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Supporting Information

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Article Title: Efficient Diastereoselective Intermolecular Rhodium-Catalysed C-H Amination

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Contents:

General. Melting points were measured in capillary tubes on a Büchi B-540 apparatus and are uncorrected. Infrared spectra were recorded on a Perkin Elmer Spectrum BX FT-IR spectrometer. Proton NMR (^{1}H) spectra were recorded with a Bruker 500 MHz or 300 MHz spectrometer. Carbon NMR (^{13}C) spectra were recorded at 125 or 75 MHz, using a broadband decoupled mode with the multiplicities obtained using a JMOD or DEPT sequence. Chemical shifts (δ) are reported in parts per million (ppm) from tetramethylsilane. NMR experiments were carried out in deuterochloroform ($CDCl_3$). Values in italics refer to the minor diastereomer, where applicable. Mass spectra were obtained either with an AEI MS-9 instrument using electrospray (ES), or from a MALDI-TOF type of instrument for the high resolution mass spectra (HRMS). Optical rotations were determined with a JASCO P-1010 polarimeter. All column chromatography was conducted on Merck silica gel 60(230-240 mesh) at medium pressure (300 mbar). All reagents were obtained from commercial suppliers unless otherwise stated. Where necessary, organic solvents were routinely dried and/or distilled prior to use and stored over molecular sieves under nitrogen.

(-)-*N*-(*p*-Toluenesulfonyl)-*p*-toluenesulfonimidamide ((-)-(*S*)-1a)

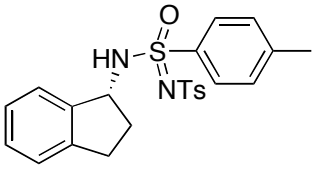
To an ice cooled suspension of anhydrous sodium *p*-toluenesulfinate (3.75 g, 21 mmol) in toluene (40 mL) under argon was slowly added thionyl chloride (7.5 mL). The reaction mixture was stirred at room temperature for 14 h before being evaporated under vacuum. The resulting yellow oil was dissolved in toluene (60 ml) and anhydrous chloramine-T (4.78 g, 21 mmol) (*Caution !* The trihydrate was dried in a drying pistol at 80°C for 8h. Explosion may occur at higher temperatures) was added at room temperature. The reaction mixture was stirred at 80 °C for 1.5 h. The sodium chloride precipitate was filtered while the reaction mixture was still hot and the filtrate was evaporated. The crude *N*-(*p*-toluenesulfonyl)-*p*-toluenesulfonimidoyl chloride was dissolved in dichloromethane (80 ml) and a mixture of (*R*)-(-)-α-methylbenzylamine (3.24 mL, 25.2 mmol) and sodium hydrogenocarbonate (2.1 g, 25.2 mmol) in water (50 ml) was added at 0°C. After 30 minutes, the ice bath was removed and the reaction mixture was stirred overnight at room temperature. The organic layer was separated and washed successively with 10% HCl and water, dried with $MgSO_4$ and concentrated under vacuum to afford a pasty yellow solid. The latter was dissolved in ethyl ether (40 ml) and after cooling, filtration afforded 2.1 g of a white solid (d.e.> 95 % as estimated by ^{1}H NMR) of a white solid. A second crop was obtained from the mother liquor (0.8 g) yielding a total of 2.9 g (6.77 mmol, 32%) of pure compound. mp 156-156.5 °C ; $[\alpha]_D^{20}$ + 118.8° (c 0.44, $CHCl_3$); IR (cm^{-1}) 3232, 1594, 1301, 1152, 1106, 1070, 1017, 813, 755, 700, 657 ; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.35 (d, J = 7.0 Hz, 3H), 2.41 (s, 3H), 2.43 (s, 3H), 4.52 (q, J = 7.0Hz, 1H), 6.18 (d, J = 7.0 Hz, 1H), 7.26 (m, 9H), 7.82 (m, 4H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.58, 21.6, 23.0, 54.0, 126.4, 126.9, 127.8, 127.9, 128.7, 129.3, 129.7, 136.2, 140.5, 141.8, 142.9, 144.7; mass spectrum (ES) m/z 451 $(M+Na)^+$; Anal. Calcd for $C_{22}H_{24}N_2O_3S_2$: C, 61.66 ; H, 5.64 ; N, 6.54 ; S, 14.96% found : C, 61.26 ; H, 5.53 ; N, 6.57 ; S, 14.93%.

2.9 g (6.77 mmol) of the pure diastereoisomer was dissolved in trifluoroacetic acid (6 mL). After stirring for 40 h at 35°C, the reaction mixture was evaporated under vacuum, leaving a crude green solid. The latter was purified by flash chromatography (heptane/ethyl acetate 1:1) and then crystallized from ethyl acetate to afford (-)-*N*-(*p*-toluenesulfonyl)-*p*-toluenesulfonimidamide **(-)-(*S*)-1a** (1.6 g, 72%). mp 152.0-152.5°C ; $[\alpha]_D^{20}$ - 110° (c 0.47, acetone); e.e.>99% (HPLC, Chiracel AD, 4.6*250, 10 μ); IR (KBr, cm^{-1}) 3212, 1284, 1149, 1107, 1087, 810, 748, 660 ; ^{1}H NMR (300 MHz, $CDCl_3$) δ 2.40 (s, 3H), 2.42 (s, 3H), 5.60 (s, 2H), 7.25 (d, J = 7.5Hz, 2H), 7.29 (d, J = 7.9 Hz, 2H), 7.79 (d, J = 7.5 Hz, 2H), 7.84 (d, J = 7.6 Hz, 2H) ; ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.5, 21.6, 126.7, 127.2, 129.3, 129.8, 137.1, 140.0, 143.1, 145.0; mass spectrum (ES) m/z 347 $(M+Na)^+$; Anal. Calcd for $C_{14}H_{16}N_2O_3S_2$: C, 51.83 ; H, 4.97 ; N, 8.63 ; S, 19.77% found : C, 51.58 ; H, 4.92 ; N, 8.55 ; S, 20.04%

Typical C-H insertion procedure:

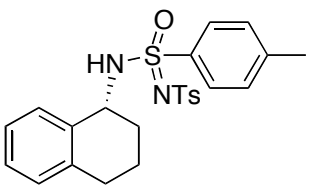
In an oven-dried tube was introduced activated 4 Å molecular sieves (100 mg), $Rh_2\{(S)\text{-nttl}\}_4$ (8.7 mg, 0.006 mmol) and (-)-*N*-(*p*-toluenesulfonyl)-*p*-toluenesulfonimidamide **(-)-(*S*)-1a** (78 mg, 0.24 mmol) *(except for compound **ent-4a** where we used $Rh_2\{(\mathbf{R})\text{-ntv}\}_4$ (8.3 mg, 0.006 mmol) and (+)-(R)-N-(p-toluenesulfonyl)-p-toluenesulfonimidamide (78 mg, 0.24 mmol))*. The tube was capped with a rubber septum and purged with argon. 1,1,2,2-Tetrachloroethane (0.75 mL) and methanol (0.25 mL) were added under argon, and the mixture was stirred for 5 min before addition of the substrate (0.2 mmol). The tube was cooled to –35°C, and bis(*tert*-butylcarbonyloxy)iodobenzene (115 mg, 0.28 mmol) was added. The mixture was stored in the freezer (-35°C) for 3 days. After dilution with dichloromethane (3 mL), the molecular sieves were removed by filtration and the filtrate was evaporated to dryness under reduced pressure. The oily residue was purified by flash chromatography on silica gel, affording the following C-H insertion products:

(1*R*)-[*N*-(*p*-Toluenesulfonyl)-*p*-toluenesulfonimidoyl]-1-aminoindane 3a



Prepared from indane **3**, the corresponding C-H insertion product was obtained (dichloromethane/ethyl acetate: 20/1) as a white solid in 88% yield and >99% d.e. (HPLC, Hypercarb column, 100*4.6mm, 5µ, MeCN+0.1%HCOOH/H_2O+0.1%HCOOH: 80/20, 1mL/min); m.p.=166-167°C; $[\alpha]_D^{20}$ + 90.1° (c 0.41, $CHCl_3$); MS *m/z* 440 (M+); HRMS *m/z* ((M+Na)+) calcd for $C_{23}H_{24}N_2NaO_3S_2$ 463.1126 found 463.1132; IR (cm^{-1}) 3229, 1593, 1478, 1315, 1241, 1155, 1081, 1066, 1014; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.65-1.79 (m, 1H, CH_2-H_a), 2.11-2.22 (m, 1H, CH_2-H_b), 2.43 (s, 3H), 2.46 (s, 3H), 2.64-2.78 (m, 1H, CH_2'-H_a), 2.85-2.95 (m, 1H, CH_2'-H_b), 4.83 (q, J = 7.3 Hz, 1H, CH-N), 6.12 (d, J = 7.6 Hz, 1H, NH), 7.18-7.41 (m, 8H), 7.84-7.92 (m, 4H); ^{13}C NMR (75MHz, $CDCl_3$) δ 21.6, 21.7, 30.0, 33.6, 58.4, 124.6, 124.8, 126.8, 127.1, 127.9, 128.6, 129.3, 129.9, 136.3, 140.4, 141.1, 142.7, 142.9, 144.9;

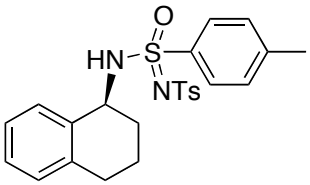
(1*R*)-[*N*-(*p*-Toluenesulfonyl)-*p*-toluenesulfonimidoyl]-1-amino-1,2,3,4-tetrahydronaphthalene 4a



Prepared from 1,2,3,4-tetrahydronaphthalene **4**, the corresponding C-H insertion product was obtained (dichloromethane/ethyl acetate: 20/1) as a white solid in 80% yield and >96% d.e. (HPLC,

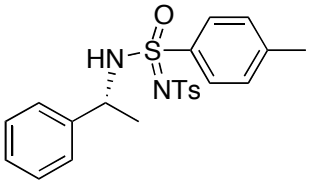
Symmetry shield column, 150*4.6mm, 5μ, MeCN+0.1%HCOOH/H_2O+0.1%HCOOH: 46/54), 1mL/min); m.p.=156-157°C; $[\alpha]_D^{20}$ + 91.9° (c 0.46, $CHCl_3$); MS *m/z* 454 (M+); HRMS *m/z* ((M+Na)+) calcd for $C_{24}H_{26}N_2NaO_3S_2$ 477.1283 found 477.1291; IR (cm^{-1}) 3222, 1596, 1489, 1302, 1292, 1259, 1143, 1093, 1053, 1016, 1001; ^1H NMR (300 MHz, $CDCl_3$) δ 1.40-1.70 (m, 4H), 2.34 (s, 3H), 2.37 (s, 3H), 2.50-2.74 (m, 2H), 4.50 (q, J = 5.2 Hz, 1H, CH-N), 5.97 (d, J = 7.1 Hz, 1H, NH), 6.97-7.36 (m, 8H), 7.72-7.81 (m, 4H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 19.1, 21.6, 21.7, 28.7, 29.7, 51.8, 126.6, 126.8, 127.8, 128.0, 129.2, 129.3, 129.5, 129.9, 134.5, 136.9, 137.4, 140.4, 142.9, 144.8

(1*S*)-[*N*-(*p*-Toluenesulfonyl)-*p*-toluenesulfonimidoyl]-1-amino-1,2,3,4-tetrahydronaphthalene ent-4a



Prepared from 1,2,3,4-tetrahydronaphthalene **using the rhodium complex and sulfonimidamide of opposite configuration (see procedure above)**, the corresponding C-H insertion product was obtained (dichloromethane/ethyl acetate:20/1) as a white solid in 83% yield and >99% d.e. (HPLC, Symmetry shield column, 150*4.6mm, 5μ, MeCN+0.1%HCOOH/H_2O+0.1%HCOOH: 46/54), m.p.=156-157°C; $[\alpha]_D^{20}$ - 92.1° (c 0.48, $CHCl_3$); MS *m/z* 454 (M+); HRMS *m/z* ((M+Na)+) calcd for $C_{24}H_{26}N_2NaO_3S_2$ 477.1283 found 477.1297; IR (cm^{-1}) 3222, 1596, 1489, 1302, 1292, 1259, 1143, 1093, 1053, 1016, 1001; ^1H NMR (300 MHz, $CDCl_3$) δ 1.51-1.76 (m, 4H), 2.44 (s, 3H), 2.47 (s, 3H), 2.63-2.81 (m, 2H), 4.60 (q, J = 5.6 Hz, 1H, CH-N), 6.03 (d, J = 7.2 Hz, 1H, NH), 7.06-7.45 (m, 8H), 7.82-7.91 (m, 4H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 19.5, 21.9, 22.0, 29.2, 30.1, 52.2, 127.0 127.2, 128.2, 128.4, 129.6, 129.7, 129.9, 130.3, 134.9, 137.3, 137.8, 140.8, 143.3, 145.2

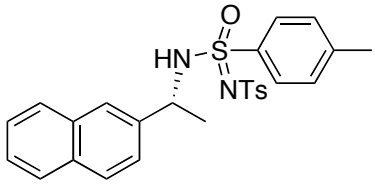
(1*R*)-[*N*-(*p*-Toluenesulfonyl)-*p*-toluenesulfonimidoyl]-1-aminoethylbenzene 5a



Prepared from ethylbenzene **5**, the corresponding C-H insertion product was obtained (dichloromethane/ethyl acetate:20/1) as a white solid in 73% yield and >97% d.e. (HPLC, Hypercarb column, 100*4.6mm, 5μ, MeCN+0.1%HCOOH/H_2O+0.1%HCOOH: 70/30, 1mL/min); m.p.=155-156°C; $[\alpha]_D^{20}$ + 121.3° (c 0.40, $CHCl_3$); MS *m/z* 428 (M+); HRMS *m/z* ((M+Na)+) calcd for $C_{22}H_{24}N_2NaO_3S_2$ 451.1126 found 451.1103; I.R. (cm^{-1}) 3289, 1597, 1493, 1317, 1244, 1153,

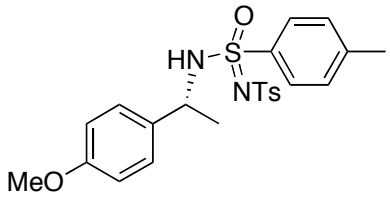
1113, 1087, 1068, 1033; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.26 (d, J = 6.9 Hz, 3H), 2.31 (s, 3H), 2.33 (s, 3H), 4.41 (quint, J = 6.8 Hz, 1H, CH-N), 6.09 (d, J = 6.8 Hz, 1H, NH), 7.09-7.22 (m, 8H), 7.67-7.71 (m, 4H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.9, 23.4, 54.3, 126.8, 127.2, 128.1, 128.2, 129.0, 129.6, 130.0, 136.4, 140.8, 142.1, 143.2, 145.0

(1*R*)-[*N*-(*p*-Toluenesulfonyl)-*p*-toluenesulfonimidoyl]-2-(1-aminoethyl)naphthalene 6a



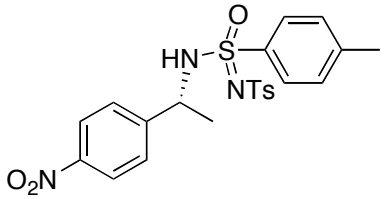
Prepared from ethylnaphthalene **6**, the corresponding C-H insertion product was obtained (dichloromethane/ethyl acetate:20/1) as a white solid in 87% yield and 96% d.e. (HPLC, Symmetry shield column, 150*4.6mm, 5µ, MeCN+0.1%HCOOH/H_2O+0.1%HCOOH: 46/54); m.p.=160-161°C; $[\alpha]_D^{20}$ + 169.1° (c 0.41, $CHCl_3$); MS *m/z* 478 (M+); HRMS *m/z* ((M+Na)+) calcd for $C_{26}H_{26}N_2NaO_3S_2$ 501.1283 found 501.1298; IR (cm^{-1}) 3262, 1595, 1493, 1306, 1263, 1146, 1100, 1046, 1015; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.37 (d, J = 6.9 Hz, 3H), 2.22 (s, 3H), 2.26 (s, 3H), 4.60 (quint, J = 6.8 Hz, 1H, CH-N), 6.09 (d, J = 6.7 Hz, 1H, NH), 7.02-7.07 (m, 4H), 7.25-7.30 (m, 1H), 7.37-7.43 (m, 2H), 7.53-7.55 (m, 1H), 7.64-7.74 (m, 7H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.5, 22.9, 54.2, 124.2, 125.3, 126.1, 126.3, 126.7, 127.6, 127.8, 128.0, 128.5, 129.2, 129.6, 132.8, 133.1, 135.8, 138.7, 140.3, 142.8, 144.6

(1*R*)-[*N*-(*p*-Toluenesulfonyl)-*p*-toluenesulfonimidoyl]-4-(1-aminoethyl)anisole 7a



