Supporting Information

Significant Steroids: Effective and General Synthesis of 4*α*- and 4*β*-Amino-5*α*-Androstanes

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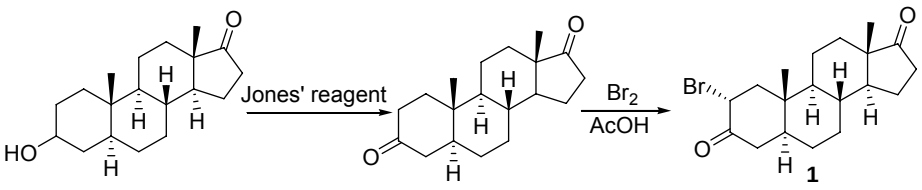
Contents

General Methods: Melting points were uncorrected and measured on an XT-4 apparatus. IR spectra were recorded from KBr pellets at a range of 400-4000 cm^{-1} on a Thermo Nicolet Nexus 470 FTIR spectrometer. ^{1}H and ^{13}C NMR spectra were obtained on a Varian Mercury VX300 apparatus or a Bruker DPX400 apparatus in $CDCl_3$, D_2O or DMSO-d_6 with TMS as internal standard. The elemental analysis (C, H, and N) data were obtained from a VarioEL III (German) elemental analyzer. Single-crystal X-ray-diffraction measurements were carried out on a Bruker Smart-APEX-CCD diffractometer. Column chromatography was performed using EM silica gel 60 (230-400 mesh). Thin-layer chromatography (TLC) was performed on glass plates precoated with silica gel (5-40 μm) to monitor the reactions. Visualization was accomplished by spraying chromatograms with a solution of sulfuric acid-ethanol (1:10, v/v) and heating in an oven at 105°C for 3 min until color developed.

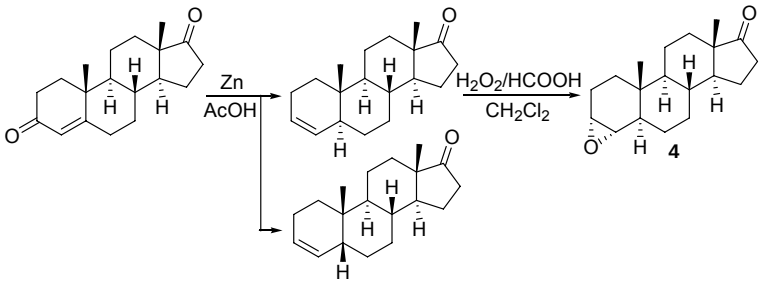
Materials: All solvents were purified according to reported procedures. Unless otherwise noted, reagents and materials were obtained from commercial suppliers and were used without further purification.

Single Crystal Structure Determination: Single-crystal X-ray diffraction measurements for the four compounds (**3a**, **3e**, **5e** and 2*α*-(1H-pyrazol-1-yl)-5*α*-androstan-3,17-dione) were carried out on a Bruker Smart APEX CCD-based diffractometer equipped with a graphite crystal monochromator for data collection. The determinations of unit cell parameters and data collections were performed with MoK_α radiation (λ = 0.71073 Å), and unit cell dimensions were obtained with least-squares refinements. The program Bruke SAINT7 was used for reduction date. All structures were solved by direct methods using SHELXS-97 (Sheldrick, 1990) and refined with SHELXL-97 (Sheldrick, 1997);[1] non-hydrogen atoms were located in successive difference Fourier syntheses. The final refinement was performed by full matrix least-squares methods with anisotropic thermal parameters for non-hydrogen atoms on F^2. The hydrogen atoms were treated by a mixture of independent and constrained refinement. The absolute configurations of the starting materials are known and certain stereocentres (including the carbon atoms with an angle methyl) do not change, then the absolute structure of products can be inferred. Therefore, the results of the Flack parameter fields are meaningless. The ORTEPs of the four compounds are showed at the 30% probability level.

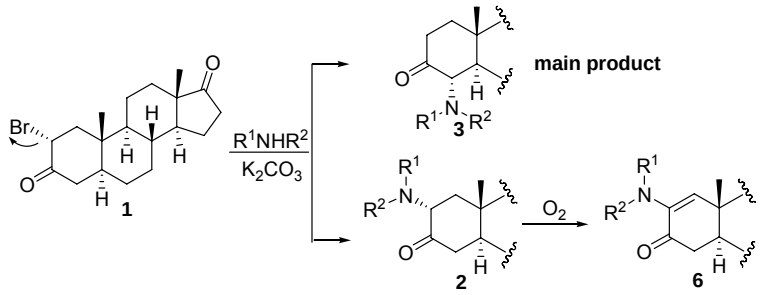
2*α*-Bromo-5*α*-androstan-3,17-dione (1) To a solution of 3*β*-hydroxy-5*α*-androstan-17-one (5α-epiandrosterone, 1.58g, 5.37 mmol) in acetone (50 mL) was added Jones' reagent (2.7 M chromium trioxide in diluted sulfuric acid) at 5°C until the orange color persisted. The mixture was stirred for a further 1 h. Ethanol (2 mL) was added to decompose the excess reagent and the solution was concentrated in vacuo and poured into water (70 mL). The mixture was extracted with methylene chloride (3 x 40 mL). The organic layer was washed with saturated $NaHCO_3$ and H_2O, dried over anhydrous $MgSO_4$. The solvent was evaporated to give 5α-androstane-3,17-dione (1.44g, 93%). Mp 126-128°C (lit[2] 129-130°C); IR (KBr): 1712.39 (CO-3), 1741.48 (CO-17) cm^{-1}. Thus suspension of obtained 5α-androstane-3,17-dione (0.923 g, 3.2 mmol) in glacial acetic acid (16.0 mL) was added bromine (0.176 mL, 3.424 mmol) in glacial acetic acid (8.0 mL), dropwise with stirring , at room temperature. After 3 hours of stirring, saturated Na_2CO_3 (50 mL) was added to the white slurry. Methylene chloride (50.0 mL) and water (20.0 mL) were then added to the quenched reaction. The layers were then separated and the aqueous layer was extracted with methylene chloride (2 x 20 mL). The combined organic layers were washed with water, dried over anhydrous Na_2SO_4 and concentrated to a solid. The solid was then crystallized with acetone to give 1.04 g of title compound **1** (89%). Mp 207-208°C (lit[3] 207-208°C); IR (KBr): 1718.02 (CO-3), 1739.86 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.89 (3H, s, H-18), 1.12 (3H, s, H-19), 4.76 (1H, dd, *J* = 6.4 and 13.6 Hz, H-2). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 12.19, 13.88, 20.85, 21.82, 28.12, 30.35, 31.38, 34.53, 35.84, 39.12, 43.85, 47.44, 47.75, 51.06, 51.57, 53.69, 54.28, 200.96, 220.72.



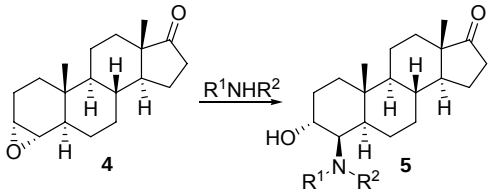
3,4*α*-Epoxy-5*α*-androstan-17-one (4) This known compound was synthesized by the method of Silva.[4] 3-olefin was prepared from androst-4-ene-3,17-dione through a Clemmensen-type reduction with zinc dust in acetic acid. To a boiling solution of androst-4-ene-3,17-dione (1.0 g, 3.50 mmol) in glacial acetic acid (60 ml), zinc dust (6.0 g, 325 mesh Aldrich) was added in several portions during 10 min after which the reaction was complete (TLC control: PE:EtOAc = 4:1). The zinc suspension was filtered, the zinc was washed with glacial acetic acid and the filtrate was evaporated to dryness. The residue was diluted with water (200 ml) and extracted with diethyl ether (3 x 200 ml). The organic layers were washed with 10% aq. $NaHCO_3$ (3 x 200 ml) and water (3 x 200 ml), dried (MgSO4) and evaporated to dryness to give a white crystalline solid (938 mg) composed by an isomeric mixture (1:1 by NMR) of 5*α*-olefin and 5*β*-olefin. Crystallization of the mixture from *n*-hexane gave the pure 5*α*-olefin (324 mg, 34%). 5*α*-olefin: mp 126-128°C (lit[4] 125-126°C); ^{1}HNMR (400 MHz $CDCl_3$): 0.80 (3H, s, H-18), 0.88 (3H, s, H-19), 5.30 (1H, m, H-4), 5.55(1H, m, H-3). A stirred solution of 5*α*-olefin (135.0 mg, 0.50 mmol) in dichloromethane (2 ml) was treated with 30% hydrogen peroxide (0.10 ml, 0.88 mmol) and 90% formic acid (0.10 ml, 2.36 mmol) at room temperature for 6 h. After dilution with methanol (20 ml) and basification with 10% aq. NaOH, the solution was neutralized with a 10% aq. HCl and extracted with dichloromethane. The extract was washed with 10% aq. $NaHCO_3$ and water, dried ($MgSO_4$) and evaporated to dryness to give 150 mg of epoxide **4** (96%) as the only detected and isolated product. Epoxide **4**: White solid from diethyl ether, mp 157-158°C (lit[4] 158-159°C); ^{1}HNMR (400 MHz $CDCl_3$): 0.80 (3H, s, H-18), 0.87 (3H, s, H-19), 2.69 (1H, d, *J* = 4.1 Hz, H-4), 3.16 (1H, dd, *J* = 2.8 and 5.6 Hz, H-3).



General synthetic procedure of 4*α*-amino-5*α*-androstanes via displacement of 2*α*-bromo ketone: All amines were freshly distilled or recrystallized before use. Compound **1** (10 mmol) was dissolved at room temperature in acetonitrile (80 mL). After addition of the amine (50 mmol) and K_2CO_3 (5 mmol), the mixture was heated at 75°C and stirred. The reaction time and yield were summarized in Table 1. The solvent was removed under reduced pressure when the reaction was complete and the residue was purified by column chromatography over silica gel (PE-EtOAc-Et_3N) to give compound **3**.



General synthetic procedure of 4*β*-amino-5*α*-androstanes via the regioselective aminolysis of 3,4*α*-epoxy-5*α*-androstanes: To the mixture of epoxide **4** (10 mmol) and amine (30 mmol), the solution of $ZnCl_2$ (20 mmol) in water (10 mL) was added. The mixture was kept at 95°C under vigorous magnetic stirring and the reaction was monitored with TLC. After completion of the reaction the mixture was condensed under reduced pressure and gave a solid mixture. Then water (15 mL) was added, and the organic materials were extracted with CH_2Cl_2 (3 x 10 mL). The organic layer was separated and dried over anhydrous Na_2SO_4. The solvent was removed under reduced pressure to give the compound **5** in the almost pure form when the amine was liquid. In the cases of solid amines, further purification was carried out by flash chromatography on silica gel (PE-EtOAc-Et_3N or CH_2Cl_2-MeOH-Et_3N).



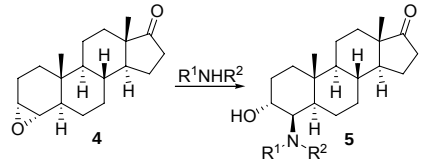
Influence of catalysts for regioselective ring opening of 3,4*α*-steroidal epoxide 4

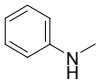
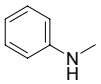
The following table showed that the role of the $ZnCl_2/H_2O$ system seemed crucial for the reaction outcome, and it both worked when aliphatic amines or aromatic amines were used. The system of $Zn(ClO_4)_2/H_2O$ was as potent as that of $ZnCl_2/H_2O$, however the perchlorate was dangerous and thus unfavorable for later drug exploitation.

Torregrosa et al.[5] recently reported the solvent-free direct regioselective ring opening of epoxides with imidazoles. We previously tried to prepare the imidazolyl alcohol under solvent-free conditions (entry 9), but it resulted very little product formation. It was luckily achieved using the $ZnCl_2/H_2O$

system.

S Table 1. Influence of catalytic system for diverse amines[a]



Entry	amine	Catalytic system	Time	T (°C)	Yield (%)[b]
1		neat	24h	110	2
2		H_2O	7d	100	9
3		$ZnCl_2$	24h	110	4
4		$ZnCl_2/H_2O$	20h	95	96
5		$AlCl_3/H_2O$	24h	95	83
6		$Zn(ClO_4)_2/H_2O$	24h	95	97
7		H_2O	24h	100	5
8		$ZnCl_2/H_2O$	24h	95	90
9		neat	24h	80	3
10		$ZnCl_2/H_2O$	15h	95	94

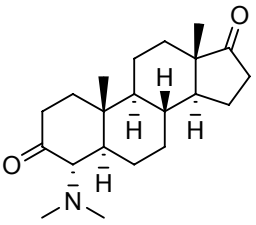
[a] Conditions for reaction: **4** (5 mmol), amine (15 mmol), Lewis acid (10 mmol), H_2O (5 mL). [b] Yield of isolated product.

Nucleophile cleavage of epoxide are favored by solvents best able to respond continuously to the demanding range of hydrogen-bonding situations that arise during these processes.[6] In this respect, water is possibly unique. It is reasonable to assume that the mild condition of Lewis acid-catalyzed aminolysis in water might be an economical and practical method for synthesis of a wide range of *β*-amino alcohols, but not only of sterically hindered steroidal epoxides. With increasing environmental concerns,[7] the use of a cheap, easy to handle, nontoxic catalyst should fulfil the "triple bottom line" philosophy of green chemistry, and thus the present methods is "environmentally friendly" for the synthesis of *β*-amino alcohols.

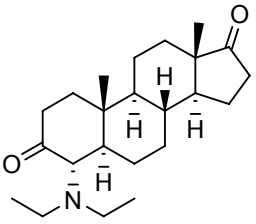
References:

[1] G. M. Sheldrick, *SHELXTL V5.1*; Madison, WI, **1998**.
[2] J. Matsuo, D. Iida, H. Yamanakaa and T. Mukaiyama, *Tetrahedron*, 2003, **59**, 6739.
[3] Y. Abul-Hajj, *J. Org. Chem*., 1986, **51**, 3380.
[4] E. J. T. da Silva, F. M. Roleira, M. L. S. Melo, A. S. C. Neves, J. A. Paixao, M. J. Almeida and L. C. R. Andrade, *Steroids*, 2002, **67**, 311.
[5] R. Torregrosa, I. M. Pastor and M. Yus, *Tetrahedron*, 2007, **63**, 469.
[6] H. C. Kolb, M. G. Finn and K. B. Sharpless, *Angew. Chem. Int. Ed.*, 2001, **40**, 2004.
[7] R. L. Garrett in *Designing Safer Chemicals* (Eds.: R. L. Garrett, S. C. De Vilto), American Chemical Society Symposium Series 640, Washington DC, **1996**, chapter 1.

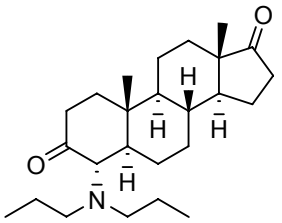
The analytical data of new compounds are as follows.



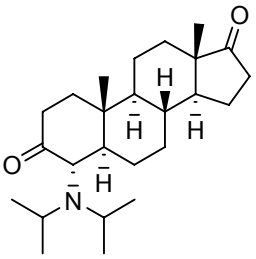
4*α*-(Dimethylamino)-5*α*-androstan-3,17-dione (3a) white crystal; mp 206-207 °C; R_f = 0.3 (PE-EtOAc, 2:1); IR (KBr): 1715.37 (CO-3), 1737.01 (CO-17) cm^{-1}. ^{1}HNMR (300 MHz, $CDCl_3$): δ = 0.90 (3H, s, H-18), 1.10 (3H, s, H-19), 2.49 (6H, s, CH_3-N), 3.03 (1H, d, *J* = 6.0 Hz, H-4). ^{13}C NMR (75 MHz, $CDCl_3$): δ = 13.12, 14.01, 20.93, 21.97, 24.78, 30.88, 31.71, 34.79, 36.08, 37.39, 38.80, 38.87, 40.94, 47.88, 50.78, 51.51, 54.73, 70.37, 212.38, 221.30. MS: *m/z* = 332 [M + H^+]. Anal. Calcd for $C_{21}H_{33}NO_2$: C, 76.09; H, 10.03; N, 4.23. Found: C, 76.24; H, 10.11; N, 4.15.



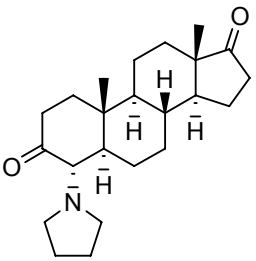
4*α*-(Diethylamino)-5*α*-androstan-3,17-dione (3b) white crystal; mp 132-134 °C; R_f = 0.5 (PE-EtOAc, 2:1); IR (KBr): 1715.05 (CO-3), 1735.74 (CO-17) cm^{-1}. ^{1}HNMR (300 MHz, $CDCl_3$): δ = 0.82 (3H, s, H-18), 1.19 (3H, s, H-19), 2.74 (4H, br, s, CH_2-N), 3.26 (1H, d, *J* = 6.0 Hz, H-4). ^{13}C NMR (75 MHz, $CDCl_3$): δ = 13.09, 14.01, 20.93, 21.96, 25.01, 25.32, 30.96, 31.71, 34.89, 36.06, 37.41, 38.81, 39.12, 47.88, 48.34, 51.51, 52.20, 54.68, 66.83, 212.05, 221.23. MS: *m/z* = 360 [M + H^+]. Anal. Calcd for $C_{23}H_{37}NO_2$: C, 76.83; H, 10.37; N, 3.90. Found: C, 76.59; H, 10.45; N, 3.94.



4*α*-(Dipropylamino)-5*α*-androstan-3,17-dione (3c) white solid; mp 155-157 °C; R_f = 0.7 (PE-EtOAc, 2:1); IR (KBr): 1719.46 (CO-3), 1738.89 (CO-17) cm^{-1}. ^{1}HNMR (300 MHz, $CDCl_3$): δ = 0.89 (3H, s, H-18), 1.06 (3H, s, H-19), 2.43-2.72 (4H, br, m, CH_2-N), 3.07 (1H, d, *J* = 5.4 Hz, H-4). ^{13}C NMR (75 MHz, $CDCl_3$): δ = 12.02, 13.13, 14.02, 20.90, 21.97, 23.44, 24.89, 30.83, 31.74, 35.01, 36.08, 37.30, 38.07, 38.70, 47.92, 50.84, 51.55, 54.74, 54.86, 69.38, 213.07, 221.39. MS: *m/z* = 388 [M + H^+]. Anal. Calcd for $C_{25}H_{41}NO_2$: C, 77.47; H, 10.66; N, 3.61. Found: C, 77.58; H, 10.72; N, 3.55.

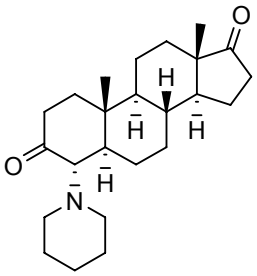


4*α*-[Bis(1-methylethyl)amino]-5*α*-androstan-3,17-dione (3d) white solid; mp 179-181 °C; R_f = 0.4 (PE-EtOAc, 4:1); IR (KBr): 1717.21 (CO-3), 1737.83 (CO-17) cm^{-1}. ^{1}HNMR (300 MHz, $CDCl_3$): δ = 0.89 (3H, s, H-18), 1.17 (3H, s, H-19), 2.87-3.27 (2H, br, m, CH-N), 3.42 (1H, d, *J* = 12.0 Hz, H-4). ^{13}C NMR (75 MHz, $CDCl_3$): δ = 13.15, 14.07, 20.94, 21.99, 22.39, 25.72, 30.89, 31.81, 35.07, 36.15, 37.37, 38.13, 38.78, 46.82, 47.94, 50.90, 51.57, 54.69, 65.17, 213.09, 221.42. MS: *m/z* = 388 [M + H^+]. Anal. Calcd for $C_{25}H_{41}NO_2$: C, 77.47; H, 10.66; N, 3.61. Found: C, 77.31; H, 10.68; N, 3.69.

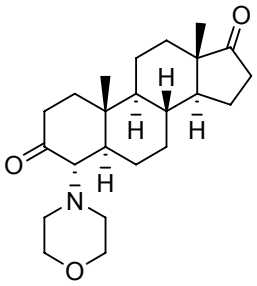


4*α*-(1-Pyrrolidinyl)-5*α*-androstan-3,17-dione (3e) white crystal; mp 195-196 °C; R_f = 0.4 (PE-EtOAc, 5:2); IR (KBr): 1717.68 (CO-3), 1739.34 (CO-17) cm^{-1}. ^{1}HNMR (300 MHz, $CDCl_3$): δ = 0.89 (3H, s, H-18), 1.10 (3H, s, H-19), 2.82 (4H, br, s, CH_2-N), 3.34 (1H, d, *J* = 6.3 Hz, H-4). ^{13}C NMR (75 MHz, $CDCl_3$): δ = 11.86, 12.78, 19.70, 20.73, 23.78, 24.08, 29.75, 30.48, 33.66, 34.83, 36.19, 37.59, 37.90, 46.66, 47.12, 50.28, 50.98, 53.45, 65.60, 210.86, 220.06. MS: *m/z* = 358 [M + H^+]. Anal. Calcd for $C_{23}H_{35}NO_2$: C, 77.27; H, 9.87; N, 3.92. Found: C, 77.44; H, 9.90; N, 3.73.

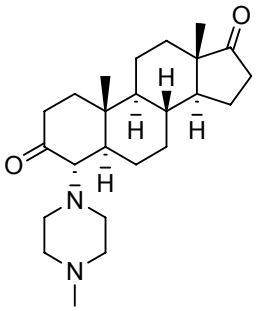
4*α*-(1-Piperidinyl)-5*α*-androstan-3,17-dione (3f) white crystal; mp 223-225 °C; R_f = 0.4 (PE-EtOAc, 5:2); IR (KBr): 1720.21 (CO-3), 1737.43 (CO-17) cm^{-1}. ^{1}HNMR (300 MHz, $CDCl_3$): δ = 0.89 (3H, s, H-18), 1.06 (3H, s, H-19), 2.66-2.83 (4H, br, m, CH_2-N), 2.96 (1H, d, *J* = 12.3 Hz, H-4). ^{13}C NMR (75 MHz, $CDCl_3$): δ = 12.96, 13.86, 20.78, 21.82, 24.90, 25.17, 25.38, 30.88, 31.56, 34.72, 35.93, 37.25, 38.66, 38.94, 46.28, 47.74, 51.30, 52.99, 54.58, 66.91, 211.92, 221.13. MS: *m/z* = 372 [M + H^+]. Anal. Calcd for $C_{24}H_{37}NO_2$: C, 77.58; H, 10.04; N, 3.77. Found: C, 77.26; H, 10.30; N, 3.83.



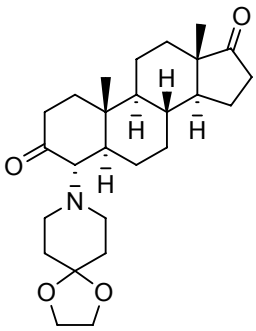
4*α*-(4-Morpholinyl)-5*α*-androstan-3,17-dione (3g) white solid; mp 174-176 °C; R_f = 0.3 (PE-EtOAc, 1:1); IR (KBr): 1713.34 (CO-3), 1741.29 (CO-17) cm^{-1}. ^{1}HNMR (300 MHz, $CDCl_3$): δ = 0.89 (3H, s, H-18), 1.09 (3H, s, H-19), 2.78-2.94 (4H, br, m, CH_2-N), 2.98 (1H, d, *J* = 12.3 Hz, H-4), 3.62 (4H, m, CH_2-O). ^{13}C NMR (75 MHz, $CDCl_3$): δ = 12.95, 14.07, 21.14, 21.99, 28.33, 30.71, 31.68, 34.76, 36.03, 37.05, 41.49, 45.23, 47.98, 48.08, 49.75, 51.35, 54.49, 67.61, 68.24, 209.12, 221.00. MS: *m/z* = 374 [M + H^+]. Anal. Calcd for $C_{23}H_{35}NO_3$: C, 73.96; H, 9.44; N, 3.75. Found: C, 74.12; H, 9.37; N, 3.68.



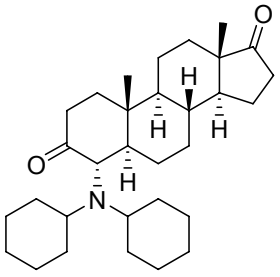
4*α*-(4-Methyl-1-piperazinyl)-5*α*-androstan-3,17-dione (3h) white solid; mp 146-148 °C; R_f = 0.2 (PE-EtOAc, 1:1); IR (KBr): 1719.59 (CO-3), 1740.66 (CO-17) cm^{-1}. ^{1}HNMR (300 MHz, $CDCl_3$): δ = 0.89 (3H, s, H-18), 1.10 (3H, s, H-19), 2.29 (3H, s, CH_3-N), 2.32-2.77 (8H, br, m, CH_2-N), 3.33 (1H, d, *J* = 13.1 Hz, H-4). ^{13}C NMR (75 MHz, $CDCl_3$): δ = 12.90, 14.04, 21.10, 21.98, 24.62, 30.71, 31.66, 34.75, 36.01, 37.00, 38.34, 38.74, 41.25, 47.95, 49.06, 50.06, 51.35, 54.50, 55.68, 67.97, 209.08, 221.10. MS: *m/z* = 387 [M + H^+]. Anal. Calcd for $C_{24}H_{38}N_2O_2$: C, 74.57; H, 9.91; N, 7.25. Found: C, 74.46; H, 9.98; N, 7.37.



