Angewandte Chemie
Eine Zeitschrift der Gesellschaft Deutscher Chemiker

Supporting Information

© Wiley-VCH 2007

69451 Weinheim, Germany

Development of the First Enantioselective Organocatalytic Electrocyclic Reaction – Chiral Brønsted Acids in the Catalytic Asymmetric Nazarov Cyclization

Magnus Rueping,[*] Winai Ieawsuwan, Andrey P. Antonchick and Boris J. Nachtsheim

General: Unless otherwise noted, all commercially available compounds were used as provided without further purification. Solvents for chromatography were technical grade and distilled prior to use. Chloroform used in reaction was reagent grade and distilled from CaH_2. Analytical thin-layer chromatography (TLC) was performed on Merck silica gel aluminium plates with F-254 indicator, visualised by irradiation with UV light. Column chromatography was performed using silica gel Merck 60 (particle size 0.063-0.2 mm). Solvent mixtures are understood as volume/volume.

^{1}H-NMR and ^{13}C-NMR were recorded on a Bruker AM 250 spectrometer or a Bruker AV 300 in $CDCl_3$. Data are reported in the following order: chemical shift (δ) in ppm; multiplicities are indicated, s (singlet), d (doublet), t (triplet), m (multiplet)); coupling constants (*J*) are in Hertz (Hz). Mass spectra (MS-ESI) were conducted on ESI-MS: *VG-Platform* II (Fisons Instruments). IR spectra were recorded on a Jasco FT/IR-420 spectrometer and are reported in terms of frequency of absorption (cm^{-1}). Optical rotations were measured on a Perkin Elmer 241 polarimeter. The enantiomeric excesses were determined by HPLC analysis using a chiral stationary phase column (column, Daicel Co. CHIRALCEL OD-H or AD-H; eluent: hexane/2-propanol).

[*] E-mail: M.rueping@chemie.uni-frankfurt.de

The HPLC methods were calibrated with the corresponding racemic mixtures. Chemical yields refer to mixture of two diastereoisomers of products. The isolated yields and enantiomeric excesses are given in the tables.

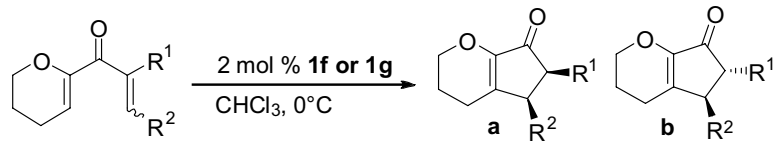
Preparation of substrates: Preparation of substrates **2, 11** and **12** were reported.[1] Preparation of substrates **3-10** were carried out following the same general procedures.[1]

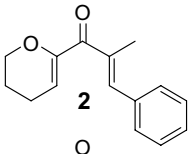
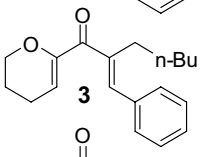
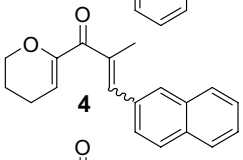
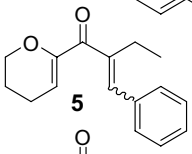
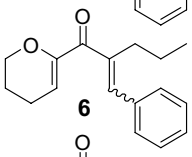
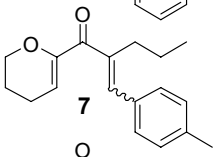
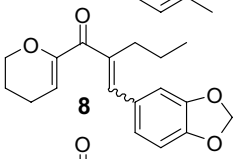
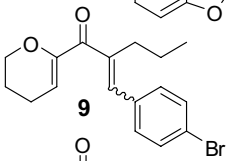
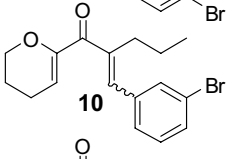
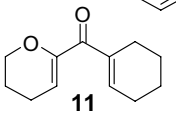
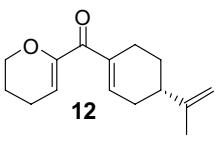
Preparation of catalysts: The chiral-phosphoric acids **1a-1e** were prepared according to the reported procedure.[2-3] The chiral *N*-triflyl phosphoramide **1f** and **1g** were prepared in a slightly modified procedure than originally reported by Yamamoto et al.[4]

General procedure for the Nazarov reaction: The substrate was suspended in chloroform (1 mL) in a screw-capped test-tube and allowed to stir at 0 °C for 10 min. The catalyst (2 mol%) was quickly added to this solution and the reaction mixture was stirred at 0 °C for 1-4 h (see table). Subsequently, the reaction mixture was purified by column chromatography on silica gel (ethyl acetate/hexane) to afford the product.

General procedure for alumina-catalysed epimerization:[5] The *cis*-substrate and basic alumina (activity I, Fluka cat. 6290, 5 mg per 1 mg of substrate) were suspended in dichloromethane (1 mL) in a screw-capped vial and allowed to stir at room temperature for 24 h. The reaction mixture was filtered through silica gel and washed with dichloromethane to give the *trans*-product without loss of enantiomeric excess.

Table 1 supp. Comparison of chiral *N*-triflyl phosphoramides **1f** and **1g** in the catalytic enantioselective Nazarov Reaction.



Entry[a]	Substrate	Cat.	Time [h]	Yield [%][b]	cis/trans[c]	*ee* (cis/trans) [%][d]
1	 **2**	**1g**	2	88	6/1	**87 / 95 % ee**
2		**1f**	2	83	5.4/1	**85 / 95 % ee**
3	 **3**	**1g**	1	78	3.2/1	**91 / 91 % ee**
4		**1f**	1	82	2/1	**88 / 92 % ee**
5	 **4**	**1g**	2	92	9.3/1	**88 / 99% ee**
6		**1f**	2	83	7.9/1	**83 / 99% ee**
7	 **5**	**1g**	2	61	4.3/1	**92 / 96% ee**
8		**1f**	2	78	2.6/1	**86 / 96% ee**
9	 **6**	**1g**	1	85	3.2/1	**93 / 91 % ee**
10		**1f**	1	84	2.2/1	**89 / 94 % ee**
11	 **7**	**1g**	1	77	2.6/1	**91 / 90% ee**
12		**1f**	1	79	2.3/1	**90 / 88% ee**
13	 **8**	**1g**	1	83	1.5/1	**87 / 92% ee**
14		**1f**	1	86	2.5/1	**86 / 88% ee**
15	 **9**	**1g**	1.5	87	4.6/1	**92 / 92% ee**
16		**1f**	1.5	76	2.2/1	**90 / 95% ee**
17	 **10**	**1g**	2	72	3.7/1	**90 / 91% ee**
18		**1f**	2	82	2.5/1	**88 / 92% ee**
19	 **11**	**1g**	4.5	68	cis	**86% ee**
20	 **12**	**1g**	6	45	cis	**98% de**

[a] Substrate, 2 mol-% **1g** or **1f** in 1 ml $CHCl_3$ at 0 °C. [b] After column chromatography. [c] Determined by 1H-NMR spectroscopy. [d] Determined by HPLC analysis with a chiral stationary phase column.

Physical data:

(5*S*,6*S*)-6-Methyl-5-phenyl-3,4,5,6-tetrahydrocyclopenta[*b*]pyran-7(2*H*)-one [2a].[1]

^{1}H-NMR (250 MHz, $CDCl_3$): δ 7.29-7.17 (m, 3H), 7.00-6.92 (m, 2H), 4.21-4.03 (m, 2H), 3.95 (d, *J* = 6.7 Hz, 1H), 2.76-2.72 (m, 1H), 2.12 (t, *J* = 6.4 Hz, 2H), 1.95-1.83 (m, 2H), 0.62 ppm(d, *J* = 7.6 Hz, 3H); ^{13}C-NMR (63 MHz, $CDCl_3$): δ 203.00, 151.63, 144.89, 138.66, 128.91, 128.53, 127.17, 67.13, 48.90, 43.33, 22.55, 21.71, 12.34 ppm. IR (KBr): ν 2964, 2927, 1704, 1653, 1492, 1454, 1398, 1290, 1278, 1165, 1140, 1095, 1068, 1047, 981, 903, 756, 704 cm^{-1}; ESI-MS: m/z = 229 $[M+H]^+$; $[\alpha]_D^{RT}$ = −38 (*c* = 0.1 in $CHCl_3$); HPLC conditions: OD-H column, *n*-hexane/2-propanol = 98/2, flow rate = 1 mL min^{-1}, major enantiomer: t_R = 48.6 min; minor enantiomer: t_R = 36.7 min.

(5*S*,6*S*)-6-Pentyl-5-phenyl-3,4,5,6-tetrahydrocyclopenta[*b*]pyran-7(2*H*)-one [3a].

^{1}H-NMR (300 MHz, $CDCl_3$): δ 7.30-7.14 (m, 3H), 6.99 (d, *J* = 6.7 Hz, 2H), 4.16-4.01 (m, 2H), 3.92 (d, *J* = 6.3 Hz, 1H), 2.58-2.46 (m, 1H), 2.18-1.73 (m, 4H), 1.60-1.45 (m, 1H), 1.28-1.07 (m,1H), 1.06-1.89 (m, 4H), 0.89-0.70 (m, 2H), 0.65 ppm (t, *J* = 7.0 Hz, 3H); ^{13}C-NMR (75 MHz, $CDCl_3$): δ 202.40, 151.23, 145.13, 138.55, 128.36, 127.15, 67.03, 49.38, 48.73, 31.53, 27.13, 26.44, 22.38, 22.09, 21.71, 13.86 ppm; IR (neat): ν 2954, 2929, 2858, 1712, 1653, 1493, 1454, 1400, 1298, 1270, 1163, 1138, 1107, 1053, 704 cm^{-1}; ESI-MS: m/z = 285 $[M+H]^+$; $[\alpha]_D^{RT}$ = +53 (*c* = 0.1 in $CHCl_3$); HPLC conditions: OD-H column, *n*-hexane/2-propanol = 99/1, flow rate = 1 mL min^{-1}, major enantiomer: t_R = 49.4 min; minor enantiomer: t_R = 46.1 min.

(5*S*,6*S*)-6-Methyl-5-(2-naphthyl)-3,4,5,6-tetrahydrocyclopenta[*b*]pyran-7(2*H*)-one [4a].

^{1}H-NMR (300 MHz, $CDCl_3$): δ 7.79-7.69 (m, 3H), 7.46 (s, 1H), 7.44-7.36 (m, 2H), 7.04 (d, *J* = 8.5 Hz, 1H), 4.23-4.08 (m, 3H), 2.82-2.70 (m, 1H), 2.12 (t, *J* = 6.3 Hz, 2H), 1.99-1.80 (m, 2H), 0.65 ppm (d, *J* = 7.6 Hz, 3H); ^{13}C-NMR (75 MHz, $CDCl_3$): δ 202.92, 151.71, 144.79, 136.23, 133.40, 132.66, 128.15, 127.68, 127.59, 126.30, 125.86, 67.14, 49.08, 43.43, 22.56, 21.69, 12.28ppm; IR (neat): ν 3050, 2969, 2929, 2873, 1714, 1650, 1600, 1508, 1454, 1400, 1371, 1288, 1160, 1139, 1103, 1066, 1047, 983, 958, 914, 860, 821, 754, 733 cm^{-1}; ESI-MS: m/z = 279 $[M+H]^+$; $[\alpha]_D^{RT}$ = +7 (*c* = 0.1 in $CHCl_3$); HPLC conditions: AD-H column, *n*-hexane/2-propanol = 98.5/1.5, flow rate = 1 mL min^{-1}, major enantiomer: t_R = 55.7 min; minor enantiomer: t_R = 52.6 min.

(5*S*,6*S*)-6-Ethyl-5-phenyl-3,4,5,6-tetrahydrocyclopenta[*b*]pyran-7(2*H*)-one [5a].

^{1}H-NMR (300 MHz, $CDCl_3$): δ 7.23-7.17 (m, 3H), 6.99 (d, *J* = 6.7 Hz, 2H), 4.18-4.00 (m, 2H), 3.94 (d, *J* = 6.4 Hz, 1H), 2.49-2.40 (m, 1H), 2.17-1.94 (m, 2H), 1.94-1.73 (m, 2H), 1.64-1.48 (m, 1H), 0.94-0.73 (m, 1H), 0.66 ppm (d, *J* = 7.3 Hz, 3H); ^{13}C-NMR (75 MHz, $CDCl_3$): δ 202.25, 151.25, 145.03, 138.56, 128.40, 127.16, 67.04, 50.96, 48.57, 22.36, 21.70, 20.04, 12.36 ppm; IR (KBr): ν 2960, 2931, 2873, 1701, 1649, 1491, 1454, 1302, 1279, 1165, 1146, 1108, 1069, 1052, 750, 704 cm^{-1}; ESI-MS: m/z = 243 $[M+H]^+$; $[\alpha]_D^{RT}$ = +35 (*c* = 0.1 in $CHCl_3$); HPLC conditions: AD-H column, *n*-hexane/2-propanol = 98/2, flow rate = 1 mL min^{-1}, major enantiomer: t_R = 23.8 min; minor enantiomer: t_R = 33.4 min.

(5*S*,6*S*)-6-Ethyl-5-phenyl-3,4,5,6-tetrahydrocyclopenta[*b*]pyran-7(2*H*)-one [5b].

^{1}H-NMR (300 MHz, $CDCl_3$): δ 7.29-7.14 (m, 3H), 7.09-7.03 (m, 2H), 4.06 (t, *J* = 5.3 Hz, 2H), 3.41 (d, *J* = 1.6 Hz, 1H), 2.21-2.13 (m, 1H), 2.12-1.93 (m, 2H), 1.93-1.72 (m, 3H), 1.63-1.46 (m, 1H), 0.90 ppm (t, *J* = 7.4 Hz, 3H). ^{13}C-NMR (75 MHz, $CDCl_3$): δ 202.29, 150.88, 146.09, 141.74, 128.94, 127.38, 127.03, 66.88, 55.33, 50.67, 24.08, 22.06, 21.57, 11.33. IR (neat): ν 2962, 2931, 2875, 1710, 1650, 1492, 1454, 1400, 1290, 1268, 1164, 1122, 1045, 910, 732, 702 cm^{-1}. $[\alpha]_D^{RT}$ = +35 (*c* = 0.1 in $CHCl_3$). HPLC conditions: AD-H column, *n*-hexane/2-propanol = 98/2, flow rate = 1 mL min^{-1}, major enantiomer: t_R = 26.4 min; minor enantiomer: t_R = 28.6 min.

(5*S*,6*S*)-5-Phenyl-6-propyl-3,4,5,6-tetrahydrocyclopenta[*b*]pyran-7(2*H*)-one [6a].

^{1}H-NMR (300 MHz, $CDCl_3$): δ 7.27-7.14 (m, 3H), 6.97 (d, *J* = 7.0 Hz, 2H), 4.17-4.00 (m, 2H), 3.93 (d, *J* = 6.4 Hz, 1H), 2.59-2.49 (m, 1H), 2.1-2.93 (m, 2H), 1.93-1.73 (m, 2H), 1.59-1.42 (m, 1H), 1.26-0.93 (m, 2H), 0.84-0.67 (m, 1H), 0.58 ppm (t, *J* = 7.3 Hz, 3H); ^{13}C-NMR (75 MHz, $CDCl_3$): δ 202.42, 151.23, 145.09, 138.59, 128.38, 127.15, 67.04, 49.08, 48.73, 28.72, 22.37, 21.70, 20.78, 13.83 ppm; IR (neat): ν 2956, 2931, 2871, 1711, 1653, 1492, 1454, 1400, 1295, 1163, 1138, 1107, 1057, 733, 704 cm^{-1}; ESI-MS: m/z = 257 $[M+H]^+$; $[\alpha]_D^{RT}$ = +36 (*c* = 0.1 in $CHCl_3$); HPLC conditions: OD-H column, *n*-hexane/2-propanol = 98/2, flow rate = 0.6 mL min^{-1}, major enantiomer: t_R = 53.5 min; minor enantiomer: t_R = 51.6 min.

(5*S*,6*S*)-5-(4-Methylphenyl)-6-propyl-3,4,5,6-tetrahydrocyclopenta [*b*]pyran-7(2*H*)-one [7a].

^{1}H-NMR (300 MHz, $CDCl_3$): δ ^{1}H-NMR (300 MHz, $CDCl_3$): δ 7.03 (d, *J* = 8.0 Hz, 2H), 6.85 (d, *J* = 8.0 Hz, 2H), 4.16-4.00 (m, 2H), 3.88 (d, *J* = 6.4 Hz, 1H), 2.57-2.45 (m, 1H), 2.26 (s, 3H), 2.16-2.93 (m, 2H), 1.93-1.72 (m, 2H), 1.56-1.41 (m, 1H), 1.26-1.00 (m, 2H), 0.8-0.68 (m, 1H), 0.60 ppm (t, *J* = 7.3 Hz, 3H); ^{13}C-NMR (75 MHz, $CDCl_3$): δ 202.58, 151.09, 145.32, 136.71, 135.43, 129.08, 67.02, 49.08, 48.35, 28.71, 22.36, 21.72, 21.04, 20.80, 13.84 ppm; IR (neat): ν 2956, 2931, 2871, 1712, 1652, 1512, 1463, 1400, 1294, 1162, 1137, 1106, 1056, 825 cm^{-1}; ESI-MS: m/z = 271 $[M+H]^+$; $[\alpha]_D^{RT}$ = +48 (*c* = 0.1 in $CHCl_3$); HPLC conditions: OD-H column, *n*-hexane/2-propanol = 99/1, flow rate = 0.45 mL min^{-1}, major enantiomer: t_R = 87.1 min; minor enantiomer: t_R = 94.6 min.

(5*S*,6*S*)-5-(1,3-Benzodioxol-5-yl)-6-propyl-3,4,5,6-tetrahydro cyclopenta[*b*]pyran-7(2*H*)-one [8a].

^{1}H-NMR (300 MHz, $CDCl_3$): δ 6.68 (d, *J* = 7.8 Hz, 1H), 6.53-6.35 (m, 2H), 5.89 (s, 2H), 4.17-3.99 (m, 2H), 3.85 (d, *J* = 6.3 Hz, 1H), 2.55-2.44 (m, 1H), 2.16-1.69 (m, 2H), 1.96-1.73 (m, 2H), 1.60-1.42 (m, 1H), 1.30-1.00 (m, 2H), 0.88-0.72 (m, 1H), 0.64 ppm (t, *J* = 7.3 Hz, 3H); ^{13}C-NMR (75 MHz, $CDCl_3$): δ 202.31, 151.14, 147.76, 146.65, 144.95, 132.40, 108.12, 101.07, 67.03, 49.08, 48.44, 28.72, 22.32, 21.70, 20.92, 13.92 ppm; IR (neat): ν 2956, 2931, 2871, 1712, 1653, 1504, 1486, 1465, 1442, 1400, 1393, 1294, 1267, 1247, 1186, 1165, 1138, 1106, 1038, 935, 914, 862, 813, 731 cm^{-1}; ESI-MS: m/z = 301 $[M+H]^+$; $[\alpha]_D^{RT}$ = +59 (*c* = 0.1 in $CHCl_3$); HPLC conditions: AD-H column, *n*-hexane/2-propanol = 98.5/1.5, flow rate = 1 mL min^{-1}, major enantiomer: t_R = 84.7 min; minor enantiomer: t_R = 181.7 min.

(5*S*,6*S*)-5-(4-Bromophenyl)-6-propyl-3,4,5,6-tetrahydrocyclopenta [*b*]pyran-7(2*H*)-one [9].

^{1}H-NMR (300 MHz, $CDCl_3$): δ 7.36 (d, *J* = 8.2 Hz, 2H), 6.86 (d, *J* = 8.2 Hz, 2H), 4.18-4.00 (m, 2H), 3.90 (d, *J* = 6.4 Hz, 1H), 2.59-2.49 (m, 1H), 2.18-1.74 (m, 4H), 1.61-1.42 (m, 1H), 1.29-0.93 (m, 2H), 0.85-0.67 (m, 1H), 0.61 ppm (t, *J* = 7.3 Hz, 3H); ^{13}C-NMR (75 MHz, $CDCl_3$): δ 201.96, 151.41, 144.37, 137.78, 131.57, 121.01, 67.06, 48.82, 48.20, 28.68, 22.29, 21.63, 20.78, 13.83 ppm; IR (KBr): ν 2954, 2931, 2866, 1709, 1651, 1481, 1464, 1406, 1294, 1160, 1141, 1105, 1068, 1054, 1006, 845, 831 cm^{-1}; ESI-MS: m/z = 335, 337 $[M+H]^+$; $[\alpha]_D^{RT}$ = +52 (*c* = 0.1 in $CHCl_3$); HPLC conditions: AD-H column, *n*-hexane/2-propanol = 98/2, flow rate = 0.6 mL min^{-1}, major enantiomer: t_R = 42.4 min; minor enantiomer: t_R = 70.1 min.

(5*S*,6*S*)-5-(3-Bromophenyl)-6-propyl-3,4,5,6-tetrahydrocyclopenta [*b*]pyran-7(2*H*)-one [10].

^{1}H-NMR (300 MHz, $CDCl_3$): δ 7.32 (ddd, *J* = 1.0, 2.0, 7.9 Hz, 1H), 7.19 (s, 1H), 7.11 (dd, *J* = 7.7, 7.9 Hz, 1H), 6.90 (d, *J* = 7.7 Hz, 1H), 4.18-4.01 (m, 2H), 3.89 (d, *J* = 6.5 Hz, 1H), 2.60-2.49 (m, 1H), 2.17-1.92 (m, 2H), 1.93-1.74 (m, 2H), 1.60-1.42 (m, 1H), 1.30-0.95 (m, 2H), 0.87-0.67 (m, 1H), 0.62 ppm (t, *J* = 7.3 Hz, 3H); ^{13}C-NMR (75 MHz, $CDCl_3$): δ 201.84, 151.51, 144.13, 141.22, 130.39, 129.95, 122.61, 67.08, 48.88, 48.44, 28.69, 22.32, 21.62, 20.79, 13.82 ppm; IR (neat): ν 2956, 2929, 2871, 1712, 1652, 1590, 1567, 1473, 1427, 1400, 1295, 1162, 1137, 1106, 1070, 1054, 705, 681 cm^{-1}; ESI-MS: m/z = 335, 337 $[M+H]^+$; $[\alpha]_D^{RT}$ = +45 (*c* = 0.1 in $CHCl_3$); HPLC conditions: AD-H column, *n*-hexane/2-propanol = 98/2, flow rate = 0.45 mL min^{-1}, major enantiomer: t_R = 67.3 min; minor enantiomer: t_R = 90.0 min.

(4*bR*,8*aS*)-3,4,4*b*,5,6,7,8,8*a*-Octahydroindeno[2,1-*b*]pyran-9(2*H*)-one [11a].[1]

Colorless oil; ^{1}H-NMR (300 MHz, $CDCl_3$): δ 4.12-3.95 (m, 2H), 2.72-2.63 (m, 1H), 2.41-2.25 (m, 2H), 2.17 (dt, *J* = 5.7, 18.9 Hz, 1H), 1.99-1.59 (m, 5H), 1.52-1.22 (m, 4H), 1.21-1.06 ppm (m, 1H); ^{13}C-NMR (75 MHz, $CDCl_3$): δ 202.82, 150.37, 148.14, 66.86, 43.76, 37.58, 26.72, 22.49, 22.02, 21.69, 20.55, 20.41 ppm; IR (neat): ν 2931, 2861, 1707, 1645, 1446, 1400, 1290, 1165, 1138, 1082, 1065, 957, 908 cm^{-1}; ESI-MS: m/z = 193 $[M+H]^+$; $[\alpha]_D^{RT}$ = +12 (*c* = 0.1 in $CHCl_3$); HPLC conditions: OD-H column, *n*-hexane/2-propanol = 97/3, flow rate = 1 mL min^{-1}, major enantiomer: t_R = 28.9 min; minor enantiomer: t_R = 24.2 min.

(4*bR*,6*S*,8*aS*)-6-Isopropenyl-3,4,4*b*,5,6,7,8,8*a*-octahydroindeno [2,1-*b*]pyran-9(2*H*)-one [12a].[1]

Colorless oil; ^{1}H-NMR (300 MHz, $CDCl_3$): δ 4.63-4.59 (m, 2H), 4.12-3.98 (m, 2H), 2.96-2.87 (m, 1H), 2.48-2.09 (m, 3H), 2.07-1.50 (m, 8H), 1.63 (s, 3H), 1.31-1.15 ppm (m, 1H); ^{13}C-NMR (75 MHz, $CDCl_3$): δ 203.30, 150.90, 149.81, 146.83, 108.61, 66.85, 43.07, 36.93, 36.71, 28.28, 25.75, 22.95, 21.89, 21.61, 20.67 ppm; IR (neat): ν 2935, 2866, 1709, 1645, 1442, 1402, 1375, 1290, 1171, 1124, 1084, 1033, 945, 887 cm^{-1}; ESI-MS: m/z = 233 $[M+H]^+$; $[\alpha]_D^{RT}$ = +44 (*c* = 0.1 in $CHCl_3$); HPLC conditions: OD-H column, *n*-hexane/2-propanol = 97/3, flow rate = 1 mL min^{-1}, major diastereoisomer: t_R = 31.8 min; minor diastereoisomer: t_R = 21.6 min.

