Supporting Information

Direct Catalytic Asymmetric Aldol Reactions of Thioamides: Toward a Stereocontrolled Synthesis of 1,3-Polyols

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1. General

Catalytic asymmetric aldol reaction was performed in a flame-dried 20 mL test tube with a Teflon-coated magnetic stirring bar unless otherwise noted. The test tubes were fitted with a 3-way glass stopcock and reactions were run under Ar atmosphere. All work-up and purification procedures were carried out with reagent-grade solvents under ambient atmosphere.

2. Instrumentation

Infrared (IR) spectra were recorded on a JASCO FT/IR 410 Fourier transform infrared spectrophotometer. NMR was recorded on JEOL LA-500, JEOL ECX-500 spectrometers. Chemical shifts for proton are reported in parts per million downfield from tetramethylsilane and are referenced to residual protium in the NMR solvent ($CDCl_3$: δ 7.26 ppm, C_6D_6: δ 7.16 ppm). For ^{13}C NMR, chemical shifts were reported in the scale relative to NMR solvent ($CDCl_3$: 77.0 ppm, C_6D_6: δ 128.0) as an internal reference. NMR data are reported as follows: chemical shifts, multiplicity (s: singlet, d: doublet, dd: doublet of doublets, t: triplet, q: quartet, sep: septet, m: multiplet, br: broad signal), coupling constant (Hz), and integration. Optical rotation was measured using a 1 mL cell with a 0.5 dm path length on a JASCO polarimeter P-1010. ESI mass spectra were measured on Waters-ZQ4000. High-resolution mass spectra (ESI TOF (+)w) were measured on JEOL AccuTOF JMS-T100LC. HPLC analysis was conducted on a JASCO HPLC system equipped with Daicel chiral stationary phase columns.

3. Materials

Unless otherwise noted, materials were purchased from commercial suppliers and were used without purification. THF was distilled from sodium/benzophenone ketyl. Dry DMF and ^{n}BuLi in *n*-hexane were purchased from Kanto Chemical Co. Ltd. (*R*,*R*)-Ph-BPE and (*S*,*S*)-Ph-BPE were purchased from Strem Chemical Co. Ltd. and used as received (handled in a dry box). 2,2,5,7,8-Pentamethylchromanol was purchased from Aldrich and recrystallized from benzene. $[Cu(CH_3CN)_4]PF_6$ was purchased from Aldrich and used as received. Aldehydes used in Table 1 and 2 were distilled before use. *o*-Methoxyphenol was purchased from Wako Pure Chemical Co. Ltd. and distilled before use. $Cp_2Zr(H)Cl$ was purchased from TCI and used as received (handled in a dry box). Column chromatography was performed with silica gel Merck 60 (230–400 mesh ASTM).

4. General Procedure for the Direct Aldol Reaction of Thioamide

For Table 2, entry 1.

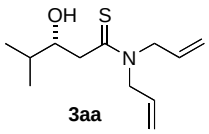
To a flame-dried 5 mL pear-shaped flask equipped with a magnetic stirring bar and a 3-way-top was charged with 2,2,5,7,8-pentamethylchromanol (17.6 mg, 0.08 mmol) and dried under vacuum for 60 min. Ar was back-filled to the flask and dry THF (0.4 mL) was added via a stainless steel needle and a syringe. To the solution was added ^{n}BuLi (51 μL, 0.08 mmol, 1.57 M in *n*-hexane) at –78 °C and stirred at the same temperature for 60 min to give 0.2 M lithium 2,2,5,7,8-Pentamethylchromanolate solution in THF, which was stored at room temperature and used within 15 min.

To a flame-dried 5 mL pear-shaped flask equipped with a magnetic stirring bar and a 3-way-top were charged with (*R*,*R*)-Ph-BPE (40.5 mg, 0.08 mmol) and $[Cu(CH_3CN)_4]PF_6$ (29.8 mg, 0.08 mmol) in a dry box. To the mixture was added THF (0.8 mL) via syringe to give 0.1 M THF solution of (*R*,*R*)-Ph-BPE/Cu solution, which was stored at room temperature and used within 3 h.

To a flame-dried 20 mL test tube equipped with a magnetic stirring bar and a 3-way-top were added (*R*,*R*)-Ph-BPE/Cu solution (0.1 M/THF, 120 μL, 0.012 mmol), dry DMF (4 mL), *N*,*N*-diallylthioacetamide (**1a**)

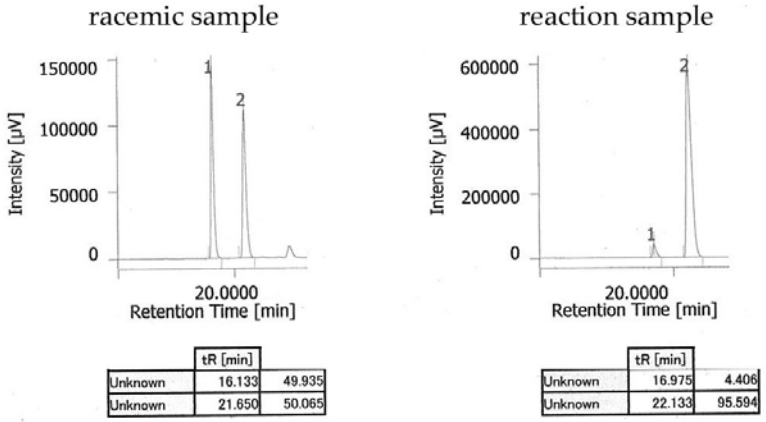
(76.4 μL, 0.48 mmol) and isobutyraldehyde (**2a**) (36.3 μL, 0.4 mmol) under Ar at room temperature. The test tube was immersed into the electronically-controlled cooling bath at –60 °C with 2-propanol as medium. To the solution was added lithium 2,2,5,7,8-Pentamethylchromanolate (0.2M/THF, 60 μL, 0.012 mmol) and stirred at –60 °C. After 40 h of stirring, sat. NH_4Cl aq. and bipyridine (18.7 mg) were added to the reaction mixture (essential to make sure the dissociation of the product from Cu complex) and aqueous layer was extracted with ethyl acetate. The combined organic layers were washed with brine, then dried over Na_2SO_4. Filtrate was concentrated under reduced pressure and the resulting residue was purified by silica gel column chromatography (eluent *n*-hexane/CH_2Cl_2 = 2/1 – 1/5) to give **3aa** as a colorless oil (78.8 mg, 0.35 mmol, 87%). Enantiomeric excess was determined by HPLC analysis.

(*R*)-*N*,*N*-Diallyl-3-hydroxy-4-methylpentanethioamide (3aa)



3aa

Colorless oil; IR (KBr) ν 3405, 2956, 2929, 2856, 1521, 1073, 835 cm^{-1}; ^1H NMR ($CDCl_3$) δ 5.86 (dddd, *J* = 17.7, 10.4, 5.8, 5.8 Hz, 1H), 5.77 (dddd, *J* = 17.1, 10.7, 4.6, 4.6 Hz, 1H), 5.29-5.12 (m, 4H), 4.69 (dd, *J* = 14.7, 5.8 Hz, 1H), 4.57 (dd, *J* = 14.7, 5.8 Hz, 1H), 4.29-4.22 (m, 1H), 4.14-4.08 (m, 1H), 3.90 (ddd, *J* = 9.8, 5.5, 1.9 Hz, 1H), 3.70 (brs, 1H), 2.80 (dd, *J* = 15.6, 1.9 Hz, 1H), 2.65 (dd, *J* = 15.6, 9.8 Hz, 1H), 1.79-1.70 (m, 1H), 0.95 (d, *J* = 7.0 Hz, 3H), 0.93 (d, *J* = 7.3 Hz, 3H); ^{13}C NMR ($CDCl_3$) δ 203.5, 130.6, 130.5, 118.6, 117.9, 74.6, 55.8, 52.9, 45.2, 33.3, 18.5, 17.8; $[\alpha]_D^{23}$ +92.1 (*c* 1.0, $CHCl_3$, 91% ee sample); ESI-MS *m*/*z* 250 $[M+Na]^+$; HRMS (ESI-TOF) Anal. calcd. for $C_{12}H_{21}NNaOS$ *m*/*z* 250.1232 $[M+Na]^+$, found 250.1246; HPLC: Daicel CHIRALCEL OD-H (ϕ 0.46 cm x 25 cm), 2-propanol/*n*-hexane = 1/99, flow rate 0.5 mL/min, detection 254 nm, t_R = 17.0 min (minor), 22.1 min (major).

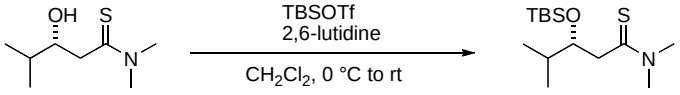


	tR [min]	
Unknown	16.133	49.935
Unknown	21.650	50.065

	tR [min]	
Unknown	16.975	4.406
Unknown	22.133	95.594

5. Procedures for the Synthesis of Compounds 5 and 6

5-1. TBS protection of 3ba.



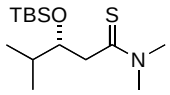
3ba
94% ee

S1
94% ee

(*R*)-3-(*tert*-Butyldimethylsilyloxy)-*N*,*N*,4-trimethylpentanethioamide (S1)

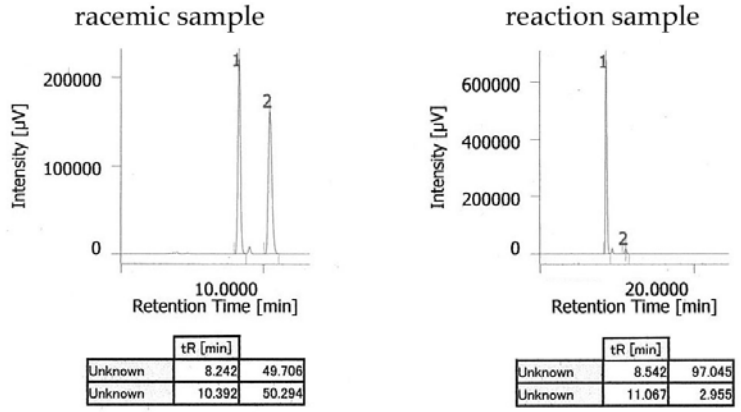
To a stirred solution of **3ba** (296 mg, 1.69 mmol, 94% ee) in CH_2Cl_2 (20 mL) were added 2,6-lutidine (390 μL, 3.38 mmol) and TBSOTf (580 μL, 2.53 mmol) at 0 °C. After stirring the resulting solution at room temperature for 10 h, sat. NH_4Cl aq. was added and the aqueous layer was extracted with CH_2Cl_2. The combined organic layers were washed with brine and dried over Na_2SO_4. The filtrate was concentrated under reduced pressure and the resulting residue was purified by silica gel column chromatography (eluent: *n*-hexane/ethyl acetate = 1/0 – 20/1) to give **S1** as colorless oil (479.4 mg, 1.66 mmol, 98% yield). Enantiomeric excess remained unchanged in the transformation as confirmed by HPLC analysis.

(*R*)-3-(*tert*-Butyldimethylsilyloxy)-*N*,*N*,4-trimethylpentanethioamide (S1)



S1

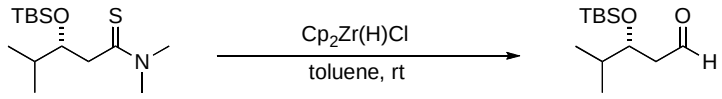
Pale yellow oil; IR (KBr) ν 2956, 2929, 2886, 2456, 1519, 1086, 962 cm^{-1}; ^1H NMR ($CDCl_3$) δ 4.28 (ddd, *J* = 9.8, 3.4, 3.1 Hz, 1H), 3.47 (s, 3H), 3.38 (s, 3H), 3.12 (dd, *J* = 12.8, 9.8 Hz, 1H), 2.66 (dd, *J* = 12.8, 3.1 Hz, 1H), 1.84 (dsep, *J* = 7.0, 3.7 Hz, 1H), 0.93 (d, *J* = 7.0 Hz, 3H), 0.92 (d, *J* = 7.0 Hz, 3H), 0.86 (s, 9H), 0.05 (s, 3H), –0.03 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 203.0, 78.7, 45.0, 44.8, 42.5, 34.2, 25.9, 18.1, 18.0, 16.5, –4.2, –5.1; $[\alpha]_D^{23}$ +52.7 (*c* 1.2, $CHCl_3$, 94% ee sample); ESI-MS *m*/*z* 312 $[M+Na]^+$; HRMS (ESI-TOF) Anal. calcd. for $C_{14}H_{31}NNaOSiS$ *m*/*z* 312.1788 $[M+Na]^+$, found 312.1784; HPLC: Daicel CHIRALCEL OZ-H (ϕ 0.46 cm x 25 cm), 2-propanol/*n*-hexane = 1/99, flow rate 1.0 mL/min, detection 254 nm, t_R = 8.5 min (major), 11.1 min (minor).



	tR [min]	
Unknown	8.242	49.706
Unknown	10.392	50.294

	tR [min]	
Unknown	8.542	97.045
Unknown	11.067	2.955

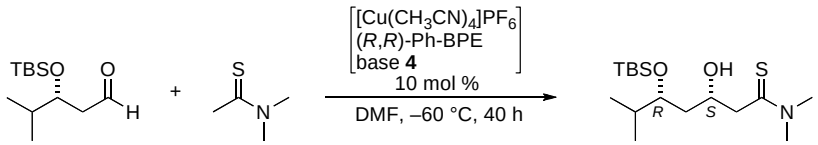
5-2. Reduction of thioamide functionality of S1 to aldehyde.



S1 **5**

To a white suspension of $Cp_2Zr(H)Cl$ (597 mg, 2.31 mmol) in toluene (8.5 mL) was added **S1** (335 mg, 1.16 mmol) in toluene (17 mL) at room temperature and the resulting suspension was stirred at the same temperature for 1h. The resulting green solution was cooled to –78 °C and silica gel (c.a. 600 mg) was added. The resulting mixture was stirred at –78 °C for 15 min and at room temperature for 2 h, then filtered through a short pad of silica gel with CH_2Cl_2 as eluent. The filtrate was concentrated and the resulting residue was purified by silica gel column chromatography (eluent: *n*-hexane/ether = 1/0 – 15/1) to give aldehyde **5** as a colorless solid (224.7 mg, 0.98 mmol, 84% yield).

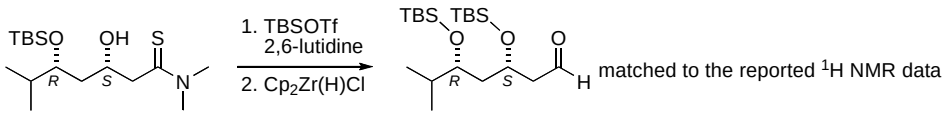
5-3. Direct catalytic asymmetric aldol reaction of aldehyde 5 with (*R*)-catalyst.



5 **1b** (3*S*,5*R*)-**6**

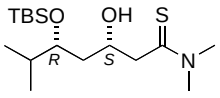
To a flame-dried 20 mL test tube equipped with a magnetic stirring bar and a 3-way-top were added (*R*,*R*)-Ph-BPE/Cu solution (0.1 M/THF, 180 μL, 0.018 mmol, prepared by following the procedure described in section 4), dry DMF (1.8 mL), *N*,*N*-dimethylthioacetamide (**1b**) (21.8 mg, 0.211 mmol, 500 μL in DMF) and

aldehyde **5** (40.5 mg, 0.176 mmol, 500 μL in DMF) under Ar at room temperature. The test tube was immersed into the electronically-controlled cooling bath at –60 °C with 2-propanol as medium. To the solution was added lithium 2,2,5,7,8-Pentamethylchromanolate (0.2M/THF, 90 μL, 0.018 mmol, prepared by following the procedure described in section 4) and stirred at –60 °C. After 40 h of stirring, sat. NH_4Cl aq. and bipyridine (8.4 mg) were added to the reaction mixture (essential to make sure the dissociation of the product from Cu complex) and aqueous layer was extracted with ethyl acetate. The combined organic layers were washed with brine, then dried over Na_2SO_4. Filtrate was concentrated under reduced pressure and the resulting crude residue was submitted to the NMR analysis to determine diastereomeric ratio (*syn*/*anti* = 95/5, ^{1}H NMR (C_6D_6): *syn* δ 4.07 ($(CH_3)_2CHC\underline{\boldsymbol{H}}(OTBS)CH_2$..); *anti* δ 4.23 ($(CH_3)_2CHC\underline{\boldsymbol{H}}(OTBS)CH_2$..)). The crude material was purified by silica gel column chromatography (eluent: *n*-hexane/ethyl acetate = 15/1 – 5/1) to give aldol product as a pale yellow oil (45.6 mg, 0.137 mmol, 78% yield, 99% ee). Enantiomeric excess was determined by HPLC analysis. Relative configuration was determined after converting the each diastereomer to the corresponding di-TBS protected aldehyde **S2**. Chemical shifts in ^{1}H NMR of **S2** matched to those of *syn*-**S2** reported in the literature.[S1]



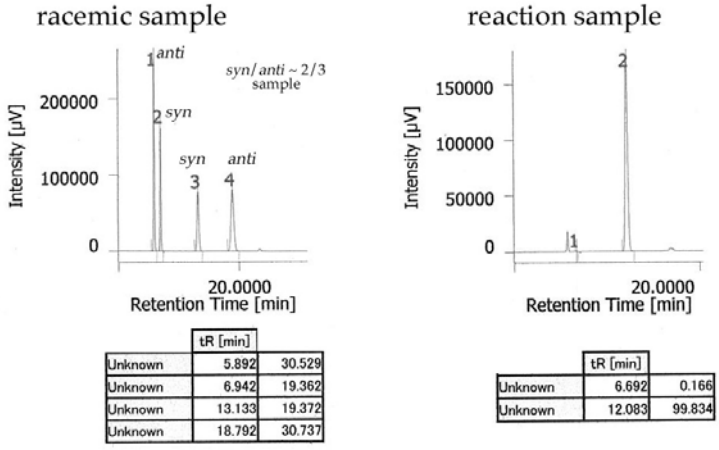
(3*S*,5*R*)-**6** (3*S*,5*R*)-**S2**

(3*S*,5*R*)-*N*,*N*-Dimethyl-5-(*tert*-butyldimethylsilyloxy)-3-hydroxy-6-methylheptanethioamide ((3*S*,5*R*)-6)



(3*S*,5*R*)-**6**

Pale yellow oil; IR (KBr) ν 3406, 2955, 2929, 2856, 1519 cm^{-1}; ^{1}H NMR (C_6D_6) δ 4.60 (brs, 1H), 4.54-4.48 (m, 1H), 4.07 (ddd, *J* = 7.6, 5.5, 3.4 Hz, 1H), 2.91 (s, 3H), 2.34 (dd, *J* = 15.9, 8.7 Hz, 1H), 2.27 (dd, *J* = 15.9, 2.4 Hz, 1H), 2.13 (s, 3H), 1.19-1.93 (m, 1H), 1.89 (ddd, *J* = 13.9, 9.8, 5.5 Hz, 1H), 1.70 (ddd, *J* = 13.9, 7.6, 3.4 Hz, 1H), 1.03 (d, *J* = 6.7 Hz, 3H), 1.02 (s, 9H), 0.94 (d, *J* = 7.0 Hz, 3H), 0.22 (s, 3H), –0.12 (s, 3H); ^{13}C NMR (C_6D_6) δ 201.4, 74.6, 67.9, 49.2, 43.4, 41.2, 40.3, 32.1, 26.2, 19.3, 18.4, 16.4, –4.0, –4.4; $[\alpha]_D^{24}$ +65.7 (*c* 2.0, $CHCl_3$, 99% ee sample); ESI-MS *m*/*z* 356 $[M+Na]^+$; HRMS (ESI-TOF) Anal. calcd. for $C_{16}H_{35}NNaO_2SiS$ *m*/*z* 356.2050 $[M+Na]^+$, found 356.2056; HPLC: Daicel CHIRALPAK IC (ϕ 0.46 cm x 25 cm), 2-propanol/*n*-hexane = 1/9, flow rate 1.0 mL/min, detection 254 nm, t_R = 6.7 min (minor), 12.1 min (major).



	tR [min]	
Unknown	5.892	30.529
Unknown	6.942	19.362
Unknown	13.133	19.372
Unknown	18.792	30.737

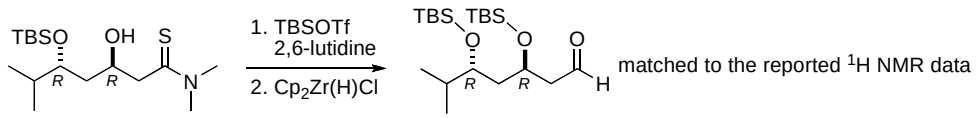
	tR [min]	
Unknown	6.692	0.166
Unknown	12.083	99.834

5-4. Direct catalytic asymmetric aldol reaction of aldehyde 5 with (*S*)-catalyst.

