Electronic Supplementary Material (ESI) for MedChemComm.

Supplementary material

Development of selective agents targeting $5HT_{1A}$ receptor with subnanomolar activities based on coumarin core

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Contents

Single crystal X-ray diffraction data

The X-ray measurements of **3b** and **6d** were performed at 100(2) K on a Bruker D8 Venture Photon100 diffractometer equipped with a TRIUMPH monochromator and a MoK_α fine focus sealed tube (λ=0.71073 Å). The frames were collected with Bruker APEX2 program[S1] and integrated with the Bruker SAINT software package[S2] using a narrow-frame algorithm. The deposition number CCDC 1541420 for **3b** and CCDC 1541465 for **6d** contains the supplementary crystallographic data for this paper. These data can be obtained free of chargé via www.ccdc.cam.ac.uk or by contacting The Cambridge Crystallographic Data Centre, 12, Union Road, Cambridge CB2 1EZ, UK; fax 44 1223 336033

Crystals of 6-acetyl-4,7-dimethyl-5-[3-(morpholin-4-yl)propoxycoumarin **6d** are twinned by pseudomerohedry with every third layer of reflections: 0*kl*, 3*kl*, $\overline{3}kl$, 6*kl*, $\overline{6}kl$, … almost ideally overlapped (see Figure S1). The twin lattice has pseudo orthorhombic symmetry with base-centered unit cell and twin obliquity calculated for (100) plane and [610] lattice vector equal to 0.38º. The twin domains are related by the (100) mirror reflection and compared with the single component real lattice. At the twin boundary the morpholine groups are meshed together similarly as in the single lattice of **6d**. In the crystals of 6-acetyl-4,7-dimethyl-5-[3-(morpholin-4-yl)propoxycoumarin **6d** two methyl groups (C9A/C9B and C12A/C12B) have disordered hydrogen atoms over two positions. These positions however are not equally occupied by the H atoms. This observation is confirmed by H-NMR measurement of the crystalline powder of **6d** where the signal splitting for C9 and C12 methyl groups is visible. The structure of **6d**, due to the lack of typical hydrogen bond donors, is dominated by weak interactions. The molecule of 4,7-dimethyl-5-{3-[4-(2-fluorophenyl)piperazin-1-yl]propoxy}coumarin (**3b**) is shorter C_3H_6 linker analogue of the 4,7-dimethyl-5-{4-[4-(1-fluorobenzyl)-piperazin-1-yl]-butoxy} coumarin[S3] which has four carbon atoms aliphatic chain between chromene and piperazine fragments. Due to different conformation of these molecules their packing in the crystal lattices is different. Similarly as in the **6d** structure in the **3b** there are also only weak intermolecular interactions. The shortest contacts are observed between two neighboring coumarin fragments with O…H distance yielding 2.52 Å.

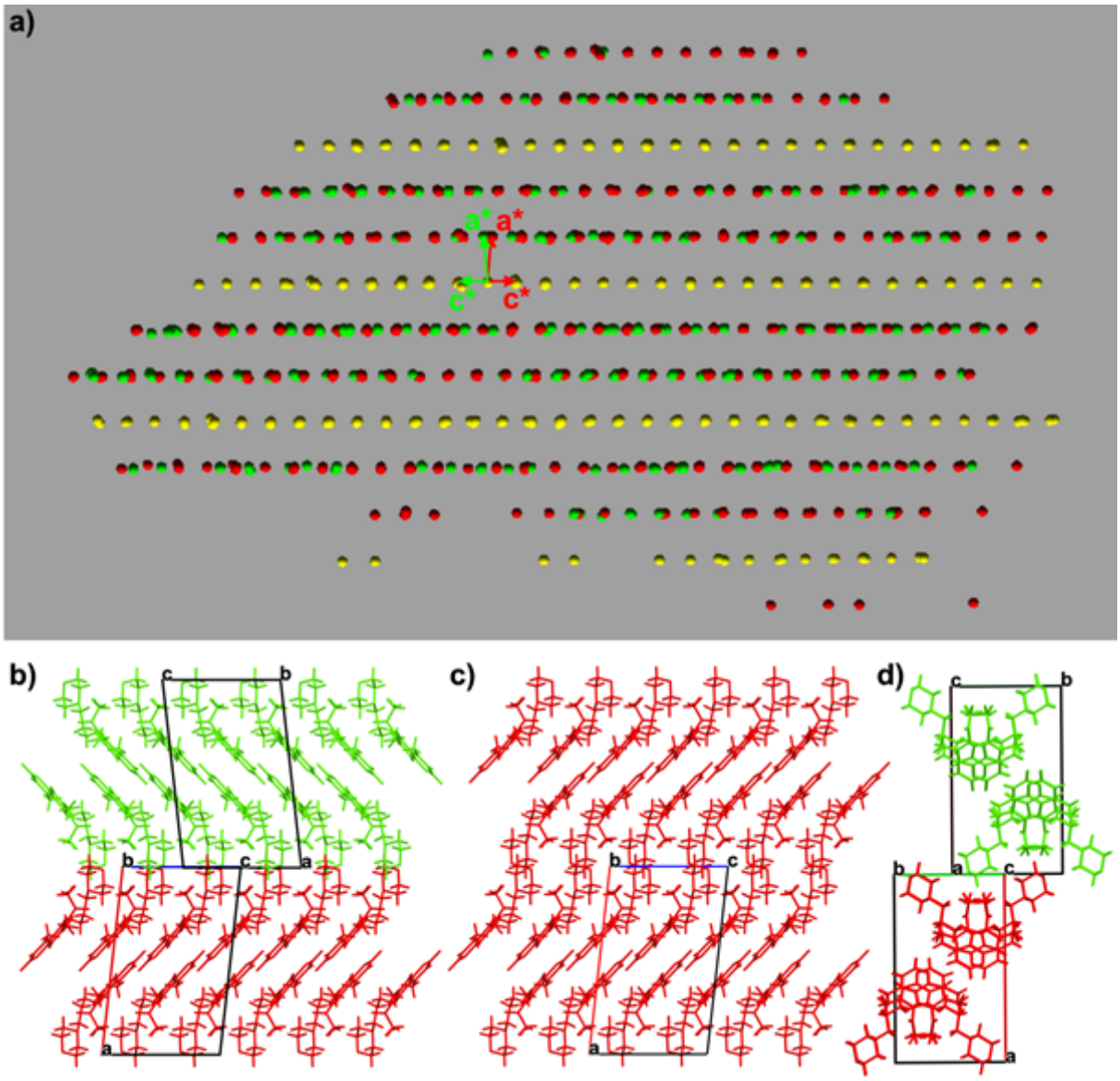


Figure S1 Twining of the crystals of 6-acetyl-4,7-dimethyl-5-[3-(morpholin- 4-yl)propoxycoumarin **6b** – visualization of reciprocal lattice – composite reflections are coloured in yellow a); possible relation between twin real lattices b), d); visualization of single component real lattice c).

The crystal of **6d** is twinned with part of reflection separated and the others overlapped, thus the further processing of the data was based on two twin domains. The integration of the diffraction spots using a monoclinic unit cell yielded a total of 27947 reflections to a maximum θ angle of 25.43° (0.83 Å resolution), of which 3346 were independent (average redundancy 8.352, completeness = 99.6%, R_{int}=4.98%, R_{sig}=4.62%) and 2502 (74.78%) were greater than $2\sigma(F^2)$. The final cell constants of a=17.1277(16) Å, b=9.9821(9) Å,

c=10.6929(9) Å, β=96.349(2)°, V=1817.0(3) Å^3, are based upon the refinement of the XYZ-centroids of 9147 reflections above 20 $\sigma(I)$ with 5.922° < 2θ < 50.87° belonging to two twin components. Data were corrected for absorption effects using the multi-scan method (TWINABS).[S4] The ratio of minimum to maximum apparent transmission was 0.830. The calculated minimum and maximum transmission coefficients (based on crystal size) are 0.9580 and 0.9940. The structure was solved and refined using SHELXTL software package[S5] using the space group $P2_1/c$, with Z=4 for the formula unit, $C_{20}H_{25}NO_5$, with HKLF5 reflection format based on two components of the twin. The refinement gave twin fractions equal to 0.805(1) and 0.195(1). After the refinement converged the reflection file was converted to HKLF4 format with help of WinGX software.[S6] The final anisotropic full-matrix least-squares refinement on F^2 with 242 variables converged at $R1$=4.40%, for the observed data and $wR2$=12.38% for all data. The goodness-of-fit was 1.065. The largest peak in the final difference electron density synthesis was 0.295 e$^-$/Å^3 and the largest hole was -0.240 e$^-$/Å^3 with an RMS deviation of 0.049 e$^-$/Å^3. On the basis of the final model, the calculated density was 1.314 g/cm^3 and F(000), 768 e$^-$. In the crystal lattice of DG405 two methyl groups are disordered with hydrogen atoms occupying alternative positions. Relative orientation of H atoms of each CH_3 group was refined together with the occupancy ratio yielding 0.74(2):0.26(2) and 0.17(3):0.83(3) for C9A/C9B and C12A/C12B methyl group respectively.

The structure of **6b**, due to the lack of typical hydrogen bond donors, is dominated by weak interactions. These interactions are visualized in Figure 2S with the help of Hirshfeld surface analysis approach[S7] performed in CrystalExplorer software.[S8] The closest interatomic contacts can be observed between carbonyl O atom of the coumarin fragment and one of the H atom of the ordered methyl group as sharp spikes in the fingerprint plot[S6] displayed in Figure S2b), with the O…H distance equal to 2.44 Å. In the structure there are also some intermolecular contacts between carbon coumarin fragment atoms corresponding to π-π interactions (see Figure S2). The average distance between RMS planes[S9] fitted to chromene skeleton of neighboring molecules is equal to 3.53 Å. The rings have a large parallel separation, thus the overlay of the chromene skeletons is limited to C3 and C4 atoms of the ring. The other part of this molecule interacts with another chromene moiety which is, however, slightly tilted but with intermolecular distance from C2 atom to the average plane equal to 3.78 Å.

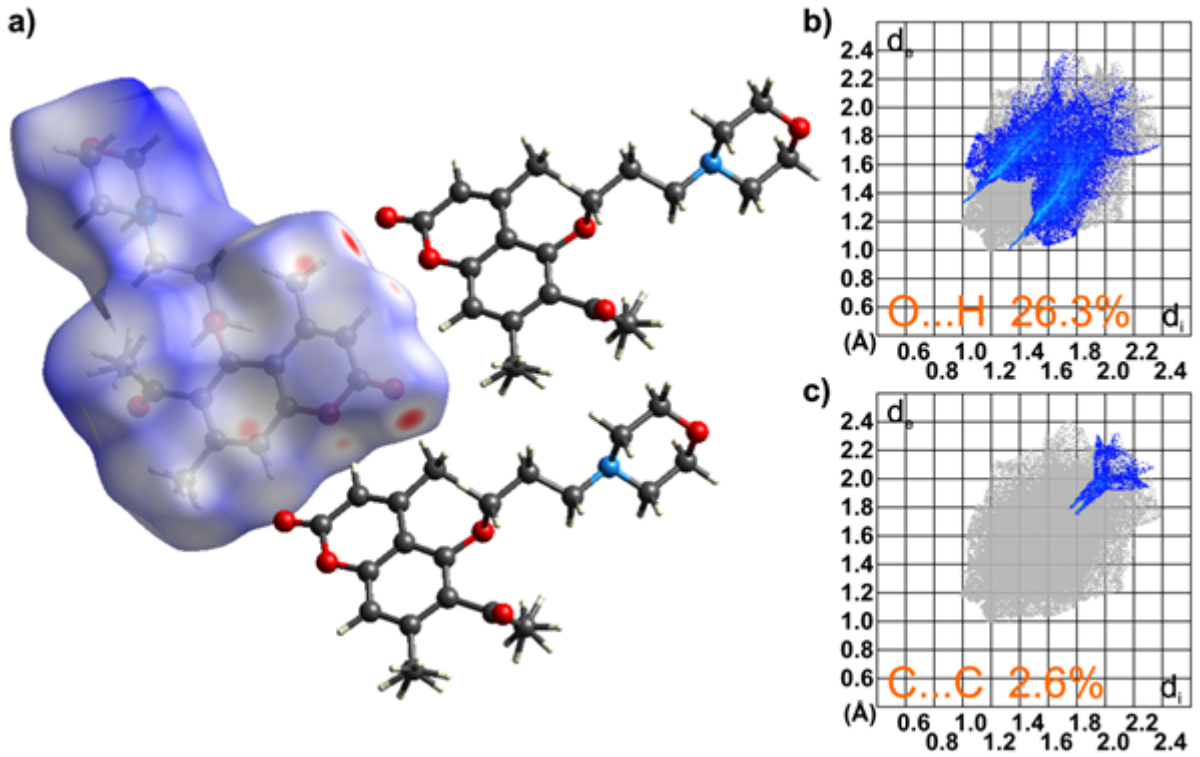


Figure S2 Hirshfeld surface generated for **6b** a) with selected 2D fingerprint plots presenting d_e and d_i distances for O…H a) and C…C b) atomic pairs in the crystal lattice.

In the case of **3b** the frames were integrated with the Bruker SAINT software package[S4] using a narrow-frame algorithm. The integration of the data using a triclinic unit cell yielded a total of 22213 reflections to a maximum θ angle of 25.05° (0.84 Å resolution), of which 3690 were independent (average redundancy 6.020, completeness = 99.8%, R_{int}=2.26%, R_{sig}=1.32%) and 3303 (89.51%) were greater than $2\sigma(F^2)$. The final cell constants of a=7.7995(6) Å, b=9.8117(8) Å, c=14.8527(12) Å, α=78.6250(19)°, β=82.4050(18)°, γ=69.9762(18)°, V=1044.36(14) Å^3, are based upon the refinement of the XYZ-centroids of 9962 reflections above 20 $\sigma(I)$ with 6.037° < 2θ < 50.75°. Data were corrected for absorption effects using the multi-scan method (SADABS).[S10] The ratio of minimum to maximum apparent transmission was 0.930. The calculated minimum and maximum transmission coefficients (based on crystal size) are 0.9390 and 0.9880. The structure was solved and refined using SHELXTL Software Package[S5] using the space group $P\,\bar{1}$, with Z=2 for the formula unit, $C_{24}H_{27}FN_2O_3$. The final anisotropic full-matrix least-squares refinement on F^2 with 274 variables converged at $R1$=3.32%, for the observed data and $wR2$=8.99% for all data. The goodness-of-fit was 1.042. The largest peak in the final difference electron density synthesis was 0.199 e$^-$/Å^3 and the

largest hole was -0.198 $e^-/Å^3$ with an RMS deviation of 0.037 $e^-/Å^3$. On the basis of the final model, the calculated density was 1.305 g/cm^3 and F(000), 436 e^-.

Similarly as in the **6d** structure in the **3b** there are also only weak intermolecular interactions. The shortest contacts are observed between two neighboring coumarin fragments with O…H distance yielding 2.52 Å. This is visualized in Figure S3a, which shows also the Hirshfeld surface[S7,S8] generated for one molecule. The fingerprint plot[S9] for O…H contacts are shown in Figure S3b with wide spikes corresponding to O…H interaction between two coumarin fragments.

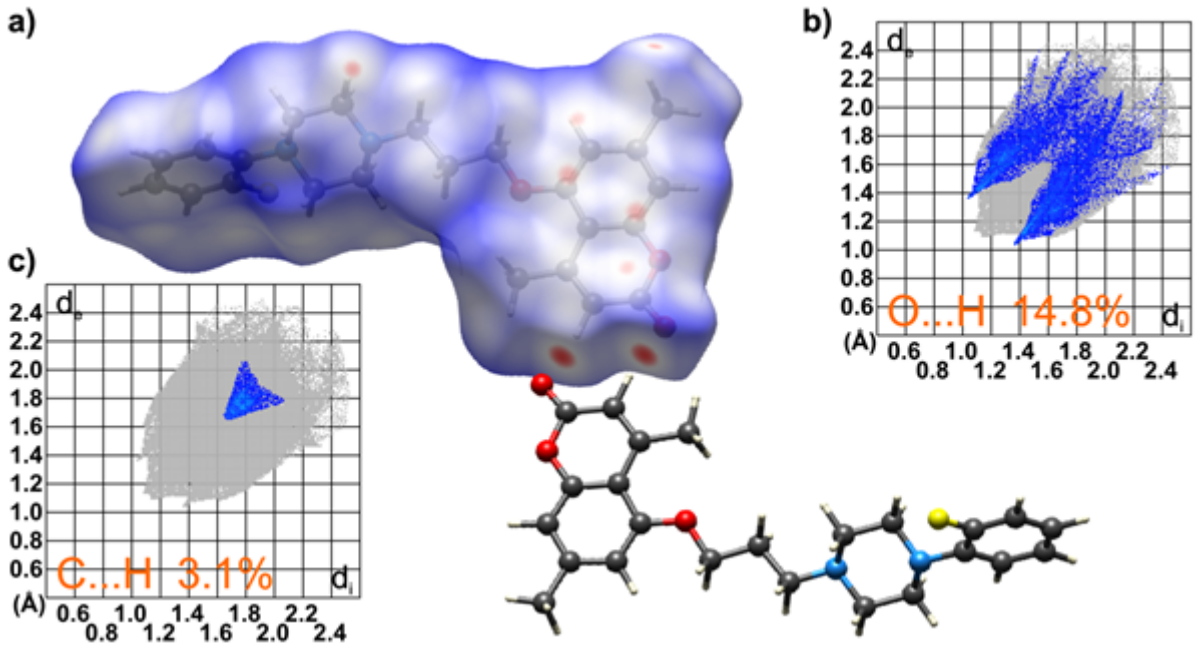


Figure S3 Hirshfeld surface generated for **3b a)** with selected 2D fingerprint plots presenting d_e and d_i distances for O…H **a)** and C…C **b)** atomic pairs in the crystal lattice.

In the structure of 4,7-dimethyl-5-{3-[4-(2-fluorophenyl)piperazin-1-yl]propoxy}coumarin **3b** the π-π interaction between two neighboring coumarin fragments is more pronounced that in the case of **6d**. Indeed C…C distances for **3b** are shorter than in **6d** (see Figures S2c and S3c). In **3b** coumarin fragments are forming dimmers with average distance between RMS planes[S10] fitted to the chromene skeleton of 3.30 Å what is presented in Figure S4.

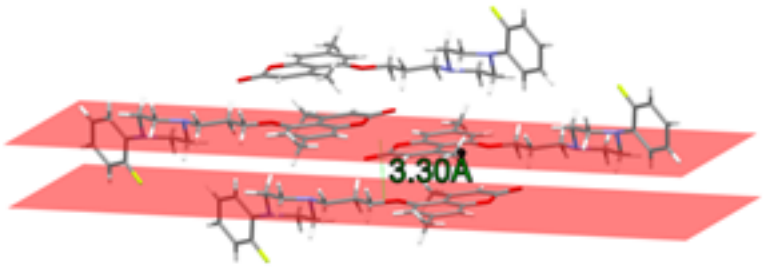


Figure S4 Stacking of molecules in the structure of 4,7-dimethyl-5-{3-[4-(2-fluorophenyl)piperazin-1-yl]propoxy}coumarin **3b**.

In the case of both structures all non-hydrogen atoms were refined anisotropically. All hydrogen atoms were placed in calculated positions and refined within the riding model. All CH_3 groups, including disordered ones in **6d**, were free to rotate along C-C bonds. The temperature factors of hydrogen atoms were not refined and were set to be equal to either 1.2 or 1.5 times larger than U_{eq} of the corresponding heavy atom. The atomic scattering factors were taken from the International Tables[S12] molecular graphics was prepared using Diamond 3.2.[S13] Crystal data and refinement parameters for **3b** and **6d** are collected in Table S1.

Table S1

Identification code	**6b**	**3a**
Chemical formula	$C_{20}H_{25}NO_5$	$C_{24}H_{27}FN_2O_3$
M	359.41	410.47
***T*/ K**	100(2)	100(2)
***λ*/ Å**	0.71073	0.71073
Crystal size/ mm	0.068×0.327×0.456	0.134×0.292×0.694
Crystal system	monoclinic	triclinic
Space group	$P2_1/c$	$P\bar{1}$
Unit cell dimensions	*a*=17.1277(16)Å *b*=9.9821(9)Å *c*=10.6929(9)Å *β*=96.349(2)°	*a*=7.7995(6)Å *b*=9.8117(8)Å *c*=14.8527(12)Å *α*=78.6250(19)° *β*=96.349(2)° *γ*=69.9762(18)°
***V*/ Å^3**	1817.0(3)Å^3	1044.36(14)Å^3
***Z*, D_x/ g·cm^{-3}**	4, 1.314	2, 1.305
***μ*/ mm^{-1}**	0.094	0.092
***F*(000)**	768	436
θ_{min}, θ_{max}	2.96°, 25.43°	2.95°, 25.05°

Reflections collected/ independent	27947/ 3346 [R_{int}=0.0498]*	22213/ 3690 [R_{int}=0.0226]
Completeness	99.6%	99.8%
Absorption correction	multi-scan	multi-scan
T_{max}, T_{min}	0.994, 0.958	0.998, 0.939
Data / restraints / parameters	3346 / 0 / 242	3690 / 0 / 274
GooF F^2	1.065	1.042
Final R indices	2502 data; $I>2\sigma(I)$ $R1$=0.0440, $wR2$=0.1122 all data $R1$=0.0553, $wR2$=0.1238	3303 data; $I>2\sigma(I)$ $R1$=0.0332, $wR2$=0.0859 all data $R1$=0.0377, $wR2$=0.0899
ρ_{max}, ρ_{min}	0.295 eÅ^{-3}, -0.240 eÅ^{-3}	0.199 eÅ^{-3}, -0.198 eÅ^{-3}

* Data scaling based on two twin components with HKLF5 refinement giving twin fractions equal to 0.805(1) and 0.195(1). Final refinement performed on merged reflections in HKLF4 format with twinning effect included.

S1 APEX2. Bruker AXS Inc., Madison, Wisconsin, USA, 2013

S2 SAINT. Bruker AXS Inc., Madison, Wisconsin, USA, 2013.

S3 K. Ostrowska, D. Grzeszczuk. D. Maciejewska, I. Młynarczuk-Biały, A. Czajkowska, A. Sztokfisz, Ł. Dobrzycki and H. Kruszewska *Monatsh. Chem.*, 2016, **147**, 1615.

S4 TWINABS. Bruker AXS Inc., Madison, Wisconsin, USA, 2012.

S5 G. M. Sheldrick, *Acta Crystallogr.,* 1990, **A46**, 467.

S6 L. J. Farrugia *J. Appl. Cryst.*, 2012, **45**, 849.

S7 M. A. Spackman and D. Jayatilaka, *Cryst. Eng. Comm.,* 2009, **11**, 19.

S8 S. K. Wolff, D. J. Grimwood, J. J. McKinnon, M. J. Turner, D. Jayatilaka and M. A. Spackman, University of Western Australia, CrystalExplorer, 2012.

S9 M. A. Spackman, and J. McKinnon J. Fingerprinting intermolecular interactions in molecular crystals. *Cryst. Eng. Comm.,* **2002**, 4, 378.

S10 C. F. Macrae, I. J. Bruno, J. A. Chisholm, P. R. Edgington, P. McCabe, E. Pidcock, L. Rodriguez-Monge, R. Taylor, J. van de Streek and P. A. Wood, *J. Appl. Cryst.,* **2008**, 41, 466.

S11 SADABS, Bruker AXS Inc., Madison, Wisconsin, USA, 2012.

S12 A. J. C. Wilson. *International Tables for Crystallography*. Kluwer: Dordrecht, 1992.

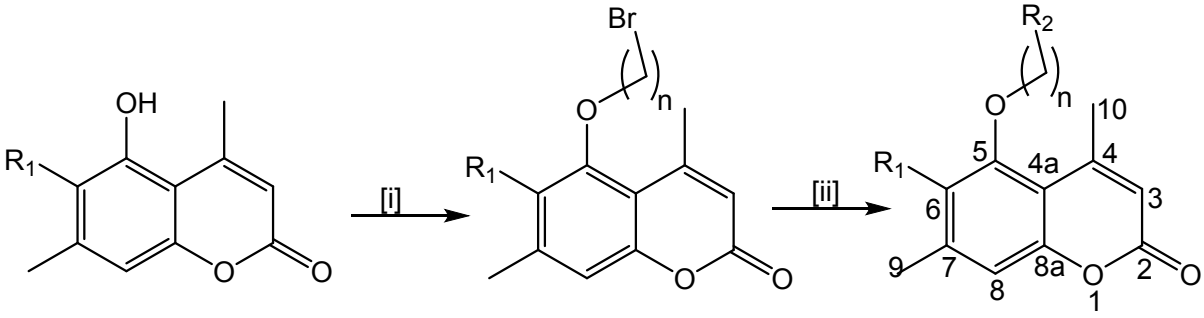
S13 Diamond – Crystal and Molecular Structure Visualization Crystal Impact – K. Brandenburg & H. Putz GbR, Rathausgasse 30, D-53111 Bonn, 2012.

ADME analysis

molecule	problems[a]	MW[b]	dipole[c]	SASA[d]	volume[e]	donorHB[f]	accptHB[g]	glob[h]	logP[i]	Ro5[j]	Ro3[k]
3a	0	424.51	8.70	768.98	1379.41	0	6.25	0.78	4.62	0	0
3b	0	410.49	9.71	732.31	1316.40	0	6.25	0.79	4.22	0	0
3c	0	424.51	8.70	768.98	1379.41	0	6.25	0.78	4.62	0	0
3d	0	452.52	5.73	772.93	1408.08	0	8.25	0.79	3.579	0	0
4a	0	408.50	7.12	769.84	1362.50	0	8.25	0.77	3.137	0	1
4b	0	394.47	7.88	727.88	1291.23	0	8.25	0.79	2.676	0	1
4c	0	450.54	5.10	790.37	1440.06	0	10.25	0.78	2.467	0	1
4d	0	436.51	5.03	756.48	1378.15	0	10.25	0.79	2.07	0	1
5a	0	436.55	7.39	796.07	1444.61	0	7	0.78	4.545	0	0
5b	0	422.52	7.18	755.04	1369.73	0	7	0.79	4.024	0	0
5c	0	478.59	7.34	810.50	1518.20	0	9	0.79	3.792	0	0
5d	0	464.56	5.45	808.09	1473.45	0	9	0.77	3.487	0	0
6a	0	331.41	7.59	636.53	1120.21	0	6.95	0.82	2.302	0	0
6b	0	317.38	7.68	598.65	1055.54	0	6.95	0.84	1.867	0	0
6c	0	373.45	4.67	663.95	1200.96	0	8.95	0.82	1.652	0	0
6d	0	359.42	6.46	620.30	1132.24	0	8.95	0.85	1.142	0	0
7a	0	451.52	7.82	794.94	1436.93	0	7.25	0.77	3.686	0	0
7b	0	437.49	6.25	768.72	1380.31	0	7.25	0.78	3.284	0	0
7c	0	493.56	9.39	831.20	1527.27	0	9.25	0.77	3.099	0	0
7d	0	479.53	8.34	791.08	1451.43	0	9.25	0.78	2.498	0	0
8a	0	440.97	7.45	780.25	1407.92	0	6.25	0.78	4.943	0	1
8b	0	426.94	9.91	741.96	1339.08	0	6.25	0.79	4.474	0	0
8c	0	483.01	6.68	802.56	1482.52	0	8.25	0.78	4.166	0	0
8d	0	468.98	3.80	795.04	1442.77	0	8.25	0.78	3.935	0	0
9a	0	475.41	6.02	803.59	1447.53	0	6.25	0.77	5.343	1	1
9b	0	461.39	9.75	767.97	1385.81	0	6.25	0.78	4.927	0	1
9c	0	517.45	7.41	825.85	1528.87	0	8.25	0.78	4.669	1	0
9d	0	503.42	2.51	792.57	1463.55	0	8.25	0.79	4.23	1	0
10a	0	431.53	7.56	796.83	1429.93	0	7.75	0.77	3.682	0	1
10b	0	417.51	12.39	766.70	1369.61	0	7.75	0.78	3.276	0	0
10d	0	459.54	7.36	805.52	1465.82	0	9.75	0.77	2.729	0	0
11a	0	407.51	7.44	760.96	1355.93	0	7.75	0.78	3.403	0	0
11b	0	393.49	9.80	710.01	1280.83	0	7.75	0.80	2.923	0	0
11c	0	449.55	3.16	800.64	1449.74	0	9.75	0.77	2.831	0	0
11d	0	435.52	6.20	758.67	1383.27	0	9.75	0.79	2.343	0	0

[a]problems – number of property or descriptor values that fall outside the 95% range of similar values for known drugs; [b]MW - molecular weight (Da); [c]dipole - dipole moment (D); [d]SASA - solvent accessible surface (Å^2); [e]volume - total molecular volume (Å^3); [f]donorHB - estimated number of hydrogen bonds that would be donated by the solute to water molecules in an aqueous solution; [g]accptHB - estimated number of hydrogen bonds that would be accepted by the solute from water molecules in an aqueous solution; [h]glob - globularity descriptor defined as $4\pi r^2$/SASA; [i]logP - octanol/water partition coefficient; [j]Ro5 - number of violations of Lipinski's rule of five; [k]Ro3 . number of violations of Jorgensen's rule of three.