References:

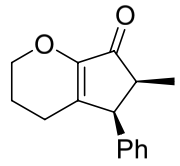
[1] G. Liang, S. N. Gradl, D. Trauner, *Org. Lett*. **2003**, *5*, 4931.

[2] (a) T. Akiyama, J.Itoh, K. Yokota, K. Fuchibe, *Angew. Chem. Int. Ed.* **2004**, *43*, 1566. (b) T. Akiyama, H. Morita, J. Itoh, K. Fuchibe, *Org. Lett*. **2005**, *7*, 2583. (c) T. Akiyama, Y. Saitoh, H. Morita, K. Fuchibe, *Adv. Synth. Catal*. **2005**, *347*, 1523.

[3] (a) D. Uraguchi, M. Terada, *J. Am. Chem. Soc*. **2004**, *126*, 5356. (b) D. Uraguchi, K. Sorimachi, M. Terada, *J. Am. Chem. Soc.* **2004**, *126*, 11804. (c) D. Uraguchi, K. Sorimachi, M. Terada, *J. Am. Chem. Soc.* **2005**, *127*, 9360.

[4] D. Nakashima, H. Yamamoto, *J. Am, Chem. Soc*. **2006**, *128*, 9626.

[5] T. K. Jones, S. E. Denmark, *Helv. Chim. Acta*. **1983**, *66*, 2377.



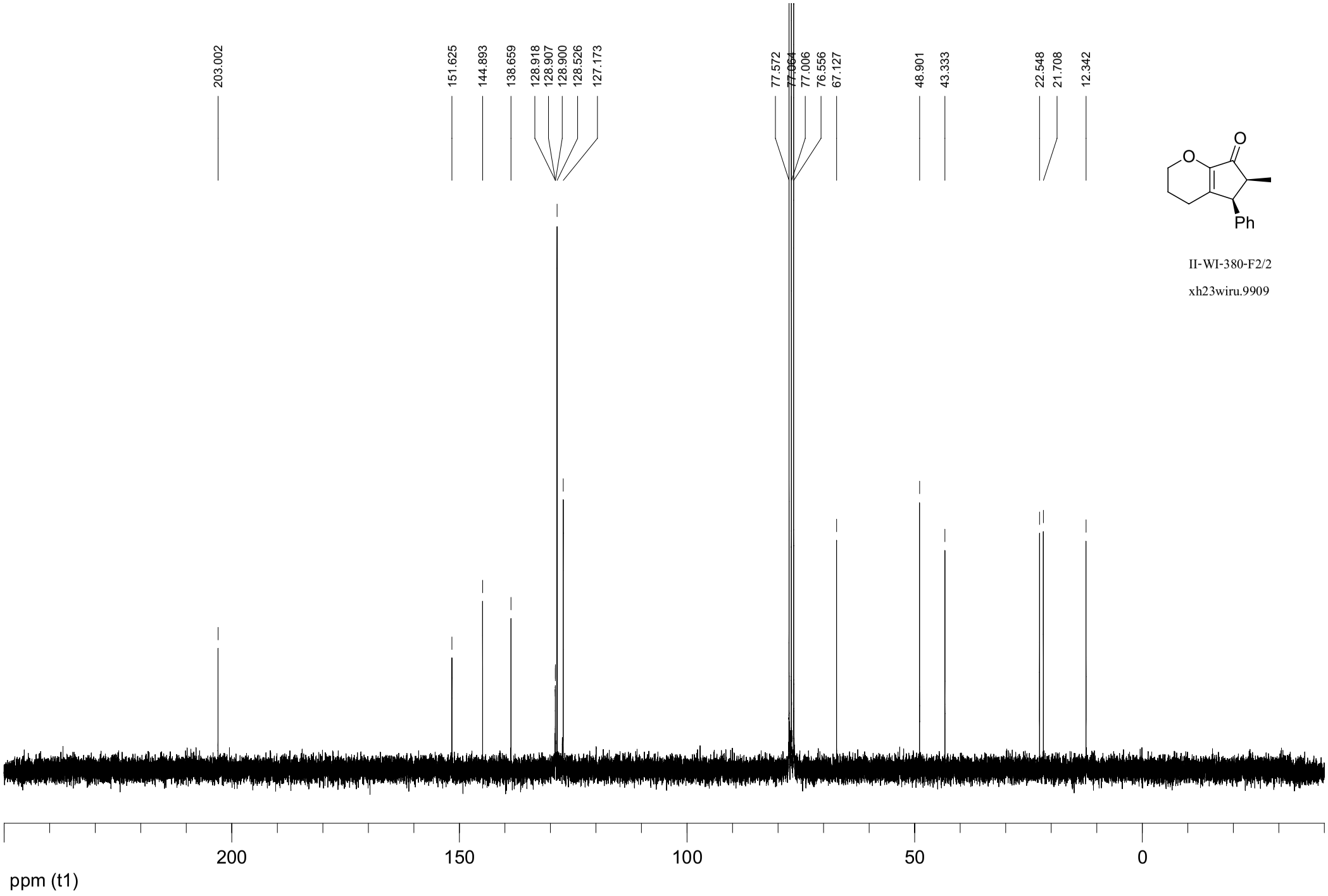
II-WI-380-F2/2

xh23wiru.9909

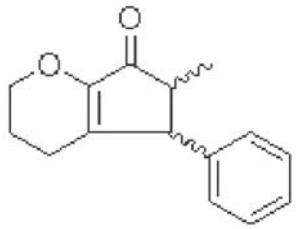
3.41 1.92 2.10 1.00 0.98 2.08 2.09 0.93 0.79 3.03

7.0 6.0 5.0 4.0 3.0 2.0 1.0 0.0

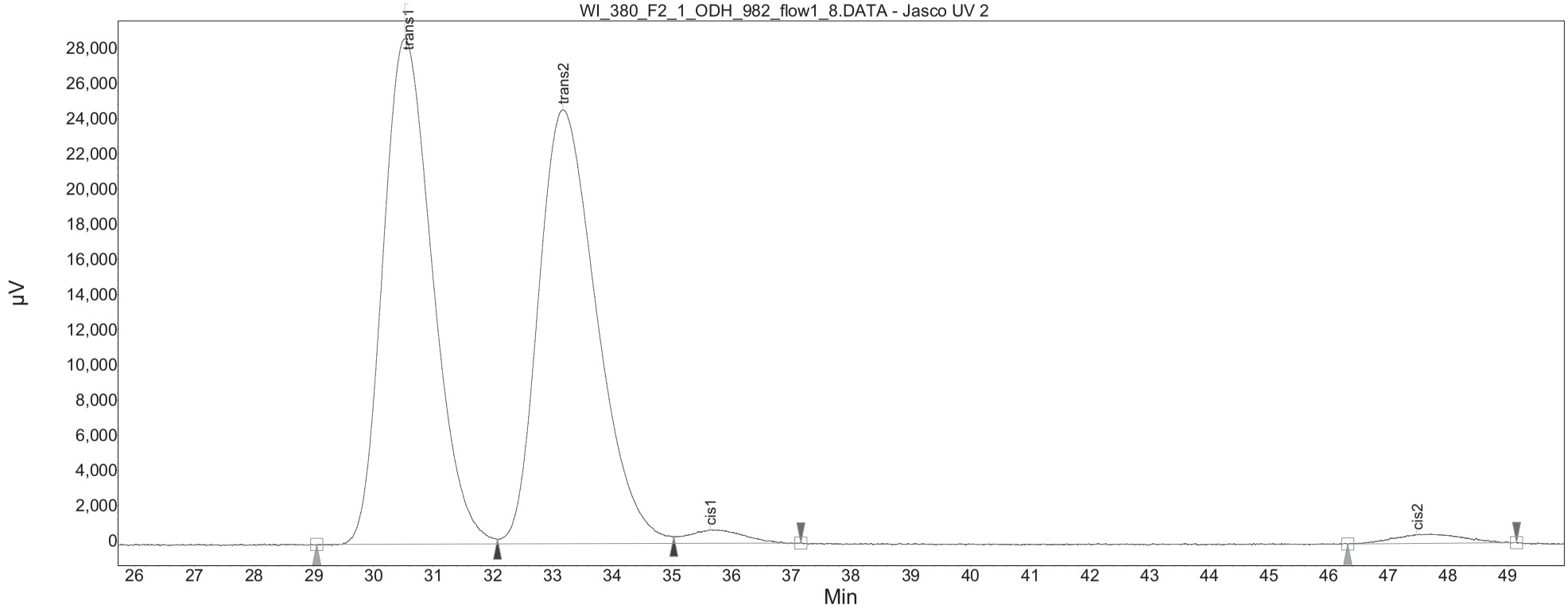
ppm (t1)


203.002
151.625
144.893
138.659
128.918
128.907
128.900
128.526
127.173
77.572
77.064
77.006
76.556
67.127
48.901
43.333
22.548
21.708
12.342
O
O
Ph
II-WI-380-F2/2
xh23wiru.9909
200
150
100
50
0
ppm (t1)

Chromatogram : WI_380_F2_1_ODH_982_flow1_8

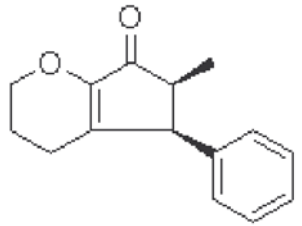


Method: ODH_982_flow1_acq50
Data file: WI_380_F2_1_ODH_982_flow1_8.DATA
Date: 8/17/2006 7:34:44 PM

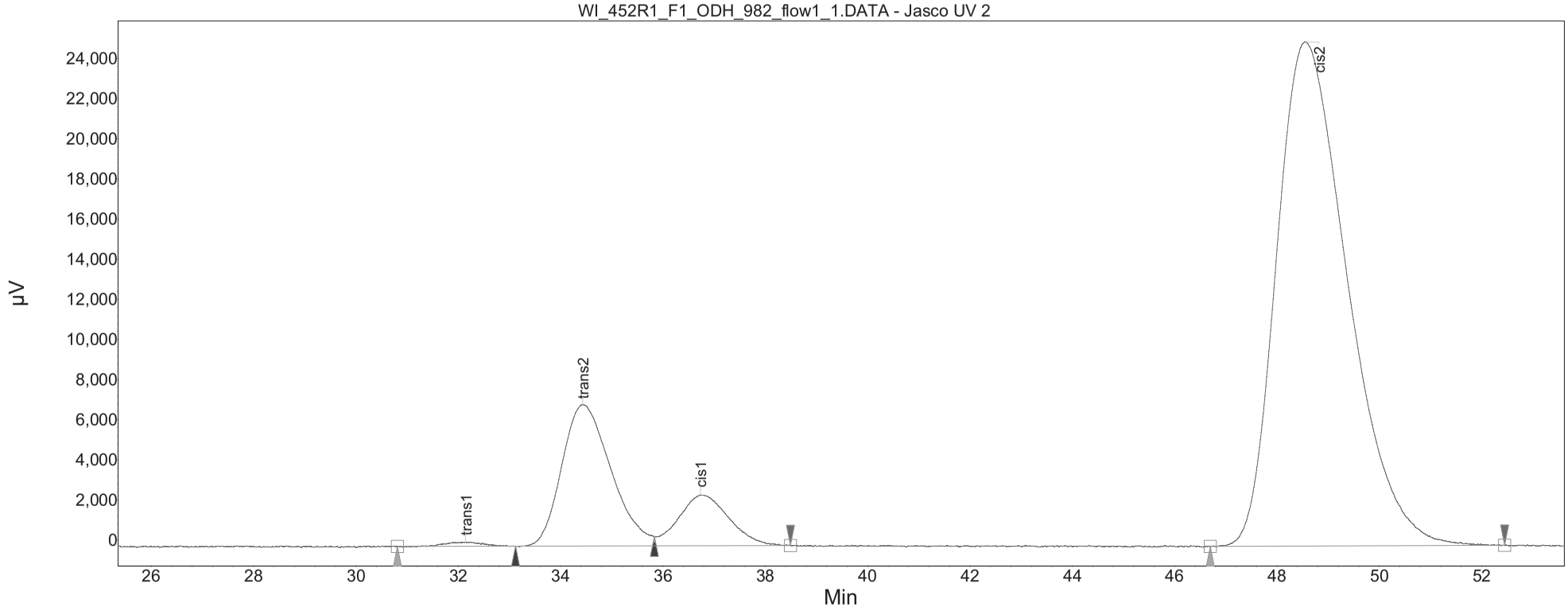


Index	Name	Start	Time	End	Area %
		[Min]	[Min]	[Min]	[%]
1	trans1	29.052	30.525	32.080	48.540
3	trans2	32.080	33.175	35.033	48.800
4	cis1	35.033	35.642	37.160	1.429
2	cis2	46.320	47.475	49.148	1.231
Total					100.000

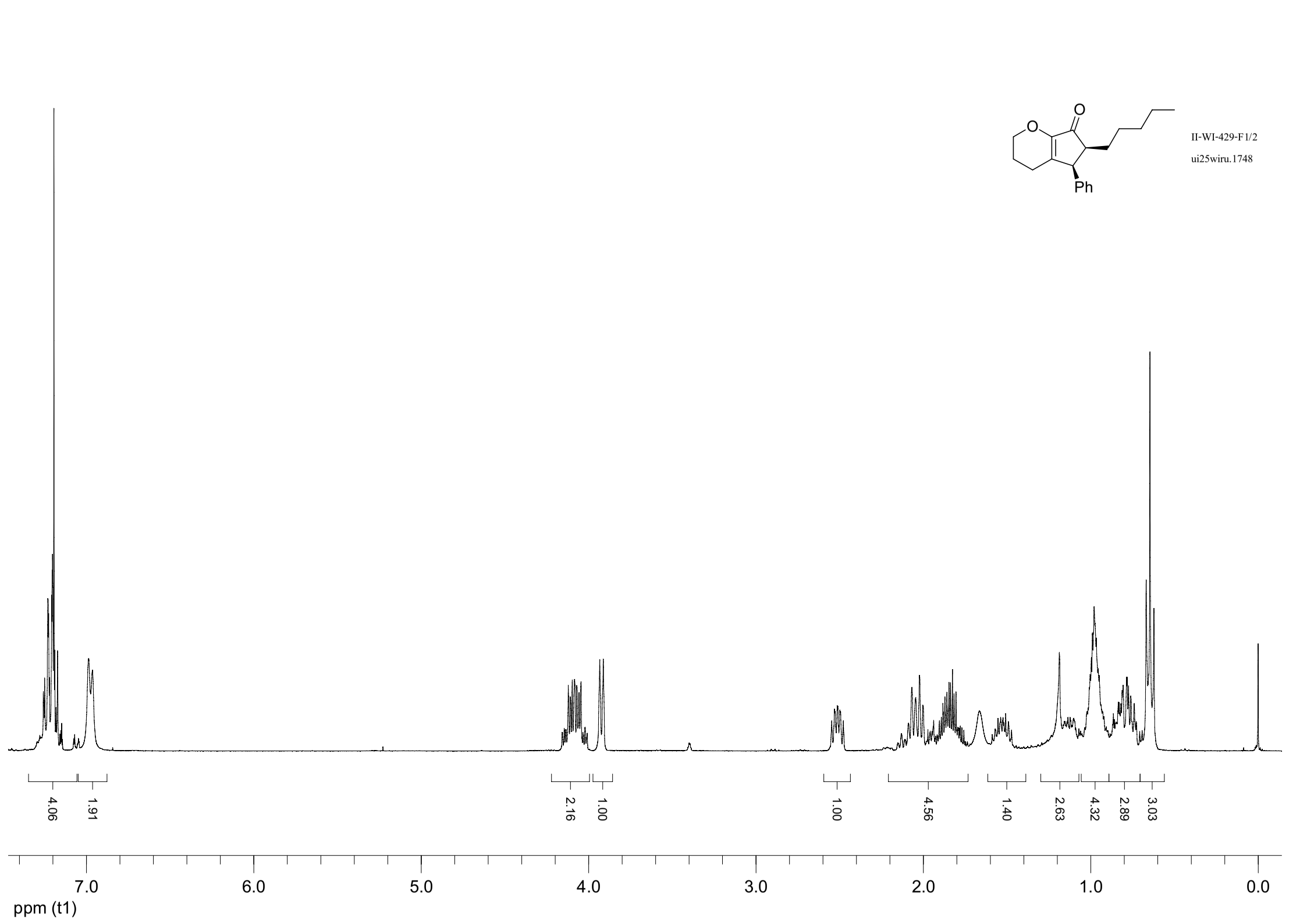
Chromatogram : WI_452R1_F1_ODH_982_flow1_1

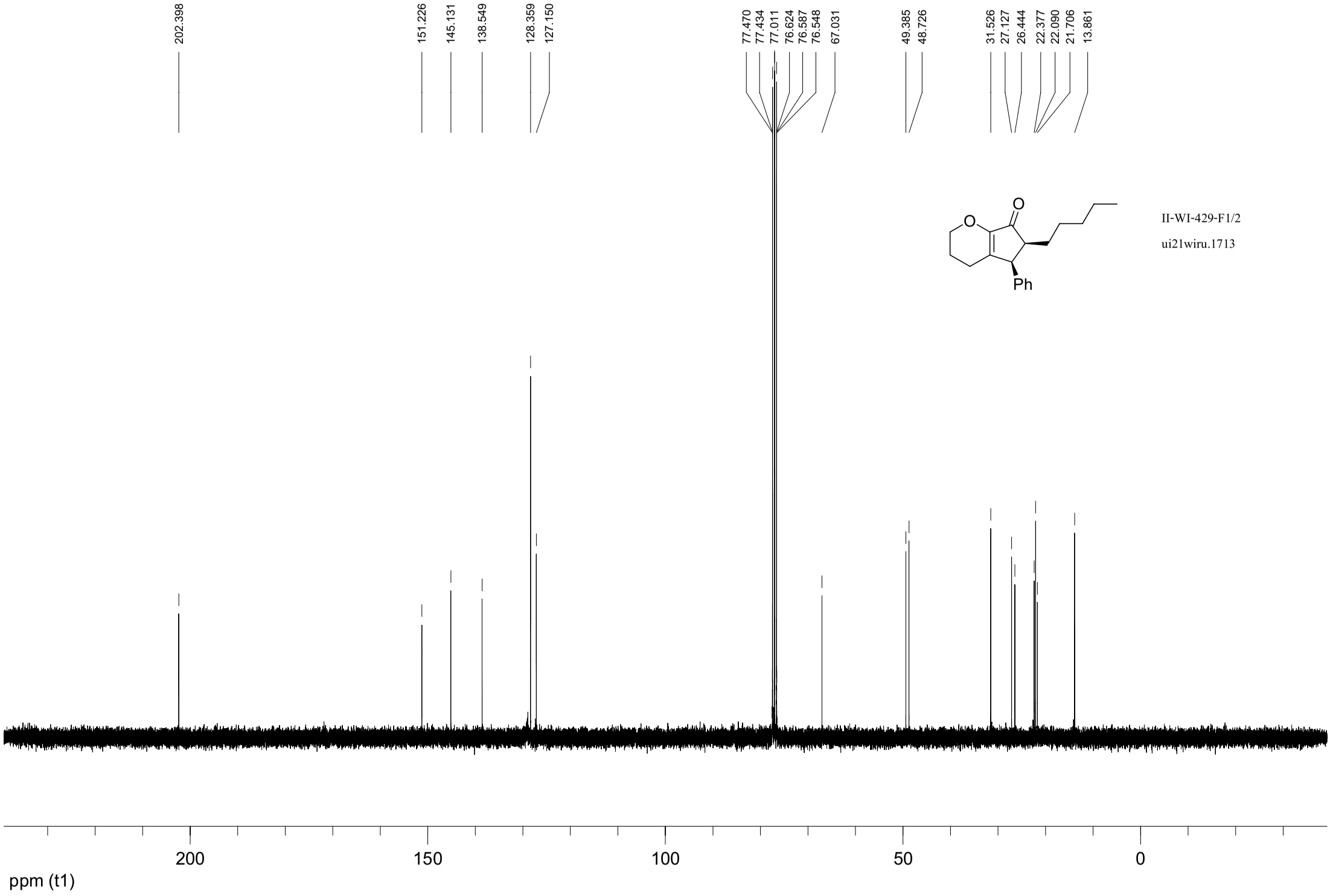


Method: ODH_982_flow1_acq60
Data file: WI_452R1_F1_ODH_982_flow1_1.DATA
Date: 10/29/2006 8:23:59 PM

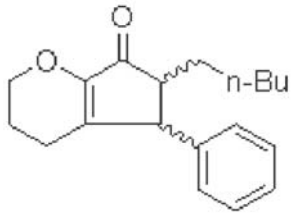


Index	Name	Start	Time	End	Area %
		[Min]	[Min]	[Min]	[%]
1	trans1	30.811	32.142	33.118	0.324
3	trans2	33.118	34.433	35.834	15.302
4	cis1	35.834	36.733	38.491	5.619
2	cis2	46.696	48.558	52.448	78.755
Total					100.000

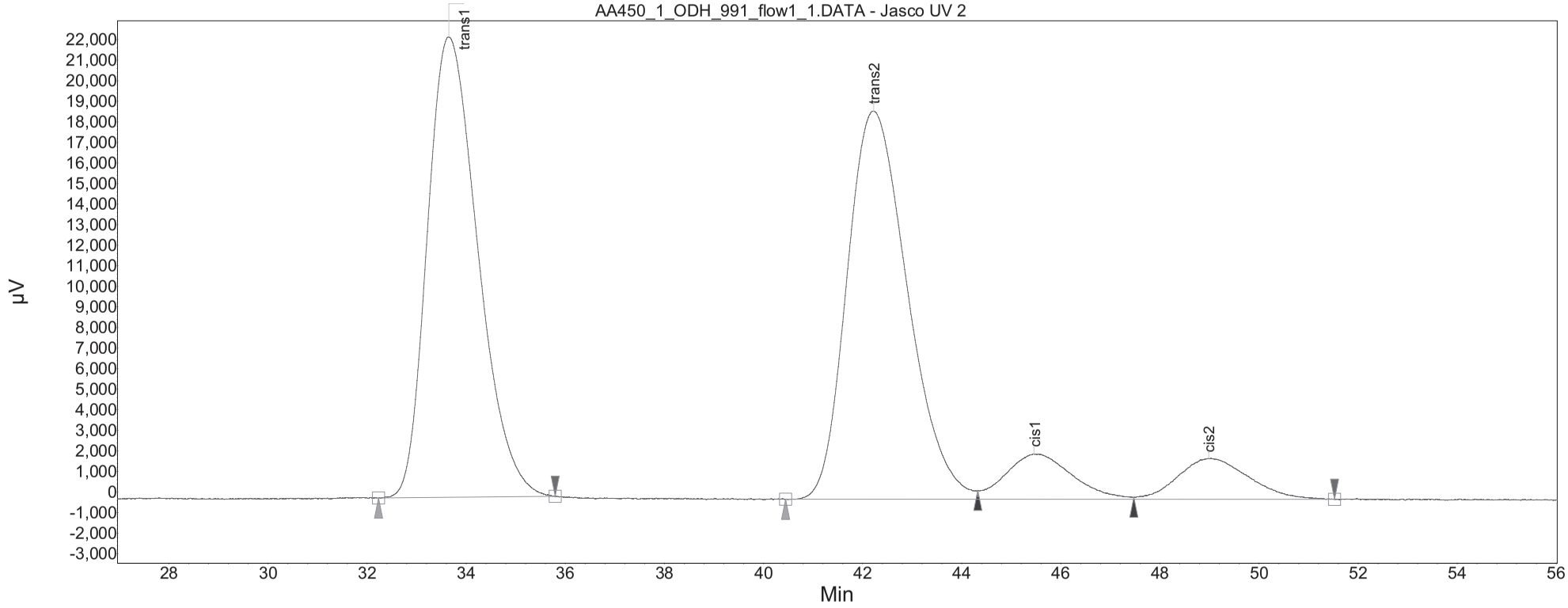

O
O
Ph
II-WI-429-F1/2
ui25wiru.1748
4.06
1.91
2.16
1.00
1.00
4.56
1.40
2.63
4.32
2.89
3.03
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)