To a flame-dried 20 mL test tube equipped with a magnetic stirring bar and a 3-way-top were added (*S*,*S*)-Ph-BPE/Cu solution (0.1 M/THF, 180 μL, 0.018 mmol, prepared by following the procedure described

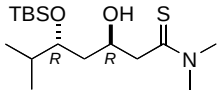
[S1] Evans, D. A.; Chapman, K. T.; Carreira, E. M. *J. Am. Chem. Soc.* **1988**, *110*, 3560.

in section 4), dry DMF (1.8 mL), *N*,*N*-dimethylthioacetamide (**1b**) (21.8 mg, 0.211 mmol, 500 μL in DMF) and aldehyde **5** (40.5 mg, 0.176 mmol, 500 μL in DMF) under Ar at room temperature. The test tube was immersed into the electronically-controlled cooling bath at –60 °C with 2-propanol as medium. To the solution was added lithium 2,2,5,7,8-Pentamethylchromanolate (0.2M/THF, 90 μL, 0.018 mmol, prepared by following the procedure described in section 4) and stirred at –60 °C. After 40 h of stirring, sat. NH_4Cl aq. and bipyridine (8.4 mg) were added to the reaction mixture (essential to make sure the dissociation of the product from Cu complex) and aqueous layer was extracted with ethyl acetate. The combined organic layers were washed with brine, then dried over Na_2SO_4. Filtrate was concentrated under reduced pressure and the resulting crude residue was submitted to the NMR analysis to determine diastereomeric ratio (*syn*/*anti* = 11/89, ^{1}H NMR (C_6D_6): *syn* δ 4.07 ($(CH_3)_2CHC\underline{\boldsymbol{H}}(OTBS)CH_2$..); *anti* δ 4.23 ($(CH_3)_2CHC\underline{\boldsymbol{H}}(OTBS)CH_2$..)). The crude material was purified by silica gel column chromatography (eluent: *n*-hexane/ethyl acetate = 15/1 – 5/1) to give aldol product as a pale yellow oil (41.7 mg, 0.125 mmol, 71% yield, 99% ee). Enantiomeric excess was determined by HPLC analysis. Relative configuration was determined after converting the major diastereomer to the corresponding di-TBS protected aldehyde **S2**. Chemical shifts in ^{1}H NMR of **S2** matched to those of *anti*-**S2** reported in the literature.[S1]



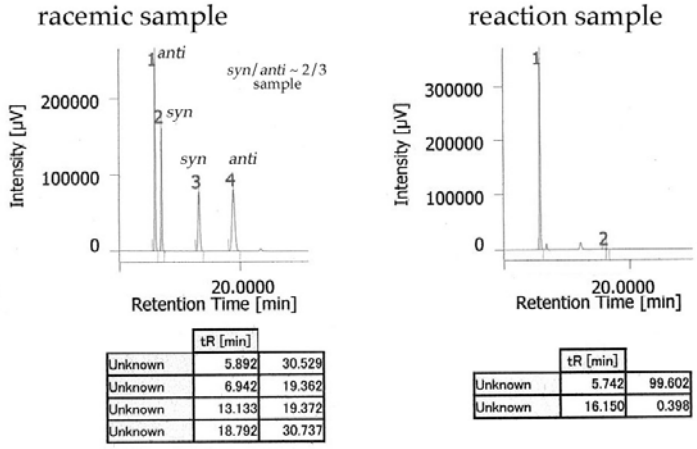
(3*R*,5*R*)-**6** (3*R*,5*R*)-**S2**

(3*R*,5*R*)-*N*,*N*-Dimethyl-5-(*tert*-butyldimethylsilyloxy)-3-hydroxy-6-methylheptanethioamide ((3*R*,5*R*)-6)



(3*R*,5*R*)-**6**

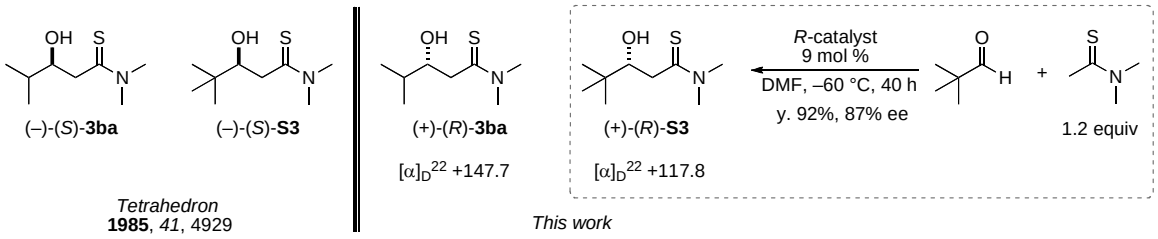
Pale yellow oil; IR (KBr) ν 3418, 3083, 2959, 2874, 1643 cm^{-1}; ^{1}H NMR (C_6D_6) δ 4.78 (brs, 1H), 4.68-4.62 (m, 1H), 4.23 (ddd, *J* = 9.5, 4.0, 2.2 Hz, 1H), 2.88 (s, 3H), 2.22 (dd, *J* = 16.2, 9.4 Hz, 1H), 2.09 (dd, *J* = 16.2, 1.1 Hz, 1H), 2.03 (s, 3H), 1.94-1.88 (m, 1H), 1.67 (ddd, *J* = 13.4, 10.7, 2.2 Hz, 1H), 1.50-1.44 (m, 1H), 1.08 (s, 9H), 1.04 (d, *J* = 7.1 Hz, 3H), 0.97 (d, *J* = 7.0 Hz, 3H), 0.39 (s, 3H), 0.19 (s, 3H); ^{13}C NMR (C_6D_6) δ 201.7, 73.3, 66.0, 49.1, 43.3, 40.0, 39.2, 34.5, 26.3, 18.5, 18.4, 17.1, –4.0, –4.3; $[\alpha]_D^{24}$ –50.2 (*c* 1.3, $CHCl_3$, 99% ee sample); ESI-MS *m*/*z* 356 $[M+Na]^+$; HRMS (ESI-TOF) Anal. calcd. for $C_{16}H_{35}NNaO_2SiS$ *m*/*z* 356.2050 $[M+Na]^+$, found 356.2047; HPLC: Daicel CHIRALPAK IC (ϕ 0.46 cm x 25 cm), 2-propanol/*n*-hexane = 1/9, flow rate 1.0 mL/min, detection 254 nm, t_R = 5.7 min (major), 16.2 min (minor).



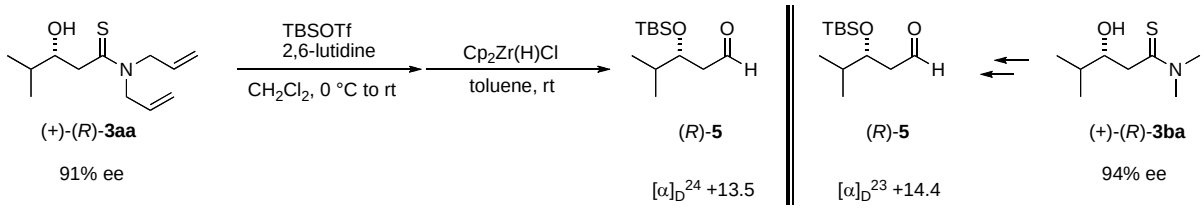
6. Determination of the Absolute Configuration of Aldol Products 3

Synthesis of (–)-(*S*)-**3ba** and (–)-(*S*)-**S3** through auxiliary approach was reported (Cinquini, M.; Manfredi, A.; Molinari, H.; Restelli, A. *Tetrahedron* **1985**, *41*, 4929). The optical rotation of **3ba** prepared from (*R*)-catalyst in Table 2, entry 2 was $[\alpha]_D^{22}$ +147.7, indicating that the absolute configuration of **3ba** prepared in our protocol

is (+)-(*R*)-**3ba** as shown below. The direct aldol reaction of pivalaldehyde (**2b**) and *N*,*N*-dimethylthioacetamide (**1b**) with (*R*)-catalyst gave the corresponding aldol product **S2** with 87% ee and (+) optical rotation, indicating that the absolute configuration of **S3** produced by the present protocol was (+)-(*R*).



Product **3aa** derived from *N*,*N*-diallylthioacetamide (**1a**) was converted to the aldehyde **5**. The optical rotation of **5** prepared from **3aa** and **3ba** was nearly identical, indicating that the absolute configuration of the aldol product from *N*,*N*-diallylthioacetamide (**1a**) was identical to that obtained from *N*,*N*-dimethylthioacetamide (**1b**).

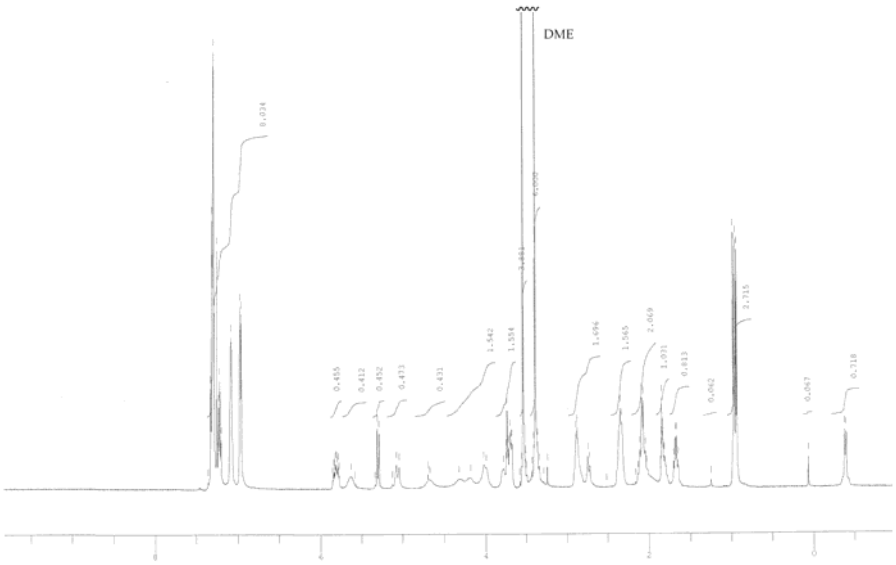


The sign of the optical rotation of other aldol products was uniformly (+). The absolute configuration of the other aldol products **3** in Table 2 was deduced by analogy.

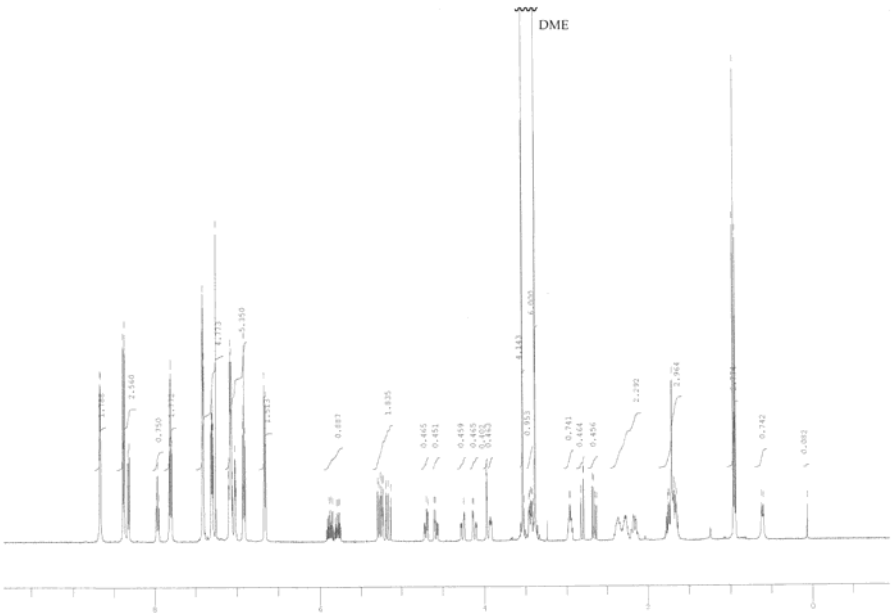
7. NMR & MS Analyses of Catalyst–Product Complex

In the direct aldol reaction of *N*,*N*-diallylthioacetamide (**1a**) and isobutyraldehyde (**2a**) in THF solvent with 10 mol % of catalyst (Table 1, entry 1), sampling a small aliquot of the reaction mixture followed by TLC analysis showed no spots corresponding to the desired product **3aa**, likely due to the tight complexation of the product and catalyst ((*R*,*R*)-Ph-BPE/Cu complex). As shown in Figure S1 (a), ^{1}H NMR of a mixture of (*R*,*R*)-Ph-BPE/[Cu(CH_3CN)$_4$]PF_6 : **3aa** = 1:1 in $CDCl_3$, broad peaks were observed, suggesting that the formation of the Cu complex. In ESI MS spectrum of the mixture (Figure S1 (d)), (*R*,*R*)-Ph-BPE/[Cu(CH_3CN)$_4$]PF_6/**3aa** = 1:1 complex was most prominently observed and the intensity of the peak derived from free **3aa** was weak, indicating that the complexation of (*R*,*R*)-Ph-BPE/Cu complex and **3aa** was sufficiently strong, and would arrest the catalytic turnover. In Figure S1 (f), the addition of pyridine would somewhat effective for releasing the 3aa from (*R*,*R*)-Ph-BPE/Cu complex, however, the population of (*R*,*R*)-Ph-BPE/Cu/**3aa** complex was still high. The beneficial effect of pyridine for catalytic turnover in (Table 2, entry 2 and 3) would be come from the competitive coordination of pyridine to (*R*,*R*)-Ph-BPE/Cu complex. As shown in Figure S1 (b) and (e), by the addition of 3 equivalents of bipyridine, **3aa** was completely released from (*R*,*R*)-Ph-BPE/Cu complex, showing a (*R*,*R*)-Ph-BPE/Cu/bipyridine complex and free **3aa** in ^{1}H NMR and ESI MS. Bipyridine was used to make sure the release of the aldol product from the (*R*,*R*)-Ph-BPE/Cu complex in the work-up procedure as described above.

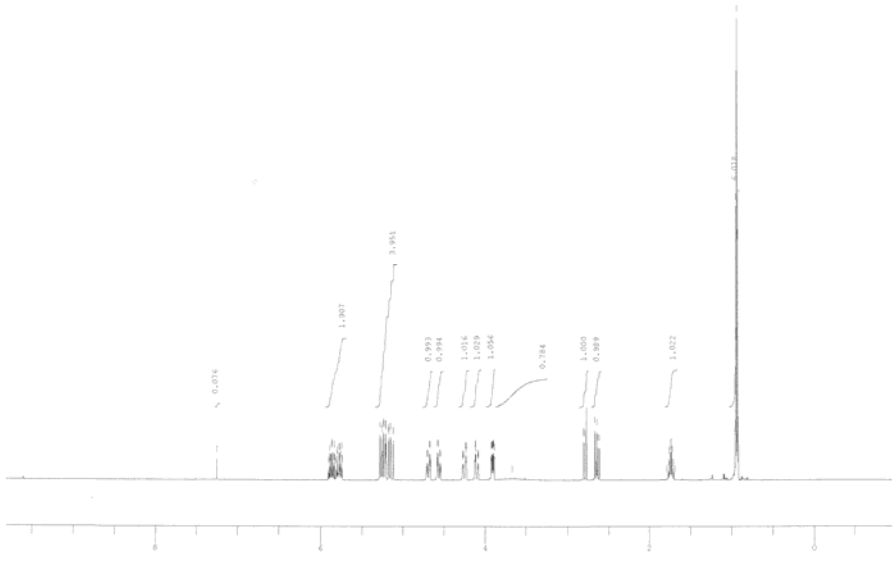
(a) ^{1}H NMR of (*R,R*)-Ph-BPE/Cu : **3aa** = 1:1 in $CDCl_3$



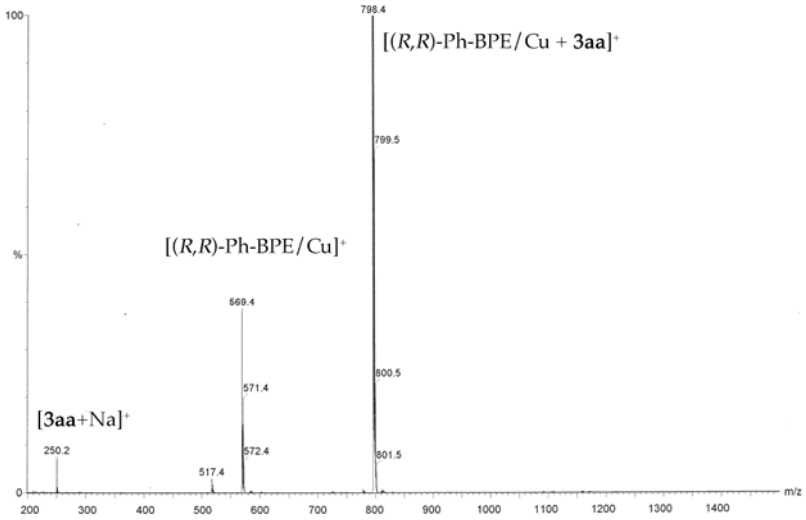
(b) ^{1}H NMR of the above mixture in $CDCl_3$ after treatment with s equivalents of bipyridine.



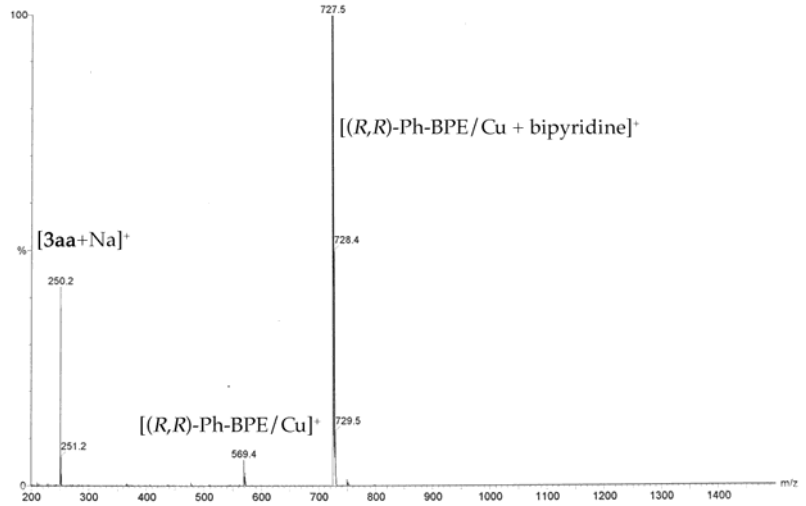
(c) ^{1}H NMR of **3aa** in $CDCl_3$



(d) ESI MS (positive ion mode) of (*R,R*)-Ph-BPE/Cu : **3aa** = 1:1.



(e) ESI MS (positive ion mode) of (*R,R*)-Ph-BPE/Cu : **3aa** : bipyridine = 1:1:3.



(f) ESI MS (positive ion mode) of (*R,R*)-Ph-BPE/Cu : **3aa** : pyridine = 1:1:3.

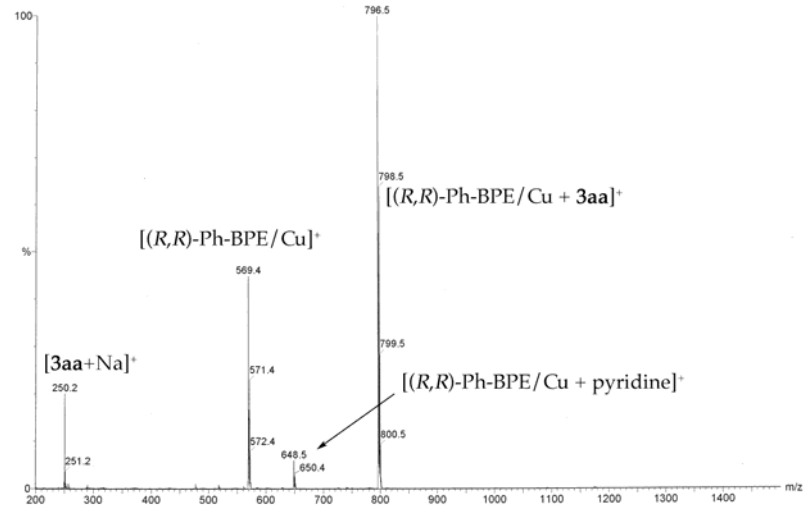


Figure S1.

