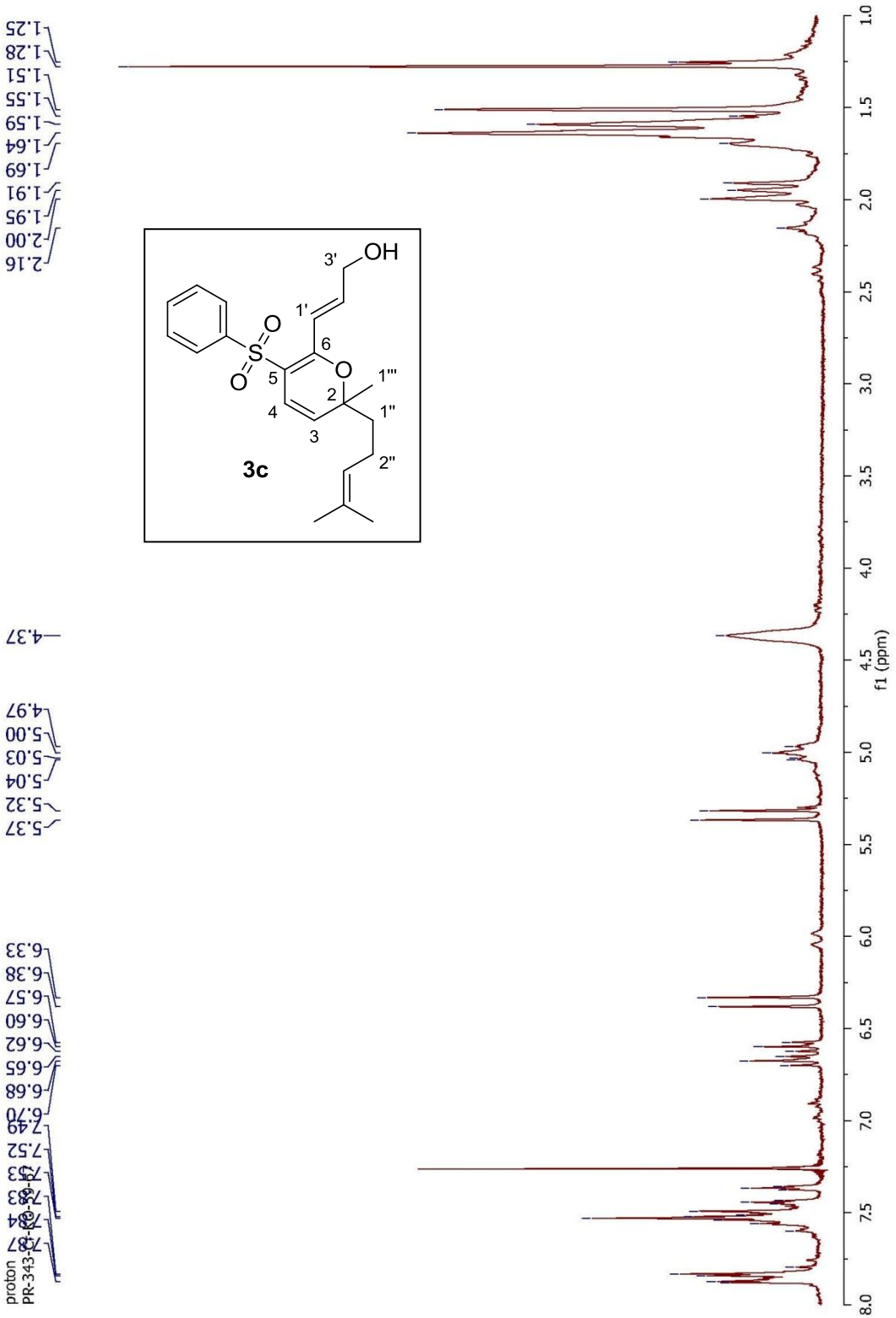
Plaza de los Caídos 1-5
37008 Salamanca

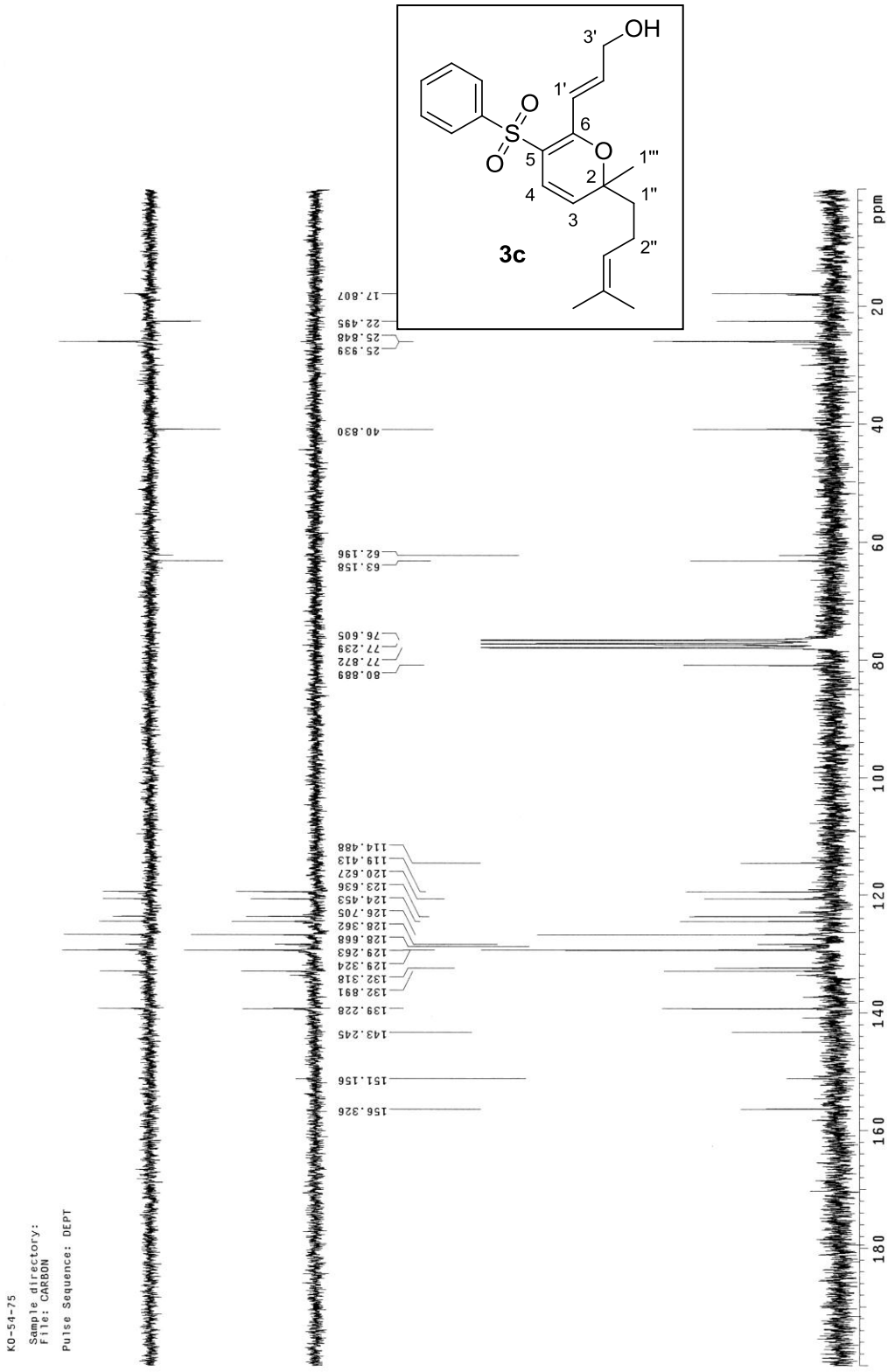
página 1 de 1
12/15/2011
Masa exacta

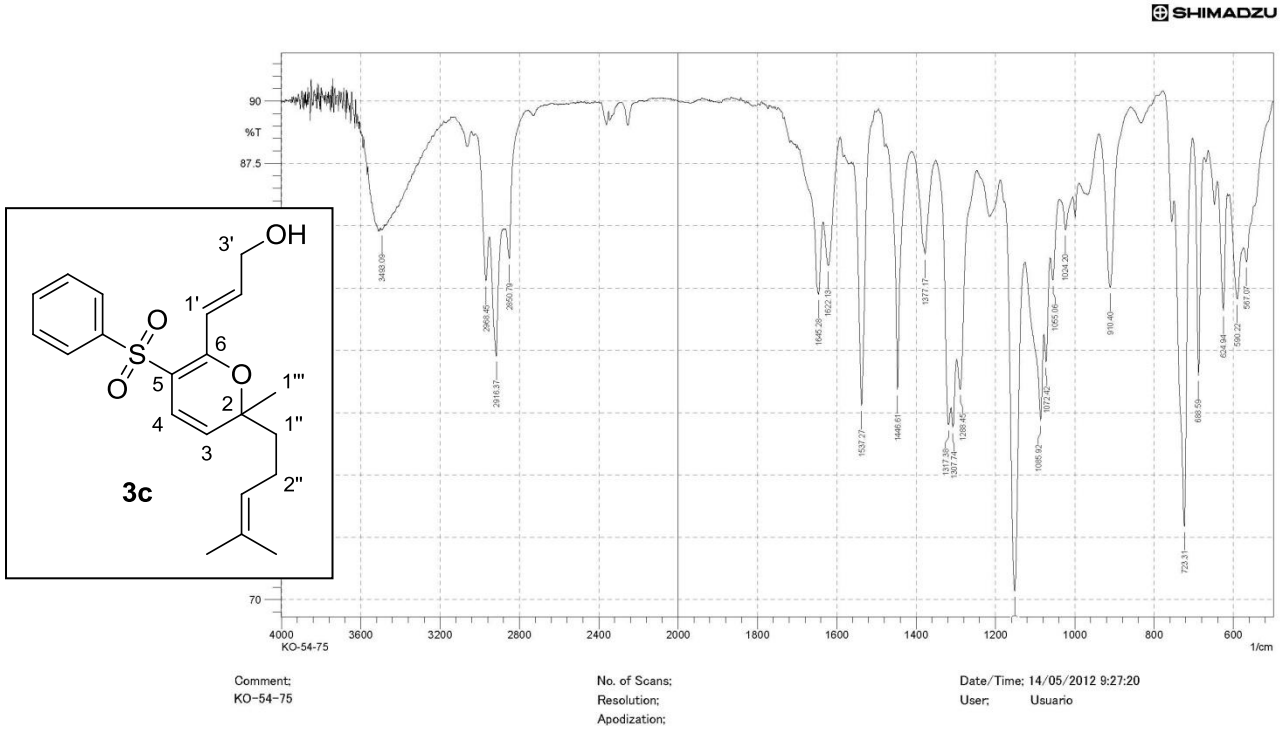
Emitido por: César Raposo
(Responsable SGEM)

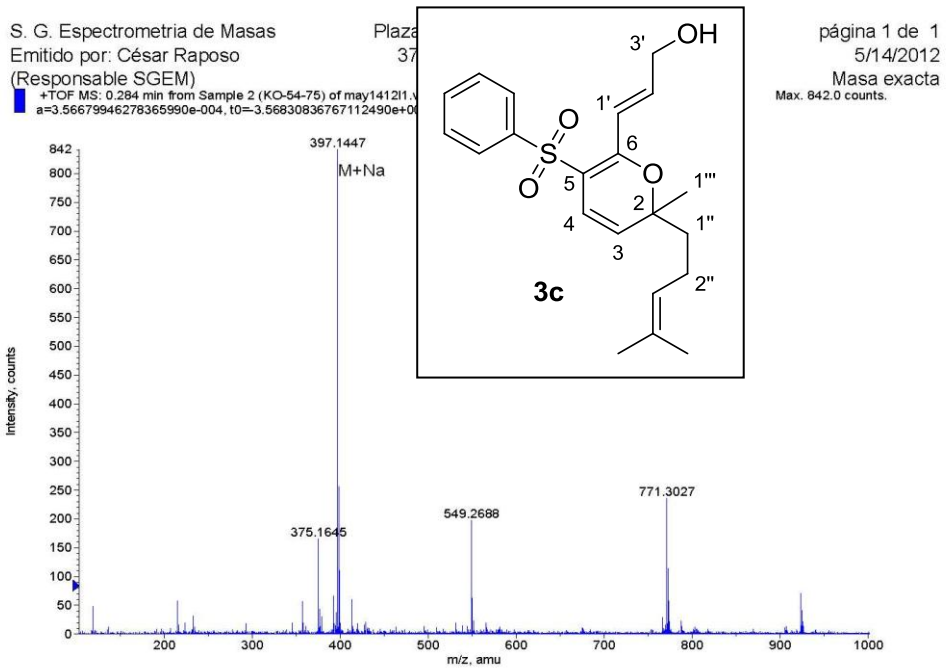


Formula	CalculatedMass	mDaError	ppmError	RDB
C27 H30 N4 O Na S	481.203255	-0.054792	-0.113864	14.5
C12 H33 N8 O10 S	481.203488	-0.288004	-0.598507	0.5
C11 H30 N12 O6 Na S	481.20242	0.779944	1.620819	2.5
C28 H33 O5 S	481.204323	-1.12274	-2.33319	12.5
C26 H34 O5 Na S	481.201917	1.28252	2.665233	9.5