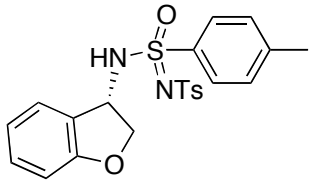
Prepared from 4-ethylanisole **7**, the corresponding C-H insertion product was obtained (dichloromethane/ethyl acetate:20/1) as a white solid in 93% yield and 98% d.e. (HPLC, Hypercarb column, 100*4.6mm, 5µ, MeCN+0.1%HCOOH/H_2O+0.1%HCOOH: 90/10, 1mL/min); m.p.=146-147°C; $[\alpha]_D^{20}$ + 114.8° (c 0.41, $CHCl_3$); MS *m/z* 458 (M+); HRMS *m/z* ((M+Na)+) calcd for $C_{23}H_{26}N_2NaO_4S_2$ 481.1232 found 481.1236; IR (cm^{-1}) 3212, 1610, 1586, 1511, 1413, 1310, 1243, 1185, 1150, 1105, 1057, 1037, 1015; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.32 (d, J = 6.8 Hz, 3H), 2.40 (s, 3H), 2.42 (s, 3H), 3.80 (s, 3H), 4.48 (quint, J = 6.7 Hz, 1H, CH-N), 6.09 (d, J = 6.5 Hz, 1H, NH), 6.78-6.83 (m, 2H), 7.15-7.28 (m, 6H), 7.76-7.79 (m, 4H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.5, 22.8, 53.4, 55.4, 114.0, 126.8, 127.6, 127.8, 129.2, 129.7, 133.6, 136.1, 140.3, 142.8, 144.6, 159.1

(1*R*)-[N-(p-Toluenesulfonyl)-p-toluenesulfonimidoyl]-1-(1-aminoethyl)-4-nitrobenzene 8a



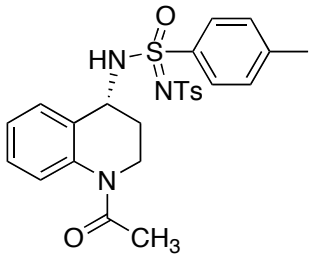
Prepared from 1-ethyl-4-nitrobenzene **8**, the corresponding C-H insertion product was obtained (dichloromethane/ethyl acetate:10/1) as an oily solid in 51% yield and 80% d.e. (HPLC, Hypercarb column, 100*4.6mm, 5µ, MeCN+0.1%HCOOH/H_2O+0.1%HCOOH: 85/15, 1mL/min); MS *m/z* 473 (M+); HRMS *m/z* ((M+Na)+) calcd for $C_{22}H_{23}N_3NaO_5S_2$ 496.0977 found 496.0961; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.31 (d, J=6.9 Hz, 3H), *1.47 (d, J=6.9 Hz, 3H),* 2.32 (s, 6H), 4.43 (quint, J=6.9 Hz, 1H, CHN), *4.54 (quint, J=6.8 Hz, 1H, CHN)*, 6.81 (d, J = 6.9 Hz, 1H, NH), *6.92 (d, J = 6.9 Hz, 1H, NH)*, 7.09-8.01 (m, 12H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.6, 22.9, *23.4*, 53.9, *123.5*, 123.7, 126.7, 127.4, *127.5, 127.6*, 127.8, 129.3, 129.8, 135.4, 140.2, 143.1, 144.9, 147.1, 149.4

(3*R*)-[*N*-(*p*-Toluenesulfonyl)-*p*-toluenesulfonimidoyl]-3-amino-2,3-dihydrobenzofuran 9a



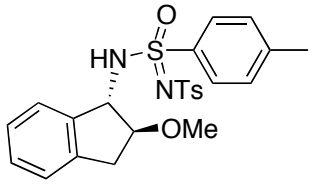
Prepared from 2,3-dihydrobenzofuran **9**, the corresponding C-H insertion product was obtained (dichloromethane/ethyl acetate: 10/1) as a white solid in 80% yield and 93% d.e. (HPLC, Hypercarb column, 100*4.6mm, 5µ, MeCN+0.1%HCOOH/H_2O+0.1%HCOOH: 90/10, 1mL/min); m.p.=163-164°C; $[\alpha]_D^{20}$ + 88.5° (c 0.475, $CHCl_3$); MS *m/z* 442 (M+); HRMS *m/z* ((M+Na)+) calcd for $C_{22}H_{22}N_2NaO_4S_2$ 465.0919 found 465.0891; IR (cm^{-1}) 3206, 1594, 1479, 1314, 1237, 1154, 1103, 1078, 1013, 981; ^{1}H NMR (300 MHz, $CDCl_3$) δ 2.34 (s, 3H), 2.38 (s, 3H), 4.14 (dd, J=4.1 Hz and J'=10.4 Hz, C_2H_a), 4.30 (dd, J=7.9 Hz and J'=10.4 Hz, C_2H_b), 5.08 (m, 1H, C_3H-N), 5.97 (d, J = 7.7 Hz, 1H, NH), 6.71-6.84 (m, 2H), 7.08-7.28 (m, 6H), 7.73-7.79 (m, 4H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.6, 21.7, 55.5, 76.0, 110.5, 121.5, 124.2, 125.7, 126.8, 127.6, 129.1, 130.1, 130.9, 136.3, 140.3, 143.1, 145.2, 160.0

(4*R*)-1-*N*-Acetyl-4-[*N*-(*p*-toluenesulfonyl)-*p*-toluenesulfonimidoyl]-amino-1,2,3,4-tetrahydroquinoline 10a



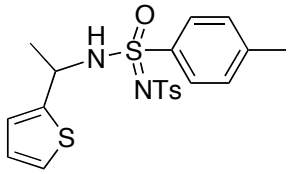
Prepared from N-acetyl-1,2,3,4-tetrahydroquinoline **10**, the corresponding C-H insertion product was obtained (dichloromethane/ethyl acetate:10/1) as a white solid in 62% yield and >99% d.e. (HPLC, Hypercarb column, 100*4.6mm, 5µ, MeCN+0.1%HCOOH/H_2O+0.1%HCOOH: 85/15, 1mL/min); m.p.=167-168°C; $[\alpha]_D^{20}$ + 96.8° (c 0.445, $CHCl_3$); MS *m/z* 497 (M+); HRMS *m/z* ((M+Na)+) calcd for $C_{25}H_{27}N_3NaO_4S_2$ 520.1341 found 520.1319; IR (cm^{-1}) 3164, 2970, 1625, 1579, 1491, 1401, 1318, 1299, 1253, 1152, 1106, 1074, 1042, 1015; ^1H NMR (300 MHz, $CDCl_3$) δ 1.66-1.81 (m, 2H, C_3H), 2.12 (s, 3H), 2.34 (s, 3H), 2.37 (s, 3H), 3.53 (m, 1H, C_2H_a), 3.68 (m, 1H, C_2H_b), 4.43 (m, 1H, C_4H-N), 6.35 (d, J = 7.0 Hz, 1H, NH), 7.10-7.25 (m, 7H), 7.46 (m, 1H), 7.73-7.78 (m, 4H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.6, 21.7, 23.2, 30.9, 50.2, 124.5, 125.7, 126.8, 127.6, 128.0, 128.3, 129.3, 130.0, 136.4, 138.4, 140.3, 143.0, 145.1, 170.1

(1*R*,2*S*)-*Trans*-[N-(p-Toluenesulfonyl)-p-toluenesulfonimidoyl]-1-amino-2-methoxyindane 11a



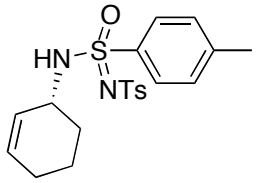
Prepared from 2-methoxyindane **11**, the corresponding C-H insertion product was obtained (dichloromethane/ethyl acetate: 10/1) as a white solid in 62% yield and >99% d.e. (HPLC, Hypercarb column, 100*4.6mm, 5µ, MeCN+0.1%HCOOH/H_2O+0.1%HCOOH: 100/0, 1mL/min); m.p.=112-113°C; $[\alpha]_D^{20}$ + 106.2° (c 0.50, $CHCl_3$); MS *m/z* 470 (M+); HRMS *m/z* ((M+Na)+) calcd for $C_{24}H_{26}N_2NaO_4S_2$ 493.1256 found 493.1208; I.R. (cm^{-1}) 3176, 2926, 1594, 1445, 1299, 1255, 1148, 1122, 1099, 1056; ^1H NMR (300 MHz, $CDCl_3$) δ 2.34 (s, 3H), 2.36 (s, 3H), 2.58 (dd, J=6.3 Hz and J'=15.7 Hz, 1H, C_3H_a), 2.93 (s, 3H, OCH_3), 3.11 (dd, J=6.9 Hz and J'=15.8 Hz, 1H, C_3H_b), 3.73 (q, J=6.5 Hz, 1H, C_2H), 4.64 (dd, J = 5.8 Hz and J'=8.2 Hz, 1H, CH-N), 6.36 (d, J = 8.2 Hz, 1H, NH), 7.05-7.37 (m, 8H), 7.74-7.84 (m, 4H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.6, 21.7, 35.8, 57.1, 63.0, 87.7, 125.0, 125.2, 126.8, 127.6, 128.2, 129.0, 129.3, 129.6, 136.4, 138.4, 139.4, 140.4, 143.0, 144.7

(1*R*)-[N-(p-Toluenesulfonyl)-p-toluenesulfonimidoyl]-2-(1-aminoethyl)-thiophene 12a



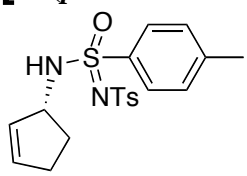
Prepared from 2-ethylthiophene **12**, the corresponding C-H insertion product was obtained (dichloromethane/ethyl acetate: 20/1) as a white solid in 78% yield and >98% d.e. (HPLC) m.p.=126-127°C; $[\alpha]_D^{20}$ + 97.3° (c 0.53, $CHCl_3$); MS *m/z* 434 (M+); HRMS *m/z* ((M+Na)+) calcd for $C_{20}H_{22}N_2NaO_3S_3$ 457.0690 found 457.0709; I.R. (cm^{-1}) 3274, 2983, 1593, 1420, 1317, 1247, 1155, 1121, 1074, 1013; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.34 (d, J=6.8 Hz, 3H), 2.32 (s, 3H), 2.34 (s, 3H), 4.72 (quint, J=6.9 Hz, 1H, CHN), 6.06 (d, J = 7.2 Hz, 1H, NH), 6.80-7.2 (m, 7H), 7.70-7.75 (m, 4H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.6, 23.3, 49.5, 125.1, 125.2, 126.8, 127.8, 129.2, 129.8, 136.0, 140.1, 142.9, 144.8, 145.1

[*N*-(*p*-Toluenesulfonyl)-*p*-toluenesulfonimidoyl]-3-aminocyclohex-1-ene 13a



Prepared from cyclohexene **13**, the corresponding C-H insertion product was obtained (dichloromethane/ethyl acetate: 20/1) as an oily solid in 75% yield and 38% d.e. (HPLC, Hypercarb column, 100*4.6mm, 5µ, MeCN+0.1%HCOOH/H_2O+0.1%HCOOH: 80/20, 1mL/min); MS *m/z* 404 (M+); HRMS *m/z* ((M+Na)+) calcd for $C_{20}H_{24}N_2NaO_3S_2$ 427.1126 found 427.1151; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.14-1.99 (m, 6H), 2.33 (s, 3H), 2.35 (s, 3H), *3.65 (m, 1H, C_3H-N)*, 3.75 (m, 1H, C_3H-N), *5.19 (m, 1H, C_1H)*, 5.53 (m, 1H, C_1H), 5.69-5.84 (m, 2H, C_2H+NH), 7.15-7.24 (m, 4H), 7.72-7.77 (m, 4H); ^{13}C NMR (75 MHz, $CDCl_3$) δ *19.1*, 19.4, 21.6, 21.7, 24.4, *24.5*, 29.3, *30.5, 49.0*, 49.1, *125.7*, 126.8, 127.0, 127.9, 129.2, 129.9, 132.0, *132.6*, *136.2*, 136.4, 140.4, 142.8, 144.7

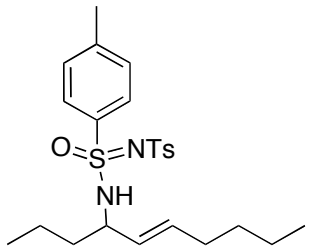
[*N*-(*p*-Toluenesulfonyl)-*p*-toluenesulfonimidoyl]-3-aminocyclopent-1-ene 14a



Prepared from cyclopentene **14**, the corresponding C-H insertion product was obtained (dichloromethane/ethyl acetate: 20/1) as an oily solid in 72% yield and 50% d.e. (HPLC, Hypercarb column, 100*4.6mm, 5µ, MeCN+0.1%HCOOH/H_2O+0.1%HCOOH: 80/20, 1mL/min); MS *m/z* 390 (M+); HRMS *m/z* ((M+Na)+) calcd for $C_{19}H_{22}N_2NaO_3S_2$ 413.0970 found 413.0990; ^{1}H

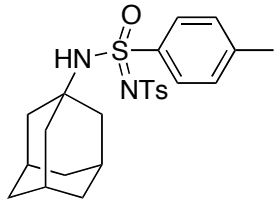
NMR (300 MHz, $CDCl_3$) δ 1.34-2.30 (m, 4H), 2.33 (s, 3H), 2.35 (s, 3H), 4.26 (m, 1H, C_3H-N), *5.29 (m, 1H, C_1H)*, 5.57 (m, 1H, C_1H), *5.71 (d, J=9.0 Hz, 1H, NH),* 5.75 (d, J=9.1 Hz, 1H, NH), 5.82-5.88 (m, 1H, C_2H), 7.15-7.24 (m, 4H), 7.72-7.77 (m, 4H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.6, 21.7, 30.7, 30.9, *31.8*, 59.6, *59.8*, 126.8, 127.9, 129.2, 129.9, 130.4, 135.6, *136.1*, 136.2, 140.5, 142.8, 144.7

[N-(p-Toluenesulfonyl)-p-toluenesulfonimidoyl]-4-amino-*trans*-5-decene 15a



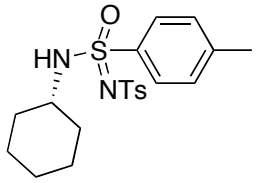
Prepared from *trans*-5-decene **15**, the corresponding C-H insertion product was obtained (dichloromethane/ethyl acetate: 20/1) as an oily solid in 55% yield and 50% d.e. (HPLC, Hypercarb column, 100*4.6mm, 5μ, MeCN+0.1%HCOOH/H_2O+0.1%HCOOH: 85/15, 1mL/min); MS *m/z* 462 (M+); HRMS *m/z* ((M+Na)+) calcd for $C_{24}H_{34}N_2NaO_3S_2$ 485.1909 found 485.1869; ^1H NMR (300 MHz, $CDCl_3$) δ 0.68-1.97 (m, 16H), 2.41 (s, 3H), 2.43 (s, 3H), 3.67 (quint, J=7.0 Hz, 1H, CH-N), *4.87 (m, 1H, C_5H),* 5.24 (m, 1H, C_5H), 5.53 (m, 1H, C_6H), 5.83 (d, J = 7.2 Hz, 1H, NH), *6.02 (d, J = 6.5 Hz, 1H, NH),* 7.22-7.31 (m, 4H), 7.73-7.87 (m, 4H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 13.5, *13.7,* 13.9, 18.5, *18.7*, 21.6, *22.1*, 22.2, *30.8*, 31.1, *31.5*, 31.8, *37.4*, 38.1, 56.2, 126.8, 127.9, 128.1, *128.2*, *128.9*, 129.2, *129.4*, 129.6, 133.6, *133.9*, 136.2, *136.6, 140.4*, 140.5, 142.7, *142.8*, 144.2, *144.5*

[*N*-(*p*-Toluenesulfonyl)-*p*-toluenesulfonimidoyl]-1-aminoadamantane 16a



Prepared from adamantane **16**, the corresponding C-H insertion product was obtained (dichloromethane/ethyl acetate: 20/1) as a white solid in 69% yield; m.p.=156-157°C; MS *m/z* 458 (M+); HRMS *m/z* ((M+Na)+) calcd for $C_{24}H_{30}N_2NaO_3S_2$ 481.1596 found 481.1604; I.R. (cm^{-1}) 3332, 2908, 1596, 1495, 1453, 1402, 1357, 1292, 1277, 1241, 1152, 1104, 1086, 1045, 1015; ^1H NMR (300 MHz, $CDCl_3$) δ 1.54-2.05 (m, 15H), 2.42 (s, 3H), 2.44 (s, 3H), 6.14 (s, 1H, NH), 7.26-7.30 (m, 4H), 7.79-7.85 (m, 4H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.6, 29.5, 35.7, 43.0, 57.6, 126.8, 127.6, 129.2, 129.6, 139.2, 140.5, 142.8, 144.2

[*N*-(*p*-Toluenesulfonyl)-*p*-toluenesulfonimidoyl]-aminocyclohexane 17a

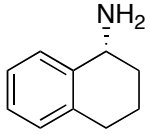


Prepared from **5 equivalents** of cyclohexane **17**, the corresponding C-H insertion product was obtained (dichloromethane/ethyl acetate:20/1) as an oily solid in 65% yield; MS *m/z* 406 (M+); HRMS *m/z* ((M+Na)+) calcd for $C_{20}H_{26}N_2NaO_3S_2$ 429.1283 found 429.1243; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.06-1.96 (m, 10H), 2.38 (s, 3H), 2.42 (s, 3H), 3.12 (m, 1H, CH-N), 5.87 (d, J = 7.8 Hz, 1H, NH), 7.22-7.29 (m, 4H), 7.77-7.83 (m, 4H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 21.6, 21.7, 24.5, 25.0, 33.1, 34.2, 52.7, 126.8, 127.8, 129.2, 129.8, 136.5, 140.4, 142.8, 144.6

Sodium/naphthalene deprotection procedure:

In an oven-dried round-bottom flask were introduced naphthalene (140 mg, 1.32 mmol), sodium (61 mg, 2.64 mmol) and freshly distilled THF (2 mL). The mixture was stirred under argon at room temperature for 2 hours, resulting in a dark green solution. Meanwhile, a solution of substrate (0.44 mmol) in freshly distilled THF (2 mL) was prepared, and then added slowly by cannula to the sodium/naphthalene solution. The solution was stirred at room temperature for 1 hour, at which time TLC showed total disappearance of the starting material. 10% aqueous HCl was added at 0°C until the solution became acidic (pH<1), and the resulting mixture was washed with diethyl ether (2*10 mL). The aqueous layer was separated, made strongly basic (pH>11) with aqueous 30% NaOH and extracted with dichloromethane (3*10 mL). The organic layer was dried on magnesium sulfate and further purified for analysis by preparative chromatography (eluent: dichloromethane/methanol: 8/2).