8. Estimation of p*Ka* of Pentamethylchromanol by DFT Calculation

Calculations were performed on Jaguar version 7.0 released in 2007 (Jaguar version 7.0, Schrödinger, LLC, New York, NY, 2007) using the B3LYP level of density functional theory.[S2] The 6-31G+(d,p) basis set of Pople and coworkers was used.[S3]

Geometry optimization of 2,2,5,7,8-pentamethylchromanol.

Input geometry:

		angstroms	
atom	x	y	z
C1	-2.3669160000	-0.2128210000	0.2147680000
C2	-3.1824290000	1.0040760000	0.5321580000
C3	-4.5396300000	0.9600530000	0.4367290000
C4	-5.2157040000	-0.3383670000	0.1295650000
C5	-4.4856840000	-1.4839990000	0.0281360000
C6	-2.9826190000	-1.3922010000	-0.0453750000
O7	-6.5955840000	-0.3409590000	0.0130140000
O8	-0.9682530000	-0.1915060000	0.2023630000
C9	-0.3958800000	1.0938360000	0.0319240000
C10	-0.9632390000	2.0887920000	1.0642890000
H11	-0.7765740000	1.6957920000	2.0890260000
H12	-0.4516810000	3.0735260000	0.9820830000
C13	-2.4630200000	2.2901350000	0.8904830000
H14	-2.8620430000	2.7001400000	1.8430620000
H15	-2.6355710000	3.0425750000	0.0907470000
C16	-0.5850570000	1.5854230000	-1.4230710000
H17	-1.6573560000	1.6628730000	-1.6959730000
H18	-0.1186410000	2.5846650000	-1.5605200000
H19	-0.1130840000	0.8730330000	-2.1333060000
C20	1.1134900000	0.9483360000	0.2899110000
H21	1.6342450000	1.9229150000	0.1669760000
H22	1.2972360000	0.5767840000	1.3212470000
H23	1.5597190000	0.2177150000	-0.4190010000
C24	-2.2109850000	-2.4774980000	-0.4104300000
H25	-2.7960710000	-3.3380180000	-0.7889000000
H26	-1.5275540000	-2.2039430000	-1.2447910000
H27	-1.6071280000	-2.8219280000	0.4567470000
C28	-5.1025340000	-2.7175380000	0.0509020000
H29	-4.5279280000	-3.4283040000	0.6828380000
H30	-6.1091700000	-2.6983200000	0.5212970000
H31	-5.1885190000	-3.1183410000	-0.9813480000
C32	-5.2987860000	2.0921750000	0.6468070000

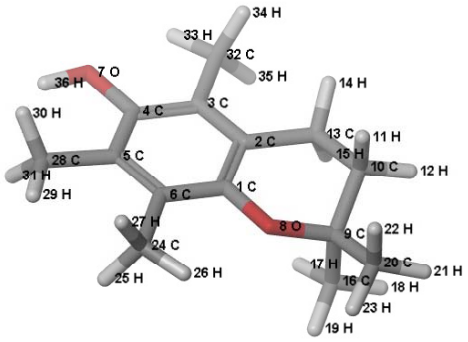
[S2] B3LYP = Becke-3-Lee-Yang-Parr density functional theory. (a) Becke, A. D. *J. Chem. Phys.* **1993**, *98*, 1372. (b) Lee, C.; Yang, W.; Parr, R. G. *Phys. Rev. B* **1988**, *37*, 785.

[S3] (a) Ditchfield, R.; Hehre, W. J.; Pople, J. A. *J. Chem. Phys.* **1971**, *54*, 724. (b) Hehre, W. J.; Ditchfield, R.; Pople, J. A. *J. Chem. Phys.* **1972,** *56*, 2257. (c) Hariharan, P. C.; Pople, J. A. *Theor. Chim. Acta.* **1973**, *28*, 213.

H33	-6.3864140000	1.9325070000	0.5069920000
H34	-5.1671140000	2.4570820000	1.6876130000
H35	-5.0085140000	2.8902460000	-0.0696680000
H36	-6.8560490000	-0.9982450000	-0.6824370000

Final optimized geometry:

		angstroms	
atom	x	y	z
C1	-1.0352573572	0.5102254941	-0.4071646233
N2	-0.1966412484	-0.0005486915	-1.3479941835
O3	-0.7503184435	1.4595032404	0.3056480205
H4	-0.5023402931	-0.7000023139	-2.0078247366
H5	0.6616974115	0.5021163122	-1.5262089221
C6	-2.3922932101	-0.2205345814	-0.2158900014
C7	-3.4891079217	0.8429676228	-0.2897155591
O8	-4.2364215795	0.8537809561	0.8252102922
O9	-3.6809803277	1.5647868916	-1.2458702864
C10	-5.3191902118	1.8162925025	0.8516803864
H11	-4.8936926764	2.8192420424	0.7489381187
H12	-5.9663693394	1.6380672355	-0.0128891043
C13	-6.0533501957	1.6349904735	2.1666127854
H14	-6.4640609531	0.6233705077	2.2496459347
H15	-5.3830972182	1.8065430383	3.0148308497
H16	-6.8812346932	2.3494481481	2.2304859126
C17	-3.1654654908	-3.5667388626	-2.8592754012
C18	-3.2517067956	-2.2612196274	-3.3463968076
C19	-3.0140356740	-1.1757845108	-2.5021550457
C20	-2.6853723610	-1.3839005917	-1.1525156191
C21	-2.6029069811	-2.6985860871	-0.6739575001
C22	-2.8412163742	-3.7824608487	-1.5192532154
H23	-3.3528311256	-4.4100356826	-3.5187686549
H24	-3.5101829485	-2.0843633152	-4.3872398978
H25	-3.1005723011	-0.1598409822	-2.8753767907
H26	-2.3498385310	-2.8733672312	0.3694436858
H27	-2.7752135011	-4.7949808368	-1.1293616722
H28	-2.3656755996	-0.5931368631	0.8123235781



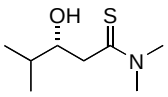
1176.296150614 hartrees

Calculation of p*K*a value of hydrogen 36H was performed on the obtained optimized geometry. The calculation was performed by following the method described in ref S3, using ab initio quantum chemical calculation on Jaguar 7.0 platform. Calculated p*K*a value of hydrogen 36H in H_2O was 12.3.[S4] Experimentally determined p*K*a of 2-methoxyphenol is reported as 9.90 (calculated as 9.62),[S5] thus lithium salt of 2,2,5,7,8-pentamethylchromanol is much stronger base than lithium salt of 2-methoxyphenol.

[S4] Klicic, J. J.; Friensner, R. A.; Liu, S.-Y.; Guida, W. C. *J. Phys. Chem. A* **2002**, *106*, 1327.
[S5] Jover, J.; Bosque, R.; Sales, J. *QSAR Comb. Sci.* **2007**, *26*, 385.

9. Characterization of Aldol Products

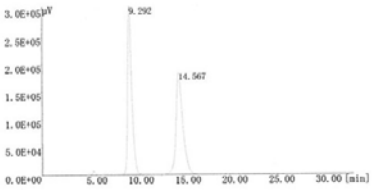
(*R*)-3-Hydroxy-*N*,*N*,4-trimethylpentanethioamide (3ba)



3ba

Pale yellow oil; IR (KBr) ν 3309, 2959, 2875, 1670, 1523, 1395, 846 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 4.05 (d, *J* = 2.7 Hz, 1H), 3.95-3.92 (m, 1H), 3.50 (s, 3H), 3.32 (s, 3H), 2.77 (dd, *J* = 15.6, 0.9 Hz, 1H), 2.63 (dd, *J* = 15.6, 9.9 Hz, 1H), 1.83-1.73 (m, 1H), 0.98 (d, *J* = 6.7 Hz, 3H), 0.97 (d, *J* = 7.0 Hz, 3H); ^{13}C NMR ($CDCl_3$) δ 202.3, 74.7, 45.8, 44.7, 41.9, 33.5, 18.9, 18.1; $[\alpha]_D^{22}$ +147.7 (*c* 1.3, $CHCl_3$, 94% ee sample); ESI-MS *m*/*z* 198 $[M+Na]^+$; HRMS (ESI-TOF) Anal. calcd. for $C_{16}H_{34}N_2NaO_2S_2$ *m*/*z* 373.1954 $[2M+Na]^+$, found 373.1946; HPLC: CHIRALCEL OD-H (ϕ 0.46 cm x 25 cm), 2-propanol/*n*-hexane = 1/19, flow rate 1.0 mL/min, detection 254 nm, t_R = 9.5 min (minor), 14.7 min (major).

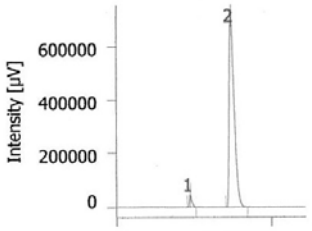
racemic sample



RT [min] Area[μV.Sec] %Area

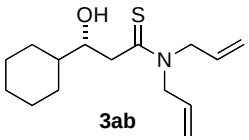
1	9.292	8895308	49.6526
2	14.567	9019765	50.3474

reaction sample



	tR [min]	
Unknown	9.475	2.924
Unknown	14.692	97.076

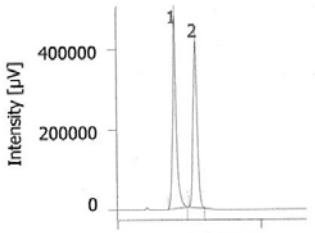
(*R*)-*N*,*N*-Diallyl-3-cyclohexyl-3-hydroxypropanethioamide (3ab)



3ab

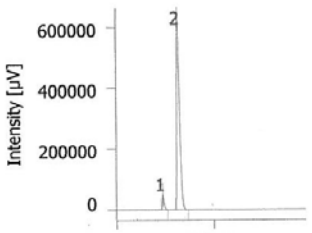
Colorless oil; IR (KBr) ν 3408, 2925, 2852, 1642, 1492 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 5.88 (dddd, *J* = 17.1, 10.4, 6.0, 6.0 Hz, 1H), 5.79 (dddd, *J* = 17.1, 9.9, 4.8, 4.8 Hz, 1H), 5.30-5.14 (m, 4H), 4.70 (dd, *J* = 14.9, 6.0 Hz, 1H), 4.59 (dd, *J* = 14.9, 6.0 Hz, 1H), 4.29-4.23 (m, 1H), 4.15-4.09 (m, 1H), 3.93 (ddd, *J* = 9.9, 5.8, 1.8 Hz, 1H), 3.15 (brs, 1H), 2.81 (dd, *J* = 15.6, 1.8 Hz, 1H), 2.68 (dd, *J* = 15.6, 9.9 Hz, 1H), 1.86-1.65 (m, 5H), 1.46-1.39 (m, 1H), 1.29-1.03 (m, 5H); ^{13}C NMR ($CDCl_3$) δ 203.6, 130.6, 130.5, 118.7, 117.9, 74.1, 55.8, 52.9, 45.5, 43.3, 29.0, 28.3, 26.5, 26.3, 26.2; $[\alpha]_D^{22}$ +84.1 (*c* 1.1, $CHCl_3$, 92% ee sample); ESI-MS *m*/*z* 290 $[M+Na]^+$; HRMS (ESI-TOF) Anal. calcd. for $C_{15}H_{25}NNaOS$ *m*/*z* 290.1549 $[M+Na]^+$, found 290.1544; HPLC: Daicel CHIRALCEL OD-H (ϕ 0.46 cm x 25 cm), 2-propanol/*n*-hexane = 1/99, flow rate 1.0 mL/min, detection 254 nm, t_R = 9.4 min (minor), 12.5 min (major).

racemic sample



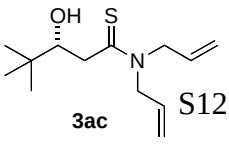
	tR [min]	
Unknown	8.025	50.113
Unknown	10.908	49.887

reaction sample



	tR [min]	
Unknown	9.425	4.141
Unknown	12.542	95.859

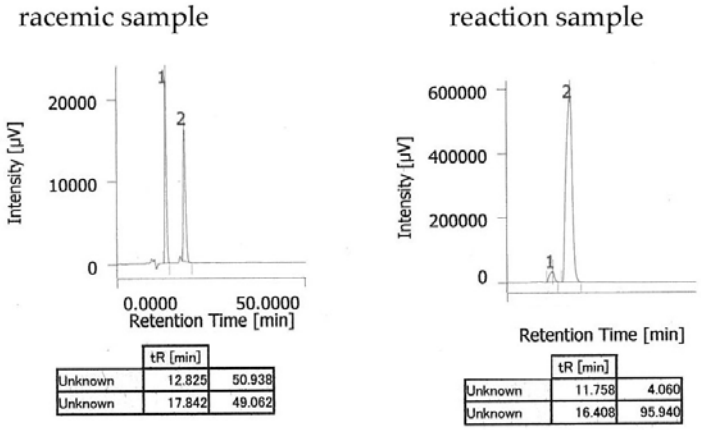
(*R*)-*N*,*N*-Diallyl-3-hydroxy-4,4-dimethylpentanethioamide (3ac)



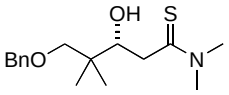
3ac

Colorless oil; IR (KBr) ν 3419, 3083, 2956, 2870, 1642 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 5.89 (dddd, *J* = 17.1, 10.4, 6.0, 6.0 Hz , 1H), 5.80 (dddd, *J* = 17.1, 10.4, 4.6, 4.6 Hz, 1H),

5.31-5.15 (m, 4H), 4.72 (dd, *J* = 15.0, 5.8 Hz, 1H), 4.58 (dd, *J* = 14.8, 6.0 Hz, 1H), 4.32-4.25 (m, 1H), 4.15-4.08 (m, 1H), 3.79 (dd, *J* = 10.4, 1.6 Hz, 1H), 2.89 (dd, *J* = 15.0, 1.6 Hz, 1H), 2.67 (dd, *J* = 15.0, 10.4 Hz, 1H), 2.65 (brs, 1H); ^{13}C NMR ($CDCl_3$) δ 203.9, 130.6, 130.6, 118.6, 117.9, 77.6, 55.9, 52.9, 43.5, 34.7, 25.8; $[\alpha]_D^{22}$ +70.0 (*c* 1.1, $CHCl_3$, 92% ee sample); ESI-MS *m*/*z* 290 $[M+Na]^+$; HRMS (ESI-TOF) Anal. calcd. for $C_{13}H_{23}NNaOS$ *m*/*z* 264.1393 $[M+Na]^+$, found 264.1388; HPLC: Daicel CHIRALCEL OD-H (ϕ 0.46 cm x 25 cm), 2-propanol/*n*-hexane = 1/99, flow rate 0.5 mL/min, detection 254 nm, t_R = 11.8 min (minor), 16.4 min (major).

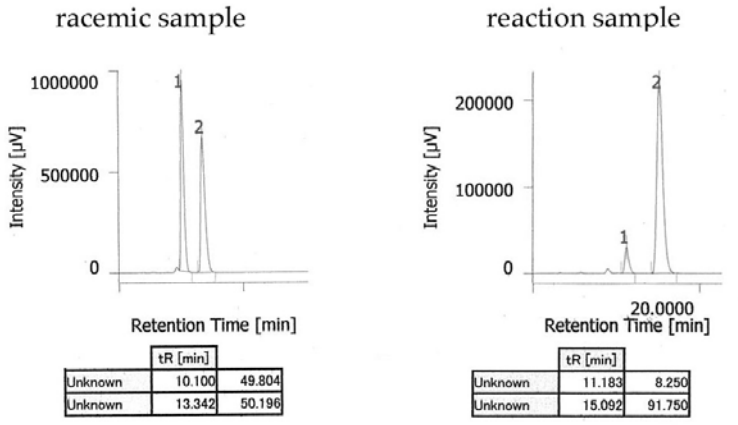


(*R*)-5-(Benzyloxy)-3-hydroxy-*N*,*N*,4,4-tetramethylpentanethioamide (3bd)

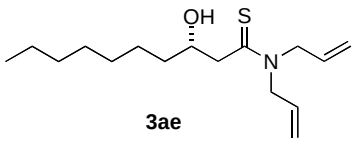


3bd

Pale yellow oil; IR (KBr) *ν* 3405, 2960, 2871, 1521, 1102 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 7.35-7.26 (m, 5H), 4.50 (s, 2H), 4.09 (dd, *J* = 10.0, 2.2 Hz, 1H), 3.50 (s, 3H), 3.39 (d, *J* = 9.2 Hz, 1H), 3.35 (d, *J* = 9.2 Hz, 1H), 3.27 (s, 3H), 2.89 (dd, *J* = 14.4, 2.2 Hz, 1H), 2.83 (dd, *J* = 14.4, 10.0 Hz, 1H), 1.01 (s, 3H), 0.96 (s, 3H); ^{13}C NMR ($CDCl_3$) δ 202.6, 138.3, 128.3, 127.5, 127.5, 78.4, 76.2, 73.5, 44.6, 44.5, 41.9, 38.7, 21.9, 20.5; $[\alpha]_D^{25}$ +57.8 (*c* 1.1, $CHCl_3$, 84% ee sample); ESI-MS *m*/*z* 318 $[M+Na]^+$; HRMS (ESI-TOF) Anal. calcd. for $C_{16}H_{25}NNaO_2S$ *m*/*z* 318.1498 $[M+Na]^+$, found 318.1501; HPLC: Daicel CHIRALCEL OD-H (ϕ 0.46 cm x 25 cm), 2-propanol/*n*-hexane = 1/19, flow rate 1.0 mL/min, detection 254 nm, t_R = 11.2 min (minor), 15.1 min (major).