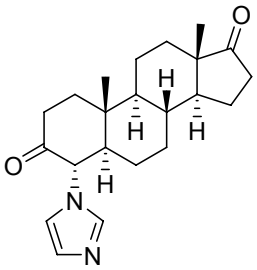
4*α*-(1,4-Dioxa-8-azaspiro[4.5]dec-8-yl)-5*α*-androstan-3,17-dione (3i) white solid; mp 237-239 °C; R_f = 0.4 (PE-EtOAc, 2:1); IR (KBr): 1711.63 (CO-3), 1743.62 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.89 (3H, s, H-18), 1.07 (3H, s, H-19), 2.80-2.96 (4H, br, m, CH_2-N), 3.05 (1H, d, *J* = 12.3 Hz, H-4), 3.95 (4H, s, CH_2-O). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 10.82, 11.81, 18.71, 19.76, 22.47, 28.73, 29.50, 32.66, 33.86, 35.15, 36.36, 36.53, 44.19, 45.67, 48.13, 49.34, 52.59, 62.16, 68.77, 105.79, 210.00, 219.07. MS: *m/z* = 430 [M + H^+]. Anal. Calcd for $C_{26}H_{39}NO_4$: C, 72.69; H, 9.15; N, 3.26. Found: C, 72.94; H, 8.96; N, 3.24.



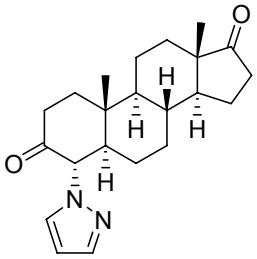
4*α*-N,N-dicyclohexyl-5*α*-androstan-3,17-dione (3j) white solid; mp 247-249 °C; R_f = 0.8 (PE-EtOAc, 2:1); IR (KBr): 1717.28 (CO-3), 1736.54 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.89 (3H, s, H-18), 1.09 (3H, s, H-19), 2.35 (2H, m, CH-N), 3.26 (1H, d, *J* = 11.9 Hz, H-4). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 13.26, 13.81, 20.79, 21.74, 25.64, 26.06, 26.73, 26.91, 30.75, 31.56, 34.74, 34.96, 35.86, 37.60, 37.96, 38.48, 47.74, 51.30, 51.40, 54.70, 65.31, 213.98, 221.09. MS: *m/z* = 468 [M + H^+]. Anal. Calcd for $C_{31}H_{49}NO_2$: C, 79.60; H, 10.56; N, 2.99. Found: C, 79.12; H, 10.81; N, 3.06.



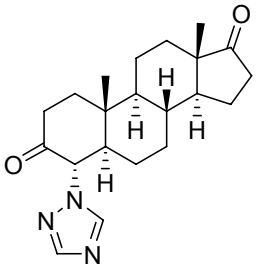
4*α*-(1H-imidazol-1-yl)-5*α*-androstan-3,17-dione (3k) white solid; mp 184-186 °C; R_f = 0.5 (EtOAc-MeOH, 4:1); IR (KBr): 1726.61 (CO-3), 1737.36 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.90 (3H, s, H-18), 1.22 (3H, s, H-19), 4.62 (1H, d, *J* = 12.8 Hz, H-4), 6.98 (1H, s, H-5′), 7.07 (1H, s, H-4′), 7.52 (1H, s, H-2′). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 12.37, 13.55, 20.34, 21.44, 23.84, 29.76, 31.15, 34.26, 35.57, 37.05, 37.23, 38.04, 47.42, 50.84, 52.62, 53.79, 64.52, 118.21, 127.94, 137.46, 204.45, 220.23. MS: *m/z* = 355 [M + H^+]. Anal. Calcd for $C_{22}H_{30}N_2O_2$: C, 74.54; H, 8.53; N, 7.90. Found: C, 74.76; H, 8.40; N, 7.82.



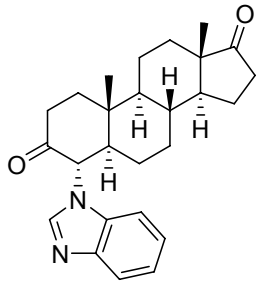
4*α*-(1H-pyrazol-1-yl)-5*α*-androstan-3,17-dione (3l) white solid; mp 205-207 °C; R_f = 0.4 (PE-EtOAc-Et_3N, 50:49:1); IR (KBr): 1726.24 (CO-3), 1736.86 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.89 (3H, s, H-18), 1.22 (3H, s, H-19), 4.89 (1H, d, *J* = 12.9 Hz, H-4), 6.35 (1H, m, H-4′), 7.35 (1H, d, *J* = 2.2 Hz, H-5′), 7.54 (1H, d, *J* = 1.7 Hz, H-3′). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 10.49, 11.65, 18.45, 19.53, 21.96, 27.87, 29.24, 32.38, 33.61, 35.16, 35.34, 36.14, 45.49, 48.96, 50.77, 51.86, 68.25, 103.90, 127.36, 136.88, 202.29, 218.49. MS: *m/z* = 355 [M + H^+]. Anal. Calcd for $C_{22}H_{30}N_2O_2$: C, 74.54; H, 8.53; N, 7.90. Found: C, 74.11; H, 8.68; N, 7.00.



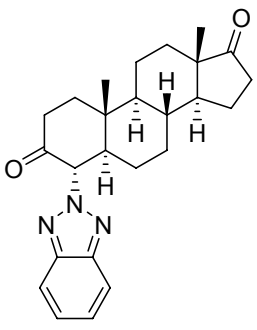
4*α*-(1H-1,2,4-triazol-1-yl)-5*α*-androstan-3,17-dione (3m) white solid; mp 180-182 °C; R_f = 0.6 (EtOAc-MeOH, 15:1); IR (KBr): 1731.09 (CO-3), 1742.31 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.90 (3H, s, H-18), 1.24 (3H, s, H-19), 4.94 (1H, d, *J* = 12.7 Hz, H-4), 7.98 (1H, s, H-3′), 8.07 (1H, s, H-5′). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 12.57, 13.81, 20.57, 21.66, 24.22, 29.82, 31.31, 34.49, 35.73, 37.09, 37.49, 38.13, 47.59, 51.03, 52.37, 53.88, 68.42, 144.15, 151.46, 202.73, 220.39. MS: *m/z* = 356 [M + H^+]. Anal. Calcd for $C_{21}H_{29}N_3O_2$: C, 70.95; H, 8.22; N, 11.82. Found: C, 70.44; H, 8.38; N, 11.89.



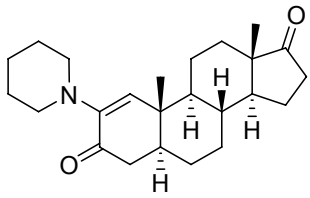
4*α*-(1H-benzimidazol-1-yl)-5*α*-androstan-3,17-dione (3n) white solid; mp 256-258 °C; R_f = 0.4 (PE-EtOAc, 1:2); IR (KBr): 1725.34 (CO-3), 1738.77 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.90 (3H, s, H-18), 1.29 (3H, s, H-19), 4.87 (1H, d, *J* = 12.8 Hz, H-4), 7.21, 7.31 and 7.88 (4H, m, H-aromatic), 7.95 (1H, s, CH=N). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 12.74, 13.80, 20.66, 21.76, 24.31, 29.77, 31.48, 34.59, 35.82, 37.18, 37.35, 37.78, 47.69, 51.14, 51.48, 53.95, 62.07, 109.77, 120.69, 122.54, 122.99, 133.51, 142.36, 143.62, 202.98, 220.58. MS: *m/z* = 405 [M + H^+]. Anal. Calcd for $C_{26}H_{32}N_2O_2$: C, 77.19; H, 7.97; N, 6.92. Found: C, 76.93; H, 8.03; N, 6.98.



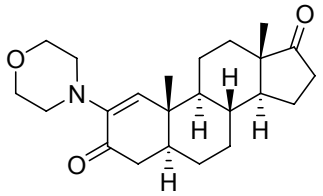
4*α*-(2H-benzotriazol-2-yl)-5*α*-androstan-3,17-dione (3o) white solid; mp 252-254 °C; R_f = 0.4 (CH_2Cl_2-EtOAc, 2:1); IR (KBr): 1725.67 (CO-3), 1739.72 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.90 (3H, s, H-18), 1.27 (3H, s, H-19), 5.48 (1H, d, *J* = 13.0 Hz, H-4), 7.40 and 7.88 (4H, m, H-aromatic). ^{13}C NMR (100 MHz, $CDCl_3$): δ =12.67, 13.82, 20.60, 21.68, 24.28, 29.72, 31.40, 34.55, 35.76, 37.10, 37.27, 37.68, 47.63, 51.07, 51.40, 53.88, 75.00, 118.18, 118.26, 126.53, 144.29, 202.16, 220.56. MS: *m/z* = 406 [M + H^+]. Anal. Calcd for $C_{25}H_{31}N_3O_2$: C, 74.04; H, 7.70; N, 10.36. Found: C, 74.31; H, 7.62; N, 10.28.



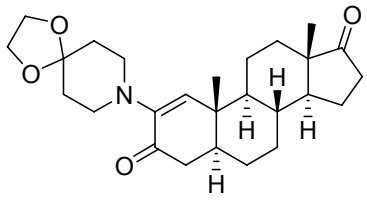
2-(1-Piperidinyl)-5*α*-androst-1-ene-3,17-dione (6f) yield: 5%; white solid; mp 147-149 °C; R_f = 0.3 (PE-EtOAc, 2:1); IR (KBr): 1689.21 (CO-3), 1738.98 (CO-17) cm^{-1}. ^{1}HNMR (300 MHz, $CDCl_3$): δ = 0.91 (3H, s, H-18), 1.00 (3H, s, H-19), 2.64-2.75 (4H, br, m, CH_2-N), 6.13 (1H, s, H-1). ^{13}C NMR (75 MHz, $CDCl_3$): δ = 14.14, 14.31, 20.97, 21.91, 24.54, 26.12, 27.21, 30.37, 31.73, 35.40, 36.03, 38.50, 42.15, 43.78, 48.08, 51.52, 51.62, 135.11, 147.04, 196.20, 220.91. MS: *m/z* = 370 [M + H^+]. Anal. Calcd for $C_{24}H_{35}NO_2$: C, 78.00; H, 9.55; N, 3.79. Found: C, 77.66; H, 9.65; N, 3.84.



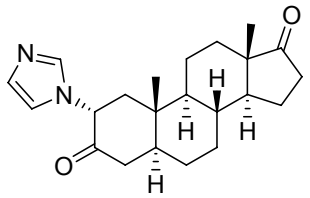
2-(4-Morpholinyl)-5*α*-androst-1-ene-3,17-dione (6g) yield: 8%; white solid; mp 131-132 °C; R_f = 0.4 (PE-EtOAc, 1:1); IR (KBr): 1684.57 (CO-3), 1740.74 (CO-17) cm^{-1}. ^{1}HNMR (300 MHz, $CDCl_3$): δ = 0.91 (3H, s, H-18), 1.02 (3H, s, H-19), 2.75-2.84 (4H, br, m, CH_2-N), 3.62 (4H, m, CH_2-O), 6.14 (1H, s, H-1). ^{13}C NMR (75 MHz, $CDCl_3$): δ = 14.04, 14.21, 20.92, 21.84, 27.09, 30.25, 31.61, 35.30, 35.93, 38.52, 41.98, 43.70, 47.95, 50.48, 51.31, 51.43, 66.97, 135.16, 145.06, 195.89, 220.71. MS: *m/z* = 372 [M + H^+]. Anal. Calcd for $C_{23}H_{33}NO_3$: C, 74.36; H, 8.95; N, 3.77. Found: C, 74.09; H, 9.03; N, 3.81.



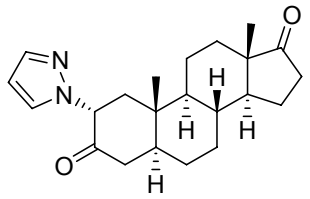
2-(1,4-Dioxa-8-azaspiro[4.5]dec-8-yl)-5*α*-androst-1-ene-3,17-dione (6i) yield: 10%; white solid; mp 168-179 °C; R_f = 0.5 (PE-EtOAc, 2:1); IR (KBr): 1680.48 (CO-3), 1739.24 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.89 (3H, s, H-18), 1.02 (3H, s, H-19), 2.80-2.93 (4H, br, m, CH_2-N), 3.96 (4H, s, CH_2-O), 6.21 (1H, s, H-1). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 14.19, 14.25, 21.00, 21.97, 27.20, 30.41, 31.76, 34.99, 35.41, 36.07, 38.65, 42.09, 43.89, 48.12, 48.60, 51.54, 51.57, 64.53, 107.28, 136.12, 146.03, 196.24, 220.97. MS: *m/z* = 428 [M + H^+]. Anal. Calcd for $C_{26}H_{37}NO_4$: C, 73.03; H, 8.72; N, 3.28. Found: C, 72.81; H, 8.79; N, 3.32.



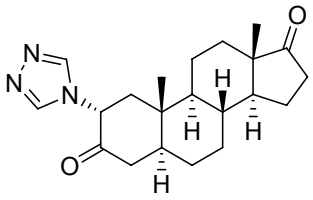
2*α*-(1H-imidazol-1-yl)-5*α*-androstan-3,17-dione (2k) yield: 8%; white solid; mp 165-168 °C; R_f = 0.6 (EtOAc-MeOH, 4:1); IR (KBr): 1723.48 (CO-3), 1738.83 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.90 (3H, s, H-18), 1.23 (3H, s, H-19), 4.85 (1H, dd, *J* = 5.9 and 13.5 Hz, H-2), 6.86 (1H, s, H-5′), 7.09 (1H, s, H-4′), 7.45 (1H, s, H-2′). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 12.42, 13.78, 20.80, 21.69, 28.04, 30.30, 31.29, 34.43, 35.71, 37.34, 43.69, 47.03, 47.52, 47.63, 50.99, 53.66, 61.68, 118.45, 128.86, 136.76, 203.59, 220.48. MS: *m/z* = 355 [M + H^+]. Anal. Calcd for $C_{22}H_{30}N_2O_2$: C, 74.54; H, 8.53; N, 7.90. Found: C, 74.41; H, 8.59; N, 7.93.



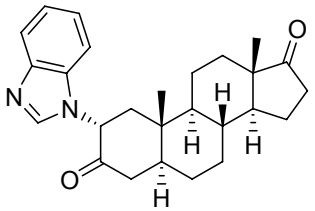
2*α*-(1H-pyrazol-1-yl)-5*α*-androstan-3,17-dione (2l) yield: 6%; white solid; mp 187-188 °C; R_f = 0.5 (PE-EtOAc-Et_3N, 50:49:1); IR (KBr): 1728.50 (CO-3), 1739.09 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.88 (3H, s, H-18), 1.23 (3H, s, H-19), 5.13 (1H, dd, *J* = 5.9 and 13.5 Hz, H-2), 6.34 (1H, m, H-4′), 7.42 (1H, d, *J* = 2.4 Hz, H-5′), 7.54 (1H, d, *J* = 1.4 Hz, H-3′). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 12.47, 13.83, 20.84, 21.74, 28.11, 30.41, 31.35, 34.50, 35.76, 37.26, 43.83, 46.06, 47.48, 47.71, 51.09, 53.84, 66.26, 105.97, 129.18, 139.14, 204.20, 220.65. MS: *m/z* = 355 [M + H^+]. Anal. Calcd for $C_{22}H_{30}N_2O_2$: C, 74.54; H, 8.53; N, 7.90. Found: C, 74.31; H, 8.68; N, 7.97.



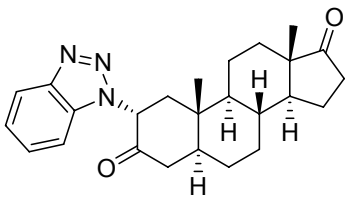
2*α*-(4H-1,2,4-triazol-4-yl)-5*α*-androstan-3,17-dione (2m) yield: 5%; white solid; mp 230-232 °C; R_f = 0.2 (EtOAc-MeOH, 15:1); IR (KBr): 1730.13 (CO-3), 1739.16 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.90 (3H, s, H-18), 1.25 (3H, s, H-19), 4.98 (1H, dd, *J* = 6.0 and 13.6 Hz, H-2), 8.13 (2H, s, CH=N). ^{13}C NMR (100 MHz, $CDCl_3$): δ =12.50, 13.81, 20.91, 21.73, 28.09, 30.30, 31.29, 34.49, 35.70, 37.56, 43.53, 47.19, 47.62, 47.68, 51.00, 53.62, 60.41, 143.53, 201.84, 220.16. MS: *m/z* = 356 [M + H^+]. Anal. Calcd for $C_{21}H_{29}N_3O_2$: C, 70.95; H, 8.22; N, 11.82. Found: C, 71.16; H, 8.15; N, 11.77.



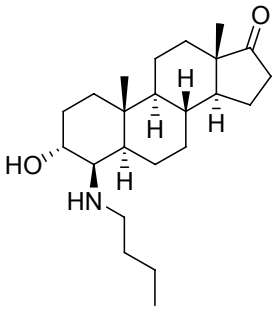
2*α*-(1H-benzimidazol-1-yl)-5*α*-androstan-3,17-dione (2n) yield: 7%; white solid; mp 232-234 °C; R_f = 0.3 (PE-EtOAc, 1:2); IR (KBr): 1728.73 (CO-3), 1740.29 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.89 (3H, s, H-18), 1.30 (3H, s, H-19), 5.10 (1H, dd, *J* = 6.0 and 13.4 Hz, H-2), 7.17, 7.27 and 7.82 (4H, m, H-aromatic), 7.94 (1H, s, CH=N). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 12.40, 13.79, 20.81, 21.73, 28.13, 30.34, 31.27, 34.47, 35.73, 37.44, 43.91, 46.35, 47.54, 47.64, 51.00, 53.70, 59.98, 109.68, 120.51, 122.31, 122.89, 133.34, 142.15, 143.30, 202.92, 220.47. MS: *m/z* = 405 [M + H^+]. Anal. Calcd for $C_{26}H_{32}N_2O_2$: C, 77.19; H, 7.97; N, 6.92. Found: C, 76.96; H, 8.04; N, 6.96.



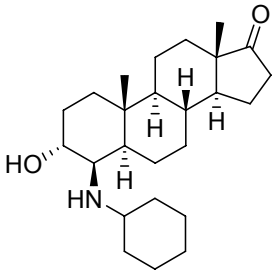
2*α*-(1H-benzotriazol-1-yl)-5*α*-androstan-3,17-dione (2o) yield: 4%; white solid; mp 227-230 °C; R_f = 0.3 (CH_2Cl_2-EtOAc, 2:1); IR (KBr): 1726.31 (CO-3), 1738.81 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.90 (3H, s, H-18), 1.31 (3H, s, H-19), 5.71 (1H, dd, *J* = 6.2 and 13.4 Hz, H-2), 7.30-7.47 and 8.08 (4H, m, H-aromatic). ^{13}C NMR (100 MHz, $CDCl_3$): δ =12.45, 13.81, 20.82, 21.75, 28.17, 30.39, 31.31, 34.44, 35.75, 37.31, 43.81, 44.72, 47.29, 47.62, 51.07, 53.78, 64.05, 110.44, 120.31, 123.92, 127.31, 132.87, 146.32, 201.91, 220.47. MS: *m/z* = 406 [M + H^+]. Anal. Calcd for $C_{25}H_{31}N_3O_2$: C, 74.04; H, 7.70; N, 10.36. Found: C, 73.86; H, 7.76; N, 10.44.



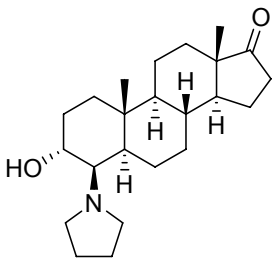
3*α*-Hydroxy-4*β*-(butylamino)-5*α*-androstan-17-one (5a) white solid; mp 179-181 °C; R_f = 0.3 (PE-EtOAc, 8:1); IR (KBr): 3462.59 (OH-3 and NH), 1727.75 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.81 (3H, s, H-18), 0.93 (3H, s, H-19), 2.41 (2H, m, CH_2-N), 2.57 (1H, m, H-4), 3.83 (1H, m, H-3). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 11.88, 12.11, 12.36, 17.75, 18.56, 19.88, 22.68, 23.41, 29.39, 29.58, 30.15, 30.65, 33.20, 33.95, 34.33, 41.26, 45.87, 48.01, 49.61, 53.54, 63.46, 66.53, 219.55. MS: *m/z* = 362 [M + H^+]. Anal. Calcd for $C_{23}H_{39}NO_2$: C, 76.40; H, 10.87; N, 3.87. Found: C, 76.68; H, 10.74; N, 3.91.



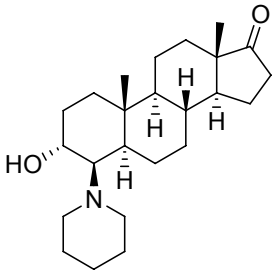
3*α*-Hydroxy-4*β*-(cyclohexylamino)-5*α*-androstan-17-one (5b) white solid; mp 181-182 °C; R_f = 0.3 (CH_2Cl_2-EtOAc, 4:1); IR (KBr): 3479.49 (OH-3 and NH), 1728.12 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.84 (3H, s, H-18), 0.97 (3H, s, H-19), 2.28 (1H, m, H-1′), 2.57 (1H, s, H-4), 3.80 (1H, m, H-3). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 11.53, 11.92, 17.38, 19.55, 22.26, 22.91, 23.02, 23.11, 23.92, 29.01, 29.25, 29.67, 31.34, 32.84, 33.12, 33.61, 34.00, 40.74, 45.52, 49.31, 53.21, 54.54, 59.99, 67.80, 219.17. MS: *m/z* = 388 [M + H^+]. Anal. Calcd for $C_{25}H_{41}NO_2$: C, 77.47; H, 10.66; N, 3.61. Found: C, 77.19; H, 10.47; N, 3.66.



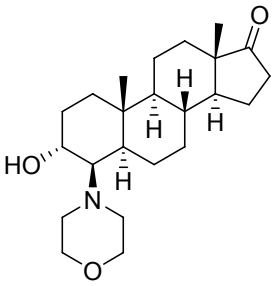
3*α*-Hydroxy-4*β*-(1-pyrrolidinyl)-5*α*-androstan-17-one (5c) white solid; mp 209-211 °C; R_f = 0.4 (PE-EtOAc, 4:1); IR (KBr): 3520.56 (OH-3), 1721.38 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.84 (3H, s, H-18), 1.18 (3H, s, H-19), 2.18 (1H, s, H-4), 2.55-2.61 (4H, br, m, CH_2-N), 4.20 (1H, s, H-3). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 13.72, 13.77, 19.75, 21.76, 23.43, 24.49, 29.44, 31.56, 32.48, 33.39, 35.63, 35.86, 37.06, 44.37, 47.73, 51.31, 53.75, 56.37, 68.84, 71.54, 221.65. MS: *m/z* = 360 [M + H^+]. Anal. Calcd for $C_{23}H_{37}NO_2$: C, 76.83; H, 10.37; N, 3.90. Found: C, 76.97; H, 10.45; N, 3.80.



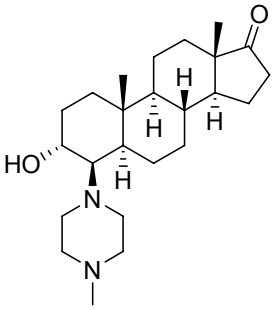
3*α*-Hydroxy-4*β*-(1-piperidinyl)-5*α*-androstan-17-one (5d) white solid; mp 191-193 °C; R_f = 0.3 (PE-EtOAc, 4:1); IR (KBr): 3422.37 (OH-3), 1727.90 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.85 (3H, s, H-18), 1.04 (3H, s, H-19), 2.32 (1H, s, H-4), 2.55 (4H, br, s, CH_2-N), 4.16 (1H, s, H-3). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 13.63, 13.71, 19.54, 21.75, 24.72, 26.76, 27.04, 27.09, 31.53, 31.70, 32.70, 34.93, 35.88, 36.14, 44.89, 47.68, 51.42, 54.20, 55.64, 66.17, 69.53, 221.71. MS: *m/z* = 374 [M + H^+]. Anal. Calcd for $C_{24}H_{39}NO_2$: C, 77.16; H, 10.52; N, 3.75. Found: C, 77.31; H, 10.10; N, 3.85.