NMR and HR-MS spectra analysis



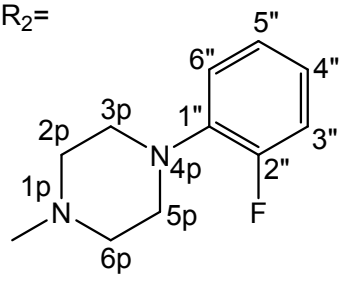
1a R_1=H
1b R_1=$COCH_3$

2a R_1=H, n=4
2b R_1=H, n=3
2c R_1=$^{11}C^{12}OCH_3$, n=4
2d R_1=$^{11}C^{12}OCH_3$, n=3

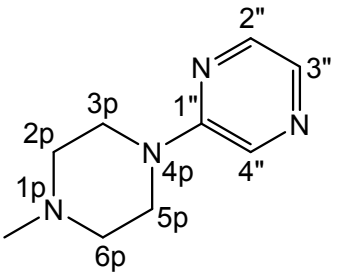
3a-11a R_1=H, n=4
3b-11b R_1=H, n=3
3c-10c R_1=$^{11}C^{12}OCH_3$, n=4
3d-10d R_1=$^{11}C^{12}OCH_3$, n=3

p=piperazine

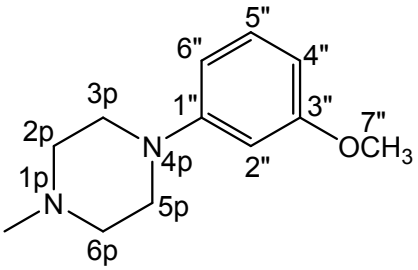
R_2=



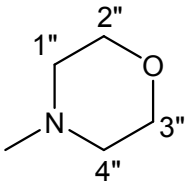
3a, 3b, 3c, 3d



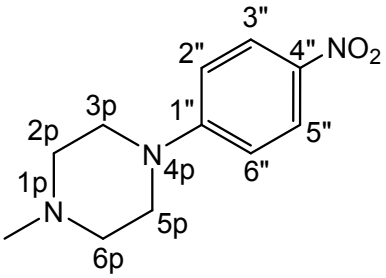
4a, 4b, 4c, 4d



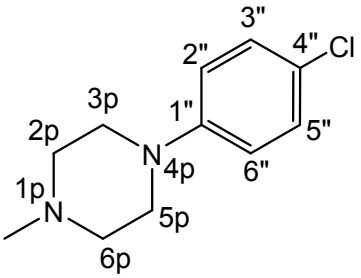
5a, 5b, 5c, 5d



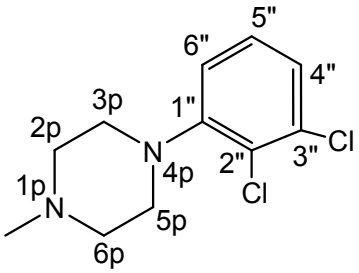
6a, 6b, 6c, 6d



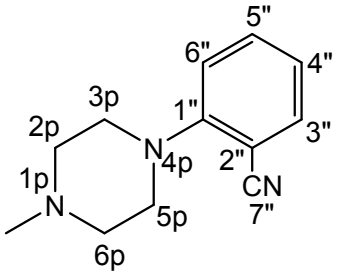
7a, 7b, 7c, 7d



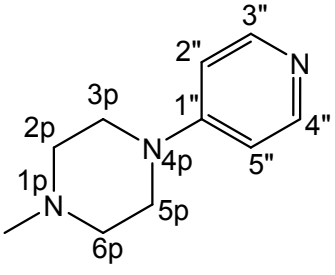
8a, 8b, 8c, 8d



9a, 9b, 9c, 9d



10a, 10b, 10d



11a, 11b, 11c, 11d

[i]: $Br(^{1'-3'}CH_2)_3Br$ or $Br(^{1'-4'}CH_2)_4Br$, KI, K_2CO_3, ACN, MW
[ii]: HR_2; KI, K_2CO_3, ACN, MW

4.2.1 5-(3-bromopropoxy)-4,7-dimethylcoumarin (**2b**)

White solid, MP**:** 135-137 °C, yield 99 %, Rf = 0.62, ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.77 (1H, m, H-8), 6.56 (1H, d, *J* = 0.9 Hz, H-6), 6.06 (1H, d, *J* = 1.2 Hz, H-3), 4.20 (2H, t, *J* = 5.8 Hz, H-1'), 3.60 (2H, t, *J* = 6.3 Hz, H-3'), 2.56 (3H, d, *J* = 1.5 Hz, H-9), 2.40 (5H, m, H-10, H-2'); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 161.0 (C-2), 157.0 (C-8a), 155.6 (C-4), 153.8 (C-5), 143.3 (C-7), 113.9 (C-3), 110.8 (C-8), 108.4 (C-4a), 108.2 (C-6), 66.7 (C-1'), 32.3 (C-2'), 29.8 (C-3'), 24.7 (C-10), 22.2 (C-9); TOF MS ES+: $[M+Na]^+$ calcd for $C_{14}H_{15}O_3Na$ Br (333.1418) found 333.0100.

4.2.2 6-acetyl-5-(3-bromopropoxy)-4,7-dimethylcoumarin (**2d**)

White solid, MP**:** 146-148 °C, yield 90 %, Rf = 0.54, ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.99 (1H, d, *J* = 0.9 Hz, H-8), 6.19 (1H, d, *J* = 1.5 Hz, H-3), 3.96 (2H, t, *J* = 6.1 Hz, H-1'), 3.52 (2H, t, *J* = 6.4 Hz, H-3'), 2.61 (3H, d, *J* = 1.5 Hz, H-12), 2.55 (3H, d, *J* = 1.2 Hz, H-9), 2.29 (m, 5H, H-10, H-2'); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 204.4 (C-11), 160.1 (C-2), 154.8 (C-8a), 153.8 (C-4), 151.9 (C-5), 139.3 (C-7), 133.7 (C-6), 116.2 (C-8), 115.6 (C-3), 112.6 (C-4a), 76.0 (C-1'), 33.1 (C-12), 32.8 (C-2'), 28.9 (C-3'), 22.7 (C-10), 19.5 (C-9); TOF MS ES+: $[M+Na]^+$ calcd for $C_{16}H_{17}O_4Na$ Br (375.0192) found 375.0208.

4.3.1 4,7-dimethyl-5-{3-[4-(2-fluorophenyl)piperazin-1-yl]propoxy}coumarin (**3b**)

White solid, MP**:** 113 –115 °C; Rf=0.47; yield 60 %; ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.04 (4H, m, H-3", H-4", H-5", H-6"), 6.75 (1H, q, *J* = 0.8 Hz, H-8), 6.55 (1H, d, *J* = 0.9 Hz, H-6), 6.05 (1H, d, *J* = 1.2 Hz, H-3), 4.12 (2H, t, *J* = 6.3 Hz, H-1'), 3.15 (4H, t, *J* = 4.6 Hz, H-3p, H-5p), 2.64 (6H, m, H-2p, H-6p, H-3'), 2.59 (3H, d, *J* = 1.5 Hz, H-9), 2.39 (3H, s, H-10), 2.10 (2H, m, H-2'); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 161.1 (C-2), 157.6 (C-8a), 157.3 (C-2", J_{F-C}=238 Hz), 155.5 (C-5), 154.3 (C-4), 154.2 (C-7), 143.3 (C-1"), 124.6 (C-5", J_{F-C}=124.9 Hz), 122.8 (C-4", J_{F-C}=8 Hz), 119.2 (C-6"), 116.4 (C-3", J_{F-C}=20 Hz), 116.2 (C-3), 113.7 (C-8), 110.4 (C-4a), 108.4 (C-6), 108.1 (C-1'), 67.4 (C-3p, C-5p), 55.5 (C-2p), 53.6 (C-6p), 50.6 (C-3'), 26.6 (C-2'), 24.8 (C-1'), 22.2 (C-9); TOF MS ES+: $[M+Na]^+$ calcd for $C_{24}H_{27}O_3N_2FNa$ (433.4428) found 433.1901.

4.3.2 4,7-dimethyl-5-{3-[4-(pyrazin-2-yl)piperazin-1-yl]propoxy}coumarin (**4b**)

White solid, MP**:** 116 –118 °C; Rf = 0.11, yield 58%; ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.15 (1H, d, *J* = 1.5 Hz, H-2"), 8.06 (1H, m, H-4"), 7.86 (1H, d, *J* = 2.4 Hz, H-3"), 6.75 (1H, q, *J* =

1.0 Hz, H-8), 6.55 (1H, d, *J* = 0.9 Hz H-6), 6.05 (1H, d, *J* = 1.2 Hz, H-3), 4.13 (2H, t, *J* = 6.3 Hz, H-1'), 3.64 (4H, t, *J* = 4.6 Hz, H-3p, H-5p), 2.62 (m, 6H, H-2p, H-6p, H-3'), 2.58 (3H, s, H-9), 2.39 (3H, s, H-10), 2.15 (2H, m, H-2'); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 161.1 (C-2), 157.3 (C-8a), 155.5 (C-5), 154.1 (C-1"), 143.2 (C-4), 141.9 (C-7), 131.2 (C-2", C-3"), 113.7 (C-4"), 110.4 (C-3, C-8a), 108.3 (C-4a), 108.1 (C-6), 67.2 (C-1'), 55.5 (C-3p, C-5p), 52.9 (C-2p, C-6p), 44.6 (C-3'), 24.8 (C-10, C-2'), 22.1 (C-9); TOF MS ES+: $[M+Na]^+$ calcd for $C_{22}H_{26}O_3N_4Na$ (417.4301) found 417.1914.

4.3.3 4,7-dimethyl-5-{3-[4-(3-methoxyphenyl)piperazin-1-yl]propoxy}coumarin (**5b**)

White solid, MP**:** 148– 149 °C; Rf = 0.29, yield 61%, ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.17 (1H, t, *J* = 8.1 Hz, H-5"), 6.74 (1H, q, *J* = 1 Hz, H-8), 6.54 (2H, m, H-6", H-6), 6.47 (1H, t, *J* = 2.2 Hz, H-2"), 6.43 (1H, dd, *J* = 11.0, 3.6 Hz, H-4"), 6.04 (1H, d, *J* = 1.2 Hz, H-3), 4.15 (2H, t, *J* = 6.3 Hz, H-1'), 3.79 (3H, s, H-7"), 3.22 (4H, t, *J* = 5.1 Hz, H-3p, H-5p), 2.64 (6H, m, H-2p, H-6p, H-3'), 2.58 (3H, s, H-9), 2.38 (3H, s, H-10), 2.09 (2H, m, H-2'); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 161.1 (C-2), 160.8 (C-3"), 157.3 (C-8a), 155.5 (C-5), 154.1 (C-4), 152.6 (C-1"), 143.2 (C-7), 130.0 (C-5"), 113.7 (C-3), 110.4 (C-8), 109.1 (C-2"), 108.4 (C-4a), 108.1 (C-6), 104.8 (C-4"), 102.9 (C-6"), 67.4 (C-1'), 55.5 (C-7"), 55.4 (C-3p, C-5p), 53.4 (C-2p, C-6p), 49.0 (C-2'), 26.6 (C-10), 24.8 (C-3'), 22.2 (C-9); TOF MS ES+: $[M+Na]^+$ calcd for $C_{25}H_{30}O_4N_2Na$ (445.4771) found 445.2117.

4.3.4 4,7-dimethyl-5-[3-(morpholin-4-yl)propoxy]coumarin (**6b**)

White solid, MP**:** 118 – 120 °C; Rf = 0.16, yield 74 %; ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.73 (1H, q, *J* = 1.0 Hz, H-8), 6.54 (1H, d, *J* = 0.9 Hz, H-6), 6.03 (1H, d, *J* = 1.2 Hz, H-3), 4.09 (2H, t, *J* = 6.3 Hz, H-1'), 3.73 (4H, t, *J* = 4.6 Hz, H-2", H-3"), 2.57 (3H, s, H-9), 2.54 - 2.46 (6H, m, H-1", H-4", H-3'), 2.38 (3H, s, H-10), 2.05 (2H, m, H-2'); ^{13}C NMR (75 MHz, $CDCl_3$,): δ = 161.1 (C-2), 157.3 (C-8a), 155.5 (C-5), 154.1 (C-4), 143.2 (C-7), 113.6 (C-3), 110.3 (C-8), 108.3 (C-4a), 108.0 (C-6), 67.3 (C-1'), 67.0 (C-2", C-3"), 55.8 (C-3'), 53.9 (C-1', C-4'), 26.4 (C-2', C-10), 22.1 (C-9); TOF MS ES+: $[M+Na]^+$ calcd for $C_{18}H_{23}O_4NNa$ (340.3383) found 340.1540.

4.3.5 4,7-dimethyl-5-{3-[4-(4-nitrophenyl)piperazin-1-yl]propoxy}coumarin (**7b**)

White solid, MP**:** 195 – 198 °C; Rf = 0.15, yield 45%; ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.14 (2H, d, *J* = 9.3 Hz, H-3", H-5"), 6.84 (2H, m, H-2", H-6"), 6.75 (1H, d, *J* = 0.6 Hz, H-8), 6.54 (1H, d, *J* = 0.9 Hz, H-6), 6.05 (1H, d, *J* = 1.2 Hz, H-3), 4.13 (2H, t, *J* = 6.3 Hz, H-1'), 3.46

(4H, m, H-3p, H-5p), 2.63 (6H, m, H-2p, H-6p, H-3'), 2.58 (3H, d, *J* = 1.2 Hz, H-9), 2.39 (3H, s, H-10), 2.10 (3H, m, H-2'); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 161.0 (C-2), 157.2 (C-1"), 155.5 (C-4, C-5), 154.8 (C-8a), 153.9 (C-7), 143.2 (C-4"), 126.1 (C-3", C-5"), 113.8 (C-4a), 113.0 (C-6), 110.5 (C-2", C-6"), 108.4 (C-3), 108.1 (C-8), 67.2 (C-1'), 55.3 (C-3'), 52.9 (C-3p, C-5p), 47.1 (C-2p, C-6p), 26.64 (C-3'), 24.8 (C-10), 22.2 (C-9); TOF MS ES+: $[M+Na]^+$ calcd for $C_{24}H_{27}O_5N_3Na$ (460.4496) found 460.1515

4.3.6 4,7-dimethyl-5-{3-[4-(4-chlorophenyl)piperazin-1-yl]propoxy}coumarin (**8b**)

White solid, MP**:** 153 – 155 °C, Rf = 0.05, yield 71%; ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.22 (2H, m, H-3", H-5"), 6.85 (2H, m, H-2", H-6"), 6.75 (1H, q, *J* = 1.0 Hz, H-8), 6.54 (1H, d, *J* = 0.9 Hz, H-6), 6.05 (1H, d, *J* = 1.2 Hz, H-3), 4.12 (2H, t, *J* = 6.3 Hz, H-1'), 3.19 (4H, t, *J* = 3 Hz, H-3p, H-5p), 2.64 (6H, m, H-2p, H-6p, H-3'), 2.59 (3H, s, H-9), 2.39 (3H, s, H-10), 2.09 (3H, m, H-2'); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 161.1 (C-2), 157.2 (C-8a), 155.1 (C-5), 154.0 (C-4, C-1"), 143.3 (C-7), 129.2 (C-3", C-5"), 117.7 (C-2", C-6"), 113.8 (C-4", C-3), 110.6 (C-8), 108.4 (C-4a), 108.1 (C-6), 67.2 (C-1'), 55.5 (C-3p), 53.2 (C-5p), 49.0 (C-2p, C-6p), 26.3 (C-3'), 24.8 (C-10), 23.8 (C-2'), 22.2 (C-9); TOF MS ES+: $[M+NaCl]^+$ calcd for $C_{24}H_{27}O_3N_2NaCl$ (449.8974) found 449.1619.

4.3.7 4,7-dimethyl-5-{3-[4-(2,3-dichlorophenyl)piperazin-1yl]propoxy}coumarin (**9b**)

White solid, MP**:** 170 – 173 °C; Rf = 0.17, yield 82%; ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.16 (2H, m, H-4", H-6"), 6.97 (1H, m, H-5"), 6.75 (1H, q, *J* = 0.9 Hz, H-8), 6.55 (1H, s, 1H, H-6), 6.05 (1H, d, *J* = 1.2 Hz, H-3), 4.12 (2H, t, *J* = 6.3 Hz, H-1'), 3.09 (4H, s, H-3p, H-5p), 2.67 (6H, m, H-2p, H-6p, H-3'), 2.59 (3H, s, H-9), 2.39 (3H, s, H-10), 2.09 (3H, m, H-2'); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 161.0 (C-2), 155.6 (C-8a, C-5), 154.7 (C-4), 150.6 (C-1"), 143.3 (C-7), 134.4 (C-3", C-5"), 127.8 (C-2", C-6"), 119.0 (C-4"), 113.9 (C-3), 110.7 (C-8), 108.4 (C-4a), 108.2 (C-6), 67.2 (C-1'), 55.5 (C-3p, C-5p), 53.3 (C-2p, C-6p), 24.8 (C-3', C-10), 22.2 (C-2', C-9); TOF MS ES+: $[M+2Cl]^+$ calcd for $C_{24}H_{26}O_3N_2Cl_2$ (483.3425) found 483.1234.

4.3.8 4,7-dimethyl-5-{3-[4-(2-cyanophenyl)piperazin-1-yl] propoxy}coumarin (**10b**)

White solid, MP**:** 171 – 172 °C; Rf = 0.14, yield 83%; ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.58 (1H, dd, *J* = 7.9, 1.5 Hz, H-3"), 7.49 (1H, m, H-4"), 7.01 (2H, m, H-5", H-6"), 6.75 (1H, m, H-8), 6.55 (1H, d, *J* = 0.9 Hz, H-6), 6.05 (1H, d, *J* = 1.2 Hz, H-3), 4.12 (2H, t, *J* = 6.3 Hz, H-1'), 3.27 (4H, t, *J* = 4.6 Hz, H-3p, H-5p), 2.72 (6H, m, H-2p, H-6p, H-3'), 2.59 (3H, d, *J* = 1.2

Hz, H-9), 2.39 (3H, s, H-10), 2.10 (2H, m, H-2'); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 161.1 (C-2), 157.3 (C-8a), 155.5 (C-1", C-5), 154.1 (C-4), 143.2 (C-7), 134.5 (C-3"), 134.0 (C-5"), 118.9 (C-7"), 118.6 (C-4"), 113.7 (C-6"), 110.5 (C-2"), 108.3 (C-3), 108.1 (C-4a, C-8), 106.2 (C-6), 67.2 (C-1'), 58.6 (C-3p), 55.3 (C-5p), 53.3 (C-2p), 51.6 (C-6p), 24.8 (C-3'), 22.2 (C-10, C-2'), 22.1 (C-9); TOF MS ES+: $[M+Na]^+$ calcd for $C_{25}H_{27}O_3N_3Na$ (440.4604) found 440.1962.

4.3.9 4,7-dimethyl-5-(3-(4-(pyridin-4-yl)piperazin-1-yl)propoxy)coumarin (**11b**)

White solid, MP**:** 157 – 159 °C; Rf = 0.06, yield 48 %; ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.28 (2H, m, H-4", H-3"), 6.75 (1H, d, *J* = 0.6 Hz, H-8), 6.69 (2H, dd, *J* = 5.1, 1.5 Hz, H-2", H-5"), 6.54 (1H, d, *J* = 7.0 Hz, H-6), 6.05 (1H, d, *J* = 1.2 Hz, H-3), 4.12 (2H, t, *J* = 6.3 Hz, H-1'), 3.38 (4H, t, *J* = 5.1 Hz, H-3p, H-5p), 2.61 (6H, m, H-2p, H-6p, H-3'), 2.58 (3H, s, H-9), 2.39 (3H, s, H-10), 2.08 (2H, m, H-2'); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 160.0 (C-2), 157.3 (C-8a), 155.5 (C-5), 155.4 (C-18), 154.0 (C-4), 148.6 (C-3", C-4"), 143.2 (C-7), 113.7 (C-3), 110.4 (C-8), 108.4 (C-2", C-5"), 108.0 (C-4a, C-6), 67.2 (C-1'), 55.2 (C-3p, C-5p), 52.8 (C-2p, C-6p), 46.2 (C-3'), 26.7 (C-10), 24.7 (C-2'), 22.1 (C-9); TOF MS ES+: $[M+H]^+$ calcd for $C_{23}H_{27}O_3N_3Na$ (394.4594) found 394.2139.

4.3.10 6-acetyl-4,7-dimethyl-5-{3-[4-(2-fluorophenyl)piperazin-1-yl]propoxy}coumarin (**3d**)

White solid, MP: 99 – 102 °C; Rf = 0.24, yield 56 %; ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.97 (5H, m, H-8, H-3", H-4", H-5", H-6"), 6.18 (1H, d, *J* = 1.5 Hz, H-3), 3.90 (2H, t, *J* = 6.7 Hz, H-1'), 3.15 (4H, t, *J* = 4.5 Hz, H-3p, H-5p), 2.67 (4H, m, H-2p, H-6p), 2.62 (3H, d, *J* = 1.2 Hz, H-3'), 2.54 (3H, m, H-12), 2.55 (3H, s, H-9), 2.29 (3H, d, *J* = 0.6 Hz, H-10), 2.00 (2H, m, H-2'); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 204.6 (C-11), 160.2 (C-2), 157.5 (C-2", J_{F-C}=245 Hz), 154.9 (C-8a), 154.4 (C-4), 152.3 (C-5), 140.11 (C-1", J_{F-C}=9 Hz), 139.4 (C-7), 124.7 (C-5", J_{F-C}=4 Hz), 122.8 (C-4", J_{F-C}=8 Hz), 119.2 (C-6", J_{F-C}=3 Hz), 116.3 (C-3", J_{F-C}=20 Hz), 116.2 (C-8), 115.4 (C-3), 112.7 (C-4a), 110.9 (C-6), 76.6 (C-1'), 54.6 (C-3'), 53.3 (C-3p, C-5p), 50.4 (C-2p, C-6p), 32.7 (C-12), 27.1 (C-2'), 22.7 (C-10), 19.5 (C-9); TOF MS ES+: $[M+Na]^+$ calcd for $C_{26}H_{29}O_4N_2FNa$ (475.2009) found 475.2025.

4.3.11 6-acetyl-4,7-dimethyl-5-{3-[4-(pyrazin-2-yl)piperazin-1-yl]propoxy}coumarin (**4d**)

White solid, MP**:** 118 –120 °C; Rf = 0.11, yield 58 %; ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.15 (1H, d, *J* = 1.5 Hz, H-2"), 8.07 (1H, m, H-4"), 7.87 (1H, d, *J* = 2.4 Hz, H-3"), 6.98 (1H, d, *J* = 0.6 Hz, H-8), 6.18 (1H, d, *J* = 1.2 Hz, H-3), 3.91 (t, *J* = 6.6 Hz, 2H, H-1'), 3.67 (4H, m, H-3p,

H-5p), 2.60 (9H, m, H-2p, H-6p, H-3', H-12), 2.55 (3H, s, H-9), 2.29 (3H, d, *J* = 0.6 Hz, H-10), 2.03 (2H, m, H-2'); ^{13}C NMR (75 MHz, $CDCl_3$,): δ = 204.55 (C-11), 160.2 (C-2), 155.2 (C-1"), 154.9 (C-5), 154.4 (C-4), 152.2 (C-8a), 141.9 (C-2"), 139.4 (C-7), 133.7 (C-3"), 133.2 (C-4"), 131.2 (C-6), 116.1 (C-3), 115.4 (C-8), 112.7 (C-4a), 76.6 (C-1'), 54.6 (C-3'), 52.9 (C-3p, C-5p), 44.6 (C-2p, C-6p), 32.7 (C-12), 27.2 (C-2'), 22.7 (C-10), 19.5 (C-9); TOF MS ES+: $[M+Na]^+$ calcd for $C_{24}H_{28}O_4N_4Na$ (459.2011) found 459.2008.

4.3.12 6-acetyl-4,7-dimethyl-5-{3-[4-(3-methoxyphenyl)piperazin-1-yl]propoxy}coumarin (**5d**)

White solid, MP**:** 93 – 95 °C; Rf = 0.22, yield 55 %; ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.17 (1H, t, *J* = 8.2 Hz, H-5"), 6.97 (1H, d, *J* = 0.6 Hz, H-2"), 6.55 (1H, m, H-8), 6.47-6.40 (2H, m, H-4", H-6"), 6.17 (1H, d, *J* = 1.2 Hz, H-3), 3.90 (2H, t, *J* = 6.6 Hz, H-1'), 3.79 (3H, s, H-7"), 3.27 (4H, t, *J* = 4.8 Hz, H-3p, H-5p), 2.64 (6H, m, H-2p, H-6p, H-3'), 2.61 (3H, d, *J* = 1.5 Hz, H-12), 2.55 (3H, s, H-9), 2.29 (2H, d, *J* = 0.6 Hz, H-10), 2.00 (2H, t, *J* = 7 Hz, H-2'); ^{13}C NMR (75 MHz, $CDCl_3$,): δ = 204.6 (C-11), 160.8 (C-3"), 160.1 (C-2), 154.8 (C-5), 152.6 (C-4), 152.2 (C-8a), 139.3 (C-1"), 133.7 (C-7), 130.0 (C-5"), 116.2 (C-6), 115.4 (C-3), 112.7 (C-8), 109.1 (C-4"), 105.8 (C-4a), 104.8 (C-6"), 102.8 (C-2"), 76.6 (C-1'), 55.4 (C-3'), 54.6 (C-3p, C-5p), 53.2 (C-7"), 49.0 (C-2p, C-6p), 32.7 (C-12), 27.0 (C-2'), 22.7 (C-10), 19.5 (C-9); TOF MS ES+: $[M+H]^+$ calcd for $C_{27}H_{33}O_5N_2$ (465.2374) found 465.2389.

4.3.13 6-acetyl-4,7-dimethyl-5-[3-(morpholin-4-yl)propoxycoumarin (**6d**)

White solid, MP**:** 128 – 131 °C; Rf = 0.27, yield 80 %; ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.97 (1H, d, *J* = 0.3 Hz, H-8), 6.18 (1H, d, *J* = 0.6 Hz, H-3), 3.88 (2H, t, *J* = 6.6 Hz, H-1'), 3.74 (4H, t, *J* = 5 Hz, H-2", H-3"), 2.61 (3H, d, *J* = 1 Hz, H-12), 2.54 (3H, s, H-9), 2.48 (6H, m, H-1", H-4", H-3'), 2.29 (3H, s, H-10), 1.96 (2H, d, *J* = 6.7 Hz, H-2'); NMR ^{13}C (75 MHz, $CDCl_3$): δ = 204.5 (C-11), 160.1 (C-2), 154.8 (C-8a), 152.1 (C-5), 143.3 (C-4), 139.3 (C-7), 133.7 (C-6), 116.2 (C-8), 115.4 (C-3), 113.8 (C-4a), 112.7 (C-1'), 67.1 (C-2"), 76.4 (C-3"), 66.7 (C-1"), 55.0 (C-4"), 32.7 (C-12), 26.6 (C-2'), 24.7 (C-3'), 22.6 (C-10), 19.5 (C-9); TOF MS ES+: $[M+Na]^+$ calcd for $C_{20}H_{25}O_5NNa$ (382.3826) found 382.1630.

4.3.14 6-acetyl-4,7-dimethyl-5-{3-[4-(4-nitrophenyl)piperazin-1-yl]propoxy}coumarin (**7d**)

White solid, MP**:** 172 –174 °C; Rf = 0.27, yield 45 %; ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.14 (2H, d, *J* = 9.3 Hz, H-3", H-5"), 6.98 (1H, s, H-8), 6.85 (2H, d, *J* = 9.3 Hz, H-2", H-6"), 6.18 (1H, s, H-3), 3.91 (2H, t, *J* = 6.5 Hz, H-1'), 3.47 (4H, m, H-3p, H-5p), 2.61 (3H, s, H-12),

2.58 (6H, m, H-2p, H-6p, H-3'), 2.55 (3H, s, H-9), 2.29 (3H, s, H-10), 2.12 (2H, m, H-2'); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 204.6 (C-11), 160.6 (C-2), 154.8 (C-5, C-1"), 152.1 (C-4), 147.5 (C-8a), 139.2 (C-7), 133.7 (C-4"), 126.1 (C-5", C-3"), 116.2 (C-6), 115.5 (C-3), 113.1 (C-8), 113.0 (C-2", C-6"), 112.7 (C-4a), 78.2 (C-1'), 54.5 (C-3'), 52.6 (C-3p, C-5p), 47.0 (C-2p, C-6p), 32.8 (C-12), 24.8 (C-2'), 22.6 (C-10), 19.5 (C-9); TOF MS ES+: $[M+Na]^+$ calcd for $C_{26}H_{29}O_6N_3Na$ (502.4840) found 502.1955.