(*S*)-*N*,*N*-Diallyl-3-hydroxydecanethioamide (3ae)

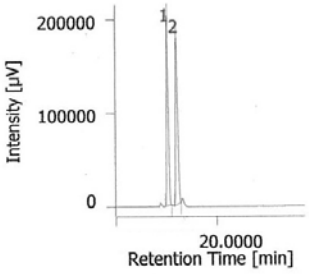


3ae

Pale yellow oil; IR (KBr) *ν* 3408, 3084, 2925, 2854, 1642 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 5.87 (dddd, *J* = 17.1, 10.5, 5.9, 5.9 Hz, 1H), 5.77 (dddd, *J* = 17.1, 10.4, 4.9, 4.9 Hz, 1H), 5.30-5.13 (m, 4H), 4.69 (dd, *J* = 14.9, 5.9 Hz, 1H), 4.58 (dd, *J* = 14.9, 5.9 Hz, 1H), 4.27-4.20 (m, 1H), 4.19-4.10 (m, 3H), 2.76 (dd, *J* = 15.9, 1.9 Hz, 1H), 2.63 (dd, *J* = 15.9, 9.6 Hz, 1H), 1.60-1.26 (m, 12H), 0.88-0.86 (m, 3H); ^{13}C NMR ($CDCl_3$) δ 203.0, 130.6, 130.4, 118.7, 117.9, 69.9, 55.6, 52.8, 47.9, 36.6, 31.8, 29.6, 29.2, 25.6, 22.6, 14.1; $[\alpha]_D^{23}$ +74.0 (*c* 1.3, $CHCl_3$, 89% ee

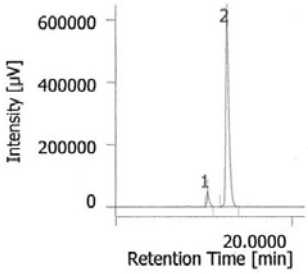
sample); ESI-MS *m*/*z* 306 $[M+Na]^+$; HRMS (ESI-TOF) Anal. calcd. for $C_{16}H_{29}NNaOS$ *m*/*z* 306.1862 $[M+H]^+$, found 306.1859; HPLC: Daicel CHIRALCEL OD-H (ϕ 0.46 cm x 25 cm), 2-propanol/*n*-hexane = 1/19, flow rate 0.5 mL/min, detection 254 nm, t_R = 10.4 min (minor), 12.5 min (major).

racemic sample



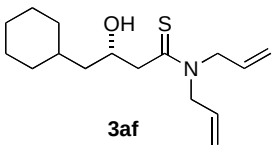
	tR [min]	
Unknown	10.175	49.686
Unknown	12.000	50.314

reaction sample



	tR [min]	
Unknown	10.375	5.714
Unknown	12.542	94.286

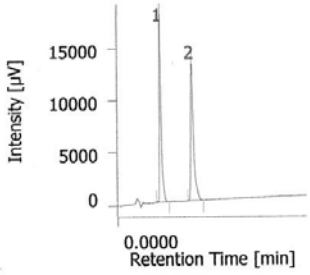
(*S*)-*N*,*N*-Diallyl-4-cyclohexyl-3-hydroxybutanethioamide (3af)



3af

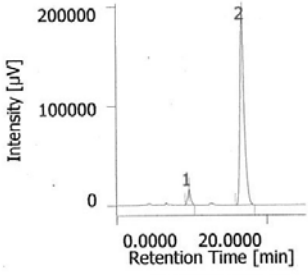
Colorless oil; IR (KBr) ν 3419, 3082, 2922, 2849, 1643 cm^{-1}; ^1H NMR ($CDCl_3$) δ 5.88 (dddd, *J* = 17.1, 10.1, 5.8, 5.8 Hz, 1H), 5.77 (dddd, *J* = 17.1, 10.4, 4.6, 4.6 Hz, 1H), 5.30-5.13 (m, 4H), 4.69 (dd, *J* = 14.7, 5.8 Hz, 1H), 4.59 (dd, *J* = 14.7, 5.8 Hz, 1H), 4.32-4.27 (m, 1H), 4.26-4.20 (m, 1H), 4.14-4.10 (m, 1H), 3.30 (brs, 1H), 2.71 (dd, *J* = 16.1, 2.0 Hz, 1H), 2.67 (dd, *J* = 16.1, 9.4 Hz, 1H), 1.85-1.83 (m, 1H), 1.70-1.62 (m, 4H), 1.56-1.47 (m, 2H), 1.29-1.10 (m, 4H), 0.98-0.82 (m, 2H); ^{13}C NMR ($CDCl_3$) δ 203. 1, 130.6, 130.5, 118.7, 118.0, 67.4, 55.6, 52.6, 48.3, 44.3, 34.1, 34.0, 32.9, 26.6, 26.3, 26.2; $[\alpha]_D^{24}$ +84.9 (*c* 1.2, $CHCl_3$, 90% ee sample); ESI-MS *m*/*z* 304 $[M+Na]^+$; HRMS (ESI-TOF) Anal. calcd. for $C_{16}H_{27}NNaOS$ *m*/*z* 304.1706 $[M+H]^+$, found 304.1721; HPLC: Daicel CHIRALCEL OD-H (ϕ 0.46 cm x 25 cm), 2-propanol/*n*-hexane = 1/99, flow rate 1.0 mL/min, detection 254 nm, t_R = 9.6 min (minor), 16.7 min (major).

racemic sample



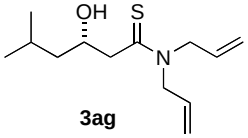
	tR [min]	
Unknown	9.283	46.737
Unknown	16.242	53.263

reaction sample



	tR [min]	
Unknown	9.608	5.234
Unknown	16.683	94.766

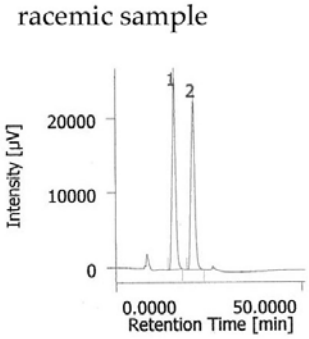
(*S*)-*N*,*N*-Diallyl-3-hydroxy-5-methylhexanethioamide (3ag)



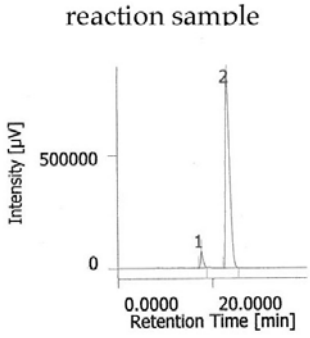
3ag

Colorless oil; IR (KBr) ν 3407, 3084, 2954, 2925, 1642 cm^{-1}; ^1H NMR ($CDCl_3$) δ 5.87 (dddd, *J* = 17.1, 10.4, 5.8, 5.8 Hz, 1H), 5.76 (dddd, *J* = 17.1, 10.4, 4.8, 4.8 Hz, 1H), 5.28-5.12 (m, 4H), 4.69 (dd, *J* = 14.7, 5.8 Hz, 1H), 4.58 (dd, *J* = 14.7, 5.8 Hz, 1H), 4.28-4.21 (m, 2H), 4.13-4.09 (m, 1H), 3.60 (brs, 1H), 2.71 (dd, *J* = 16.1, 2.0 Hz, 1H), 2.61 (dd, *J* = 16.1, 9.4 Hz, 1H), 1.88-1.78 (m, 1H), 1.57-1.51 (m, 1H), 1.19-1.14 (m, 1H), 0.92 (d, *J* = 6.4 Hz, 3H), 0.92 (d, *J* = 6.4 Hz, 3H); ^{13}C NMR ($CDCl_3$) δ 202.9, 130.6, 130.5, 118.7, 117.9, 68.0, 55.6, 52.6, 48.3, 45.7, 24.4, 23.4, 22.1; $[\alpha]_D^{23}$ +93.0 (*c* 1.1, $CHCl_3$, 90% ee sample); ESI-MS *m*/*z* 264 $[M+Na]^+$; HRMS (ESI-TOF) Anal. calcd. for $C_{13}H_{23}NNaOS$ *m*/*z* 264.1393 $[M+H]^+$, found 264.1396; HPLC: Daicel CHIRALCEL OD-H (ϕ 0.46 cm x 25 cm),

2-propanol/*n*-hexane = 1/99, flow rate 0.5 mL/min, detection 254 nm, t_R = 17.6 min (minor), 23.1 min (major).

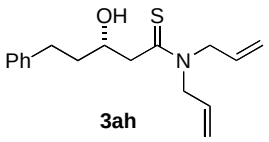


	tR [min]	
Unknown	15.667	50.345
Unknown	20.775	49.655



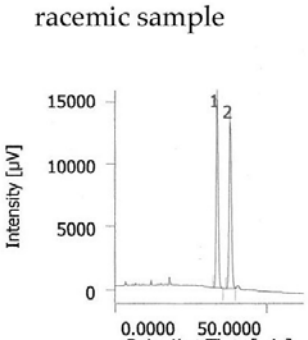
	tR [min]	
Unknown	17.625	5.002
Unknown	23.058	94.998

(*S*)-*N*,*N*-Diallyl-3-hydroxy-5-phenylpentanethioamide (3ah)

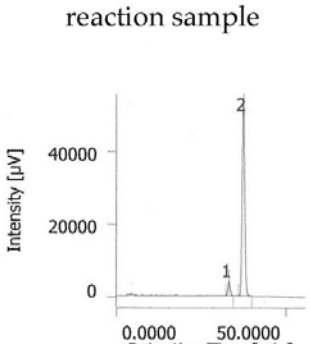


3ah

Pale yellow oil; IR (KBr) ν 3406. 3025, 2925, 1721, 1642 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 7.29-7.26 (m, 5H), 5.88 (dddd, *J* = 17.4, 10.4, 6.1, 6.1 Hz, 1H), 5.75 (dddd, *J* = 17.4, 10.1, 4.9, 4.9 Hz, 1H), 5.29-5.11 (m, 4H), 4.68 (dd, *J* = 15.0, 6.1 Hz, 1H), 4.60 (dd, *J* = 15.0, 6.1 Hz, 1H), 4.24-4.17 (m, 3H), 4.11-4.06 (m, 1H), 2.91-2.85 (m, 1H), 2.75 (dd, *J* = 15.9, 2.1 Hz, 1H), 2.75-2.70 (m, 1H), 2.66 (dd, *J* = 15.9, 9.2 Hz, 1H), 1.95-1.88 (m, 1H), 1.78-1.71 (m, 1H); ^{13}C NMR ($CDCl_3$) δ 202.6, 142.1, 130.6, 130.4, 128.4, 128.4, 125.8, 118.8, 118.0, 69.2, 55.6, 52.8, 47.8, 38.3, 32.0; $[\alpha]_D^{25}$ +56.3 (*c* 1.1, $CHCl_3$, 88% ee sample); ESI-MS *m*/*z* 312 $[M+Na]^+$; HRMS (ESI-TOF) Anal. calcd. for $C_{17}H_{23}NNaOS$ *m*/*z* 312.1393 $[M+Na]^+$, found 312.1387; HPLC: Daicel CHIRALPAK IC (ϕ 0.46 cm x 25 cm), 2-propanol/*n*-hexane = 1/19, flow rate 1.0 mL/min, detection 254 nm, t_R = 26.3 min (minor), 30.8 min (major).

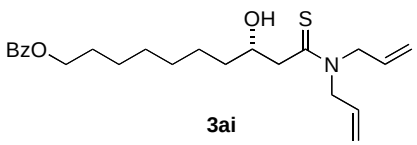


	tR [min]	
Unknown	33.517	49.996
Unknown	37.800	50.004



	tR [min]	
Unknown	33.075	6.223
Unknown	37.325	93.777

(*S*)-10-(Diallylamino)-8-hydroxy-10-thioxodecyl benzoate (3ai)

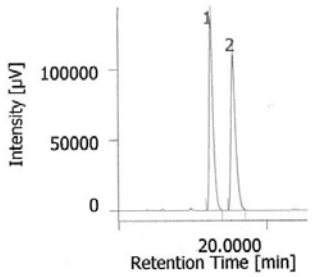


3ai

Colorless oil; IR (KBr) ν 3414, 2929, 2856, 1717, 1276 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 8.03 (d, *J* = 7.3 Hz, 2H), 7.54 (t, *J* = 7.9 Hz, 1H), 7.43 (dd, *J* = 7.9, 7.3 Hz, 2H), 5.88 (dddd, *J* = 16.8, 10.7, 6.0, 6.0 Hz, 1H), 5.77 (dddd, *J* = 17.1, 10.9, 4.5, 4.5 Hz, 1H), 5.81-5.73 (m, 1H), 5.29-5.13 (m, 4H), 4.69 (dd, *J* = 14.9, 6.0 Hz, 1H), 4.59 (dd, *J* = 14.9, 6.0 Hz, 1H), 4.31 (t, *J* = 6.6 Hz, 2H), 4.25-4.09 (m, 3H), 3.50 (brs, 1H), 2.75 (dd, *J* = 15.9, 1.5 Hz, 1H), 2.63 (dd, *J* = 15.9, 9.5 Hz, 1H), 1.79-1.73 (m, 2H), 1.61-1.34 (m, 10H); ^{13}C NMR ($CDCl_3$) δ 202.9, 166.6, 132.7, 130.6, 130.5, 130.5, 129.5, 128.3, 118.7, 117.9, 69.8, 65.0, 55.6, 52.8, 47.9, 36.5, 29.4, 29.2, 28.7, 25.9, 25.5; $[\alpha]_D^{23}$ +55.6 (*c* 1.2, $CHCl_3$, 90% ee sample); ESI-MS *m*/*z* 264 $[M+Na]^+$; HRMS (ESI-TOF) Anal. calcd. for $C_{23}H_{33}NNaOS$ *m*/*z* 426.2062 $[M+Na]^+$, found 426.2081; HPLC: Daicel CHIRALCEL

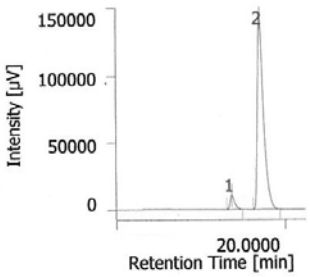
OD-H (ϕ 0.46 cm x 25 cm), 2-propanol/*n*-hexane = 1/19, flow rate 1.0 mL/min, detection 254 nm, t_R = 13.6 min (minor), 17.0 min (major).

racemic sample



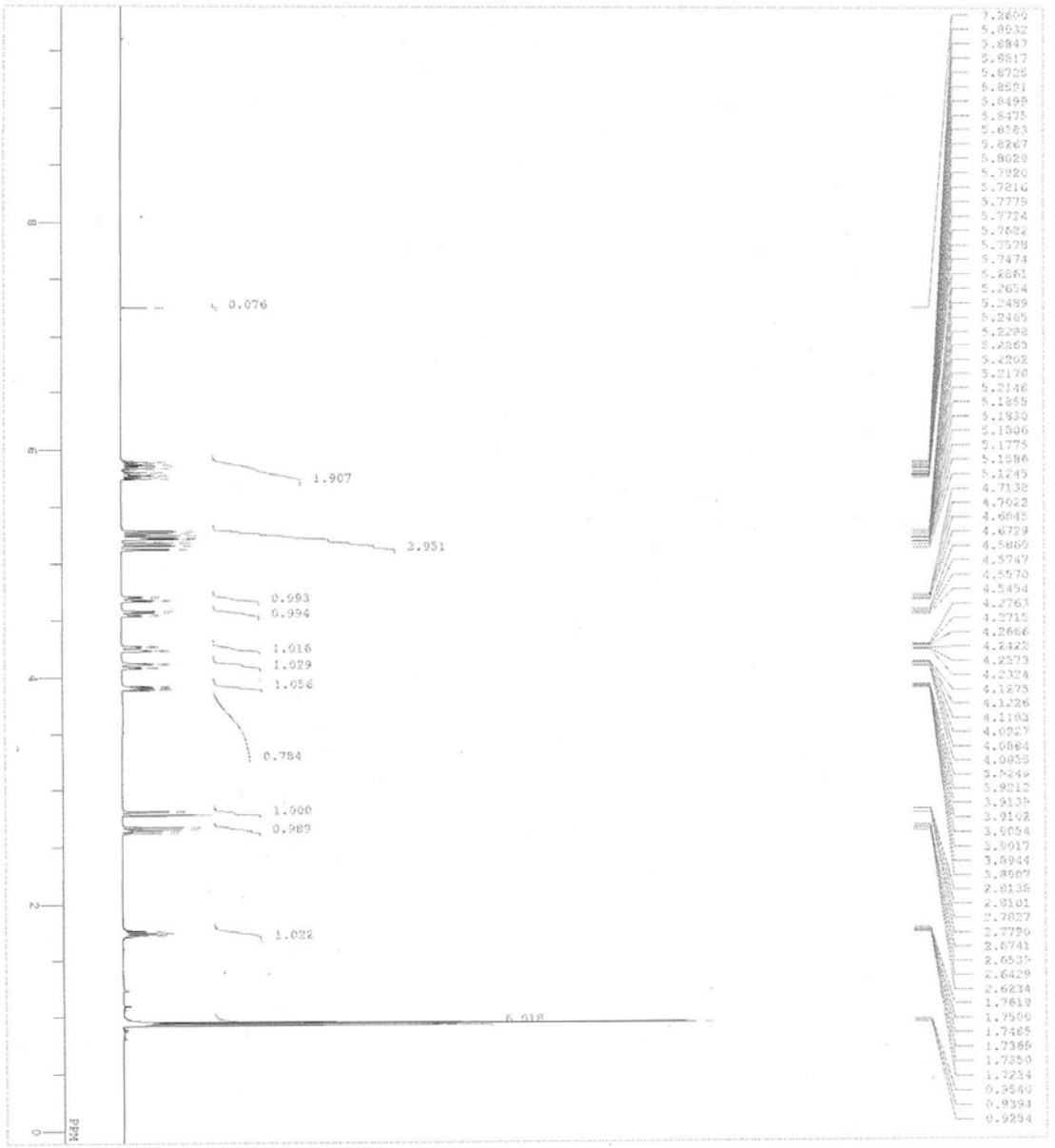
	tR [min]	
Unknown	12.408	50.384
Unknown	15.358	49.616

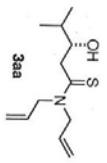
reaction sample



	tR [min]	
Unknown	13.600	5.240
Unknown	16.950	94.760

10. NMR Spectra of New Compounds





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OBSET 160.00 KHz
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POINT 32768
FREQU 10000.00 Hz
SCANS 16
ACQTM 3.2768 sec
PD 3.7232 sec
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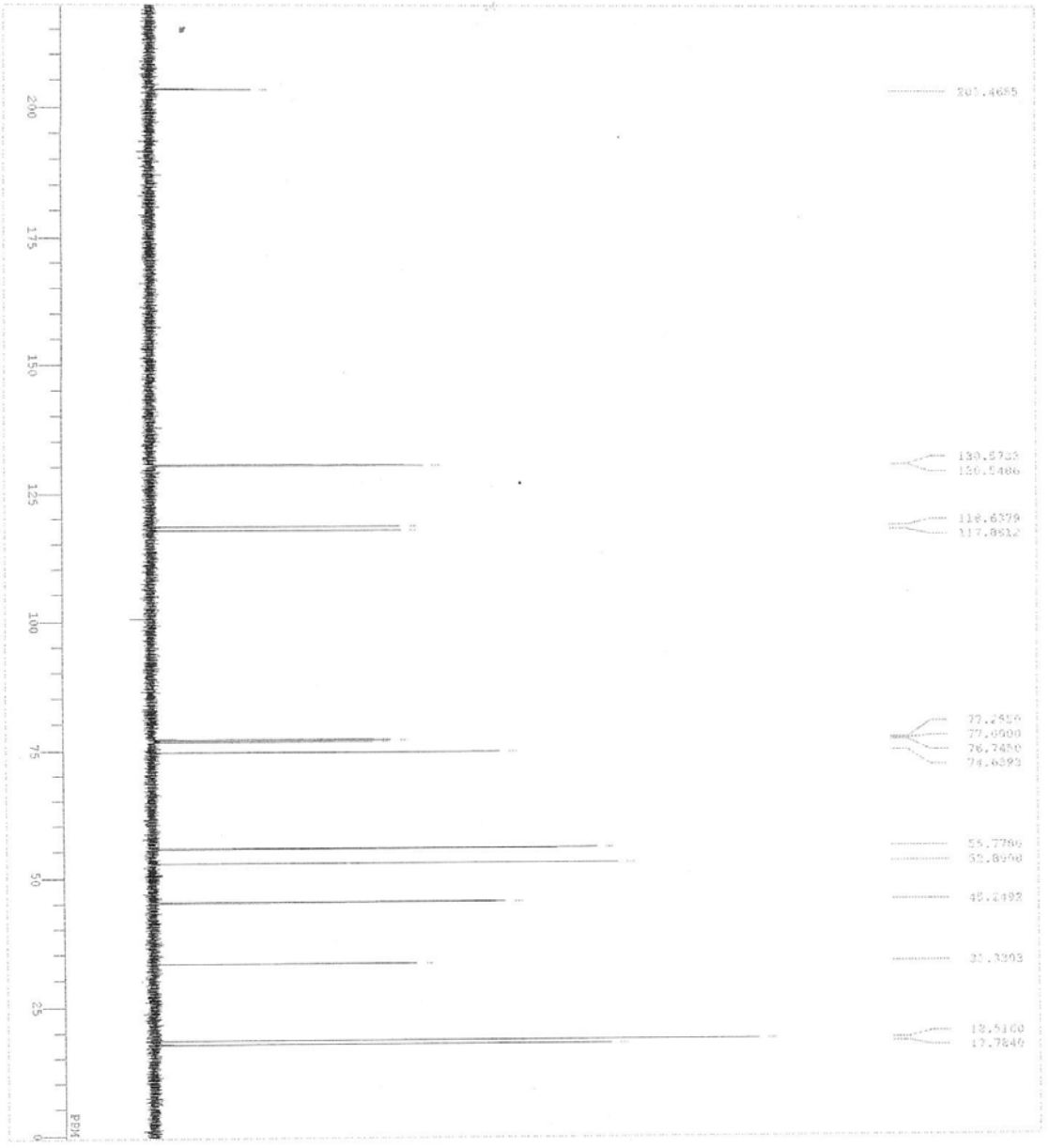
EXREF 7.26 ppm
BF 0.22 Hz
RGAIN 14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77.0000
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74.6293
55.7780
52.8908
40.4492
31.3303
18.5163
17.7840
PPM
DFILE MIB-091-C.nmdata
COMNT MIB-091-C
DATIM The Oct 6 12:28:54 2009
OBNUC 13C
EXMOD bcm
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OBSET 120.00 kHz
OBFIN 7958.00 Hz
POINT 32768
FRQDU 33898.30 Hz
SCANS 111
ACQTM 0.9667 sec
PD 2.0333 sec
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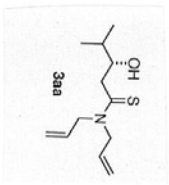
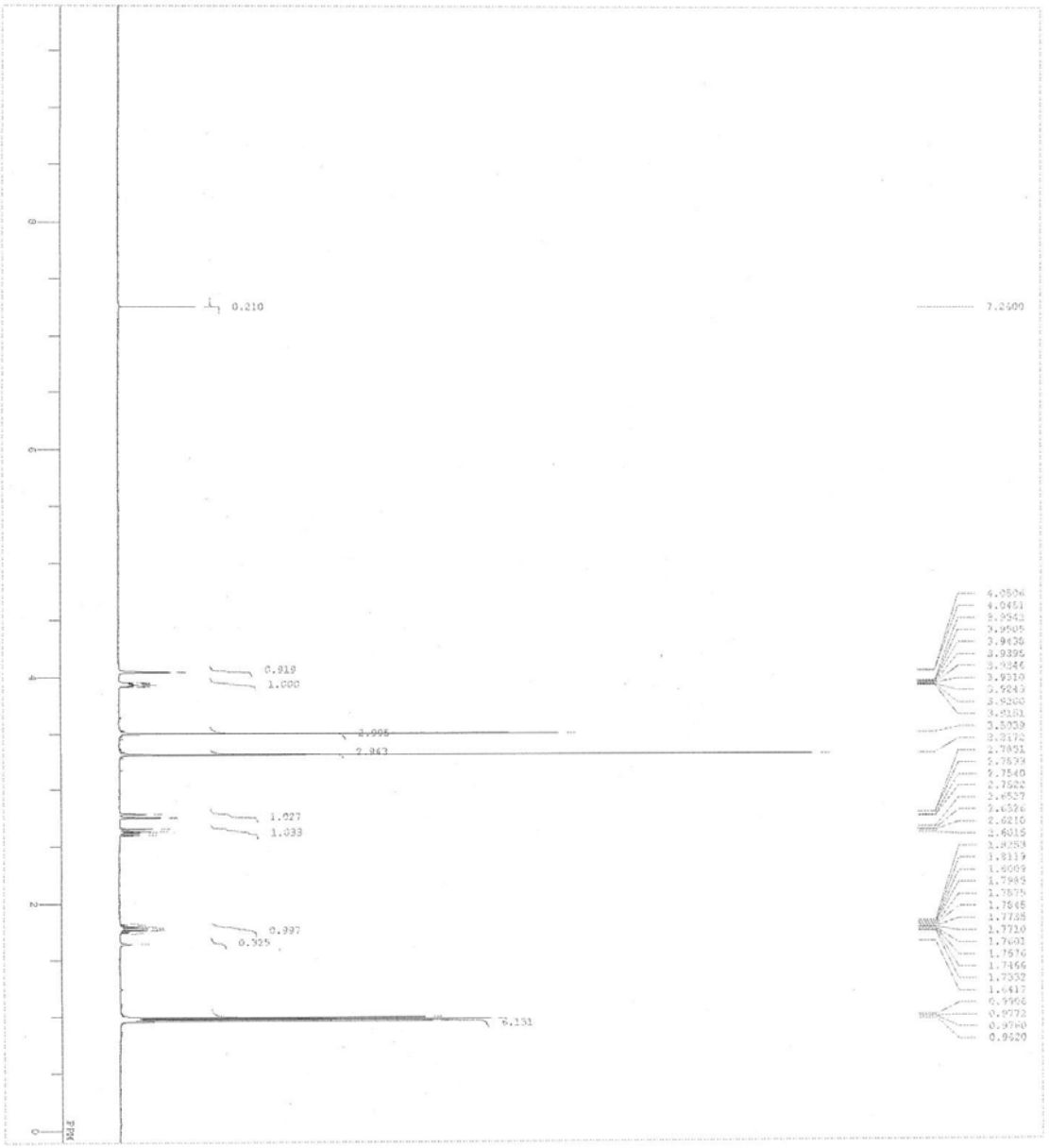
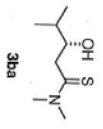
BF 0.22 Hz
RGAIN 31