202.398
151.226
145.131
138.549
128.359
127.150
77.470
77.434
77.011
76.624
76.587
76.548
67.031
49.385
48.726
31.526
27.127
26.444
22.377
22.090
21.706
13.861
O
O
Ph
II-WI-429-F1/2
ui21wiru.1713
200
150
100
50
0
ppm (t1)

Chromatogram : AA450_1_ODH_991_flow1_1

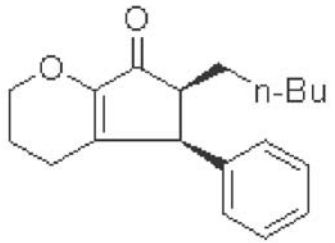


Method: ODH_991_flow1_acq75
Data file: AA450_1_ODH_991_flow1_1.DATA
Date: 9/11/2006 11:08:42 PM

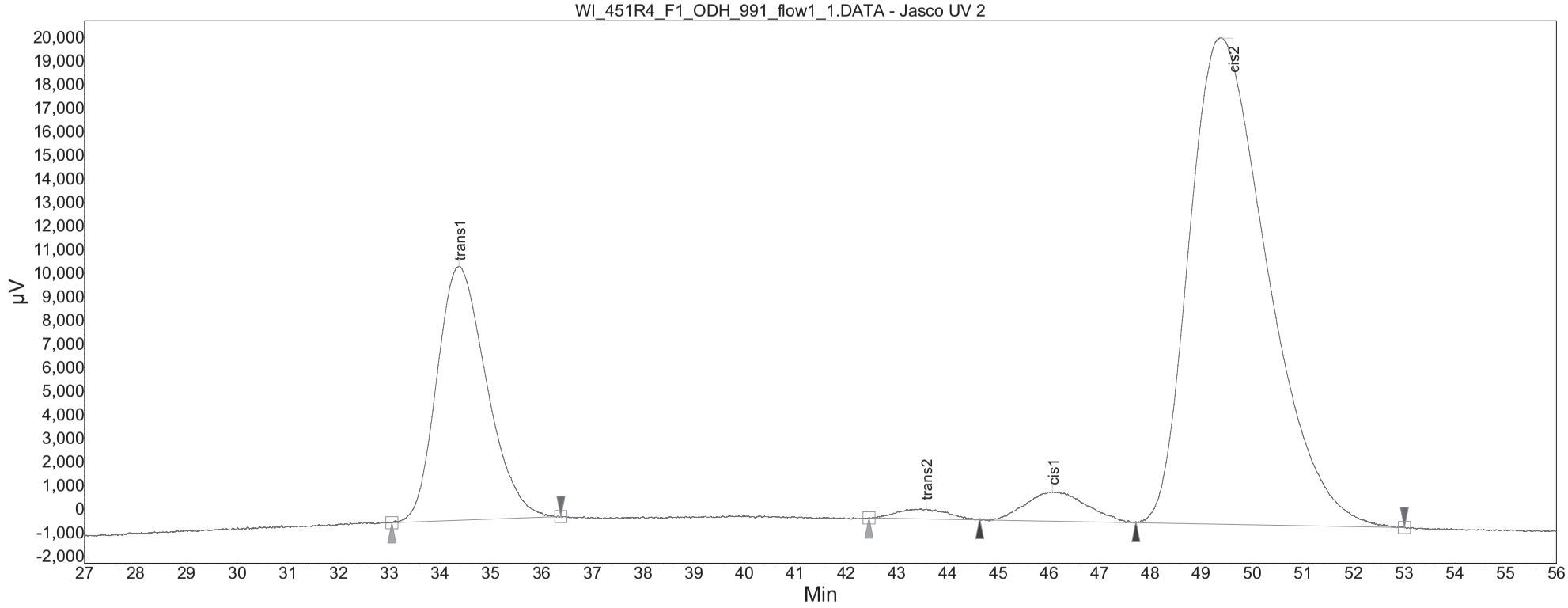


Index	Name	Start	Time	End	Area %
		[Min]	[Min]	[Min]	[%]
1	trans1	32.231	33.650	35.795	44.217
2	trans2	40.444	42.225	44.323	44.617
3	cis1	44.323	45.458	47.474	5.679
4	cis2	47.474	48.983	51.524	5.488
Total					100.000

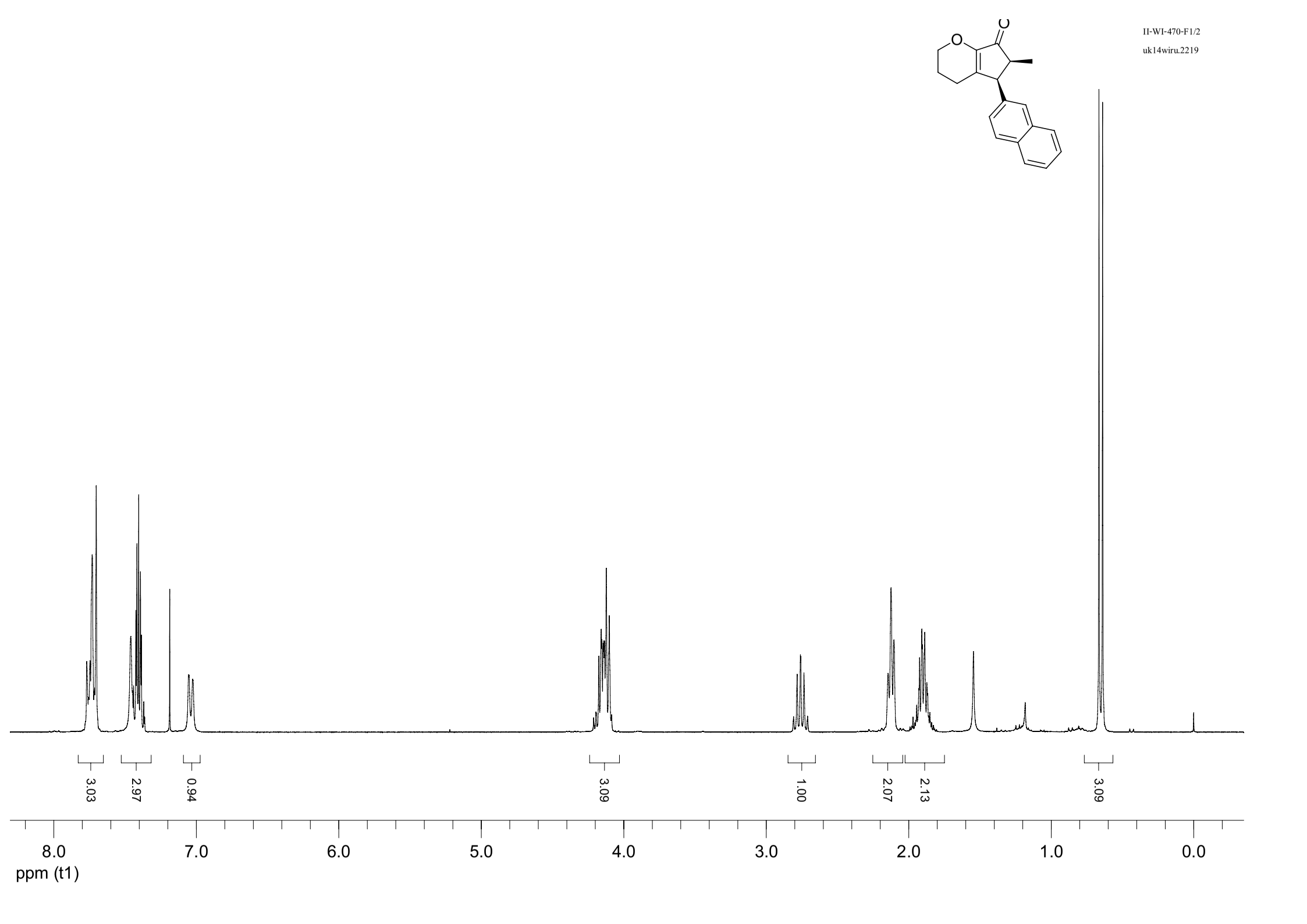
Chromatogram : WI_451R4_F1_ODH_991_flow1_1

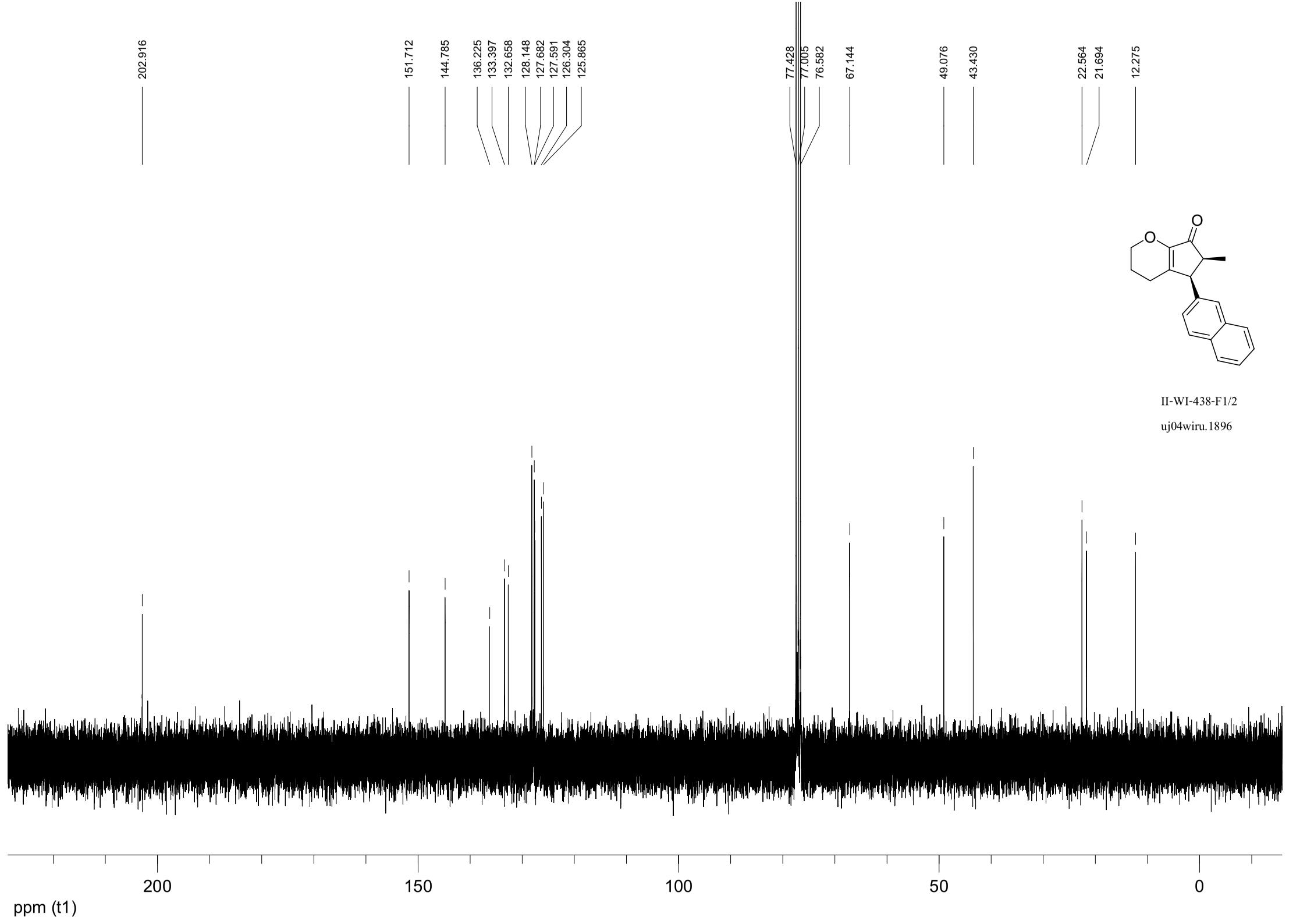


Method: ODH_991_flow1_acq60
Data file: WI_451R4_F1_ODH_991_flow1_1.DATA
Date: 10/18/2006 3:05:08 PM



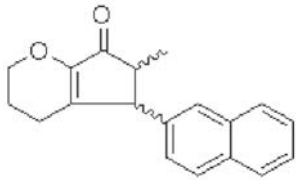
Index	Name	Start	Time	End	Area %
		[Min]	[Min]	[Min]	[%]
1	trans1	33.052	34.375	36.382	23.903
2	trans2	42.454	43.583	44.636	0.925
3	cis1	44.636	46.067	47.715	3.368
4	cis2	47.715	49.375	53.003	71.805
Total					100.000

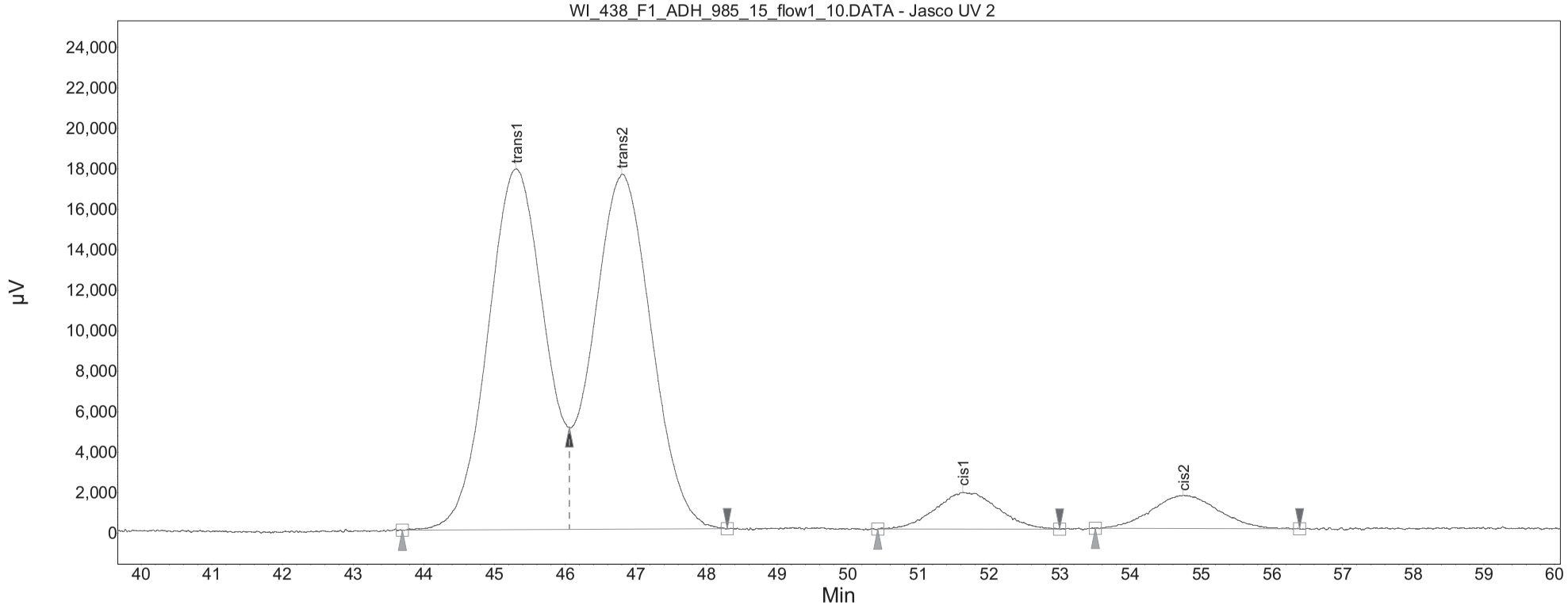

II-WI-470-F1/2
uk14wiru.2219
O
O
3.03
2.97
0.94
3.09
1.00
2.07
2.13
3.09
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)


202.916
151.712
144.785
136.225
133.397
132.658
128.148
127.682
127.591
126.304
125.865
77.428
77.005
76.582
67.144
49.076
43.430
22.564
21.694
12.275
O
O
II-WI-438-F1/2
uj04wiru.1896
200
150
100
50
0
ppm (t1)

Chromatogram : WI_438_F1_ADH_985_15_flow1_10

Method: ADH_985_15_flow1_acq90
Data file: WI_438_F1_ADH_985_15_flow1_10.DATA
Date: 11/5/2006 1:48:45 PM

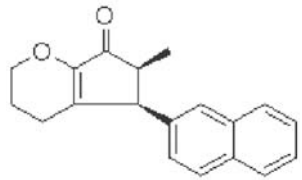


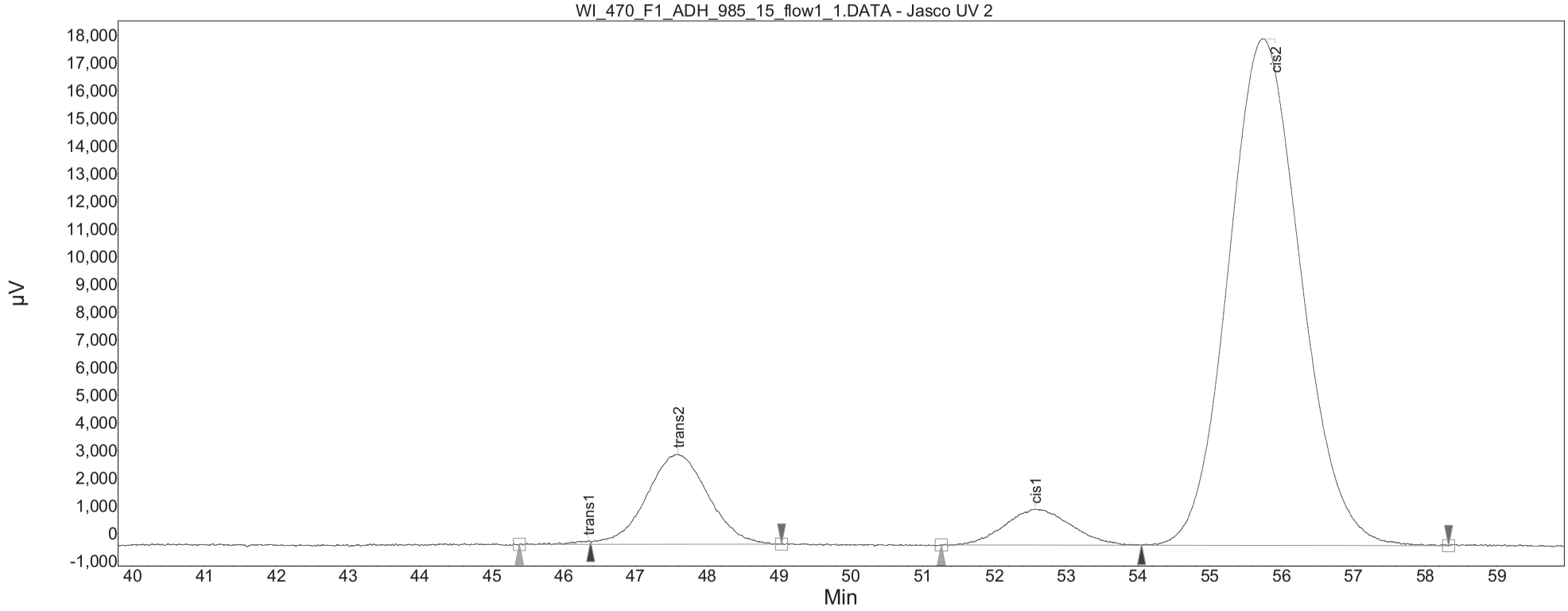


Index	Name	Start	Time	End	Area %
		[Min]	[Min]	[Min]	[%]
1	trans1	43.697	45.300	46.059	44.804
4	trans2	46.059	46.800	48.294	45.303
2	cis1	50.424	51.625	52.997	5.045
3	cis2	53.503	54.742	56.393	4.847
Total					100.000

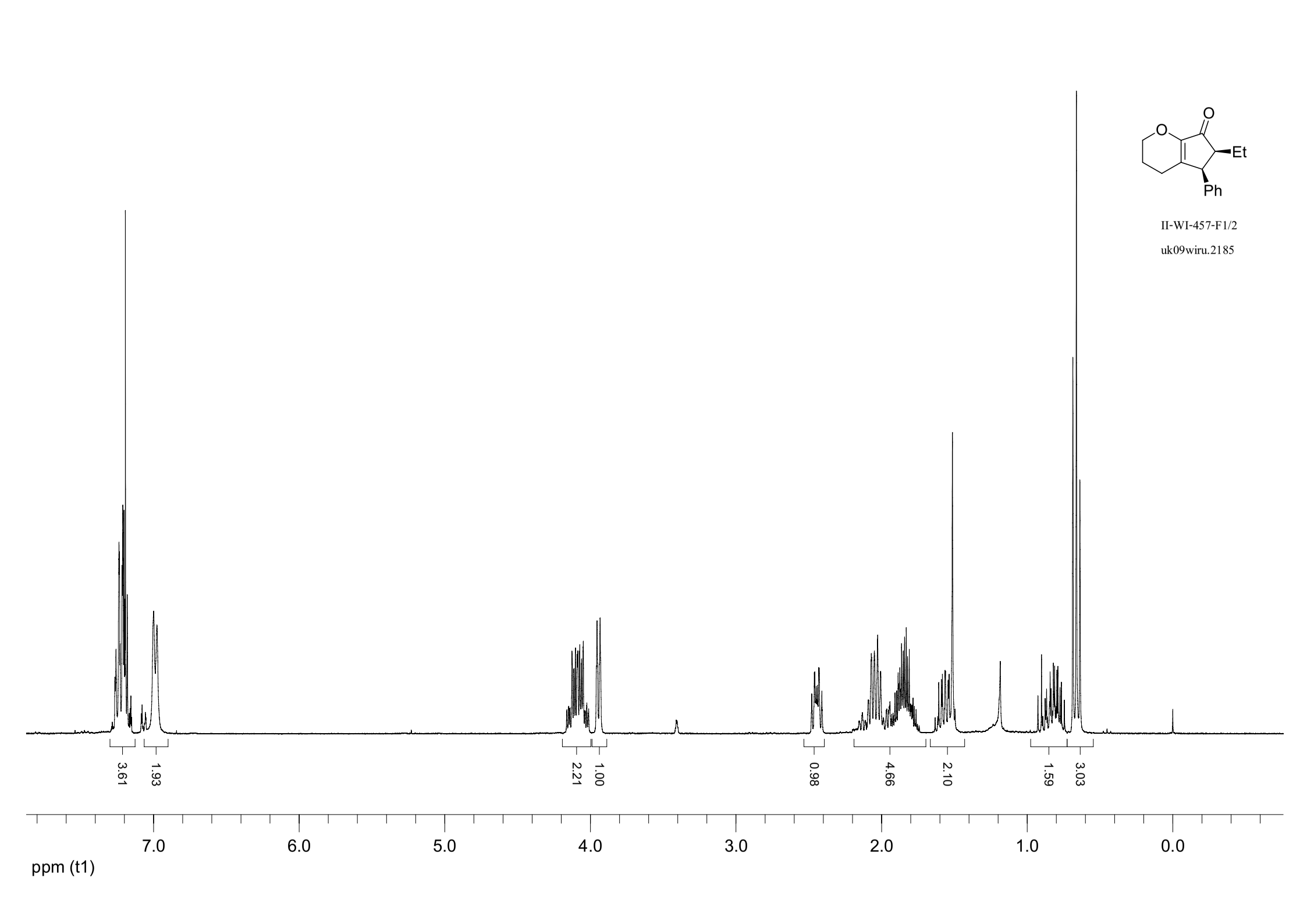
Chromatogram : WI_470_F1_ADH_985_15_flow1_1