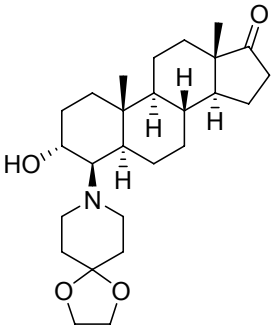
3*α*-Hydroxy-4*β*-(4-morpholinyl)-5*α*-androstan-17-one (5e) white solid; mp 216-218 °C; R_f = 0.2 (PE-EtOAc, 4:1); IR (KBr): 3496.61 (OH-3), 1720.16 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.86 (3H, s, H-18), 1.08 (3H, s, H-19), 2.32 (1H, s, H-4), 2.60-2.64 (4H, br, m, CH_2-N), 3.59-3.71 (4H, br, m, CH_2-O), 4.17 (1H, m, H-3). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 13.70, 13.80, 19.58, 21.73, 26.23, 27.99, 31.51, 31.89, 32.62, 35.10, 35.83, 36.28, 44.42, 47.65, 51.35, 53.47, 55.76, 65.72, 67.63, 69.45, 221.49. MS: *m/z* = 376 [M + H^+]. Anal. Calcd for $C_{23}H_{37}NO_3$: C, 73.56; H, 9.93; N, 3.73. Found: C, 73.62; H, 9.87; N, 3.66.



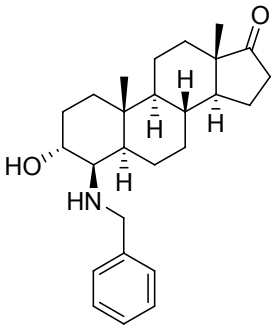
3*α*-Hydroxy-4*β*-(4-methyl-1-piperazinyl)-5*α*-androstan-17-one (5f) white solid; mp 231-232 °C; R_f = 0.5 (CH_2Cl_2-MeOH-Et_3N, 89:10:1); IR (KBr): 3404.54 (OH-3), 1735.98 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, D_2O): δ = 0.54 (3H, s, H-18), 0.68 (3H, s, H-19), 2.07 (1H, s, H-4), 2.20-2.30 and 2.71-3.10 (8H, br, m, CH_2-N), 2.49 (3H, s, CH_3-N), 3.79 (1H, s, H-3). ^{13}C NMR (100 MHz, DMSO-d_6): δ = 13.24, 13.55, 19.12, 21.32, 25.48, 27.30, 31.21, 31.55, 32.26, 34.61, 35.24, 35.72, 41.86, 43.36, 46.86, 50.43, 53.20, 55.15, 63.68, 68.23, 219.84. MS: *m/z* = 389 [M + H^+]. Anal. Calcd for $C_{24}H_{40}N_2O_2$: C, 74.18; H, 10.38; N, 7.21. Found: C, 73.98; H, 10.45; N, 7.29.



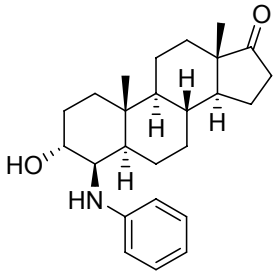
3*α*-Hydroxy-4*β*-(1,4-dioxa-8-azaspiro[4.5]dec-8-yl)-5*α*-androstan-17-one (5g) white solid; mp 116-118 °C; R_f = 0.2 (PE-EtOAc, 4:1); IR (KBr): 3491.65 (OH-3), 1734.03 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.86 (3H, s, H-18), 1.04 (3H, s, H-19), 2.42 (1H, s, H-4), 2.70 (4H, br, s, CH_2-N), 3.94 (4H, m, CH_2-O), 4.15 (1H, s, H-3). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 13.36, 13.45, 19.27, 21.46, 26.21, 26.87, 31.26, 31.43, 32.35, 34.67, 35.50, 35.59, 35.87, 44.39, 47.40, 50.41, 51.15, 55.39, 63.84, 66.06, 68.32, 106.96, 221.39. MS: *m/z* = 432 [M + H^+]. Anal. Calcd for $C_{26}H_{41}NO_4$: C, 72.35; H, 9.57; N, 3.25. Found: C, 72.11; H, 9.68; N, 3.15.



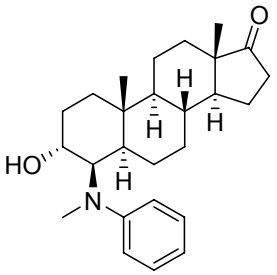
3*α*-Hydroxy-4*β*-[(phenylmethyl)amino]-5*α*-androstan-17-one (5h) white solid; mp 182-184 °C; R_f = 0.2 (CH_2Cl_2-EtOAc-Et_3N, 89:10:1); IR (KBr): 3452.30 (OH-3 and NH), 1726.24 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.83 (3H, s, H-18), 1.03 (3H, s, H-19), 2.58 (1H, s, H-4), 3.62-3.86 (2H, m, CH_2-N), 3.95 (1H, m, H-3), 7.22 and 7.52 (5H, m, H-aromatic). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 13.77, 14.35, 19.64, 21.75, 24.59, 25.28, 31.26, 31.45, 32.04, 35.04, 35.84, 36.21, 43.08, 47.77, 51.45, 53.86, 55.40, 64.46, 67.82, 126.85, 127.97, 128.67, 141.12, 221.63. MS: *m/z* = 396 [M + H^+]. Anal. Calcd for $C_{26}H_{37}NO_2$: C, 78.94; H, 9.43; N, 3.54. Found: C, 78.59; H, 9.62; N, 3.66.



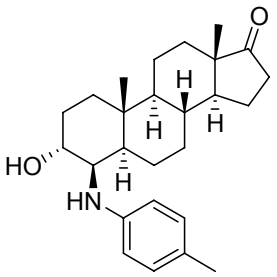
3*α*-Hydroxy-4*β*-(phenylamino)-5*α*-androstan-17-one (5i) white solid; mp 209-211 °C; R_f = 0.4 (CH_2Cl_2-EtOAc, 4:1); IR (KBr): 3444.92 (OH-3 and NH), 1720.52 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.86 (3H, s, H-18), 1.07 (3H, s, H-19), 3.35 (1H, s, H-N), 3.79 (1H, m, H-4), 4.04 (1H, s, H-3), 6.59, 6.68 and 7.16 (5H, m, H-aromatic). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 13.74, 13.95, 19.53, 21.76, 24.81, 25.33, 31.10, 31.15, 31.35, 34.94, 35.83, 36.26, 42.28, 47.67, 51.52, 55.41, 59.26, 67.28, 112.51, 117.17, 129.36, 147.93, 221.33. MS: *m/z* = 382 [M + H^+]. Anal. Calcd for $C_{25}H_{35}NO_2$: C, 78.70; H, 9.25; N, 3.67. Found: C, 78.88; H, 9.22; N, 3.51.



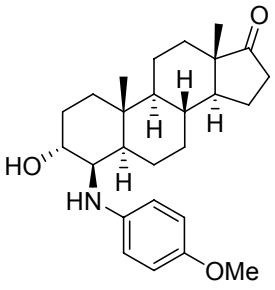
3*α*-Hydroxy-4*β*-(methylphenylamino)-5*α*-androstan-17-one (5j) white solid; mp 150-151 °C; R_f = 0.4 (PE-EtOAc, 8:1); IR (KBr): 3505.97 (OH-3), 1726.63 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.84 (3H, s, H-18), 1.08 (3H, s, H-19), 2.93 (3H, s, CH_3-N), 3.93 (1H, m, H-4), 4.27 (1H, m, H-3), 6.79, 6.86 and 7.23 (5H, m, H-aromatic). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 13.78, 18.42, 20.48, 21.71, 24.05, 27.46, 29.44, 31.33, 31.51, 33.93, 34.84, 35.15, 35.56, 35.80, 47.74, 48.10, 51.37, 56.83, 64.79, 66.75, 114.11, 117.36, 129.14, 152.47, 221.17. MS: *m/z* = 396 [M + H^+]. Anal. Calcd for $C_{26}H_{37}NO_2$: C, 78.94; H, 9.43; N, 3.54. Found: C, 78.69; H, 9.61; N, 3.59.



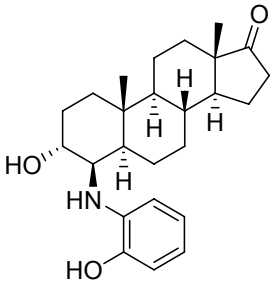
3*α*-Hydroxy-4*β*-[(4-methylphenyl)amino]-5*α*-androstan-17-one (5k) white solid; mp 225-227 °C; R_f = 0.3 (CH_2Cl_2-EtOAc-Et_3N, 89:10:1); IR (KBr): 3458.15 (OH-3 and NH), 1723.18 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.86 (3H, s, H-18), 1.06 (3H, s, H-19), 2.22 (3H, s, CH_3-4′), 3.30 (1H, s, H-N), 3.65 (1H, m, H-4), 4.02 (1H, s, H-3), 6.51 (2H, d, *J* = 8.4 Hz, H-2′ and 6′), 6.97 (2H, d, *J* = 8.4 Hz, H-3′ and 5′). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 13.74, 13.97, 19.53, 20.30, 21.75, 24.75, 25.33, 31.17, 31.37, 34.96, 35.82, 36.25, 42.37, 47.67, 51.54, 55.43, 59.68, 67.39, 112.65, 126.38, 129.83, 145.77, 221.32. MS: *m/z* = 396 [M + H^+]. Anal. Calcd for $C_{26}H_{37}NO_2$: C, 78.94; H, 9.43; N, 3.54. Found: C, 79.23; H, 9.25; N, 3.42.



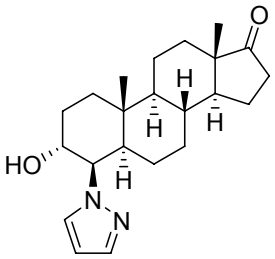
3*α*-Hydroxy-4*β*-[(4-methoxyphenyl)amino]-5*α*-androstan-17-one (5l) white solid; mp 231-232 °C; R_f = 0.4 (CH_2Cl_2-EtOAc-Et_3N, 89:10:1); IR (KBr): 3471.00 (OH-3 and NH), 1725.47 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.85 (3H, s, H-18), 1.06 (3H, s, H-19), 3.25 (1H, s, H-N), 3.50 (1H, s, H-4), 3.74 (3H, s, H-OCH_3), 4.02 (1H, s, H-3), 6.56 and 6.77 (4H, m, H-aromatic). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 13.74, 14.00, 19.54, 21.75, 24.77, 25.37, 31.17, 31.20, 31.38, 34.97, 35.82, 36.26, 42.47, 47.66, 51.53, 55.44, 55.89, 60.39, 67.50, 113.85, 115.03, 142.37, 151.95, 221.26. MS: *m/z* = 412 [M + H^+]. Anal. Calcd for $C_{26}H_{37}NO_3$: C, 75.87; H, 9.06; N, 3.40. Found: C, 75.62; H, 9.16; N, 3.47.



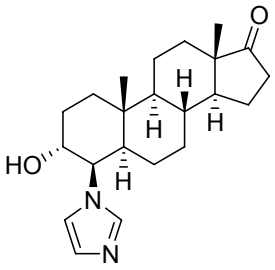
3*α*-Hydroxy-4*β*-[(2-hydroxyphenyl)amino]-5*α*-androstan-17-one (5m) white solid; mp 153-155 °C; R_f = 0.6 (CH_2Cl_2-MeOH-Et_3N, 85:14:1); IR (KBr): 3428.89 (OH and NH), 1727.21 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, DMSO-d_6): δ = 0.78 (3H, s, H-18), 1.02 (3H, s, H-19), 3.14 (1H, s, H-N), 3.72 (1H, s, OH-3) 4.31 (1H, m, H-4), 4.70 (1H, s, H-3), 6.37-6.66 (4H, m, H-aromatic), 9.30 (1H, s, OH-2′). ^{13}C NMR (100 MHz, DMSO-d_6): δ = 13.33, 13.48, 19.09, 21.30, 24.02, 25.14, 30.85, 30.99, 31.15, 34.35, 35.24, 35.64, 41.65, 46.93, 50.73, 54.94, 59.46, 65.59, 109.06, 113.18, 115.44, 119.68, 137.58, 143.77, 219.72. MS: *m/z* = 398 [M + H^+]. Anal. Calcd for $C_{25}H_{35}NO_3$: C, 75.53; H, 8.87; N, 3.52. Found: C, 75.24; H, 9.01; N, 3.58.



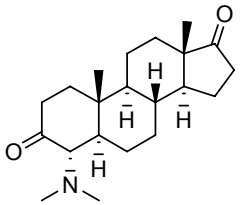
3*α*-Hydroxy-4*β*-(1H-pyrazol-1-yl)-5*α*-androstan-17-one (5n) white solid; mp 294-296 °C; R_f = 0.4 (CH_2Cl_2-MeOH, 95:5); IR (KBr): 3468.94 (OH-3), 1718.08 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.66 (3H, s, H-18), 0.82 (3H, s, H-19), 4.16 (1H, m, H-4), 4.50 (1H, m, H-3), 6.21 (1H, m, H-4′), 7.38 (1H, d, *J* = 2.2 Hz, H-5′), 7.48 (1H, d, *J* = 1.6 Hz, H-3′). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 12.29, 13.69, 19.61, 21.71, 26.13, 26.98, 31.07, 31.41, 32.10, 34.74, 35.61, 35.79, 44.03, 47.68, 51.33, 55.55, 65.78, 68.35, 104.46, 130.95, 138.04, 221.23. MS: *m/z* = 357 [M + H^+]. Anal. Calcd for $C_{22}H_{32}N_2O_2$: C, 74.12; H, 9.05; N, 7.86. Found: C, 74.39; H, 8.99; N, 7.74.

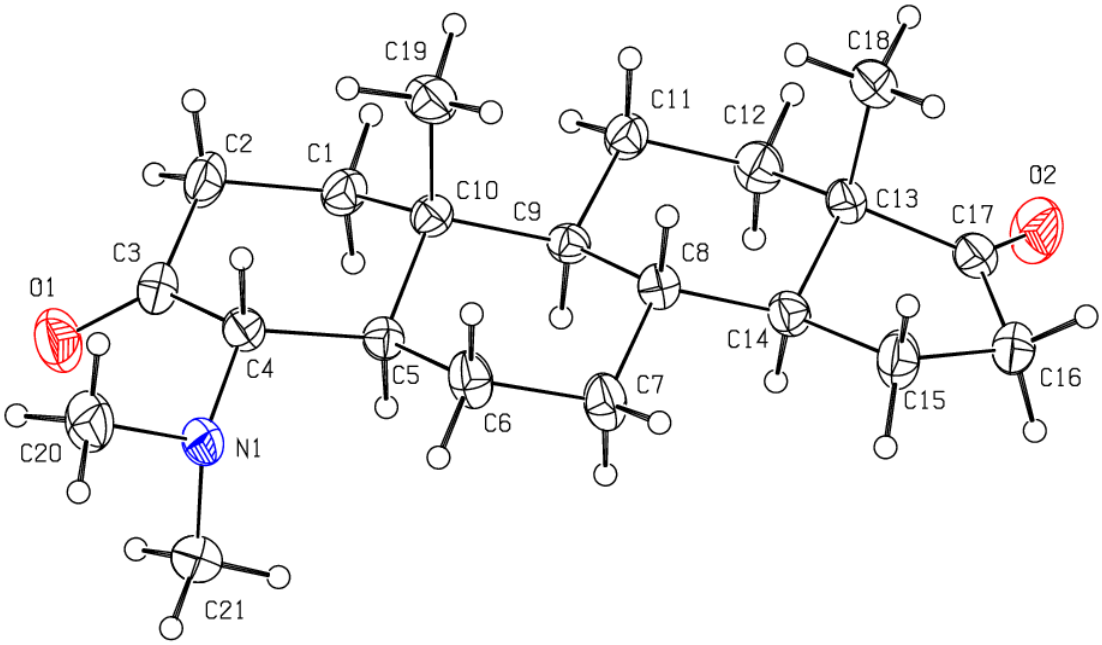


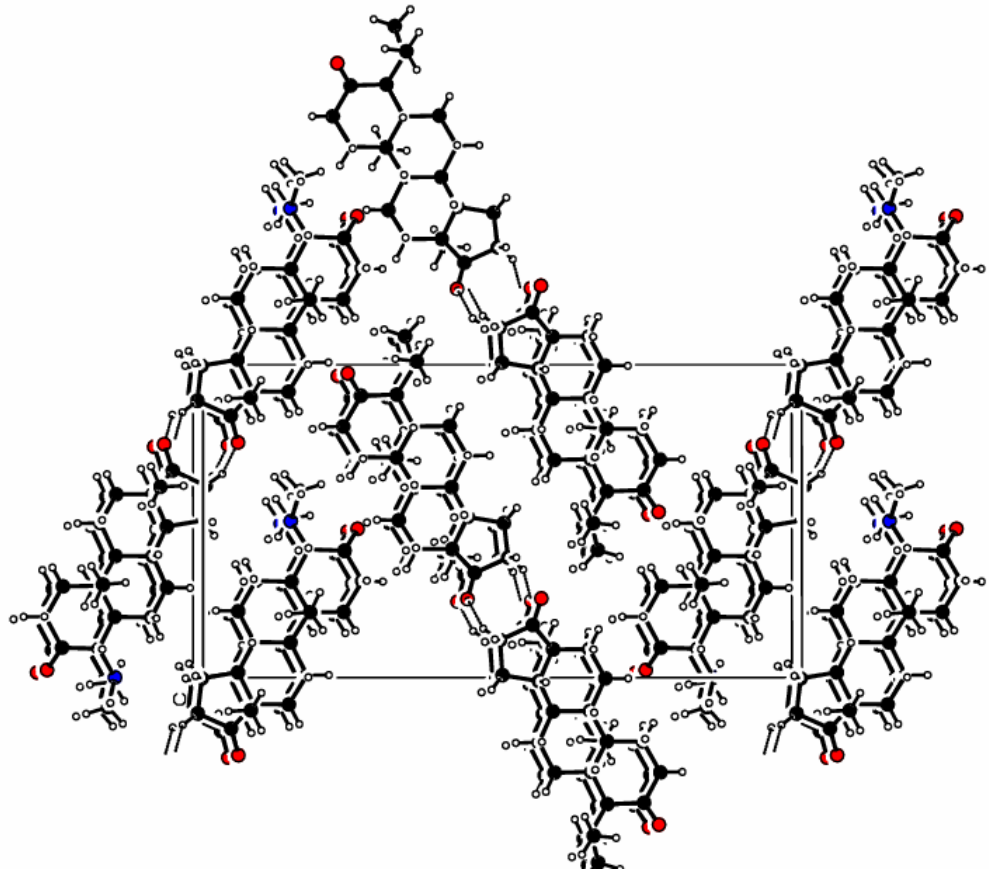
3*α*-Hydroxy-4*β*-(1H-imidazol-1-yl)-5*α*-androstan-17-one (5o) white solid; mp 260-262 °C; R_f = 0.3 (CH_2Cl_2-MeOH, 95:5); IR (KBr): 3416.13 (OH-3), 1737.49 (CO-17) cm^{-1}. ^{1}HNMR (400 MHz, $CDCl_3$): δ = 0.65 (3H, s, H-18), 0.81 (3H, s, H-19), 4.09 (1H, m, H-4), 4.36 (1H, m, H-3), 7.01 (2H, s, H-4′ and 5′), 7.53 (1H, s, H-2′). ^{13}C NMR (100 MHz, $CDCl_3$): δ = 11.91, 12.57, 18.40, 20.55, 25.05, 26.01, 29.82, 30.20, 30.66, 33.58, 34.35, 34.63, 42.39, 46.47, 50.12, 54.38, 61.58, 66.66, 118.35, 127.06, 136.26, 219.89. MS: *m/z* = 357 [M + H^+]. Anal. Calcd for $C_{22}H_{32}N_2O_2$: C, 74.12; H, 9.05; N, 7.86. Found: C, 74.41; H, 8.95; N, 7.80.



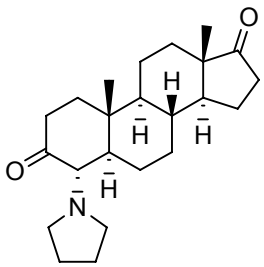
X-ray Crystal Structures of Compound 3a (CCDC-682757)

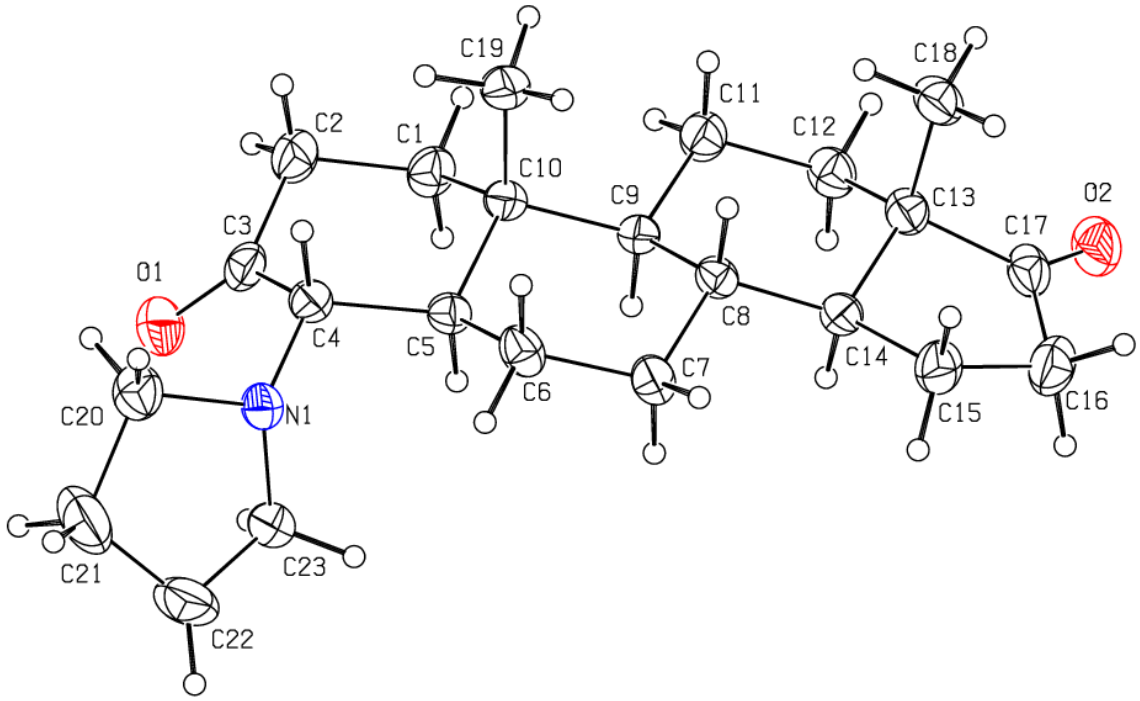


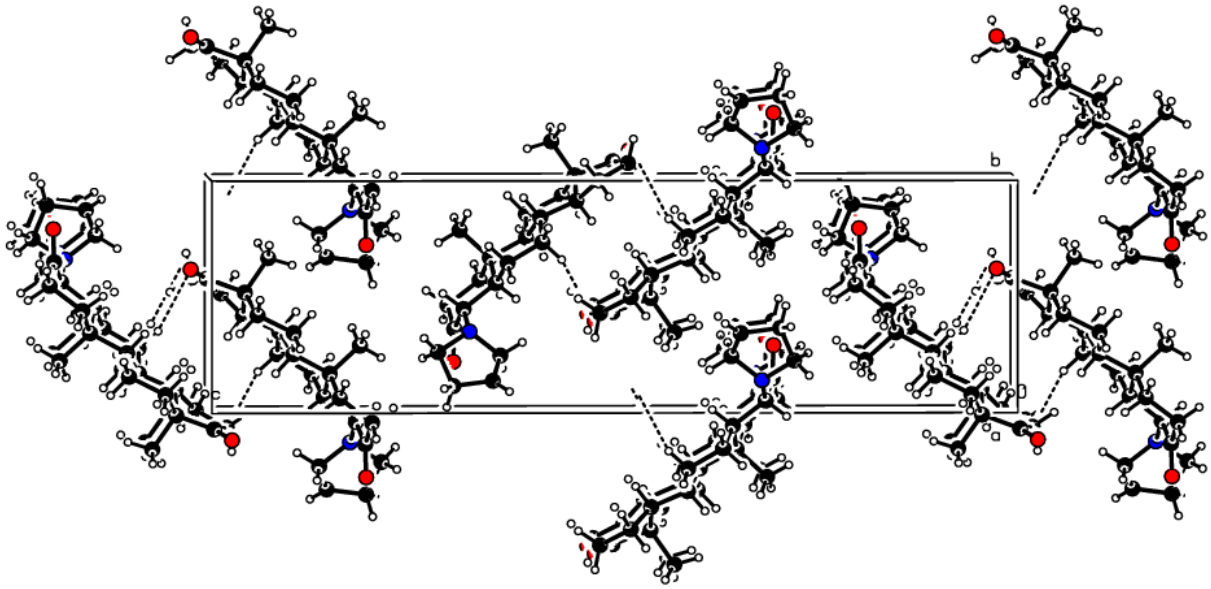




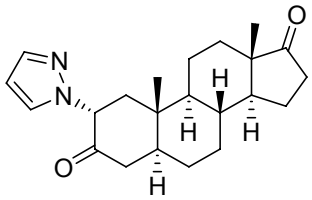
X-ray Crystal Structures of Compound 3e (CCDC-682758)