OH
S
N
3aa





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OBSET 160.00 MHz
OBFIN 2160.00 Hz
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FREQU 10000.00 Hz
SCANS 16
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PD 3.7232 sec
PW1 6.90 usec
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CTEMP 27.6 c
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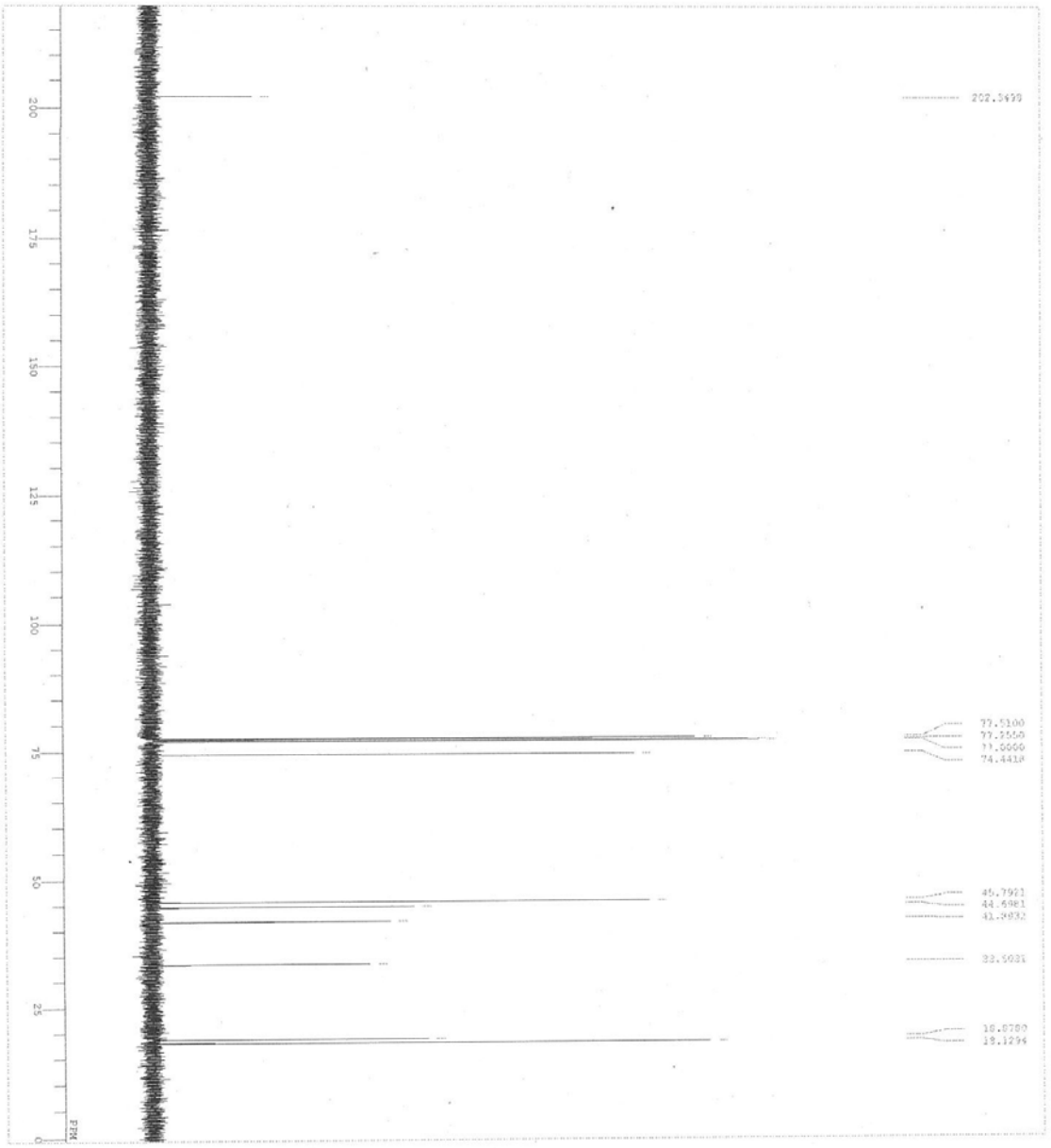
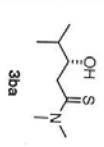
BF 0.12 Hz
RGAIN 17





3ba

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OBSET        120.00 KHz
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POINT         32768
FREQU      33896.30 Hz
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PD            2.0000 sec
PW1           3.250 usec
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CTEMP        29.0 c
SLVNT  CDCL3
EXREF        77.00 ppm
BF            0.12 Hz
RGAIN         30
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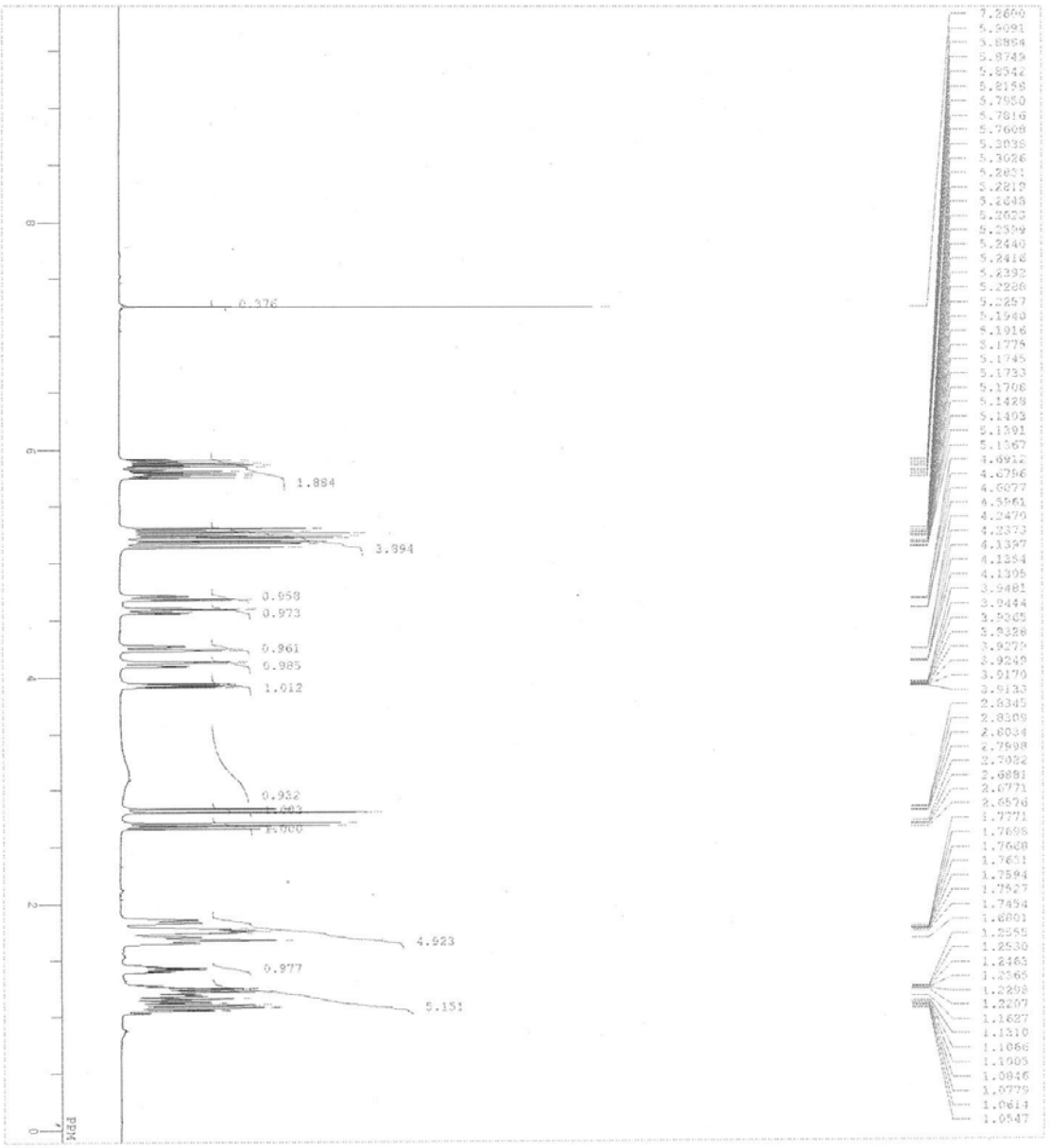

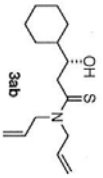

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OBSET 160.00 kHz
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POINT 32768
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IRNUC 1H
CTEMP 28.3 c
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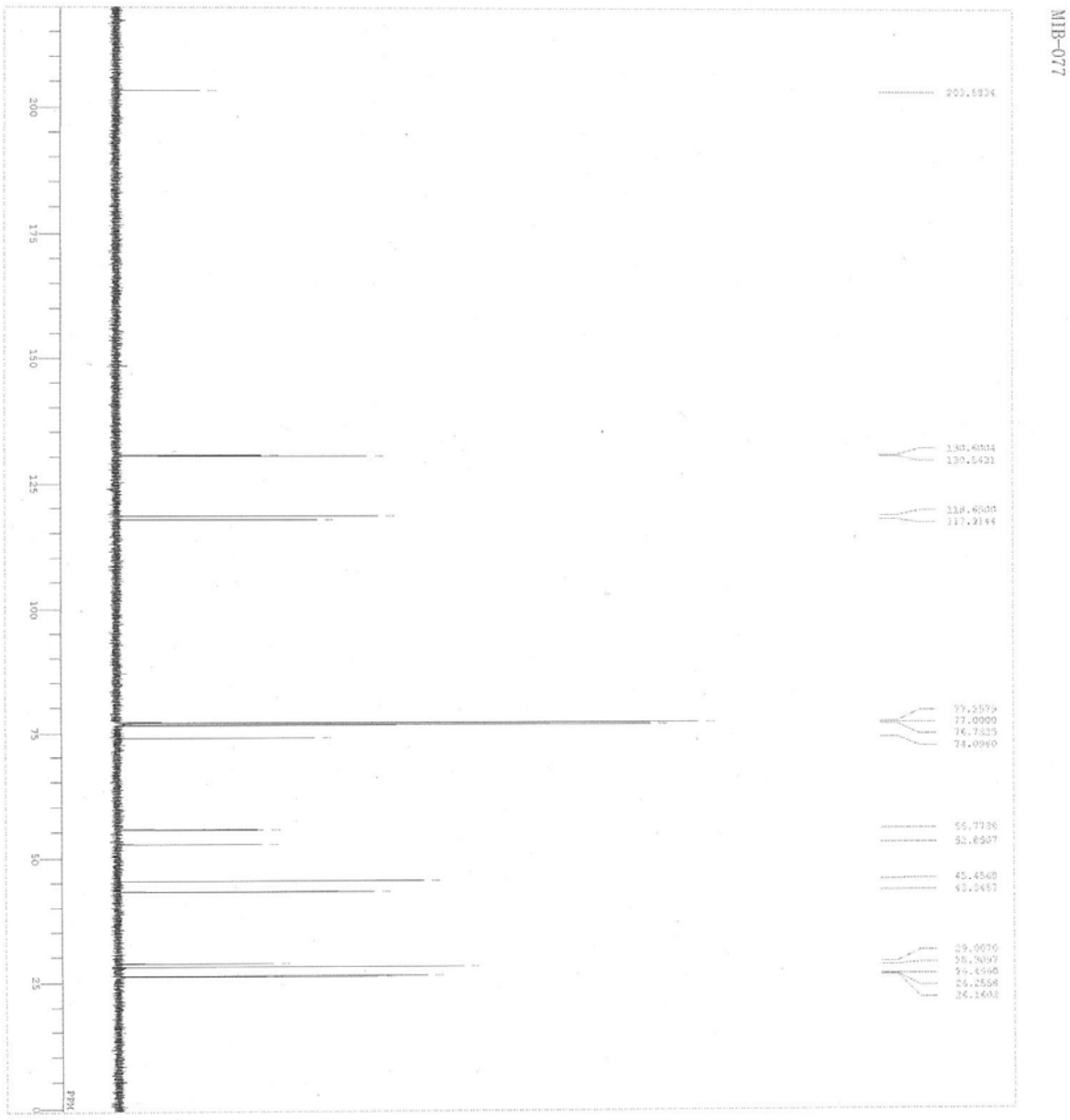
EXREF 7.26 ppm
BF 0.01 Hz
RGAIN 18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42.2457
29.9070
28.7097
27.1590
26.2558
26.1602
PPM