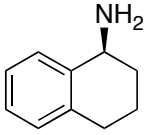
(*R*)-1,2,3,4-Tetrahydro-1-naphthylamine (*R*)-18



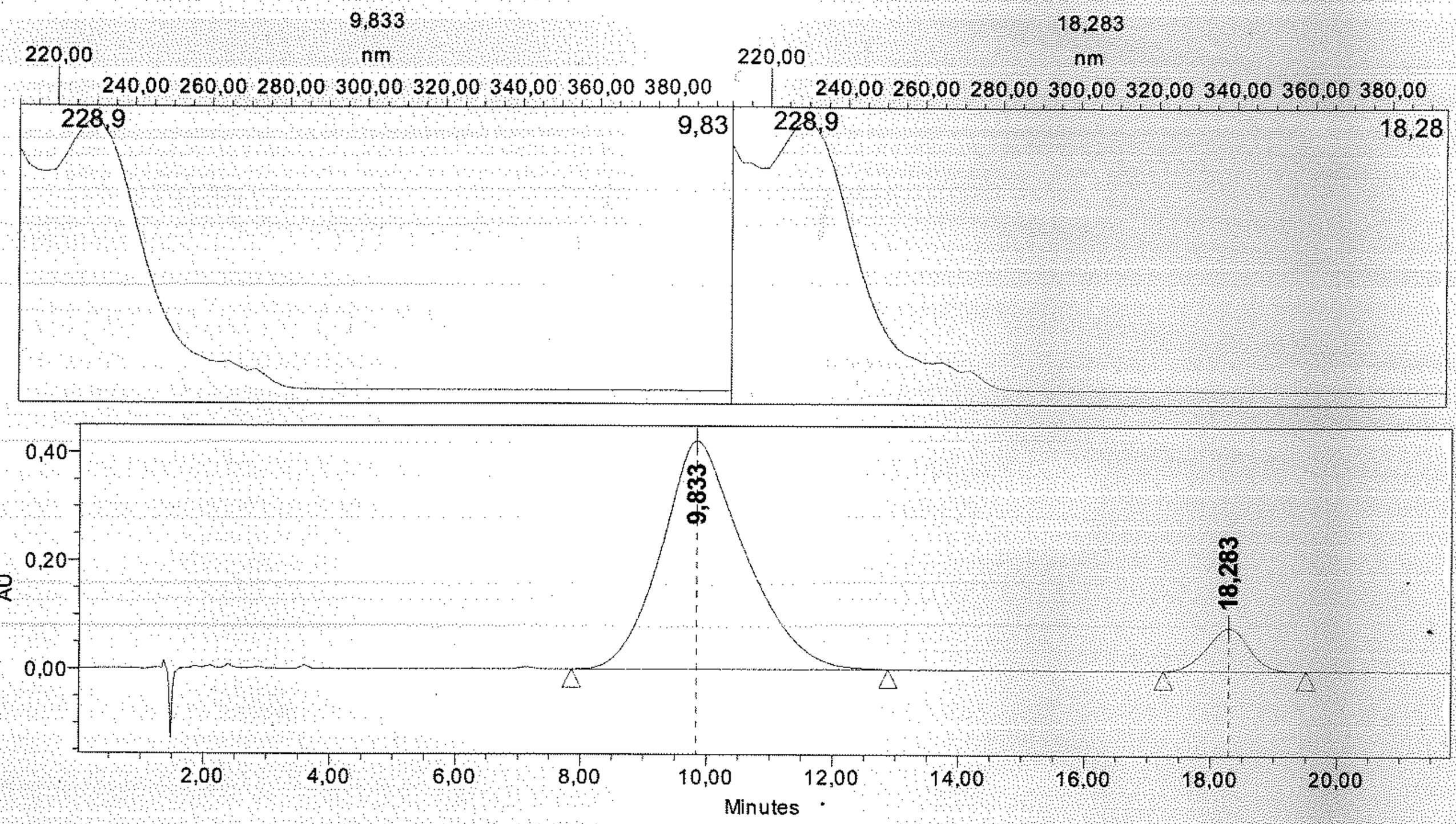
Prepared from (1*R*)-[*N*-(*p*-toluenesulfonyl)-*p*-toluenesulfonimidoyl]-1-amino-1,2,3,4-tetrahydronaphthalene **4a** (200 mg, 0.44 mmol), the corresponding deprotected product was obtained as a yellow oil in 84% yield and >95% e.e. (HPLC, Chiralcel OD, 4.6*250mm, 10µ, Hexane+0.1%NEt_3/iPrOH : 15/85, 1 mL/min); $[\alpha]_D^{20}$ - 6.5° (c 0.6, EtOH); MS *m/z* 147 (M+); HRMS *m/z* ((M+H)+) calcd for $C_{10}H_{14}N$ 148.1126 found 148.1152; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.77 (m, 2H), 2.00 (m, 2H), 2.6 (s, 2H), 2.79 (m, 2H), 4.04 (t, J=5.8 Hz, 1H), 7.09 (m, 1H), 7.17 (m,

2H), 7.41 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 19.4, 29.4, 32.9, 49.3, 126.1, 126.8, 128.1, 129.1, 136.8, 140.2

(*S*)-1,2,3,4-Tetrahydro-1-naphthylamine (*S*)-18



Prepared from (1*S*)-[*N*-(*p*-toluenesulfonyl)-*p*-toluenesulfonimidoyl]-1-amino-1,2,3,4-tetrahydronaphthalene *ent*-**4a** (200 mg, 0.44 mmol), the corresponding deprotected product was obtained as a yellow oil in 83% yield and >95% e.e. (HPLC, Chiralcel OD, 4.6*250mm, 10μ, Hexane+0.1%NEt_3/iPrOH : 15/85, 1 mL/min); $[\alpha]_D^{20}$ + 6.9° (c 0.52, EtOH) (*litt:[24] (S)-(+)* $[\alpha]_D^{20}$ *+ 1.6° (c 4.4, EtOH)*); MS *m/z* 147 (M+); HRMS *m/z* ((M+H)+) calcd for $C_{10}H_{14}N$ 148.1126 found 148.1145; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.82 (m, 2H), 2.04 (m, 2H), 2.86 (m, 2H), 4.11 (t, *J* = 5.6 Hz, 1H), 4.80 (s, 2H), 7.18 (m, 1H), 7.23 (m, 2H), 7.47 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 19.5, 29.4, 32.9, 49.5, 126.2, 126.8, 128.0, 129.1, 136.8, 140.3



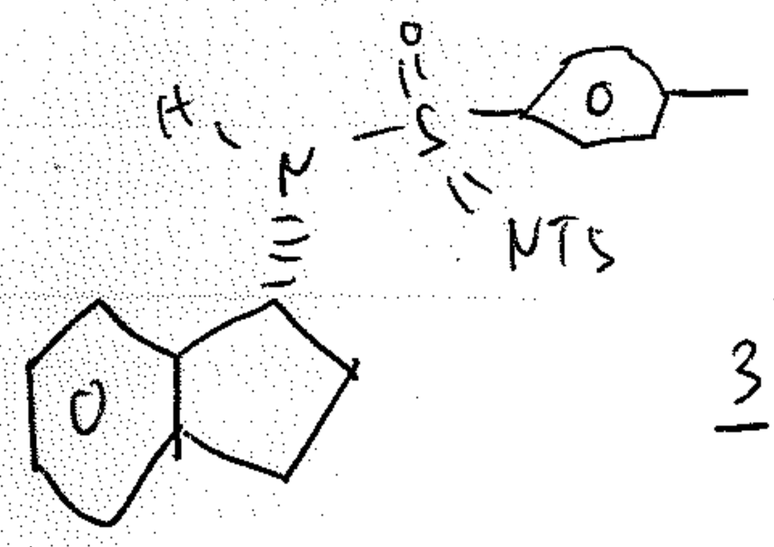
SampleName: Indane_ref_d.e.=80% (NMR); Processed Channel Descr. PDA 229,0 nm

Hypercarb column, 100*4.6 mm, 5µ
Eluent: H2O+0.1%HCOOH / MeCN+0.1%HCOOH : 20/80

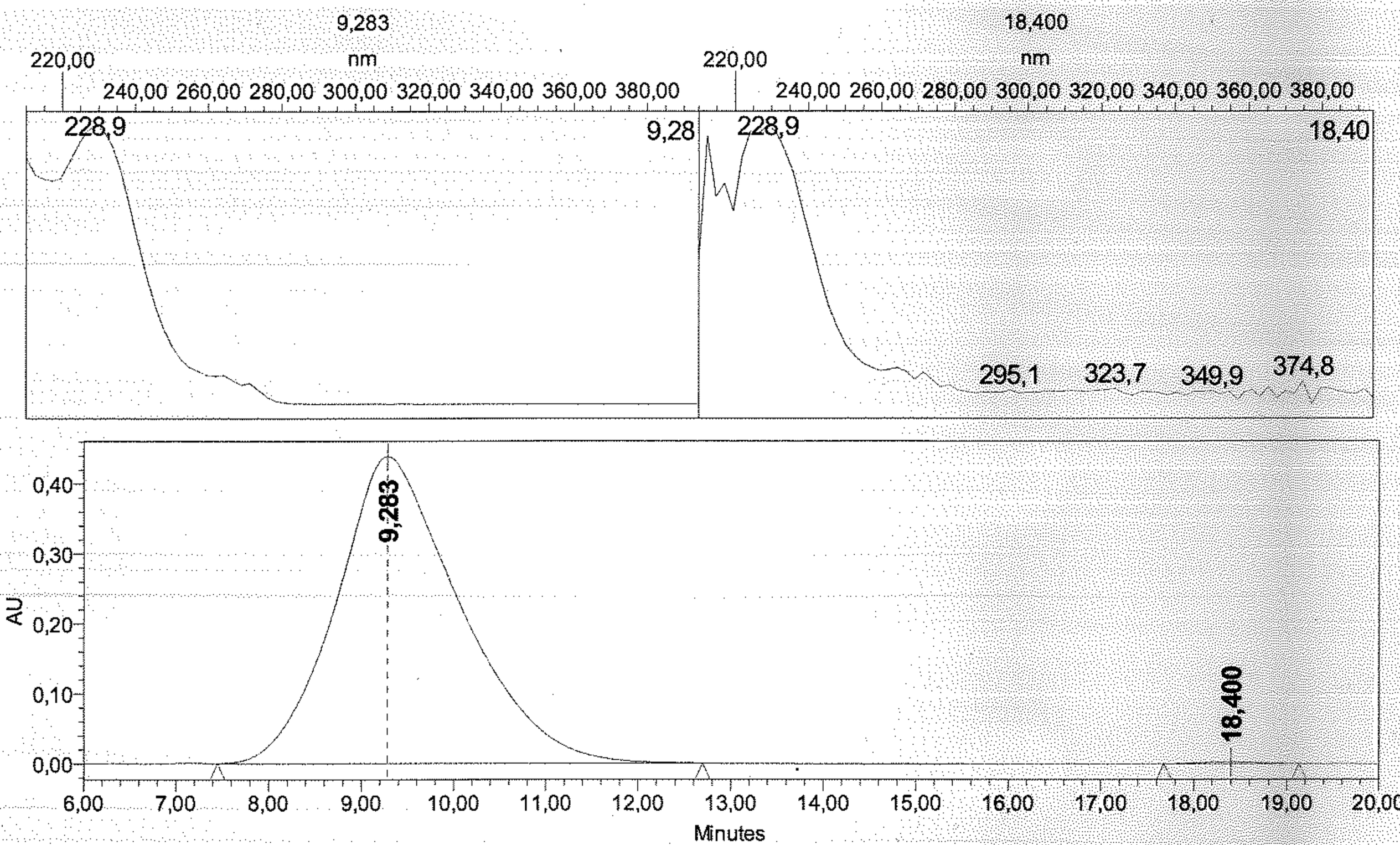
Peak Results
SampleName: Indane_ref_d.e.=80% (NMR)

	SampleName	RT	Area	Height	% Area
1	Indane_ref_d.e.=80% (NMR)	9,833	38514411	421886	91,27
2	Indane_ref_d.e.=80% (NMR)	18,283	3685009	79437	8,73

d.e = 82%



3 reference, d.e ≈ 80% (^{1}H NMR)



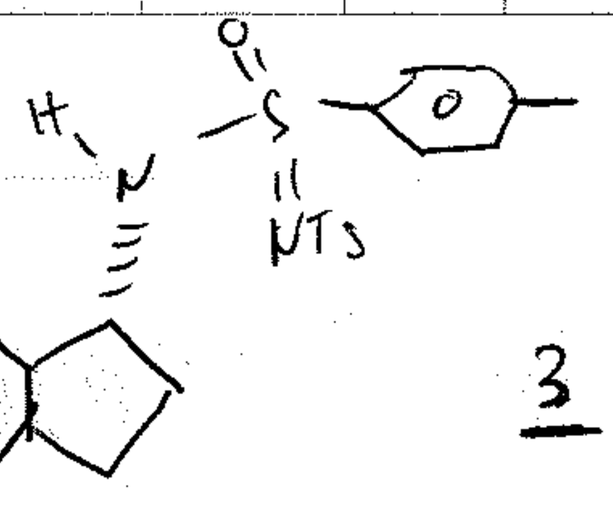
SampleName: Indane_pur; Processed Channel Descr. PDA 229,0 nm