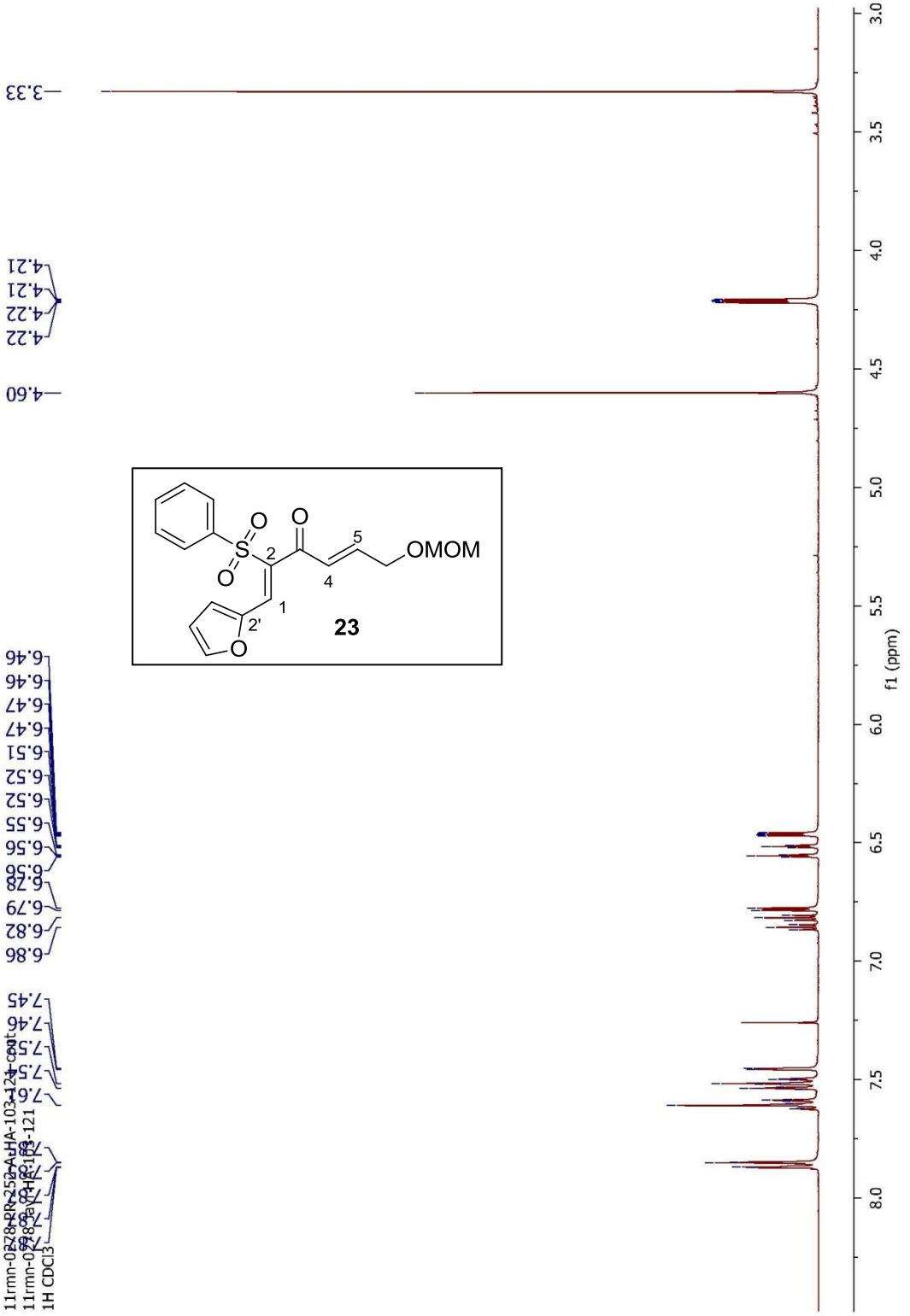

1.25
1.28
1.51
1.55
1.59
1.64
1.69
1.91
1.95
2.00
2.16
4.37
4.97
5.00
5.03
5.04
5.32
5.37
6.33
6.38
6.57
6.60
6.62
6.65
6.68
6.70
7.49
7.52
7.53
7.83
7.84
7.87
proton
PR-343-1
OH
3'
1'
6
O
S
O
O
5
2
1'''
4
1''
3
2''
3c
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
f1 (ppm)