DFILE MIB-077-C.als
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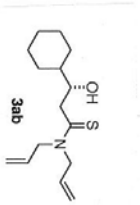
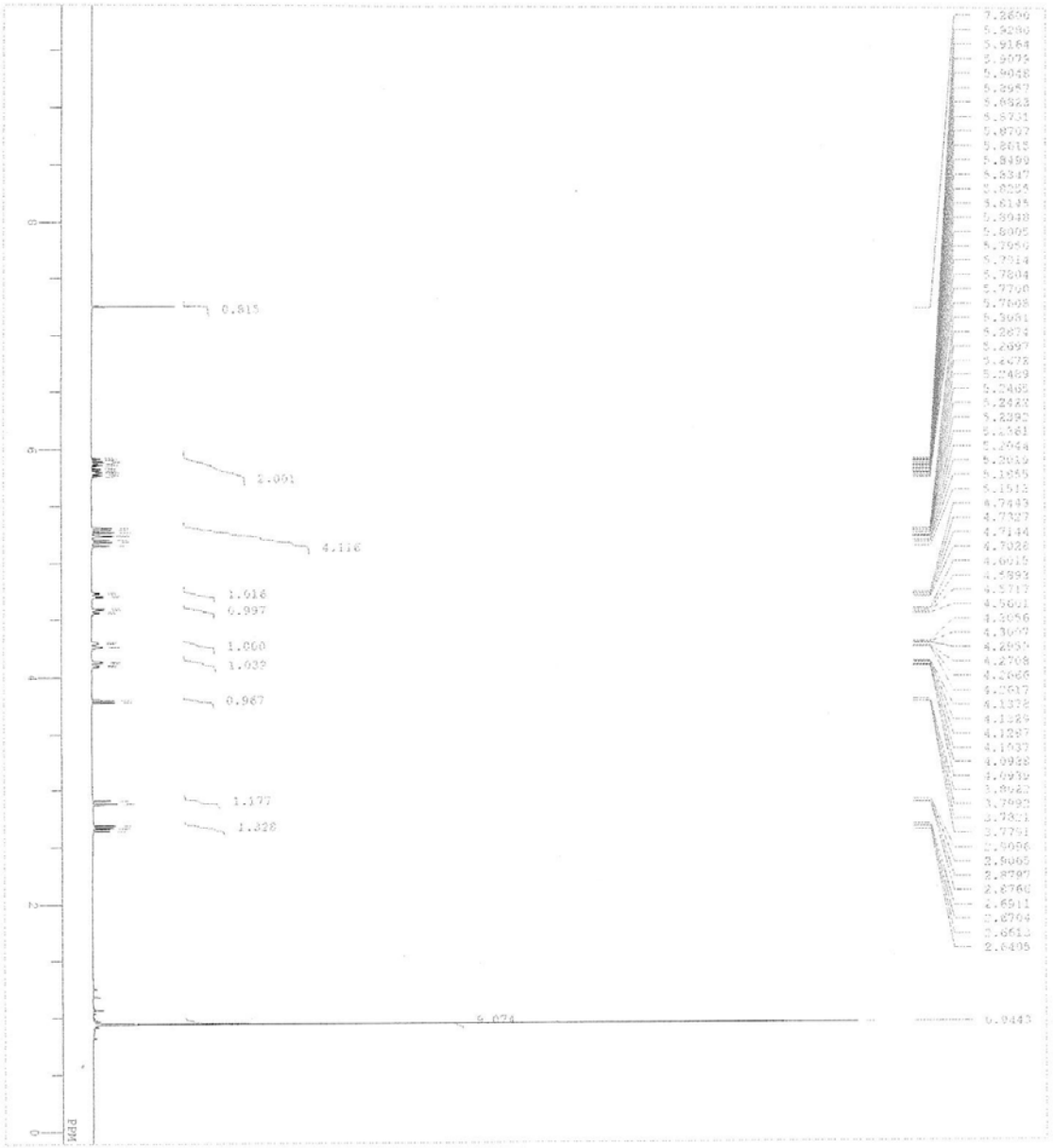
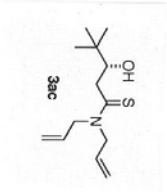
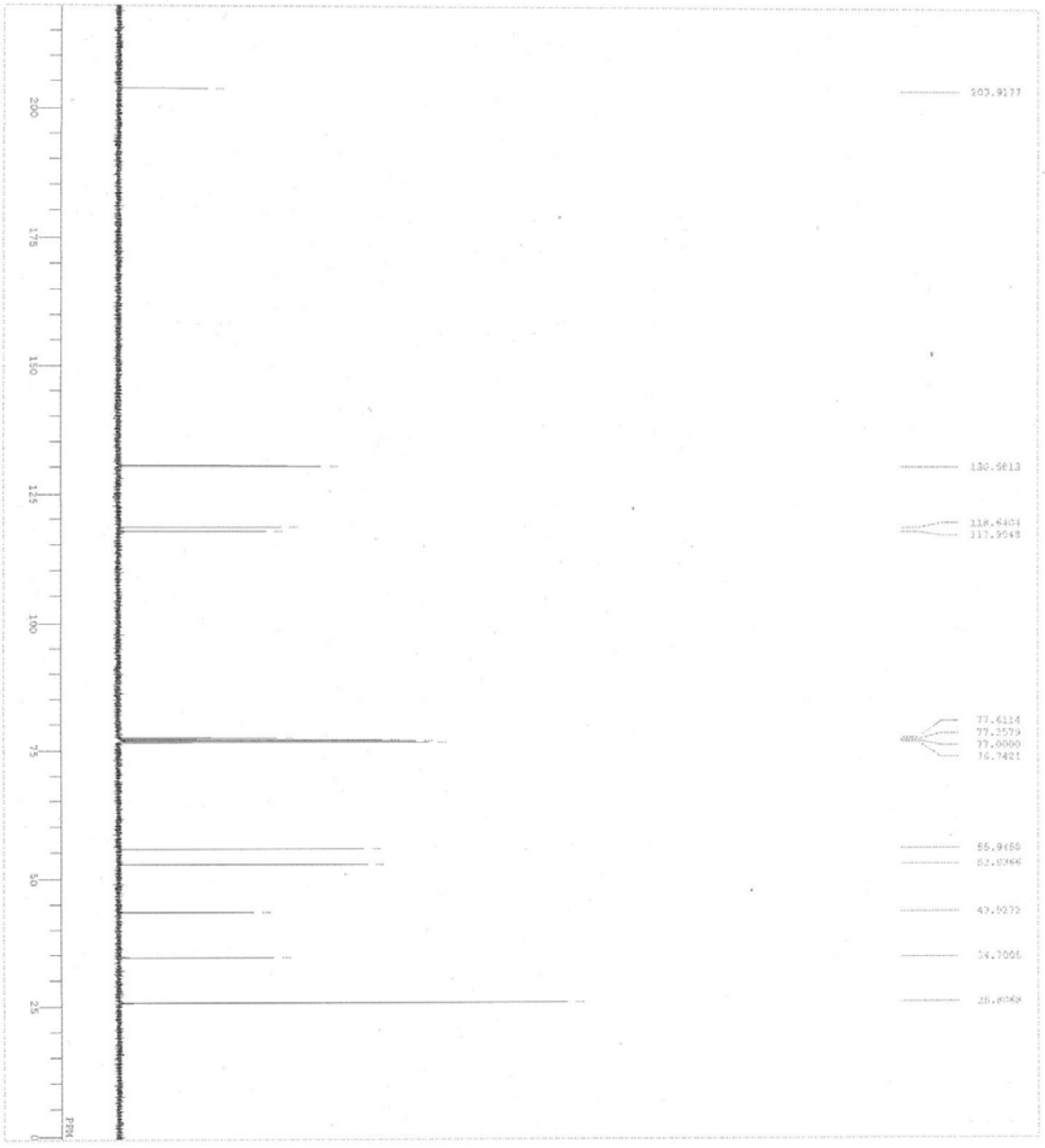
OBSET 2.31 KHz
OBFIN 6.71 Hz
POINT 26214
FREQU 30863.73 Hz
SCANS 945
ACQTM 0.8493 sec
PD 2.0000 sec
PW1 3.20 usec
IRNUC 1H
CTEMP 25.7 c
SLVNT CDCL3
EXREF 77.00 PPM
BF 0.01 HZ
RGAIN 58

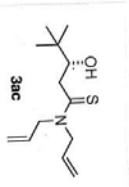

OH
S
N
3ab

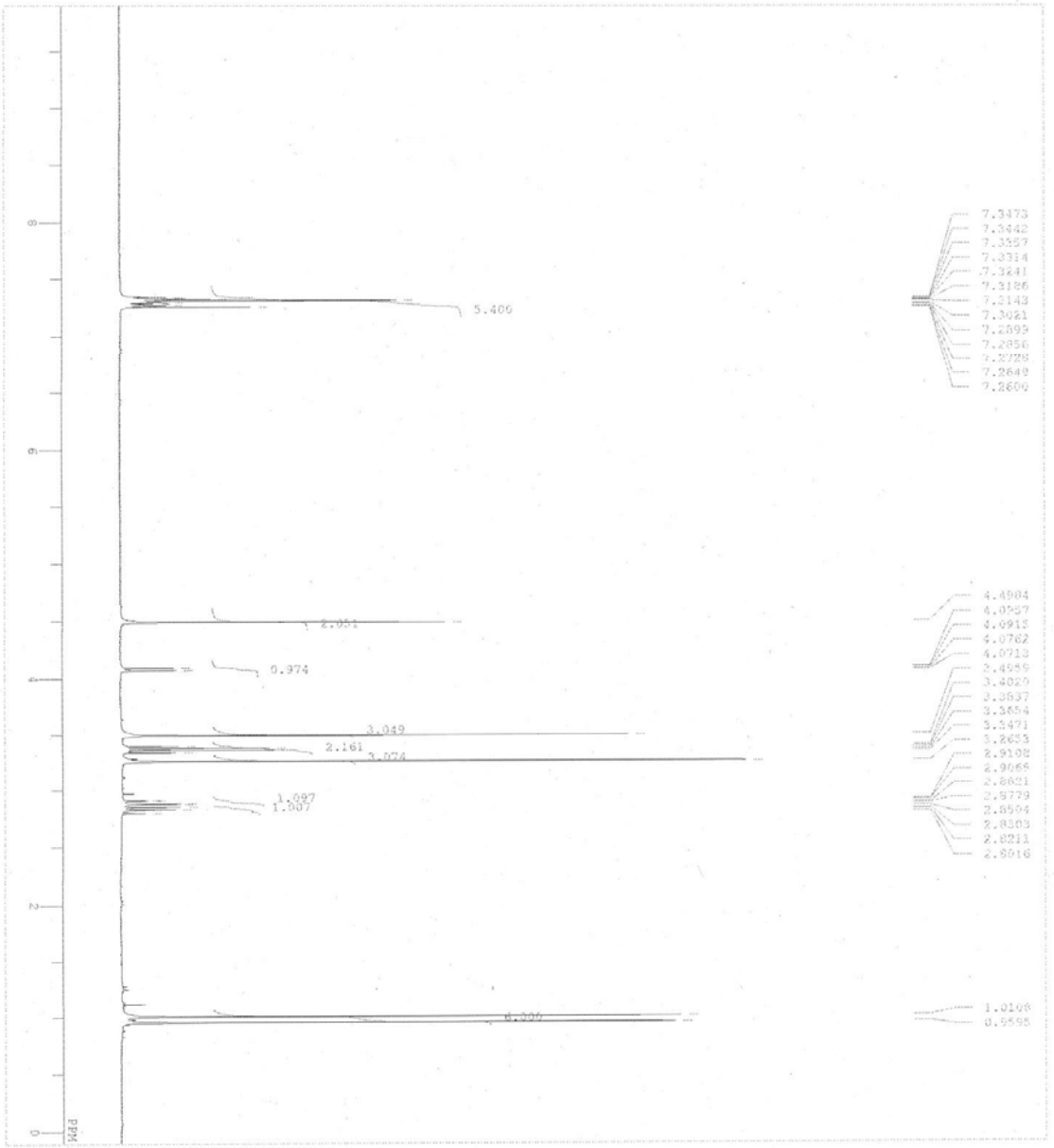


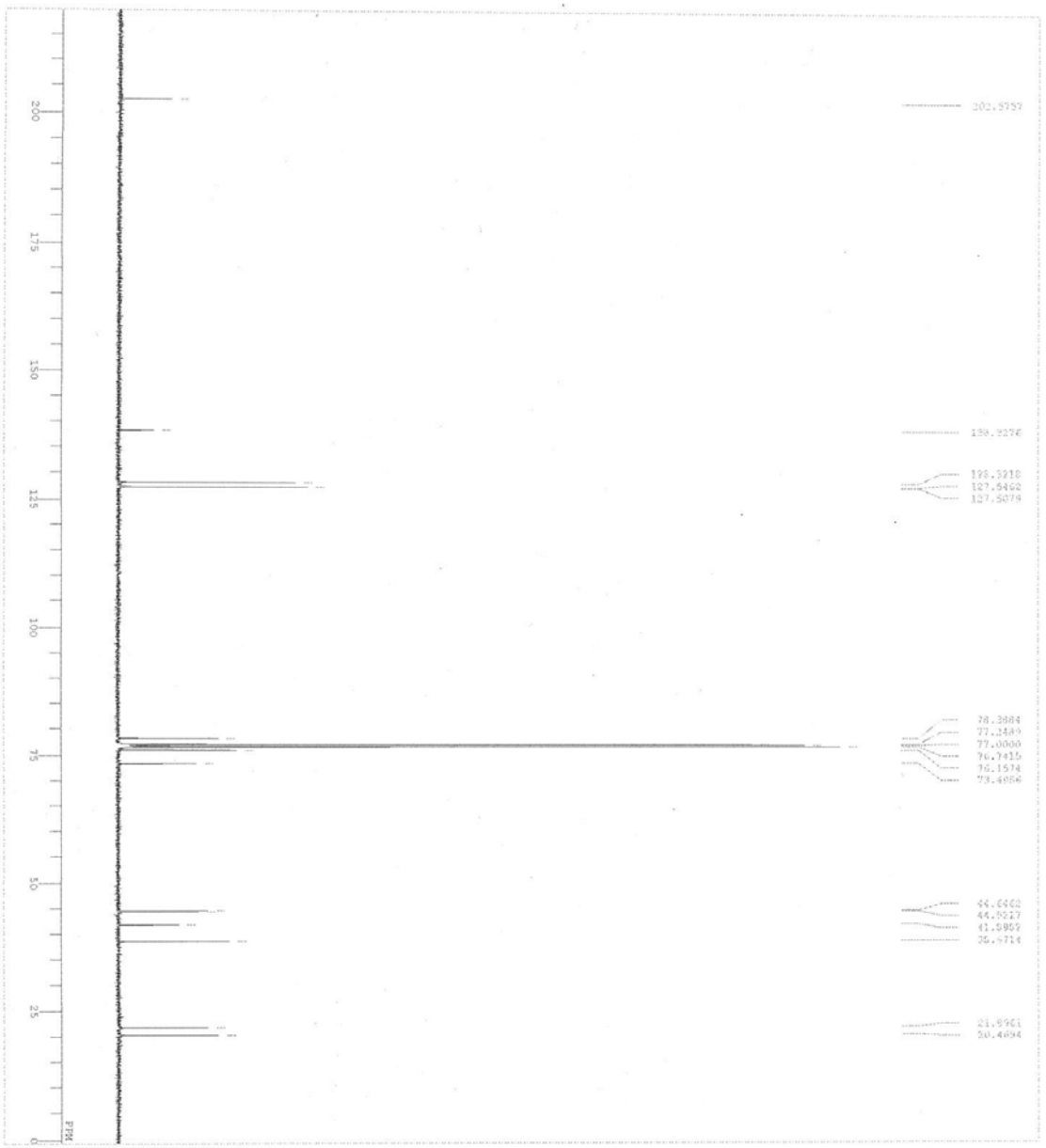


DFILE MIB-076.nmdata
COMNT MIB-076
DATIM Sat Sep 26 11:51:11 2009
OBNUC 1H
EXMOD non
OBSFRQ 500.00 MHz
OBSET 150.00 KHz
OBFIN 2160.00 Hz
POINT 32768
FREQU 10000.00 Hz
SCANS 16
ACQTM 3.2768 sec
ED 3.7232 sec
FW1 6.50 usec
IRNUC 1H
CTEMP 28.4 c
SLVNT CDCl3
EXREF 7.26 ppm
BF 0.01 Hz
RGAIN 21

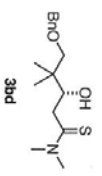

MIB-076
203.9177
130.5813
118.6403
117.9543
77.6114
77.3579
77.0000
76.7421
55.9455
52.0366
43.5072
34.7005
28.8063
PPM
DFILE MIB-076-C.als
COMNT MIB-076-C
DATIM 26-09-2009 14:55:46
OBNUC 13C
EXMOD single_pulse.dec
OBFRQ 125.75 MHz
OBSET 12.31 KHz
OBFIN 6.71 Hz
PCINT 26214
FREQU 30863.73 Hz
SCANS 648
ACQTM 0.8493 sec
FD 2.0000 sec
FW1 3.20 usec
IRNUC 1H
CTEMP 25.8 c
SLVNT CDCl3
EXREF 77.00 ppm
BF 0.01 Hz
RGAIN 60


3ac
OH
S
N

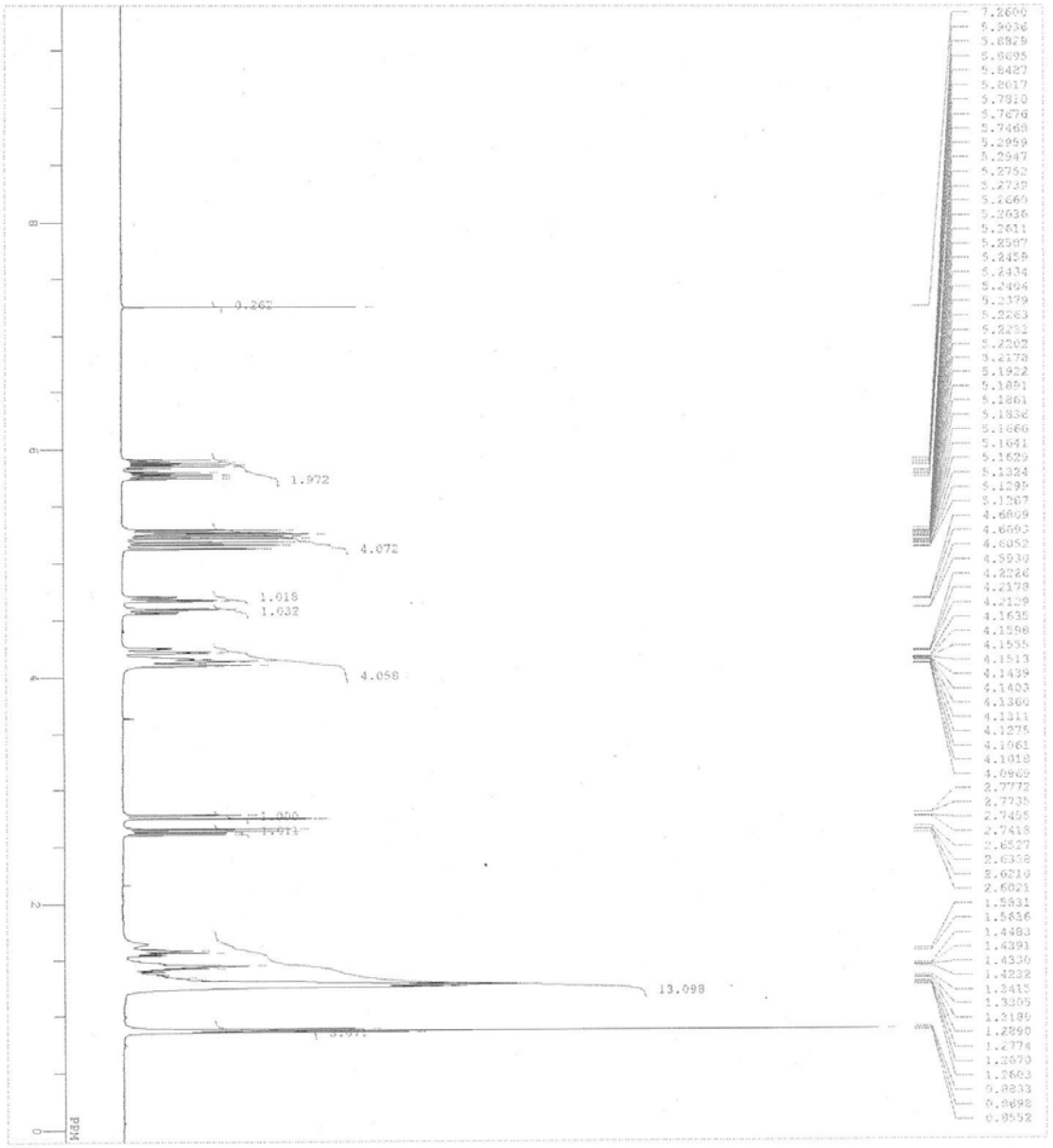

MIB-058
7.3473
7.3442
7.3357
7.3314
7.3241
7.3186
7.3143
7.3021
7.2899
7.2856
7.2728
7.2640
7.2600
5.409
2.051
0.974
3.049
2.161
3.074
1.097
1.007
6.000
4.4984
4.0957
4.0915
4.0762
4.0713
3.4659
3.4029
3.3637
3.3554
3.2471
3.2435
2.9108
2.9065
2.8621
2.8779
2.8594
2.8303
2.8211
2.8016
1.0198
0.9595
PPM
DFILE MIB-058.nmdata
COMNT MIB-058
DATIM Thu Sep 10 23:20:29 2009
OBNUC 1H
EXMOD non.
OBSFRQ 500.00 MHz
OBSET 160.00 KHz
OBSFIN 2160.00 Hz
POINT 32768
FREQU 10000.00 Hz
SCANS 16
ACQTM 3.2768 sec
PD 3.7232 sec
PW1 6.50 usec
IRNUC 1H
CTEMP 30.0 c
SLVNT CDCl3
EXREF 7.26 ppm
BF 0.22 Hz
RGAIN 19
BnO
OH
S
N
3bd

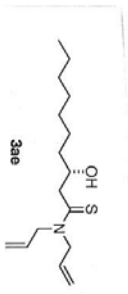

MIB-058
202.5757
138.2276
128.5218
127.5402
127.5079
78.3884
77.3849
77.0000
76.7415
76.1574
73.4856
44.6662
44.5927
41.5952
26.5714
21.5761
20.4694
200
175
150
125
100
75
50
25
0
PPM


DFILE MIB-058-C.als
COMNT MIB-058
DATIM 11-09-2009 13:26:36
OBNUC 13C
EXMOD single_pulse_dec
OBFRQ 124.51 MHz
OBSET 3.45 KHz
OBFIN 6.00 Hz
POINT 26214
FRQU 31249.52 Hz
SCANS 2715
ACQTM 0.8389 sec
PD 2.0000 sec
PW1 3.57 usec
IRNUC 1H
CTEMP 26.7 c
SLVNT CDCl3
EXREF 77.00 ppm
BF 1.00 Hz
RGAIN 54