Hypercarb column, 100*4.6 mm, 5µ
Eluent: H2O+0.1%HCOOH / MeCN+0.1%HCOOH : 20/80

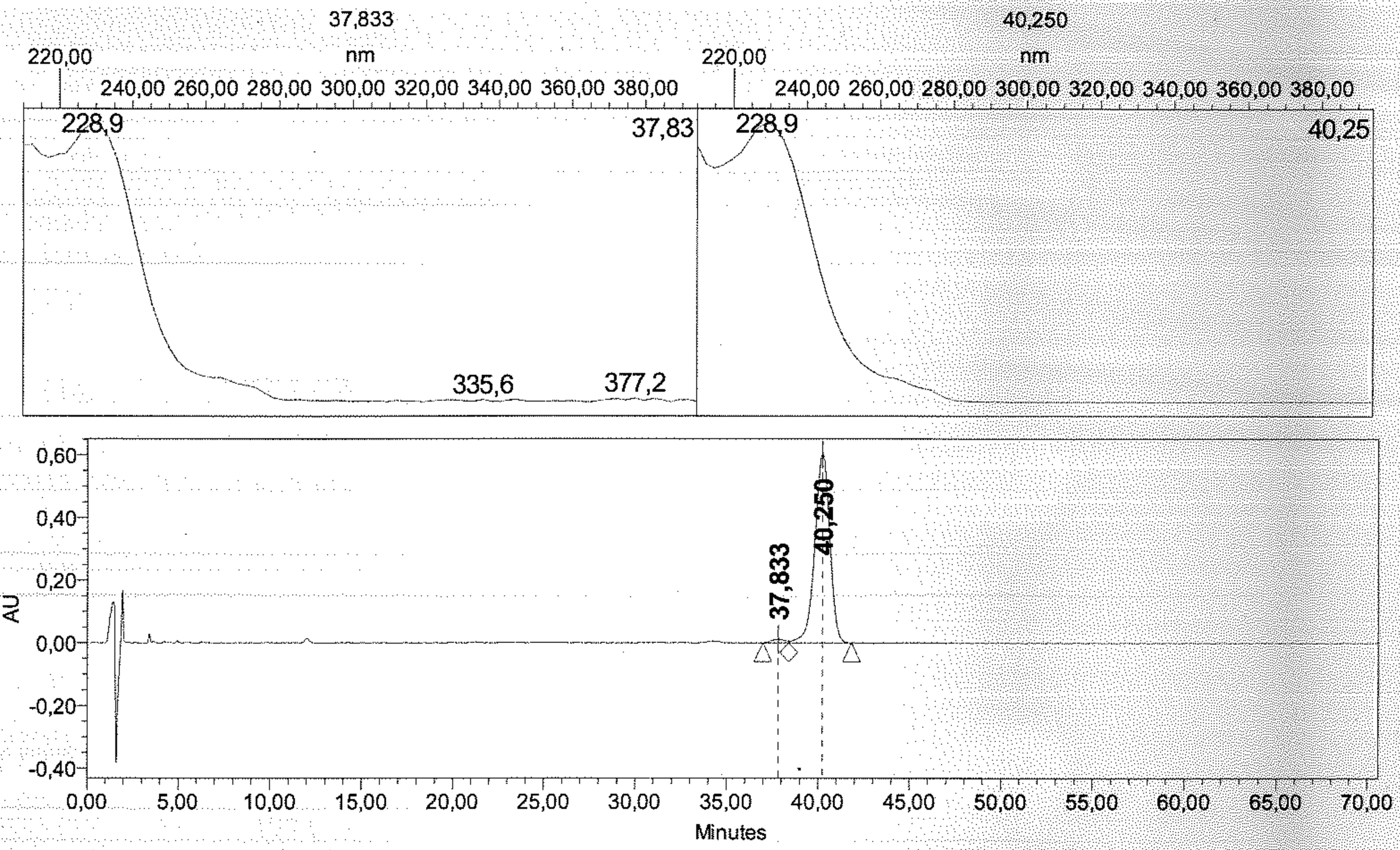
Peak Results
SampleName: Indane_pur

	SampleName	RT	Area	Height	%Area
1	Indane_pur	9,283	40711663	438813	99,75
2	Indane_pur	18,400	102191	2510	0,25

d.e > 99%



3



SampleName: (R)-Tetrahydronaphthalene_pur; Processed Channel Descr. PDA 229,0 nm

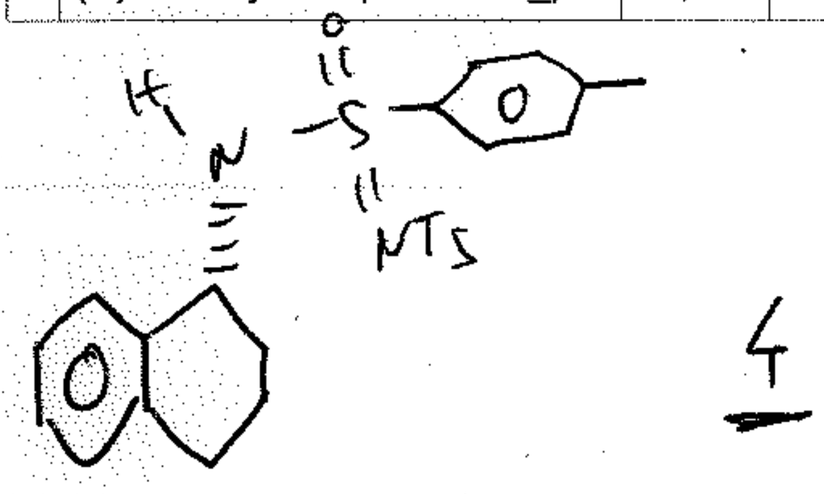
Symmetry shield column, 150*4.6, 5µ
Eluent: H2O+0.1%HCOOH / MeCN+0.1%HCOOH : 54/46

Peak Results

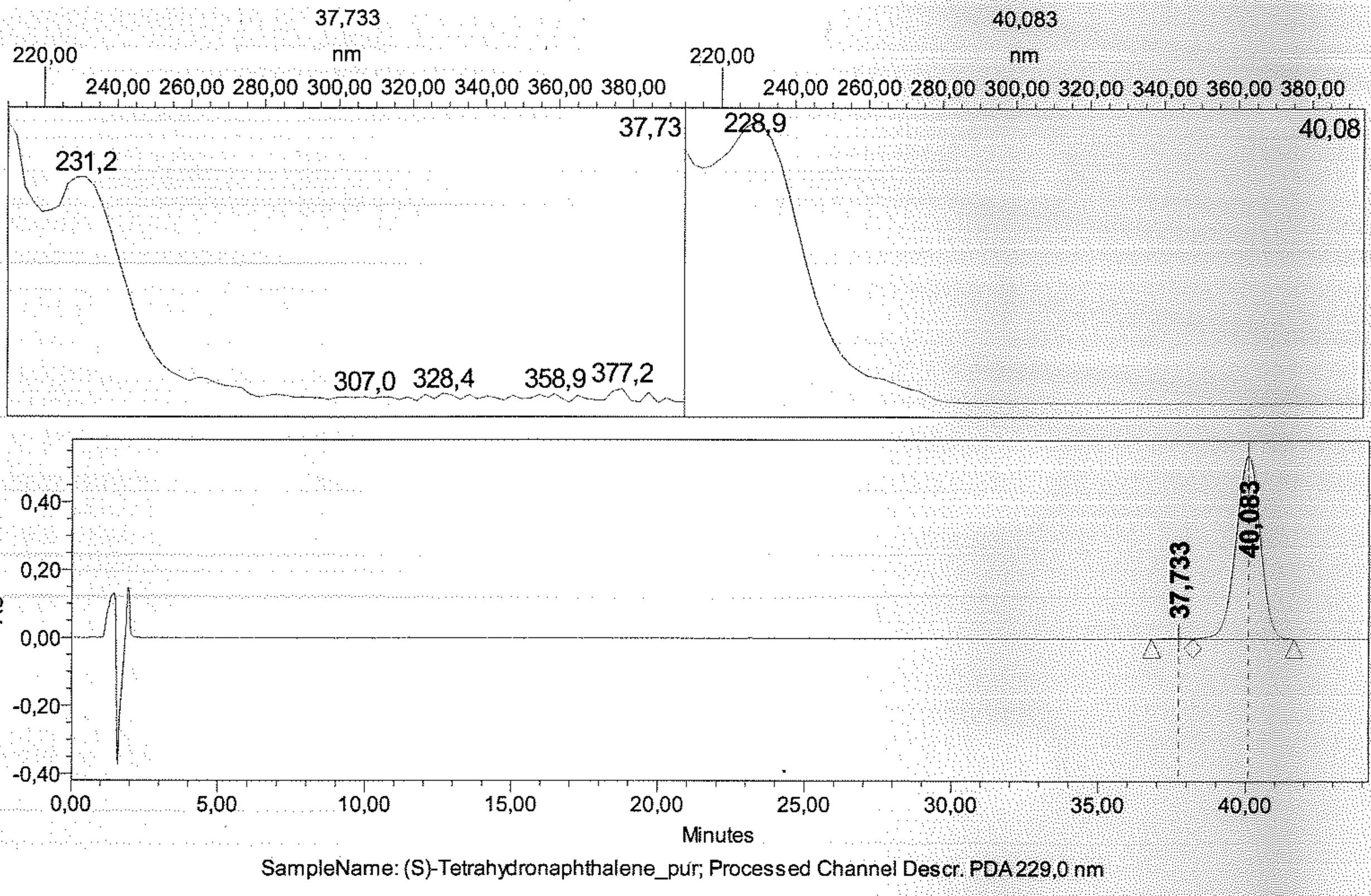
SampleName: (R)-Tetrahydronaphthalene_pur

	SampleName	RT	Area	Height	%Area
1	(R)-Tetrahydronaphthalene_pur	37,833	568770	11093	1,62
2	(R)-Tetrahydronaphthalene_pur	40,250	34480946	602057	98,38

d.e > 96%



4



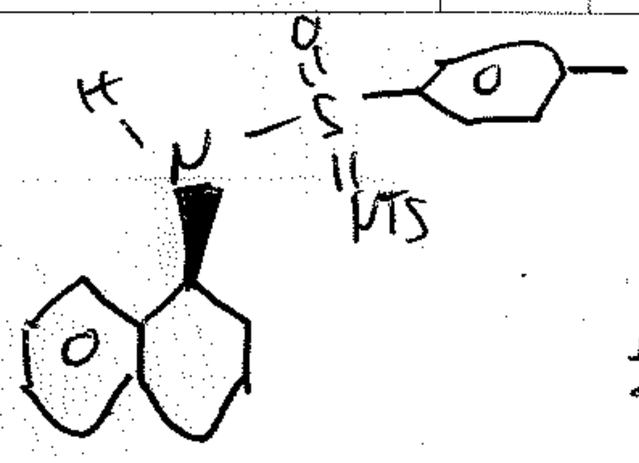
SampleName: (S)-Tetrahydronaphthalene_pur; Processed Channel Descr. PDA 229,0 nm

Symmetry shield column, 150*4.6, 5µ
Eluent: H2O+0.1%HCOOH / MeCN+0.1%HCOOH : 54/46

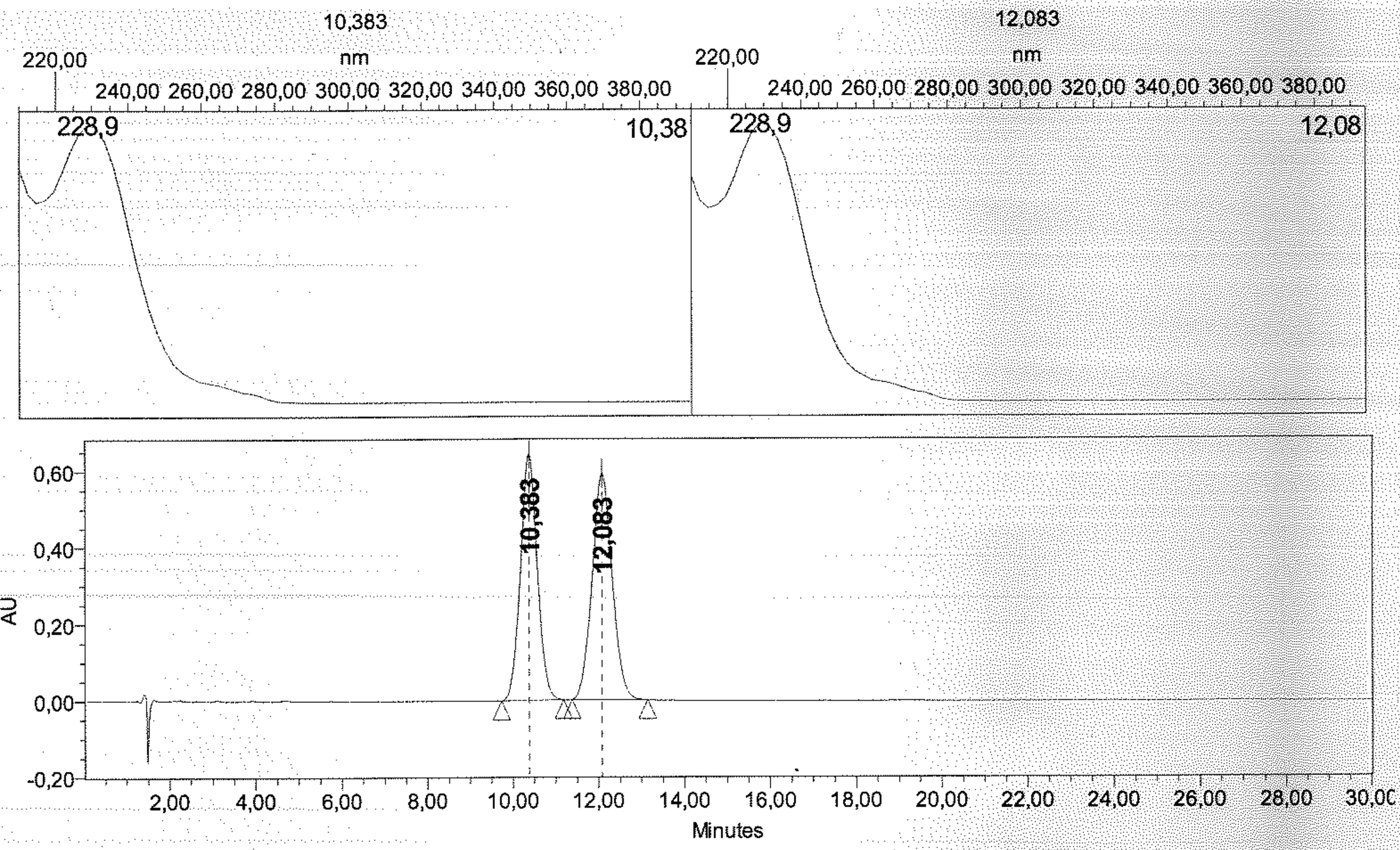
Peak Results
SampleName: (S)-Tetrahydronaphthalene_pur

	SampleName	RT	Area	Height	%Area
1	(S)-Tetrahydronaphthalene_pur	37,733	129791	2605	0,43
2	(S)-Tetrahydronaphthalene_pur	40,083	30354948	538150	99,57

d.e > 99%



ent-4



SampleName: Ethylbenzene_ref_d.e.=5% (NMR); Processed Channel Descr. PDA 229,0 nm

Hypercarb column, 100*4.6 mm, 5µ
Eluent: H2O+0.1%HCOOH / MeCN+0.1%HCOOH : 30/70

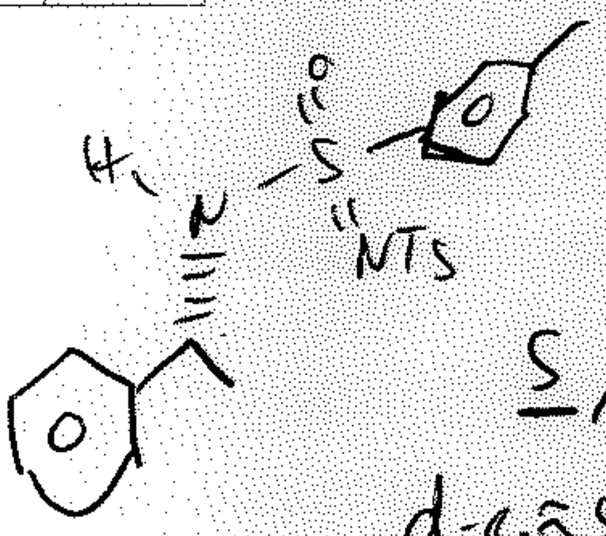
Peak Results
SampleName: Ethylbenzene_ref_d.e.=5% (NMR)

	SampleName	RT	Area	Height
1	Ethylbenzene_ref_d.e.=5% (NMR)	10,383	17480341	644522
2	Ethylbenzene_ref_d.e.=5% (NMR)	12,083	19048364	592673

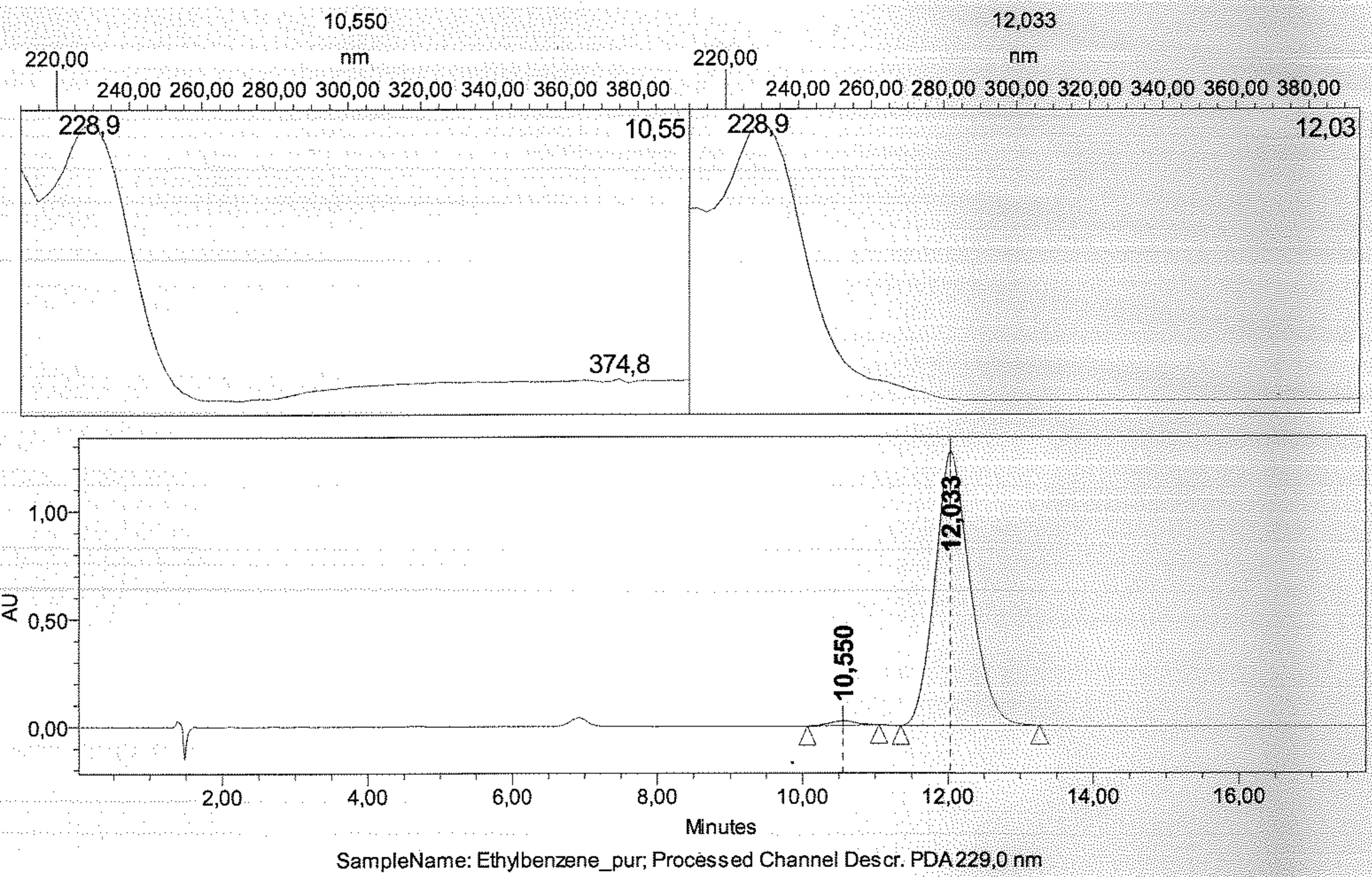
Peak Results
ampleNam
zene_ref_

	% Area
1	47,85
2	52,15

d.e = 4%



S, reference,
d.e. ≈ 5% (¹H NMR)