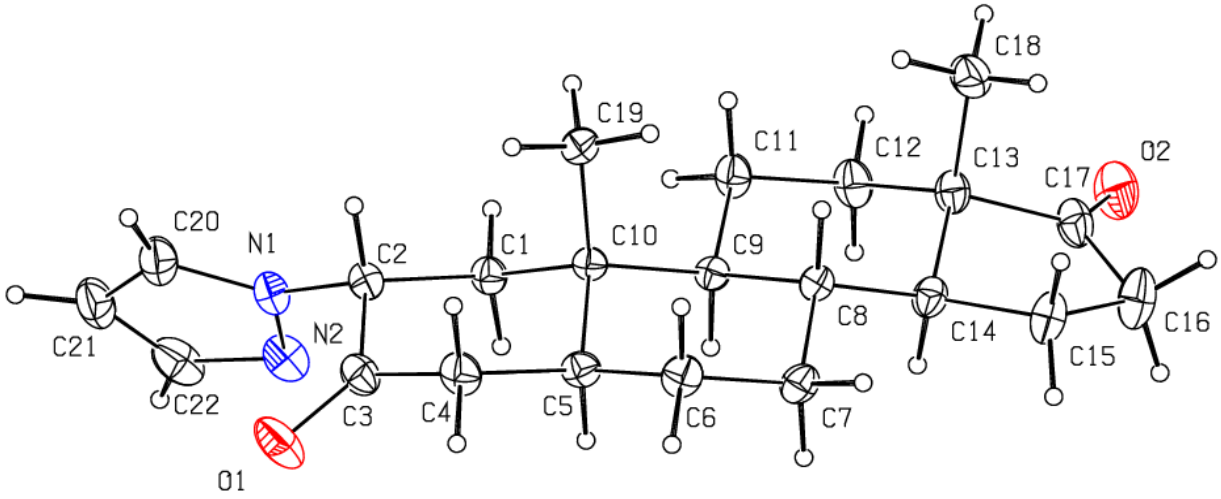


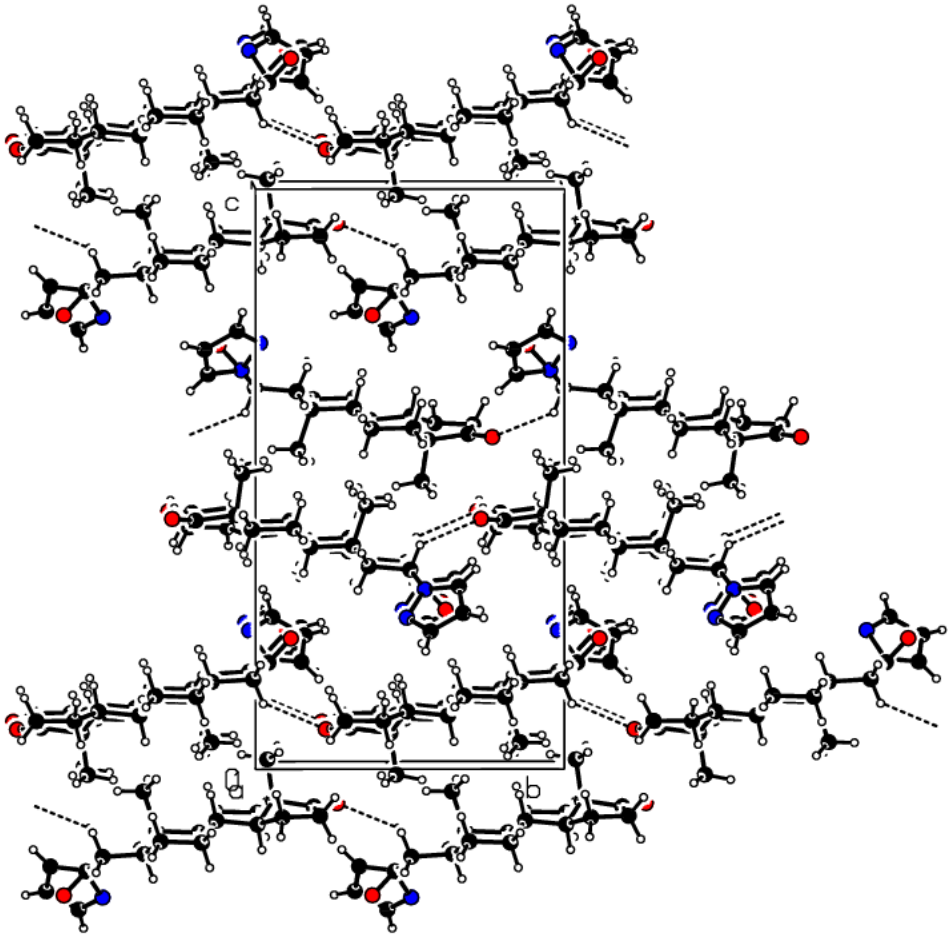




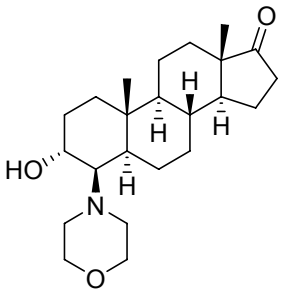
X-ray Crystal Structures of 2*α*-(1H-pyrazol-1-yl)-5*α*-androstan-3,17-dione (CCDC-695665)



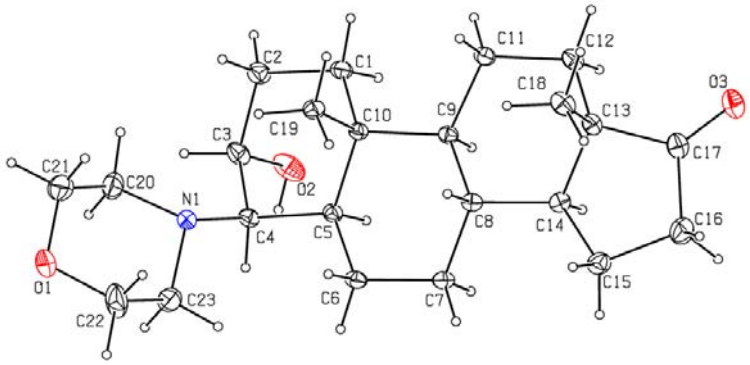




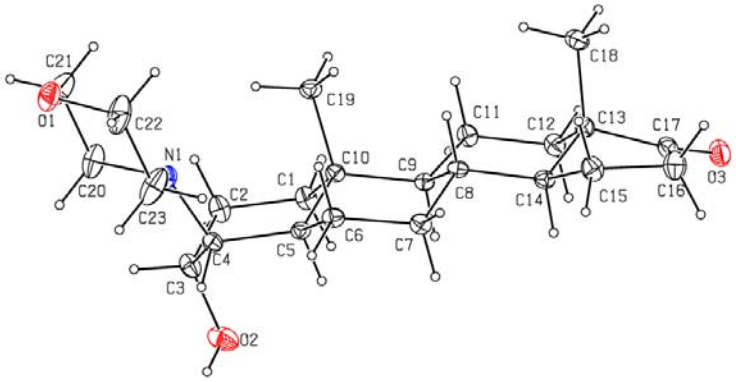
X-ray Crystal Structures of 5e (CCDC-695664)