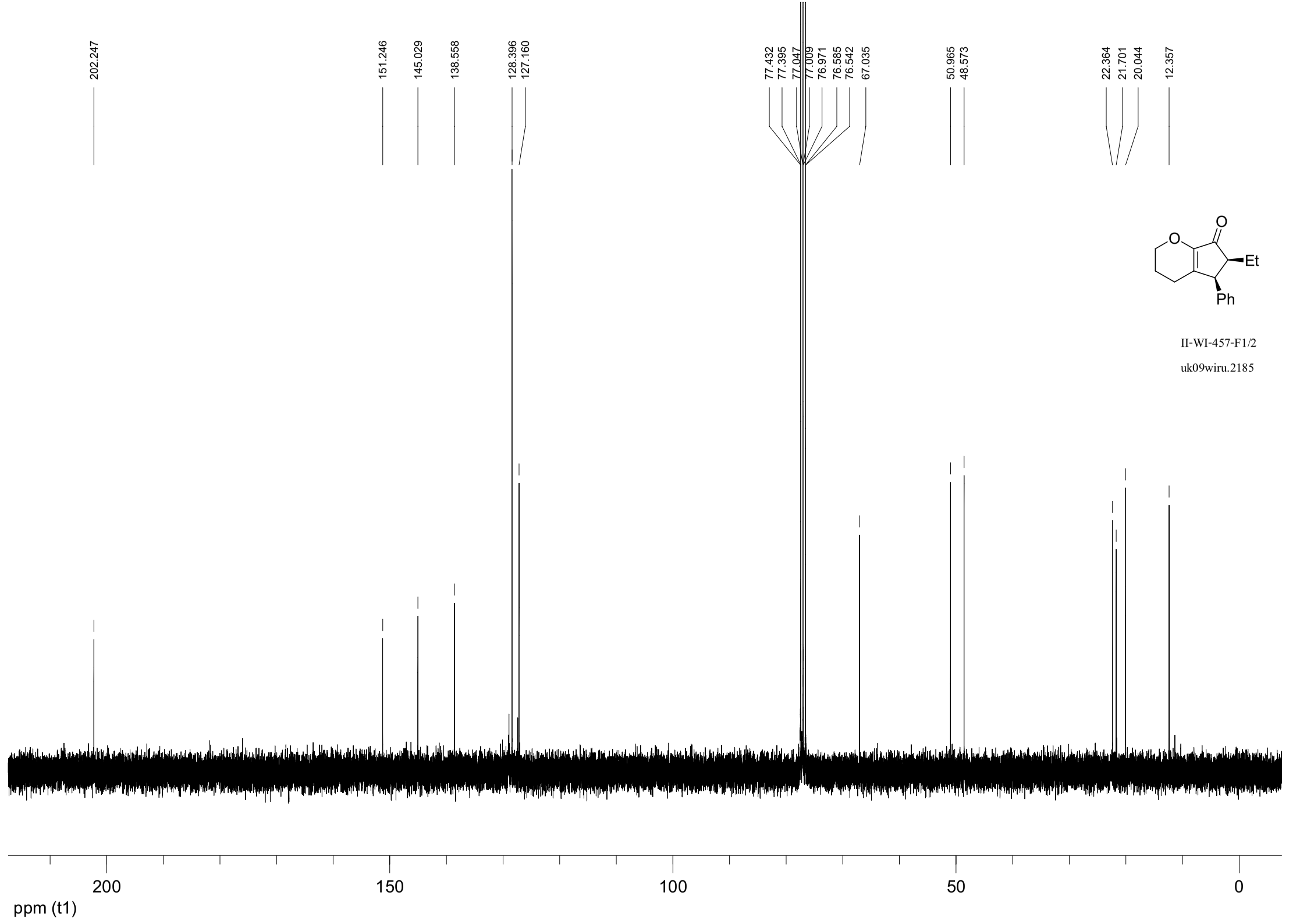
Method: ADH_985_15_flow1_acq60
Data file: WI_470_F1_ADH_985_15_flow1_1.DATA
Date: 11/5/2006 8:56:58 PM



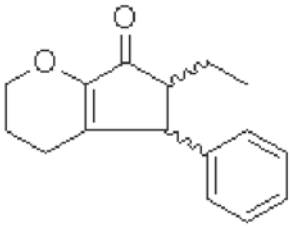


Index	Name	Start	Time	End	Area %
		[Min]	[Min]	[Min]	[%]
1	trans1	45.383	46.342	46.376	0.151
2	trans2	46.376	47.592	49.034	12.372
3	cis1	51.260	52.567	54.050	5.292
4	cis2	54.050	55.742	58.326	82.186
Total					100.000

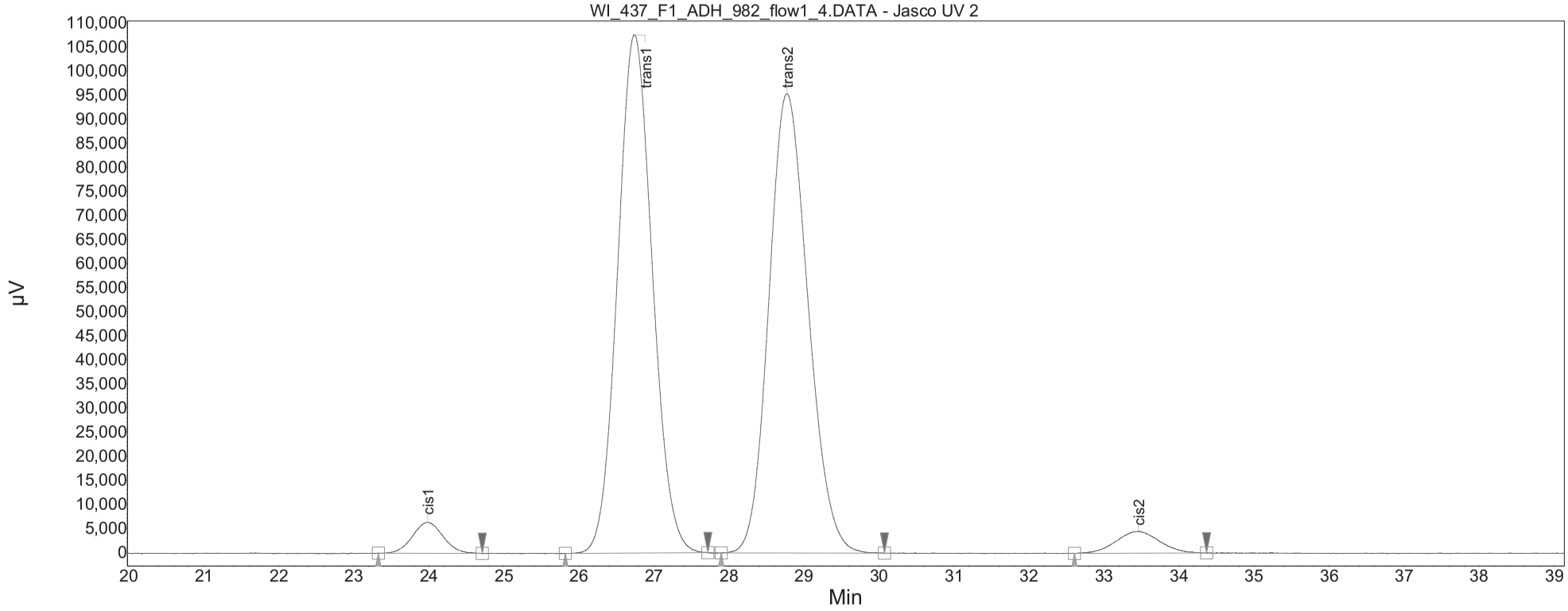

O
O
Et
Ph
II-WI-457-F1/2
uk09wiru.2185
3.61
1.93
2.21
1.00
0.98
4.66
2.10
1.59
3.03
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)


202.247
151.246
145.029
138.558
128.396
127.160
77.432
77.395
77.047
77.009
76.971
76.585
76.542
67.035
50.965
48.573
22.364
21.701
20.044
12.357
O
O
Et
Ph
II-WI-457-F1/2
uk09wiru.2185
200
150
100
50
0
ppm (t1)

Chromatogram : WI_437_F1_ADH_982_flow1_4

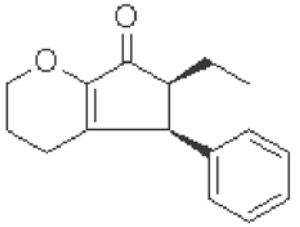


Method: ADH_982_flow1_acq60
Data file: WI_437_F1_ADH_982_flow1_4.DATA
Date: 10/1/2006 10:00:11 PM

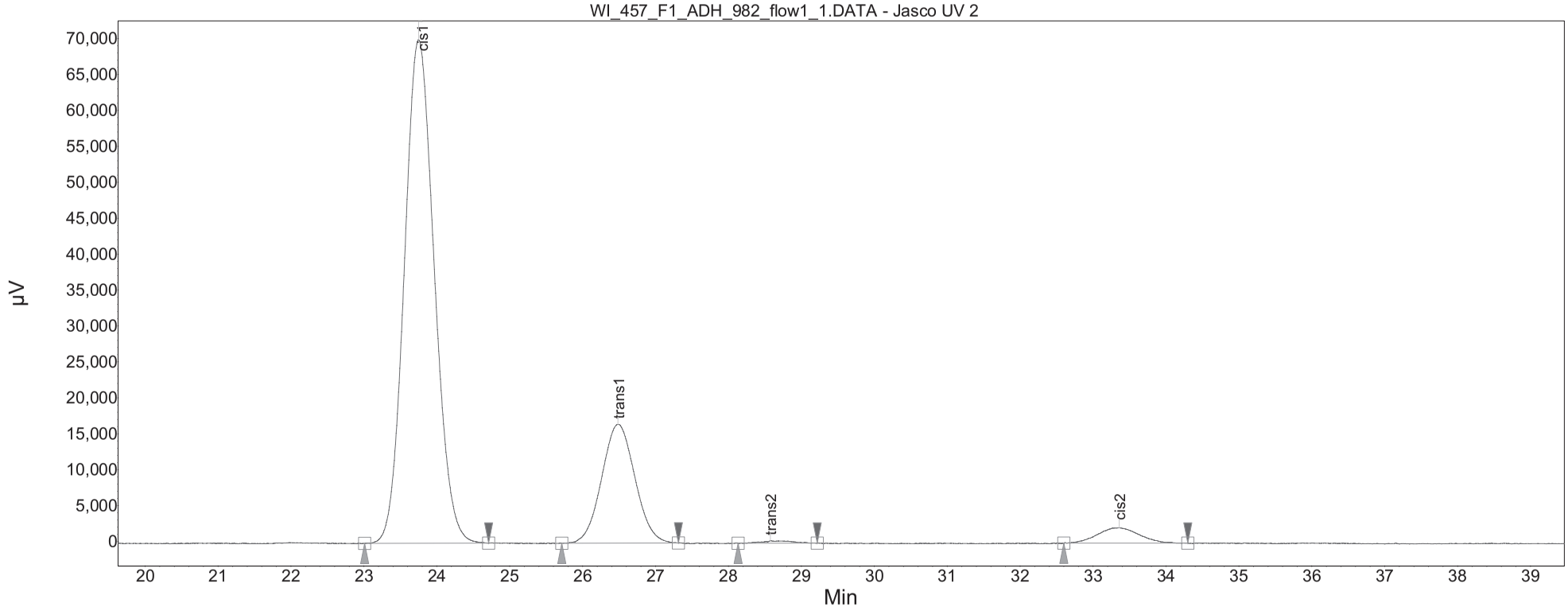


Index	Name	Start	Time	End	Area %
		[Min]	[Min]	[Min]	[%]
1	cis1	23.326	23.983	24.711	2.489
3	trans1	25.819	26.742	27.719	47.510
4	trans2	27.897	28.775	30.074	47.516
2	cis2	32.606	33.458	34.367	2.486
Total					100.000

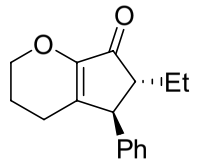
Chromatogram : WI_457_F1_ADH_982_flow1_1



Method: ADH_982_flow1_acq50
Data file: WI_457_F1_ADH_982_flow1_1.DATA
Date: 10/24/2006 1:05:08 AM

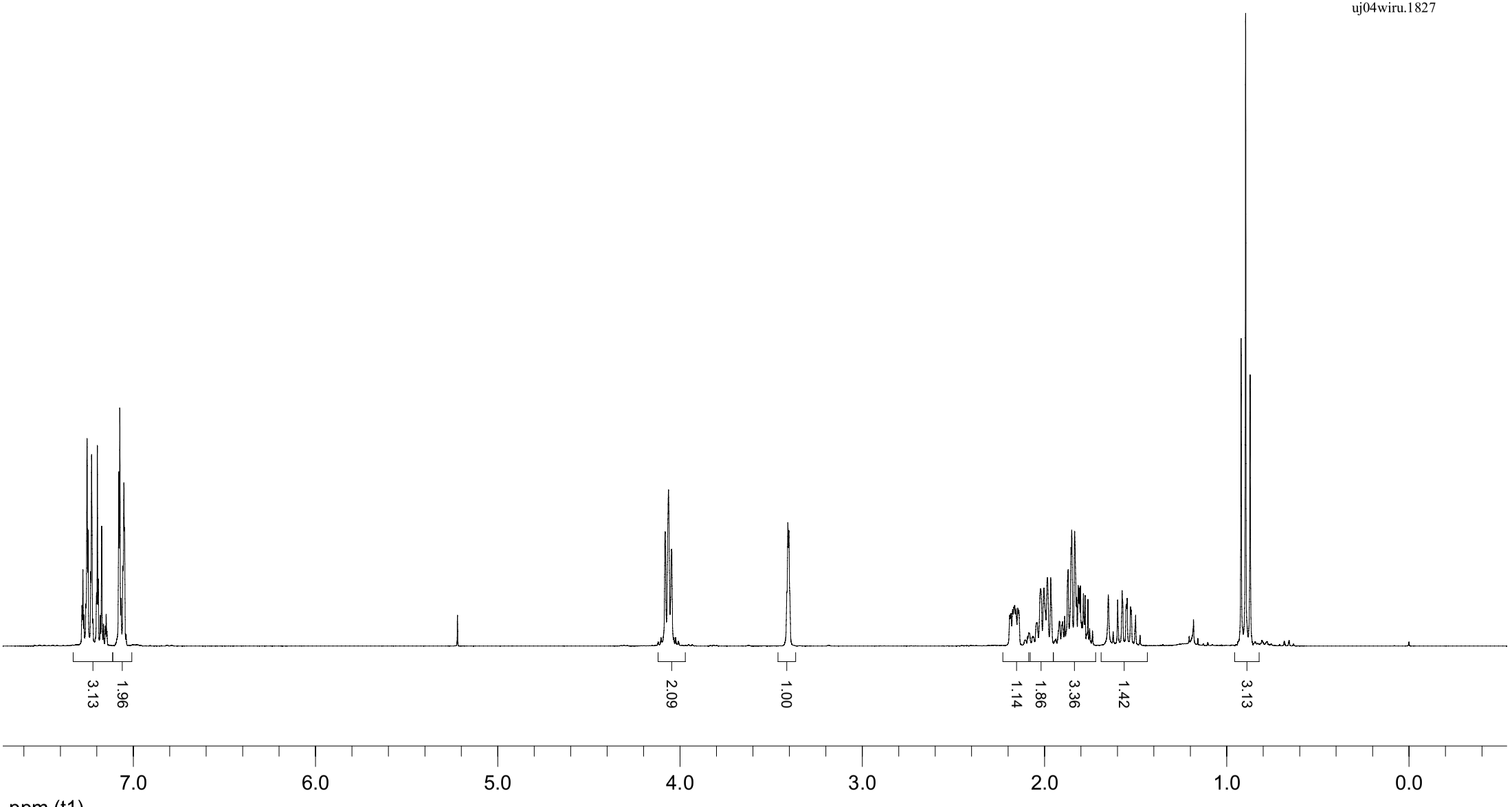


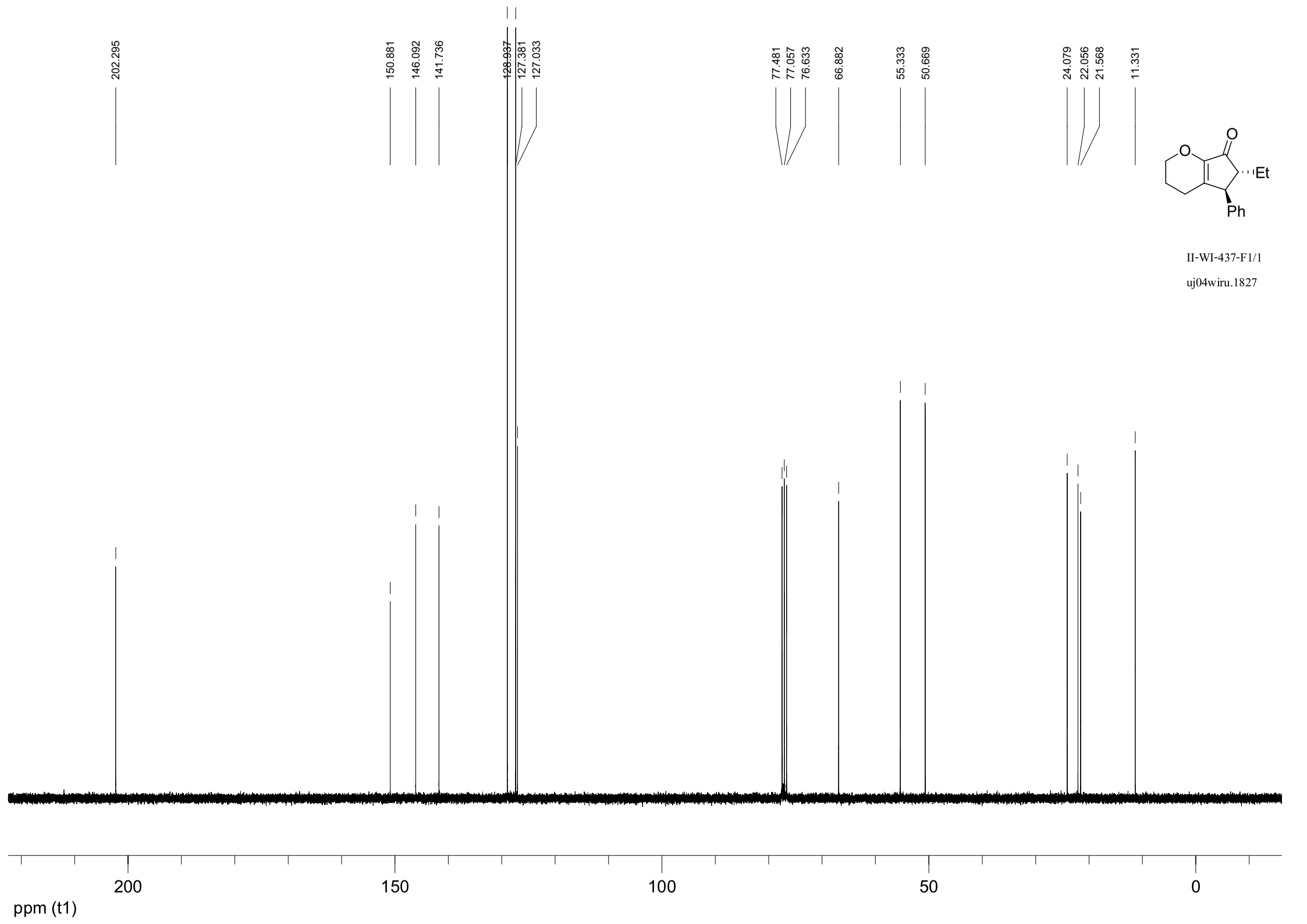
Index	Name	Start	Time	End	Area %
		[Min]	[Min]	[Min]	[%]
1	cis1	23.009	23.750	24.710	76.380
2	trans1	25.714	26.483	27.312	20.030
3	trans2	28.132	28.575	29.218	0.361
4	cis2	32.599	33.358	34.299	3.228
Total					100.000



II-WI-437-F1/1

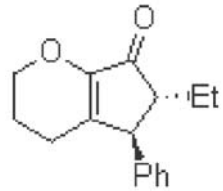
uj04wiru.1827

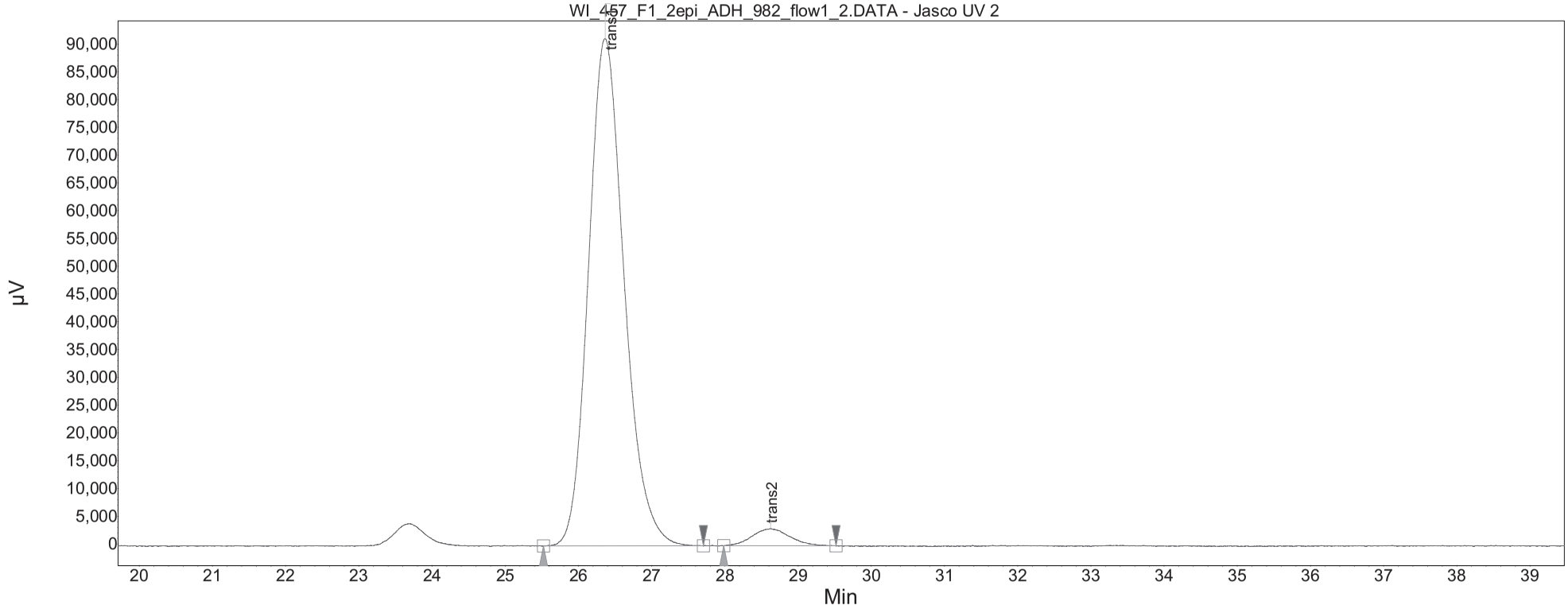



202.295
150.881
146.092
141.736
128.937
127.381
127.033
77.481
77.057
76.633
66.882
55.333
50.669
24.079
22.056
21.568
11.331
O
O
Et
Ph
II-WI-437-F1/1
uj04wiru.1827
200
150
100
50
0
ppm (t1)

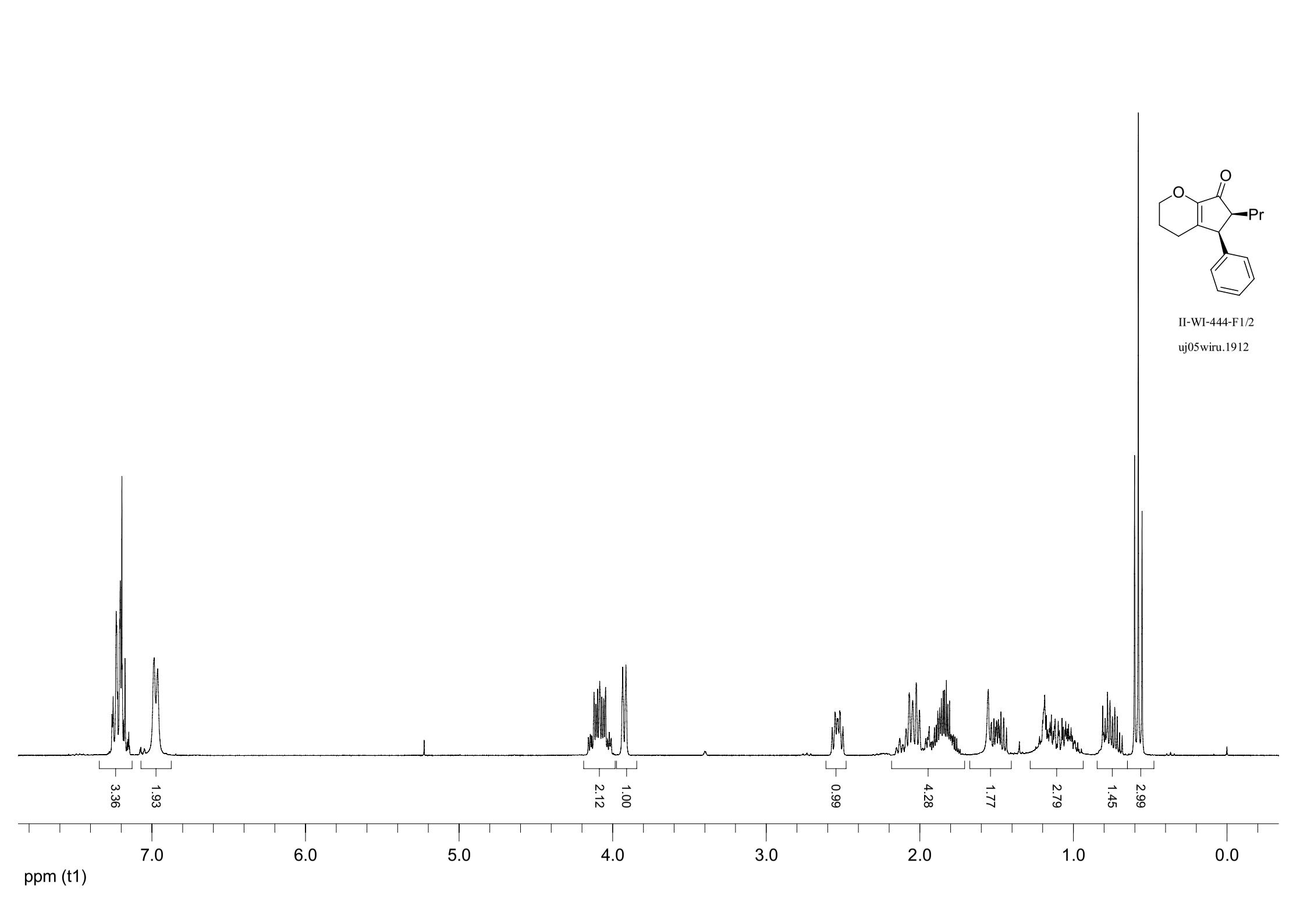
Chromatogram : WI_457_F1_2epi_ADH_982_flow1_2