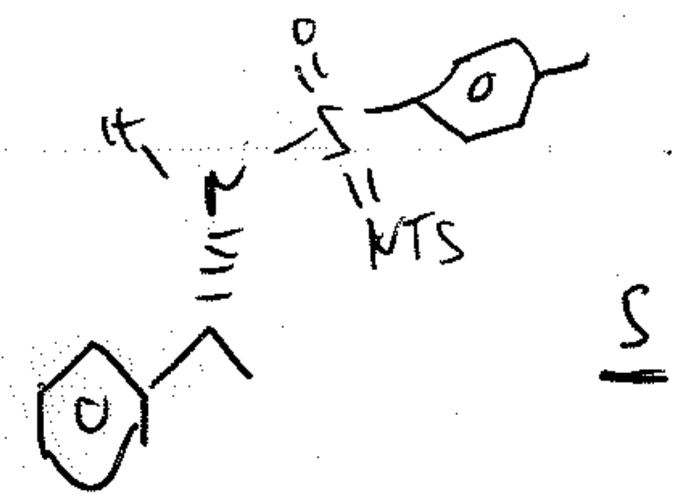
SampleName: Ethylbenzene_pur; Processed Channel Descr. PDA 229,0 nm

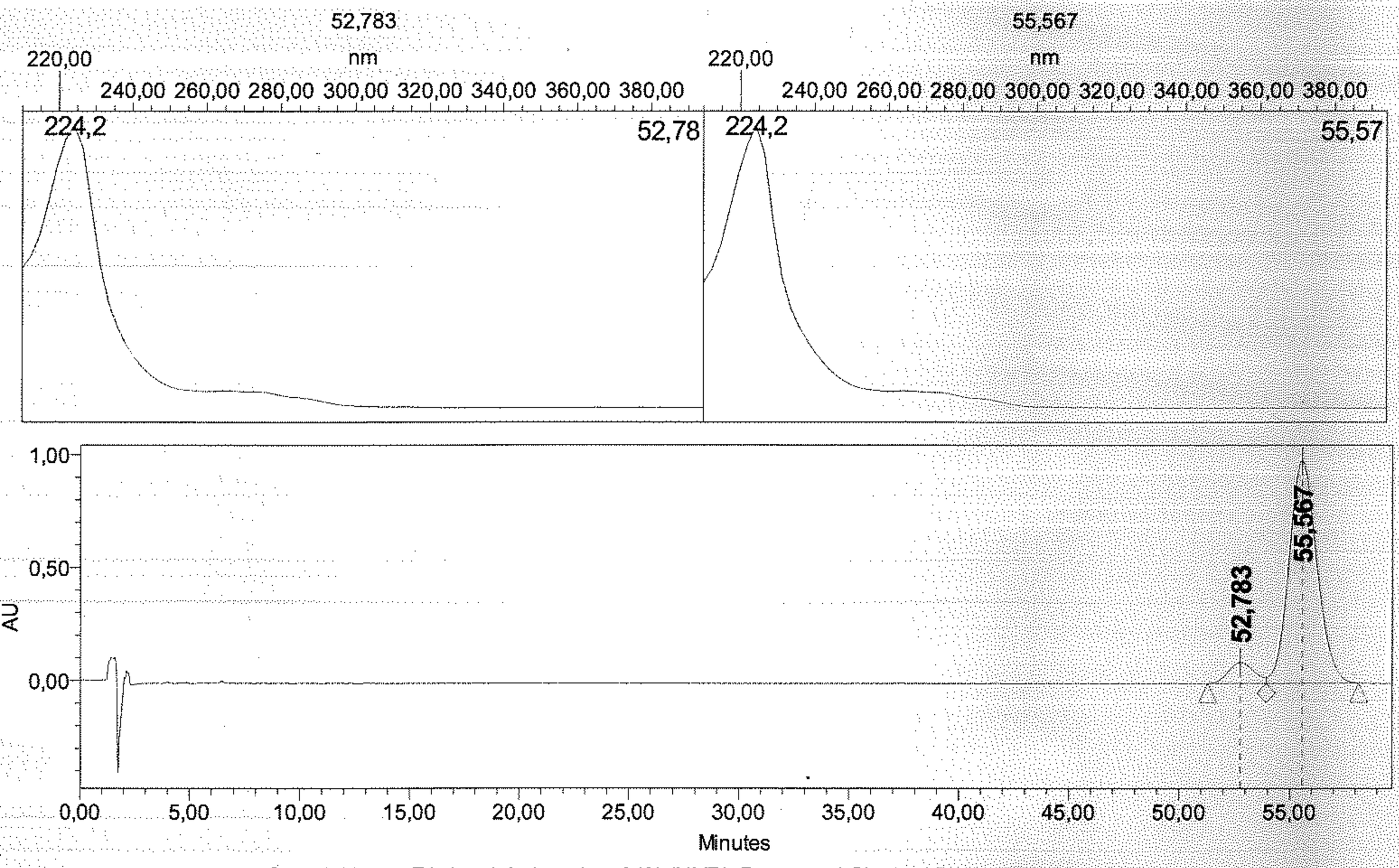
Hypercarb column, 100*4.6 mm, 5µ
Eluent: H2O+0.1%HCOOH / MeCN+0.1%HCOOH : 30/70

Peak Results
SampleName: Ethylbenzene_pur

	SampleName	RT	Area	Height	%Area
1	Ethylbenzene_pur	10,550	539862	21529	1,25
2	Ethylbenzene_pur	12,033	42576213	1267242	98,75

d-e > 97%





SampleName: Ethylnaphthalne_d.e.=84% (NMR); Processed Channel Descr. PDA 224,0 nm

Symmetry shield column, 150*4.6, 5µ
Eluent: H2O+0.1%HCOOH / MeCN+0.1%HCOOH : 54/46

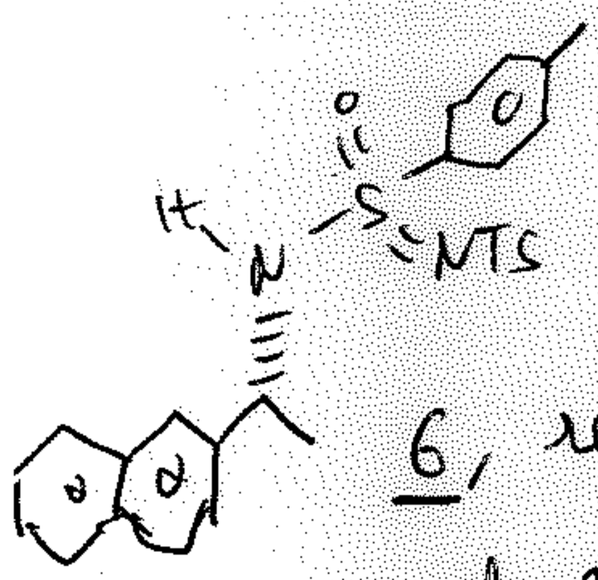
Peak Results
SampleName: Ethylnaphthalne_d.e.=84% (NMR)

	SampleName	RT	Area	Height
1	Ethylnaphthalne_d.e.=84% (NMR)	52,783	7476241	92571
2	Ethylnaphthalne_d.e.=84% (NMR)	55,567	87356127	985253

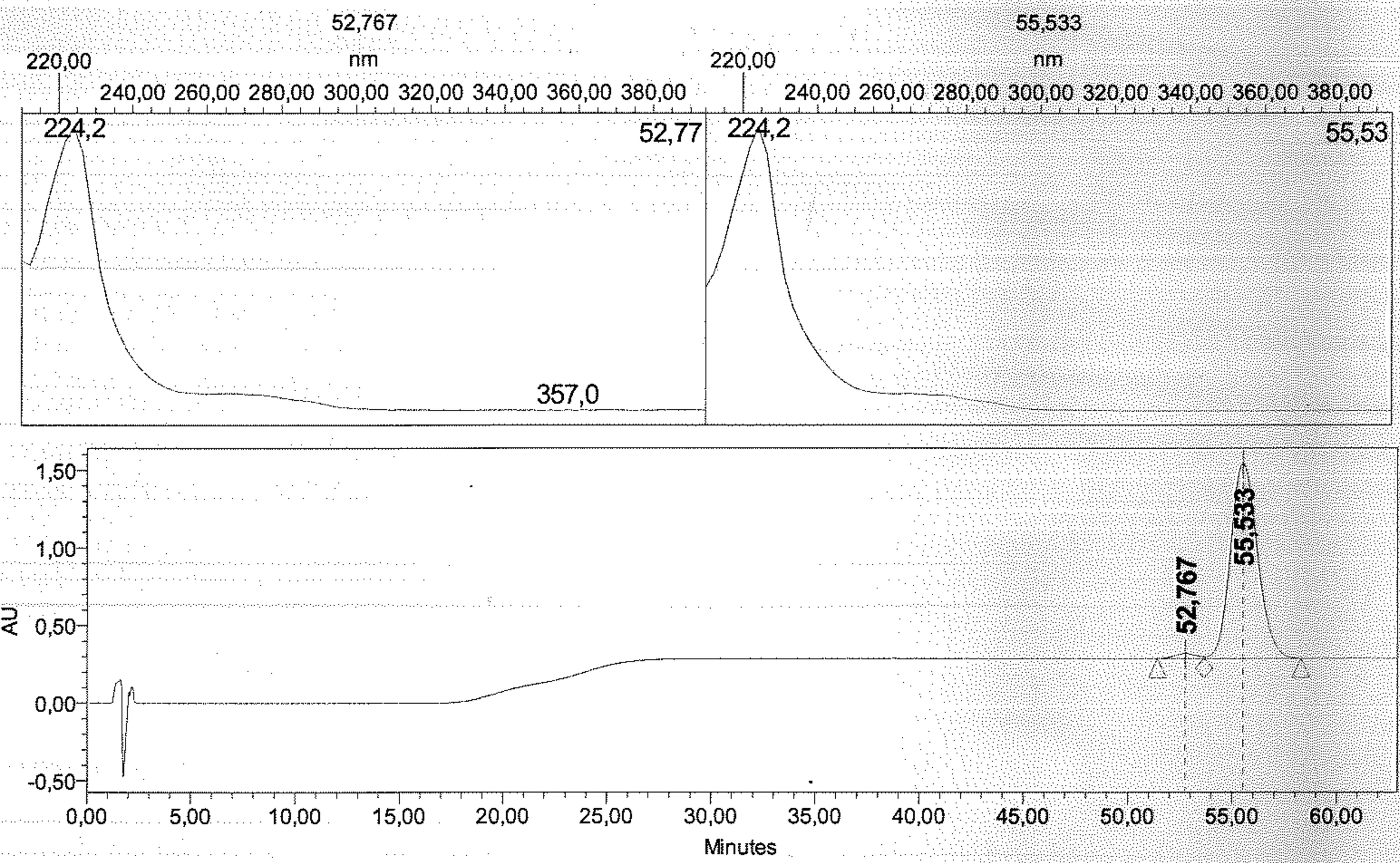
Peak Results
ampleNam
hthalne_c

	% Area
1	7,88
2	92,12

d.e = 84%



6, reference, d.e ≈ 84% (1H NMR)



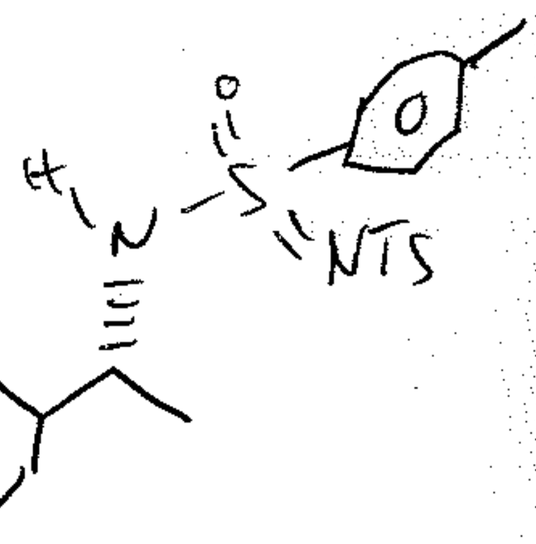
SampleName: Ethylnaphthalene_pur; Processed Channel Descr. PDA 224,0 nm

Symmetry shield column, 150*4.6, 5µ
Eluent: H2O+0.1%HCOOH / MeCN+0.1%HCOOH : 54/46

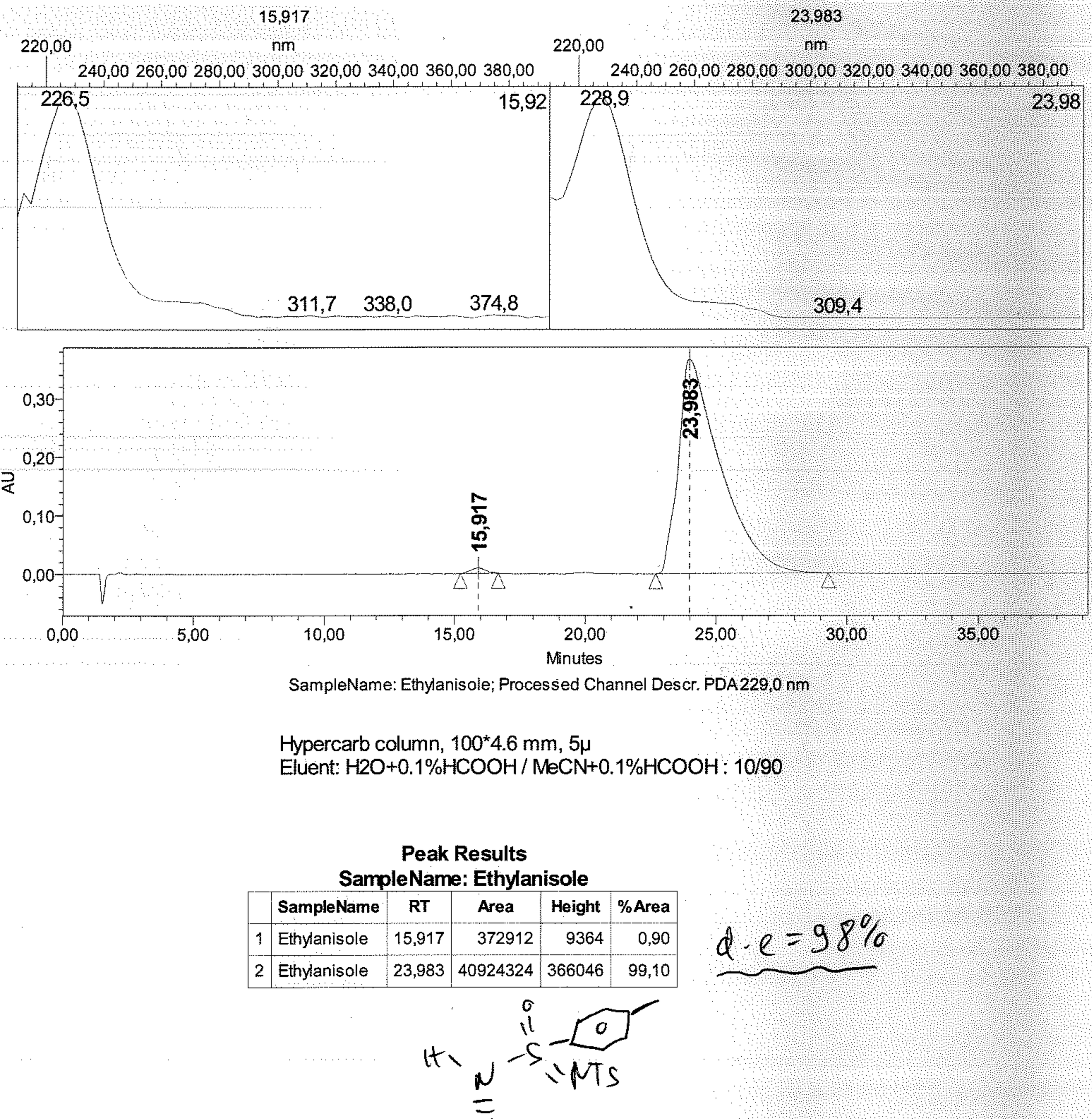
Peak Results
SampleName: Ethylnaphthalene_pur