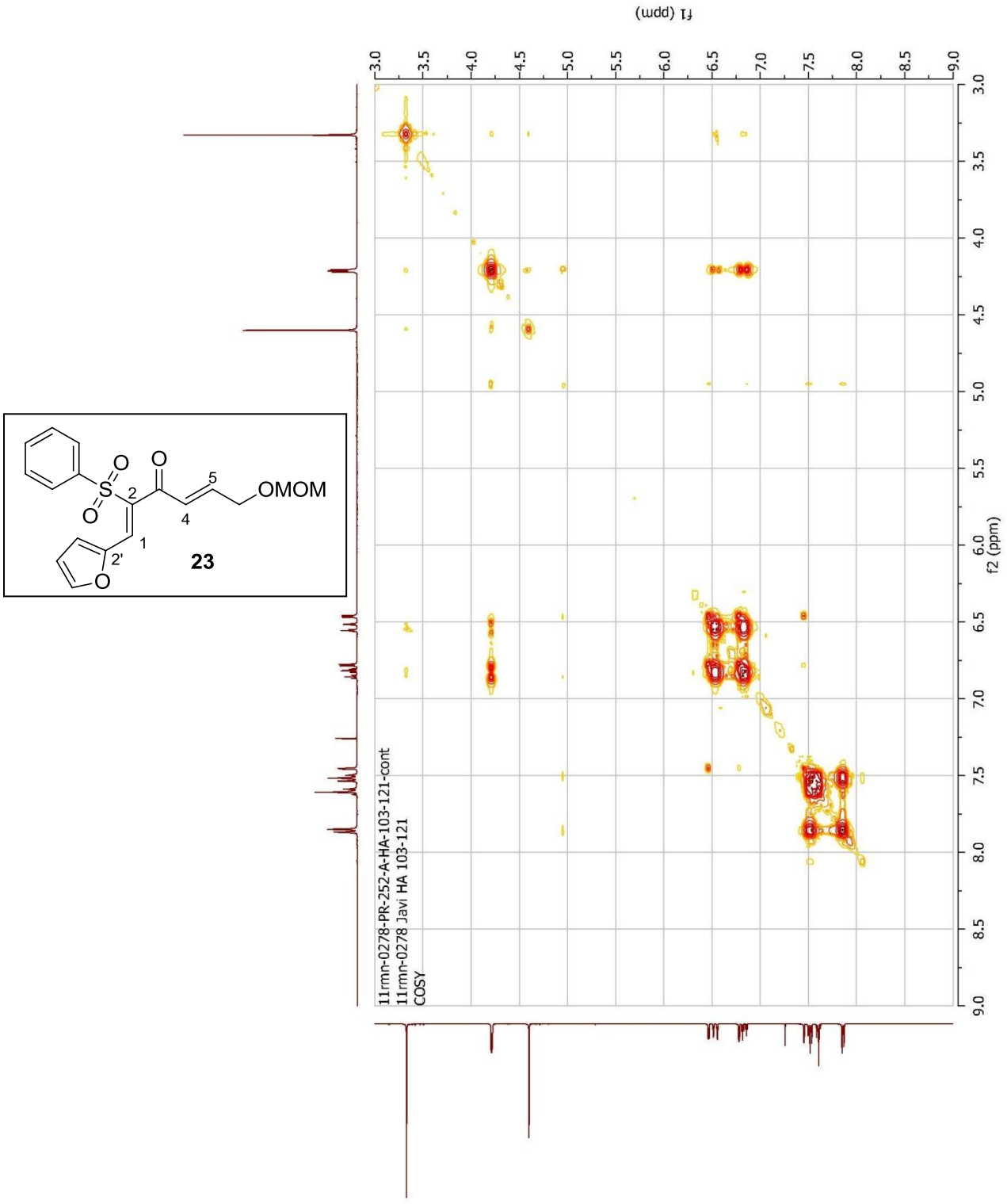


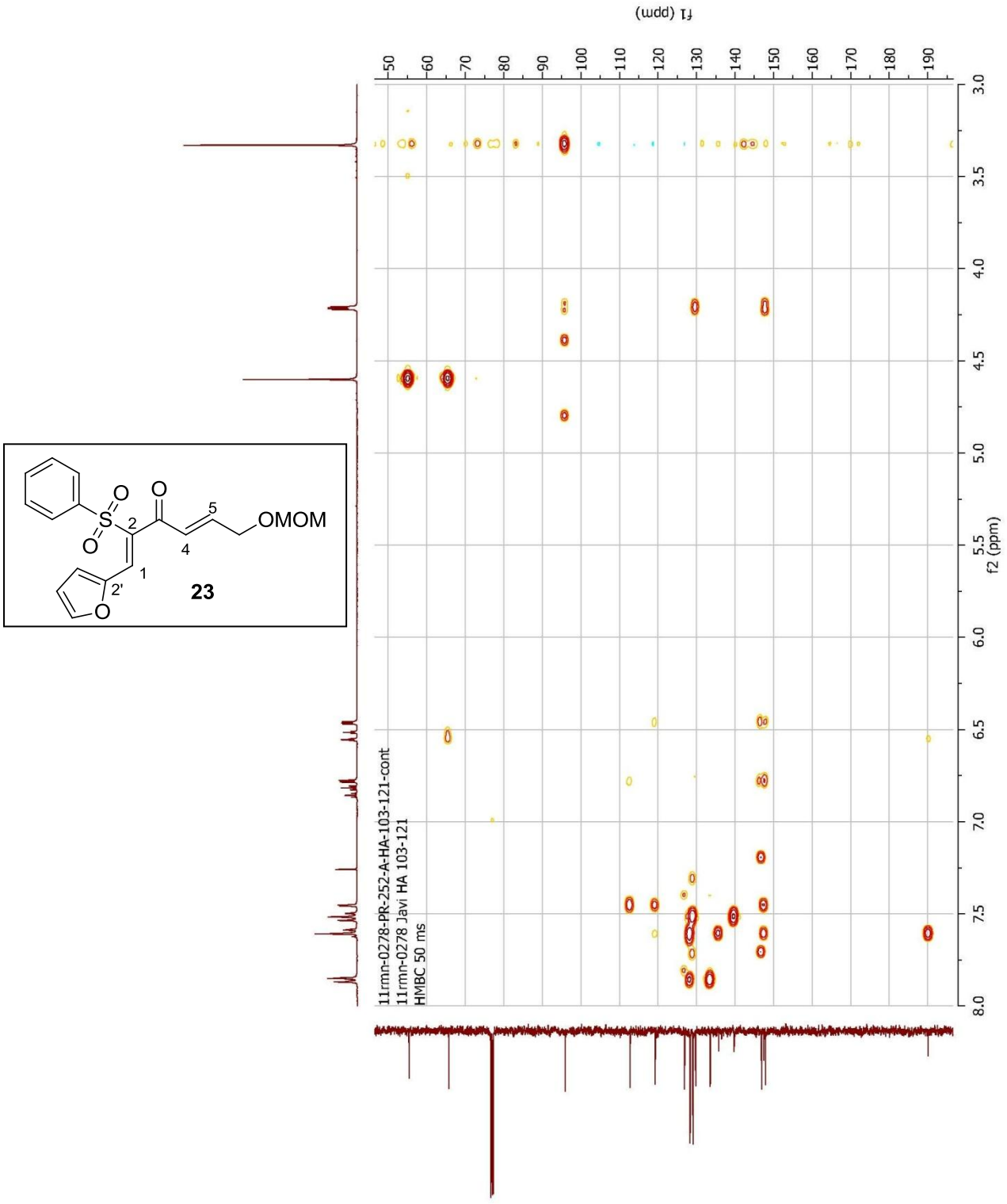


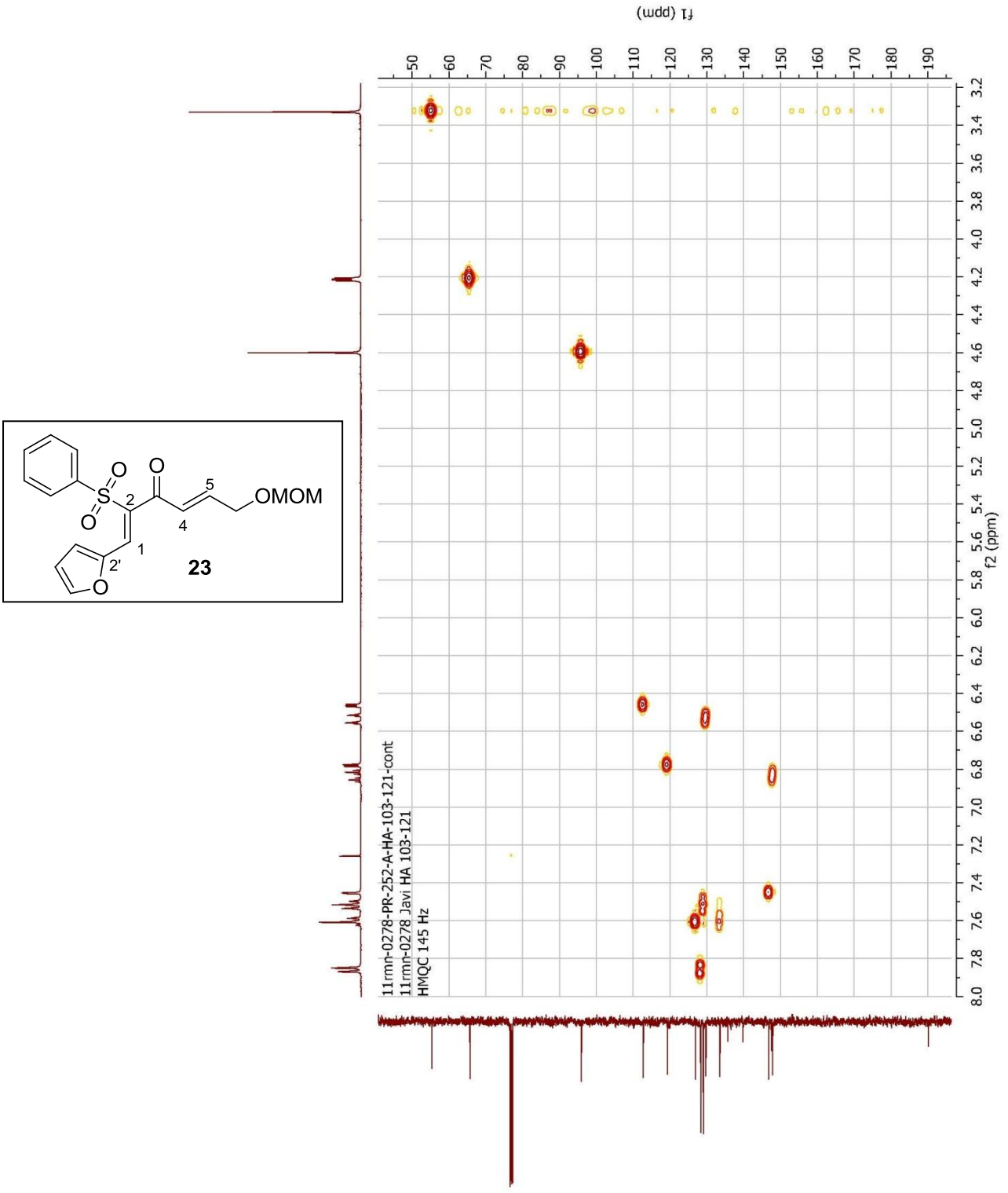


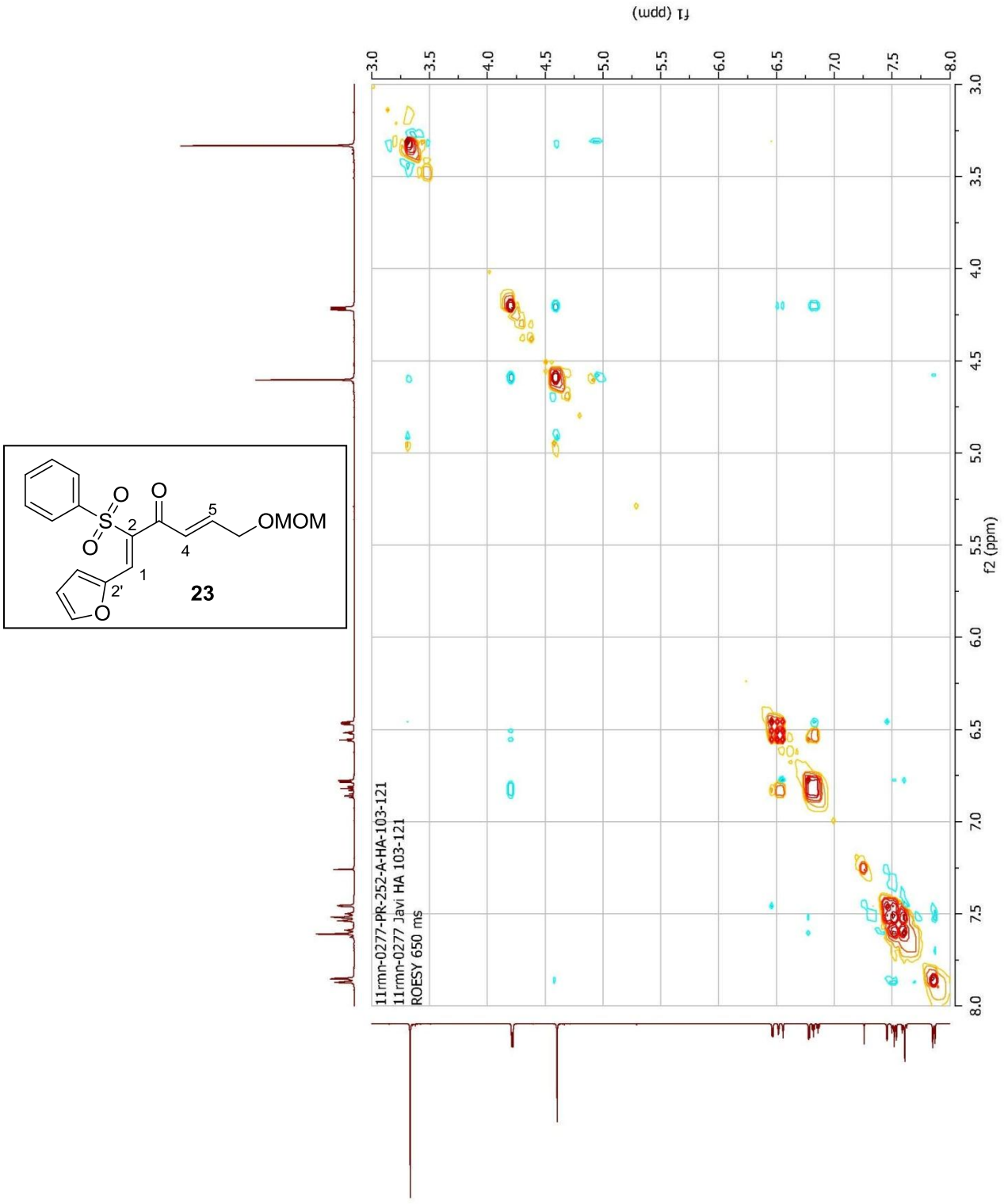
Formula	CalculatedMass	mDaError	ppmError	RDB
C27 H17 N4	397.144773	-0.073132	-0.184144	21.5
C21 H26 O4 Na S	397.144403	0.29748	0.749046	8.5