4.3.15 6-acetyl-4,7-dimethyl-5-{3-[4-(4-chlorophenyl)piperazin-1-yl]propoxy}coumarin (**8d**)

White solid, MP**:** 135 –138 °C; Rf = 0.05, yield 86%; ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.20 (2H, m, H-3", H-5"), 6.97 (1H, d, *J* = 0.9 Hz, H-8), 6.84 (2H, m, H-2", H-6"), 6.17 (1H, d, *J* = 1.5 Hz, H-3), 3.90 (2H, t, *J* = 6.7 Hz, H-1'), 3.17 (4H, m, H-3p, H-5p), 2.58 (9H, m, H-12, H-2p, H-6p, H-3'), 2.55 (3H, s, H-9), 2.29 (3H, s, H-10), 1.98 (2H, m, H-2'); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 204.6 (C-11), 160.2 (C-2), 154.8 (C-8a), 154.2 (C-5), 152.2 (C-4), 150.0 (C-1"), 139.4 (C-7), 133.7 (C-4"), 129.1 (C-5"), 117.4 (C-2", C-6"), 116.1 (C-6), 115.4 (C-8), 113.7 (C-3), 112.7 (C-3"), 110.4 (C-4a), 76.6 (C-1'), 54.5 (C-3p, C-5p), 53.3 (C-2p, C-6p), 49.2 (C-12), 32.7 (C-2'), 27.2 (C-3'), 22.7 (C-10), 19.5 (C-9); TOF MS ES+: $[M+NaCl]^+$ calcd for $C_{26}H_{29}O_4N_2NaCl$ (491.9318) found 491.1702.

4.3.16 6-acetyl-4,7-dimethyl-5-{3-[4-(2,3-dichlorophenyl)piperazin-1-yl]propoxy}coumarin (**9d**)

White solid, MP**:** 142 – 145 °C; Rf = 0.24, yield 54 %; ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.15 (2H, m, H-4", H-5"), 6.98 (2H, m, H-8, H-6"), 6.18 (1H, d, *J* = 1.2 Hz, H-8), 3.90 (2H, t, *J* = 6.7 Hz, H-1'), 3.08 (4H, s, H-3p, H-5p), 2.63 (9H, m, H-2p, H-6p, H-3', H-12), 2.56 (3H, s, H-9), 2.29 (3H, s, H-10), 1.99 (2H, m, H-2'); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 204.5 (C-11), 160.2 (C-2), 154.9 (C-8a), 154.4 (C-5), 152.3 (C-4), 151.3 (C-1"), 139.4 (C-7), 134.2 (C-5"), 133.7 (C-3"), 127.7 (C-6"), 124.9 (C-4"), 118.8 (C-2"), 116.1 (C-8), 115.4 (C-3, C-6), 112.7 (C-4a), 76.6 (C-1'), 54.6 (C-3p, C-5p), 53.4 (C-2p), 51.4 (C-6p), 32.7 (C-12), 27.2 (C-2'), 22.7 (C-3'), 22.8 (C-10), 19.5 (C-9); TOF MS ES+: $[M+Na]^+$ calcd for $C_{26}H_{28}O_4N_2Cl_2Na$ (525.3821) found 525.1320.

4.3.17 6-acetyl-4,7-dimethyl-5-{3-[4-(2-cyanophenyl)piperazin-1-yl]propoxy}coumarin (**10d**)

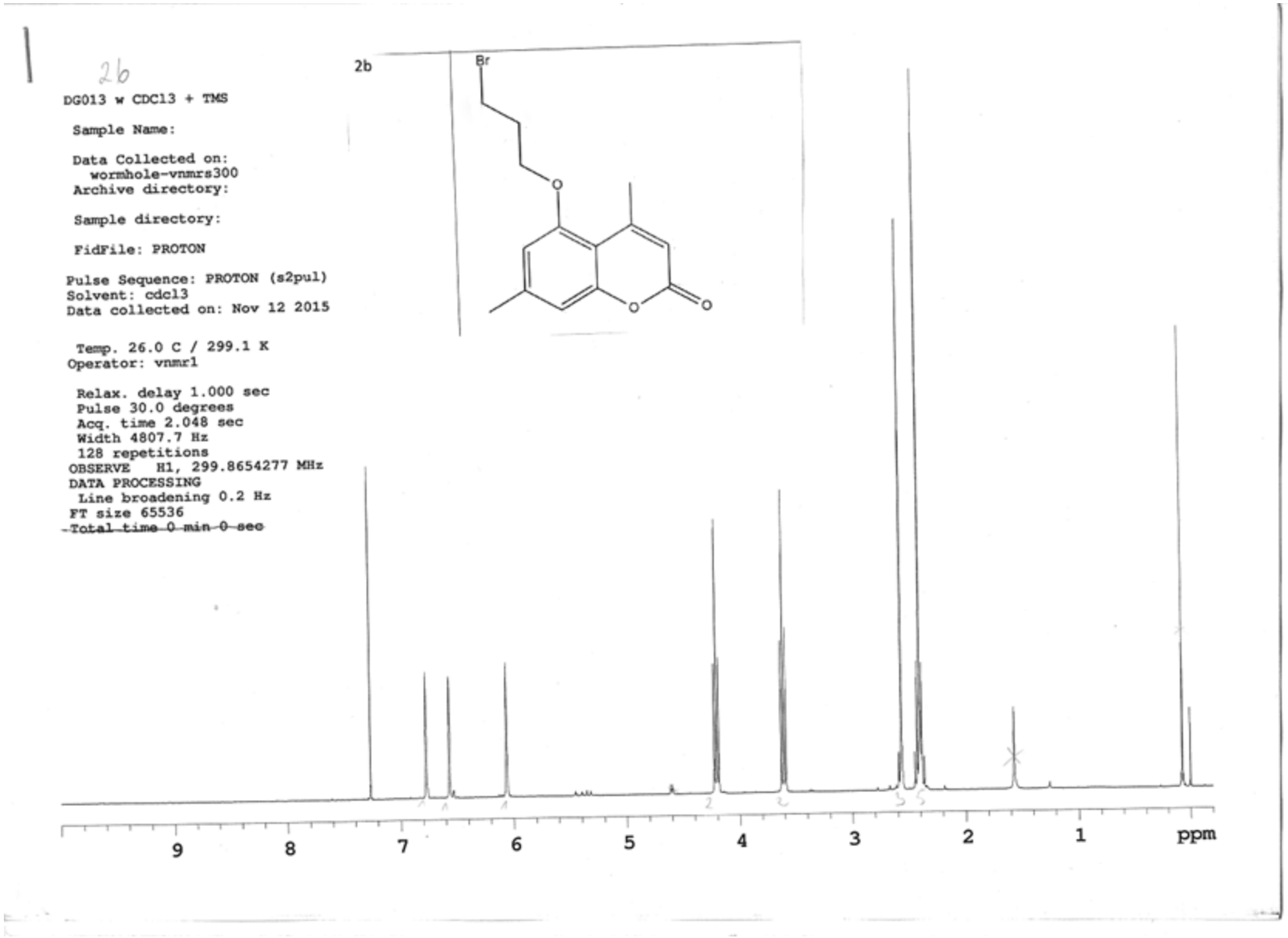
White solid, MP**:** 103 – 106 °C; Rf = 0.42, yield 87 %; ^{1}H NMR (300 MHz, $CDCl_3$): δ = 7.59 (1H, dd, *J* = 7.9, 1.5 Hz, H-5"), 7.51 (1H, m, H-3"), 7.03 (2H, m, H-4", H-6"), 7.00 (1H, s, H-

8), 6.19 (1H, H-3), 3.92 (2H, t, *J* = 6.6 Hz, H-1'), 3.29 (4H, s, H-3p, H-5p), 2.72 (4H, s, H-2p, H-6p), 2.63 (3H, s, H-12), 2.61 (2H, m, H-3'), 2.57 (3H, s, H-9), 2.30 (3H, s, H-10), 2.09 (2H, t, J = 6.1 Hz, H-2'); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 204.6 (C-11), 160.2 (C-2), 155.7 (C-8a), 154.8 (C-5"), 154.3 (C-5), 152.2 (C-4), 143.2 (C-7), 139.4 (C-3"), 134.5 (C-2"), 134.0 (C-6"), 118.9 (C-4"), 116.2 (C-3), 115.4 (C-8), 112.7 (C-4a), 108.1 (C-6), 106.3 (C-1'), 76.5 (C-11), 55.4 (C-1'), 54.5 (C-3'), 53.2 (C-3p, C-5p), 51.4 (C-2p, C-6p), 32.8 (C-12), 26.9 (C-10), 22.7 (C-2'), 19.5 (C-9); TOF MS ES+: $[M+Na]^+$ calcd for $C_{27}H_{29}O_4N_3Na$ (482.2736) found 482.2663.

4.3.18 6-acetyl-4,7-dimethyl-5-(3-(4-(pyridin-4-yl)piperazin-1-yl)propoxy)coumarin (**11d**)

White solid, MP**:** 113 –115 °C; Rf = 0.85, yield 75 %; ^{1}H NMR (300 MHz, $CDCl_3$): δ = 8.26 (2H, m, H-3", H-4"), 6.97 (1H, s, H-8), 6.66 (2H, m, H-2", H-5"), 6.17 (1H, d, *J* = 1.5 Hz, H-3), 3.90 (2H, t, *J* = 6.7 Hz, H-1'), 3.33 (4H, m, H-3p, H-5p), 3.00 (4H, m, H-2p, H-6p), 2.66 (6H, m, H-12, H-9), 2.29 (5H, m, H-10, H-3'), 1.97 (2H, m, H-2'); ^{13}C NMR (75 MHz, $CDCl_{3,}$): δ = 204.5 (C-11), 160.2 (C-2), 155.4 (C-5), 155.1 (C-4), 154.8 (C-8a), 152.1 (C-1"), 150.6 (C-3"), 150.1 (C-4"), 150.0 (C-7), 116.1 (C-6), 115.3 (C-3), 112.6 (C-8), 108.5 (C-4a), 108.4 (C-2", C-5"), 76.5 (C-1'), 54.4 (C-3'), 47.1 (C-3p, C-5p), 46.0 (C-2p, C-6p), 32.7 (C-12), 27.2 (C-2'), 22.6 (C-10), 19.4 (C-9); TOF MS ES+: $[M+Na]^+$ calcd for $C_{25}H_{29}O_4N_1Na$ (458.4756) found 458.2053.

NMR spectra


2b
DG013 w CDCl3 + TMS
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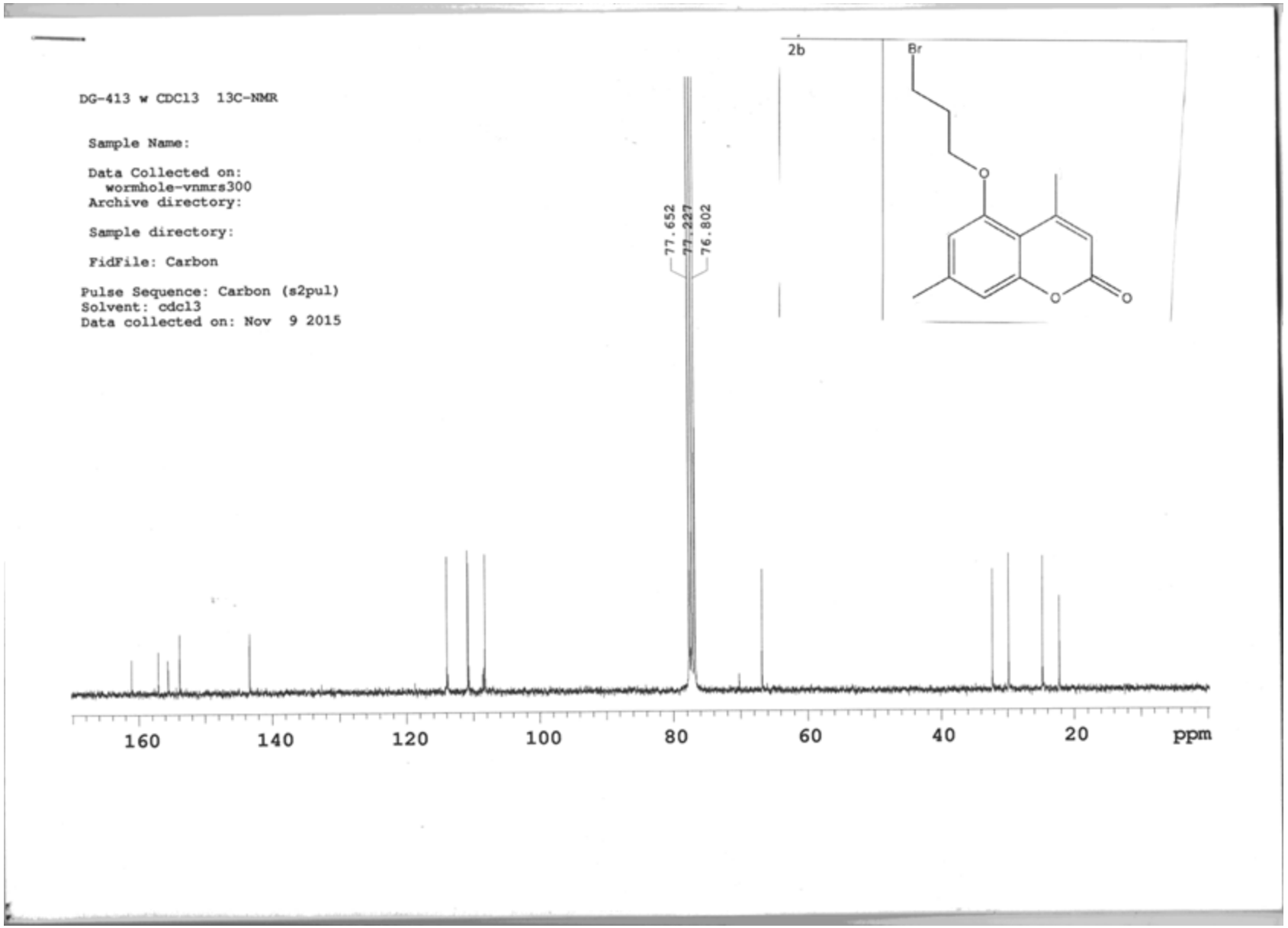
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: PROTON
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Nov 12 2015
Temp. 26.0 C / 299.1 K
Operator: vnmr1
Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 2.048 sec
Width 4807.7 Hz
128 repetitions
OBSERVE H1, 299.8654277 MHz
DATA PROCESSING
Line broadening 0.2 Hz
FT size 65536
Total time 0 min 0 sec
Br
O
O
O
9
8
7
6
5
4
3
2
1
ppm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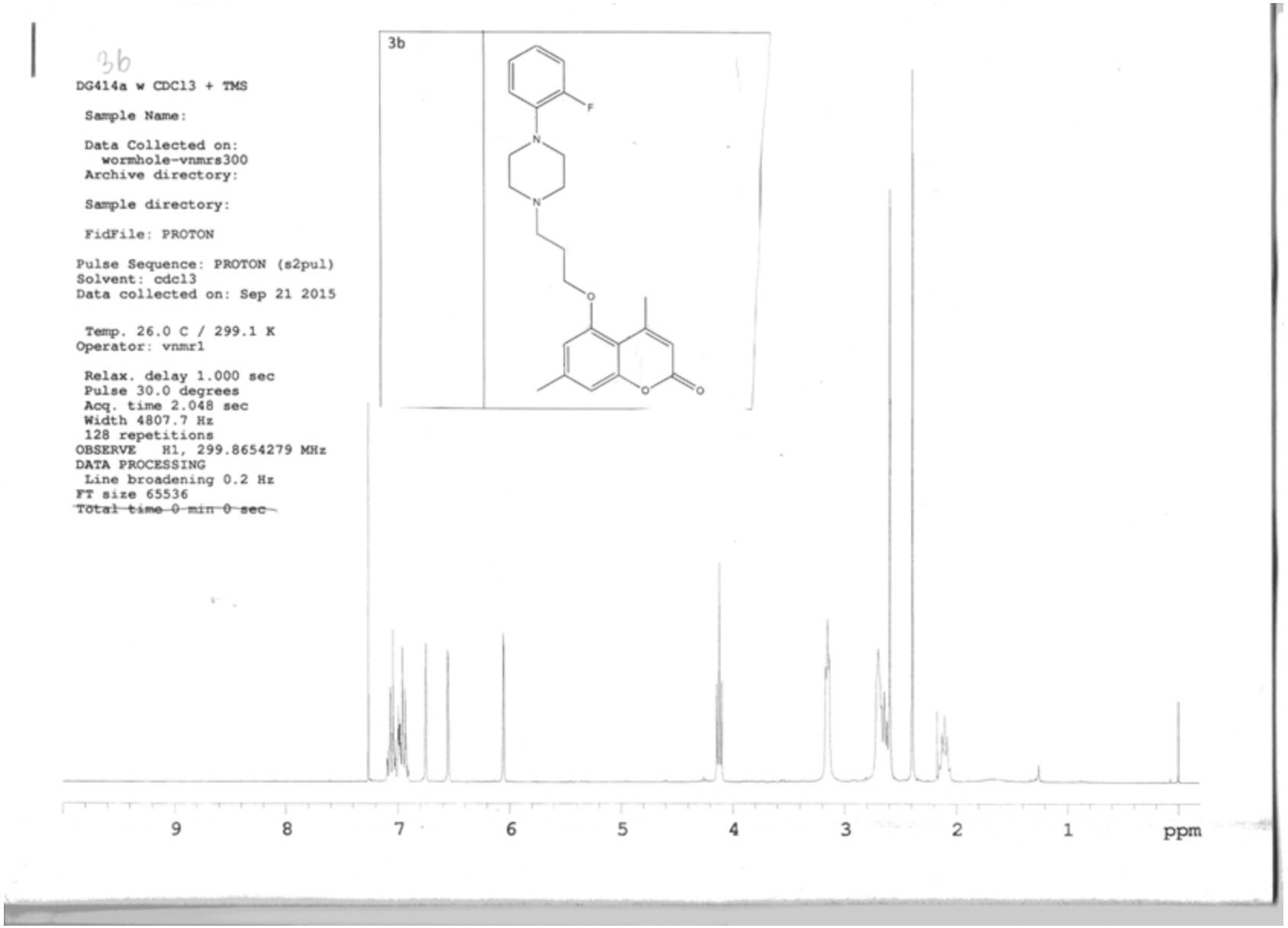
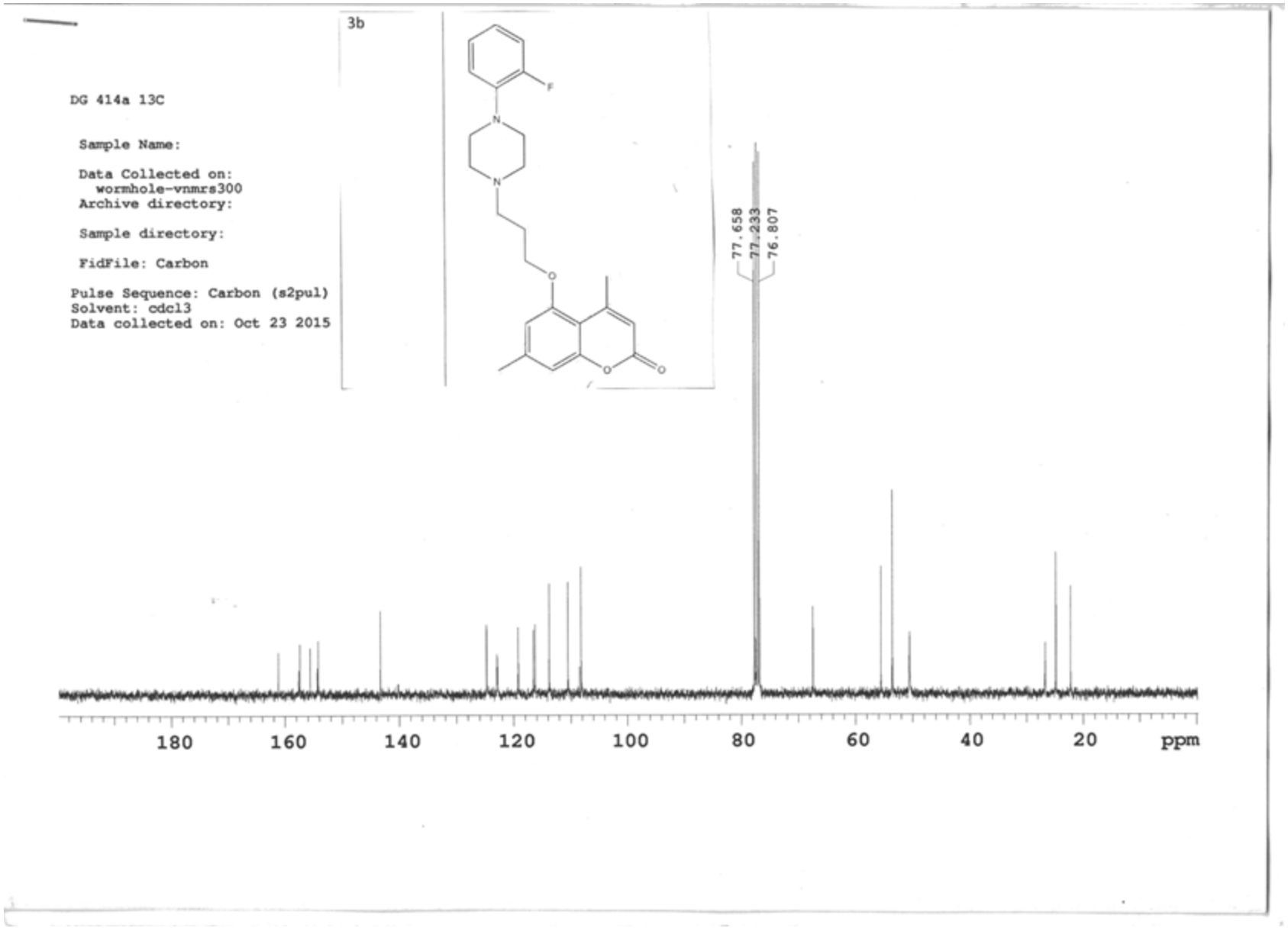
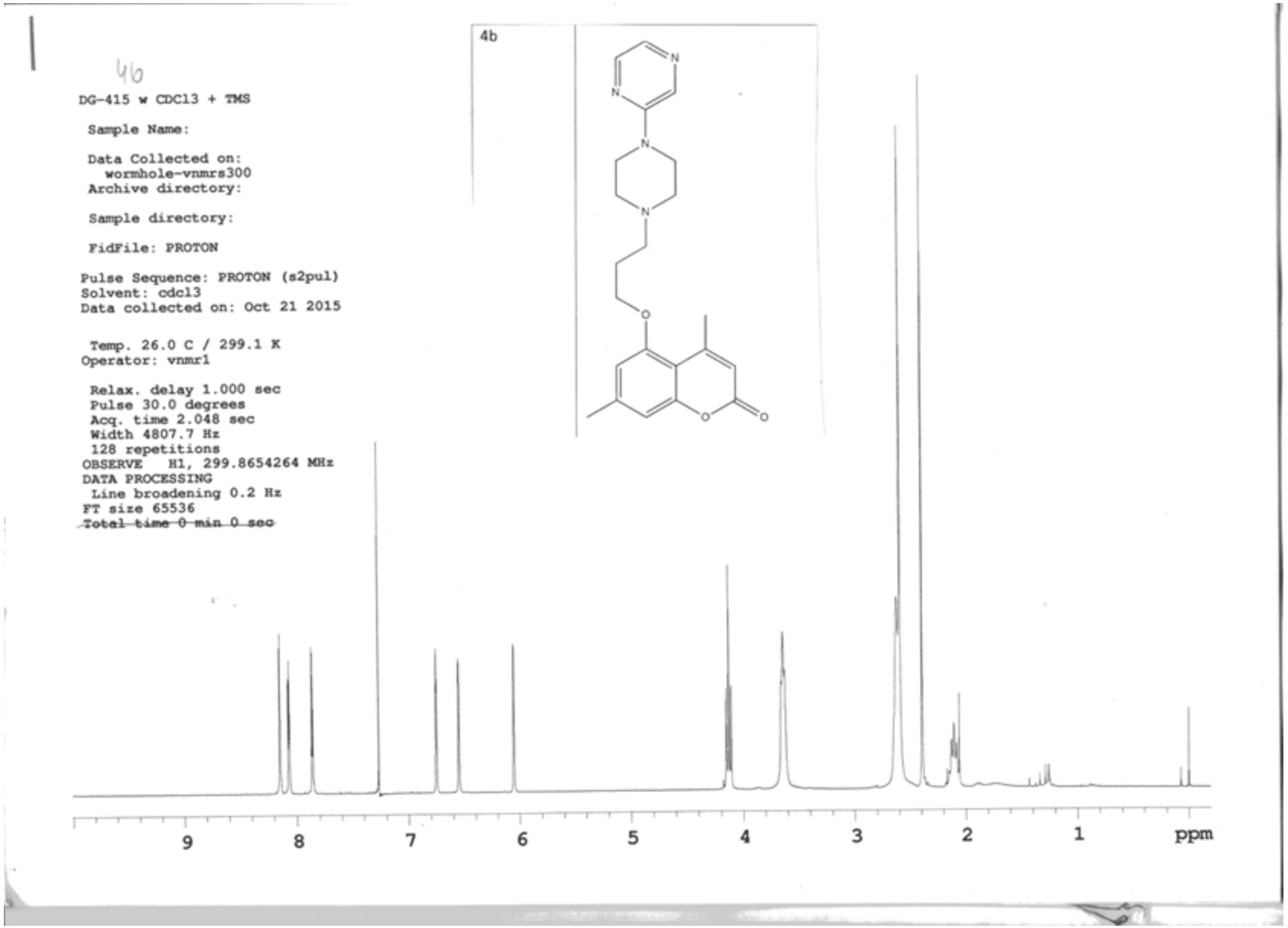
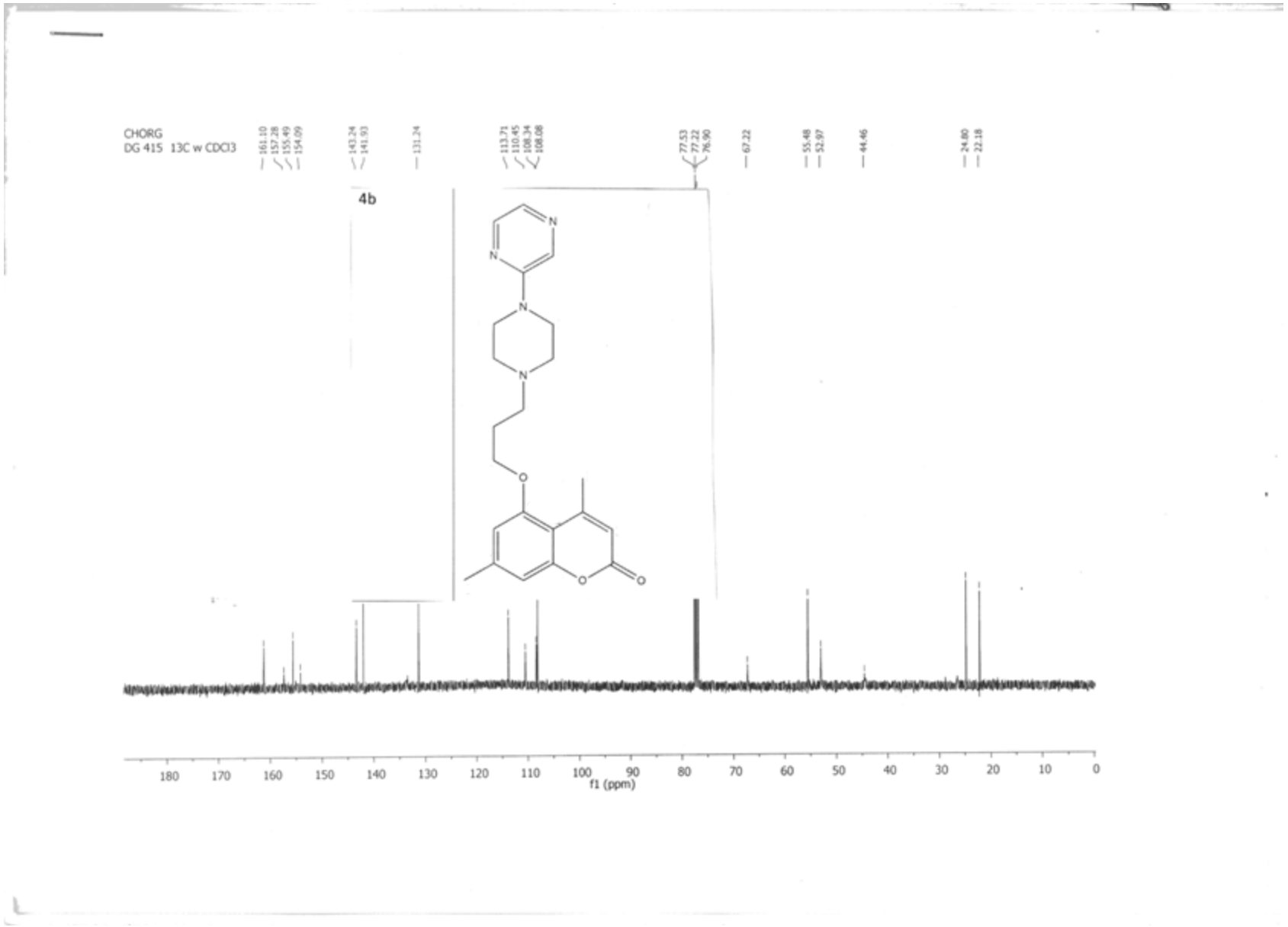
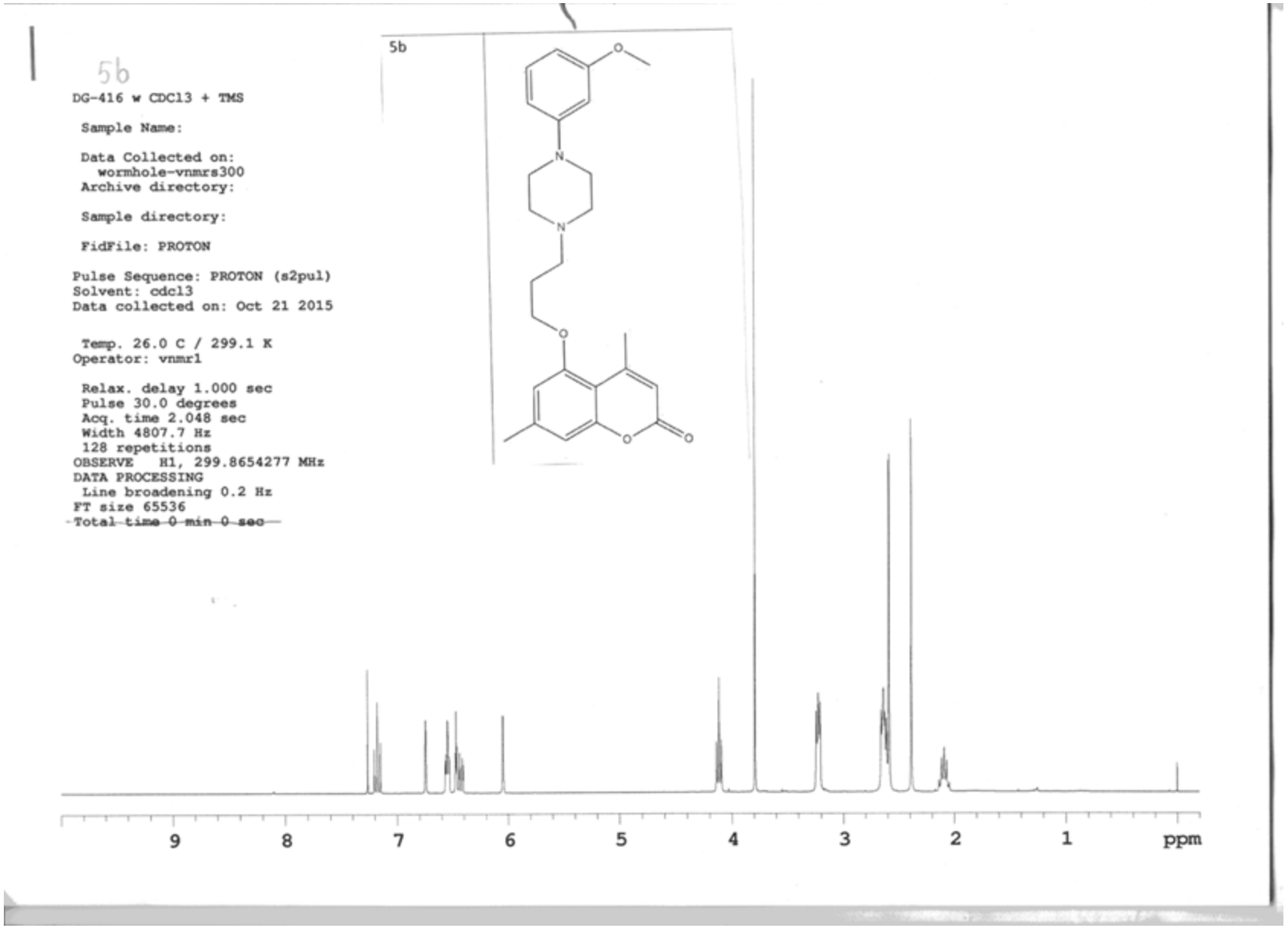
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: Carbon
Pulse Sequence: Carbon (s2pul)
Solvent: cdcl3
Data collected on: Nov 9 2015
77.652
77.227
76.802
2b
Br
O
O
O
160
140
120
100
80
60
40
20
ppm