	SampleName	RT	Area	Height	%Area
1	Ethylnaphthalene_pur	52,767	2356967	31399	2,07
2	Ethylnaphthalene_pur	55,533	111270753	1255735	97,93

d.e = 96%



6



SampleName: Ethylanisole; Processed Channel Descr. PDA 229,0 nm

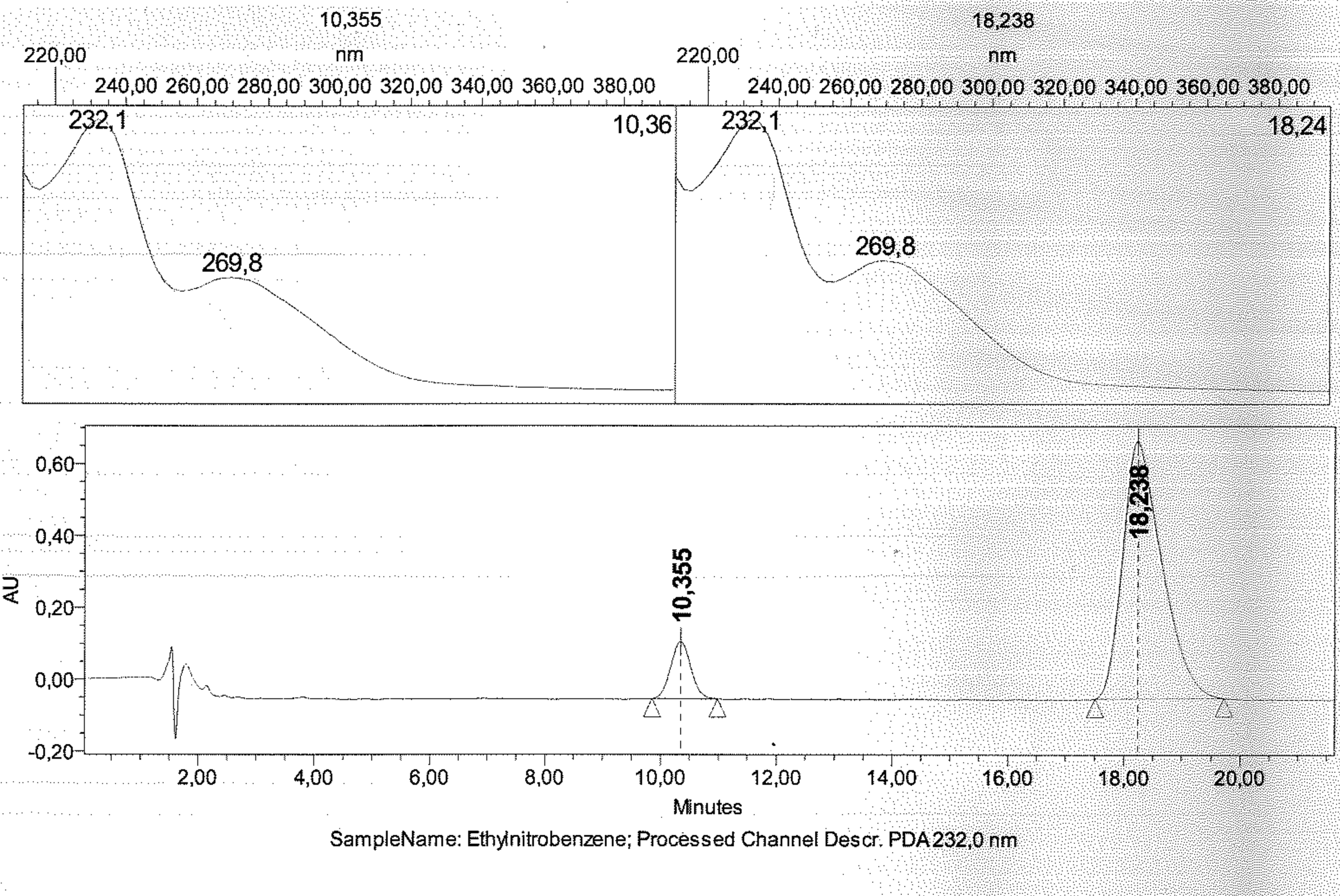
Hypercarb column, 100*4.6 mm, 5µ
Eluent: H2O+0.1%HCOOH / MeCN+0.1%HCOOH : 10/90

Peak Results
SampleName: Ethylanisole

	SampleName	RT	Area	Height	%Area
1	Ethylanisole	15,917	372912	9364	0,90
2	Ethylanisole	23,983	40924324	366046	99,10

d.e = 98%

7



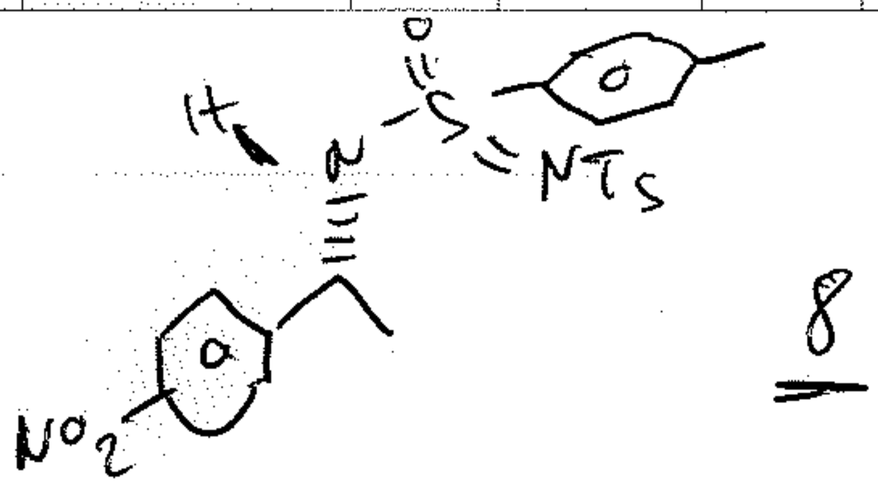
SampleName: Ethylnitrobenzene; Processed Channel Descr. PDA 232,0 nm

Hypercarb column, 100*4.6 mm, 5µ
Eluent: H2O+0.1%HCOOH / MeCN+0.1%HCOOH : 15/85

Peak Results
SampleName: Ethylnitrobenzene

	SampleName	RT	Area	Height	%Area
1	Ethylnitrobenzene	10,355	3821749	158754	10,27
2	Ethylnitrobenzene	18,238	33385913	716499	89,73

d.e = 80%



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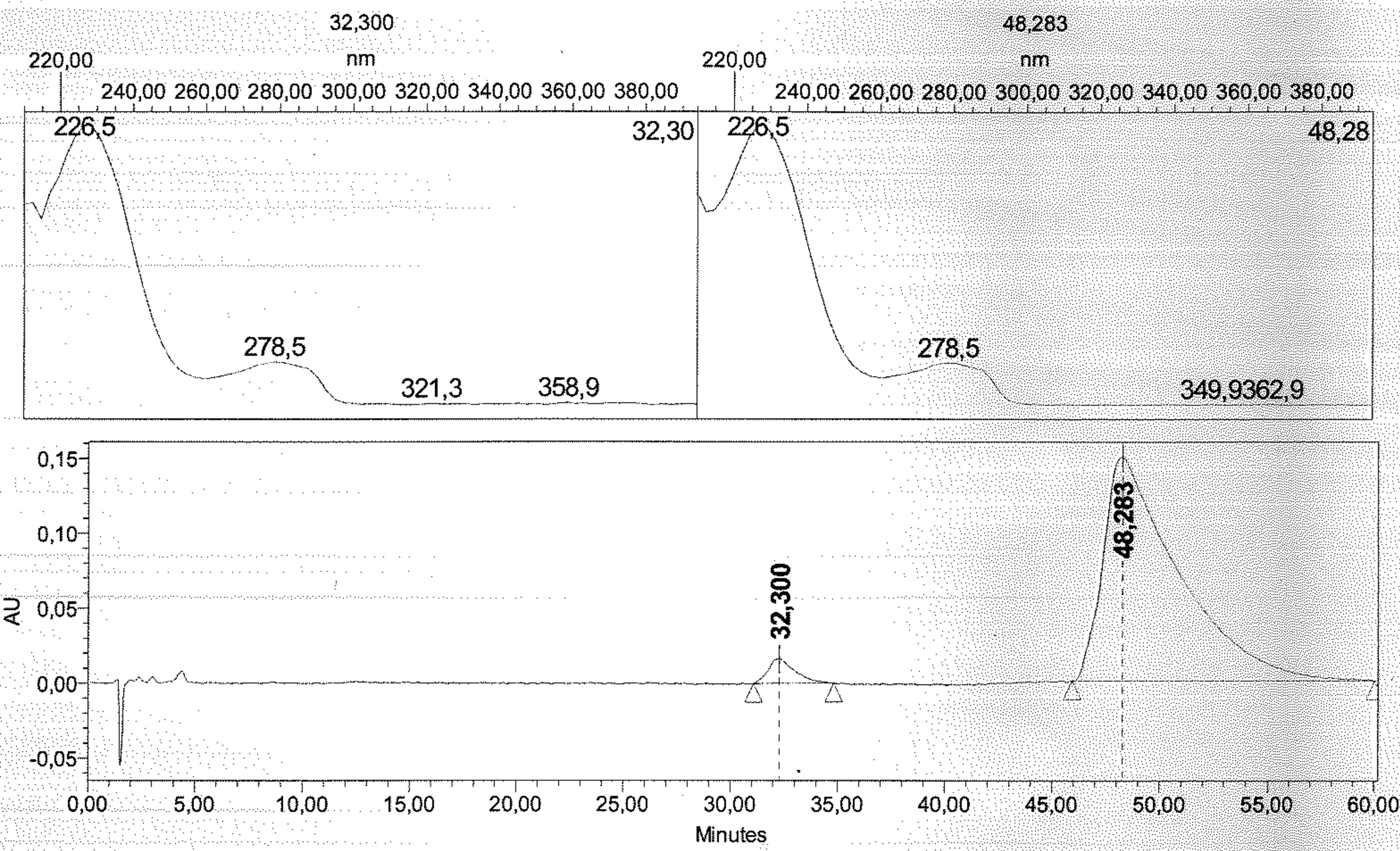


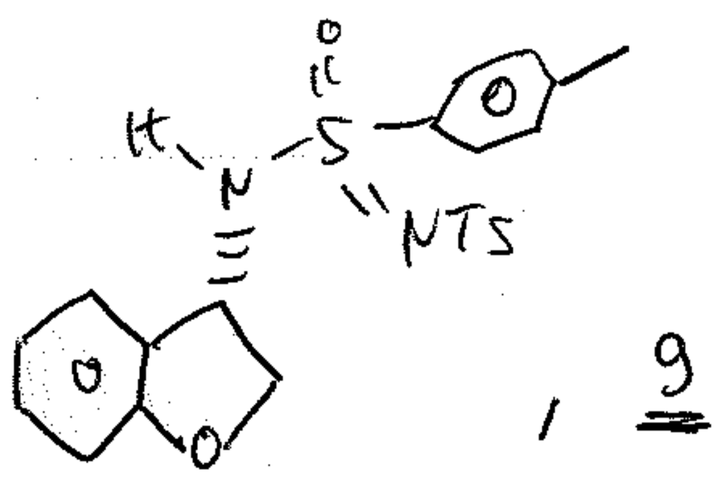
SampleName: Benzofuran; Processed Channel Descr. PDA 226,0 nm

Hypercarb column, 100*4.6 mm, 5µ
Eluent: H2O+0.1%HCOOH / MeCN+0.1%HCOOH : 10/90

Peak Results
SampleName: Benzofuran

	SampleName	RT	Area	Height	%Area
1	Benzofuran	32,300	1415894	16259	3,76
2	Benzofuran	48,283	36224318	149088	96,24

d.e = 93%



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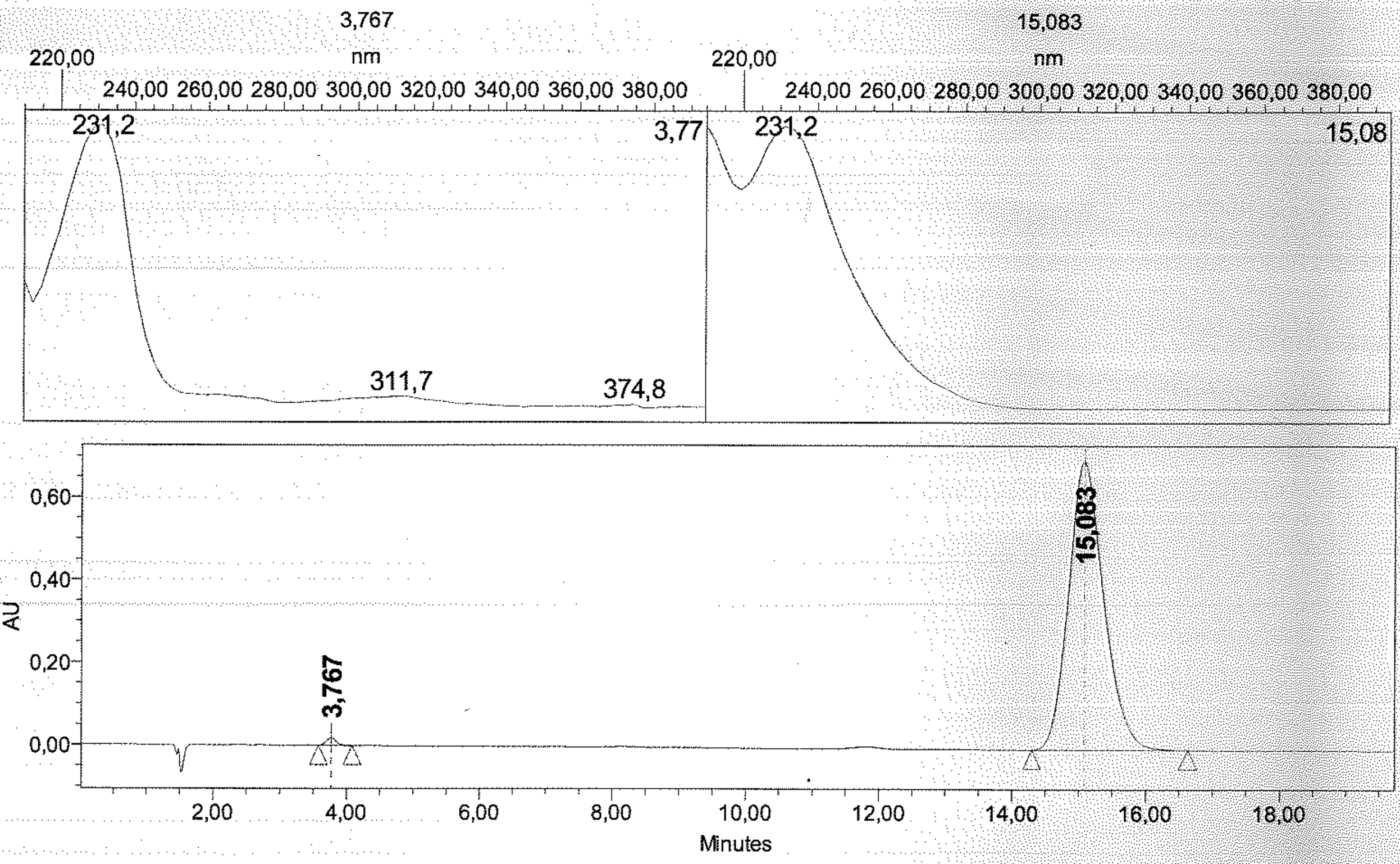


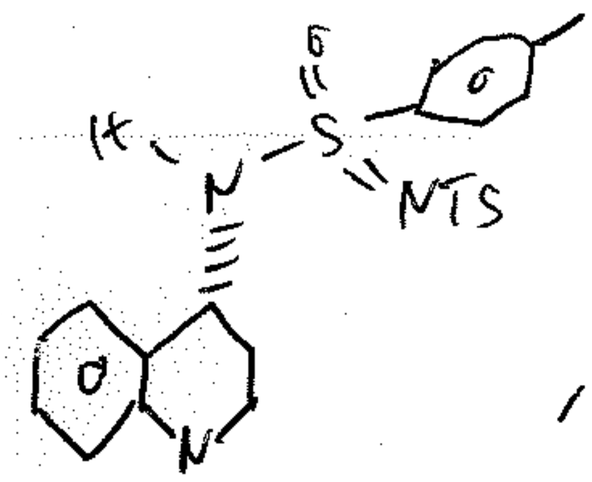
SampleName: quinoline; Processed Channel Descr. PDA 231,0 nm