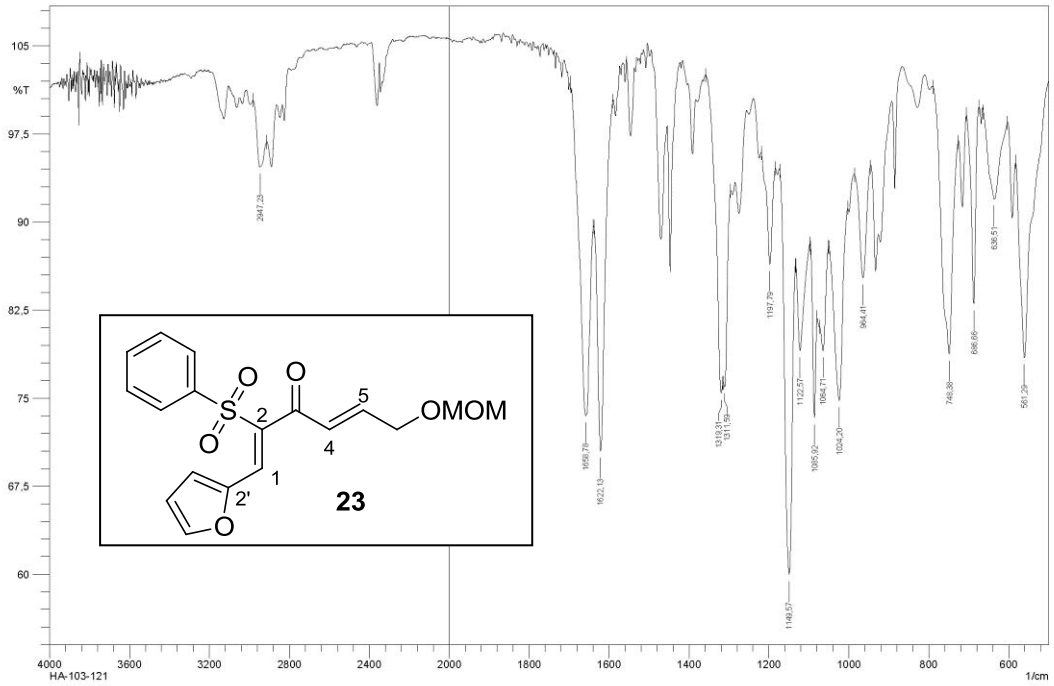



f1 (ppm)
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
f2 (ppm)
11rmn-0278-PR-252-A-HA-103-121-cont
11rmn-0278 Javi HA 103-121
COSY
O
O
S
O
2
5
OMOM
4
1
2'
O
23


f1 (ppm)
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
f2 (ppm)
11rmn-0278-PR-252-A-HA-103-121-cont
11rmn-0278 Javi HA 103-121
HMBC 50 ms
O
O
S
O
2
5
OMOM
4
1
2'
O
23


f1 (ppm)
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
f2 (ppm)
3.2
3.4
3.6
3.8
4.0
4.2
4.4
4.6
4.8
5.0
5.2
5.4
5.6
5.8
6.0
6.2
6.4
6.6
6.8
7.0
7.2
7.4
7.6
7.8
8.0
11rmn-0278-PR-252-A-HA-103-121-cont
11rmn-0278 Javi HA 103-121
HMQC 145 Hz
O
O
S
O
2
5
OMOM
4
1
2'
O
23


f1 (ppm)
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
f2 (ppm)
11rmn-0277-PR-252-A-HA-103-121
11rmn-0277 Javi HA 103-121
ROESY 650 ms
O
O
S
O
2
5
OMOM
4
1
2'
O
23



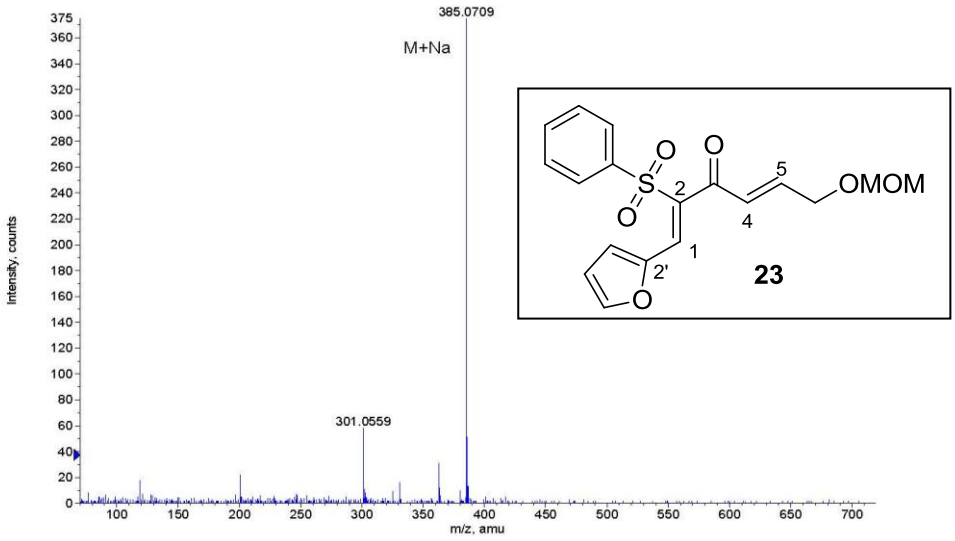
S. G. Espectrometria de Masas
Emitido por: César Raposo
(Responsable SGEM)