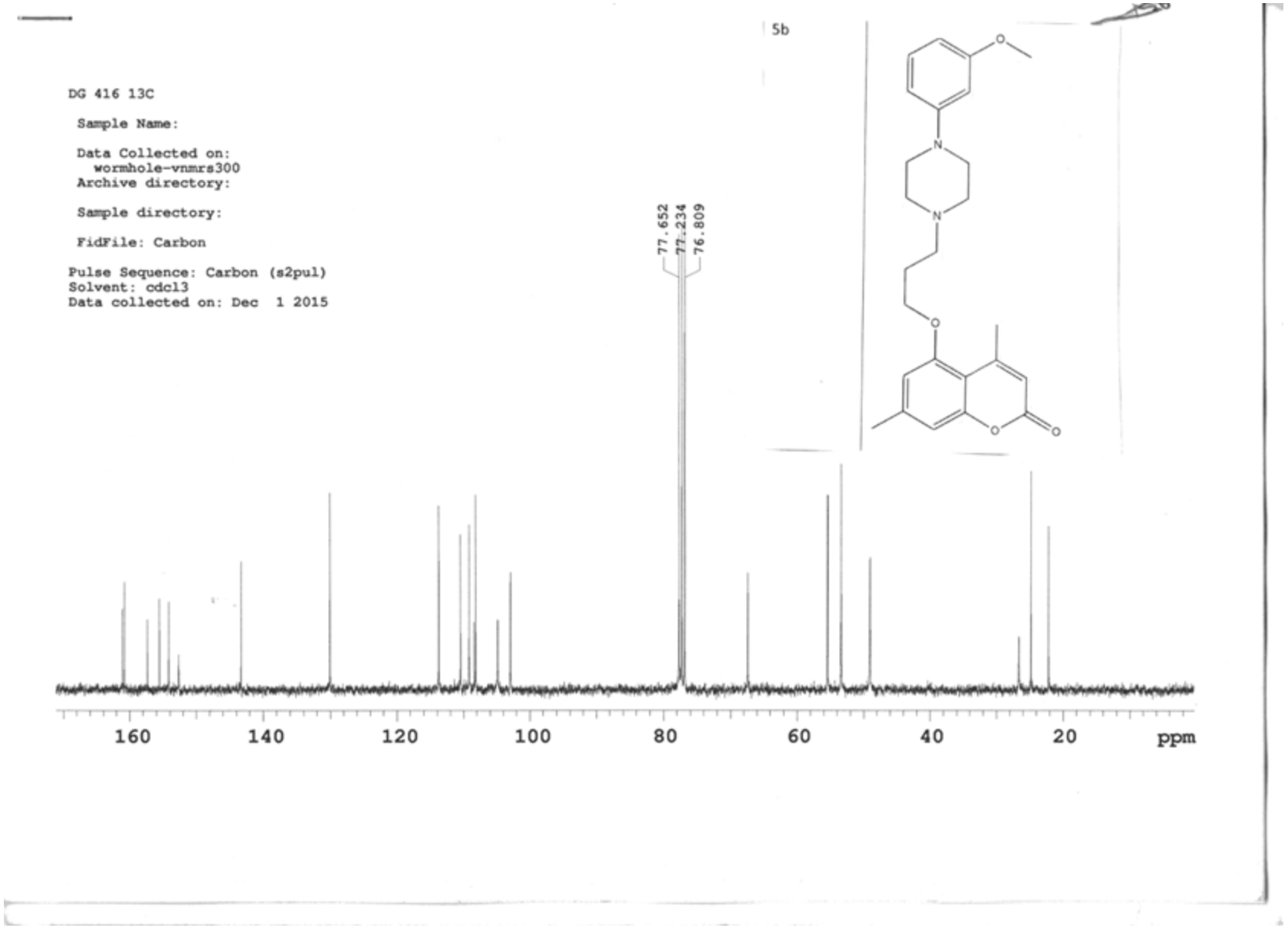

3b
DG414a w CDCl3 + TMS
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: PROTON
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Sep 21 2015
Temp. 26.0 C / 299.1 K
Operator: vnmrl
Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 2.048 sec
Width 4807.7 Hz
128 repetitions
OBSERVE H1, 299.8654279 MHz
DATA PROCESSING
Line broadening 0.2 Hz
FT size 65536
Total time 0 min 0 sec
3b
F
N
N
O
O
O
9
8
7
6
5
4
3
2
1
ppm

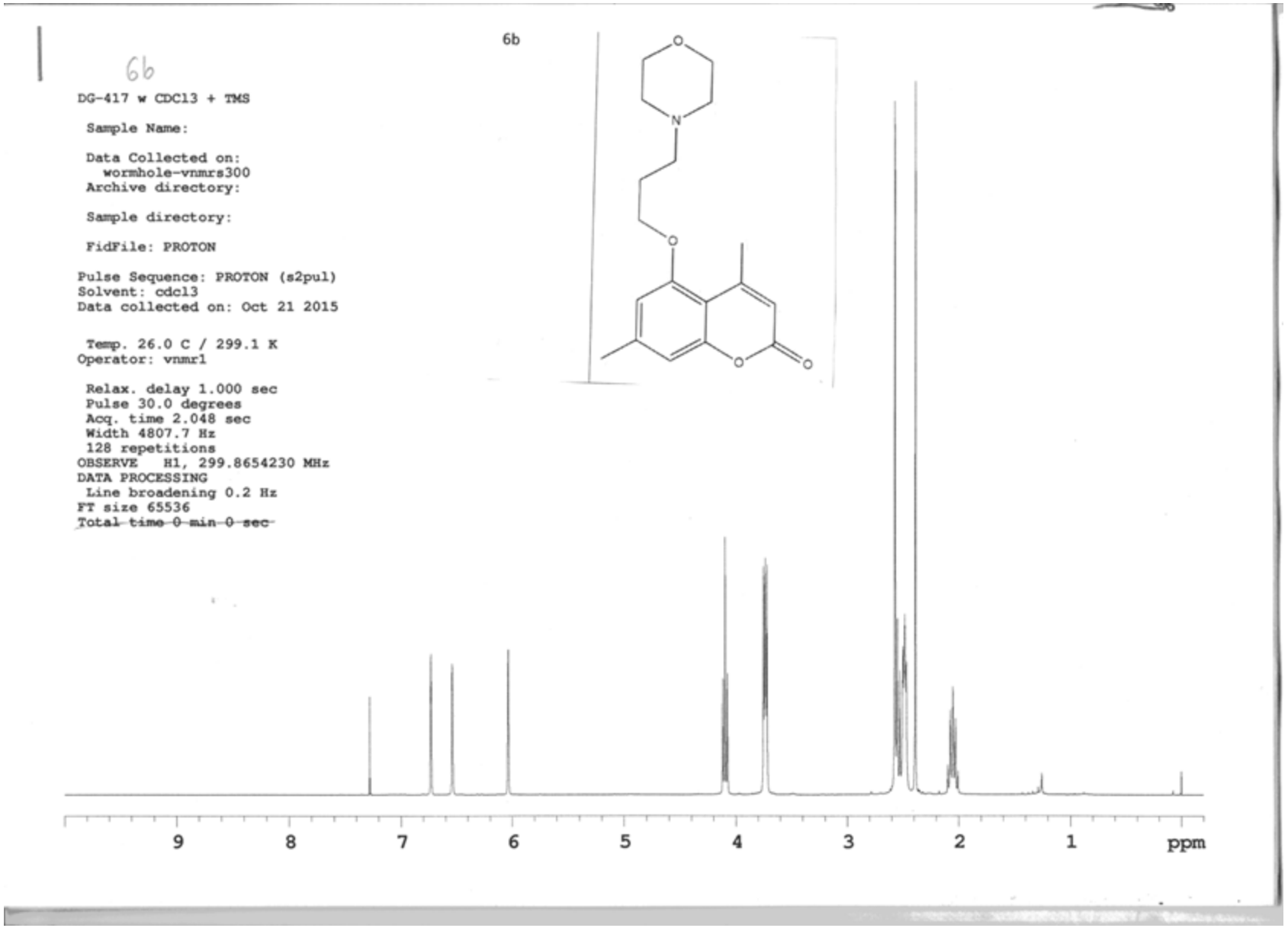

3b
DG 414a 13C
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: Carbon
Pulse Sequence: Carbon (s2pul)
Solvent: cdcl3
Data collected on: Oct 23 2015
77.658
77.233
76.807
180
160
140
120
100
80
60
40
20
ppm

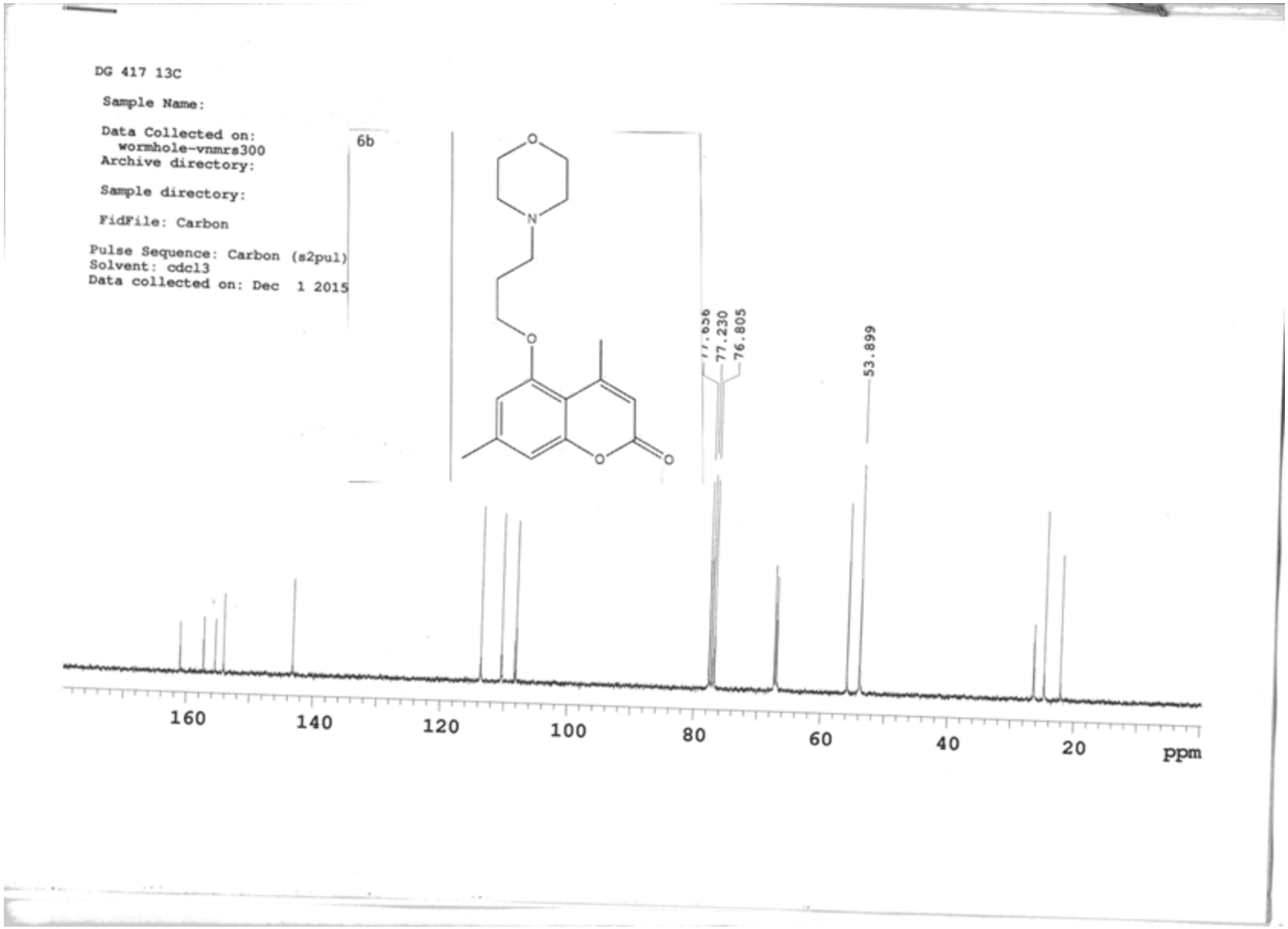

4b
46
DG-415 w CDCl3 + TMS
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: PROTON
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Oct 21 2015
Temp. 26.0 C / 299.1 K
Operator: vnmr1
Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 2.048 sec
Width 4807.7 Hz
128 repetitions
OBSERVE H1, 299.8654264 MHz
DATA PROCESSING
Line broadening 0.2 Hz
FT size 65536
Total time 0 min 0 sec
9
8
7
6
5
4
3
2
1
ppm

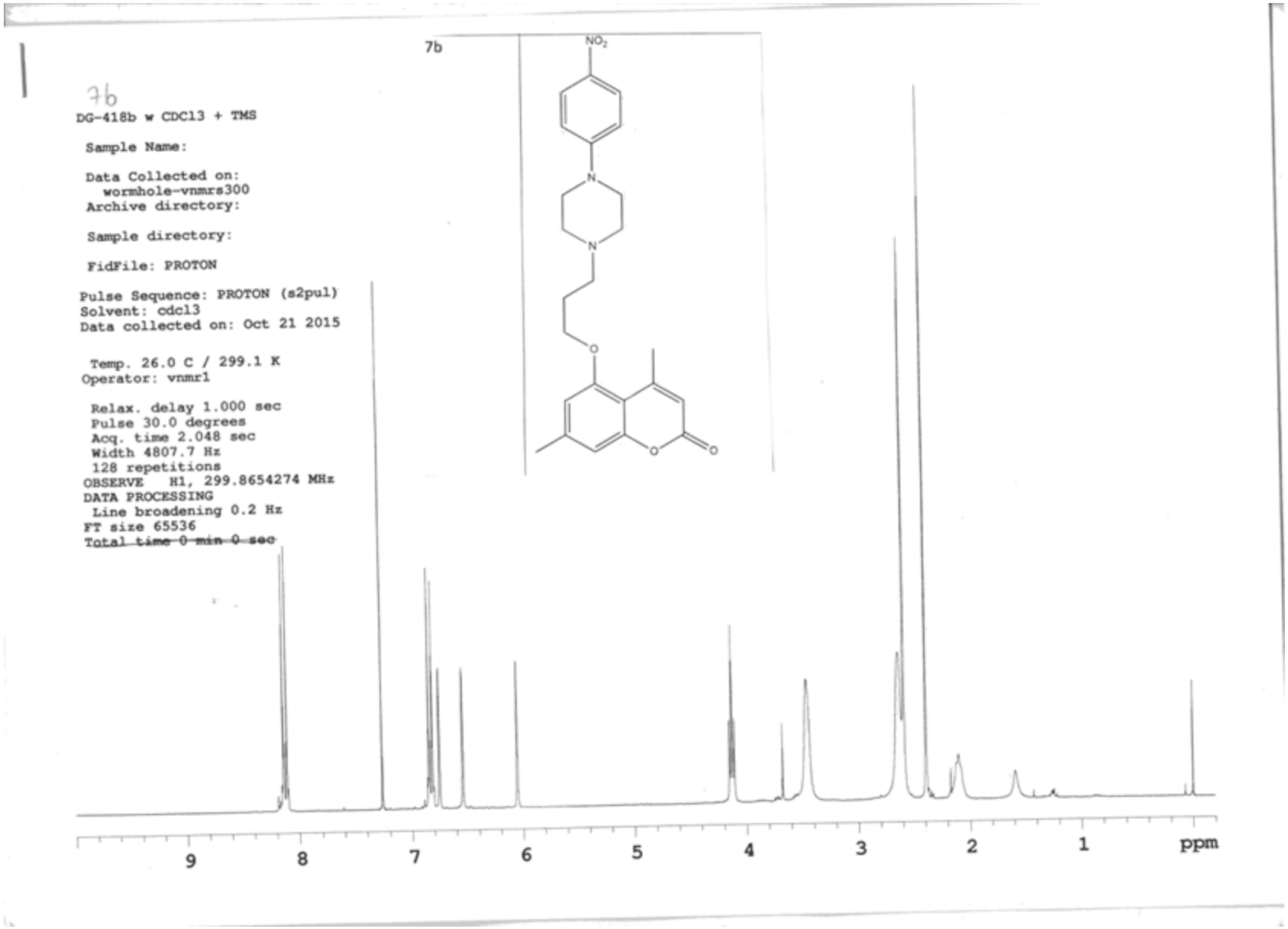

CHORG
DG 415 13C w CDCl3
161.10
157.28
155.49
154.09
143.24
141.93
131.24
113.71
110.45
108.34
108.08
77.53
77.22
76.90
67.22
55.48
52.97
44.46
24.80
22.18
4b
N
N
N
O
O
O
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

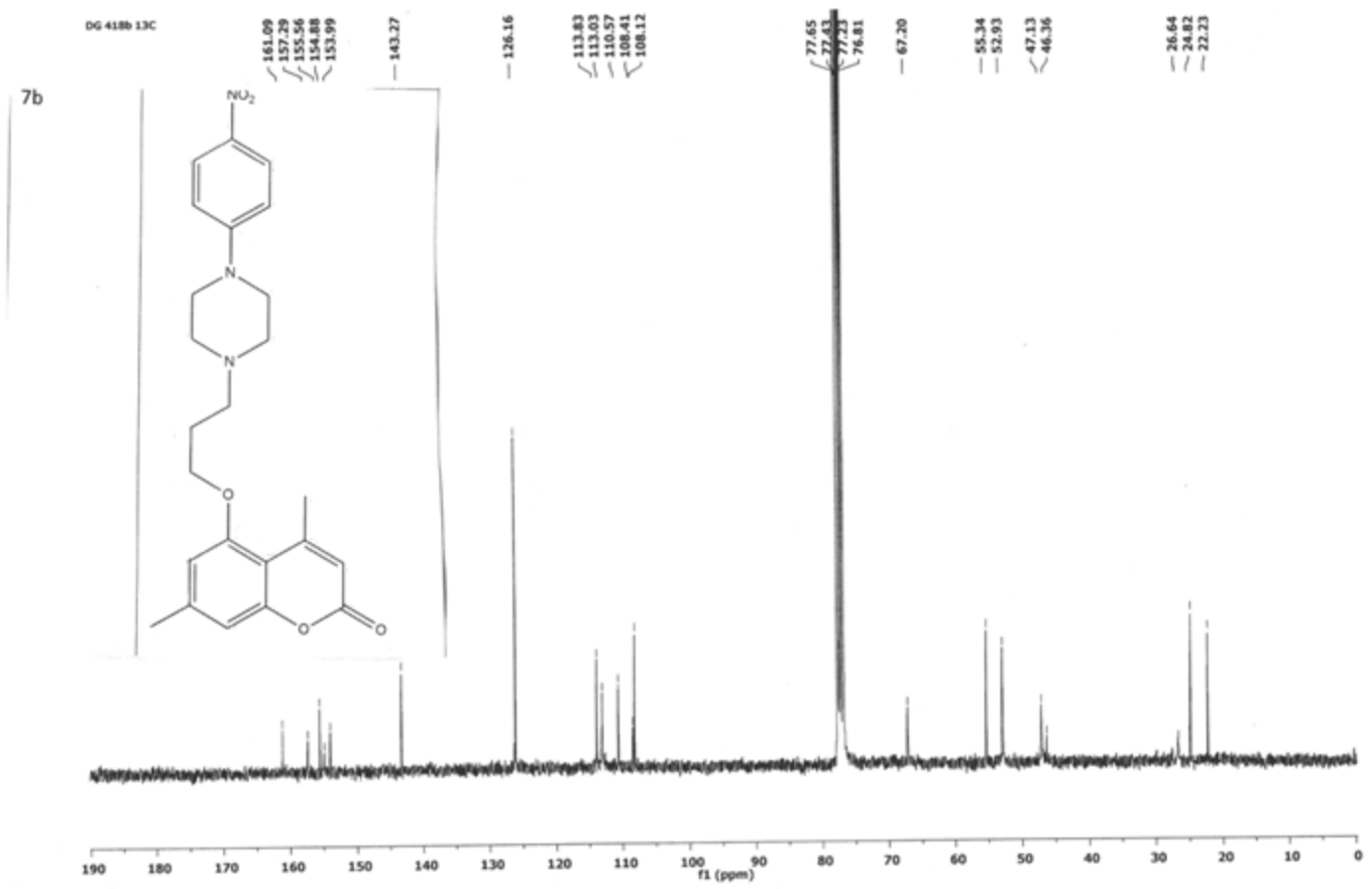

5b
DG-416 w CDCl3 + TMS
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: PROTON
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Oct 21 2015
Temp. 26.0 C / 299.1 K
Operator: vnmr1
Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 2.048 sec
Width 4807.7 Hz
128 repetitions
OBSERVE H1, 299.8654277 MHz
DATA PROCESSING
Line broadening 0.2 Hz
FT size 65536
Total time 0 min 0 sec
5b
O
N
N
O
O
O
9
8
7
6
5
4
3
2
1
ppm

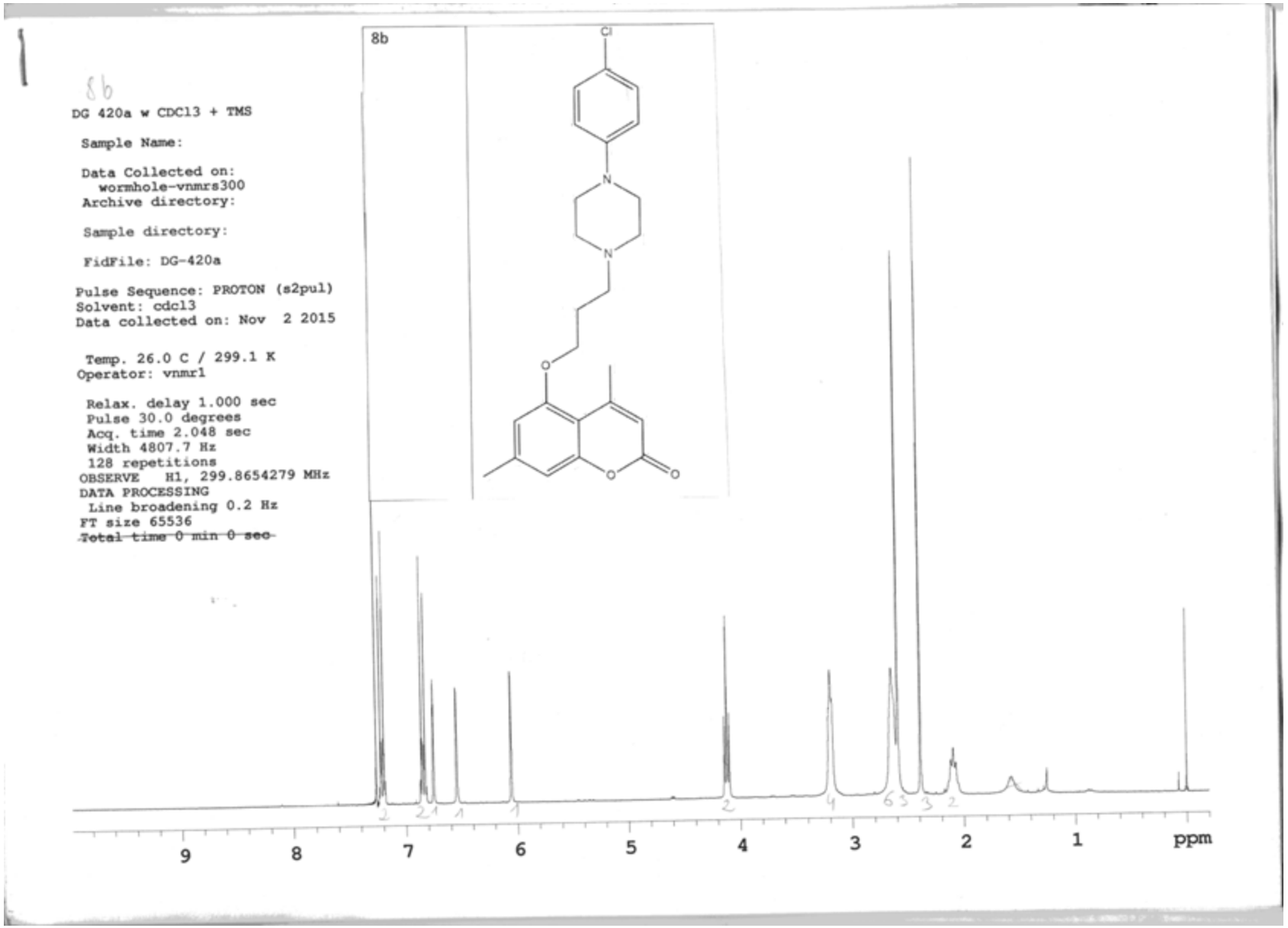

DG 416 13C
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: Carbon
Pulse Sequence: Carbon (s2pul)
Solvent: cdcl3
Data collected on: Dec 1 2015
5b
77.652
77.234
76.809
160
140
120
100
80
60
40
20
ppm