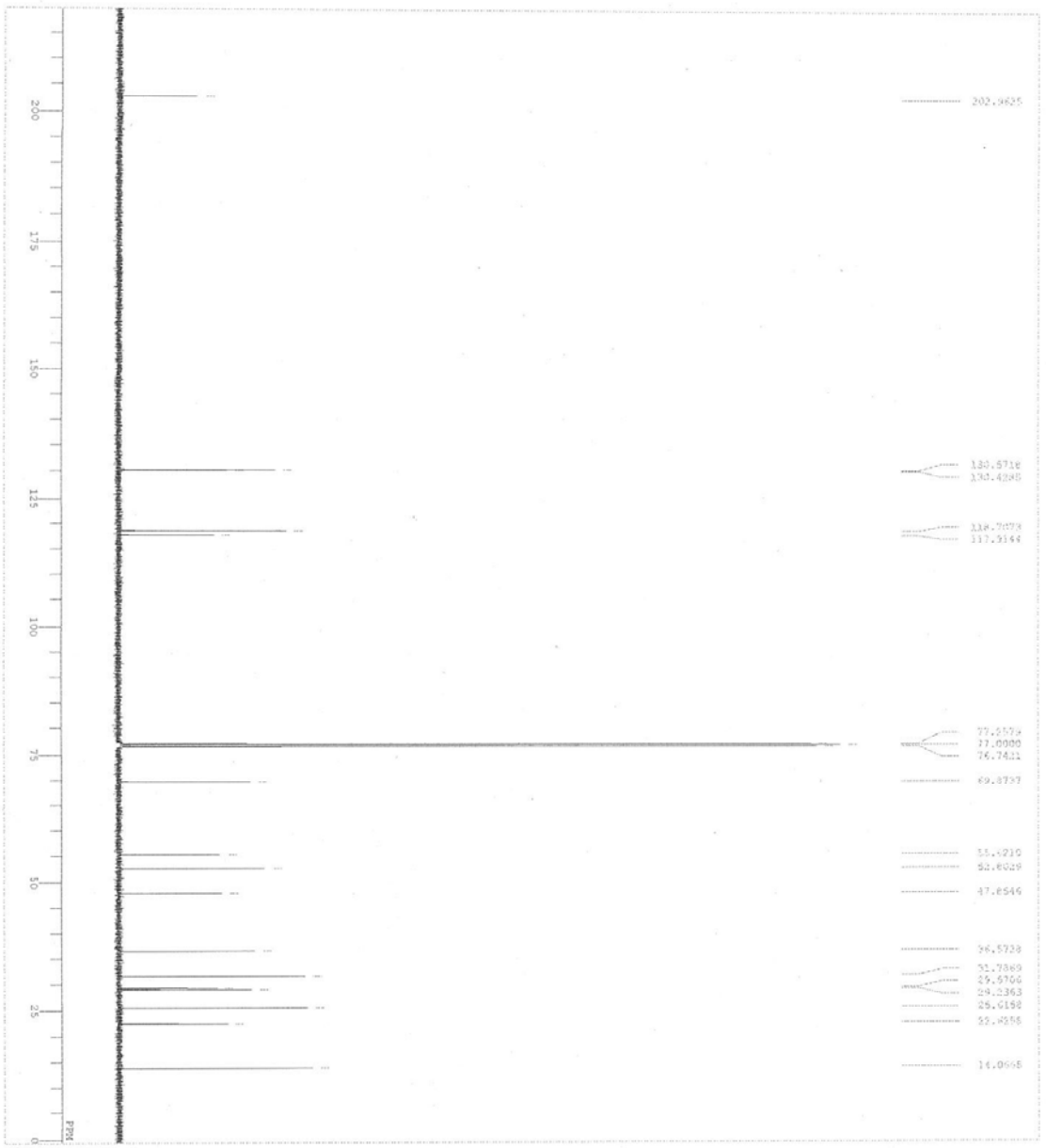

BnO
OH
S
N

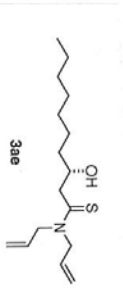
3bq

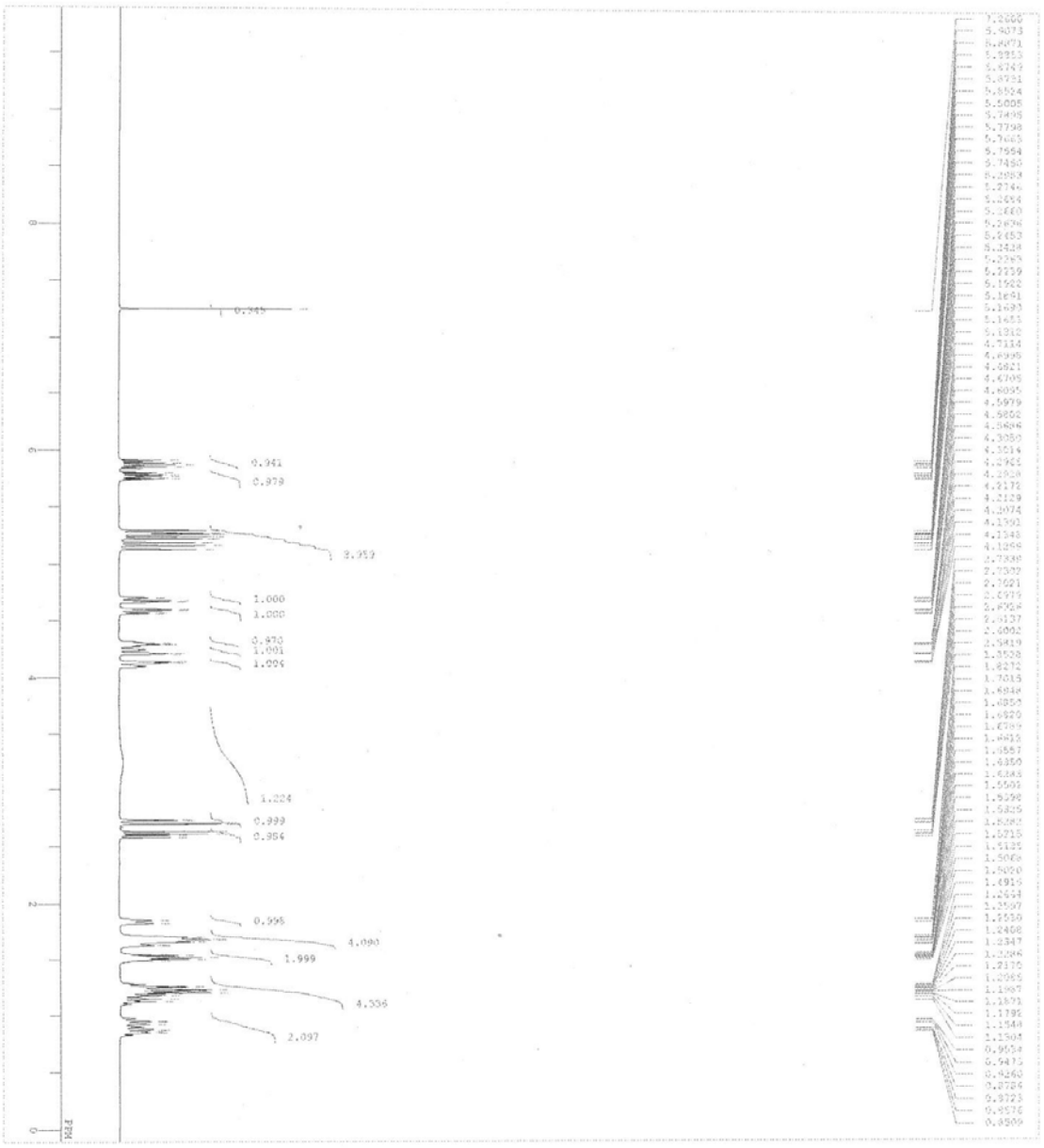




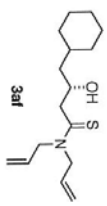
DFILE MIB-060-.nmdata
COMNT MIB-060-
DATIM Mon Sep 14 11:28:04 2009
OBNUC 1H
EXMOD non
OBFRQ 500.00 MHz
OBSET 160.00 KHz
OBFIN 21600.00 Hz
POINT 32768
FREQU 10000.00 Hz
SCANS 16
ACQTM 3.2768 sec
PD 3.7232 sec
PW1 6.50 usec
IRNUC 1H
CTEMP 26.5 c
SLVNT CDCl3
EXREF 7.26 ppm
BF 1.20 Hz
RGAIN 17

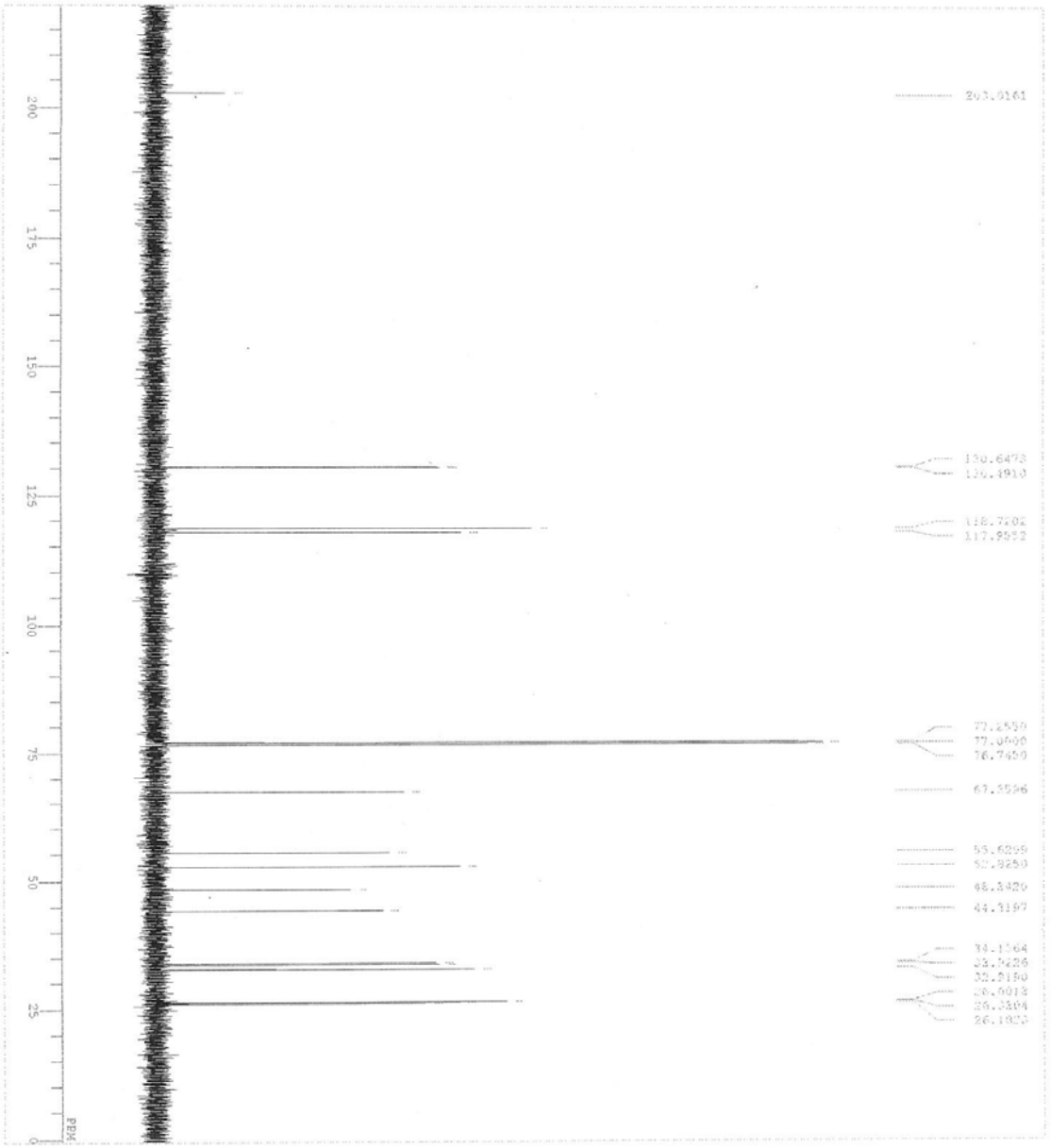

MIB-060-C
202.9635
130.5718
130.4248
118.7078
117.9164
77.2572
77.0000
76.7411
69.8737
55.4210
52.8029
47.6546
36.5738
31.7369
29.5700
29.2363
26.6198
22.8256
14.0668
PPM
DFILE MIB-060-C.als
COMNT MIB-060-C
EXMPL 13C 09-2009 12:48:37
EXPNO single pulse.dec
OBFRQ 125.26 MHz
OBSET 2.31 KHz
OBFIN 6.71 Hz
PCINT 26214
FREQU 30863.73 Hz
SCANS 1504
ACQTM 0.8493 sec
PD 2.0000 sec
PW1 3.20 usec
IRNUC 1H
CTEMP 23.4 c
SLVNT CDCL3
EXREF 77.00 PPM
BF 0.01 Hz
RGAIN 60

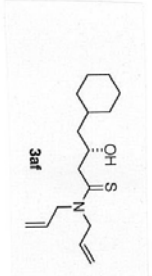

3ae
OH
S
N


MIB-085
0.941
0.979
3.952
1.000
1.000
0.970
1.001
1.006
1.224
0.999
0.964
0.995
4.090
1.999
4.336
2.097

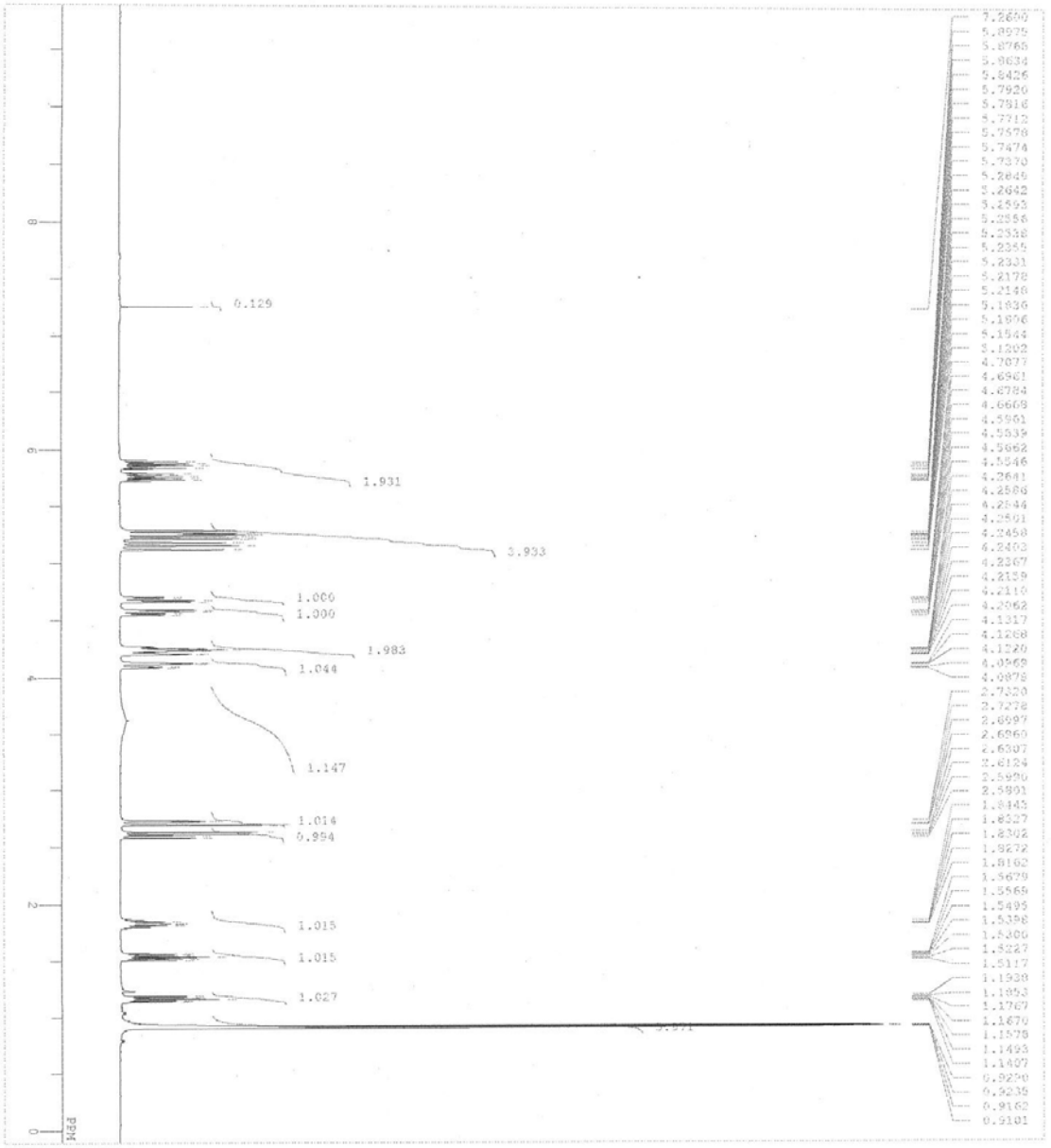

DFILE MIB-085.als
CDATE
NAME MIB-085
DATIM Thu Oct 1 23:52:09 2009
OBNUC 1H
EXMOD mon
OBFRQ 500.00 MHz
OBSET 160.00 KHz
OBFIN 2160.00 Hz
POINT 32768
FREQU 10000.00 Hz
SCANS 16
ACQTM 3.2768 sec
PD 3.7222 sec
PW1 6.50 usec
IRNUC 1H
CTEMP 29.4 c
SLVNT CDCl3
EXREF 7.26 ppm
RF 0.01 Hz
RGAIN 17

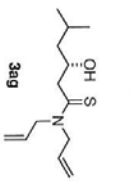

3af
OH
S
N



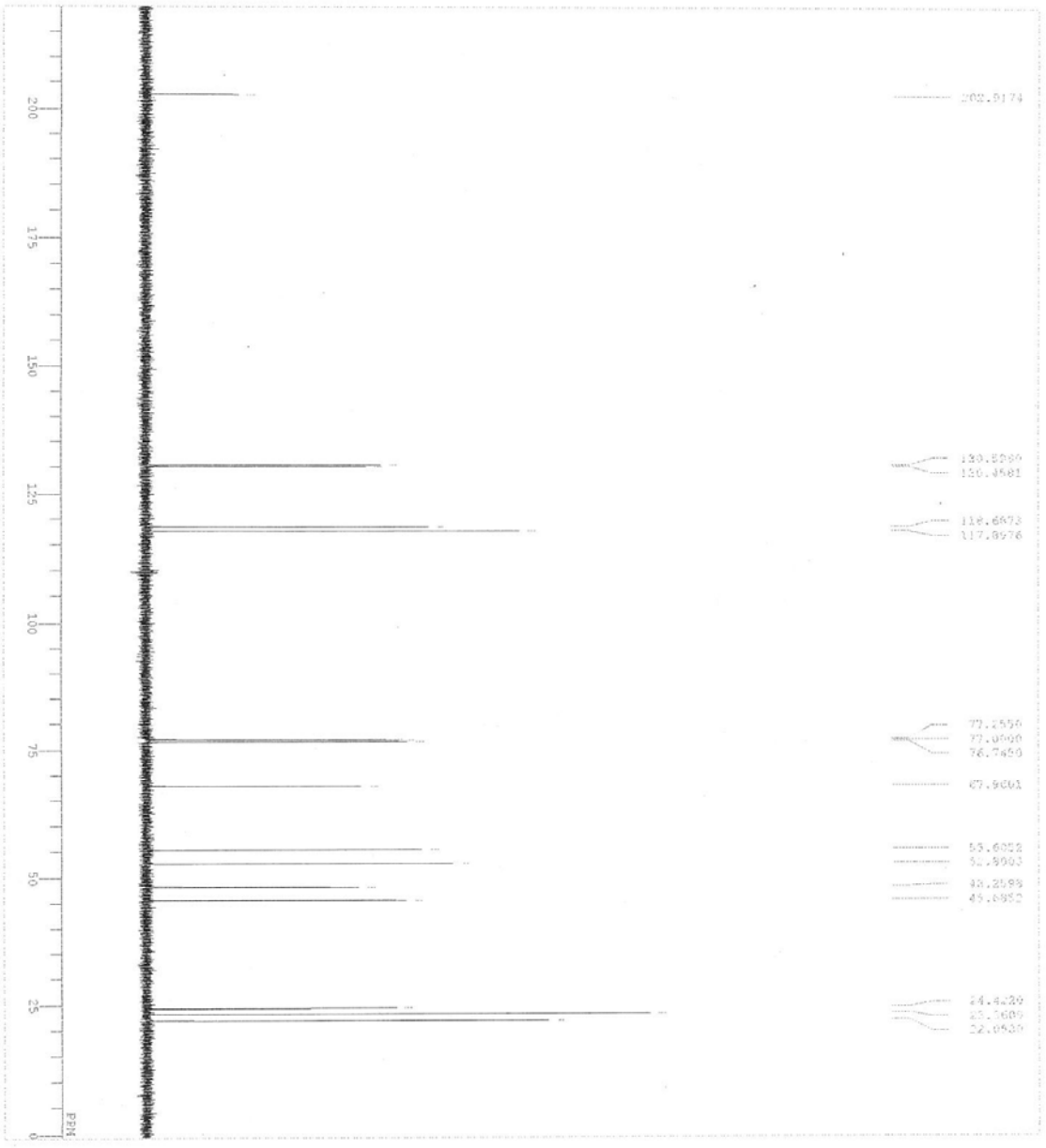


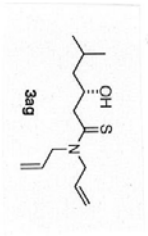
DFILE MIB-085-C.nmdata
CONNT MIB-085-C
DATIM Fri Oct 2 00:25:12 2009
OBNUC 13C
EXMOD bcm
OBSFRQ 125.65 MHz
OBSET 120.00 KHz
OBFIN 7958.00 Hz
POINT 32768
FREQU 33898.30 Hz
SCANS 209
ACQTM 0.9667 sec
PD 2.0333 sec
PW1 5.50 usec
IRNUC 1H
CTEMP 30.5 c
SLVNT CDCL3
EXREF 77.00 ppm
BF 0.01 Hz
RGAIN 31