Plaza de los Caídos 1-5
37008 Salamanca

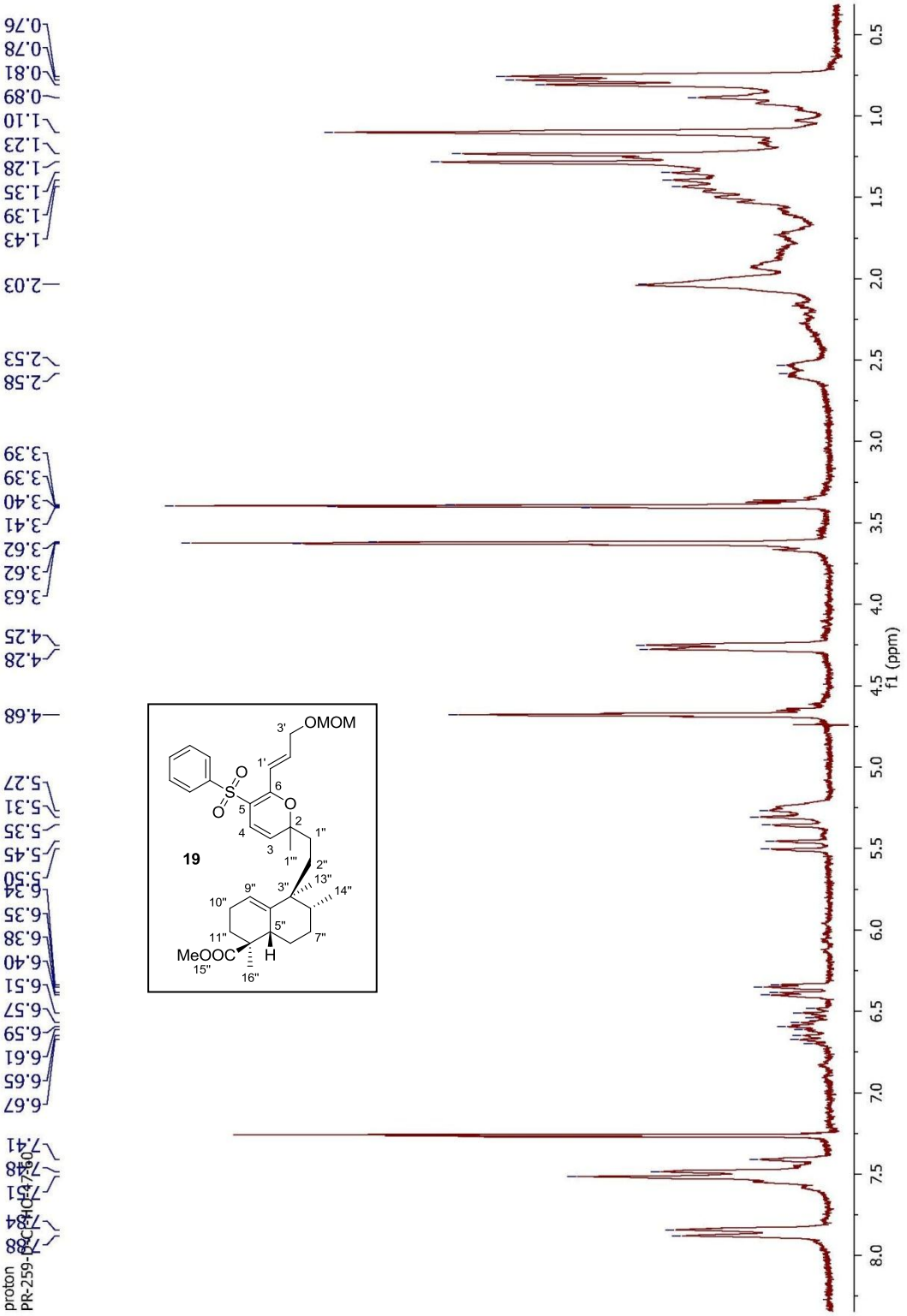
página 1 de 1
11/15/2011
Masa exacta

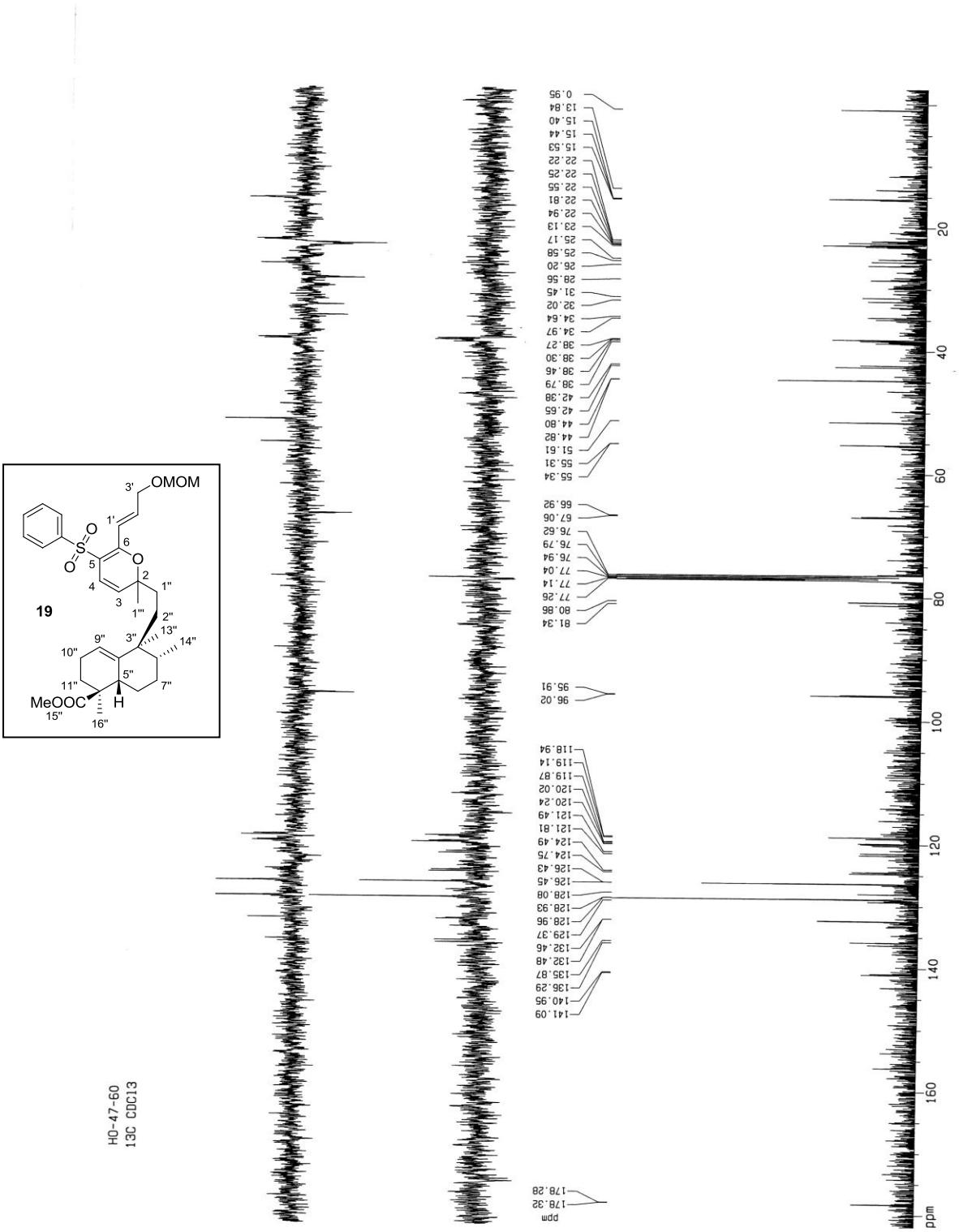
+TOF MS: 0.567 min from Sample 4 (cr- ha- 103-121) of nov1511l8.wiff
a=3.56661378329134110e-004, t0=-3.53331440221918460e+001 R:, subtracted (0.034 to 0...