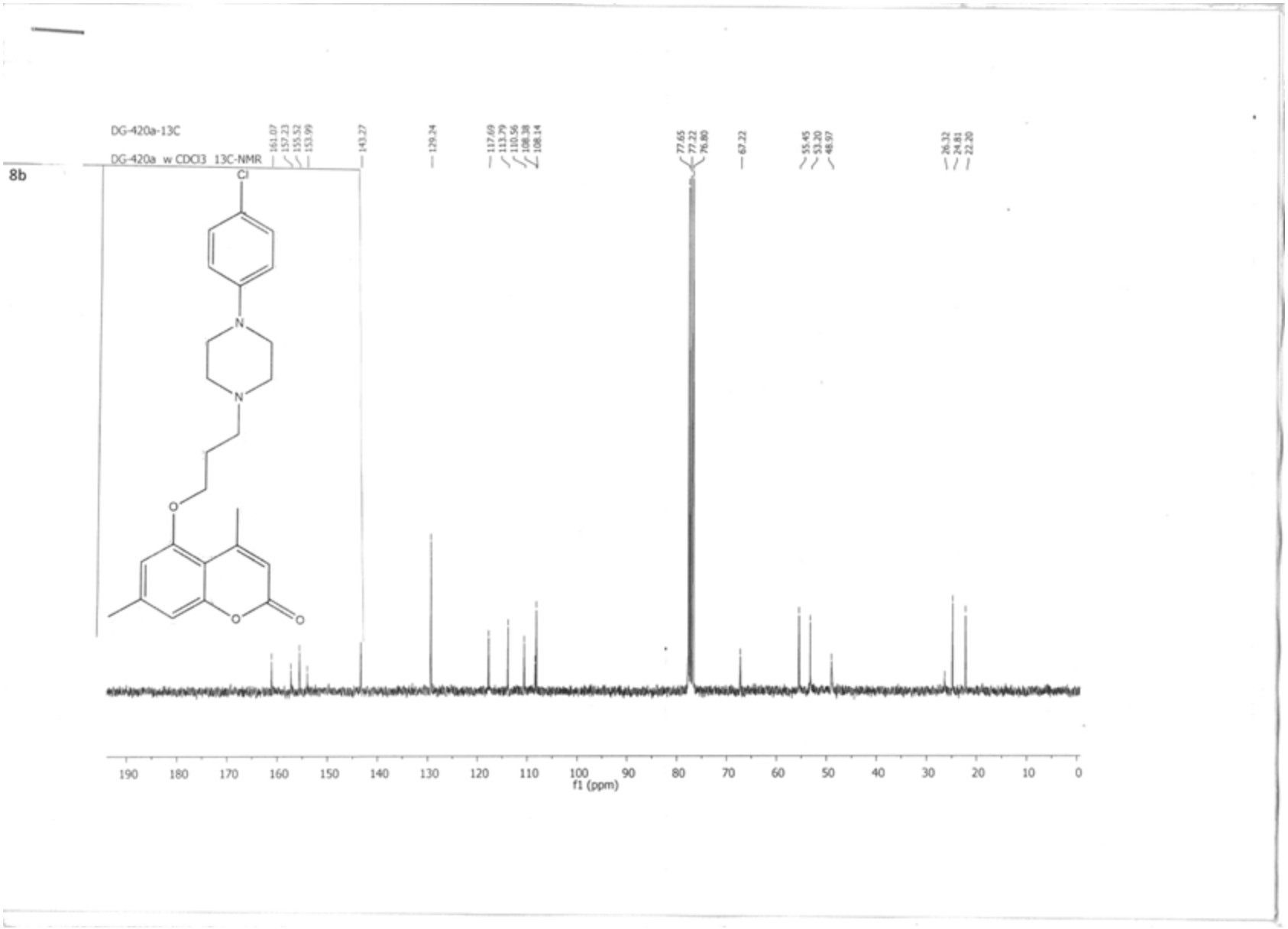

6b
6b
DG-417 w CDCl3 + TMS
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: PROTON
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Oct 21 2015
Temp. 26.0 C / 299.1 K
Operator: vnmr1
Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 2.048 sec
Width 4807.7 Hz
128 repetitions
OBSERVE H1, 299.8654230 MHz
DATA PROCESSING
Line broadening 0.2 Hz
FT size 65536
Total time 0 min 0 sec
O
N
O
O
O
9
8
7
6
5
4
3
2
1
ppm

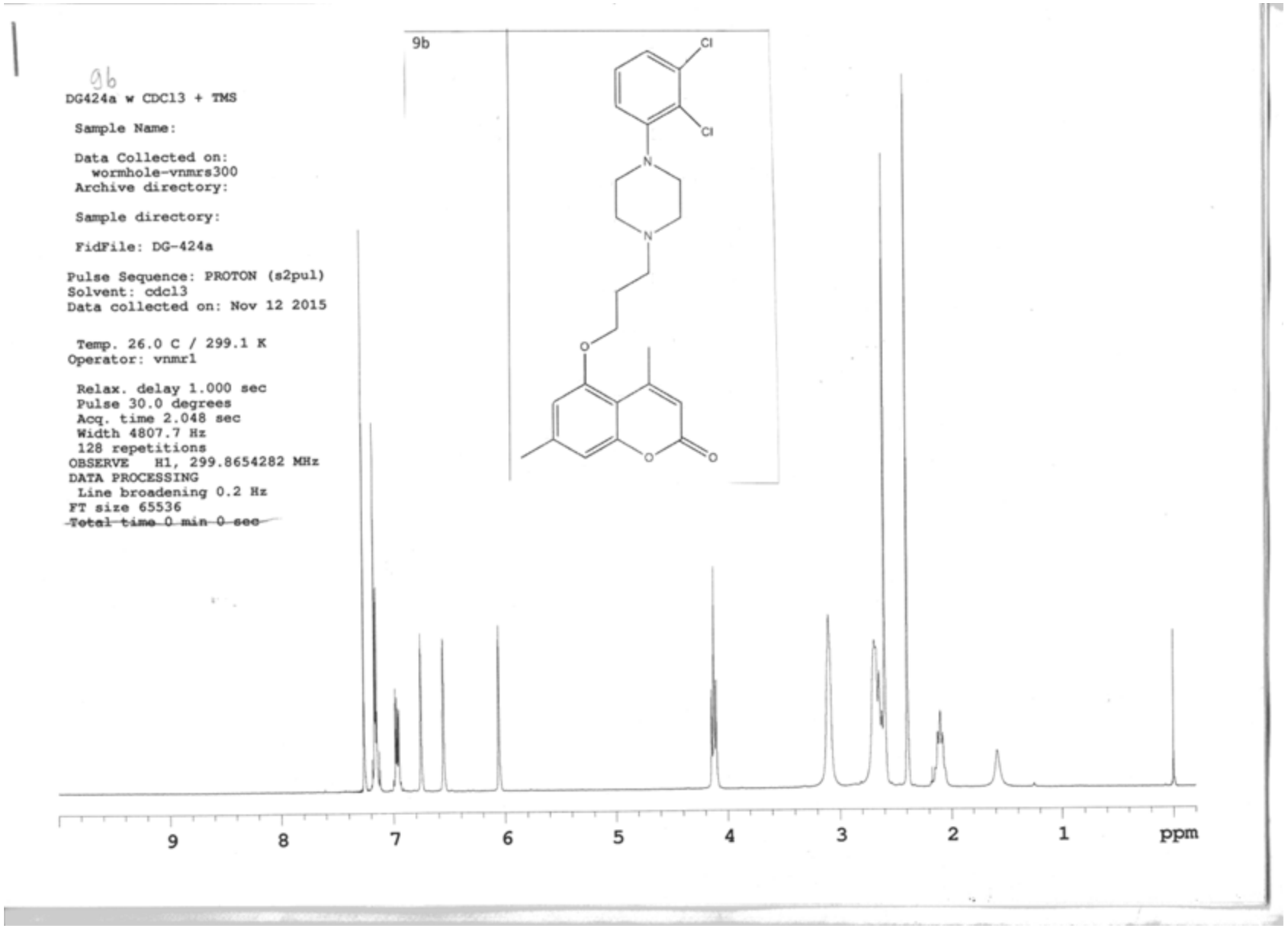

DG 417 13C
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: Carbon
Pulse Sequence: Carbon (s2pul)
Solvent: cdcl3
Data collected on: Dec 1 2015
6b
77.230
76.805
53.899
160
140
120
100
80
60
40
20
ppm

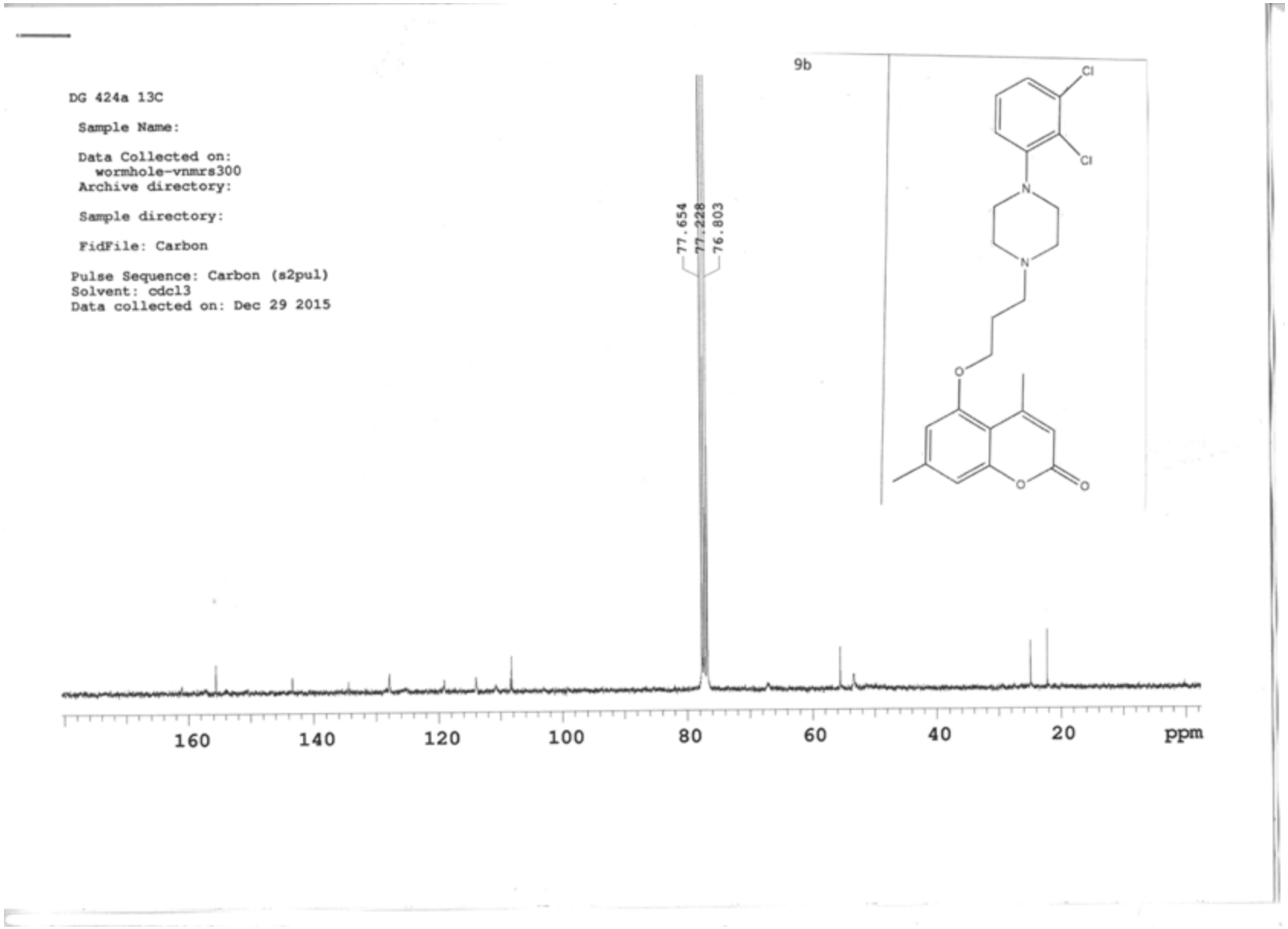

7b
7b
DG-418b w CDCl3 + TMS
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: PROTON
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Oct 21 2015
Temp. 26.0 C / 299.1 K
Operator: vnmr1
Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 2.048 sec
Width 4807.7 Hz
128 repetitions
OBSERVE H1, 299.8654274 MHz
DATA PROCESSING
Line broadening 0.2 Hz
FT size 65536
Total time 0 min 0 sec
NO2
N
N
O
O
O
9
8
7
6
5
4
3
2
1
ppm

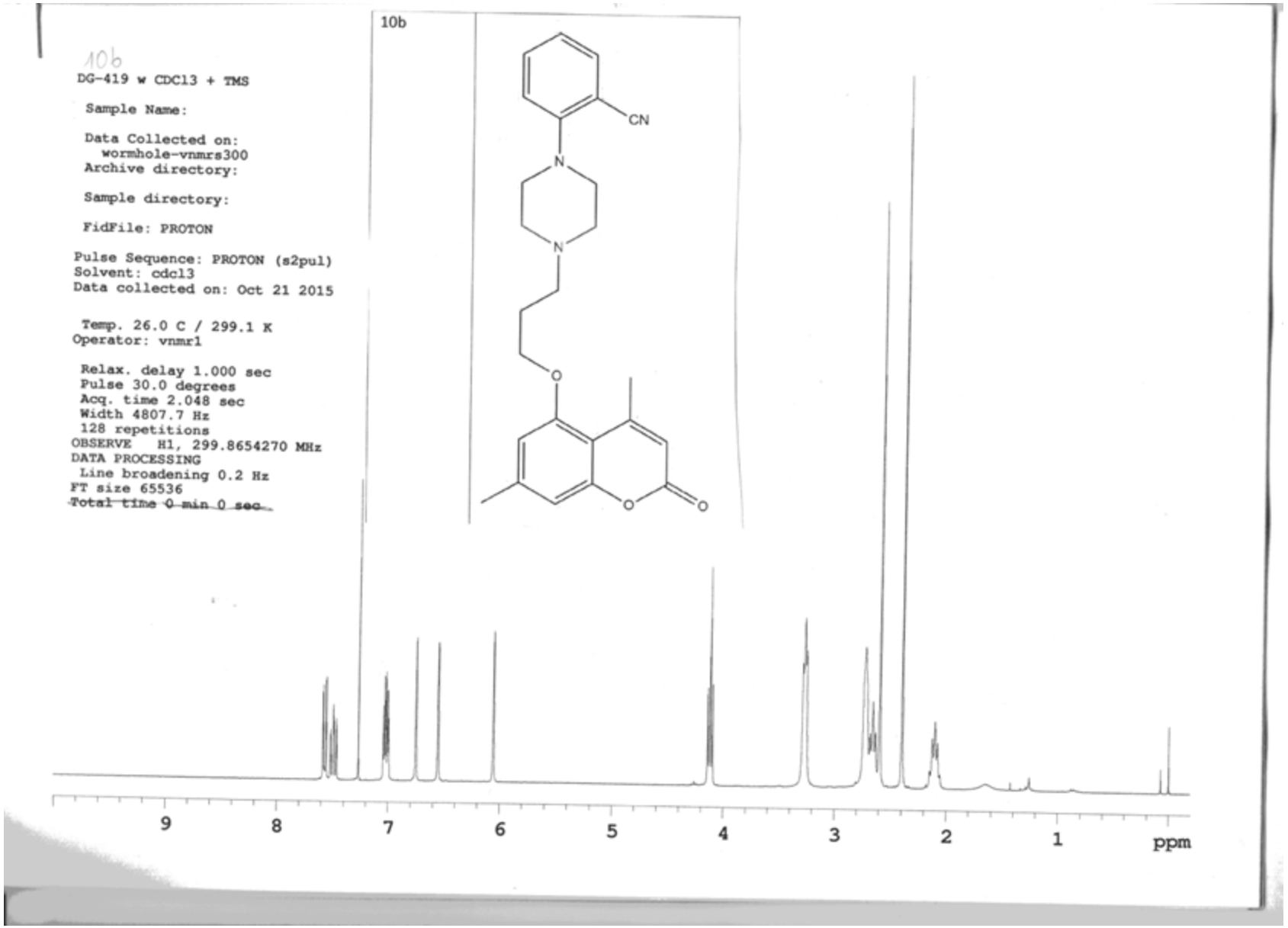

DG 418b 13C
161.09
157.29
155.56
154.88
153.99
143.27
126.16
113.83
113.03
110.57
108.41
108.12
77.65
77.43
77.21
76.81
67.20
55.34
52.93
47.13
46.36
26.64
24.82
22.23
7b
NO2
N
N
O
O
O
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

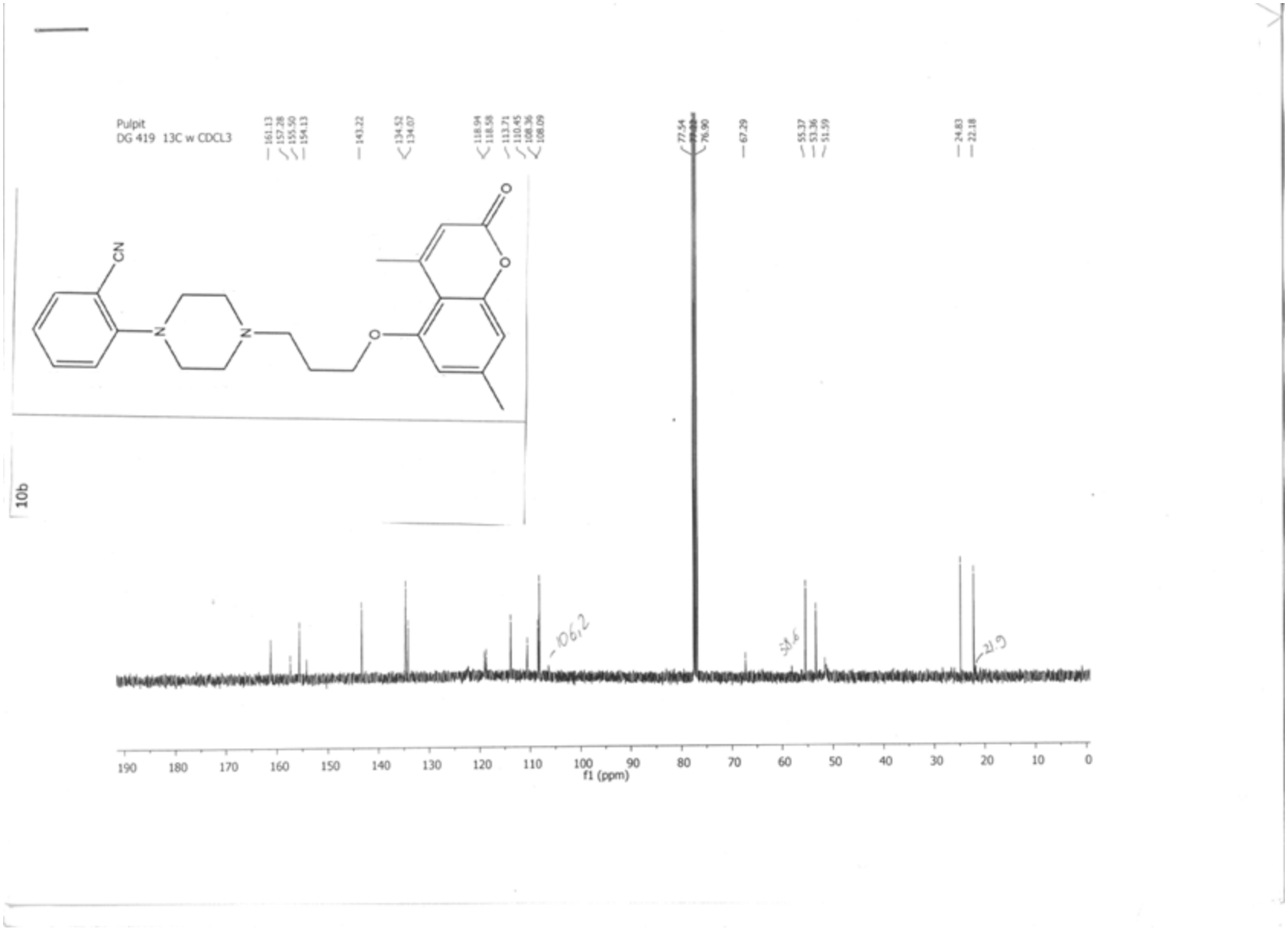

8b
8b
DG 420a w CDCl3 + TMS
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: DG-420a
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Nov 2 2015
Temp. 26.0 C / 299.1 K
Operator: vnmrl
Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 2.048 sec
Width 4807.7 Hz
128 repetitions
OBSERVE H1, 299.8654279 MHz
DATA PROCESSING
Line broadening 0.2 Hz
FT size 65536
Total time 0 min 0 sec
Cl
N
N
O
O
O
2
2
1
1
1
2
4
6
3
2
9
8
7
6
5
4
3
2
1
ppm

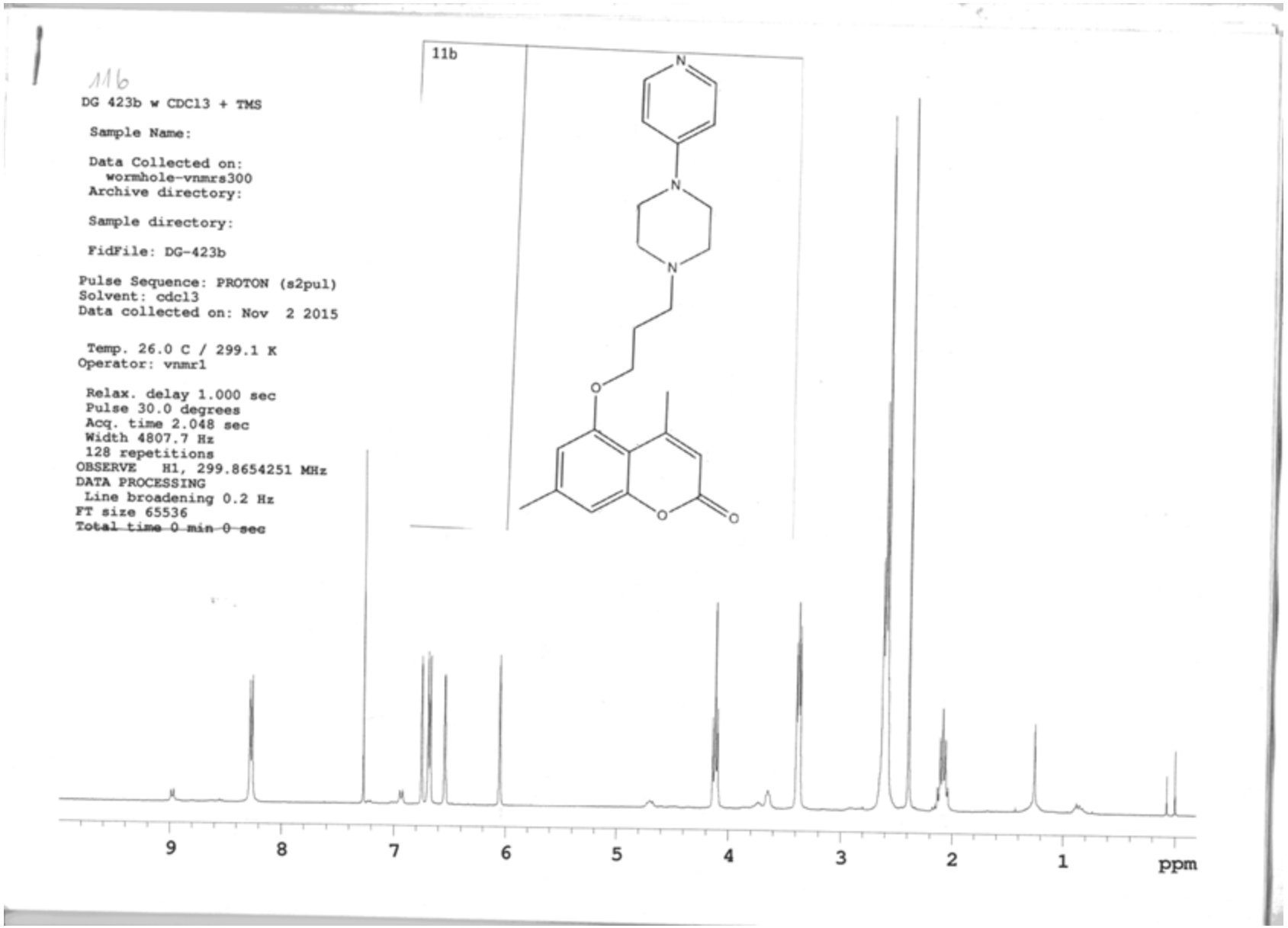

DG-420a-13C
DG-420a w CDCl3 13C-NMR
8b
161.07
157.23
155.52
153.99
143.27
129.24
117.69
113.79
110.56
108.38
108.14
77.65
77.22
76.80
67.22
55.45
53.20
48.97
26.32
24.81
22.20
Cl
N
N
O
O
O
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