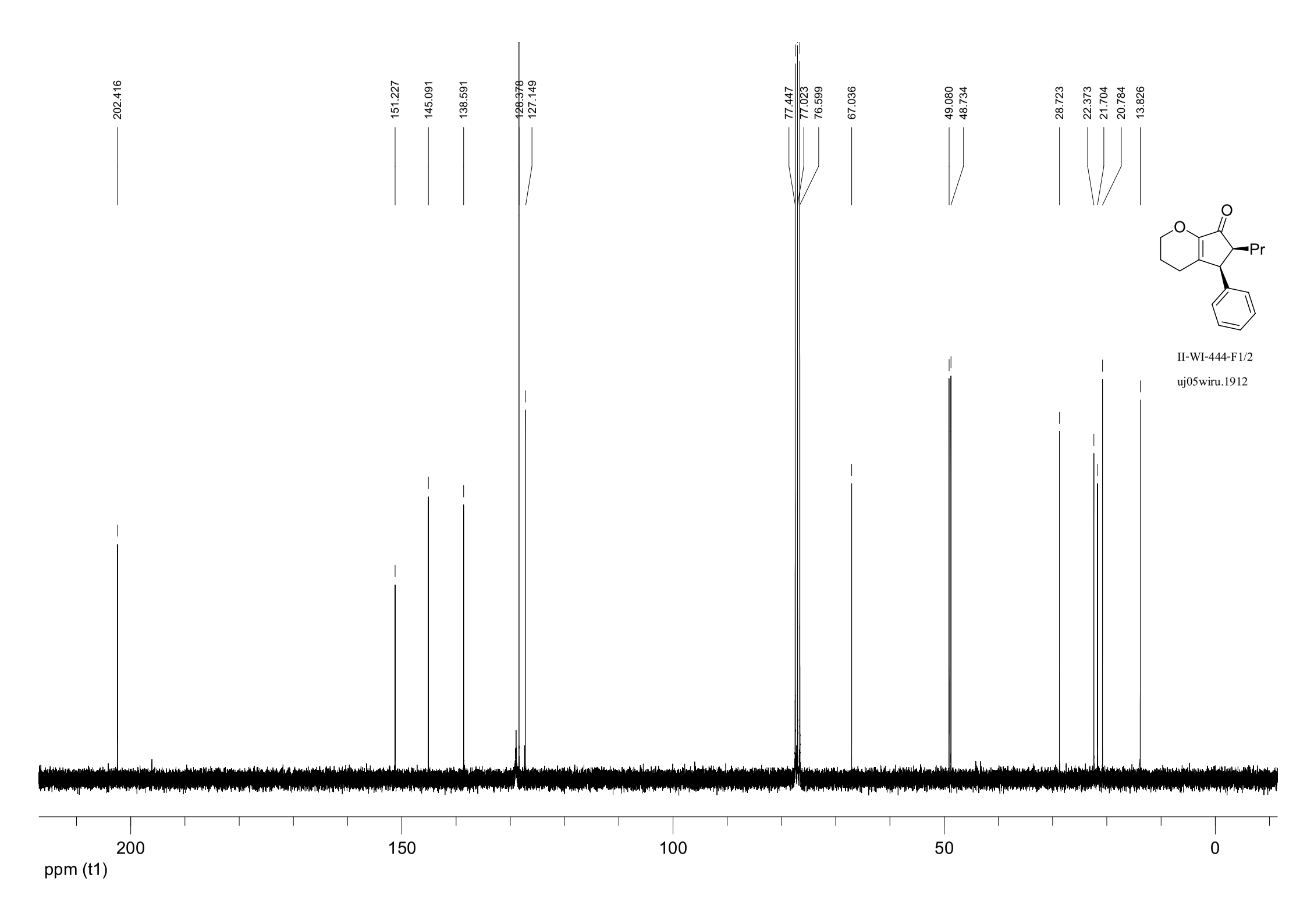
Method: HPLC1_ADH_982_flow1_acq_45
Data file: WI_457_F1_2epi_ADH_982_flow1_2.DATA
Date: 11/23/2006 5:03:23 PM



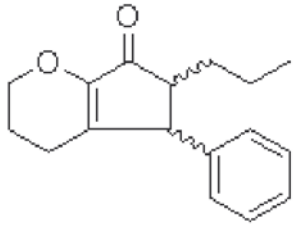


Index	Name	Start	Time	End	Area %
		[Min]	[Min]	[Min]	[%]
1	trans1	25.522	26.367	27.707	96.600
2	trans2	27.986	28.625	29.520	3.400
Total					100.000

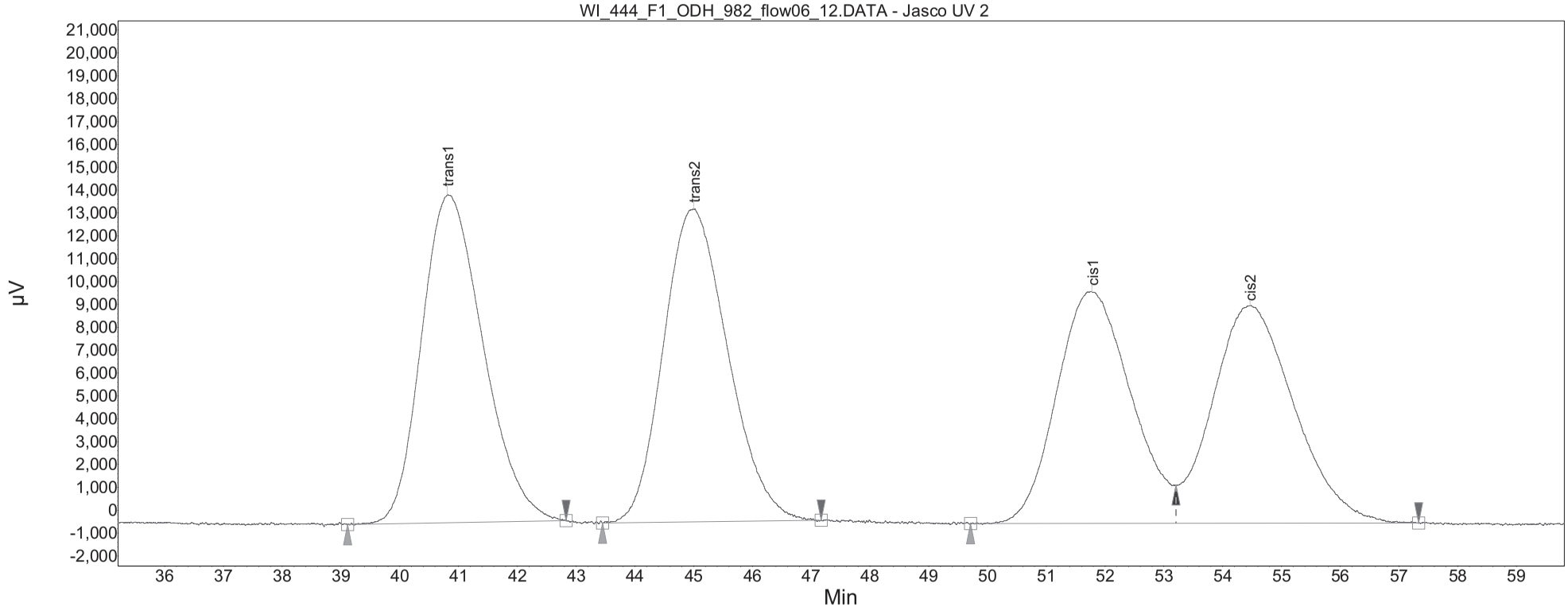

O
O
Pr
II-WI-444-F1/2
uj05wiru.1912
3.36
1.93
2.12
1.00
0.99
4.28
1.77
2.79
1.45
2.99
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)


202.416
151.227
145.091
138.591
128.378
127.149
77.447
77.023
76.599
67.036
49.080
48.734
28.723
22.373
21.704
20.784
13.826
O
O
Pr
II-WI-444-F1/2
uj05wiru.1912
200
150
100
50
0
ppm (t1)

Chromatogram : WI_444_F1_ODH_982_flow06_12

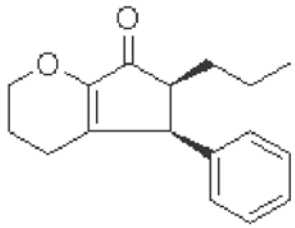


Method: ODH_982_flow06_acq60
Data file: WI_444_F1_ODH_982_flow06_12.DATA
Date: 10/31/2006 1:04:08 PM

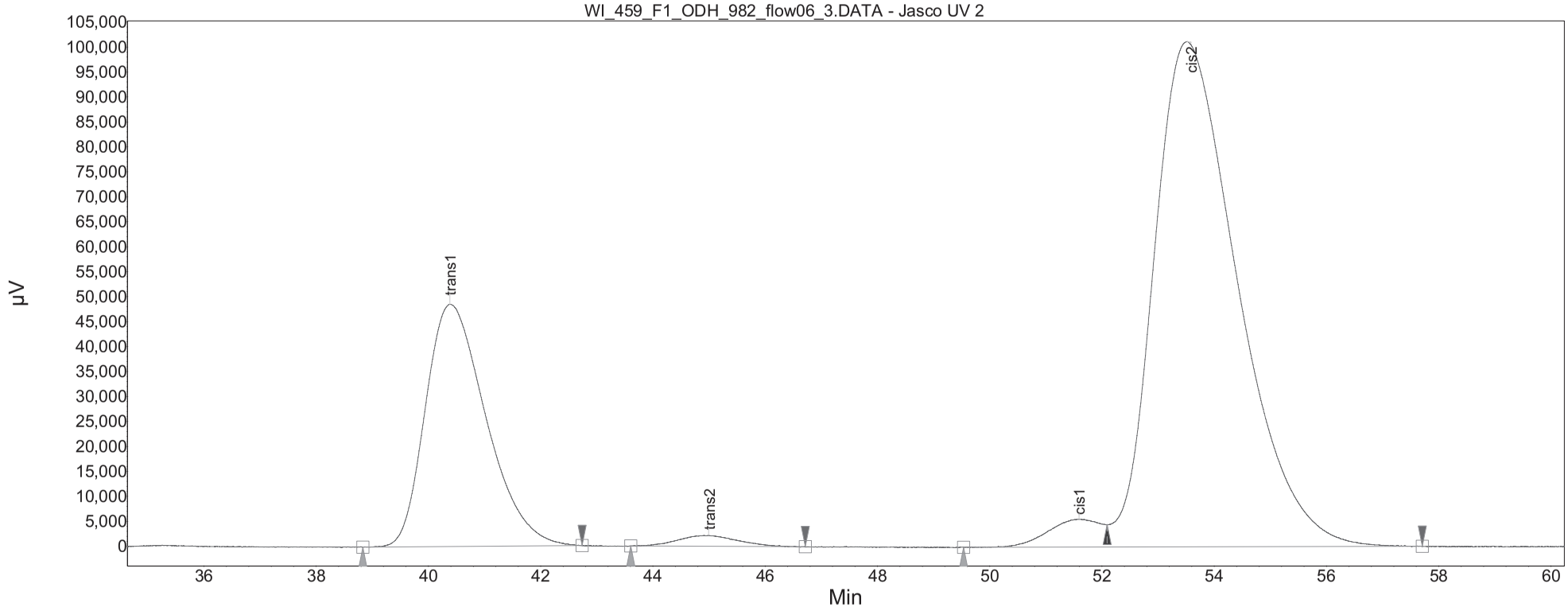


Index	Name	Start	Time	End	Area %
		[Min]	[Min]	[Min]	[%]
1	trans1	39.112	40.808	42.831	26.828
2	trans2	43.450	45.000	47.169	26.737
3	cis1	49.711	51.775	53.207	22.864
4	cis2	53.207	54.467	57.335	23.571
Total					100.000

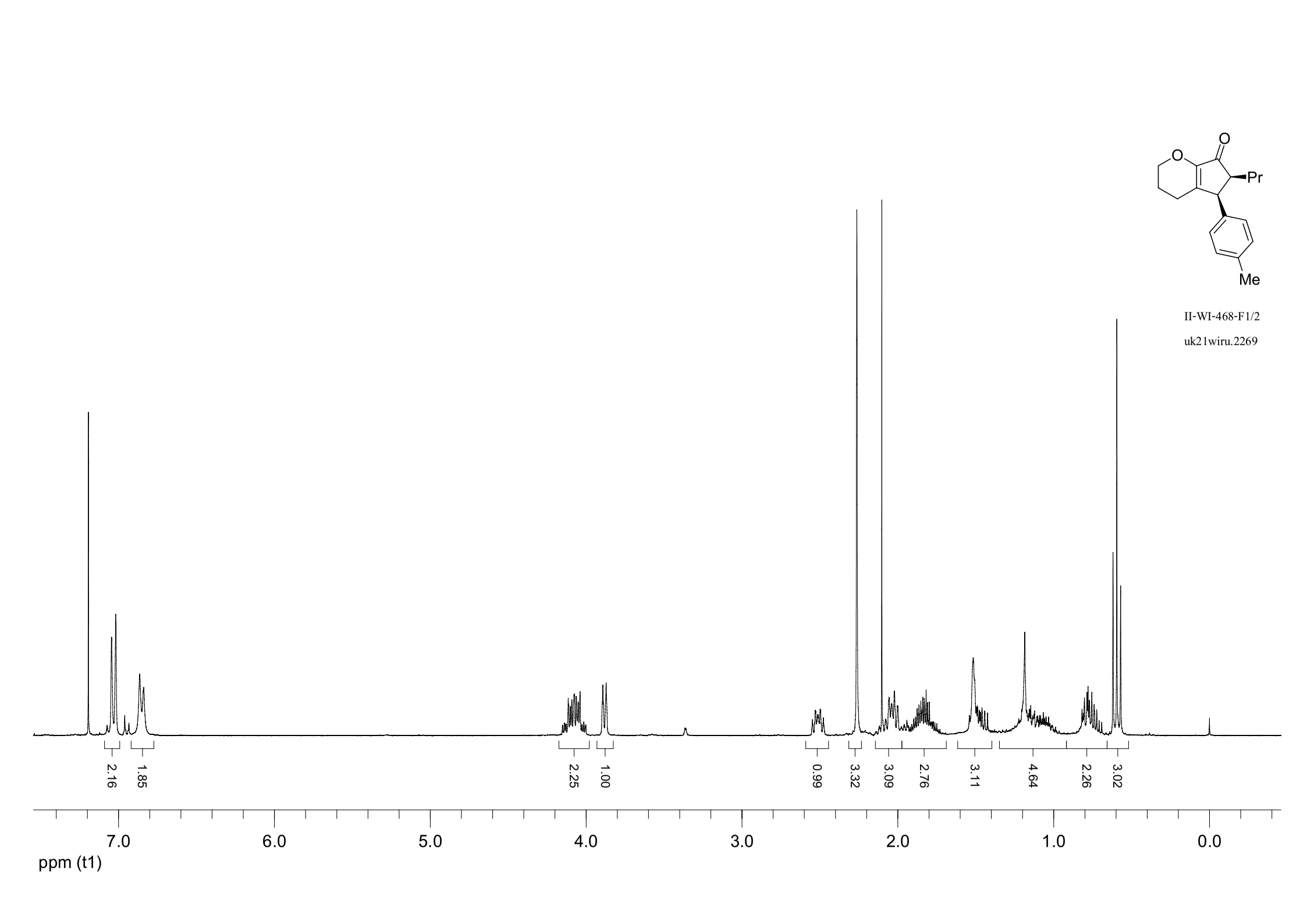
Chromatogram : WI_459_F1_ODH_982_flow06_3

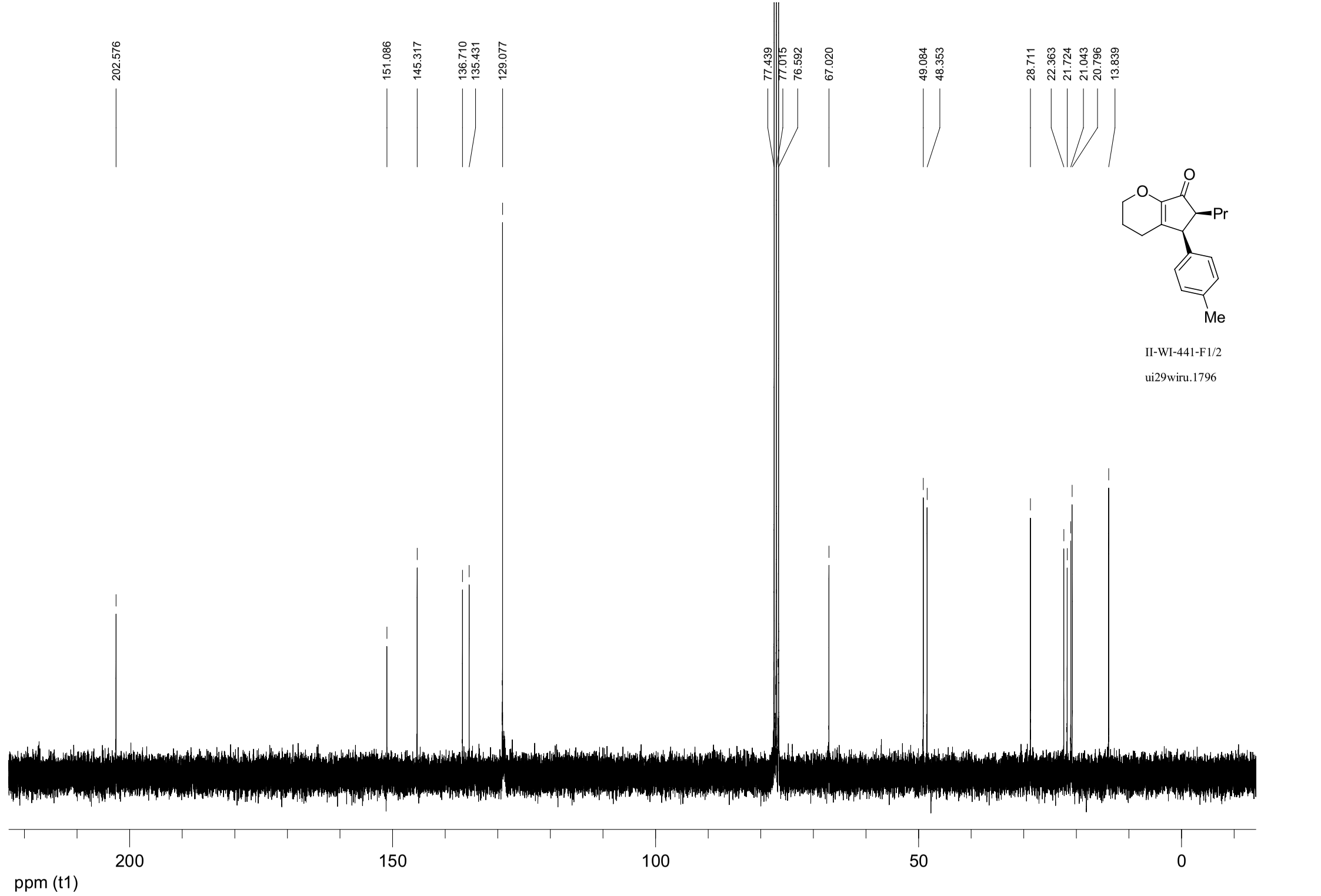


Method: ODH_982_flow06_acq70
Data file: WI_459_F1_ODH_982_flow06_3.DATA
Date: 10/31/2006 4:22:41 PM



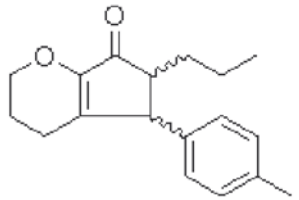
Index	Name	Start	Time	End	Area %
		[Min]	[Min]	[Min]	[%]
1	trans1	38.833	40.383	42.738	24.908
2	trans2	43.605	44.992	46.715	1.083
3	cis1	49.535	51.592	52.092	2.509
4	cis2	52.092	53.517	57.707	71.500
Total					100.000

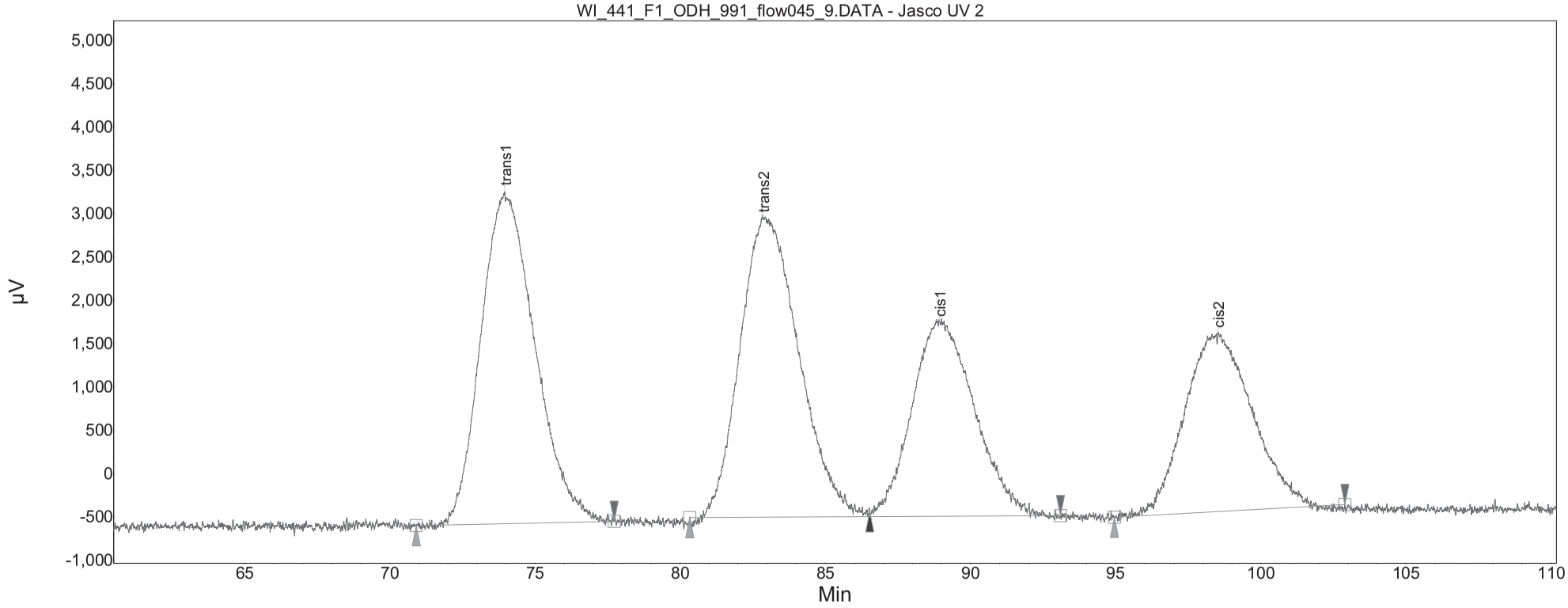

O
O
Pr
Me
II-WI-468-F1/2
uk21wiru.2269
2.16
1.85
2.25
1.00
0.99
3.32
3.09
2.76
3.11
4.64
2.26
3.02
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)


202.576
151.086
145.317
136.710
135.431
129.077
77.439
77.015
76.592
67.020
49.084
48.353
28.711
22.363
21.724
21.043
20.796
13.839
O
O
Pr
Me
II-WI-441-F1/2
ui29wiru.1796
200
150
100
50
0
ppm (t1)