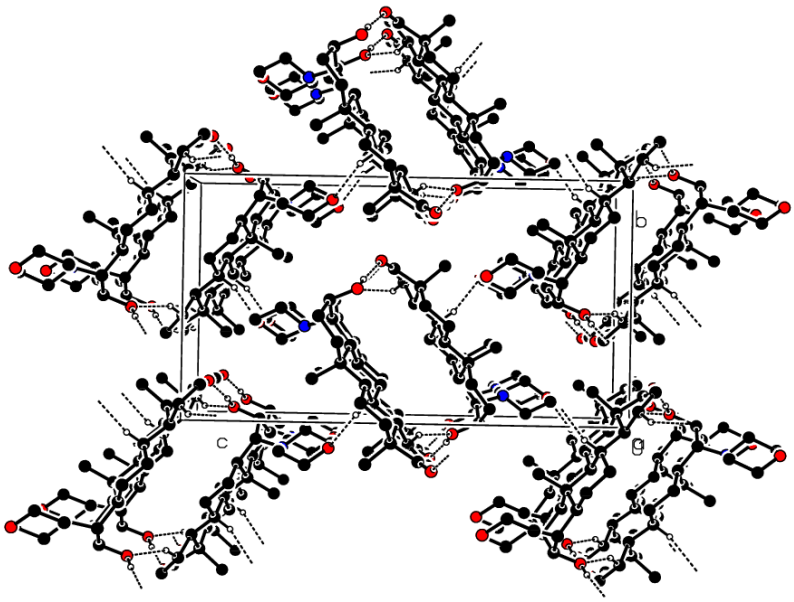


View along the [011] direction

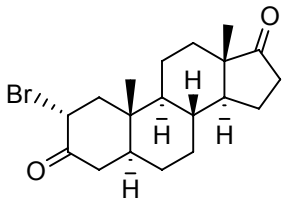


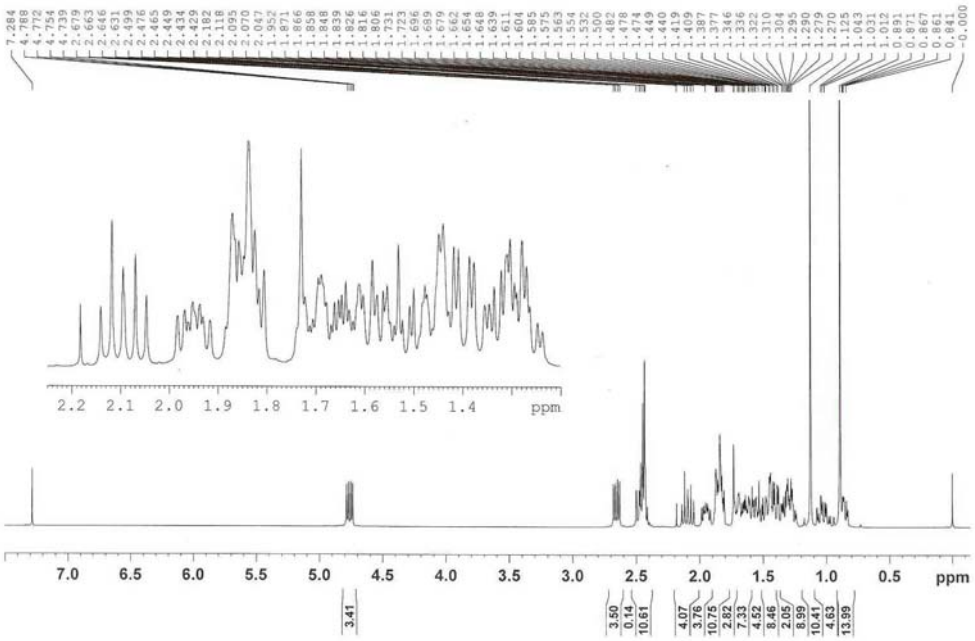
View along the [100] direction

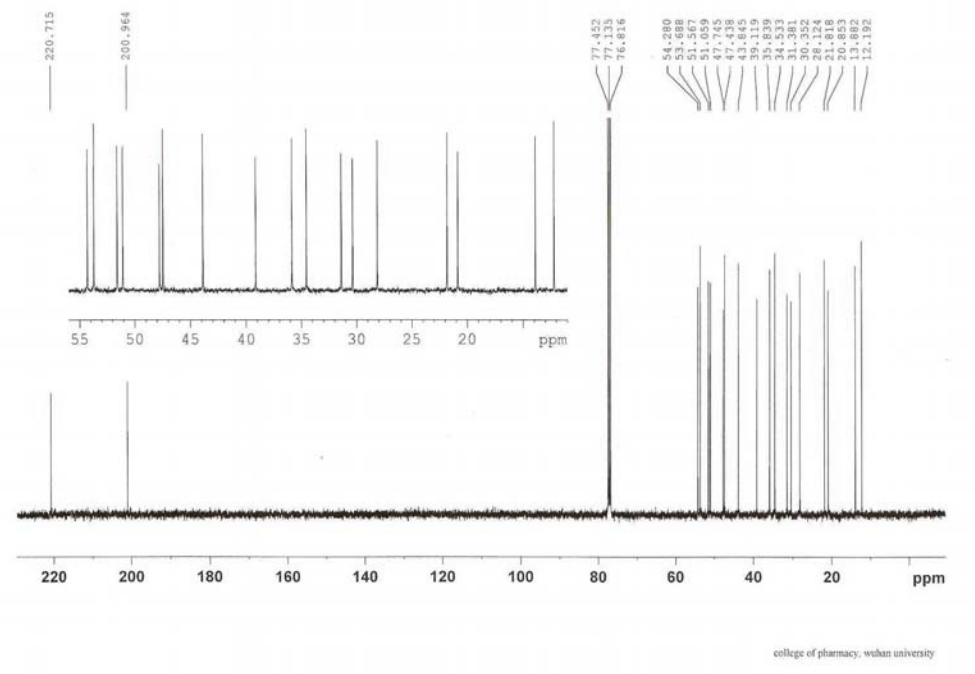




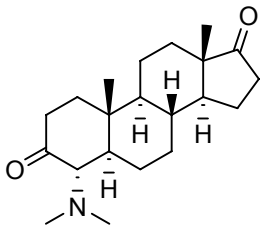
^{1}H NMR and ^{13}C NMR Spectra of 1

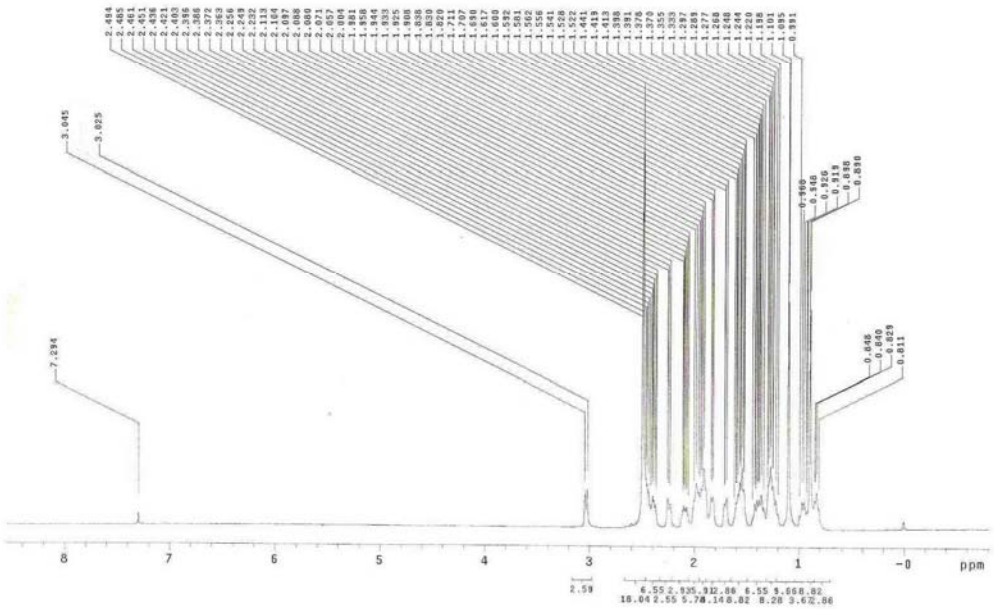


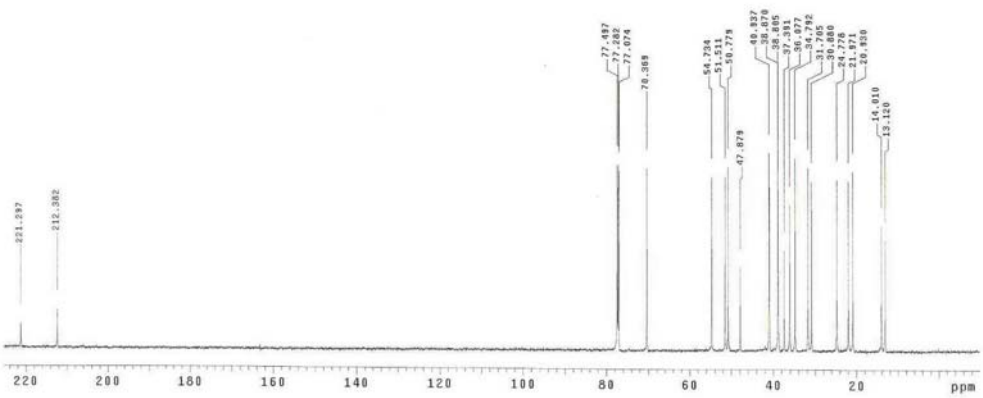




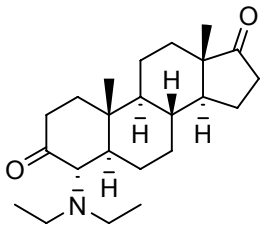
^{1}H NMR and ^{13}C NMR Spectra of 3a

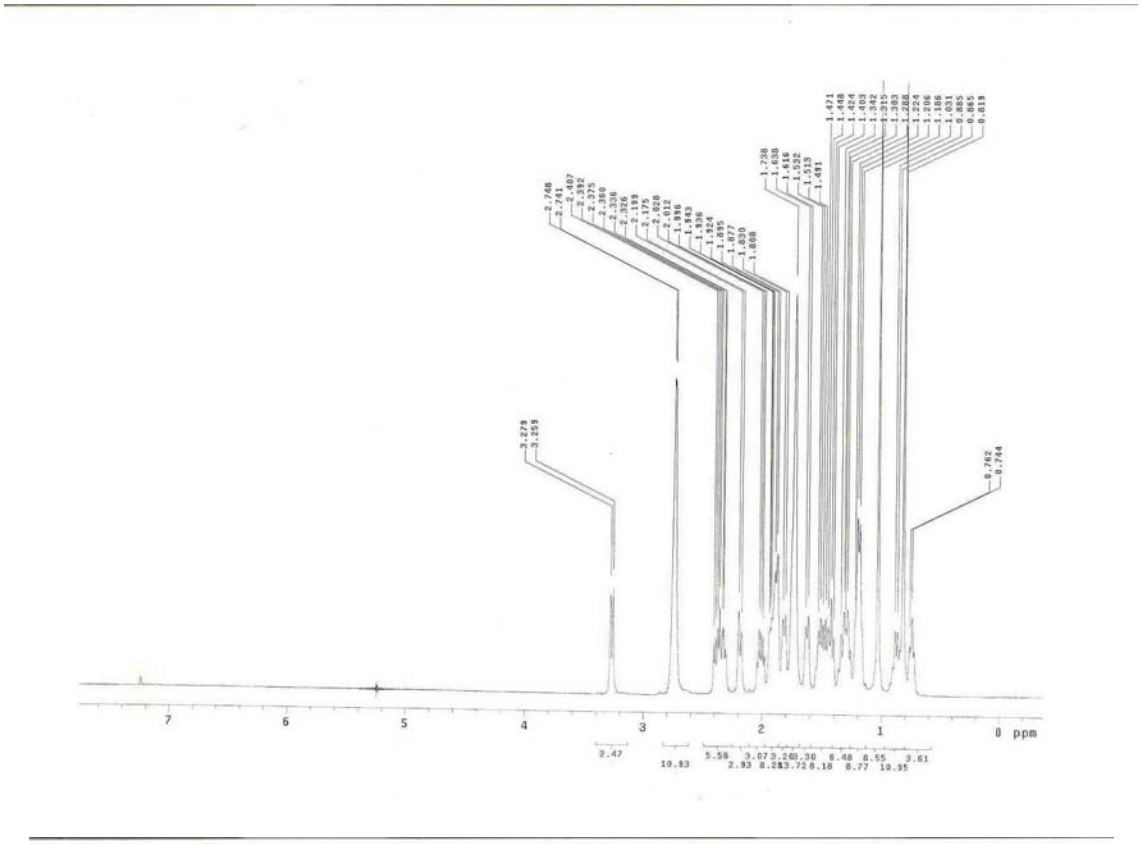


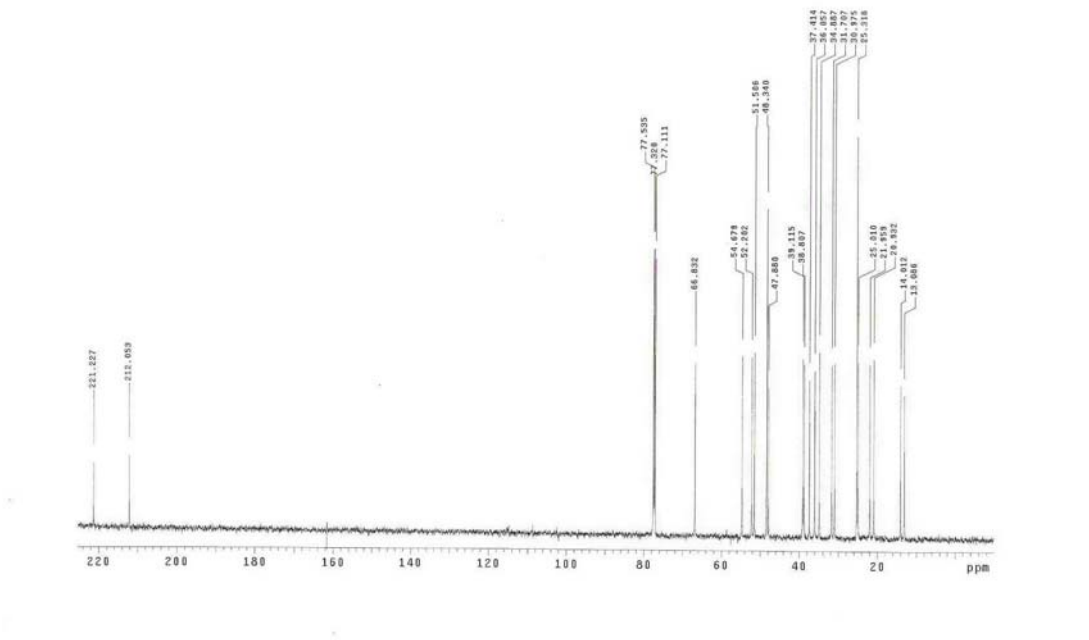




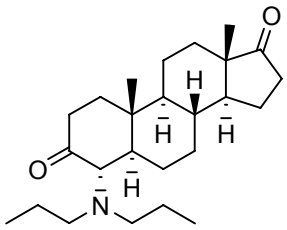
^{1}H NMR and ^{13}C NMR Spectra of 3b

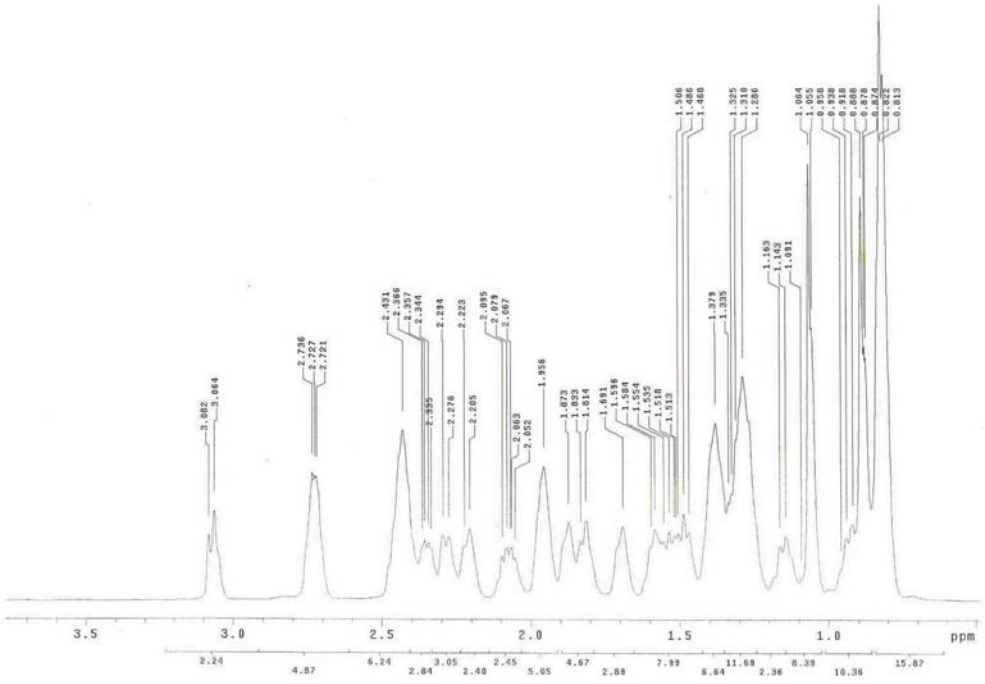


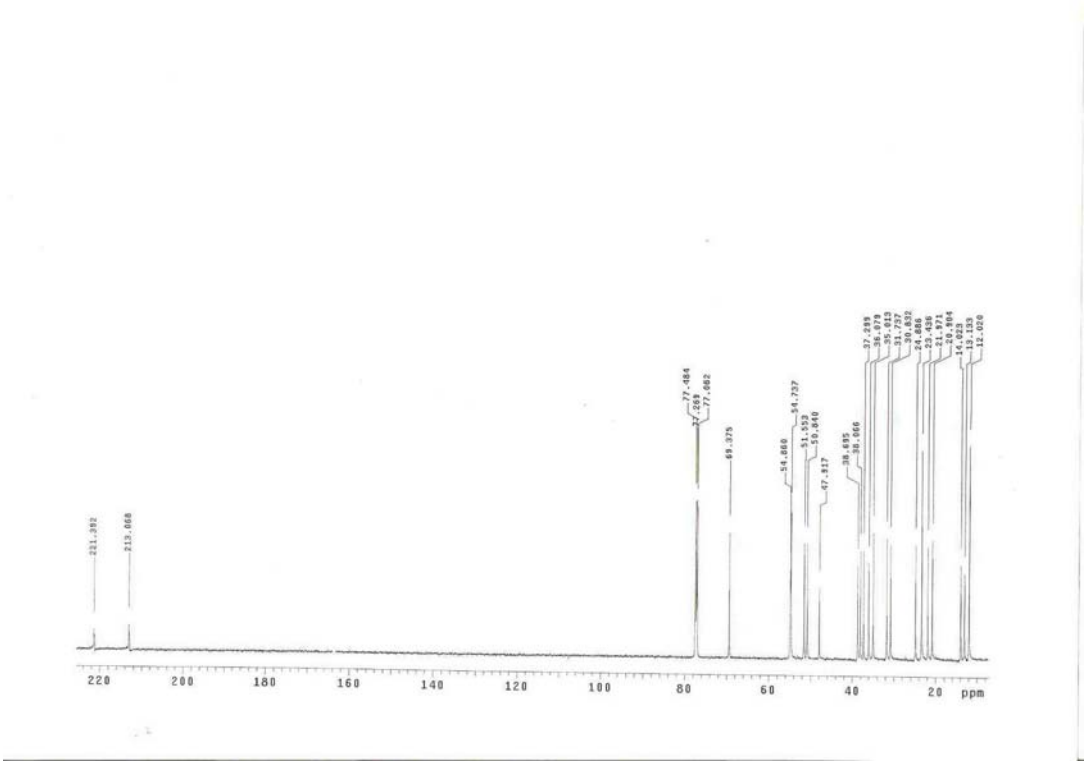




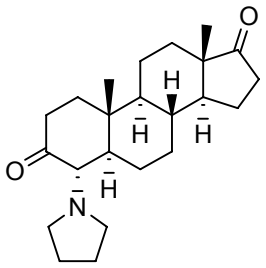
^{1}H NMR and ^{13}C NMR Spectra of 3c

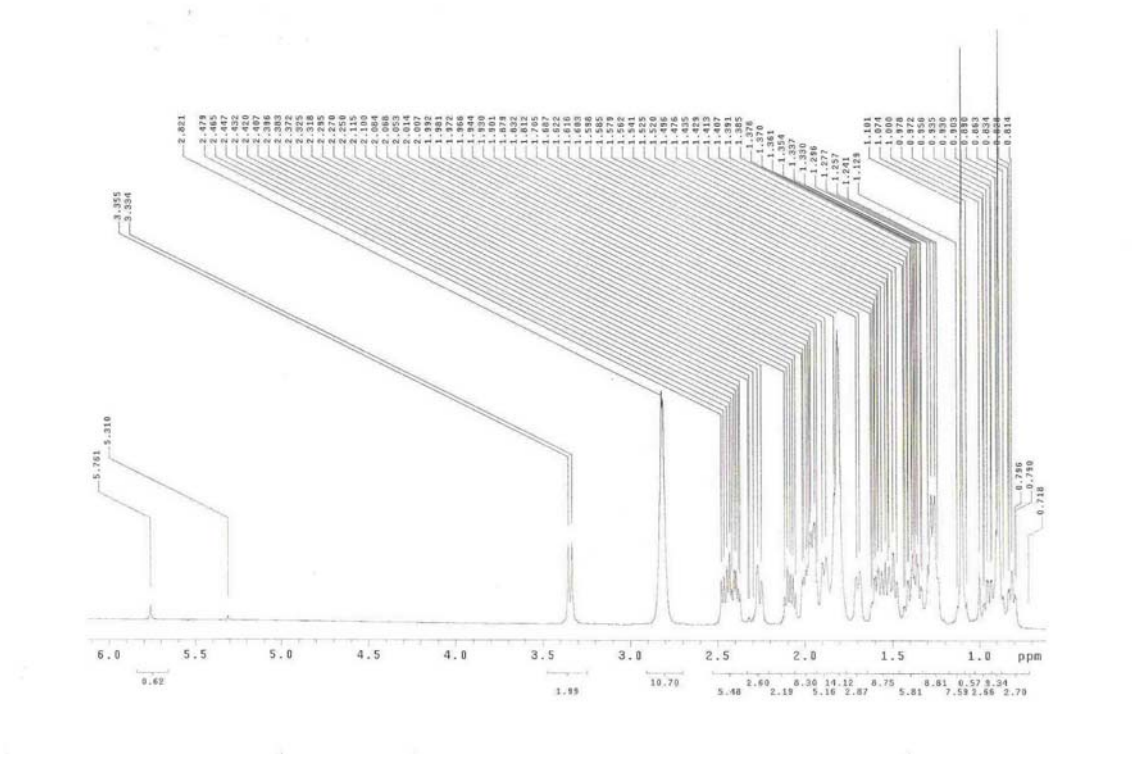


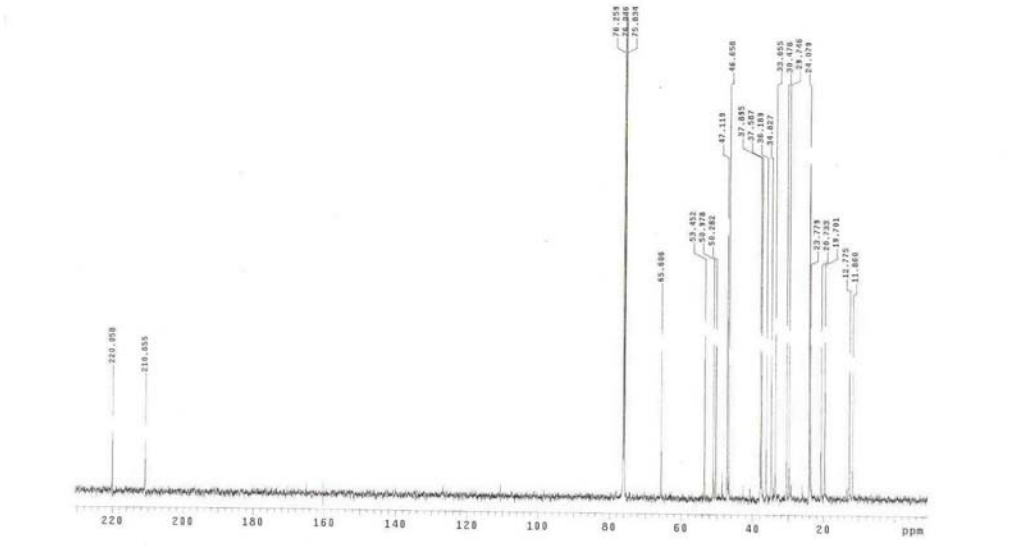




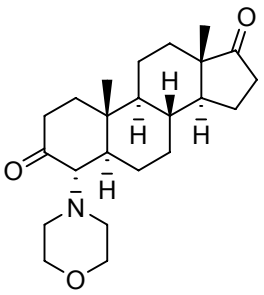
^{1}H NMR and ^{13}C NMR Spectra of 3e

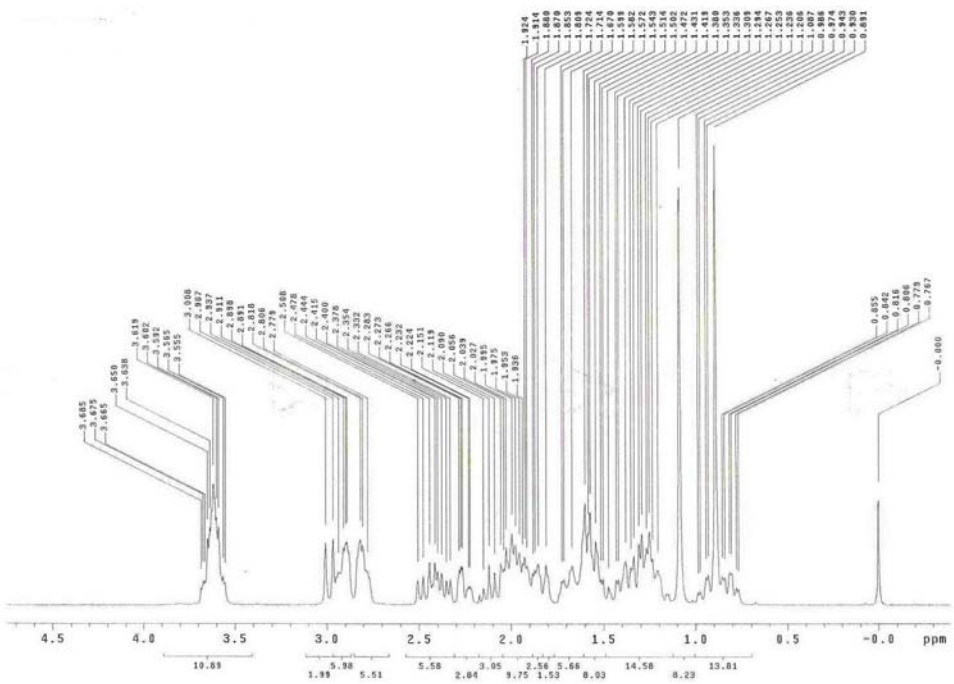


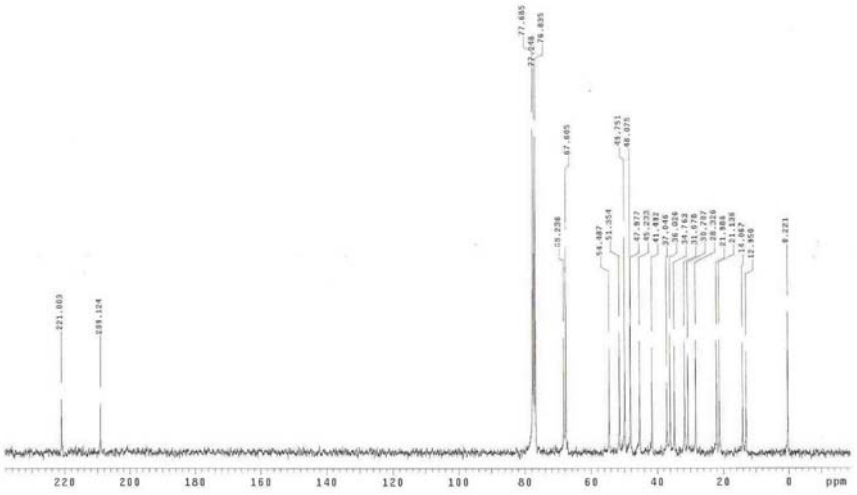