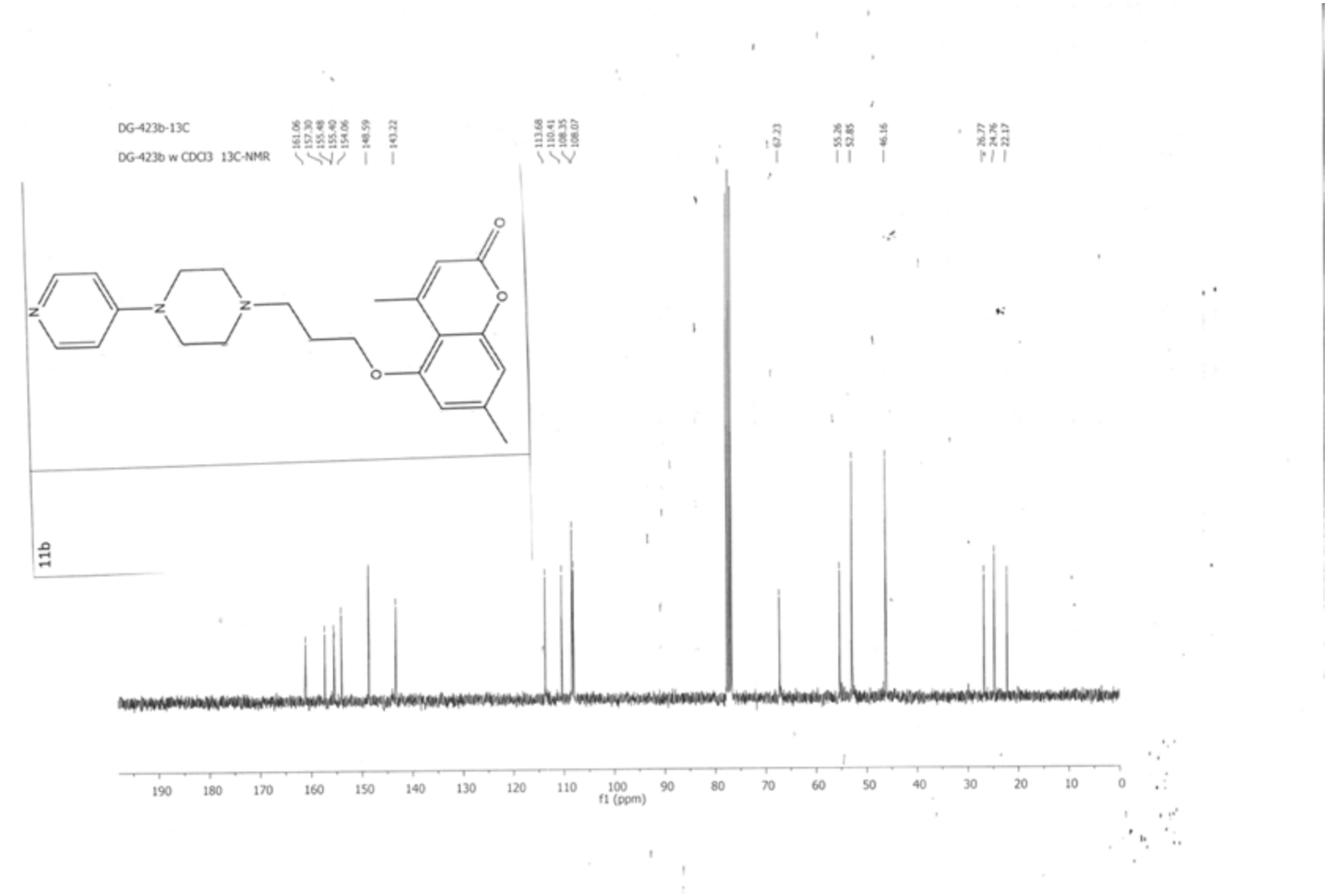

9b
DG424a w CDCl3 + TMS
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: DG-424a
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Nov 12 2015
Temp. 26.0 C / 299.1 K
Operator: vnmr1
Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 2.048 sec
Width 4807.7 Hz
128 repetitions
OBSERVE H1, 299.8654282 MHz
DATA PROCESSING
Line broadening 0.2 Hz
FT size 65536
Total time 0 min 0 sec
Cl
Cl
N
N
O
O
O
9
8
7
6
5
4
3
2
1
ppm

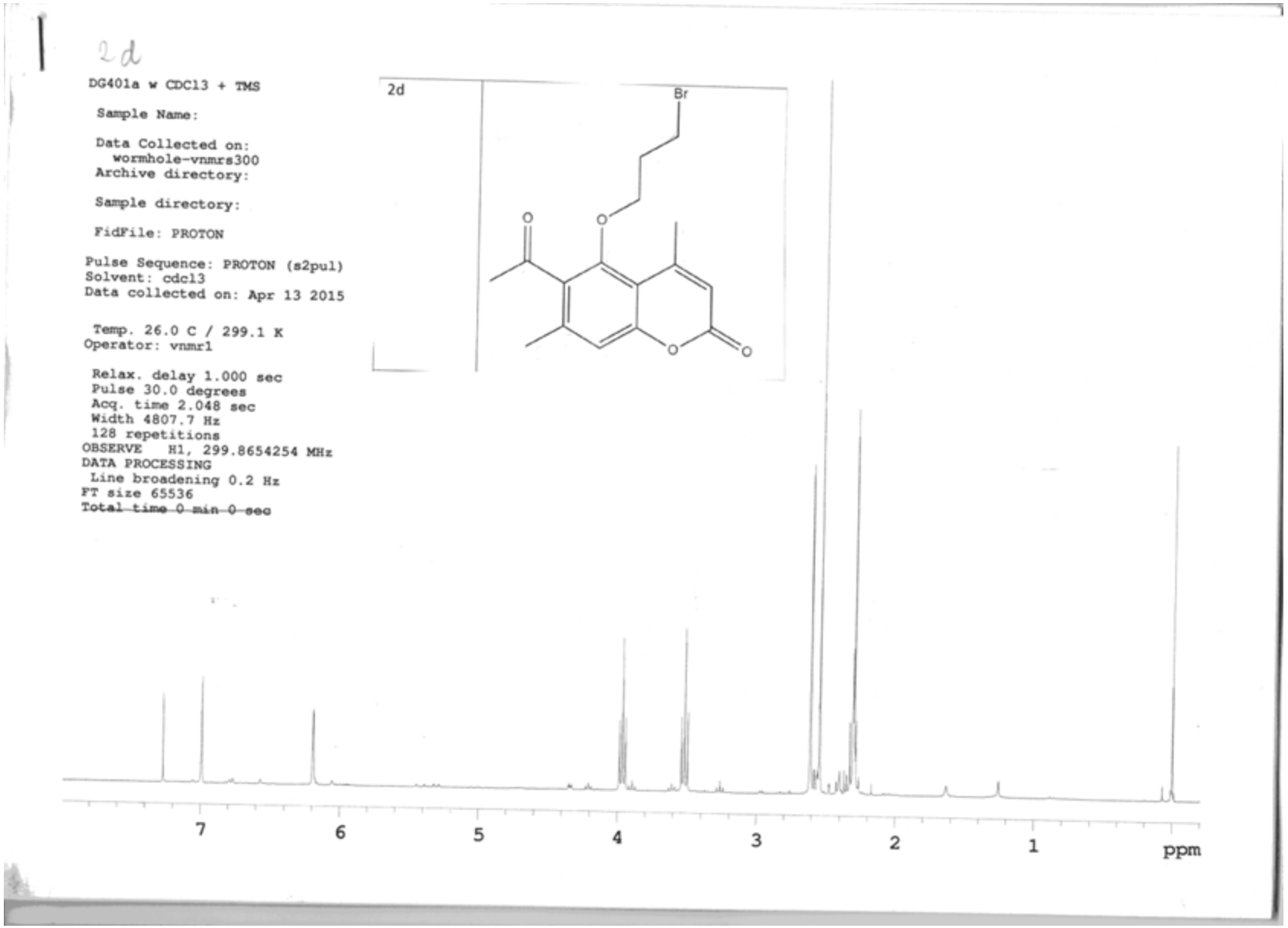

DG 424a 13C
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: Carbon
Pulse Sequence: Carbon (s2pul)
Solvent: cdcl3
Data collected on: Dec 29 2015
9b
77.654
77.228
76.803
Cl
Cl
N
N
O
O
O
160
140
120
100
80
60
40
20
ppm

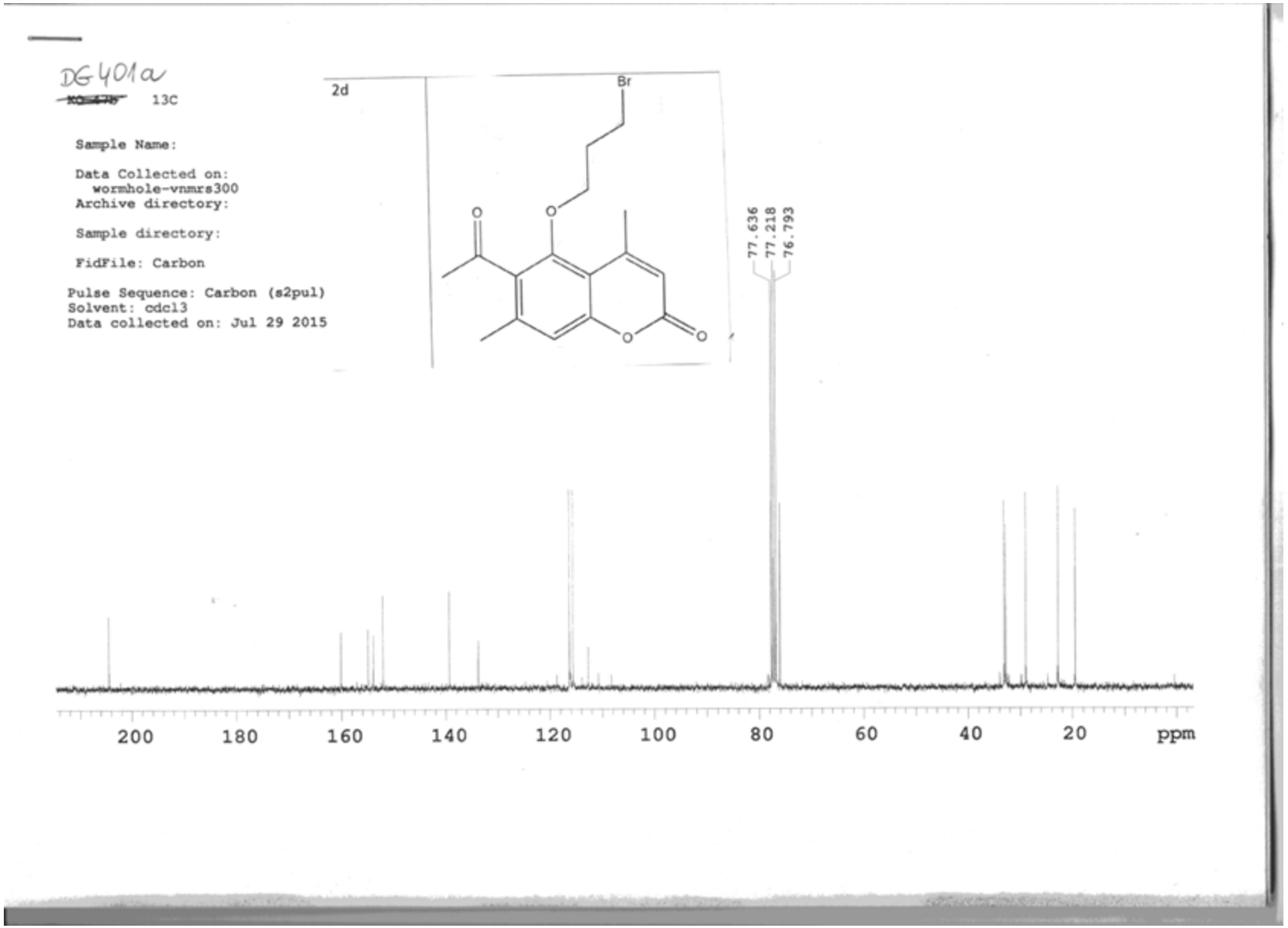

10b
DG-419 w CDCl3 + TMS
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: PROTON
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Oct 21 2015
Temp. 26.0 C / 299.1 K
Operator: vnmr1
Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 2.048 sec
Width 4807.7 Hz
128 repetitions
OBSERVE H1, 299.8654270 MHz
DATA PROCESSING
Line broadening 0.2 Hz
FT size 65536
Total time 0 min 0 sec
10b
CN
N
N
O
O
O
9
8
7
6
5
4
3
2
1
ppm

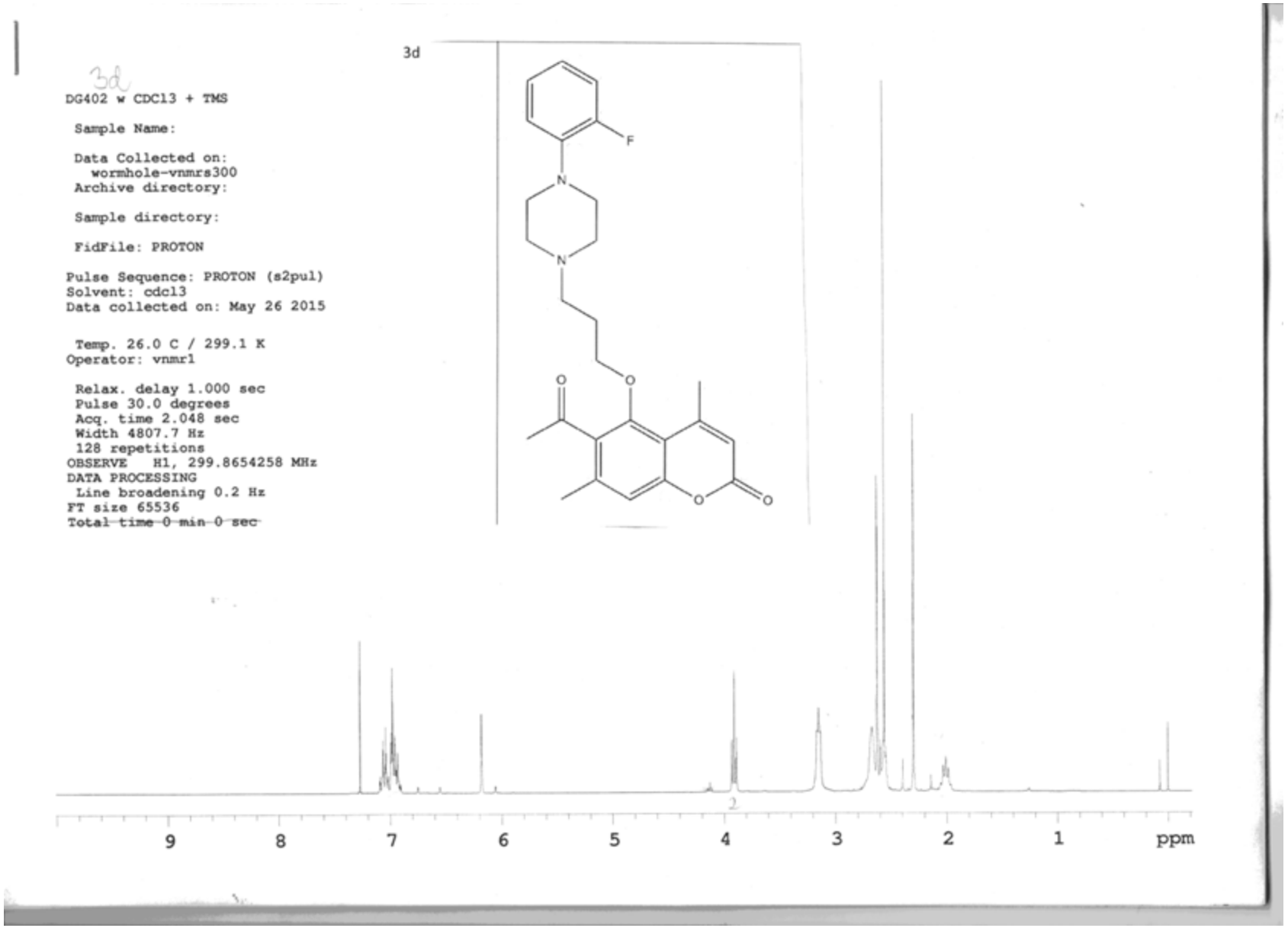

Pulpit
DG 419 13C w CDCL3
161.13
157.28
155.50
154.13
143.22
134.52
134.07
118.94
118.58
113.71
110.45
108.36
108.09
77.54
77.04
76.90
67.29
55.37
53.36
51.59
24.83
22.18
CN
N
N
O
O
O
10b
106.2
53.6
21.9
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

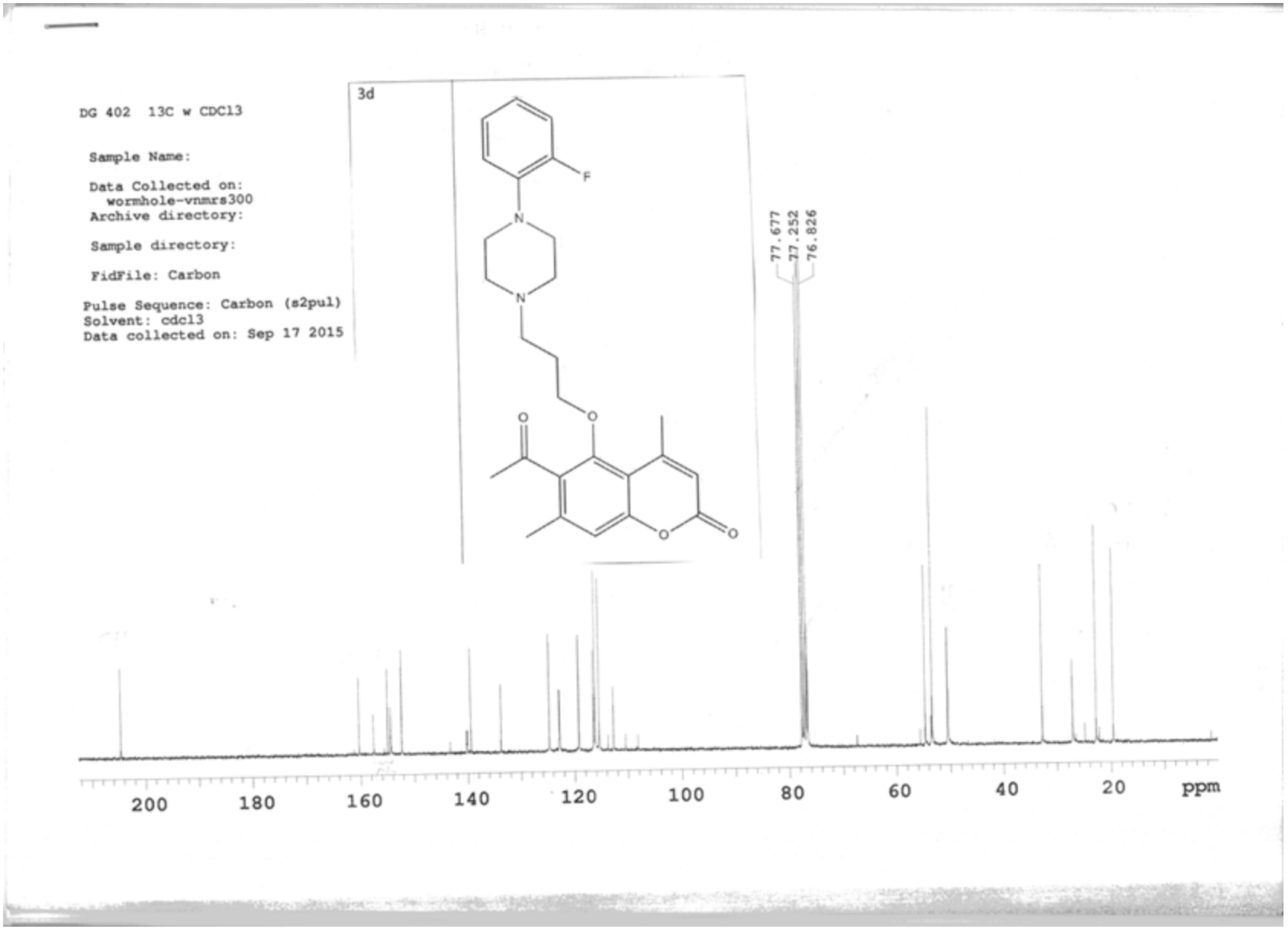

11b
DG 423b w CDCl3 + TMS
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: DG-423b
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Nov 2 2015
Temp. 26.0 C / 299.1 K
Operator: vnmr1
Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 2.048 sec
Width 4807.7 Hz
128 repetitions
OBSERVE H1, 299.8654251 MHz
DATA PROCESSING
Line broadening 0.2 Hz
FT size 65536
Total time 0 min 0 sec
N
N
N
O
O
O
9
8
7
6
5
4
3
2
1
ppm

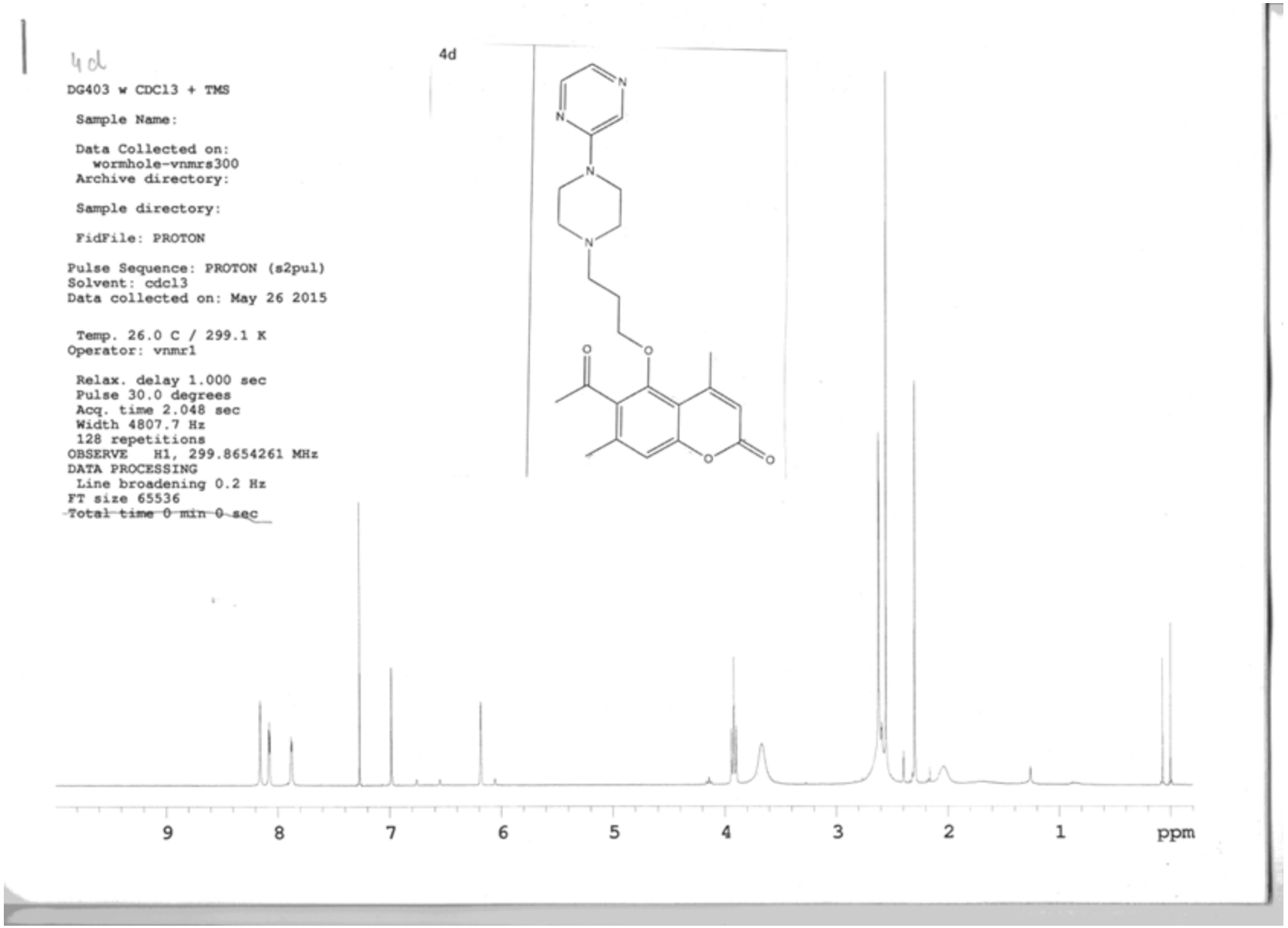

DG-423b-13C
DG-423b w CDCl3 13C-NMR
161.06
157.30
155.48
155.40
154.06
148.59
143.22
113.68
110.41
108.35
108.07
67.23
55.26
52.85
46.16
26.77
24.76
22.17
11b
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

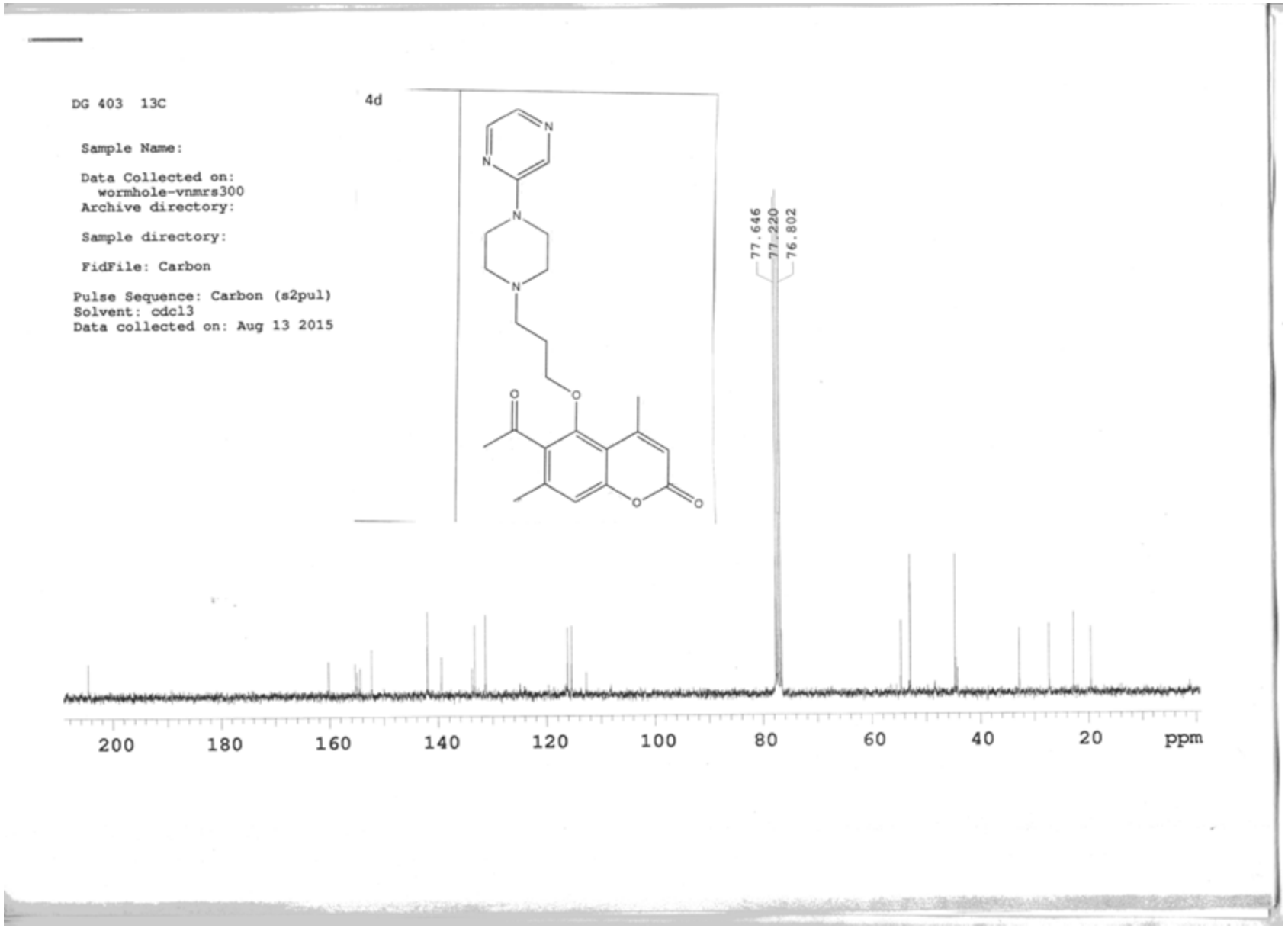

2d
DG401a w CDCl3 + TMS
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: PROTON
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Apr 13 2015
Temp. 26.0 C / 299.1 K
Operator: vnmr1
Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 2.048 sec
Width 4807.7 Hz
128 repetitions
OBSERVE H1, 299.8654254 MHz
DATA PROCESSING
Line broadening 0.2 Hz
FT size 65536
Total time 0 min 0 sec
2d
Br
O
O
O
O
7
6
5
4
3
2
1
ppm