Chromatogram : WI_441_F1_ODH_991_flow045_9

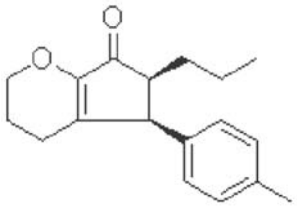
Method: ODH_991_flow045_acq120
Data file: WI_441_F1_ODH_991_flow045_9.DATA
Date: 11/2/2006 10:22:28 AM



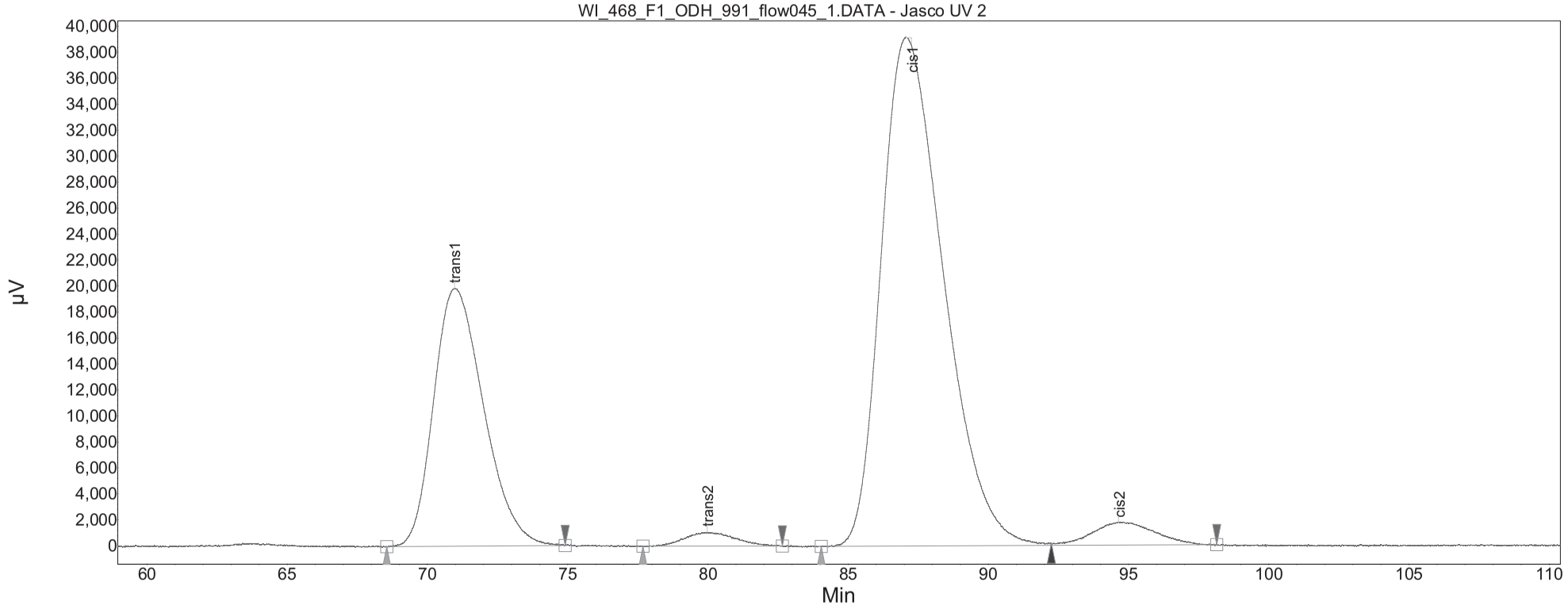


Index	Name	Start	Time	End	Area %
		[Min]	[Min]	[Min]	[%]
1	trans1	70.909	73.958	77.727	29.990
2	trans2	80.331	82.867	86.529	29.492
4	cis1	86.529	88.942	93.099	20.473
3	cis2	94.959	98.525	102.893	20.045
Total					100.000

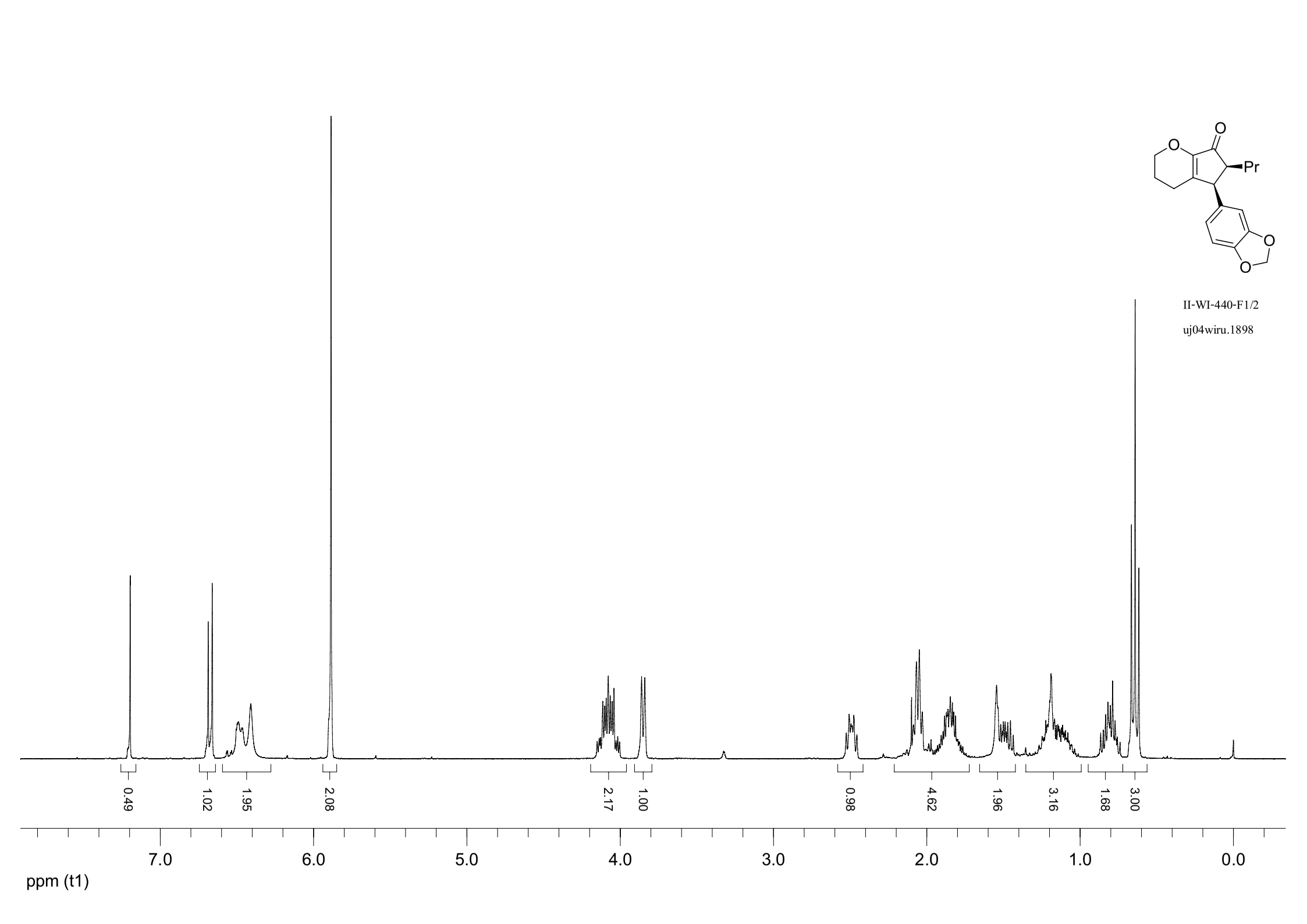
Chromatogram : WI_468_F1_ODH_991_flow045_1

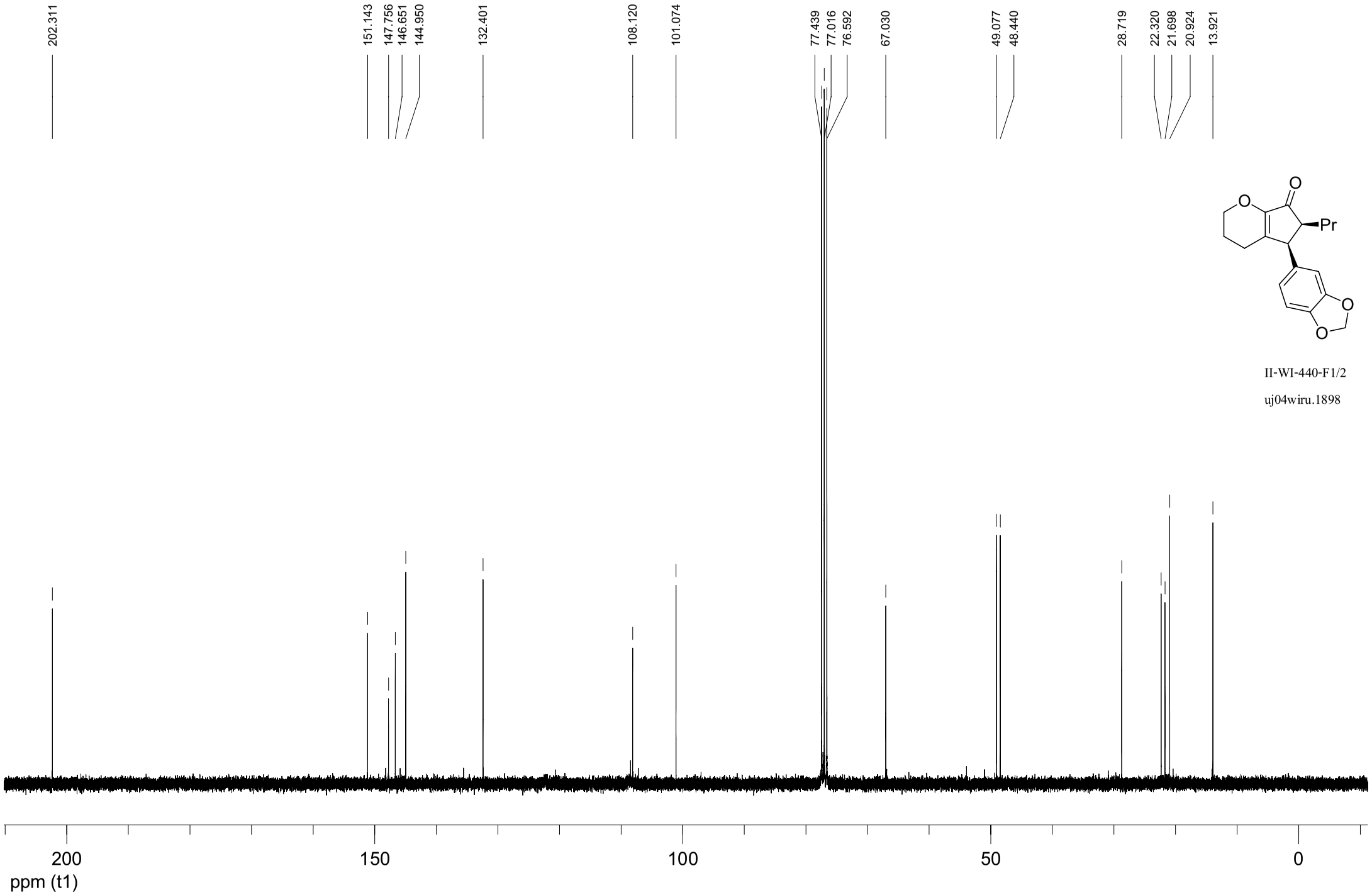


Method: ODH_991_flow045_acq120
Data file: WI_468_F1_ODH_991_flow045_1.DATA
Date: 11/2/2006 2:22:19 PM



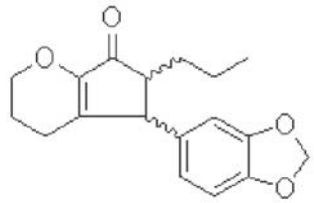
Index	Name	Start	Time	End	Area %
		[Min]	[Min]	[Min]	[%]
1	trans1	68.550	70.967	74.908	27.722
2	trans2	77.683	79.975	82.653	1.468
3	cis1	84.041	87.058	92.248	67.746
4	cis2	92.248	94.642	98.144	3.063
Total					100.000

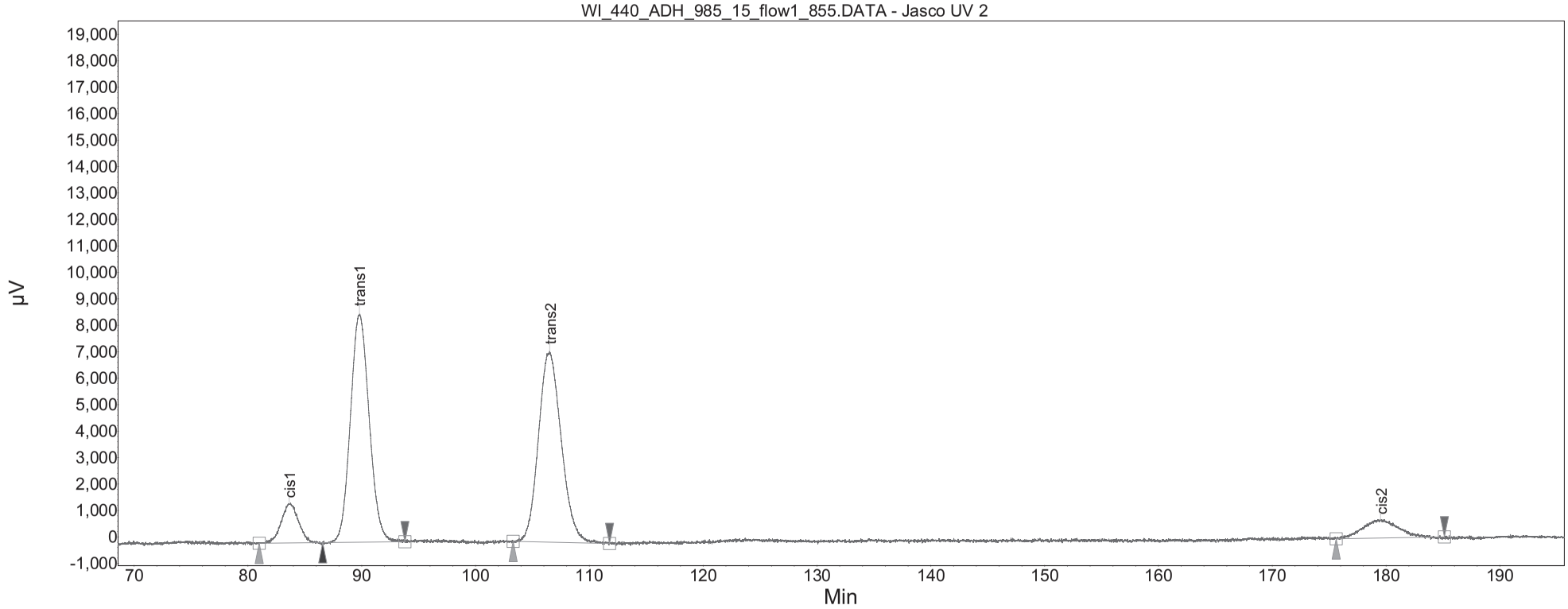

O
O
Pr
O
O
II-WI-440-F1/2
uj04wiru.1898
0.49
1.02
1.95
2.08
2.17
1.00
0.98
4.62
1.96
3.16
1.68
3.00
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)


202.311
151.143
147.756
146.651
144.950
132.401
108.120
101.074
77.439
77.016
76.592
67.030
49.077
48.440
28.719
22.320
21.698
20.924
13.921
O
O
Pr
O
O
II-WI-440-F1/2
uj04wiru.1898
200
150
100
50
0
ppm (t1)

Chromatogram : WI_440_ADH_985_15_flow1_855

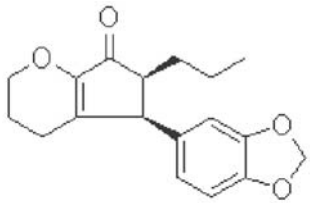
Method: ADH_985_15_flow1_acq200
Data file: WI_440_ADH_985_15_flow1_855.DATA
Date: 11/1/2006 2:38:51 PM



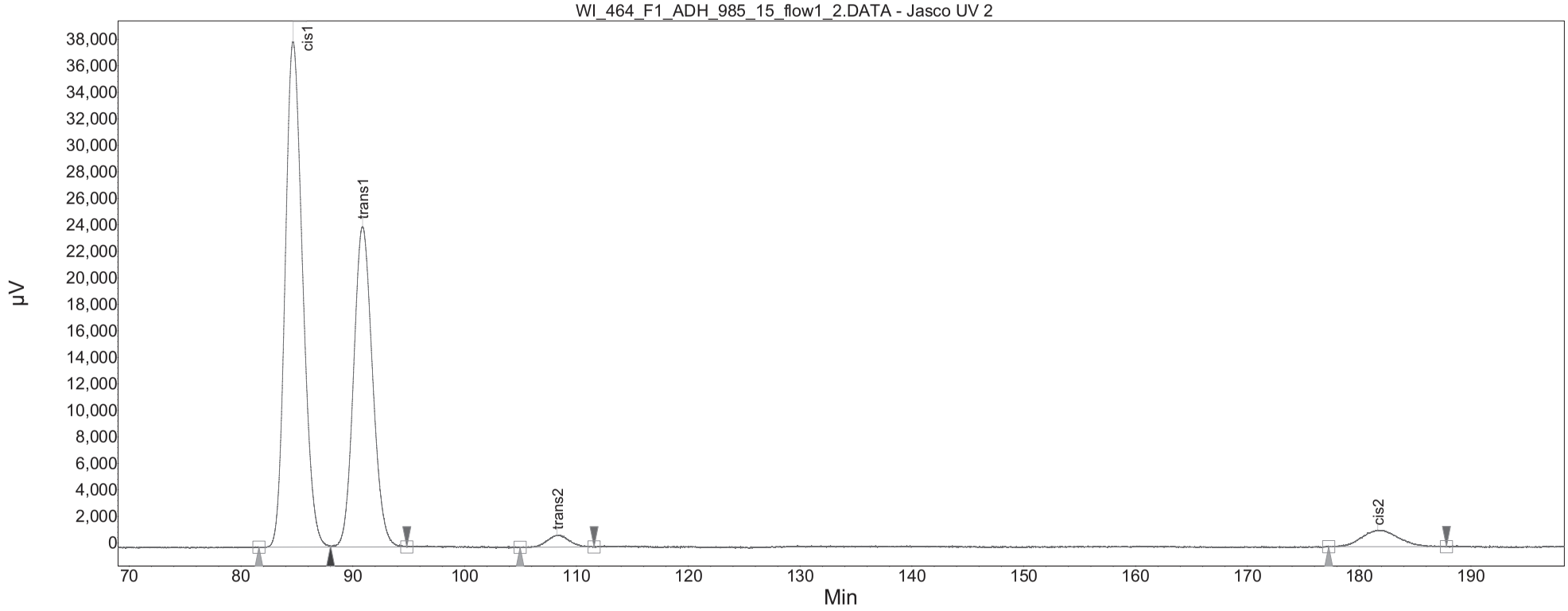


Index	Name	Start	Time	End	Area %
		[Min]	[Min]	[Min]	[%]
1	cis1	80.992	83.633	86.570	6.810
4	trans1	86.570	89.800	93.802	43.142
2	trans2	103.306	106.517	111.777	43.617
3	cis2	175.620	179.517	185.124	6.431
Total					100.000

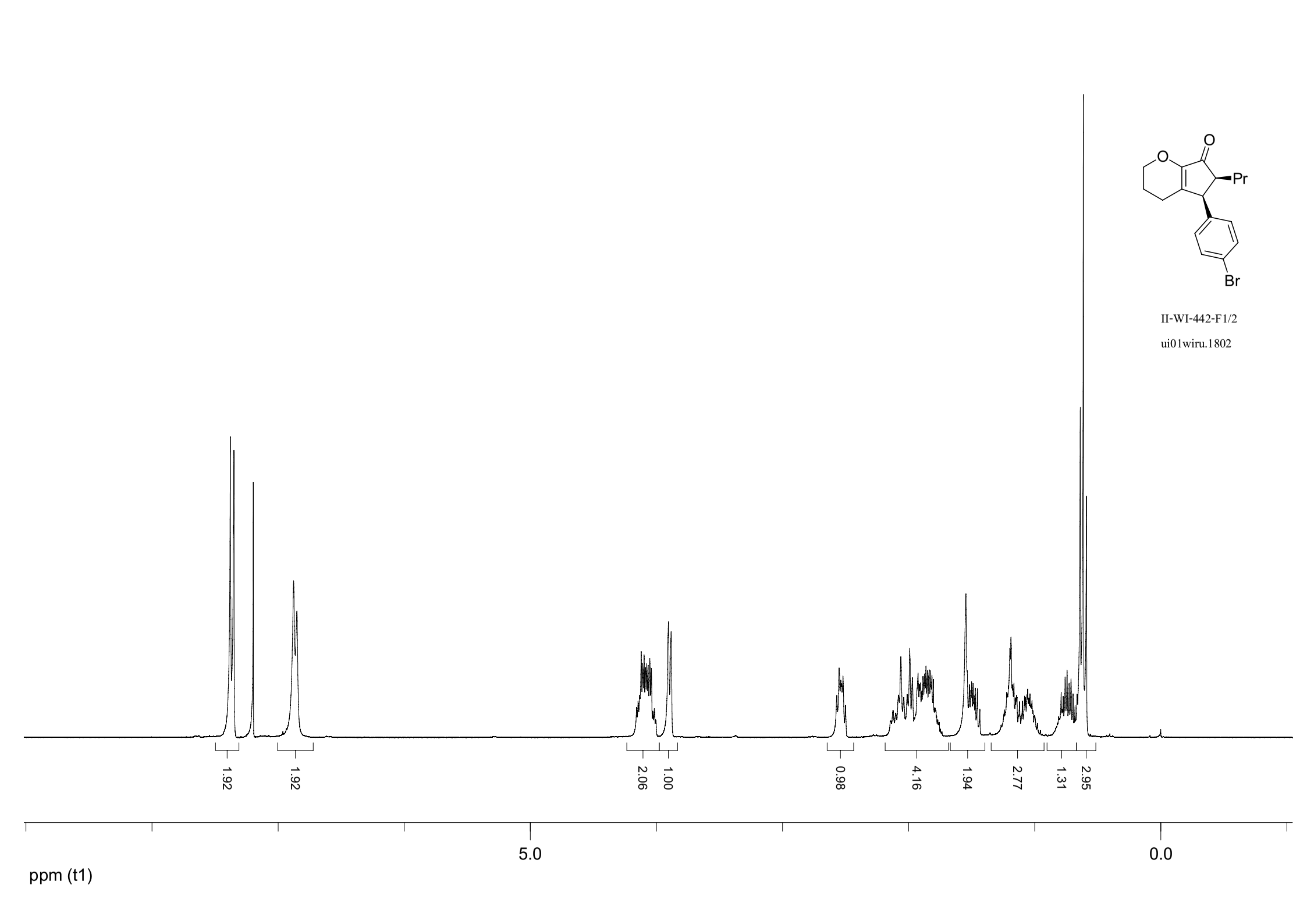
Chromatogram : WI_464_F1_ADH_985_15_flow1_2