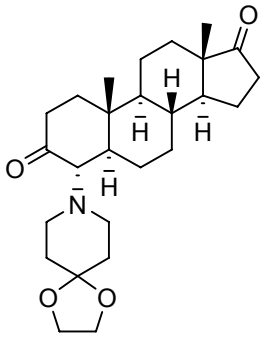
^{1}H NMR and ^{13}C NMR Spectra of 3g

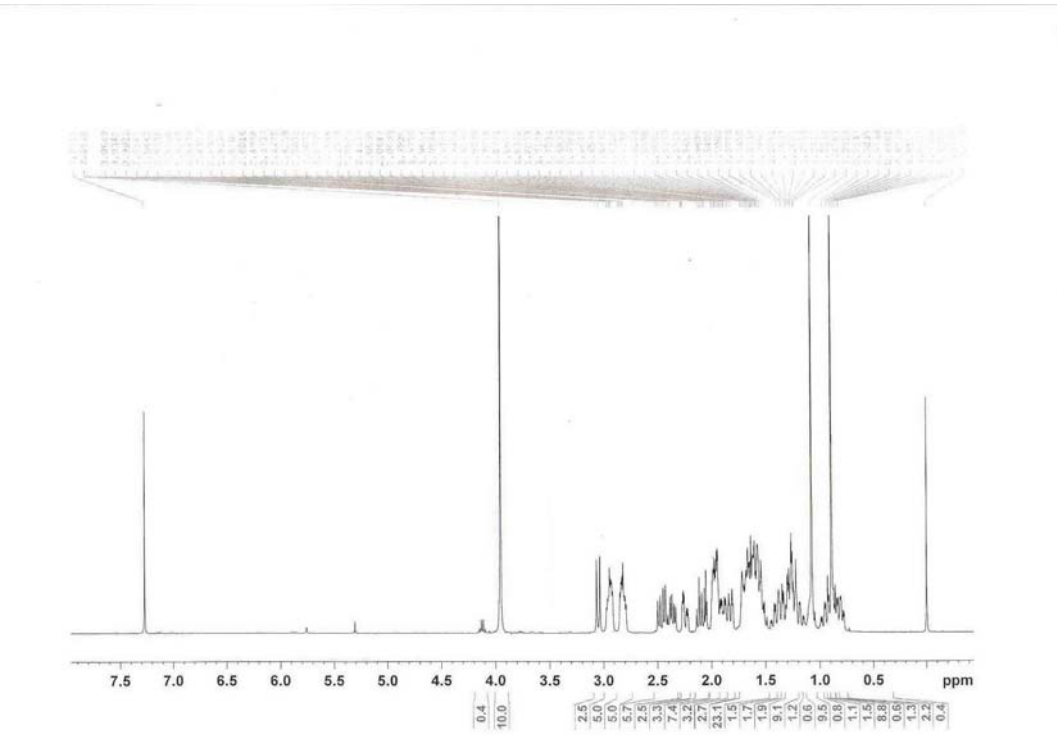


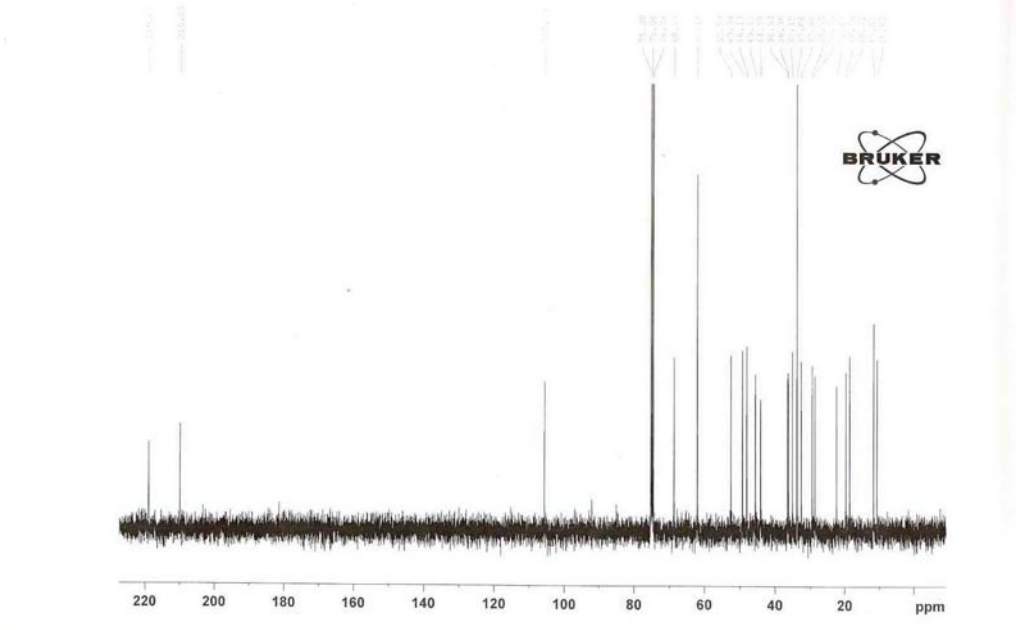




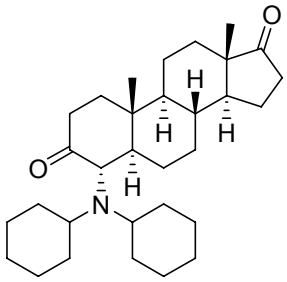
^{1}H NMR and ^{13}C NMR Spectra of 3i

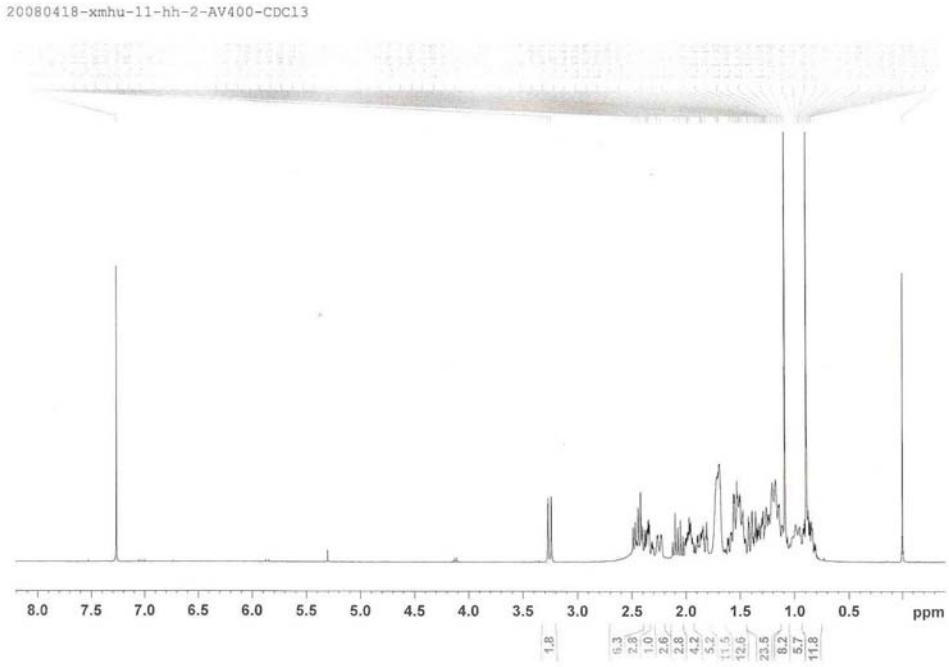


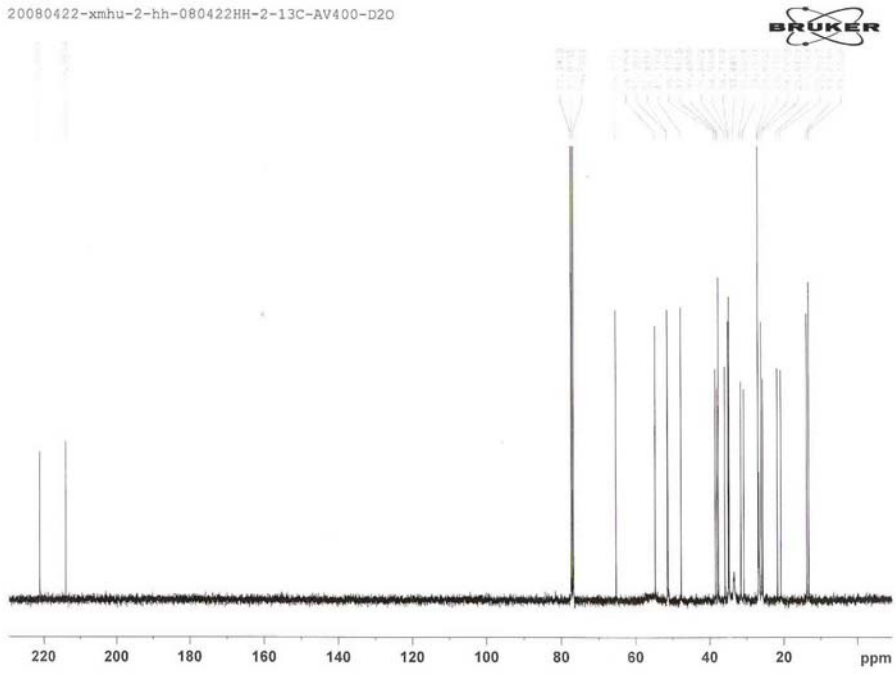




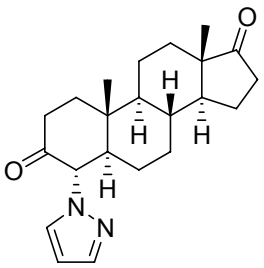
^{1}H NMR and ^{13}C NMR Spectra of 3j

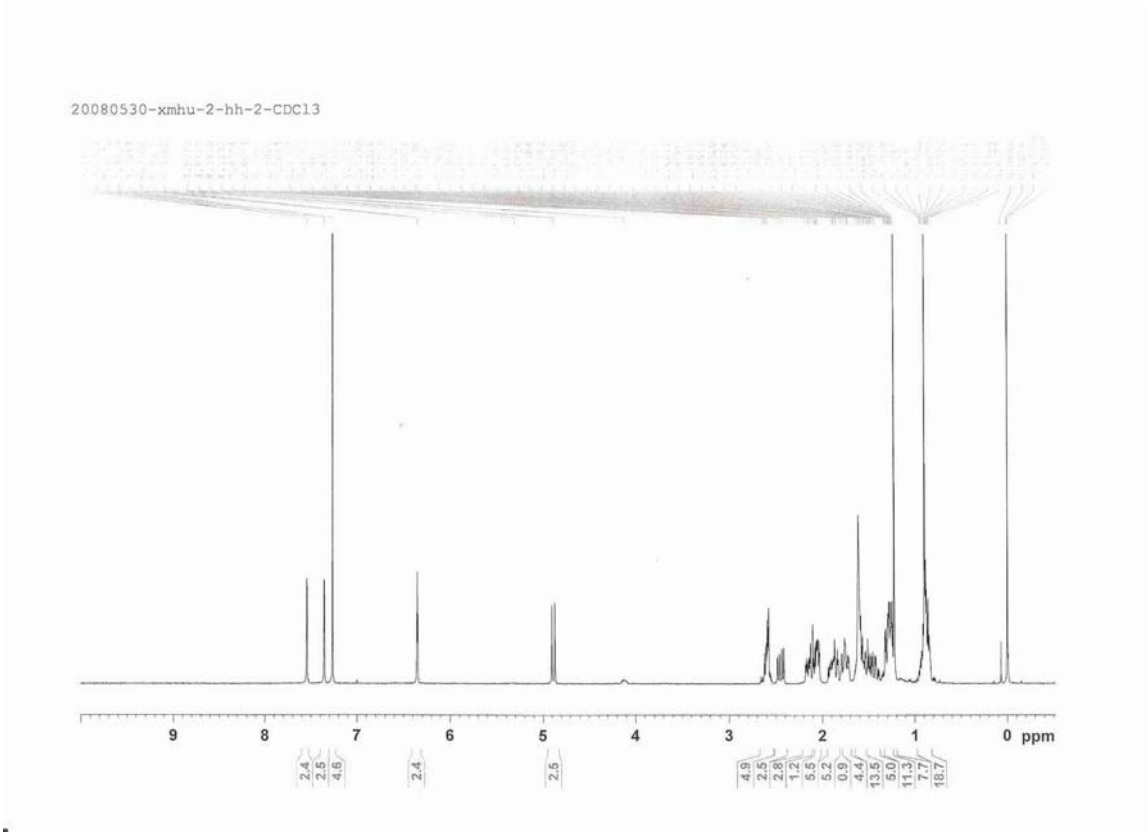


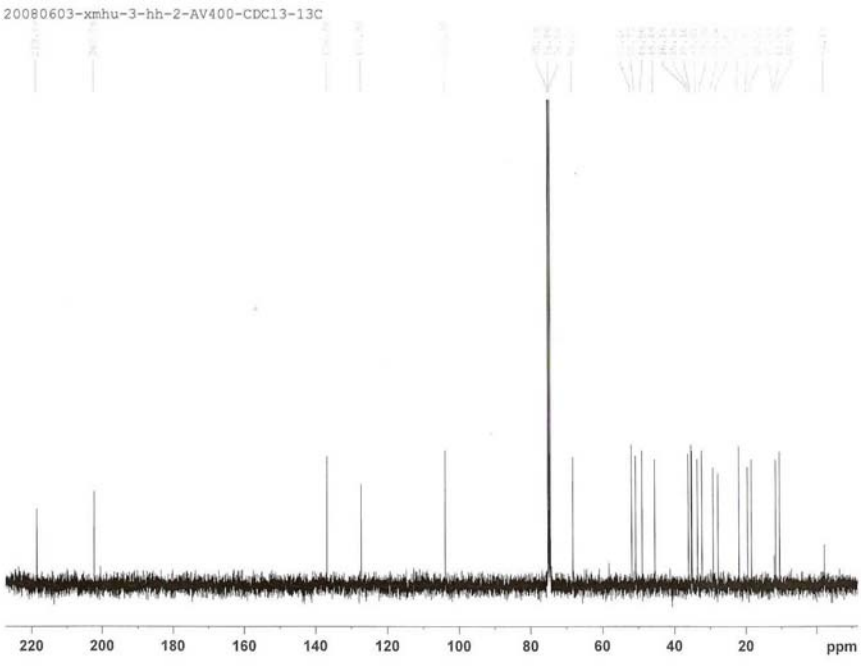




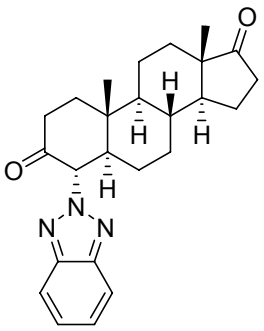
^{1}H NMR and ^{13}C NMR Spectra of 3l

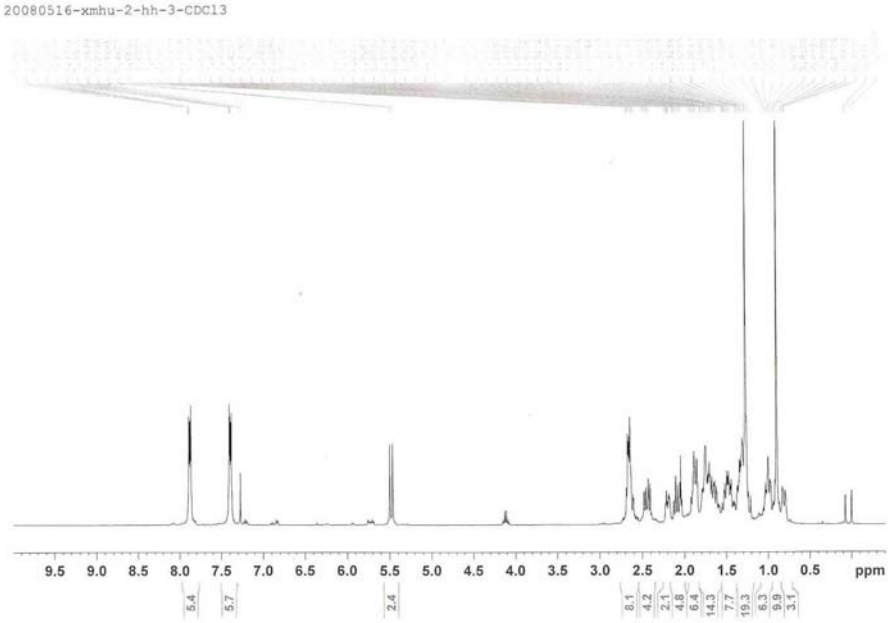


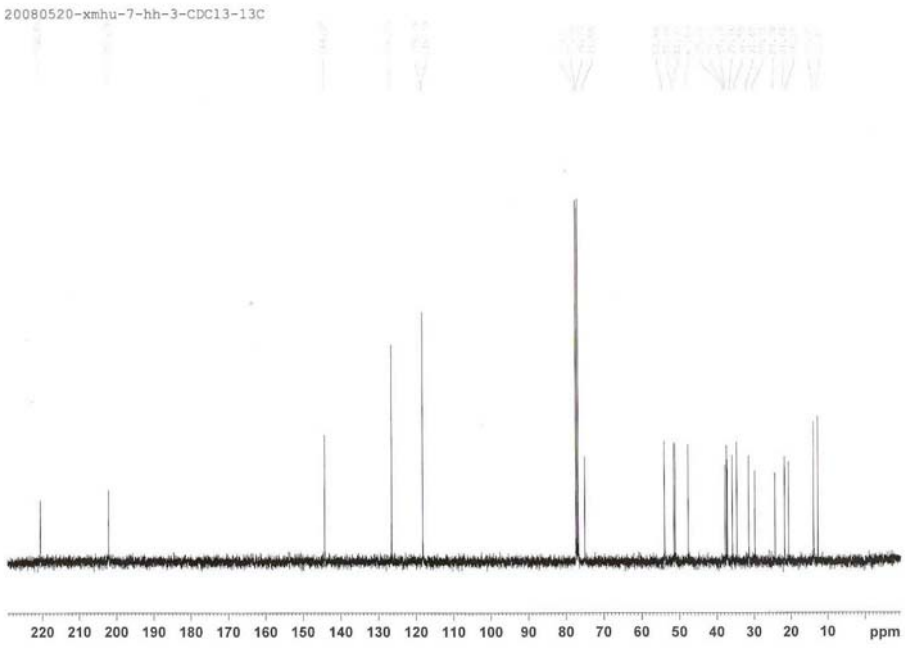




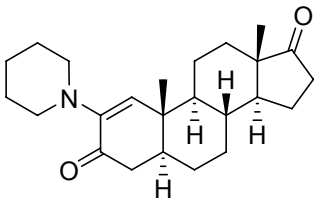
^{1}H NMR and ^{13}C NMR Spectra of 3o

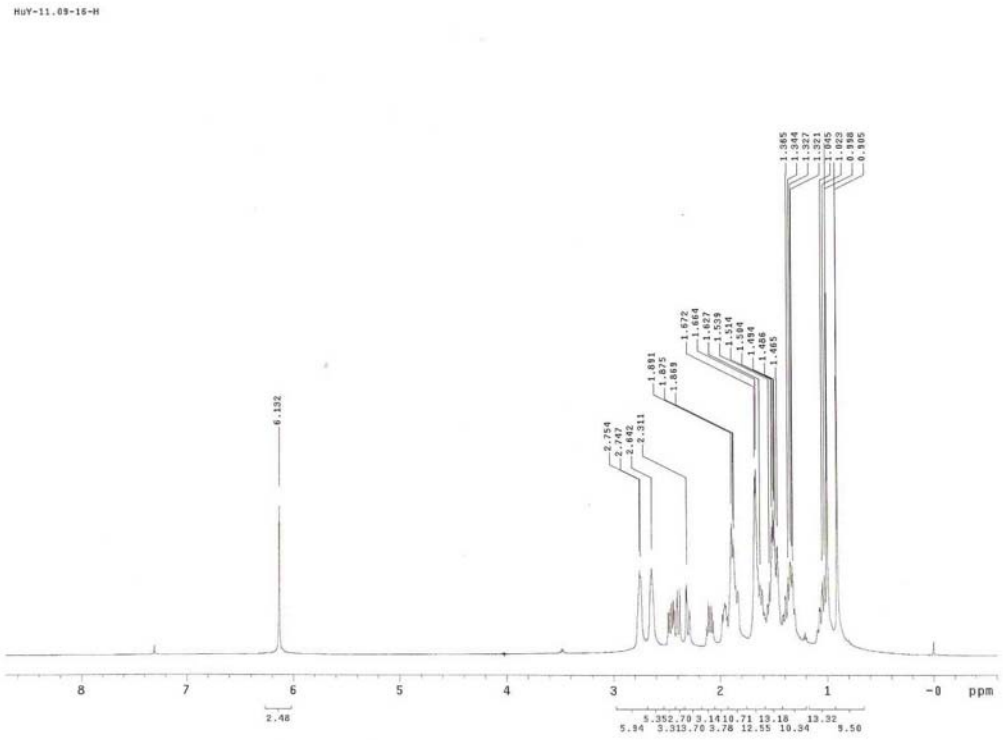


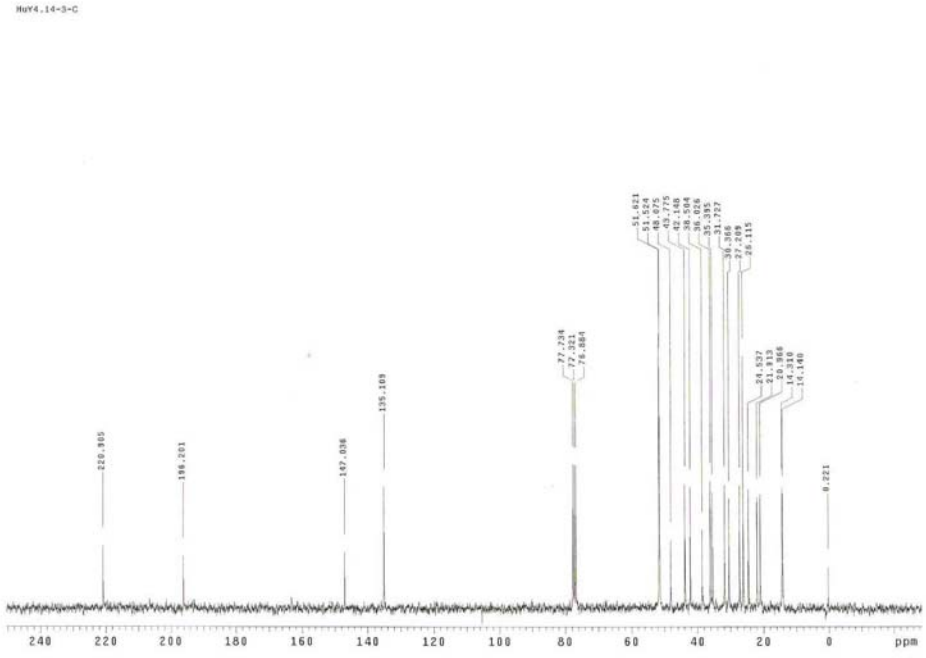




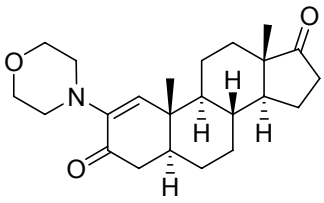
^{1}H NMR and ^{13}C NMR Spectra of 6f

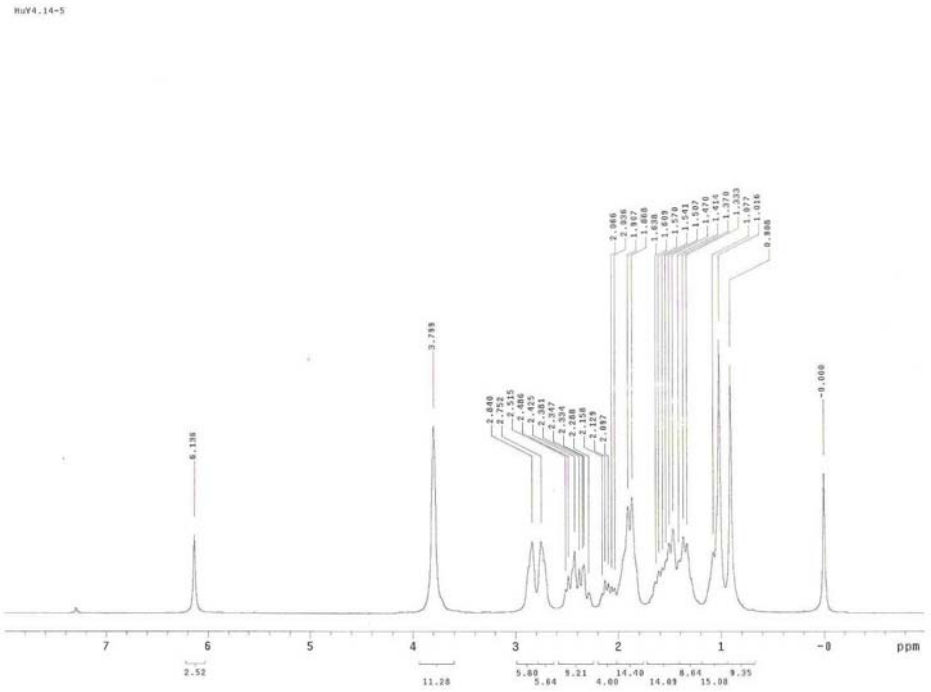


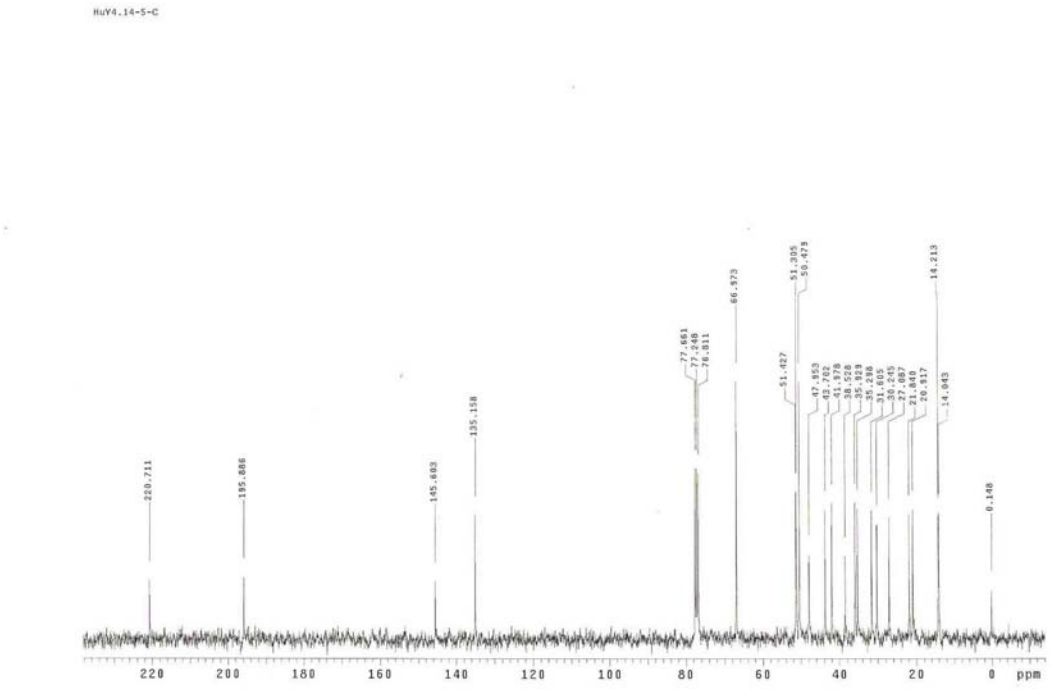




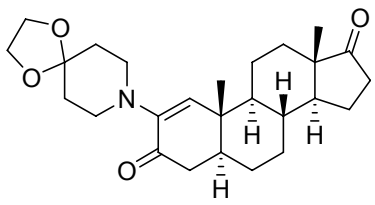