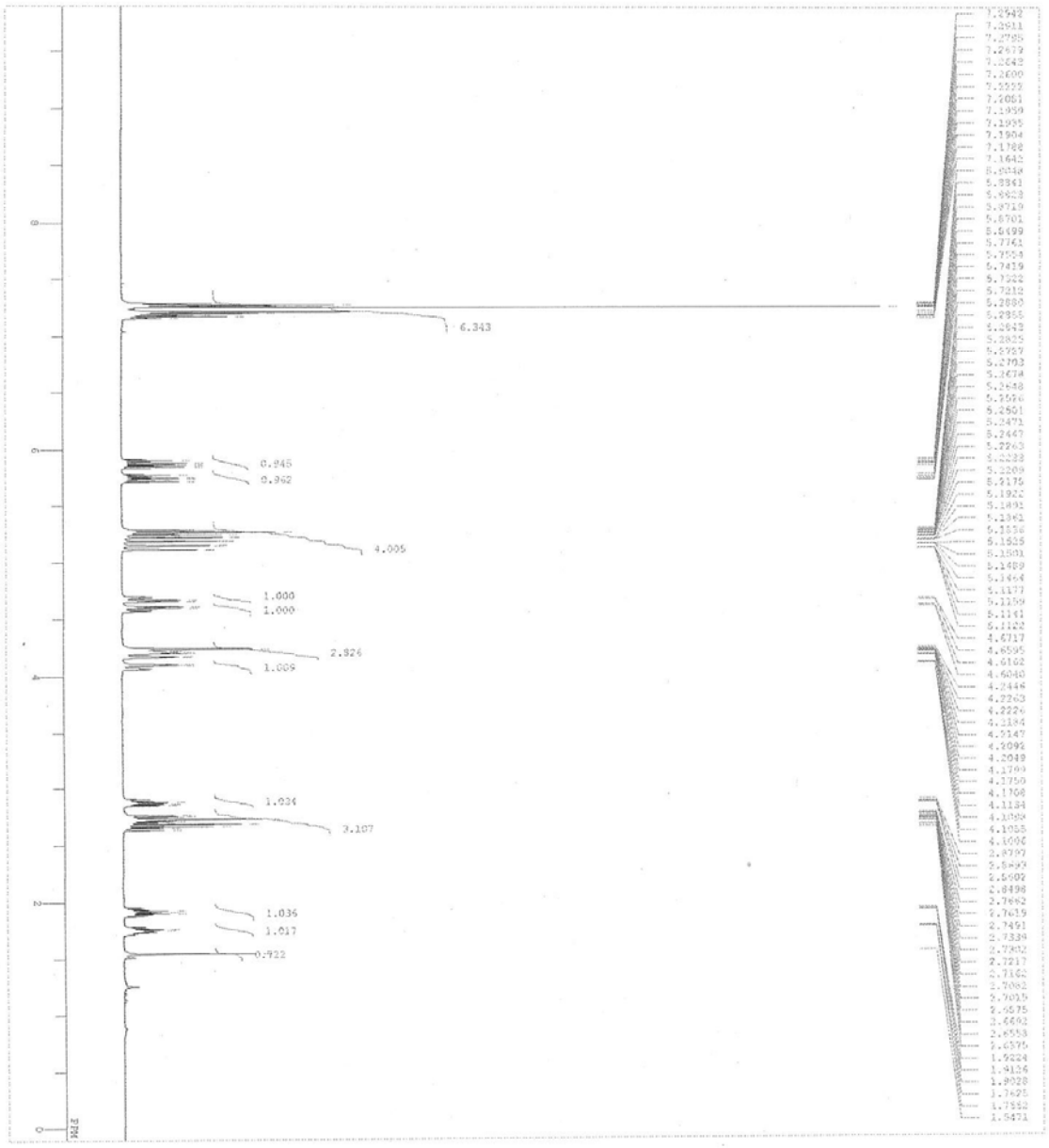


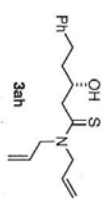
DFILE MIB-084-.nmrdata
COMNT MIB-084-
DATIM Thu Oct 1 23:46:37 2009
OBNUC 1H
EXMOD non
500.00 MHz
OBFRQ 160.00 kHz
OBSET 2160.00 Hz
OBFIN 32768
POINT 10000.00 Hz
FREQU 16
SCANS 3.2768 sec
ACQTM 3.7232 sec
PD 6.50 usec
PW1 1H
IRNUC 28.9 c
CTEMP CDCL3
SLVNT 7.26 ppm
EXREF 0.01 Hz
BF 15
RGAIN



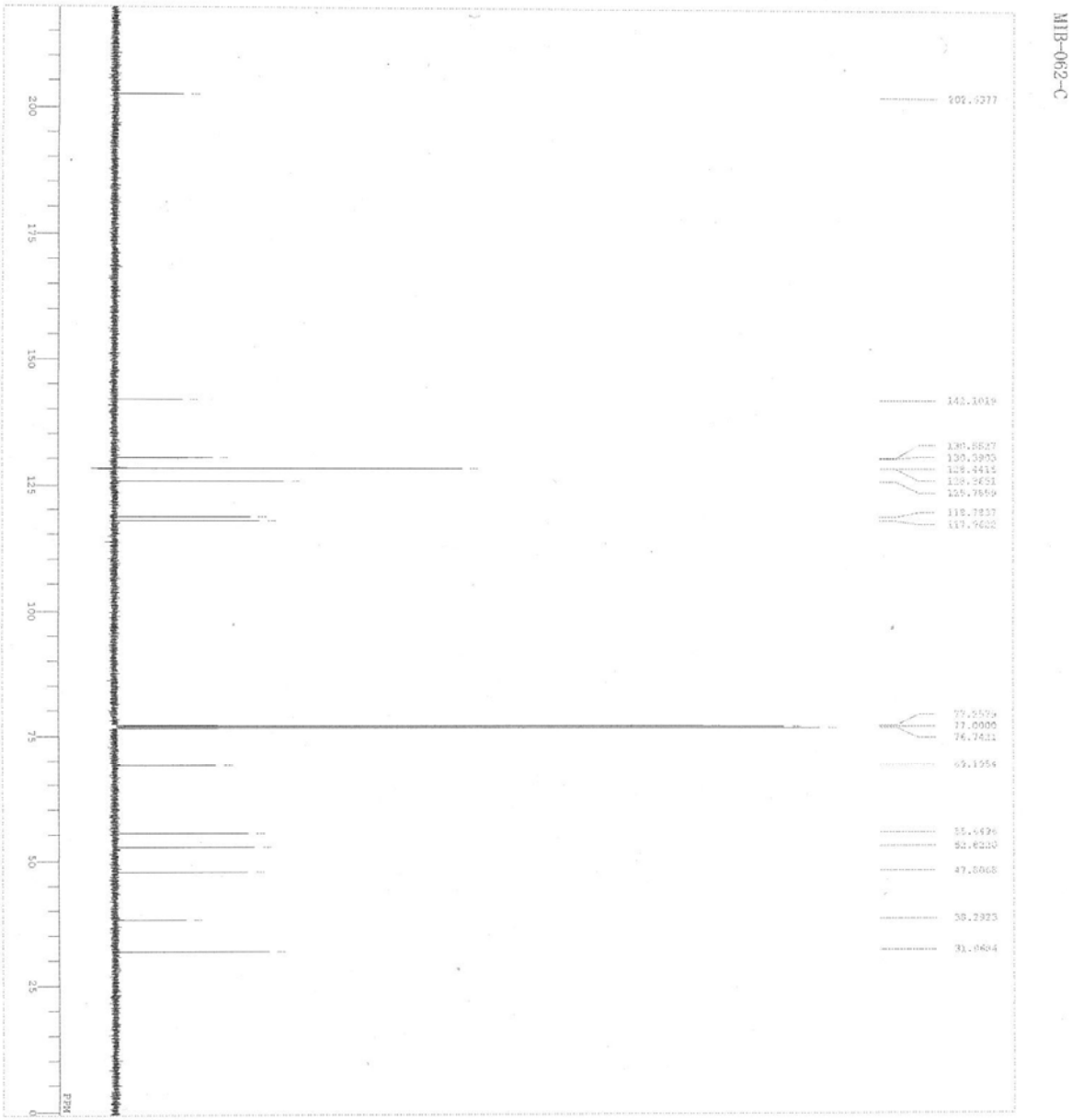


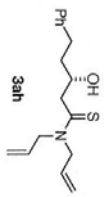

```
FILE      MIB-084-C.nmdata
COMNT     MIB-084-C
DATIM     Fri Oct  2 00:10:43 2009
OBNUC     13C
EXMOD     bcm
OBSFRQ      125.65 MHz
OBSET       120.00 KHz
OBFIN       795.00 Hz
POINT         32768
FREQU      33898.30 Hz
SCANS           146
ACQTM         0.9667 sec
PD            2.0333 sec
PW1              5.50 usec
IRNUC     1H
CTEMP       30.3 c
SLVNT     CDCl3
EXREF       77.00 ppm
BF           0.01 Hz
RGAIN          31
```



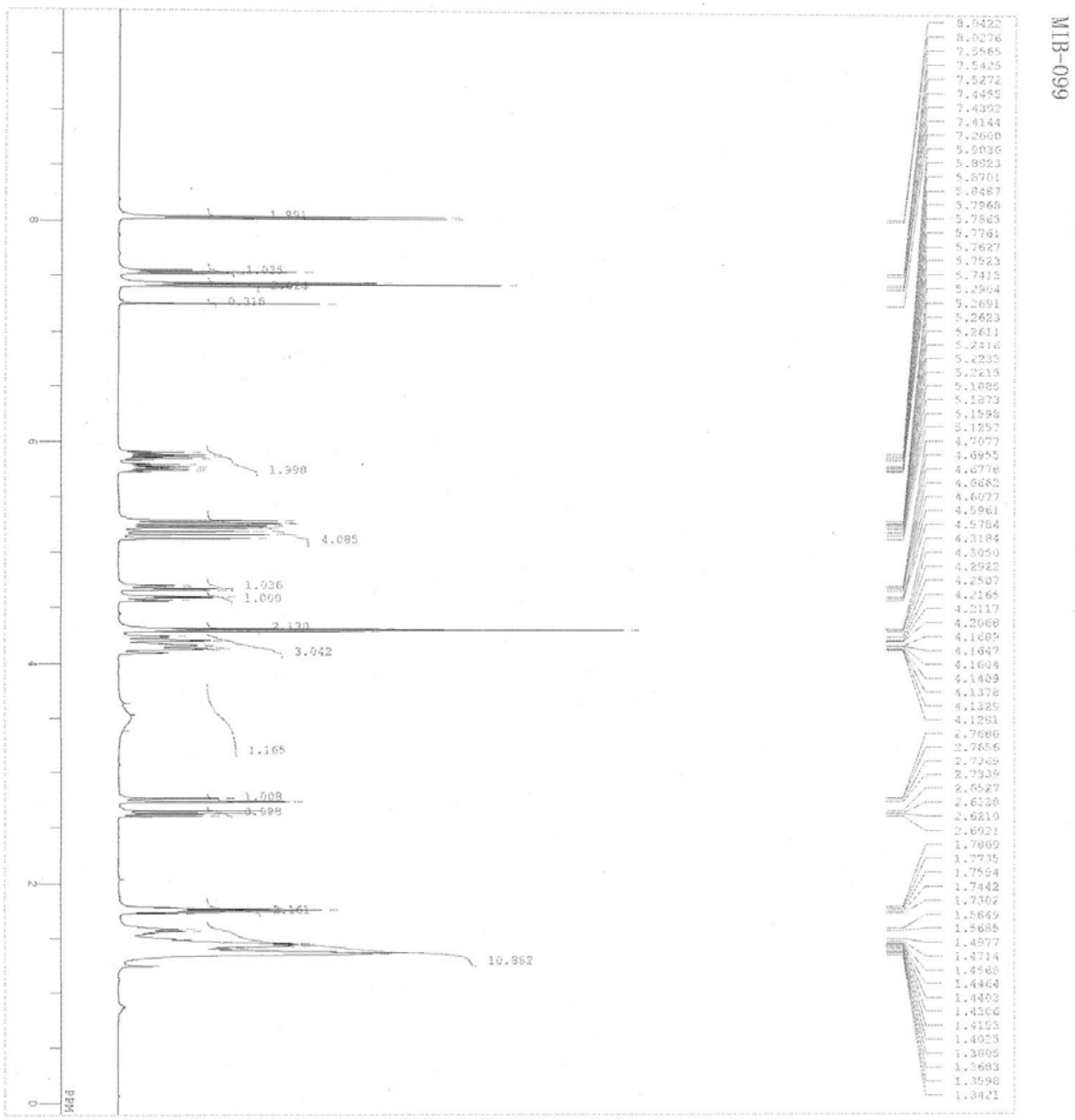


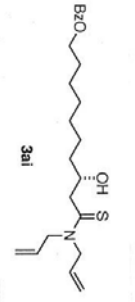

```
DFILE   MIB-087.nmdata
COMNT   MIB-087
DATIM   Wed Nov  4 12:37:30 2009
OBNUC   1H
EXMOD   noe
                    500.00 MHz
                    160.00 MHz
OBFRQ
OBSET
OBFIN               2160.00 Hz
POINT               32768
FREQU               10000.00 Hz
SCANS                   8
ACQTM               3.2768 sec
PD                  37.232 sec
PW1                 6.50 usec
IRNUC   1H
CTEMP               29.3 c
SLVNT   CDCL3
EXREF               7.26 ppm
BF                  0.12 Hz
RGAIN               22
```


MIB-062-C
202.6377
143.1019
139.8827
130.3803
128.4415
128.2651
126.7659
118.7837
117.7622
77.2572
77.0000
76.7431
69.1956
55.4626
52.8230
47.2068
38.2923
31.8604
200
175
150
125
100
75
50
25
0
PPM

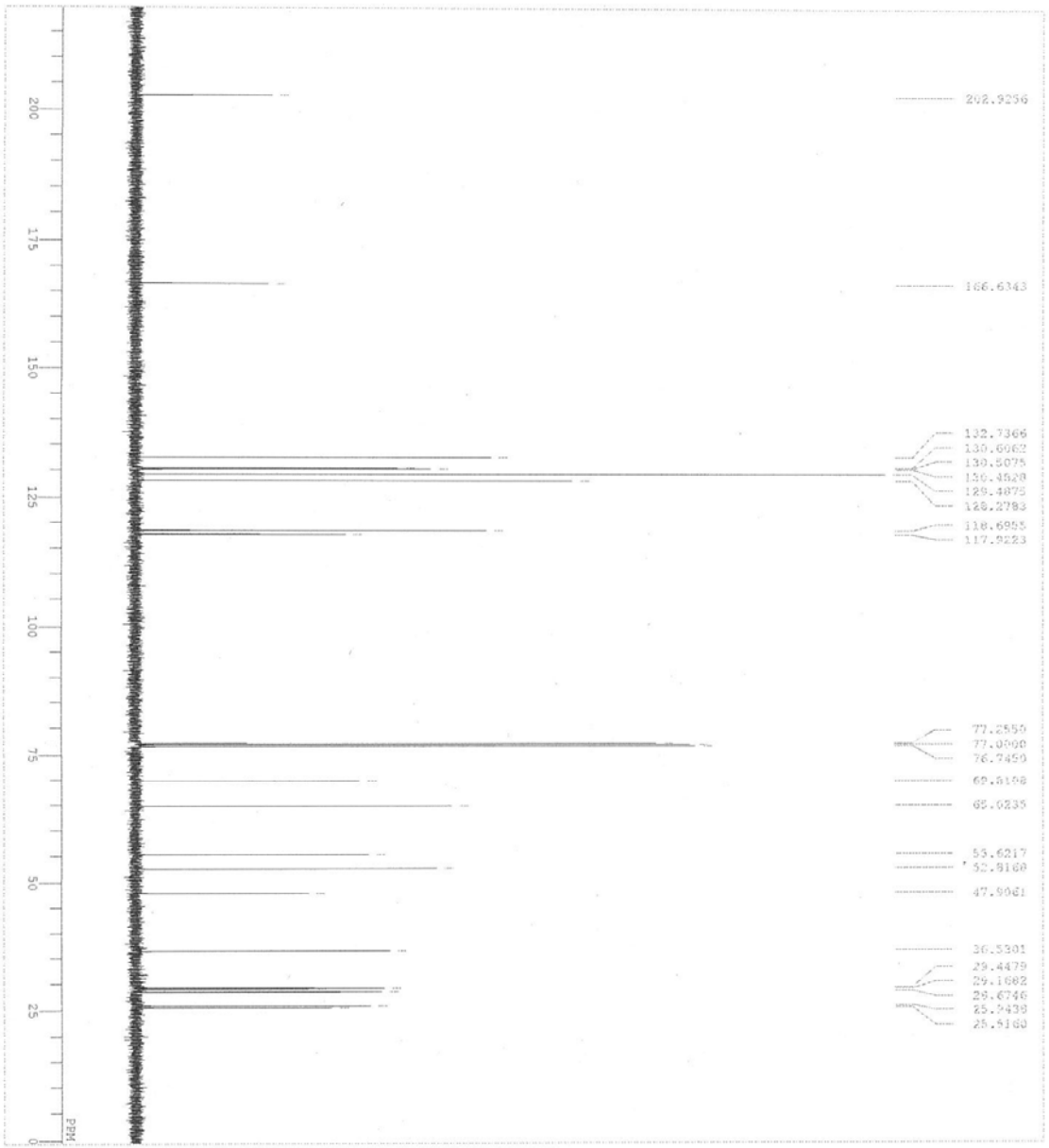

Ph
OH
S
N
3ah


DFILE MIB-062-C.als
COMNT MIB-062-C
DATIM 13-09-2009 10:37:50
OBSNU 13C
EXMOD single pulse.dec
OBFRQ 125.76 MHz
OBSET 2.51 KHz
OBFIN 6.71 Hz
POINT 26214
FREQU 30863.73 Hz
SCANS 1168
ACQTM 0.8493 sec
FD 2.0000 sec
PW1 3.20 usec
IRNUC 1H
CTEMP 25.1 c
SLVNT CDCl3
EXREF 77.00 ppm
BF 0.12 Hz
RGAIN 60





DFILE MIB-099.mndata
COMNT MIB-099
DATTM Fri Oct 9 00:11:24 2009
OBNUC 1H
EXMOD noe
OBFRQ 500.00 MHz
OBSET 160.00 KHz
OBFIN 2160.00 Hz
POINT 32768
FREQU 10000.00 Hz
SCANS 16
ACQTM 3.2768 sec
PD 3.7232 sec
PW1 6.05 usec
IRNUC 1H
CTEMP 29.0 c
SLVNT CDCL3
EXREF 7.26 ppm
BF 1.20 Hz
RGAIN 17


MIB-099-C
202.9256
166.6343
132.7366
130.6062
130.5075
130.4628
129.4875
128.2783
118.6955
117.9223
77.2550
77.0000
76.7450
69.5198
65.0235
55.6217
52.8168
47.9061
36.5301
29.4479
29.1682
28.6746
25.9438
25.5169
PPM
DFILE MIB-099-C.nmdata
COMNT MIB-099-C
DATIM Fri Oct 9 00:39:17 2009
OBNUC 13C
EXMOD bcm
OBFRQ 125.65 MHz
OBSET 120.00 KHz
OBFIN 7958.00 Hz
POINT 32768
FREQU 33898.30 Hz
SCANS 529
ACQTM 0.8667 sec
PD 2.0333 sec
PW1 5.50 usec
TRNUC 1H
CTEMP 30.1 c
SLVNT CDCL3
EXREF 77.00 ppm
SF 1.20 Hz
RGAIN 31
BzO
OH
S
N
3ai