Hypercarb column, 100*4.6 mm, 5µ
Eluent: H2O+0.1%HCOOH / MeCN+0.1%HCOOH : 15/85

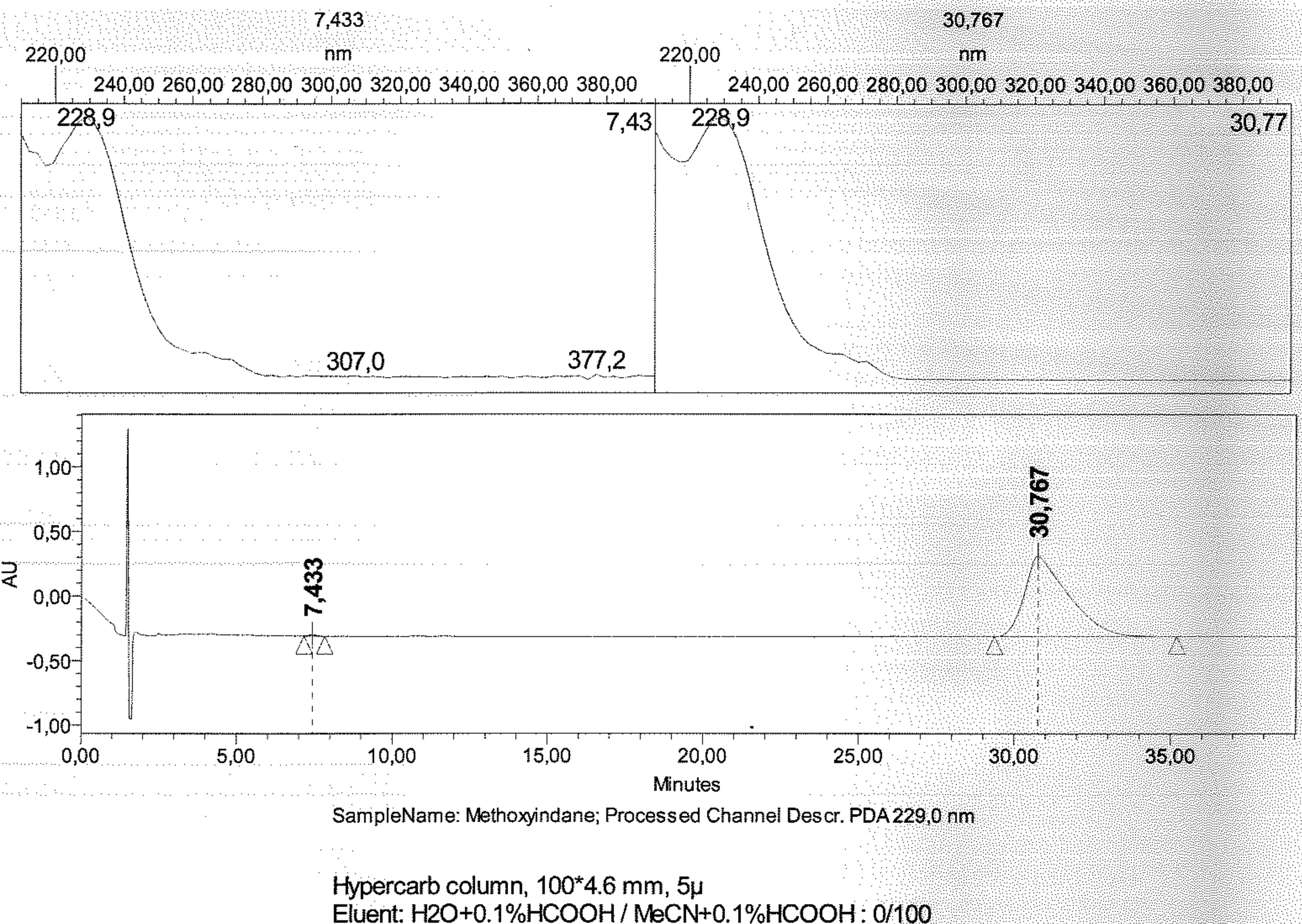
Peak Results
SampleName: quinoline

	SampleName	RT	Area	Height	%Area
1	quinoline	3,767	184485	18538	0,71
2	quinoline	15,083	25618094	698667	99,29

d.e > 99%



/ 10



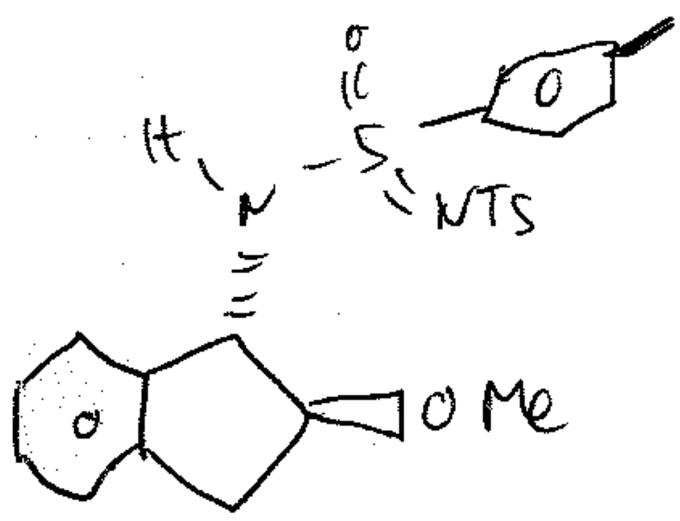
SampleName: Methoxyindane; Processed Channel Descr. PDA 229,0 nm

Hypercarb column, 100*4.6 mm, 5µ
Eluent: H2O+0.1%HCOOH / MeCN+0.1%HCOOH : 0/100

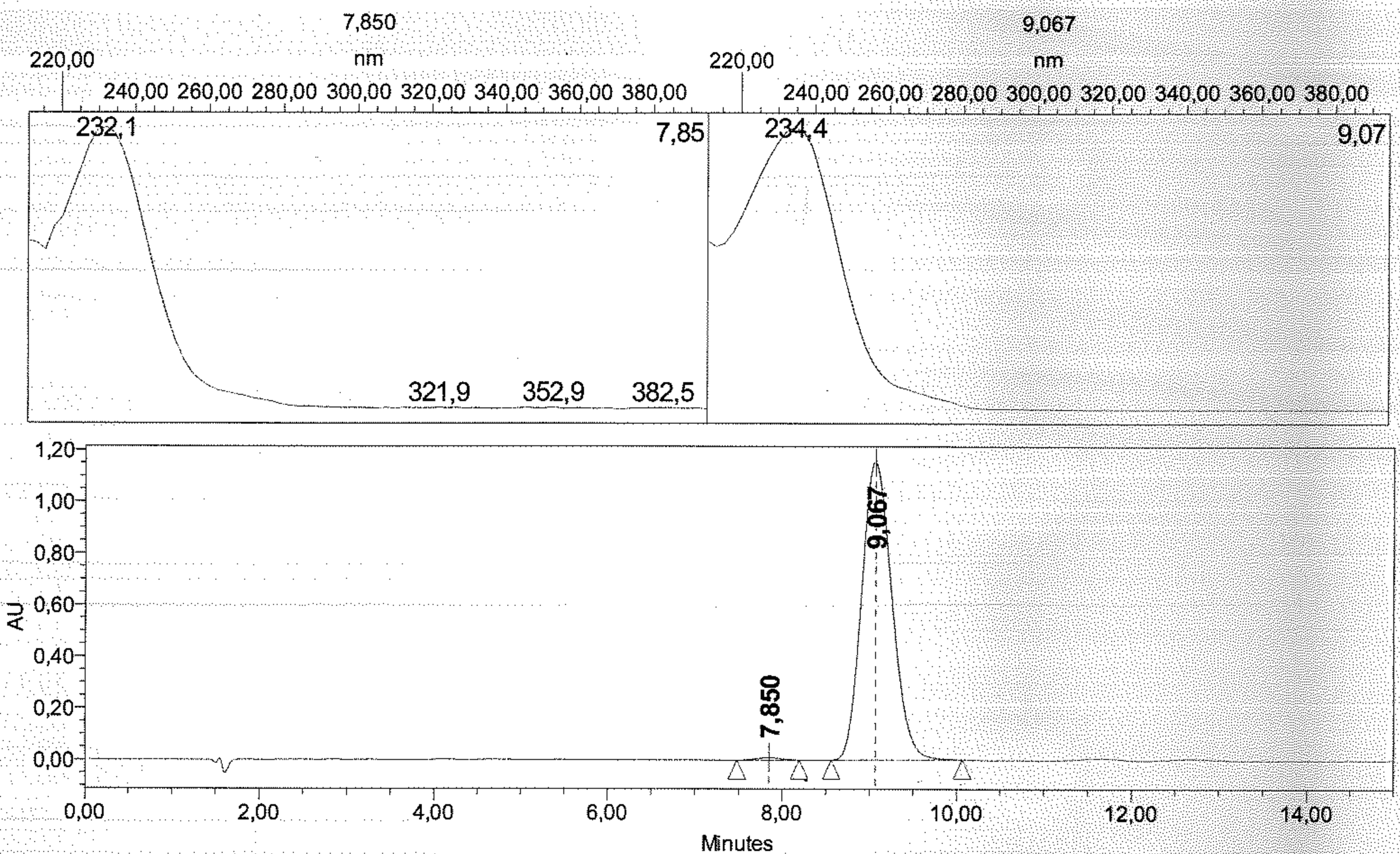
Peak Results
SampleName: Methoxyindane

	SampleName	RT	Area	Height	%Area
1	Methoxyindane	30,767	60415972	622801	99,71
2	Methoxyindane	7,433	173907	10690	0,29

d-c >99%



II



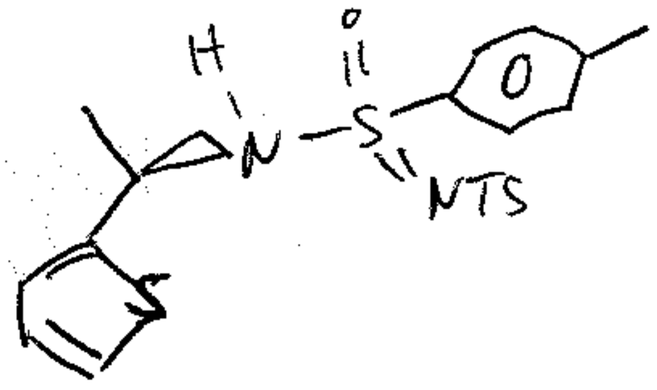
SampleName: ethylthiophene; Processed Channel Descr. PDA 234,0 nm

Hypercarb column, 100*4.6 mm, 5µ
Eluent: H2O+0.1%HCOOH / MeCN+0.1%HCOOH : 15/85

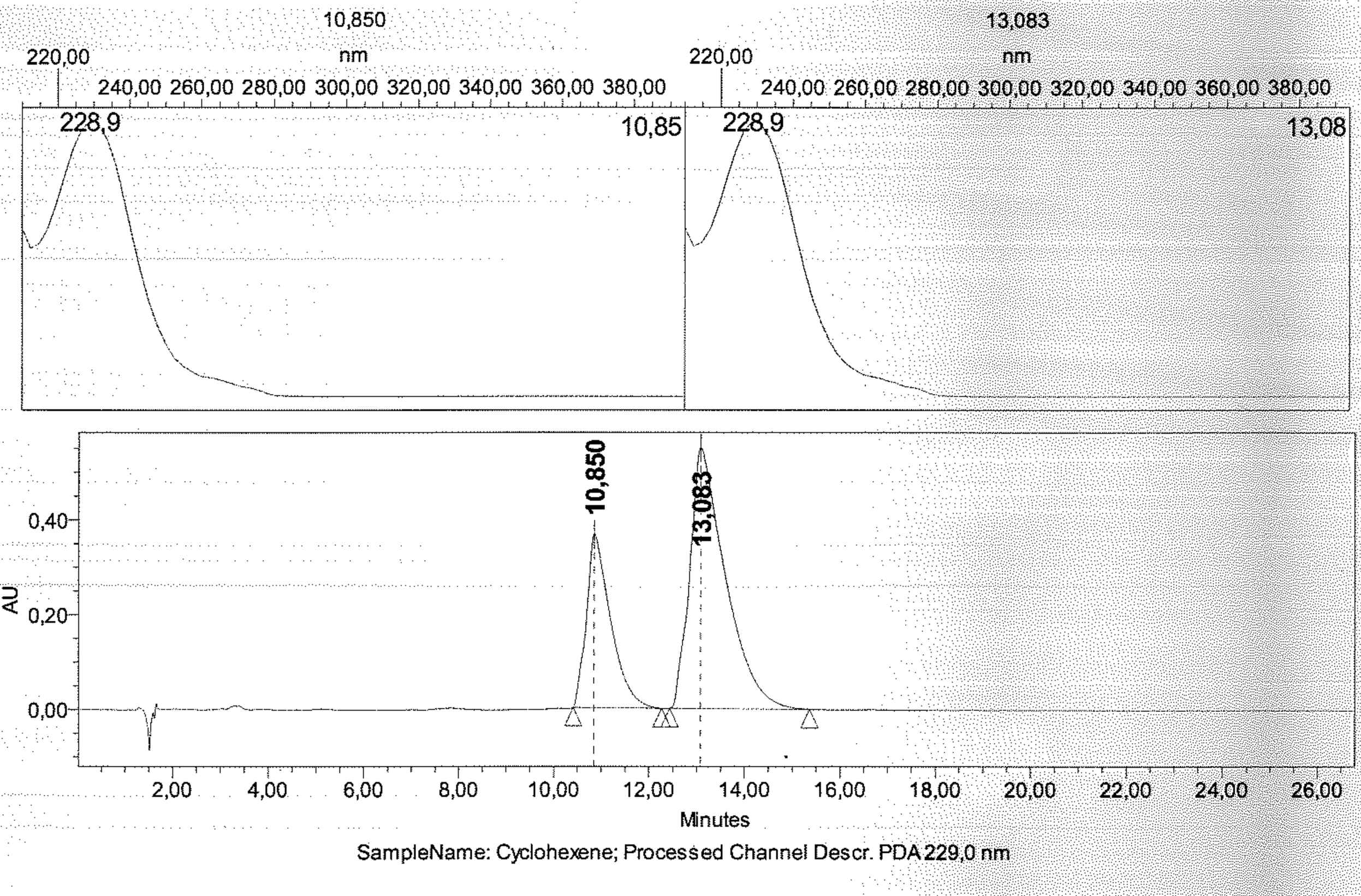
Peak Results
SampleName: ethylthiophene

	SampleName	RT	Area	Height	%Area
1	ethylthiophene	7,850	185405	9825	0,66
2	ethylthiophene	9,067	27819768	1153257	99,34

d.e. > 98%



12



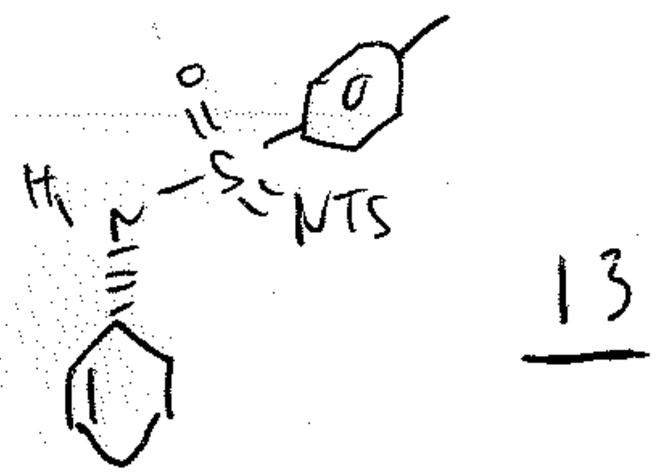
SampleName: Cyclohexene; Processed Channel Descr. PDA 229,0 nm