^{1}H NMR and ^{13}C NMR Spectra of 6g

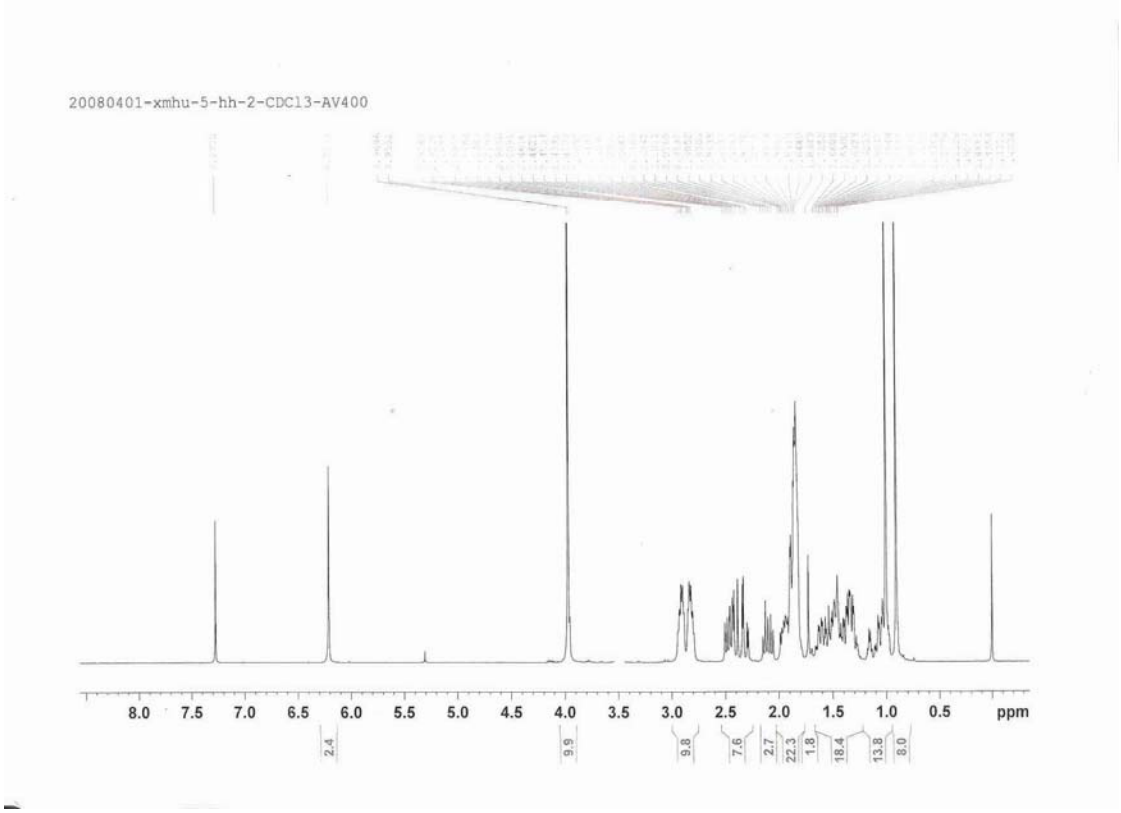


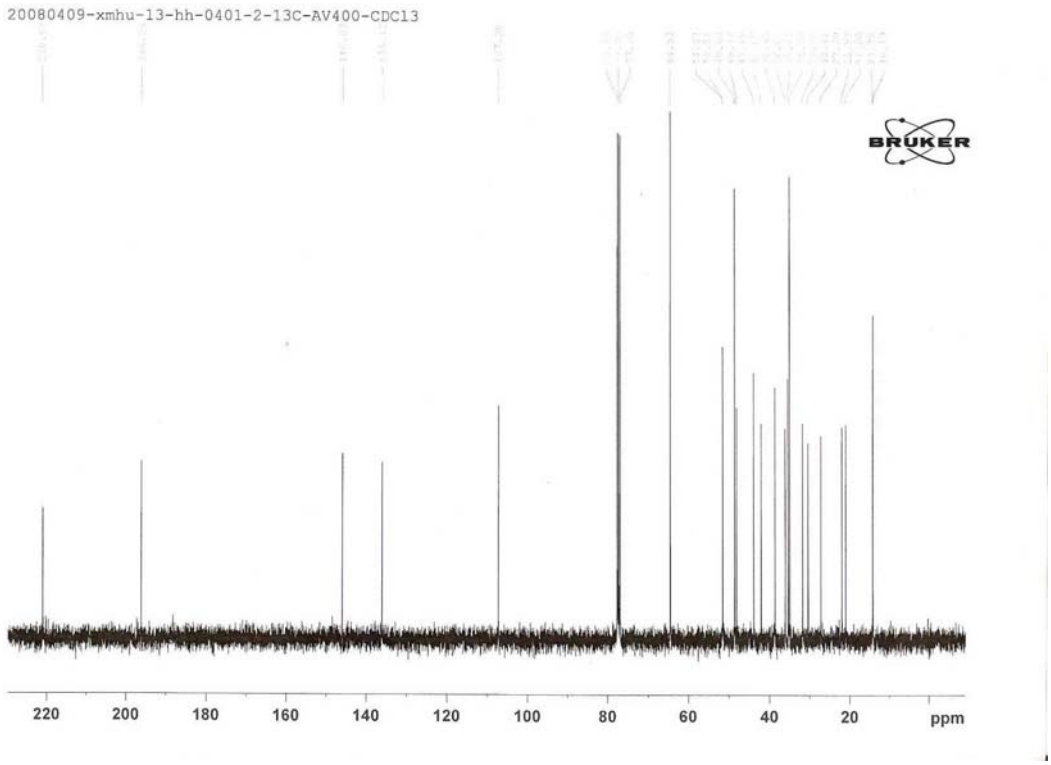




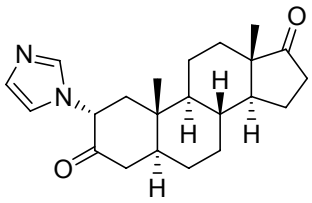
^{1}H NMR and ^{13}C NMR Spectra of 6i

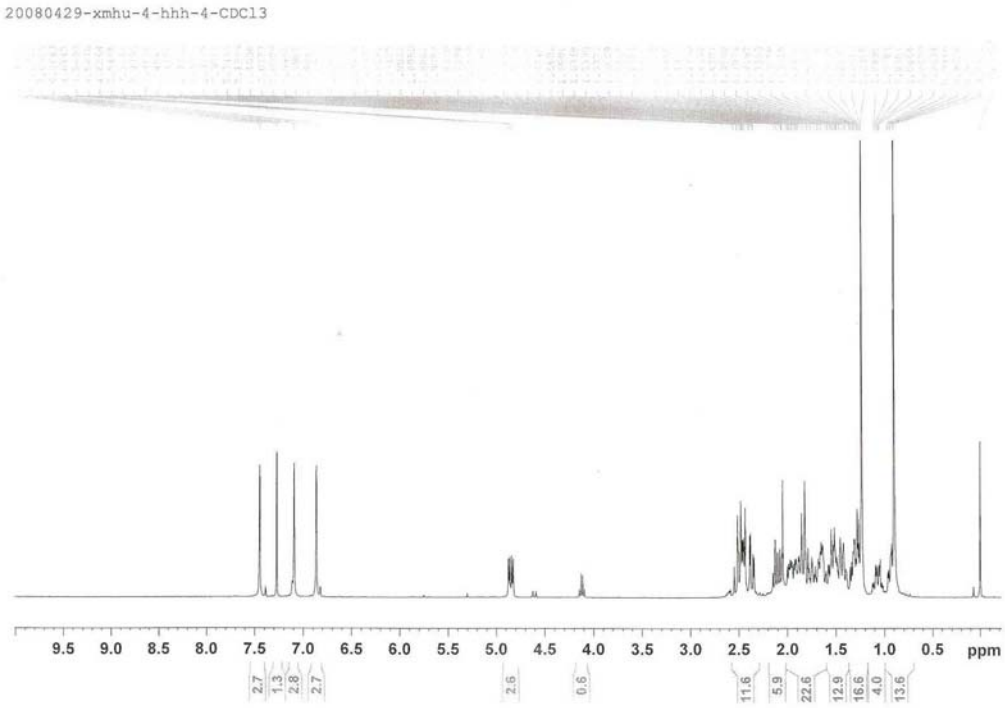


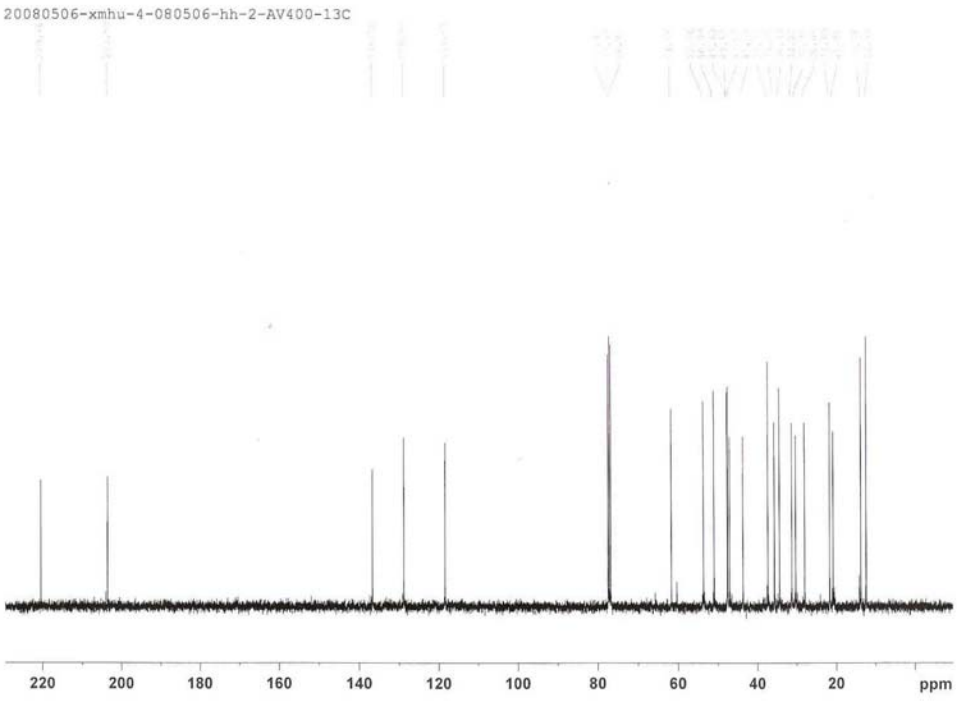




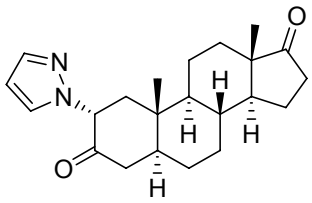
^{1}H NMR and ^{13}C NMR Spectra of 2k

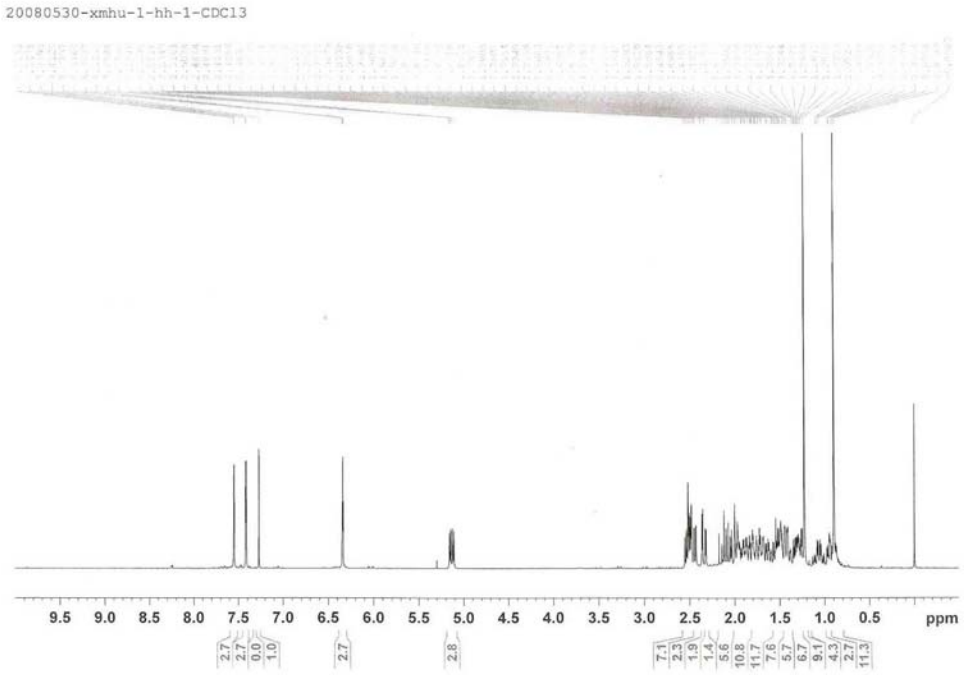


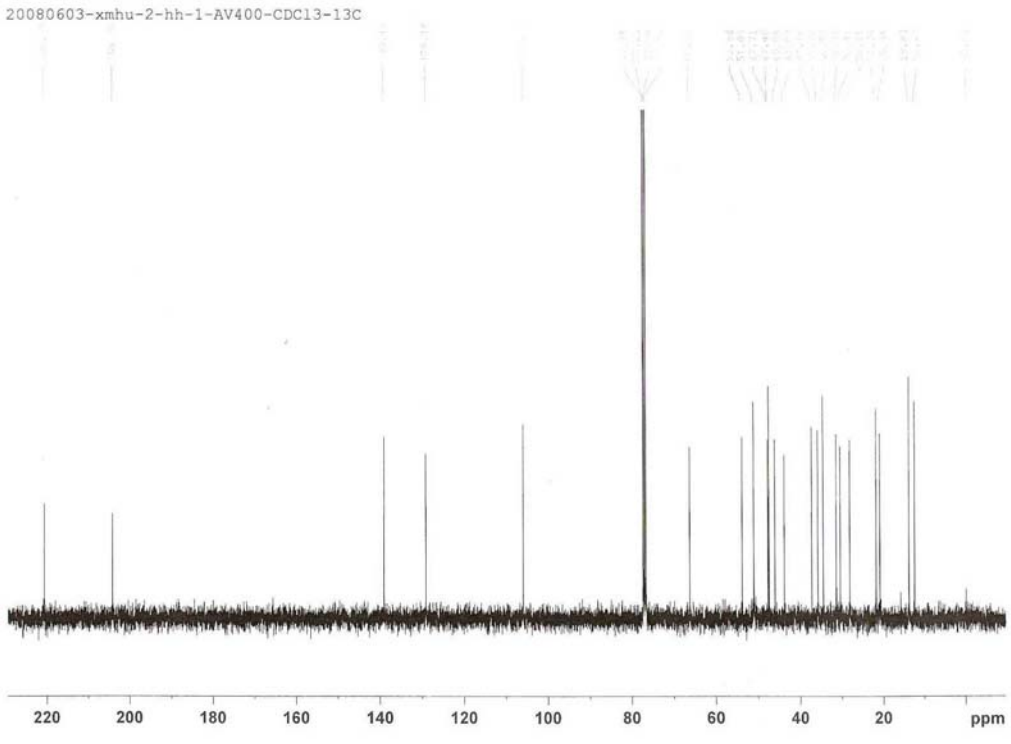




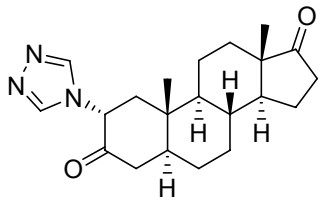
^{1}H NMR and ^{13}C NMR Spectra of 2l

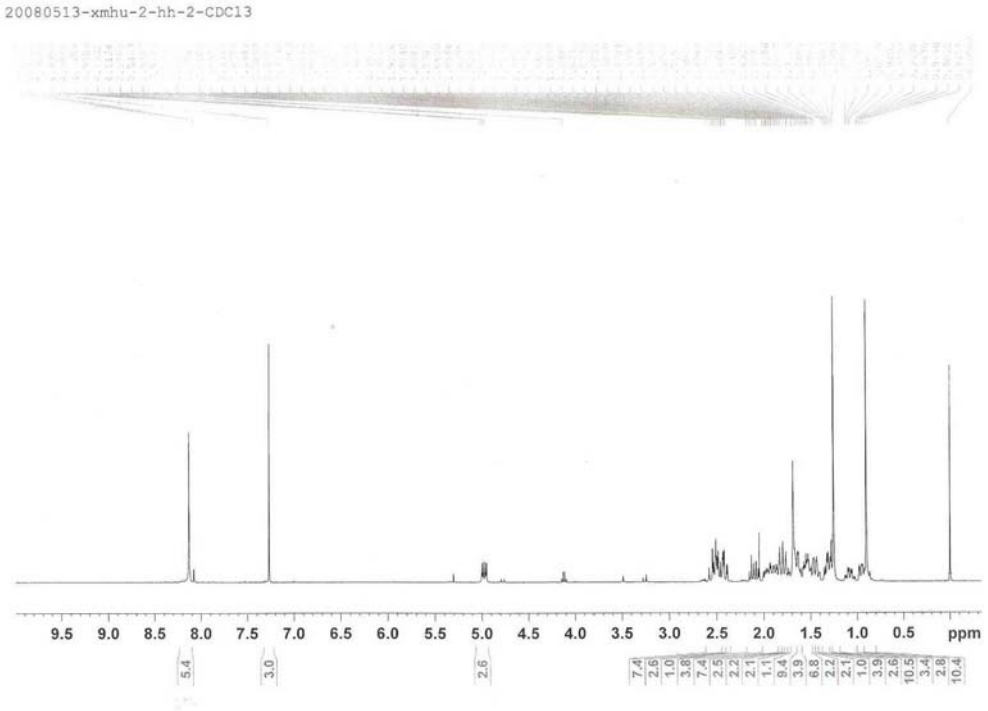


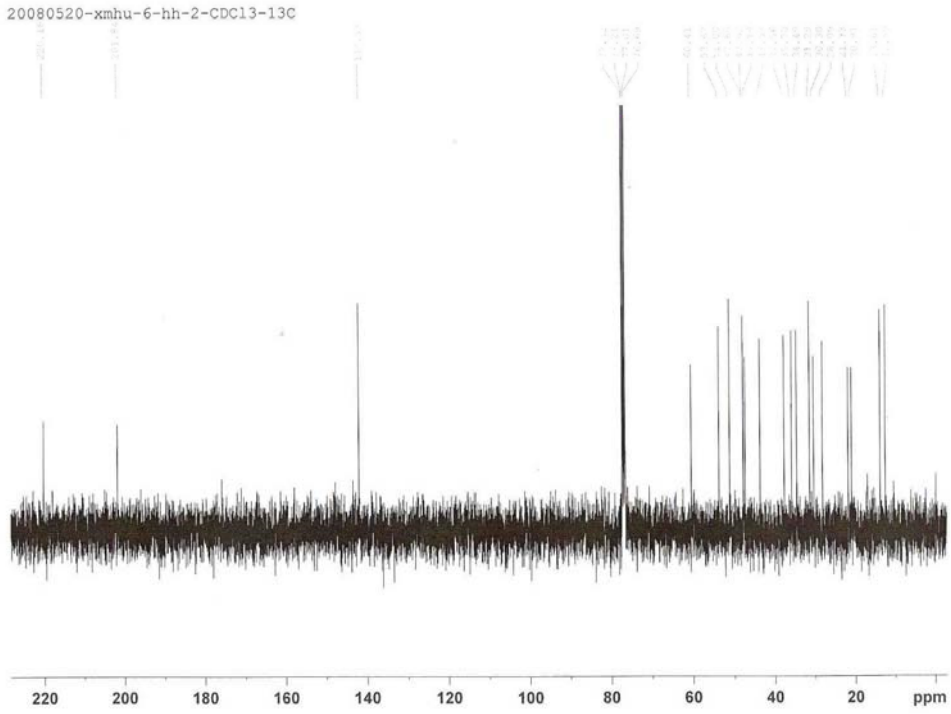




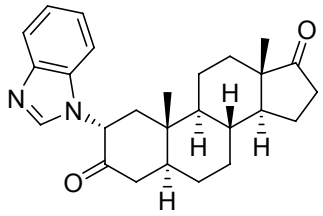
^{1}H NMR and ^{13}C NMR Spectra of 2m

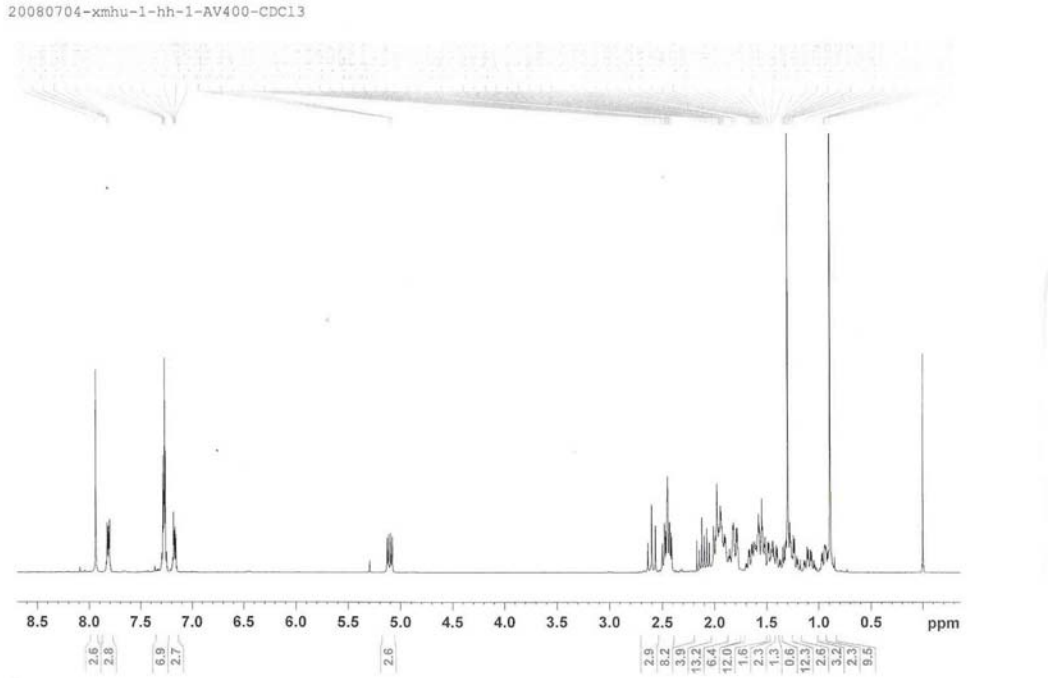


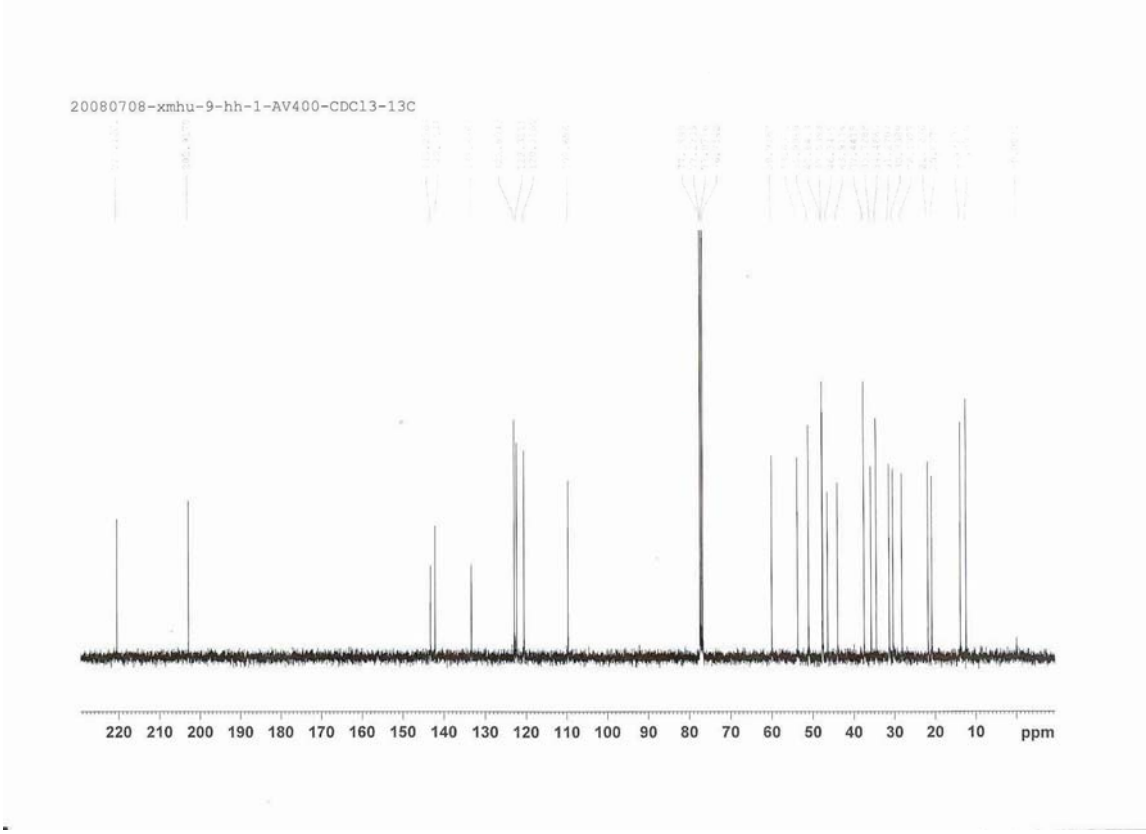




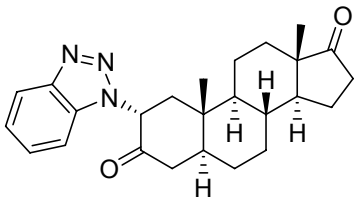
^{1}H NMR and ^{13}C NMR Spectra of 2n

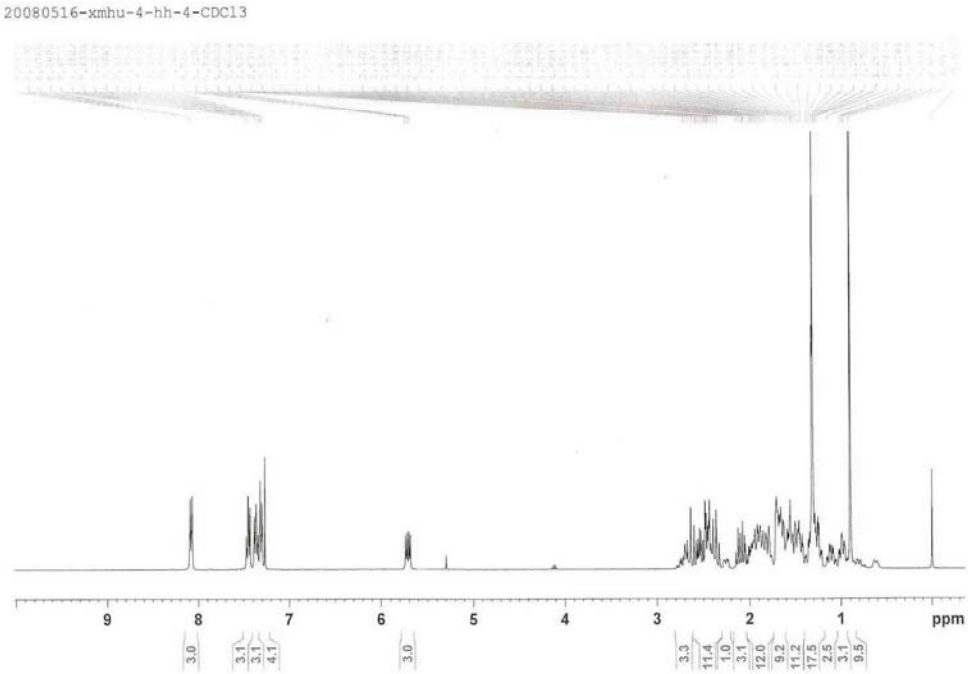


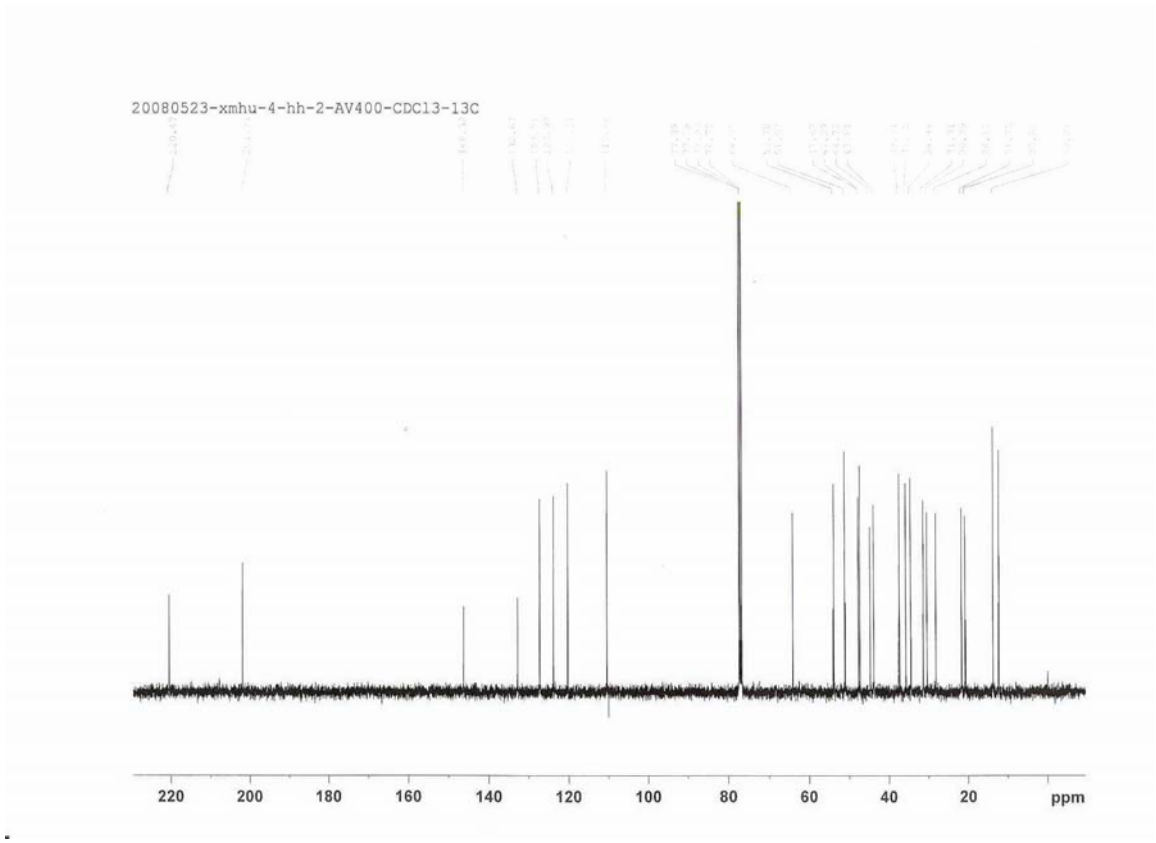




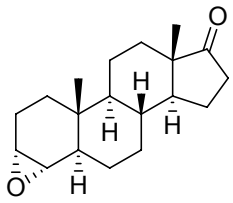
^{1}H NMR and ^{13}C NMR Spectra of 2o

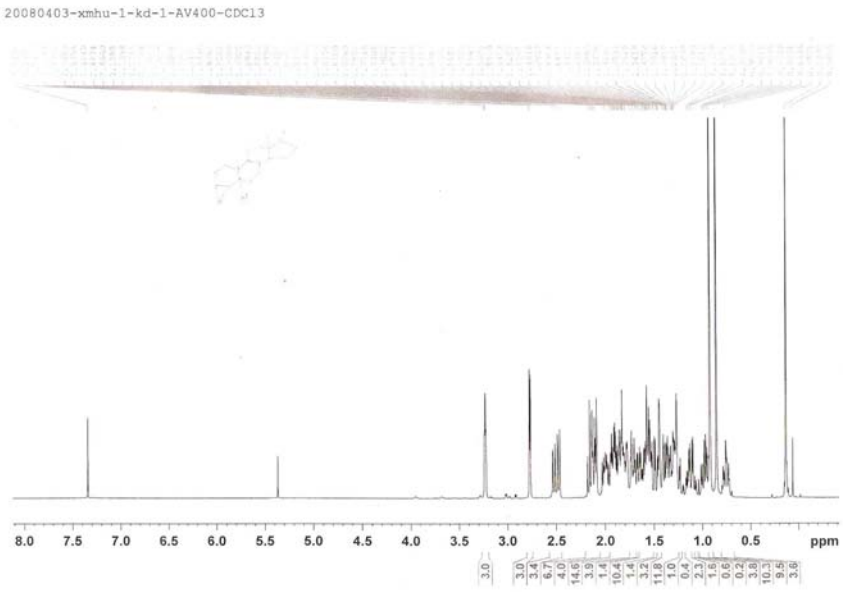