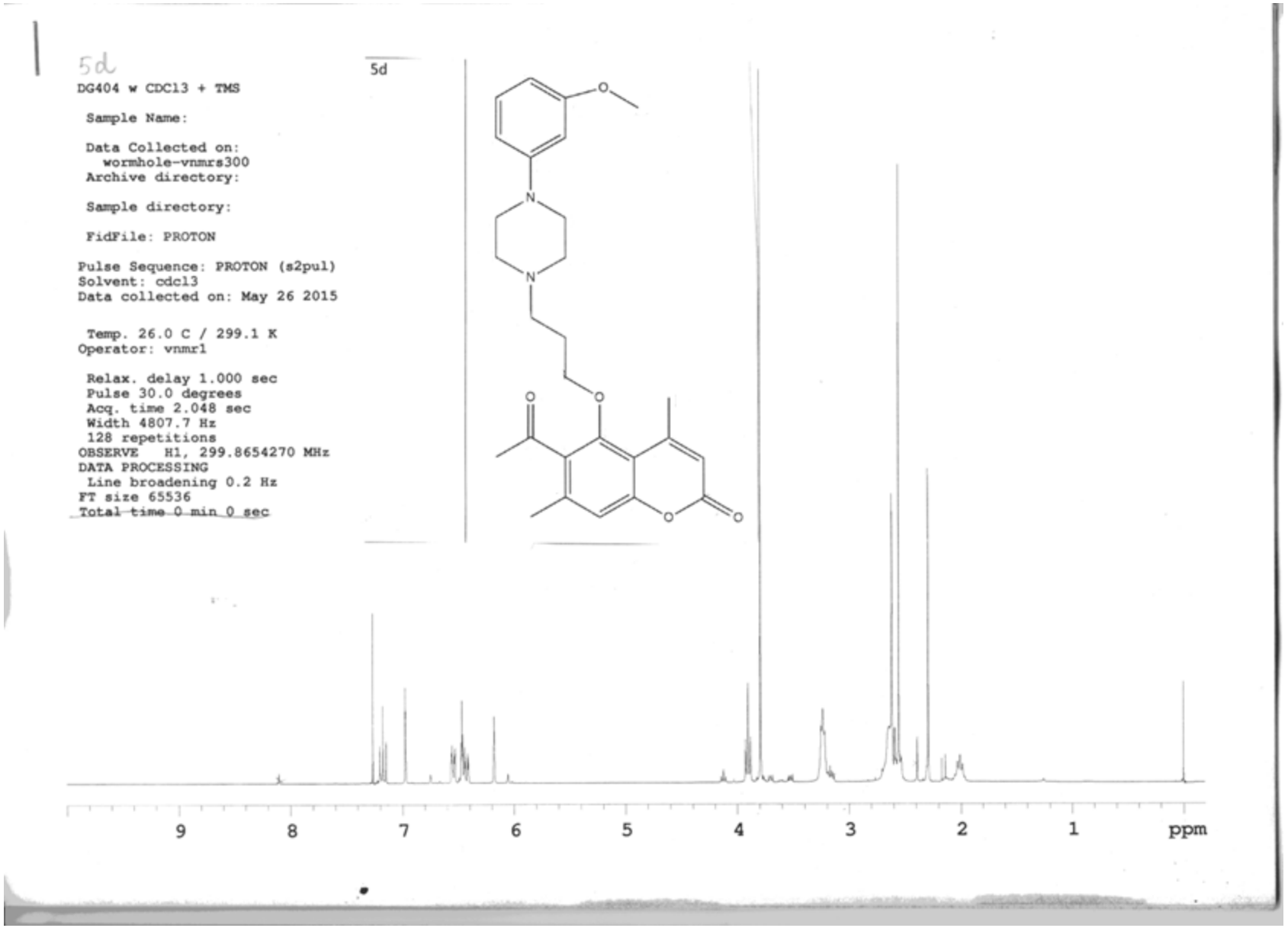

DG401a
13C
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: Carbon
Pulse Sequence: Carbon (s2pul)
Solvent: cdcl3
Data collected on: Jul 29 2015
2d
Br
O
O
O
O
77.636
77.218
76.793
200
180
160
140
120
100
80
60
40
20
ppm

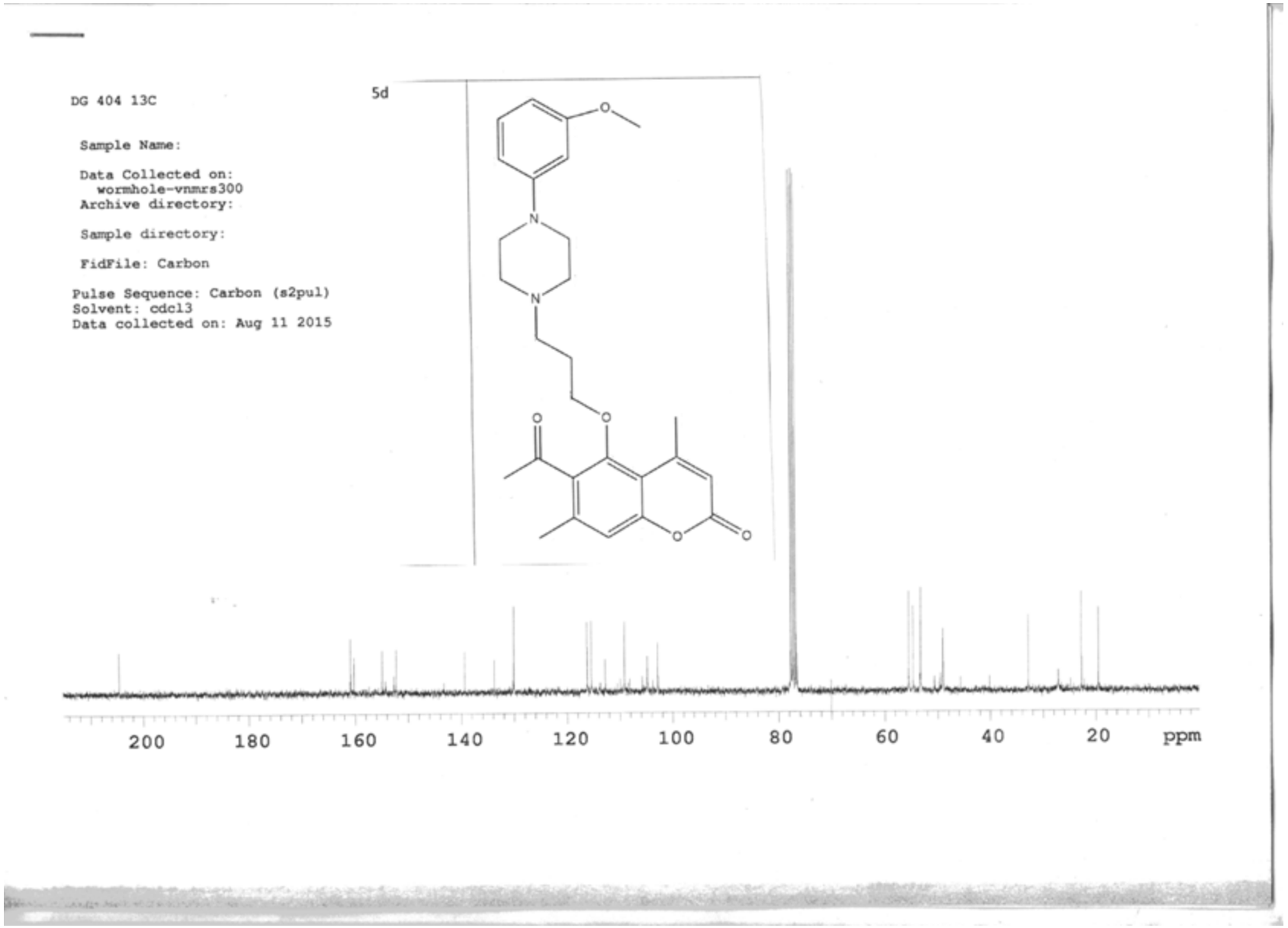

3d
DG402 w CDCl3 + TMS
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: PROTON
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: May 26 2015
Temp. 26.0 C / 299.1 K
Operator: vnmr1
Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 2.048 sec
Width 4807.7 Hz
128 repetitions
OBSERVE H1, 299.8654258 MHz
DATA PROCESSING
Line broadening 0.2 Hz
FT size 65536
Total time 0 min 0 sec
F
N
N
O
O
O
O
9
8
7
6
5
4
3
2
1
ppm

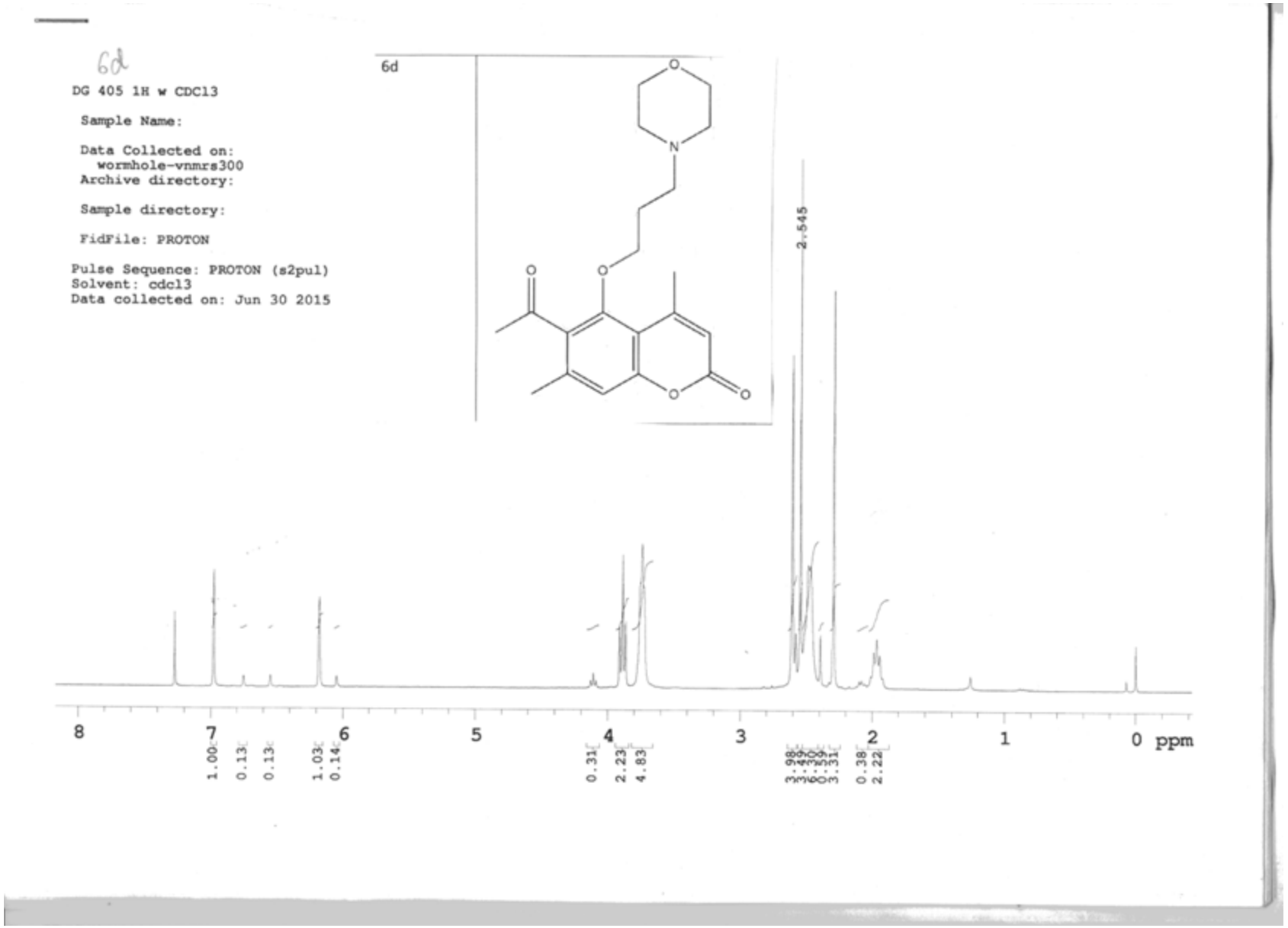

DG 402 13C w CDCl3
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: Carbon
Pulse Sequence: Carbon (s2pul)
Solvent: cdcl3
Data collected on: Sep 17 2015
3d
F
N
N
O
O
O
O
77.677
77.252
76.826
200
180
160
140
120
100
80
60
40
20
ppm

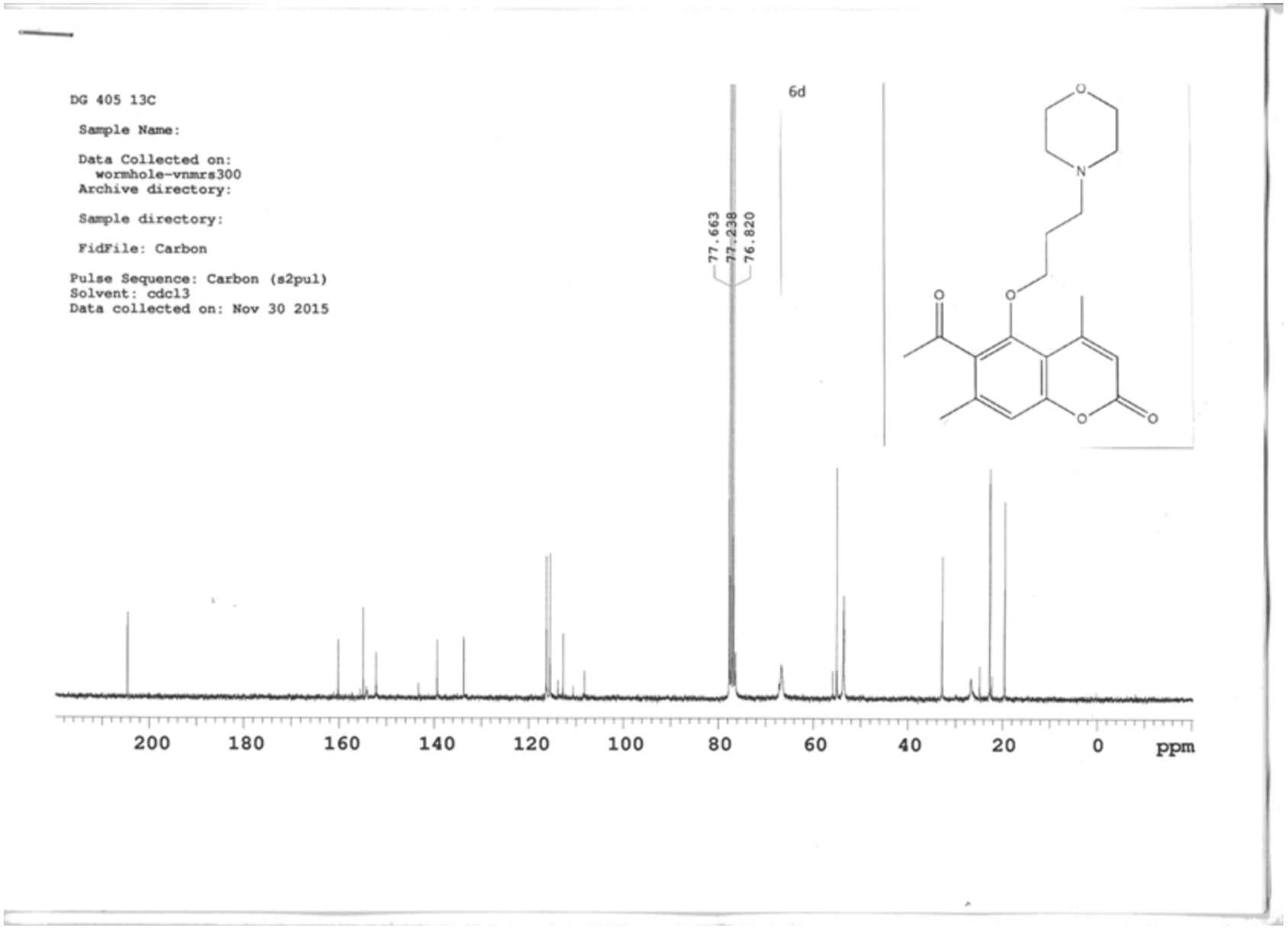

4d
DG403 w CDCl3 + TMS
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: PROTON
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: May 26 2015
Temp. 26.0 C / 299.1 K
Operator: vnmr1
Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 2.048 sec
Width 4807.7 Hz
128 repetitions
OBSERVE H1, 299.8654261 MHz
DATA PROCESSING
Line broadening 0.2 Hz
FT size 65536
Total time 0 min 0 sec
9
8
7
6
5
4
3
2
1
ppm

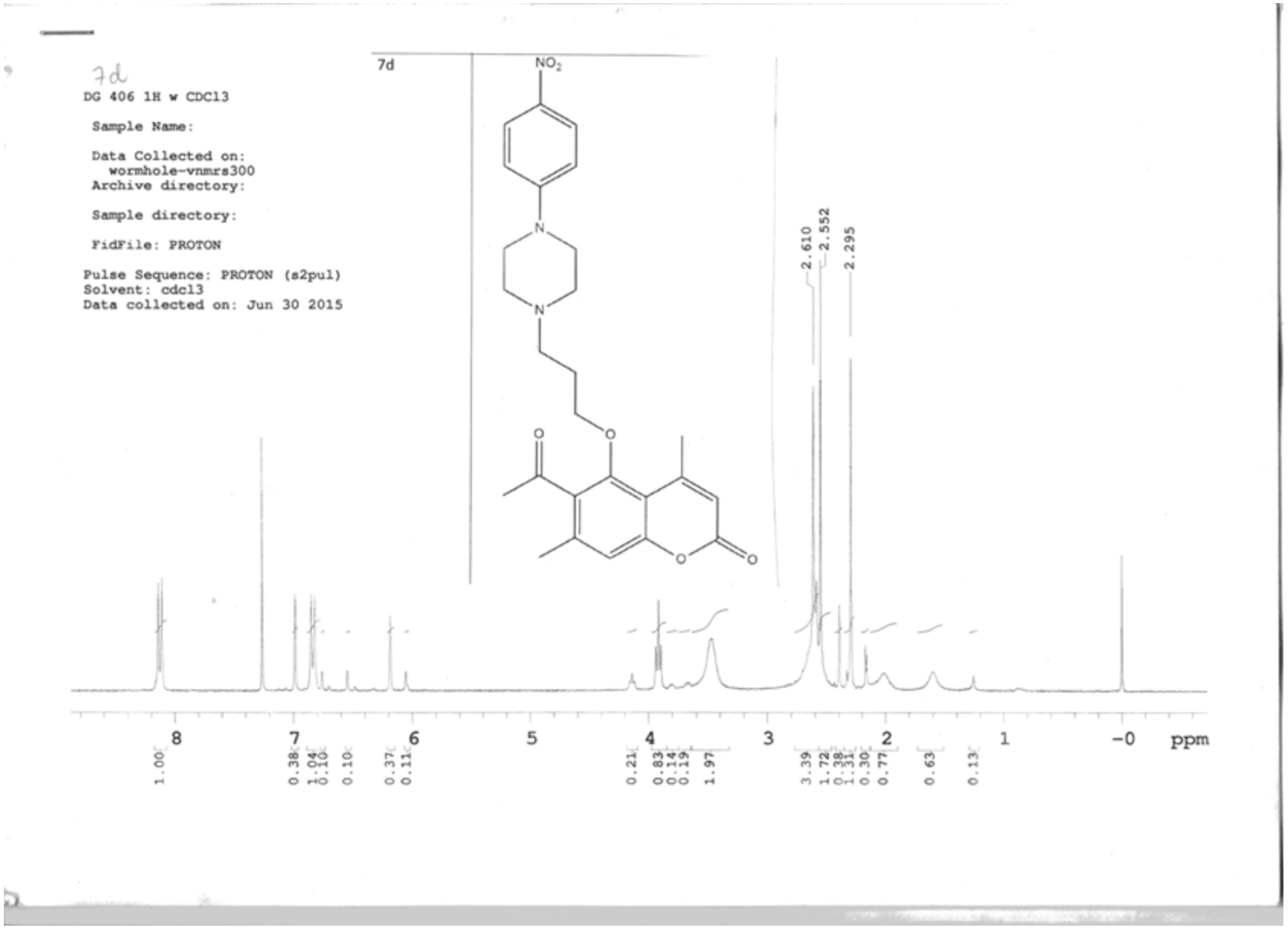

DG 403 13C
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: Carbon
Pulse Sequence: Carbon (s2pul)
Solvent: cdcl3
Data collected on: Aug 13 2015
4d
77.646
77.220
76.802
200
180
160
140
120
100
80
60
40
20
ppm

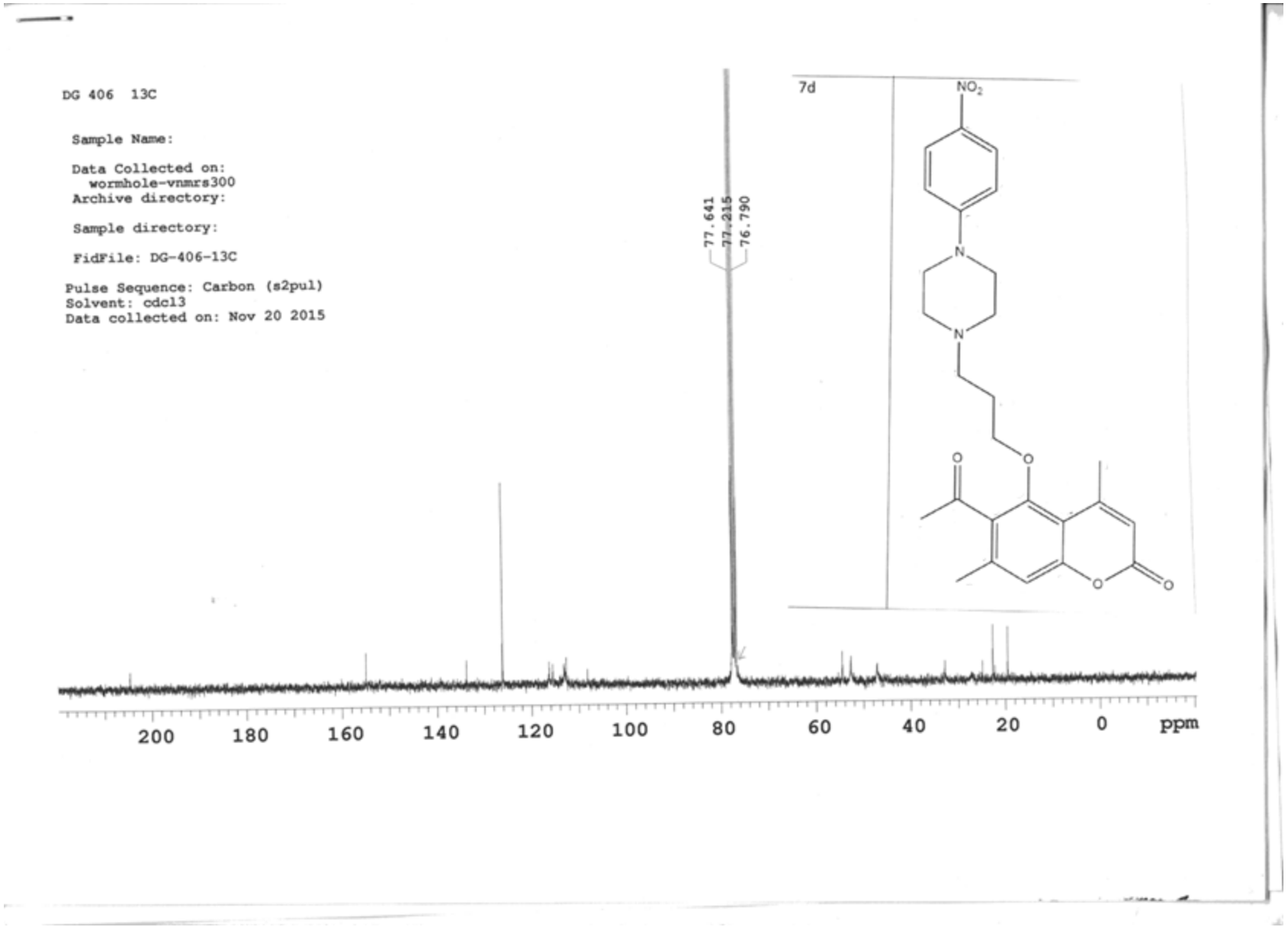

5d
DG404 w CDCl3 + TMS
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: PROTON
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: May 26 2015
Temp. 26.0 C / 299.1 K
Operator: vnmr1
Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 2.048 sec
Width 4807.7 Hz
128 repetitions
OBSERVE H1, 299.8654270 MHz
DATA PROCESSING
Line broadening 0.2 Hz
FT size 65536
Total time 0 min 0 sec
5d
O
N
N
O
O
O
O
9
8
7
6
5
4
3
2
1
ppm


DG 404 13C
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: Carbon
Pulse Sequence: Carbon (s2pul)
Solvent: cdcl3
Data collected on: Aug 11 2015
5d
O
N
N
O
O
O
O
200
180
160
140
120
100
80
60
40
20
ppm


6d
DG 405 1H w CDCl3
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: PROTON
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Jun 30 2015
6d
2.545
8
7
6
5
4
3
2
1
0 ppm
1.00
0.13
0.13
1.03
0.14
0.31
2.23
4.83
3.98
3.49
3.09
3.39
3.31
0.38
2.22


DG 405 13C
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: Carbon
Pulse Sequence: Carbon (s2pul)
Solvent: cdcl3
Data collected on: Nov 30 2015
6d
77.663
77.238
76.820
O
N
O
O
O
O
200
180
160
140
120
100
80
60
40
20
0
ppm


7d
DG 406 1H w CDCl3
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: PROTON
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Jun 30 2015
7d
NO2
N
N
O
O
O
O
2.610
2.552
2.295
8
7
6
5
4
3
2
1
-0
ppm
1.00
0.38
1.04
0.10
0.10
0.37
0.11
0.21
0.83
0.14
0.19
1.97
3.39
1.72
0.38
1.31
0.30
0.77
0.63
0.13


DG 406 13C
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: DG-406-13C
Pulse Sequence: Carbon (s2pul)
Solvent: cdcl3
Data collected on: Nov 20 2015
77.641
77.215
76.790
7d
NO2
N
N
O
O
O
O
200
180
160
140
120
100
80
60
40
20
0
ppm

8d

8d

DG408 w CDCl3 + TMS

Sample Name:

Data Collected on:
wormhole-vnmrs300
Archive directory:

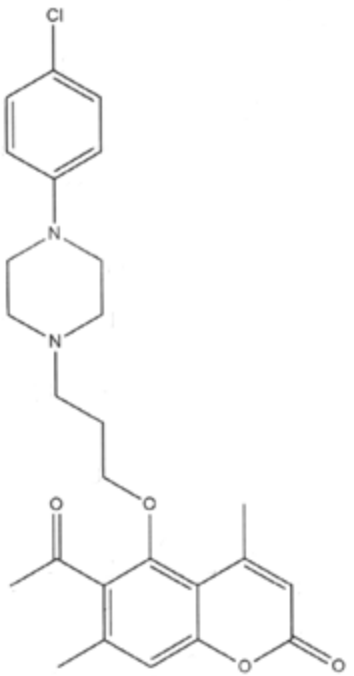
Sample directory:

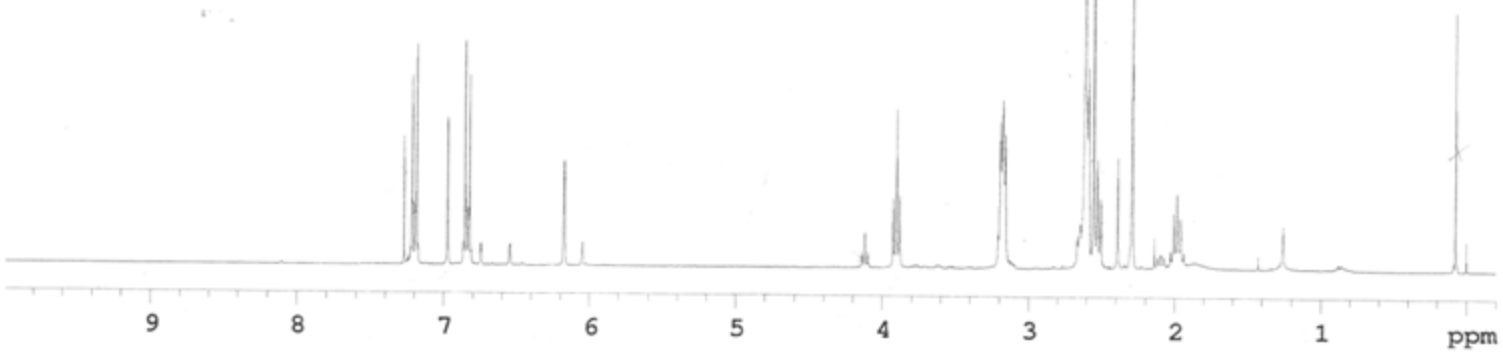
FidFile: PROTON

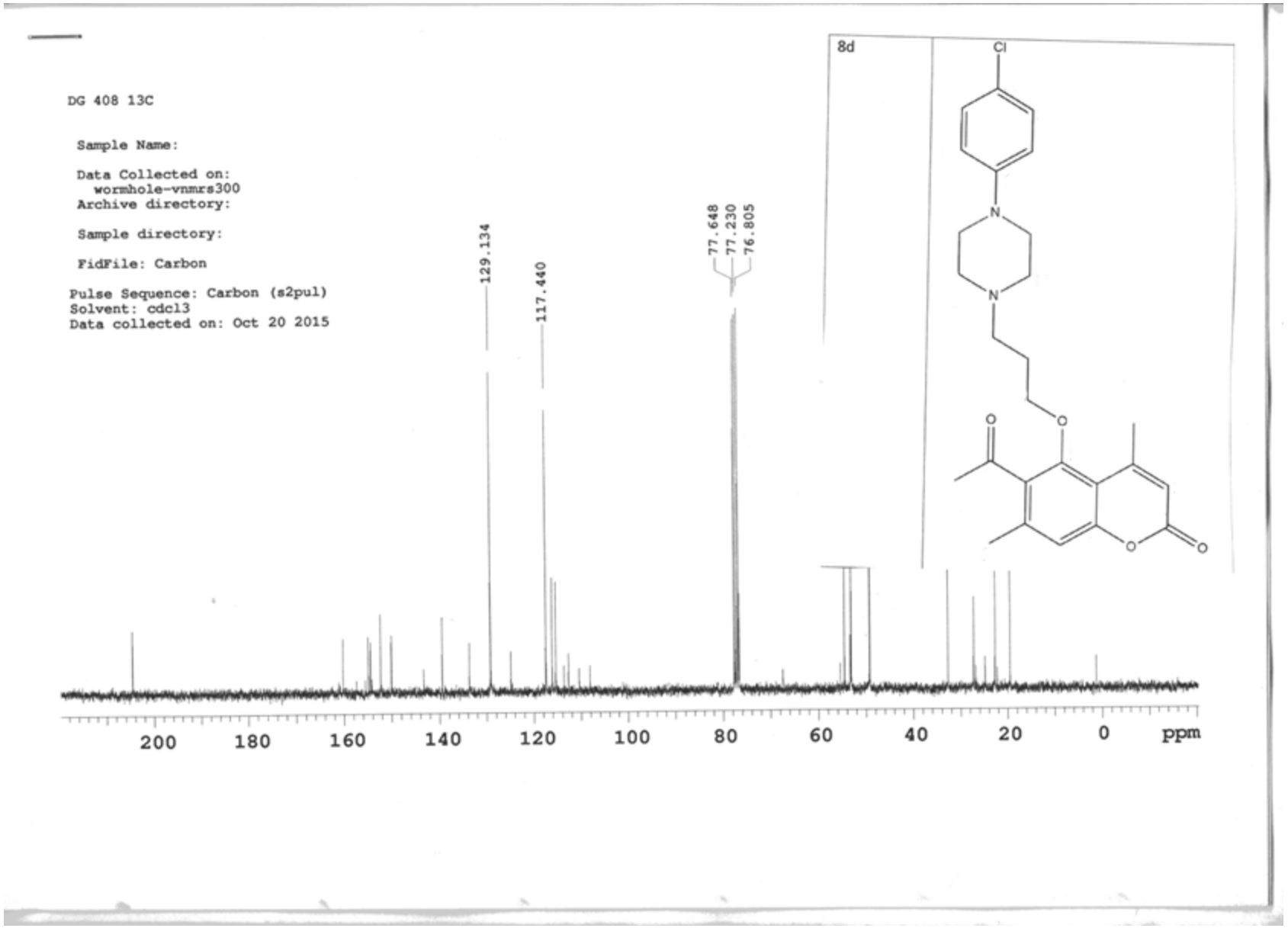
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Sep 16 2015

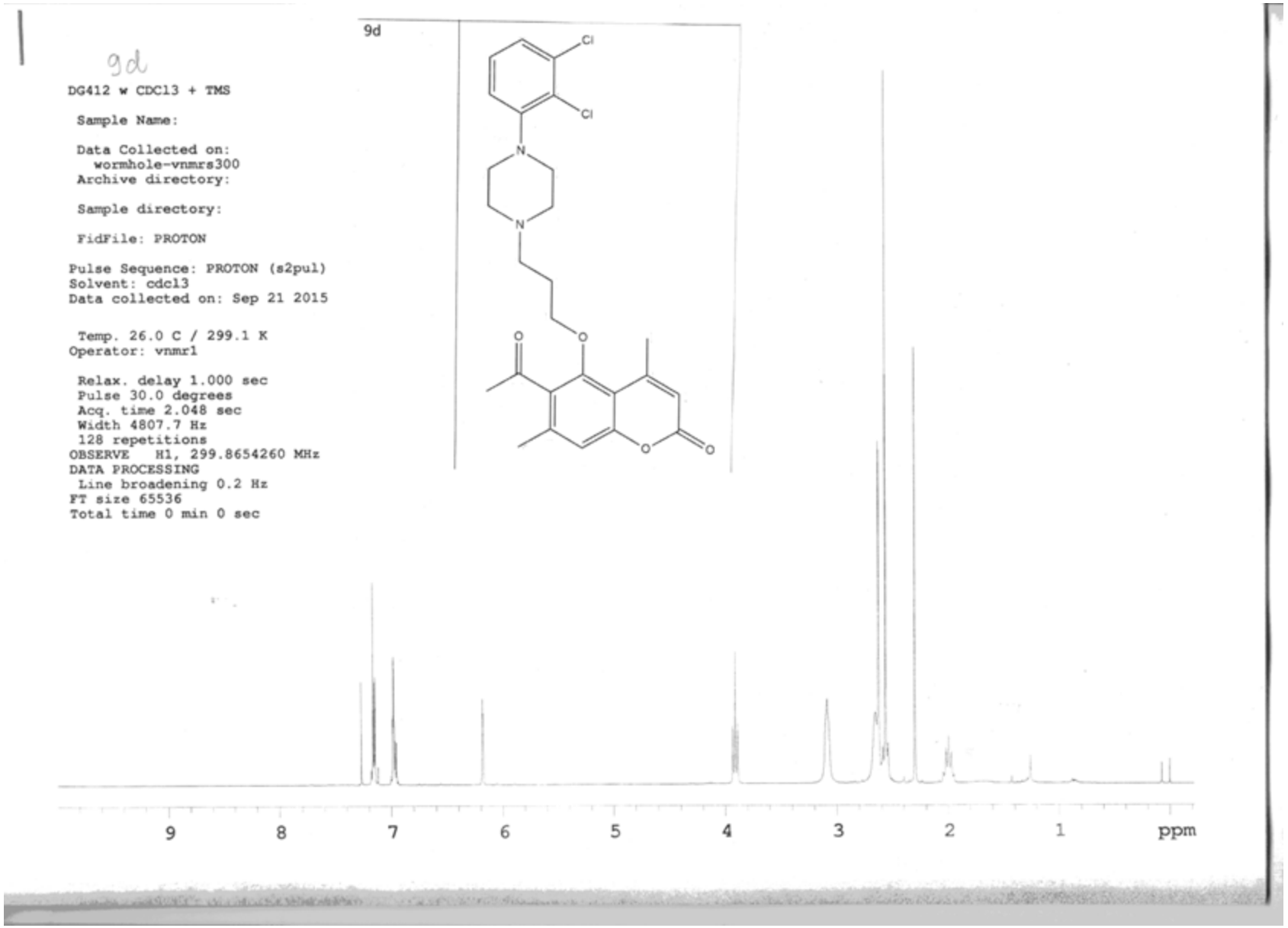
Temp. 26.0 C / 299.1 K
Operator: vnmr1

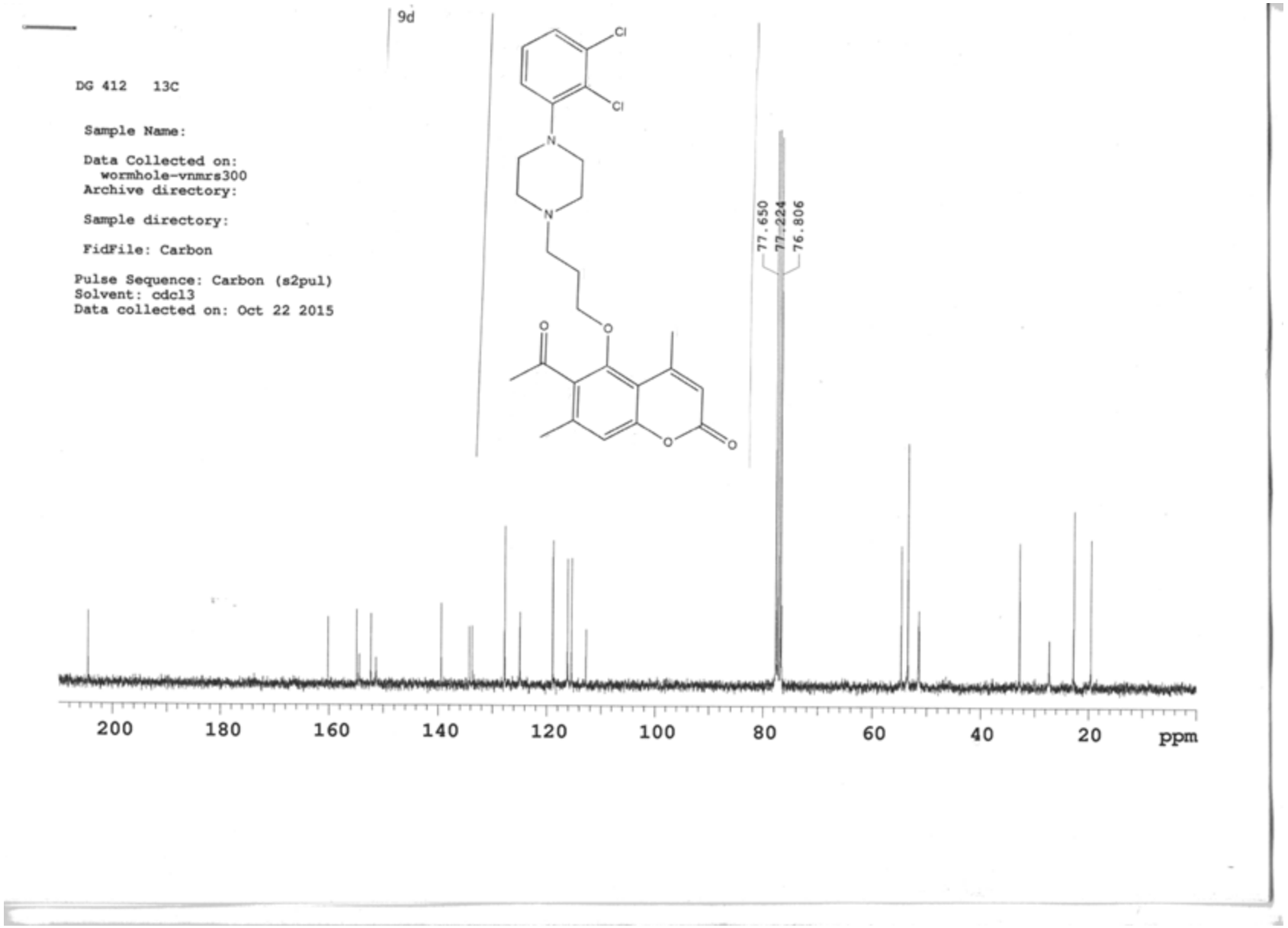
Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 2.048 sec
Width 4807.7 Hz
128 repetitions
OBSERVE H1, 299.8654257 MHz
DATA PROCESSING
Line broadening 0.2 Hz
FT size 65536
Total time 0 min 0 sec

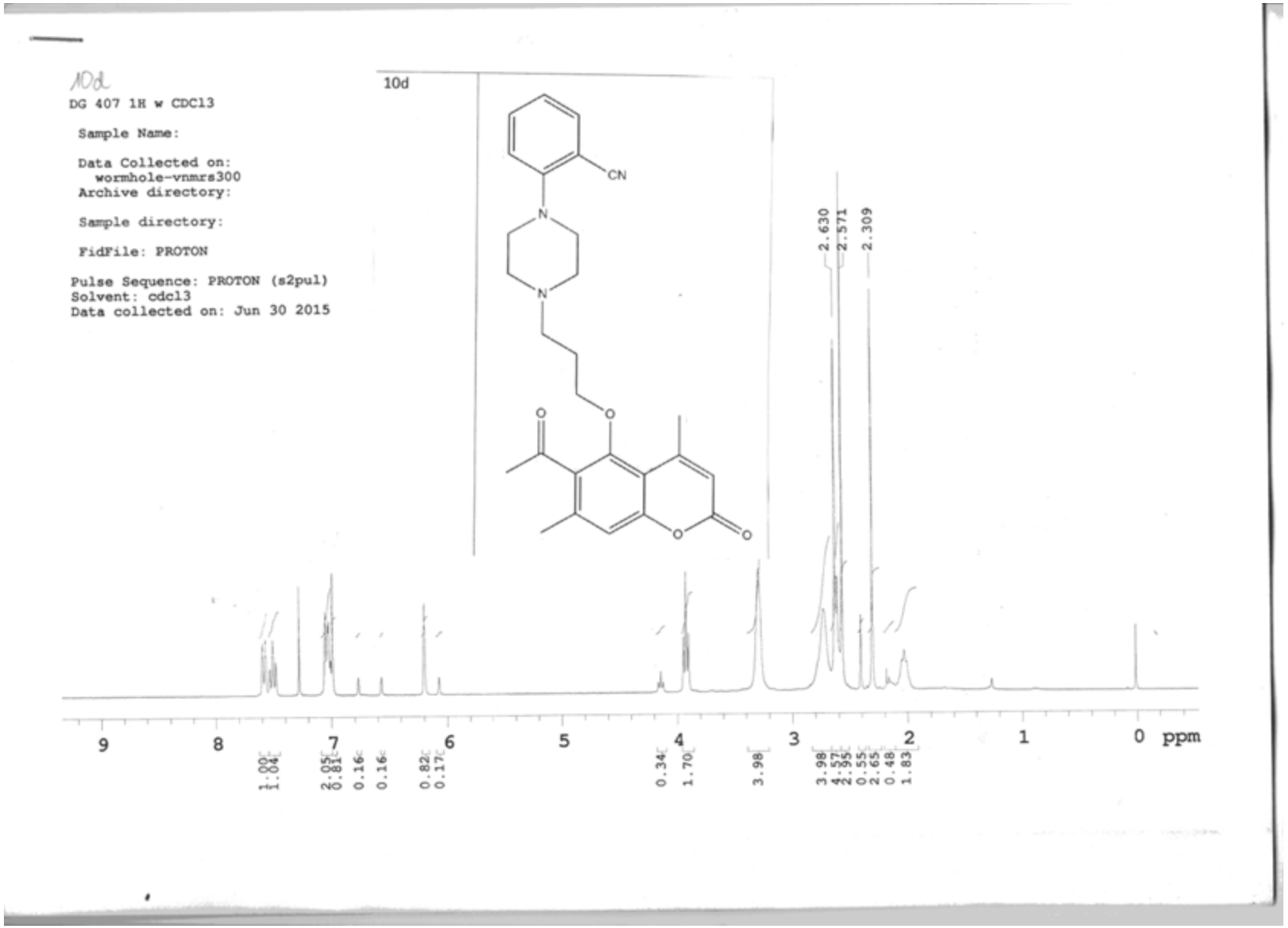


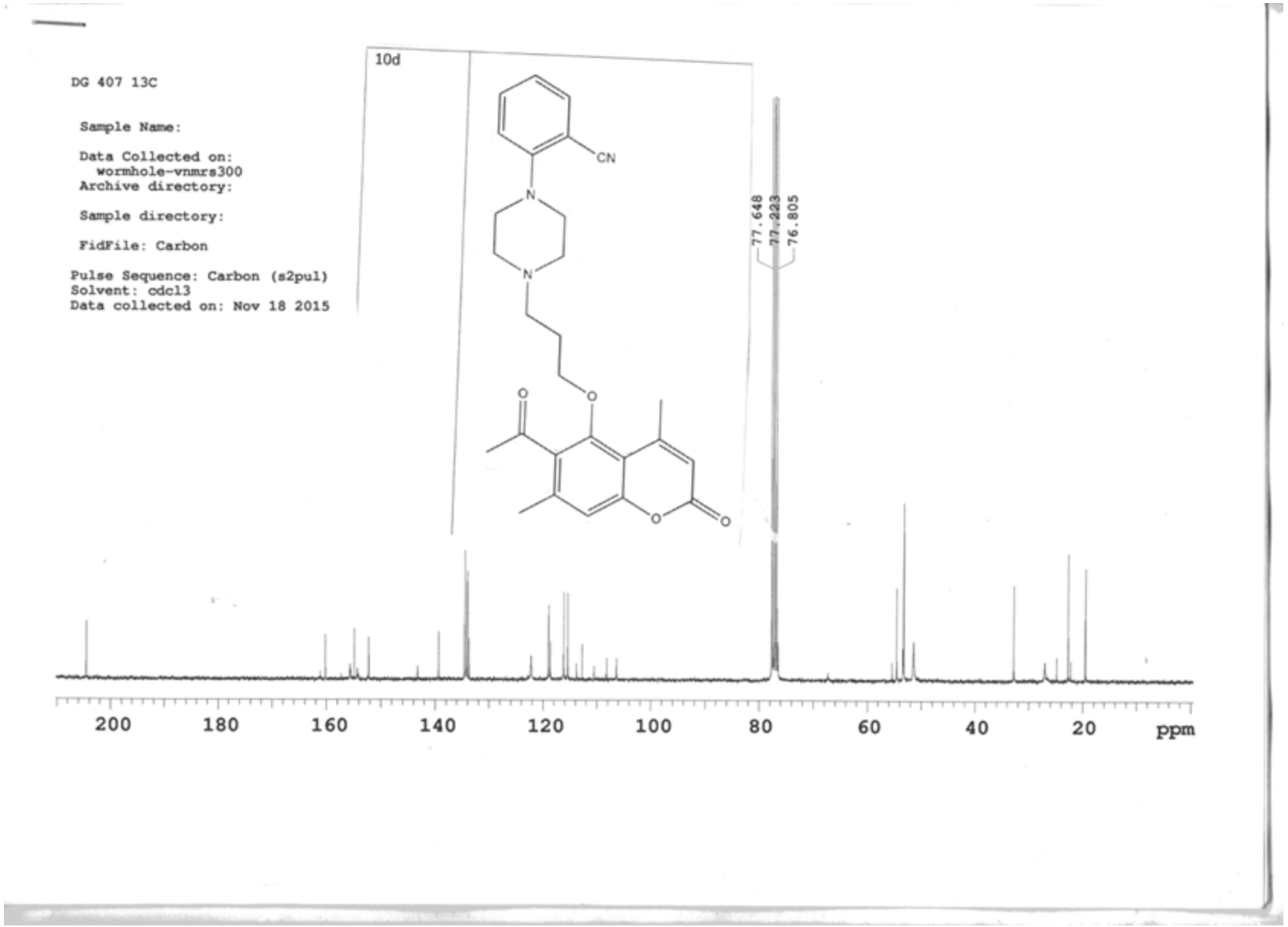


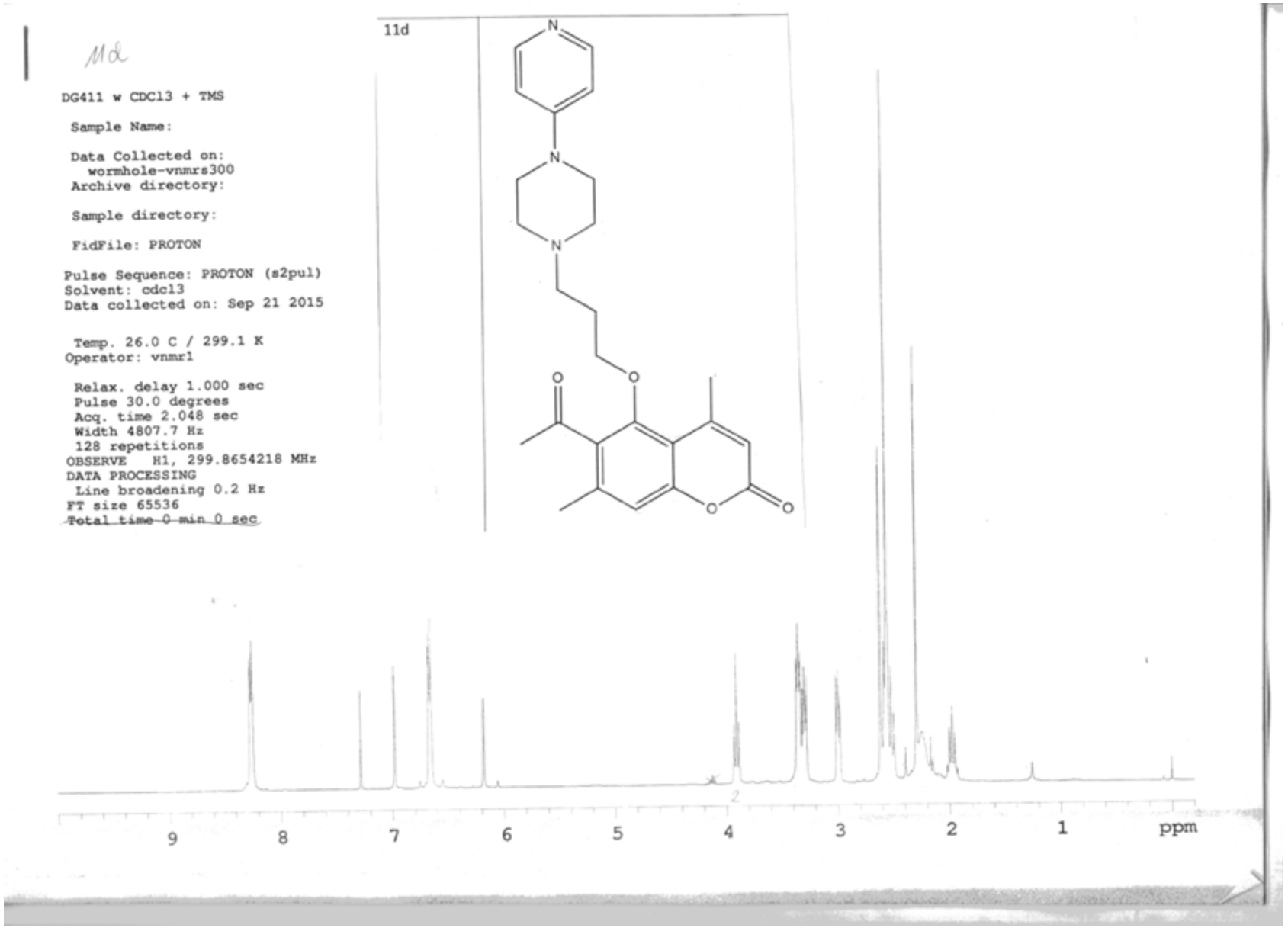

DG 408 13C
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: Carbon
Pulse Sequence: Carbon (s2pul)
Solvent: cdcl3
Data collected on: Oct 20 2015
129.134
117.440
77.648
77.230
76.805
8d
Cl
N
N
O
O
O
O
200
180
160
140
120
100
80
60
40
20
0
ppm

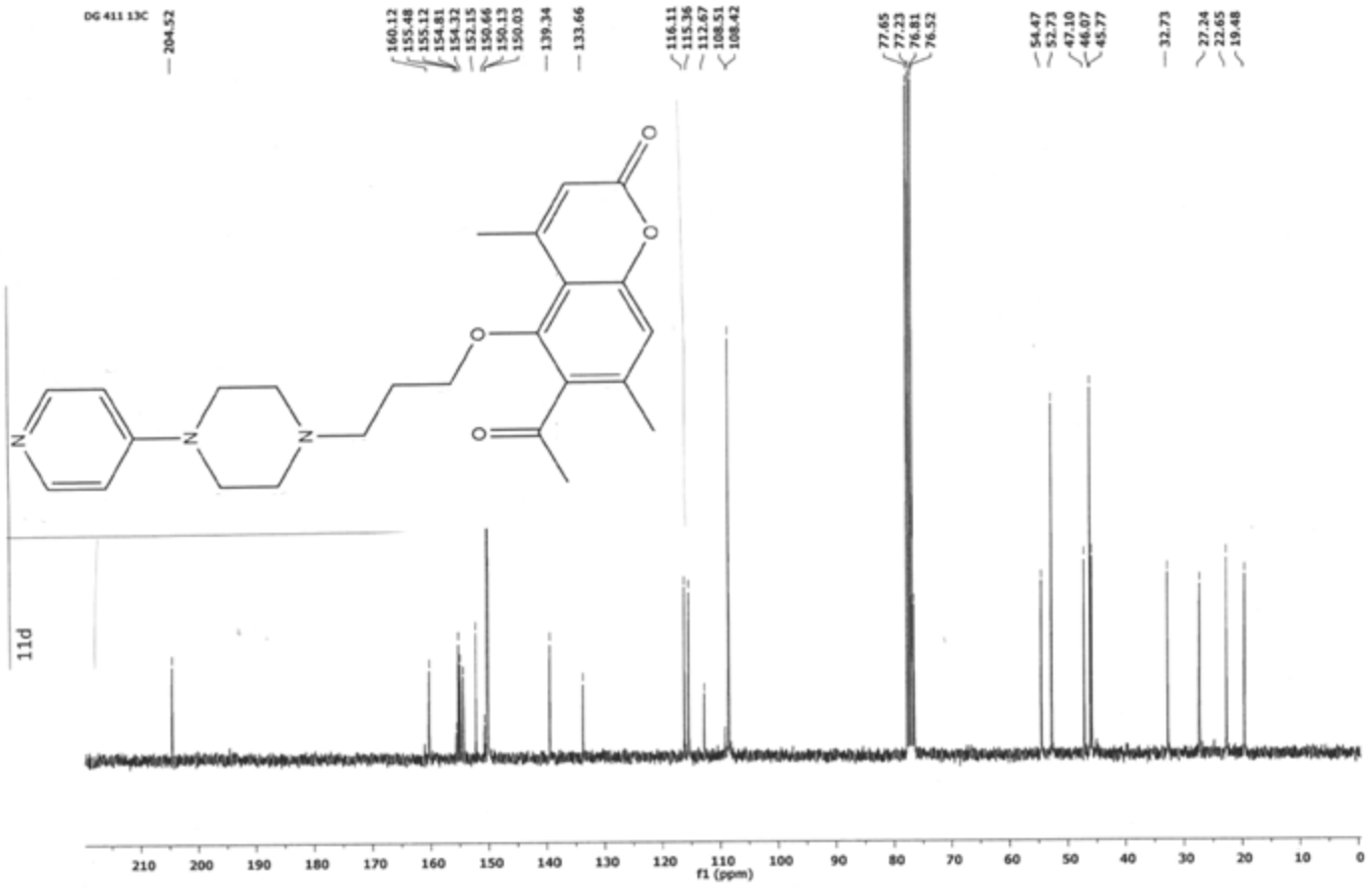

9d
DG412 w CDCl3 + TMS
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: PROTON
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Sep 21 2015
Temp. 26.0 C / 299.1 K
Operator: vnmr1
Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 2.048 sec
Width 4807.7 Hz
128 repetitions
OBSERVE H1, 299.8654260 MHz
DATA PROCESSING
Line broadening 0.2 Hz
FT size 65536
Total time 0 min 0 sec
Cl
Cl
N
N
O
O
O
O
9
8
7
6
5
4
3
2
1
ppm


9d
DG 412 13C
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: Carbon
Pulse Sequence: Carbon (s2pul)
Solvent: cdcl3
Data collected on: Oct 22 2015
Cl
Cl
N
N
O
O
O
O
77.650
77.224
76.806
200
180
160
140
120
100
80
60
40
20
ppm


10d
DG 407 1H w CDCl3
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: PROTON
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Jun 30 2015
CN
N
N
O
O
O
O
2.630
2.571
2.309
9
8
7
6
5
4
3
2
1
0 ppm
1.00
1.04
2.05
0.81
0.16
0.16
0.82
0.17
0.34
1.70
3.98
3.98
4.57
2.95
0.55
2.65
0.48
1.83


DG 407 13C
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: Carbon
Pulse Sequence: Carbon (s2pul)
Solvent: cdcl3
Data collected on: Nov 18 2015
10d
CN
N
N
O
O
O
O
77.648
77.223
76.805
200
180
160
140
120
100
80
60
40
20
ppm


11d
DG411 w CDC13 + TMS
Sample Name:
Data Collected on:
wormhole-vnmrs300
Archive directory:
Sample directory:
FidFile: PROTON
Pulse Sequence: PROTON (s2pul)
Solvent: cdcl3
Data collected on: Sep 21 2015
Temp. 26.0 C / 299.1 K
Operator: vnmrl
Relax. delay 1.000 sec
Pulse 30.0 degrees
Acq. time 2.048 sec
Width 4807.7 Hz
128 repetitions
OBSERVE H1, 299.8654218 MHz
DATA PROCESSING
Line broadening 0.2 Hz
FT size 65536
Total time 0 min 0 sec
N
N
N
O
O
O
O
9
8
7
6
5
4
3
2
1
ppm


DG 411 13C
204.52
160.12
155.48
155.12
154.81
154.32
152.15
150.66
150.13
150.03
139.34
133.66
116.11
115.36
112.67
108.51
108.42
77.65
77.23
76.81
76.52
54.47
52.73
47.10
46.07
45.77
32.73
27.24
22.65
19.48
11d
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)