Max. 375.0 counts.



Formula	CalculatedMass	mDaError	ppmError	RDB
H13 N14 O9 S	385.070517	0.383388	0.995628	1.5
C16 H13 N6 O4 S	385.071351	-0.451348	-1.172115	13.5
C15 H10 N10 Na S	385.070283	0.6166	1.601261	15.5
C18 H18 O6 Na S	385.071631	-0.73148	-1.899596	9.5

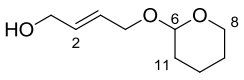

0.76
0.78
0.81
0.89
1.10
1.23
1.28
1.35
1.39
1.43
2.03
2.53
2.58
3.39
3.39
3.40
3.41
3.62
3.62
3.63
4.25
4.28
4.68
5.27
5.31
5.35
5.45
5.50
6.34
6.35
6.38
6.40
6.51
6.57
6.59
6.61
6.65
6.67
7.41
7.48
7.51
7.84
7.88
proton
PR-259-CDCl3-7760
OMOM
3'
1'
6
O
S
O
O
5
4
3
2
1"
1'"
2"
13"
14"
3"
9"
10"
11"
5"
7"
MeOOC
15"
16"
H
19
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
f1 (ppm)



1. General

Unless otherwise stated, all chemicals were purchased as the highest purity commercially available and were used without further purification, except for **1a**,[1] 10-hydroxycitral **15**,[2] farnesal,[3] **18**[4] and **20**[5] which were synthesised according to the literature procedures. IR spectra were recorded on a BOMEM 100 FT-IR or an AVATAR 370 FT-IR Thermo Nicolet spectrophotometers. ^{1}H and ^{13}C NMR spectra were performed in $CDCl_3$ and referenced to the residual peak of $CHCl_3$ at δ 7.26 ppm and δ 77.0 ppm, for ^{1}H and ^{13}C, respectively, using Varian 200 VX and Bruker DRX 400 instruments. Chemical shifts are reported in δ ppm and coupling constants *(J)* are given in hertz. MS were performed at a VG-TS 250 spectrometer at 70 eV ionising voltage. Mass spectra are presented as *m/z* (% rel int.). HRMS were recorded on a VG Platform (Fisons) spectrometer using chemical ionisation (ammonia as gas) or Fast Atom Bombardment (FAB) technique. For some of the samples, QSTAR XL spectrometer was employed for electrospray ionisation (ESI). Optical rotations were determined on a Perkin-Elmer 241 polarimeter in 1 dm cell. HPLC analysis were carried out on a CHIRALCEL™ AD-H column [cellulose tris(3,5-dimethylphenycarbamate)] on silica gel using *n*-hexane/isopropyl alcohol. Column chromatography was performed using silica gel 60 (230-400 mesh), with solvent systems indicated in the relevant experimental procedures. Dichloromethane was distilled from calcium hydride; tetrahydrofuran and diethyl ether were distilled from sodium/benzophenone ketyl under argon atmosphere prior to use. Hexane was distilled prior to use.

2. Synthesis of the Nazarov reagents, 1b-1d.



26

2.1 Monoprotection of (*E*)-1,4-butanediol with DHP: (*E*)-4-((tetrahydro-2*H*-pyran-2-yl)oxy)but-2-en-1-ol, 26.

(*E*)-1,4-butanediol (4 ml, 48.66 mmol) was dissolved in 194 ml of DCM under Ar at r.t. 3,4-Dihydro-2*H*-pyran (97%, 4.22g, 48.66 mmol) and *p*-toluenesulfonic acid monohydrate (93 mg, 0.486 mmol) were added and left to stir for 3 h. The reaction was quenched with a $NaHCO_3$ saturated solution, and extracted with DCM. The combined organics were washed with H_2O, brine, dried (Na_2SO_4), filtered and concentrated *in vacuo* to afford **26** (8.01 g, 96%). υ_{max} (liquid film) 3417, 2943, 2870, 1454, 1352, 1261, 1134; δ_H (200 MHz; $CDCl_3$) 5.88-5.33 (2H, m, H2 and H3), 4.67-4.60 (1H, m, H6), 4.32-3.99 (4H, m, H1 and H4), 3.92-3.71 (1H, m, $H8_a$), 3.57-3.40 (1H, m, $H8_b$), 1.91-1.36 (6H, m, H9, H10, and H11); δC (50 MHz; $CDCl_3$) 132.6, 127.3, 97.6, 62.6, 62.0, 57.9, 30.5, 25.4, 19.3; EIHRMS: Calcd for $C_9H_{16}O_3$ (M+Na): 195.0592; found: 195.0991 (M+Na).

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