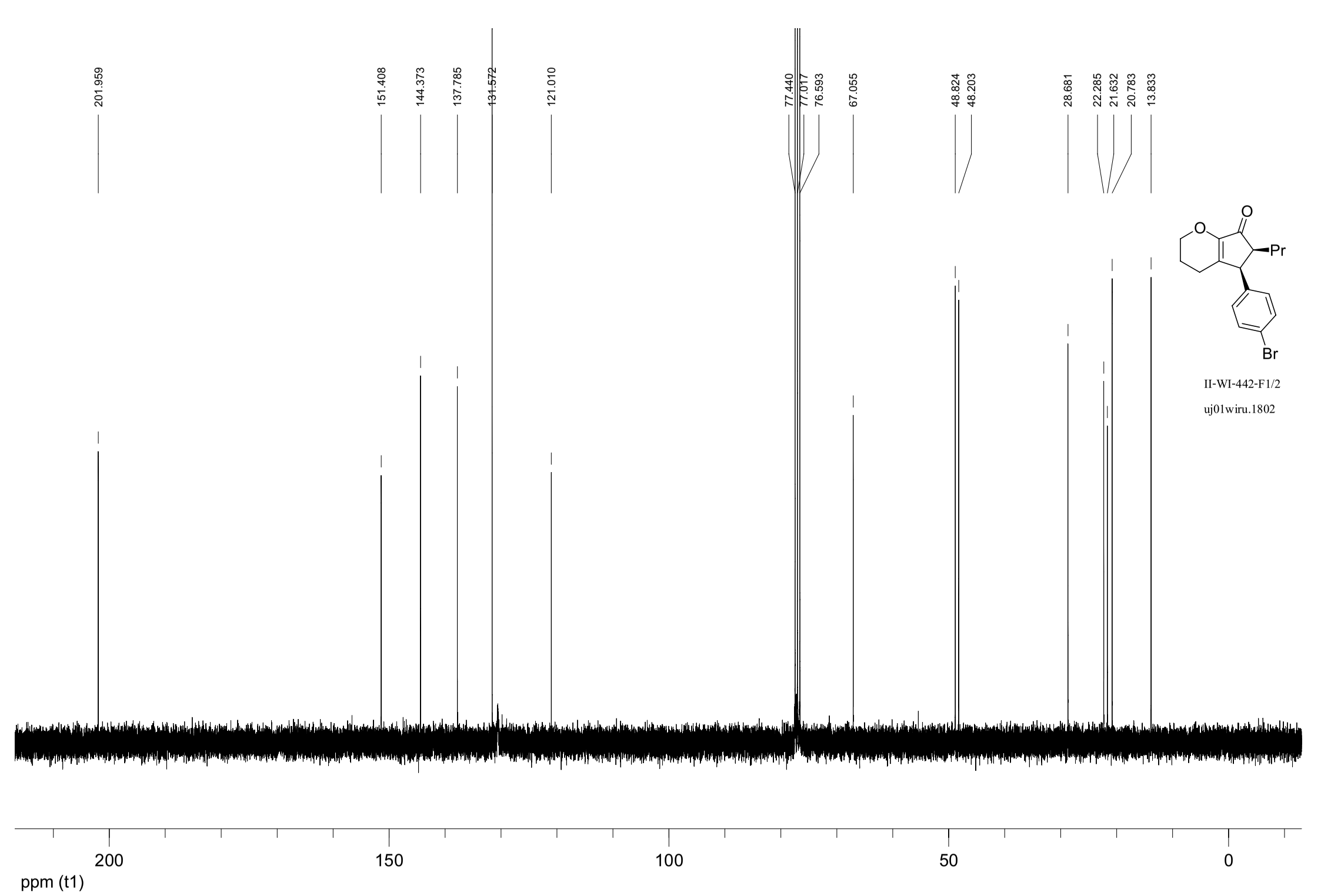


Method: ADH_985_15_flow1_acq200
Data file: WI_464_F1_ADH_985_15_flow1_2.DATA
Date: 11/1/2006 9:34:48 PM

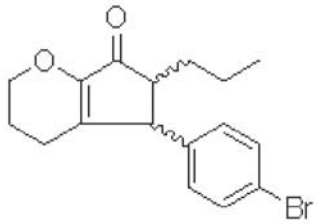


Index	Name	Start	Time	End	Area %
		[Min]	[Min]	[Min]	[%]
1	cis1	81.612	84.658	88.017	56.083
4	trans1	88.017	90.875	94.835	38.495
2	trans2	104.959	108.258	111.570	1.630
3	cis2	177.273	181.658	187.810	3.792
Total					100.000

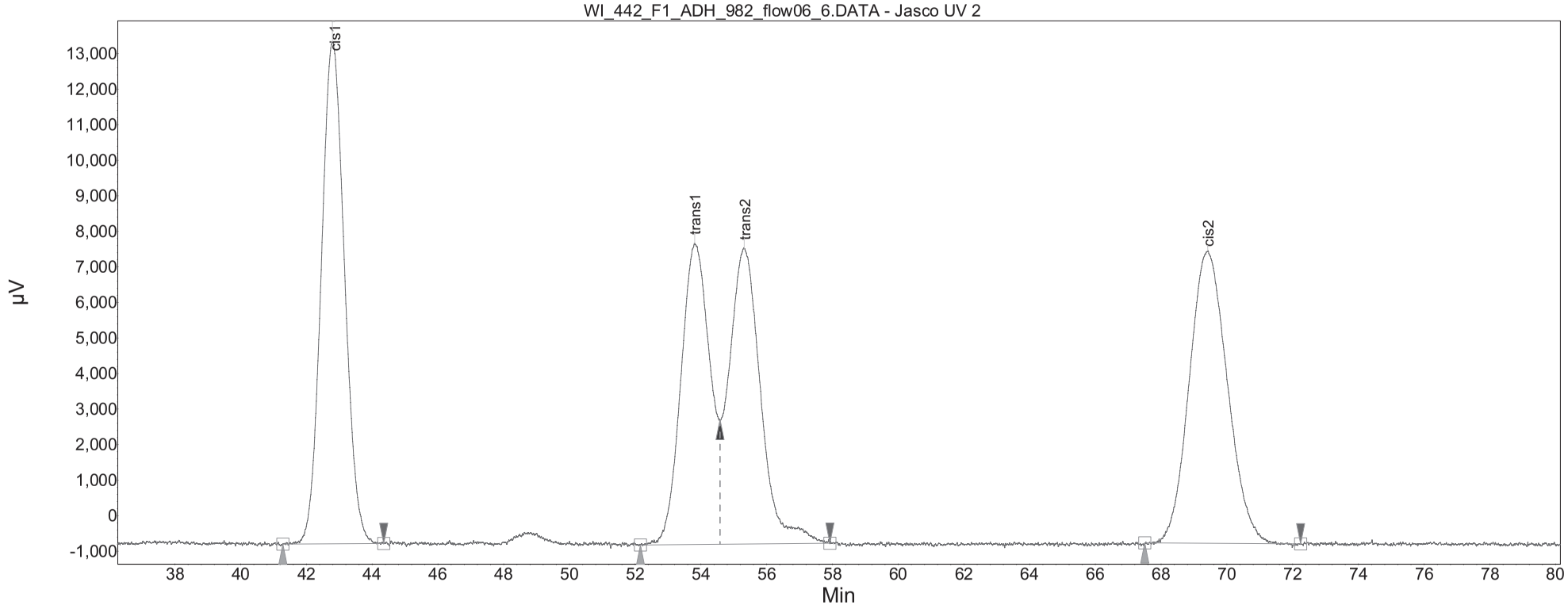

O
O
Pr
Br
II-WI-442-F1/2
ui01wiru.1802
1.92
1.92
2.06
1.00
0.98
4.16
1.94
2.77
1.31
2.95
5.0
0.0
ppm (t1)


201.959
151.408
144.373
137.785
131.572
121.010
77.440
77.017
76.593
67.055
48.824
48.203
28.681
22.285
21.632
20.783
13.833
O
O
Pr
Br
II-WI-442-F1/2
uj01wiru.1802
200
150
100
50
0
ppm (t1)

Chromatogram : WI_442_F1_ADH_982_flow06_6

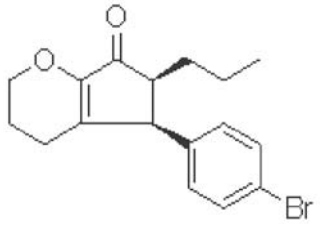


Method: ADH_982_flow06_acq90
Data file: WI_442_F1_ADH_982_flow06_6.DATA
Date: 10/3/2006 11:41:14 PM

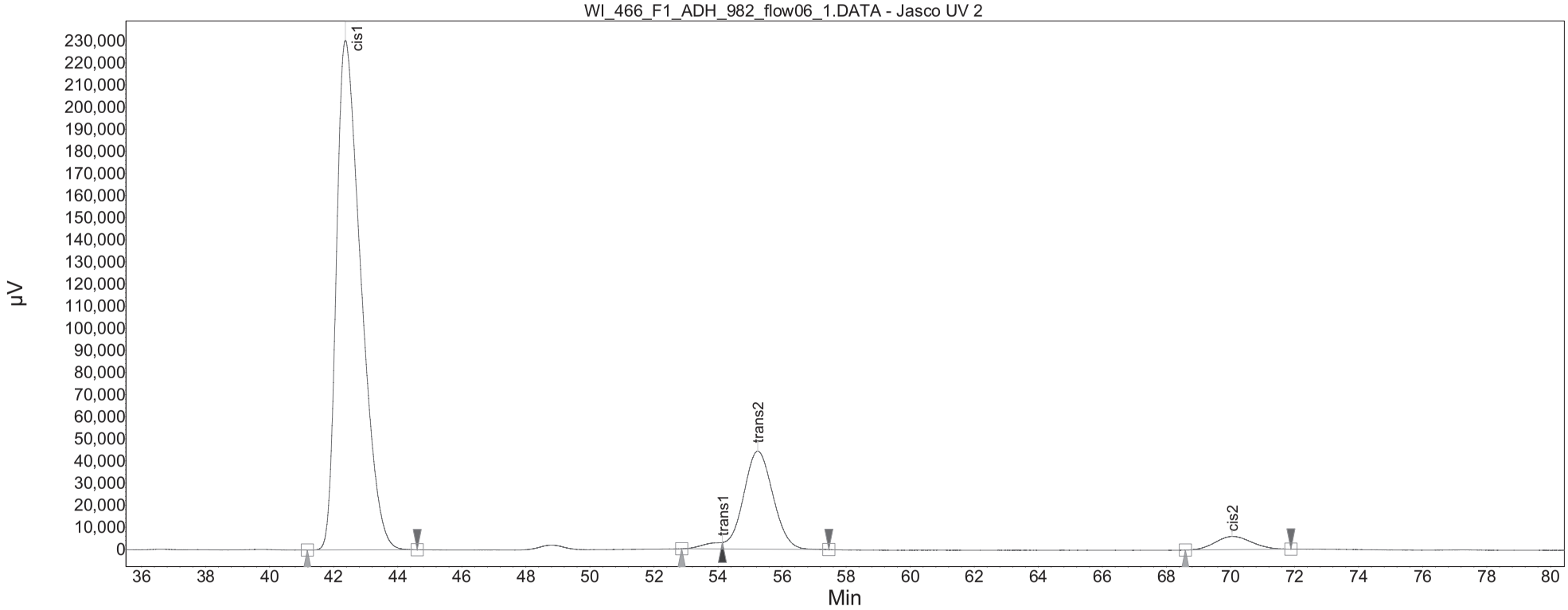


Index	Name	Start	Time	End	Area %
		[Min]	[Min]	[Min]	[%]
1	cis1	41.281	42.792	44.349	28.532
2	trans1	52.159	53.808	54.581	21.410
4	trans2	54.581	55.317	57.924	22.896
3	cis2	67.500	69.417	72.242	27.162
Total					100.000

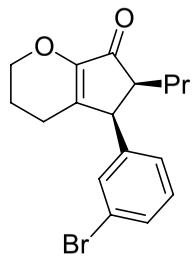
Chromatogram : WI_466_F1_ADH_982_flow06_1



Method: ADH_982_flow06_acq90
Data file: WI_466_F1_ADH_982_flow06_1.DATA
Date: 11/1/2006 5:42:08 AM



Index	Name	Start	Time	End	Area %
		[Min]	[Min]	[Min]	[%]
1	cis1	41.176	42.367	44.609	78.151
2	trans1	52.867	54.137	54.137	0.741
4	trans2	54.137	55.242	57.460	18.107
3	cis2	68.594	70.050	71.888	3.002
Total					100.000



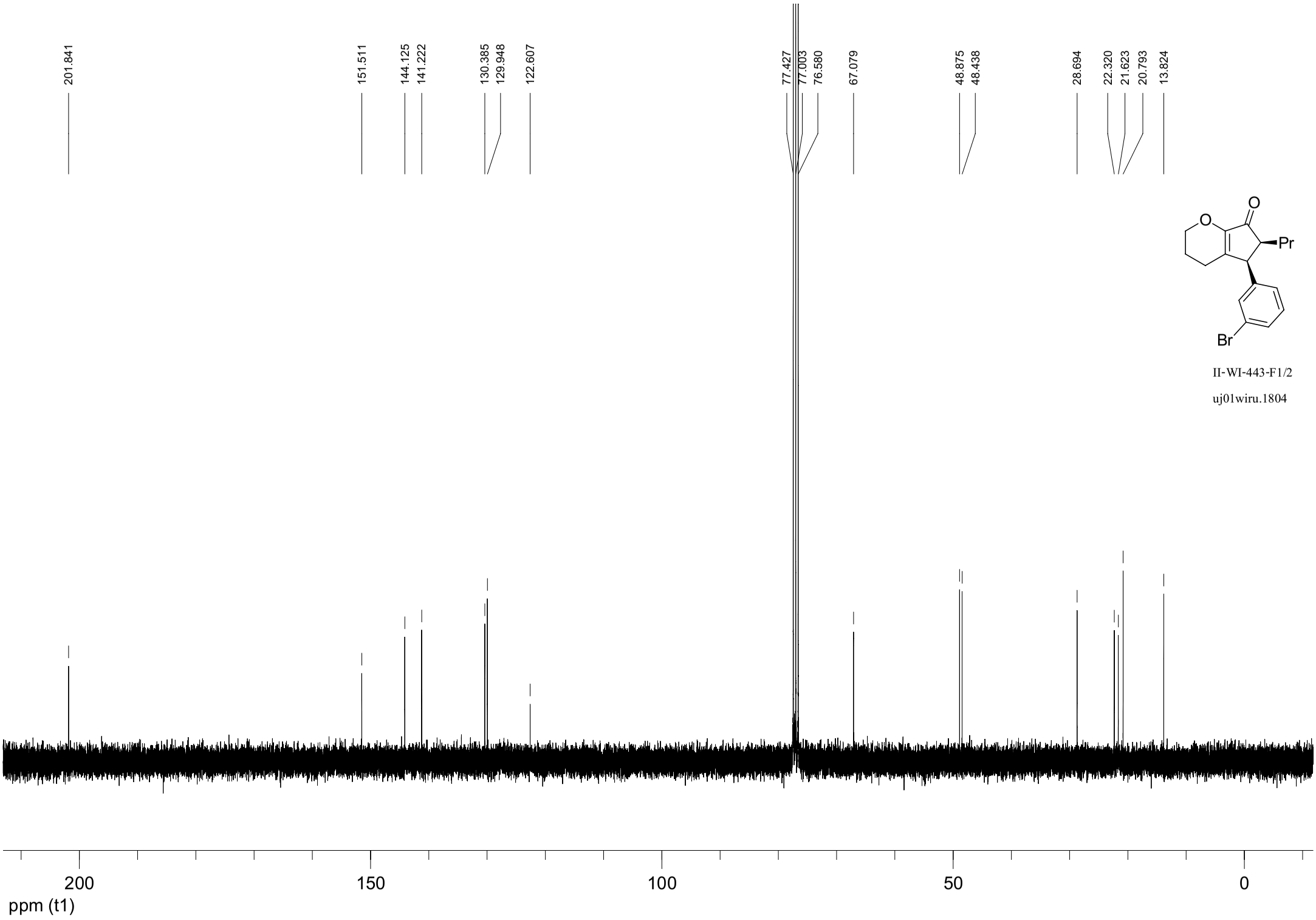
II-WI-443-F1/2

uj01wiru.1804

1.00 1.20 1.35 0.93 2.09 1.00 0.98 4.23 3.32 3.74 1.68 3.03

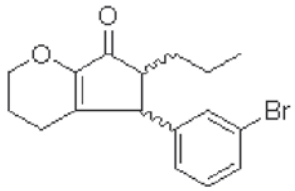
7.0 6.0 5.0 4.0 3.0 2.0 1.0 0.0

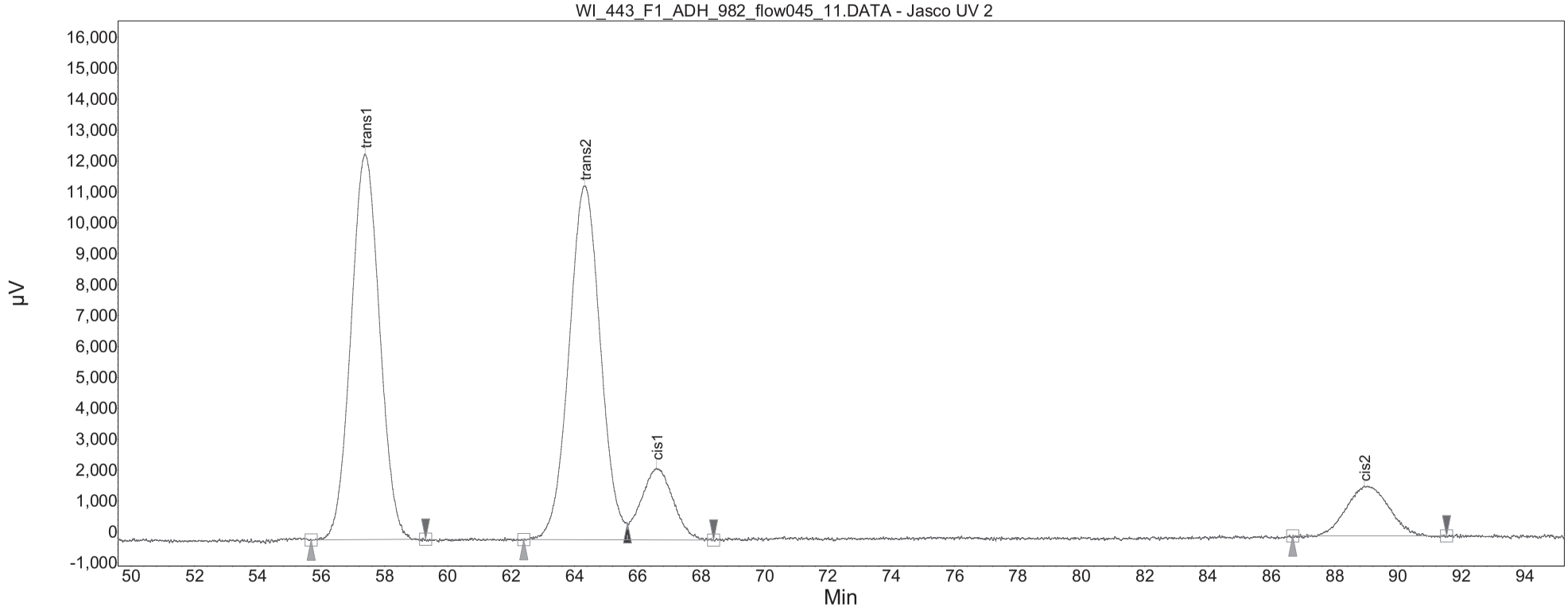
ppm (t1)


201.841
151.511
144.125
141.222
130.385
129.948
122.607
77.427
77.003
76.580
67.079
48.875
48.438
28.694
22.320
21.623
20.793
13.824
O
O
Pr
Br
II-WI-443-F1/2
uj01wiru.1804
200
150
100
50
0
ppm (t1)

Chromatogram : WI_443_F1_ADH_982_flow045_11

Method: ADH_982_flow045_acq100
Data file: WI_443_F1_ADH_982_flow045_11.DATA
Date: 10/30/2006 12:52:18 PM

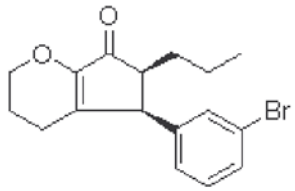


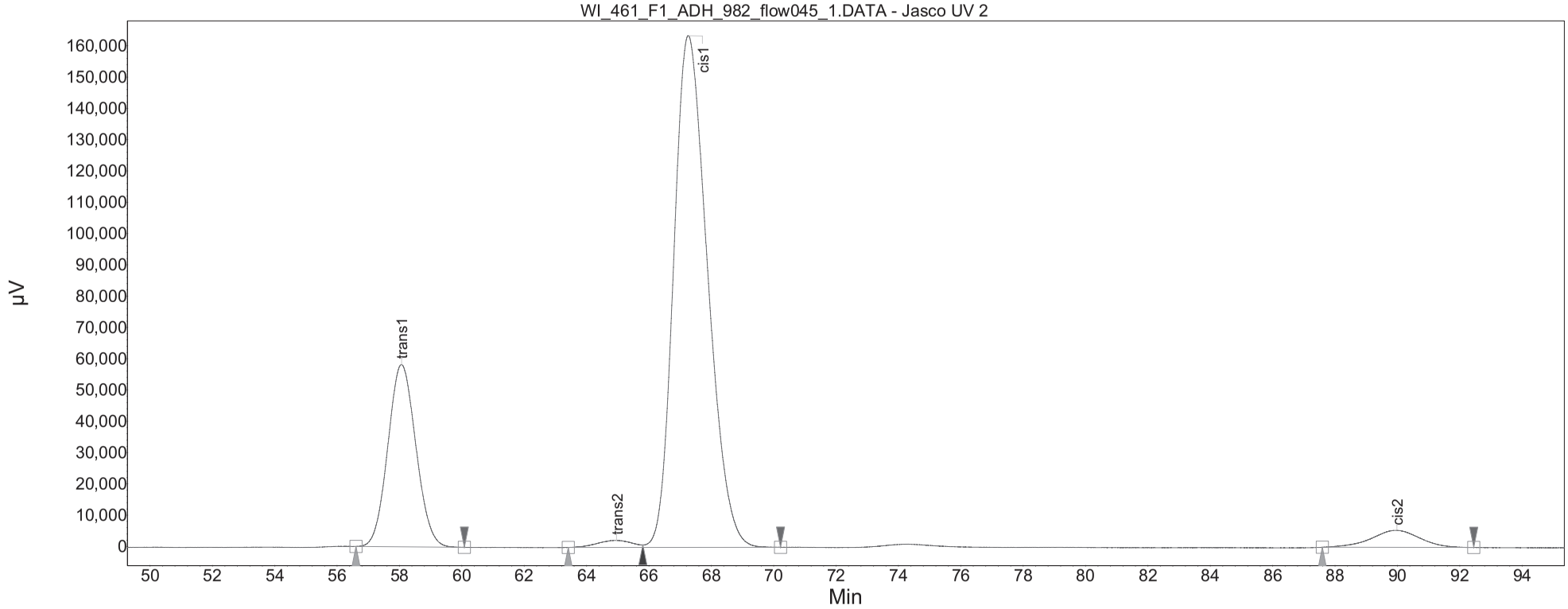


Index	Name	Start	Time	End	Area %
		[Min]	[Min]	[Min]	[%]
1	trans1	55.682	57.392	59.298	41.570
2	trans2	62.397	64.317	65.671	41.992
4	cis1	65.671	66.583	68.388	8.603
3	cis2	86.674	88.933	91.529	7.834
Total					100.000

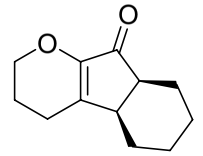
Chromatogram : WI_461_F1_ADH_982_flow045_1

Method: ADH_982_flow045_acq100
Data file: WI_461_F1_ADH_982_flow045_1.DATA
Date: 10/31/2006 9:21:08 PM





Index	Name	Start	Time	End	Area %
		[Min]	[Min]	[Min]	[%]
1	trans1	56.607	58.067	60.081	21.770
2	trans2	63.413	64.958	65.805	1.022
4	cis1	65.805	67.258	70.220	73.709
3	cis2	87.593	89.983	92.448	3.499
Total					100.000