Hypercarb column, 100*4.6 mm, 5µ
Eluent: H2O+0.1%HCOOH / MeCN+0.1%HCOOH : 20/80

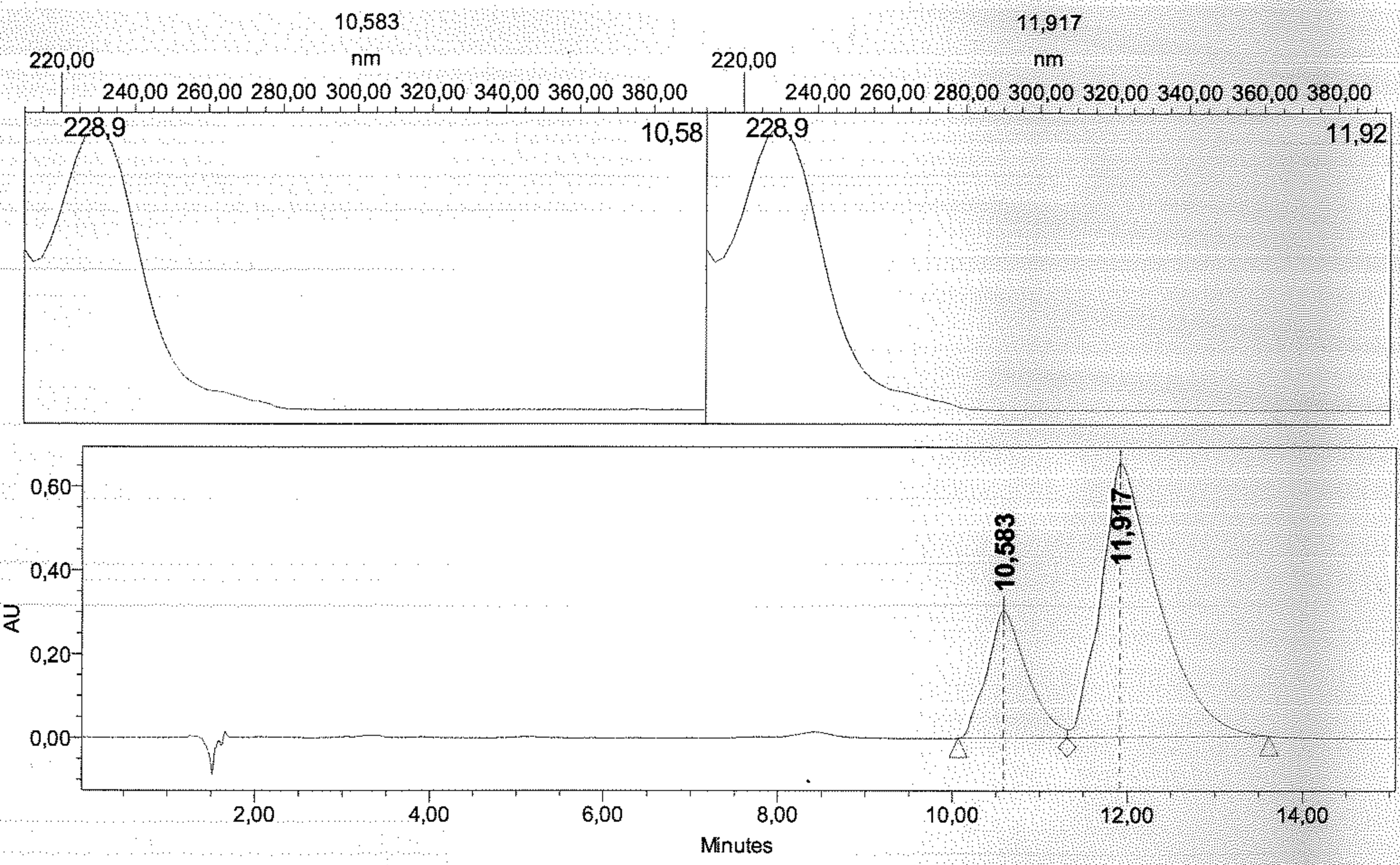
Peak Results
SampleName: Cyclohexene

	SampleName	RT	Area	Height	%Area
1	Cyclohexene	10,850	12763725	365351	30,92
2	Cyclohexene	13,083	28510226	550467	69,08

d.e = 38%



13



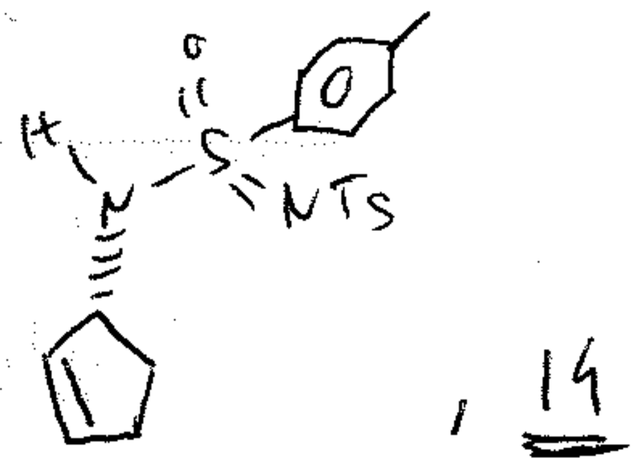
SampleName: Cyclopentene; Processed Channel Descr. PDA 229,0 nm

Hypercarb column, 100*4.6 mm, 5µ
Eluent: H2O+0.1%HCOOH / MeCN+0.1%HCOOH : 20/80

Peak Results
SampleName: Cyclopentene

	SampleName	RT	Area	Height	%Area
1	Cyclopentene	10,583	9689680	303034	24,57
2	Cyclopentene	11,917	29752427	654316	75,43

d.e = 50%



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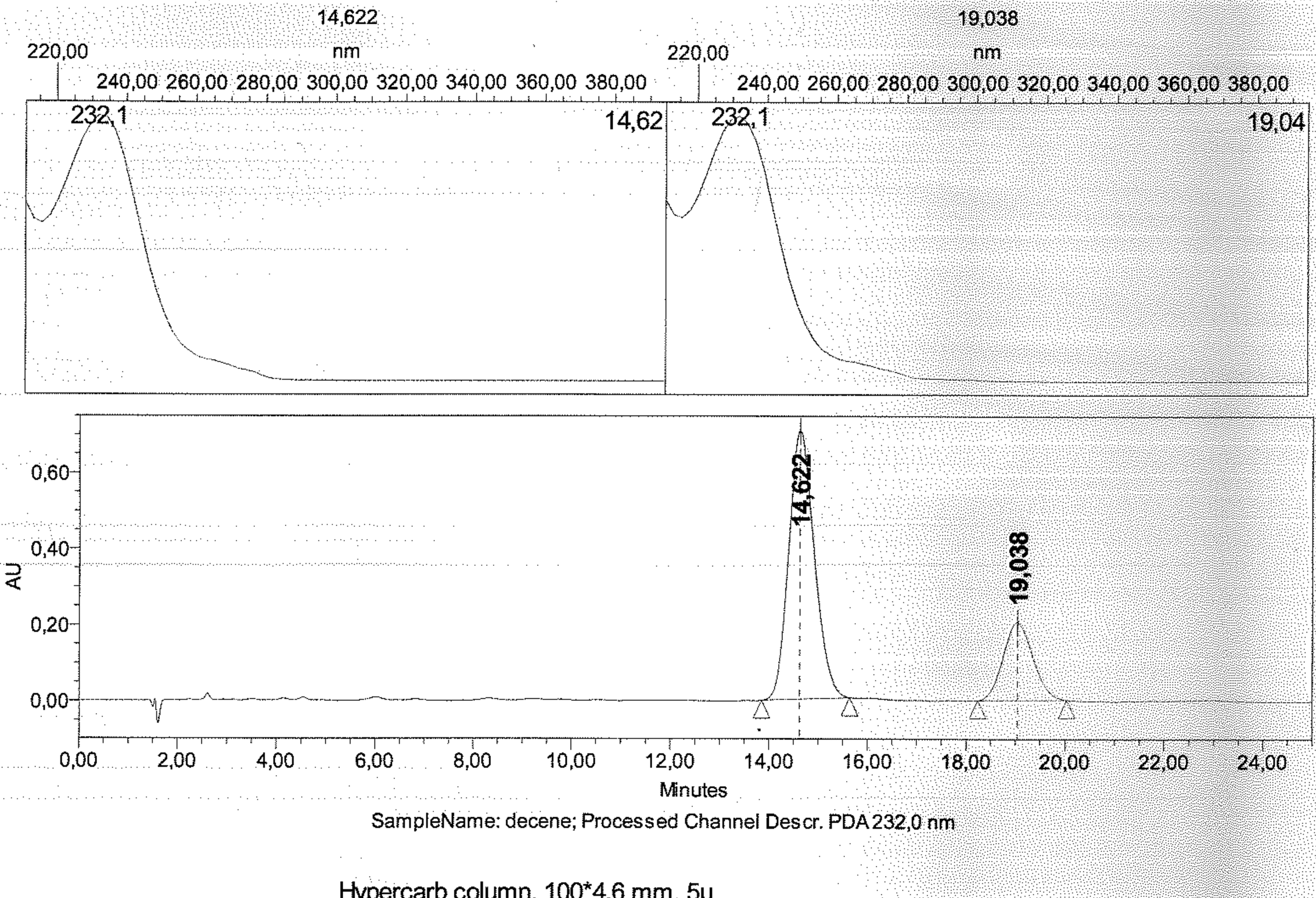


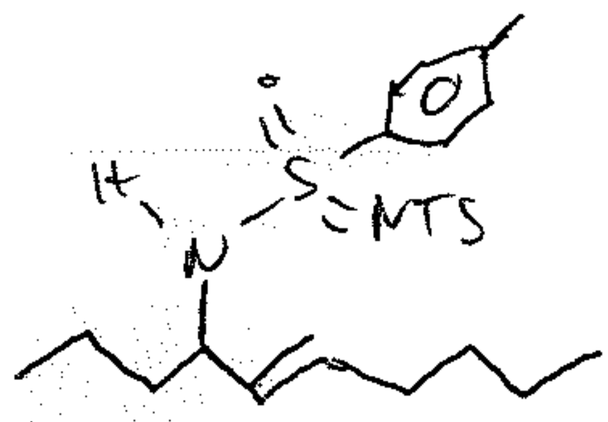
SampleName: decene; Processed Channel Descr. PDA 232,0 nm

Hypercarb column, 100*4.6 mm, 5µ
Eluent: H2O+0.1%HCOOH / MeCN+0.1%HCOOH : 15/85

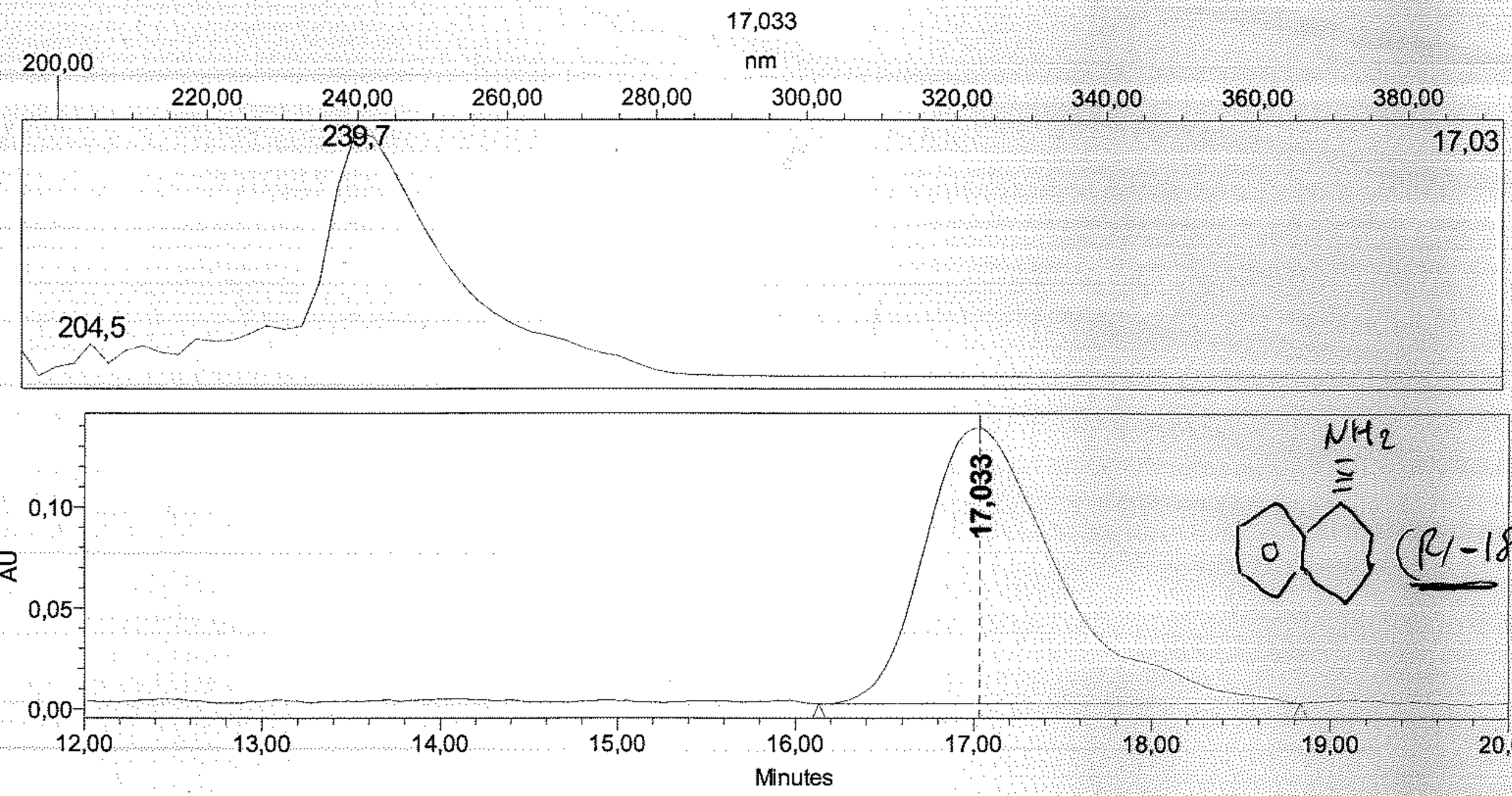
Peak Results
SampleName: decene

	SampleName	RT	Area	Height	%Area
1	decene	14,622	25186996	706102	74,65
2	decene	19,038	8551030	204451	25,35

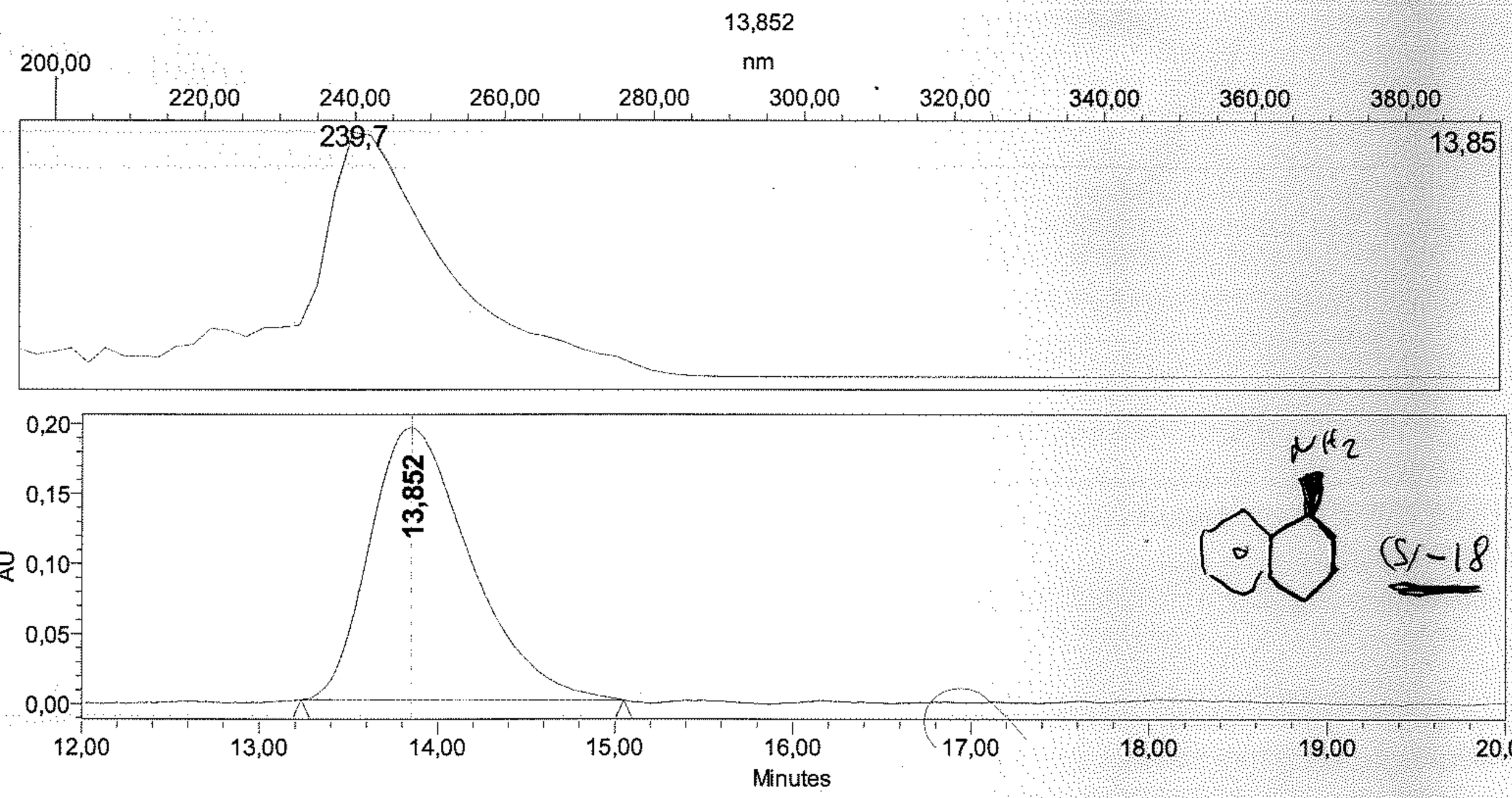
d.e. = 50%



15



SampleName: deprotected-(R)-Tetrahydronphtha; Processed Channel Descr. PDA 240,0 nm



SampleName: deprotected-(S)-Tetrahydronaphth; Processed Channel Descr. PDA 240,0 nm

Column: Chiralcel OD, 4.6*250, 10µ
Eluent: Hexane+0.1%NEt3/ iPrOH : 15/85