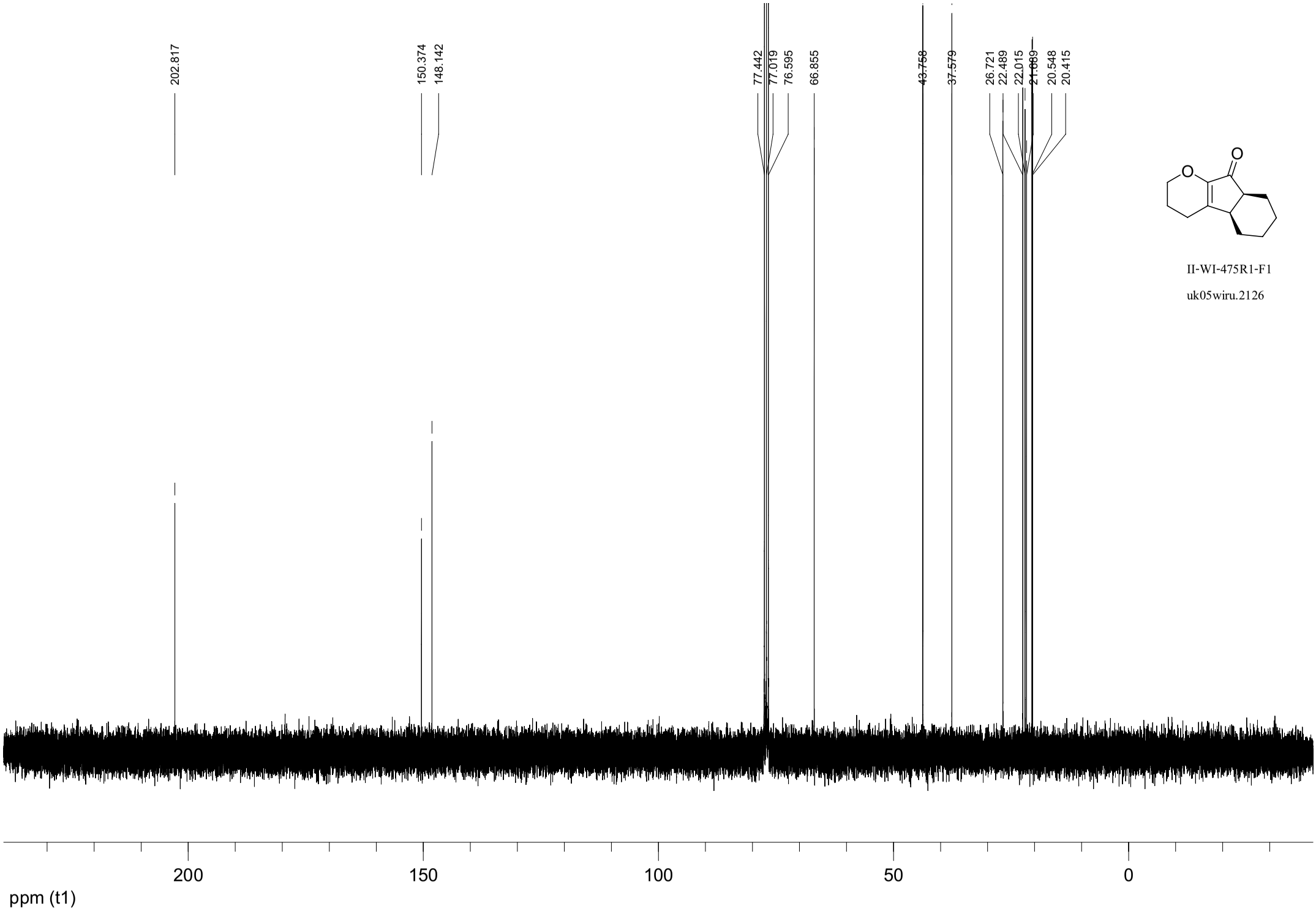
II-WI-475R1-F1

uk05wiru.2126

2.10 1.00 2.06 1.11 5.40 4.27 1.26

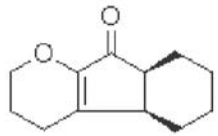
8.0 7.0 6.0 5.0 4.0 3.0 2.0 1.0 0.0

ppm (t1)

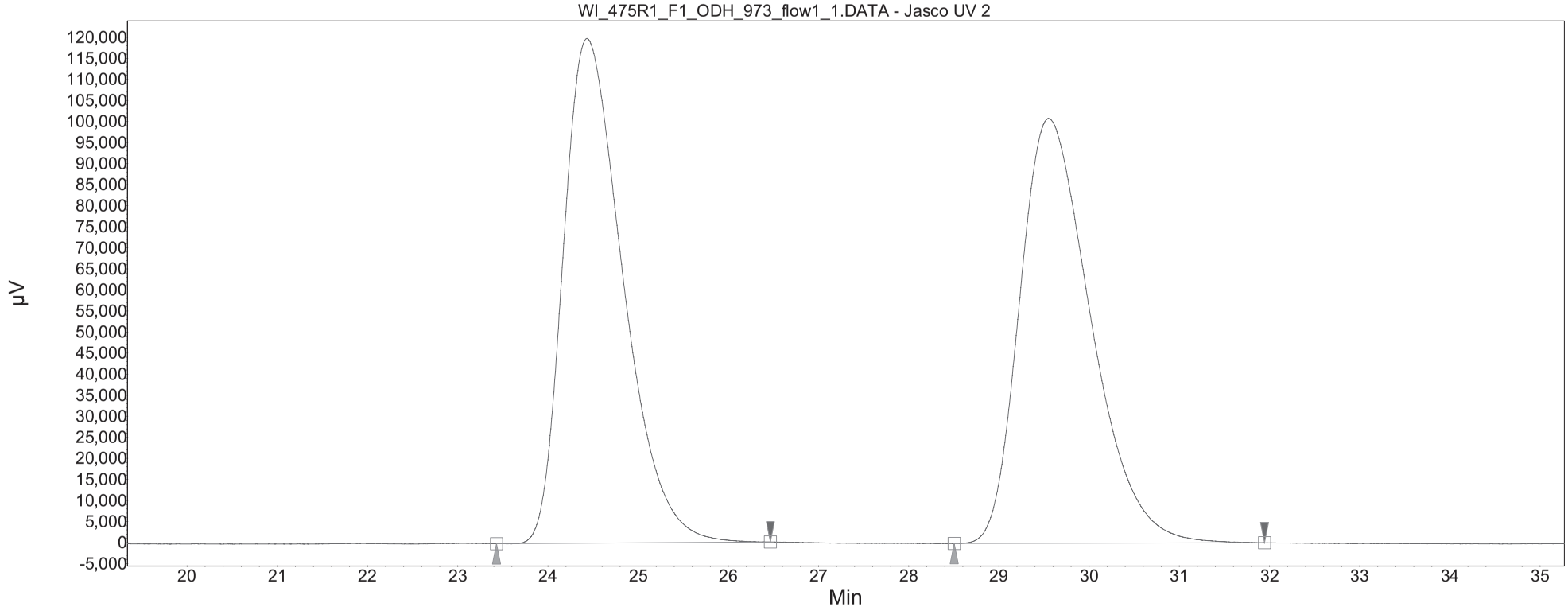

202.817
150.374
148.142
77.442
77.019
76.595
66.855
43.758
37.579
26.721
22.489
22.015
21.089
20.548
20.415
O
O
II-WI-475R1-F1
uk05wiru.2126
200
150
100
50
0
ppm (t1)

Chromatogram : WI_475R1_F1_ODH_973_flow1_1

Method: ODH_973_flow1_acq60
Data file: WI_475R1_F1_ODH_973_flow1_1.DATA
Date: 11/4/2006 6:48:23 PM



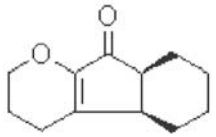
racemic

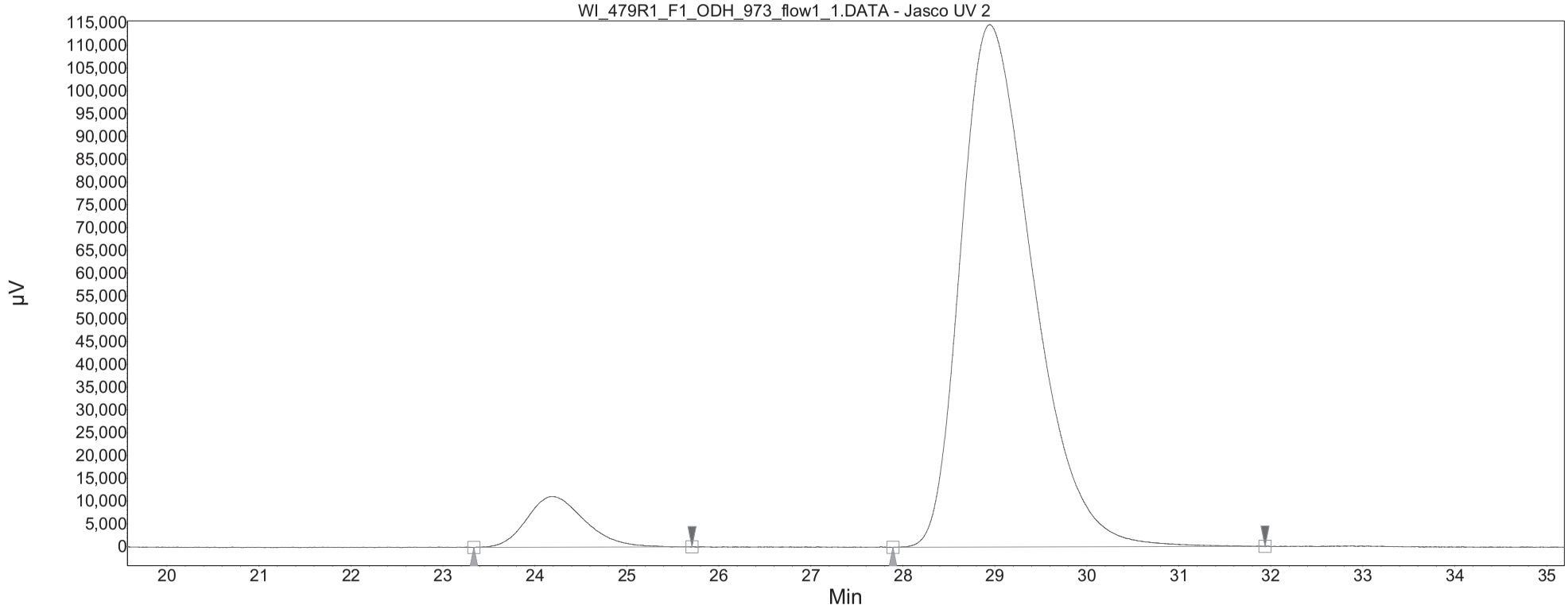


Index	Start	Time	End	Area %
	[Min]	[Min]	[Min]	[%]
1	23.430	24.433	26.467	49.944
2	28.505	29.550	31.944	50.056
Total				100.000

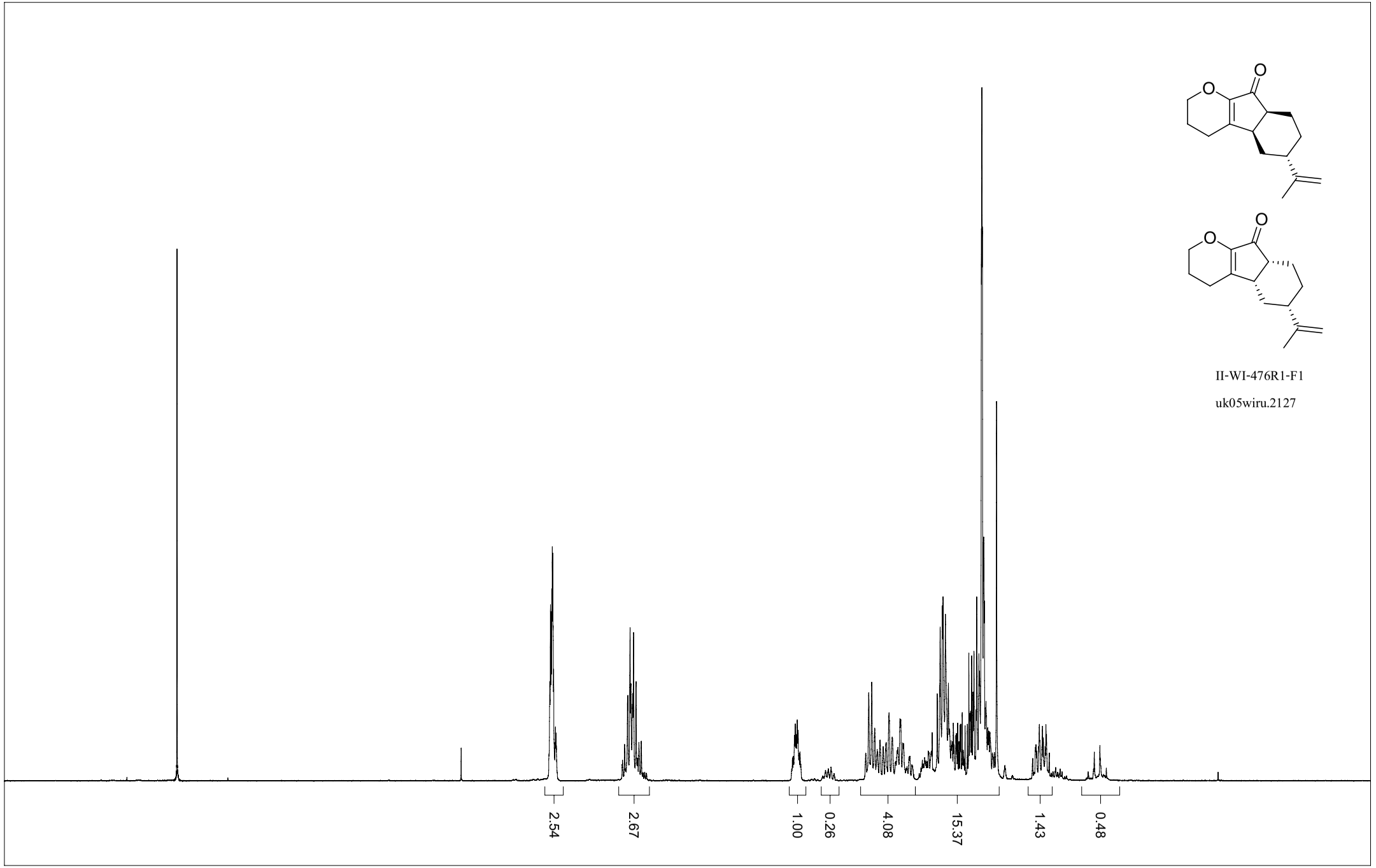
Chromatogram : WI_479R1_F1_ODH_973_flow1_1

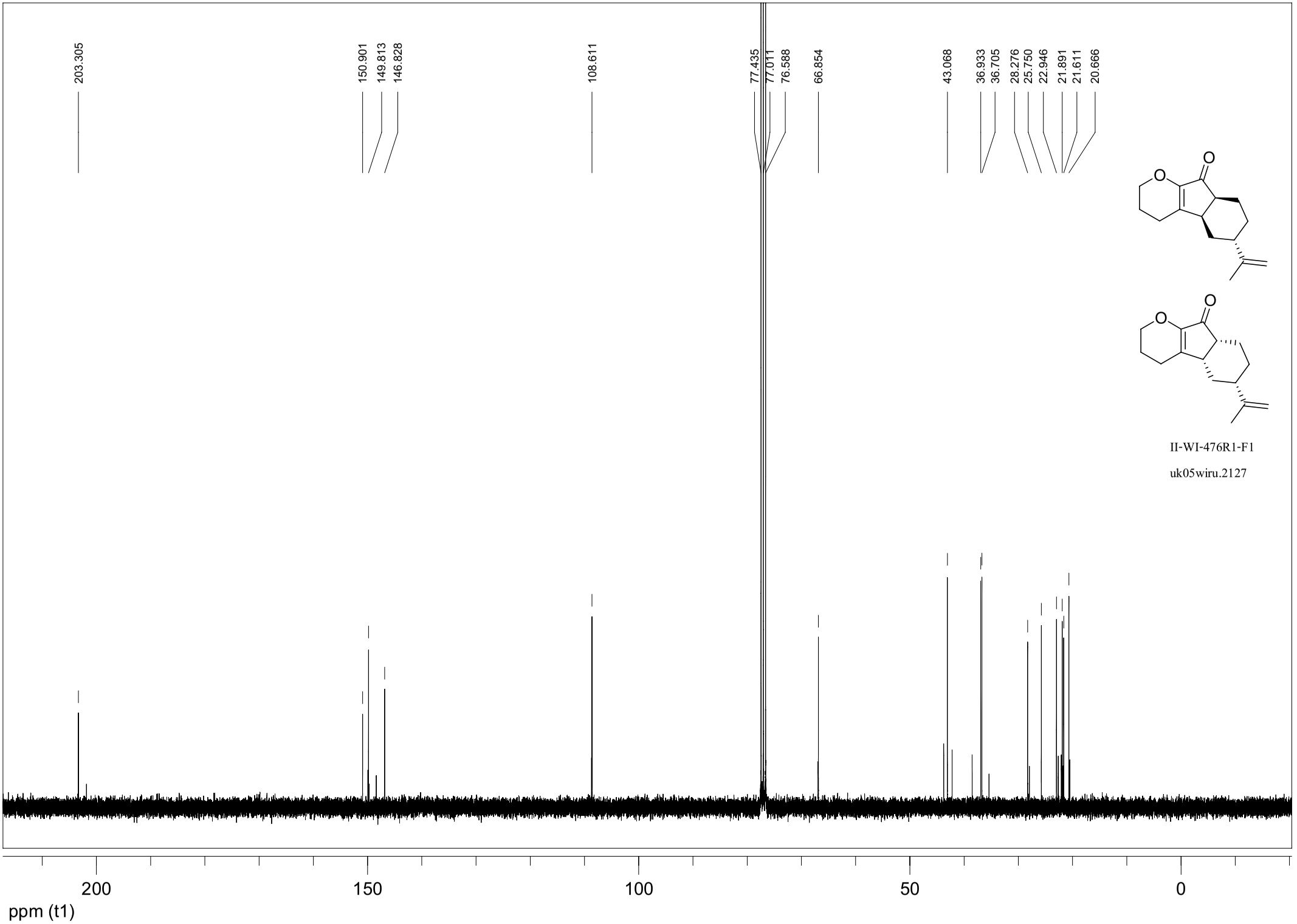
Method: ODH_973_flow1_acq45
Data file: WI_479R1_F1_ODH_973_flow1_1.DATA
Date: 11/8/2006 10:58:15 PM





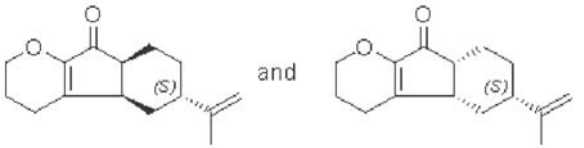
Index	Start	Time	End	Area %
	[Min]	[Min]	[Min]	[%]
1	23.337	24.192	25.708	7.240
2	27.893	28.942	31.937	92.760
Total				100.000

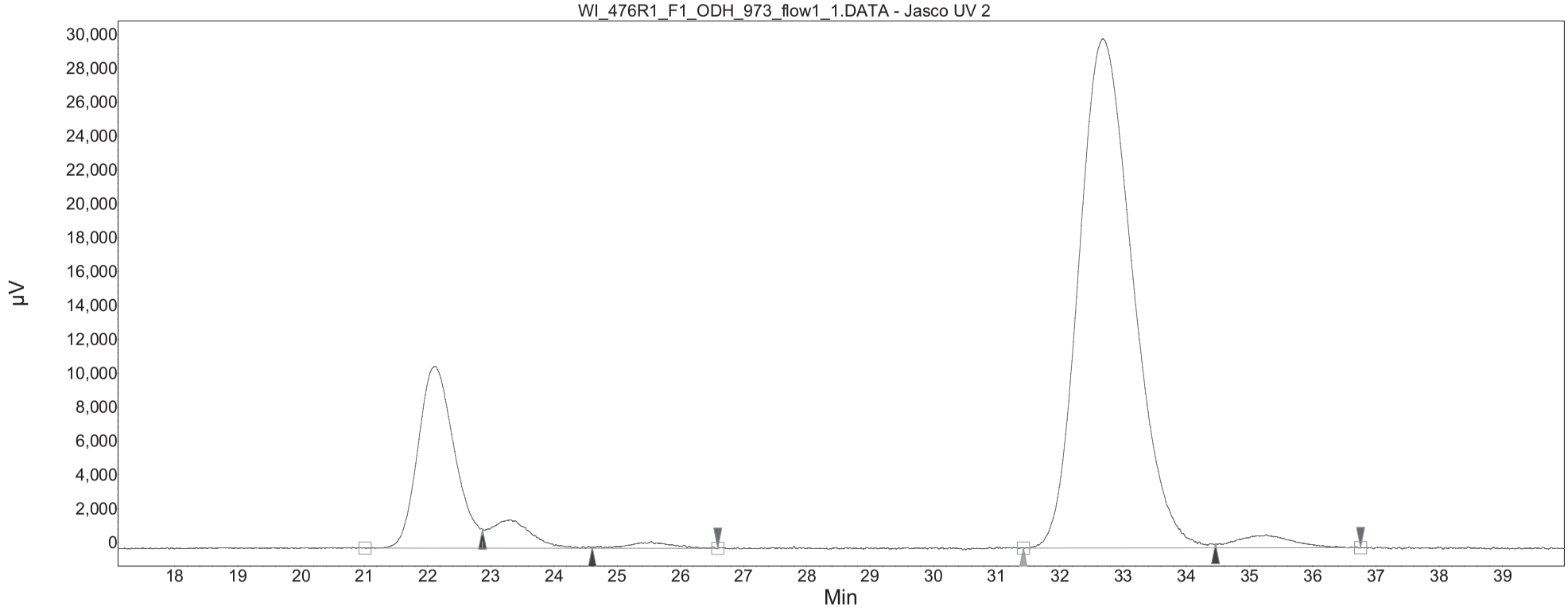

II-WI-476R1-F1
uk05wiru.2127
2.54
2.67
1.00
0.26
4.08
15.37
1.43
0.48
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
ppm (t1)


203.305
150.901
149.813
146.828
108.611
77.435
77.011
76.588
66.854
43.068
36.933
36.705
28.276
25.750
22.946
21.891
21.611
20.666
O
O
O
O
II-WI-476R1-F1
uk05wiru.2127
200
150
100
50
0
ppm (t1)

Chromatogram : WI_476R1_F1_ODH_973_flow1_1

Method: ODH_973_flow1_acq60
Data file: WI_476R1_F1_ODH_973_flow1_1.DATA
Date: 11/4/2006 7:51:09 PM

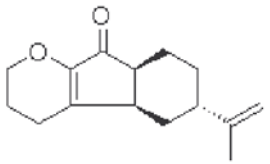


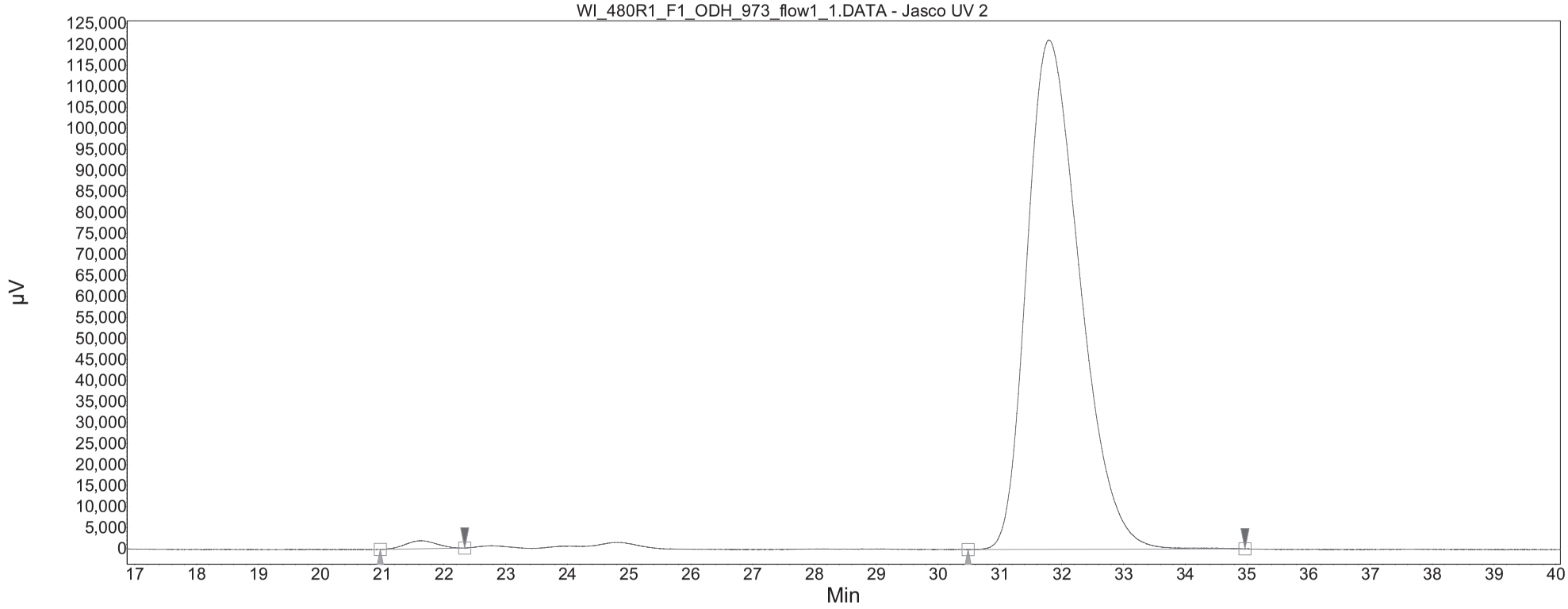


Index	Start	Time	End	Area %
	[Min]	[Min]	[Min]	[%]
1	0.000	22.117	22.872	16.749
5	22.872	23.317	24.607	3.312
4	24.607	25.533	26.591	0.769
2	31.426	32.683	34.463	77.179
3	34.463	35.267	36.756	1.991
Total				100.000

Chromatogram : WI_480R1_F1_ODH_973_flow1_1

Method: ODH_973_flow1_acq45
Data file: WI_480R1_F1_ODH_973_flow1_1.DATA
Date: 11/8/2006 11:46:01 PM





Index	Start	Time	End	Area %
	[Min]	[Min]	[Min]	[%]
1	20.973	21.608	22.339	0.915
2	30.487	31.792	34.968	99.085
Total				100.000