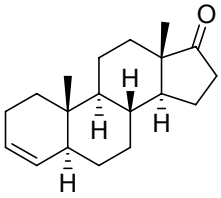


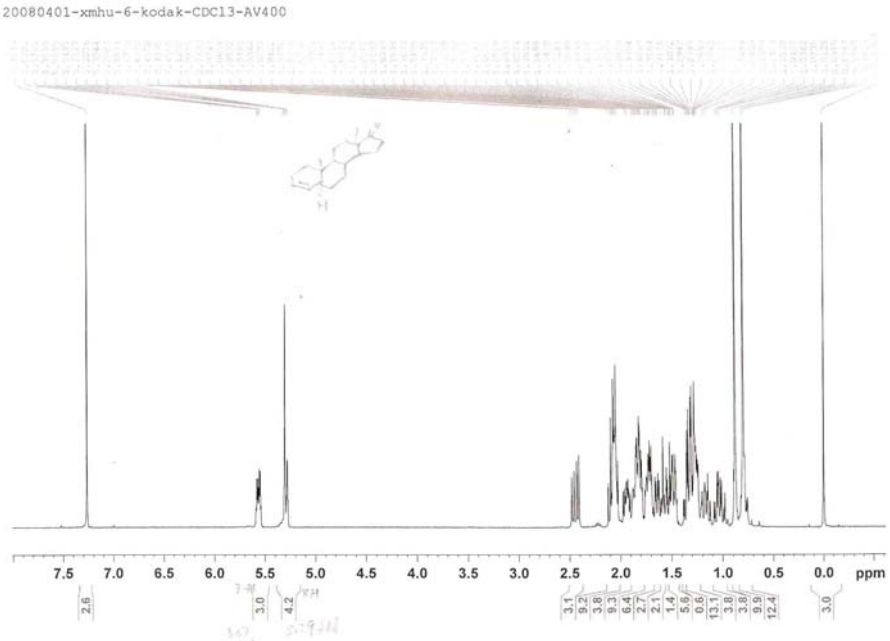


^{1}H NMR Spectra of 4 and Its Corresponding 5α-olefin

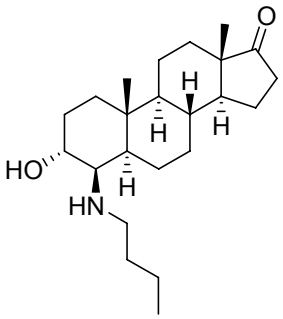


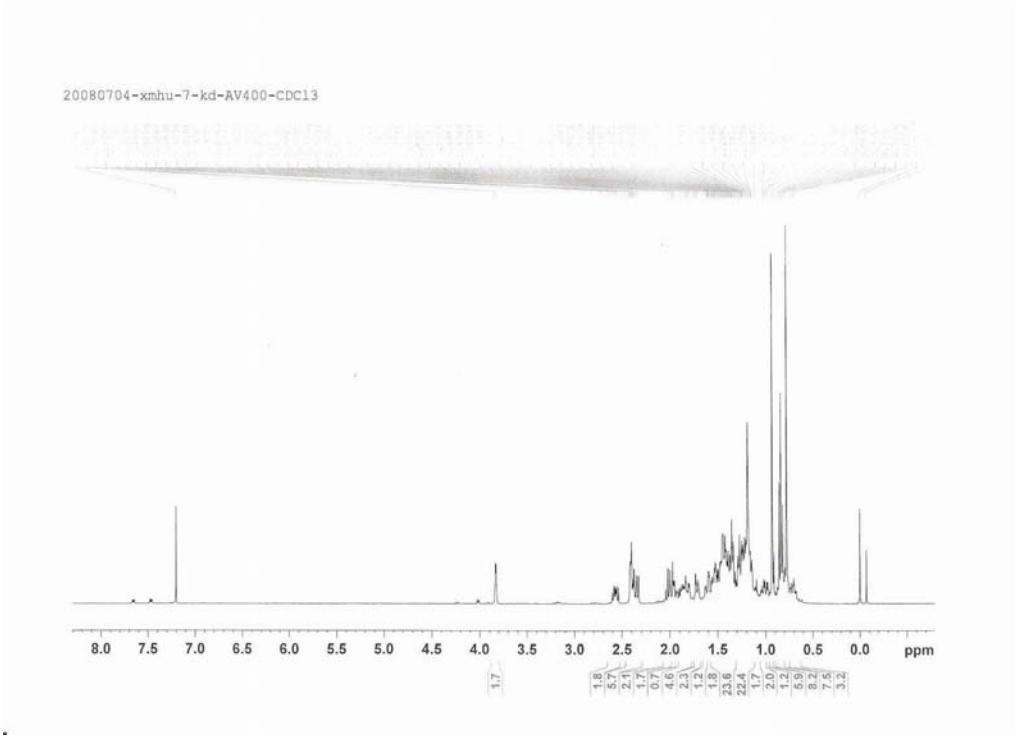


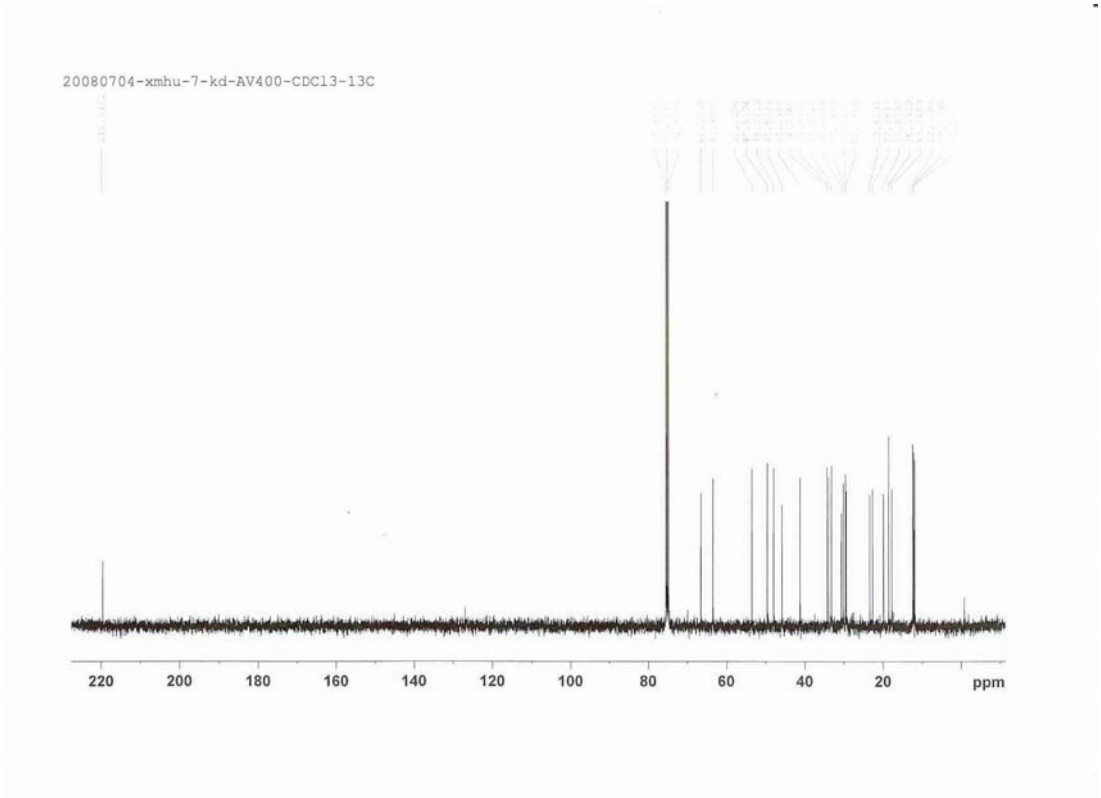




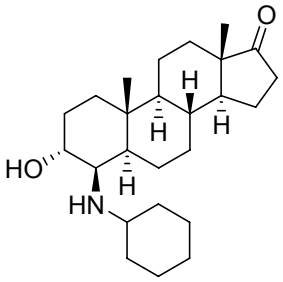
^{1}H NMR and ^{13}C NMR Spectra of 5a

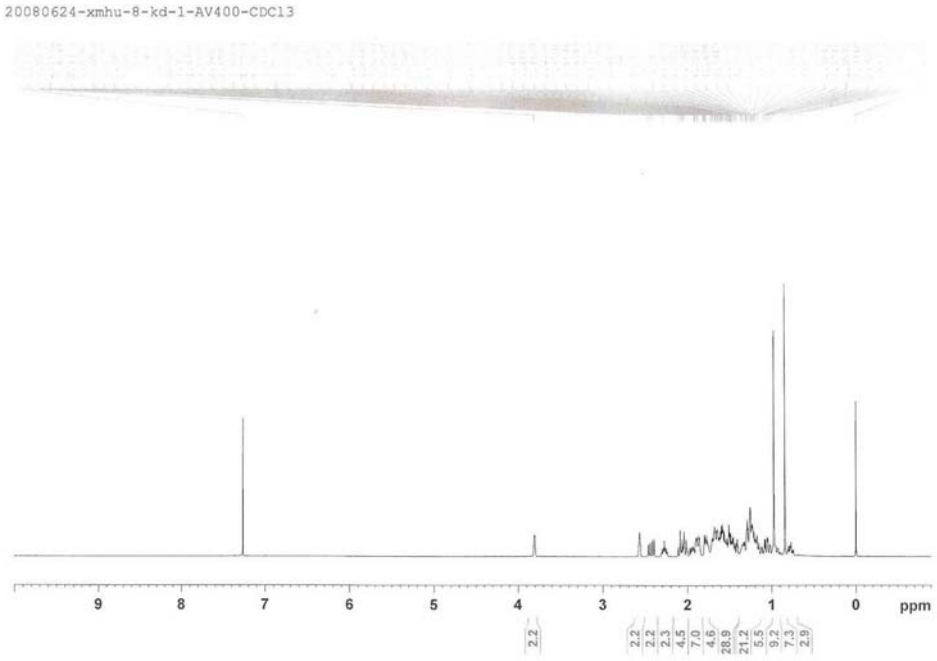


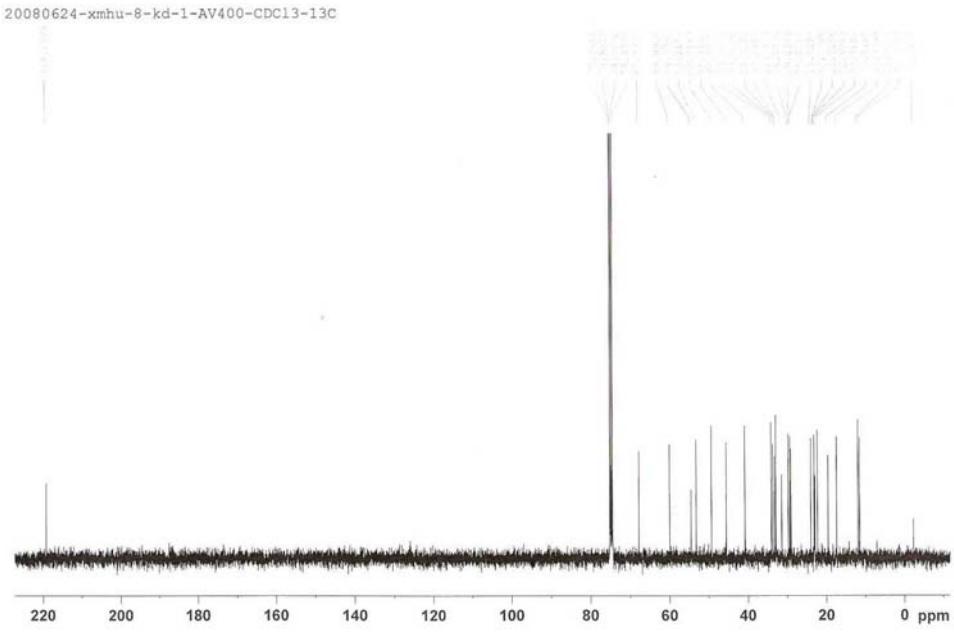




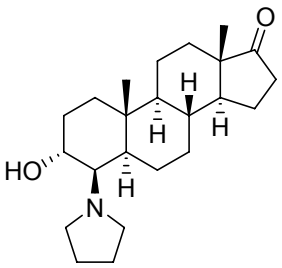
^{1}H NMR and ^{13}C NMR Spectra of 5b

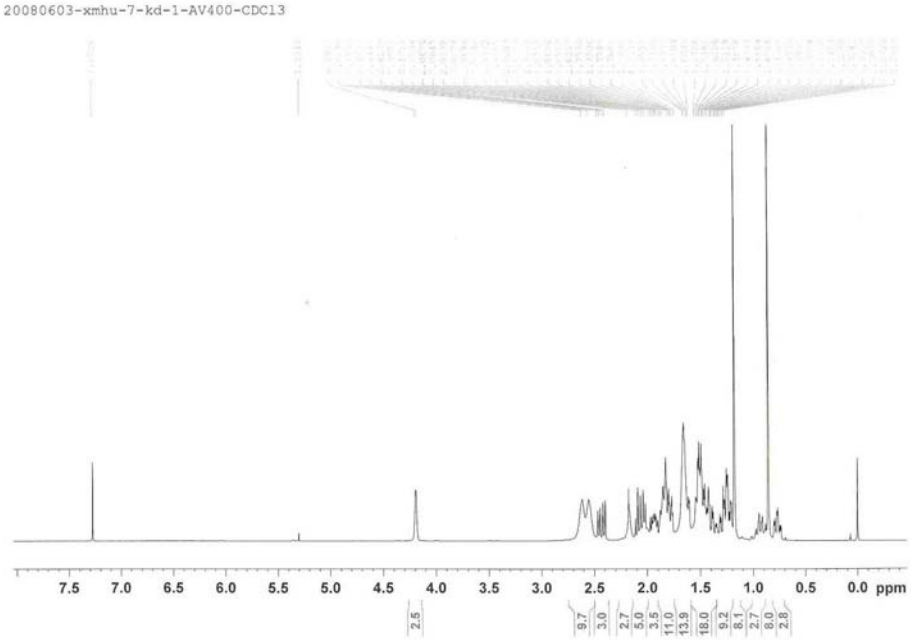


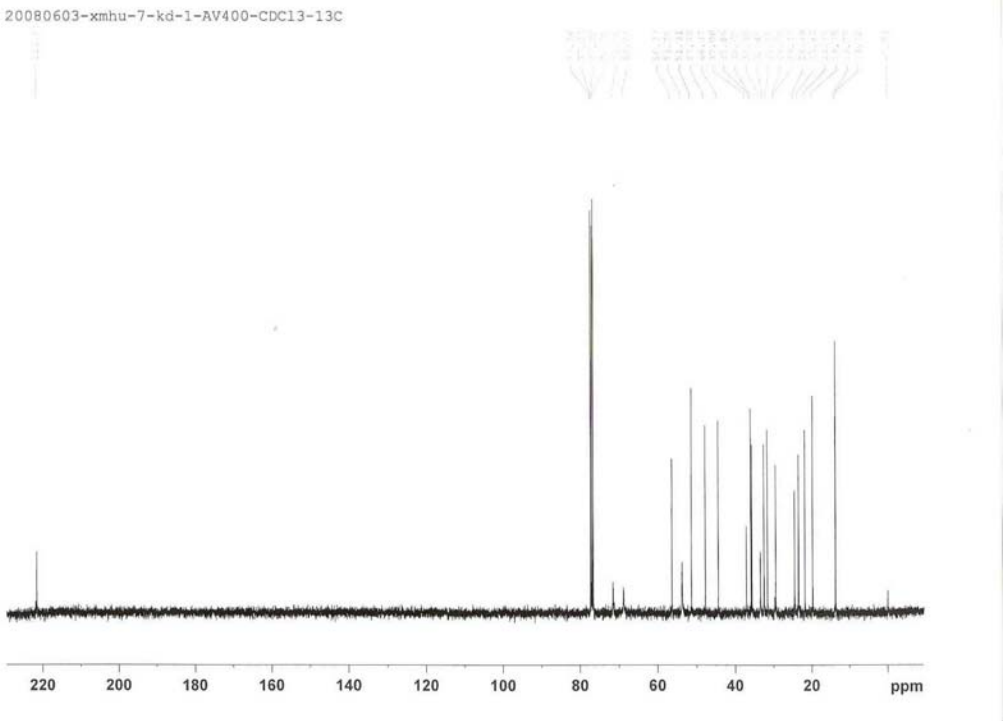




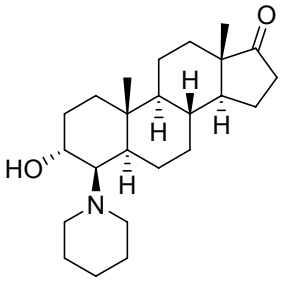
^{1}H NMR and ^{13}C NMR Spectra of 5c

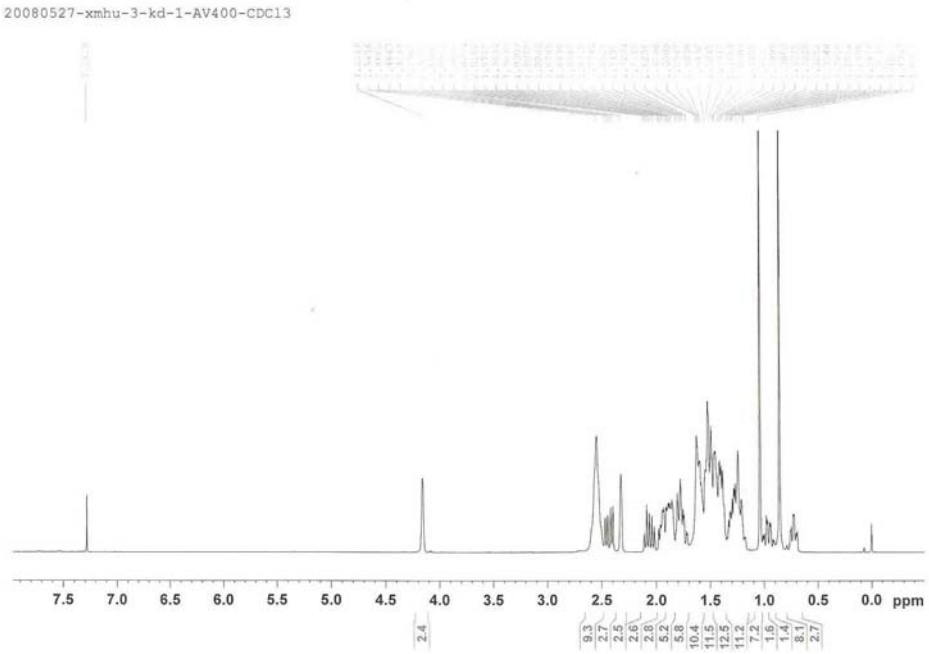


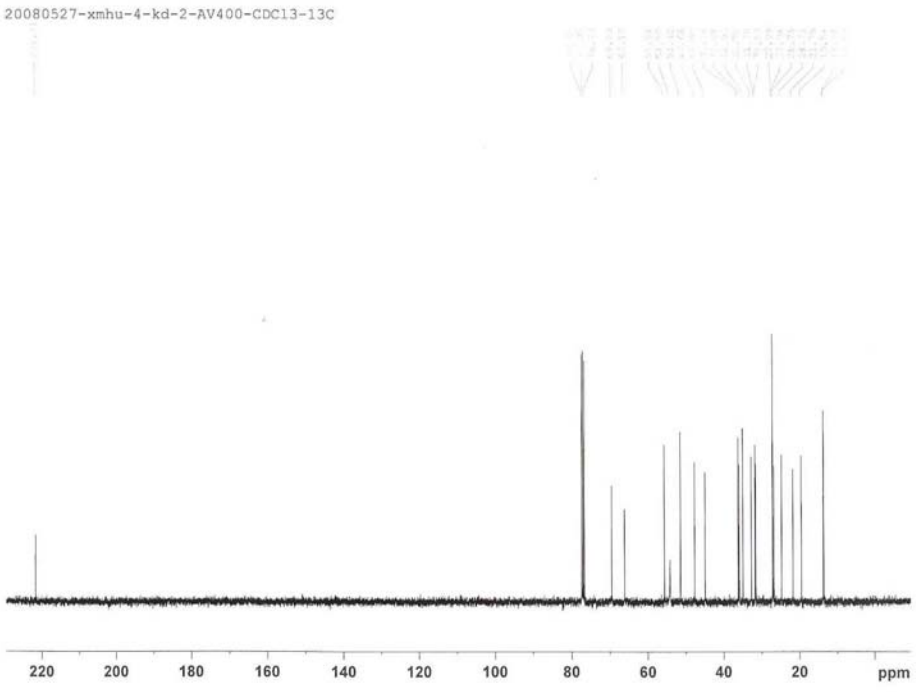




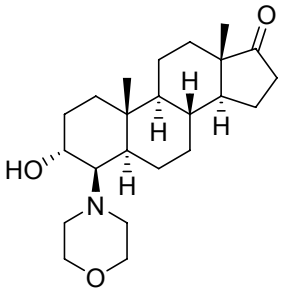
^{1}H NMR and ^{13}C NMR Spectra of 5d

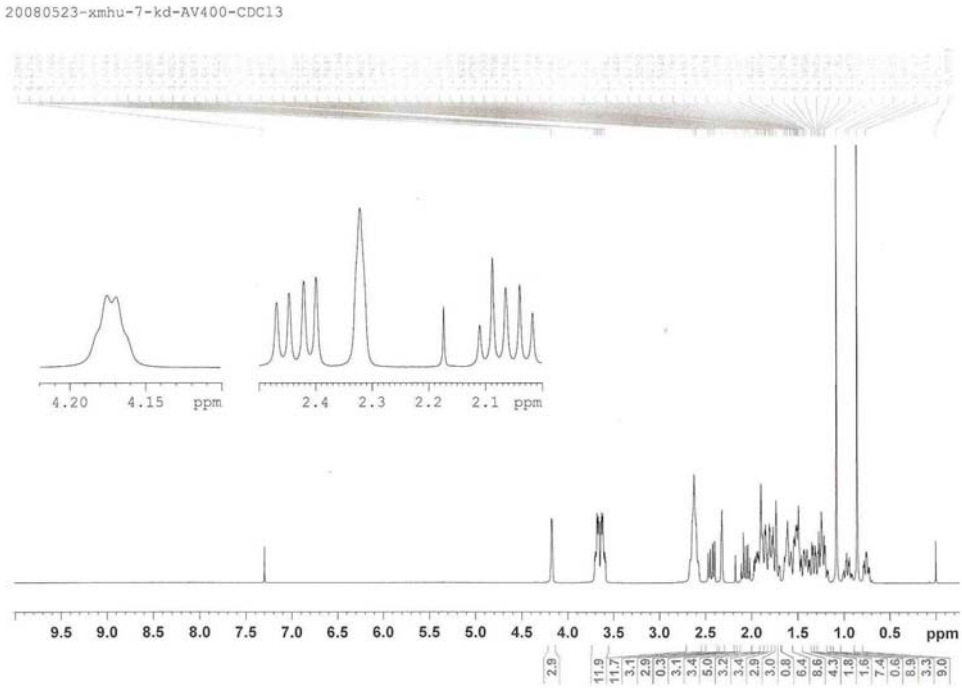


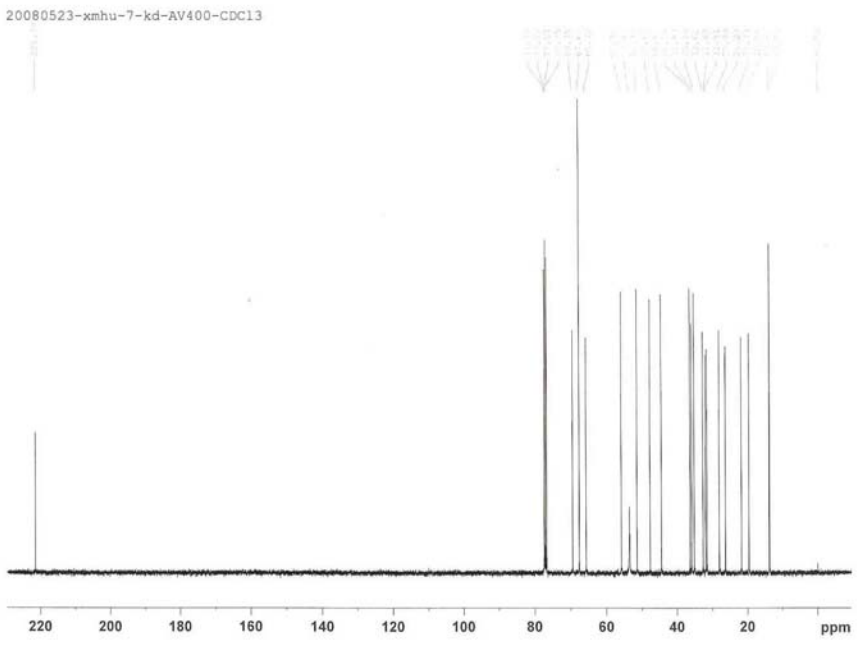




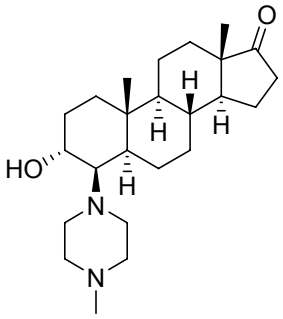
^{1}H NMR and ^{13}C NMR Spectra of 5e

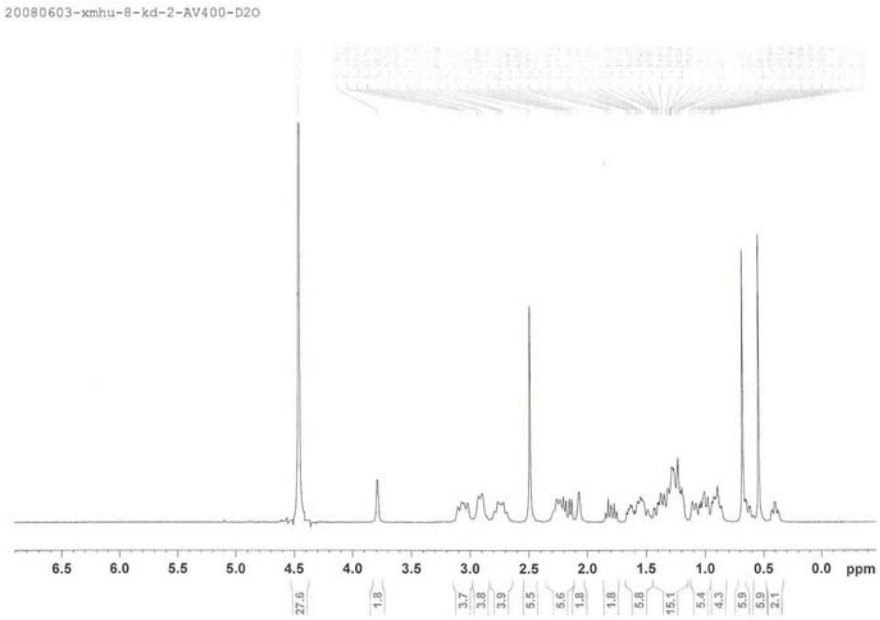


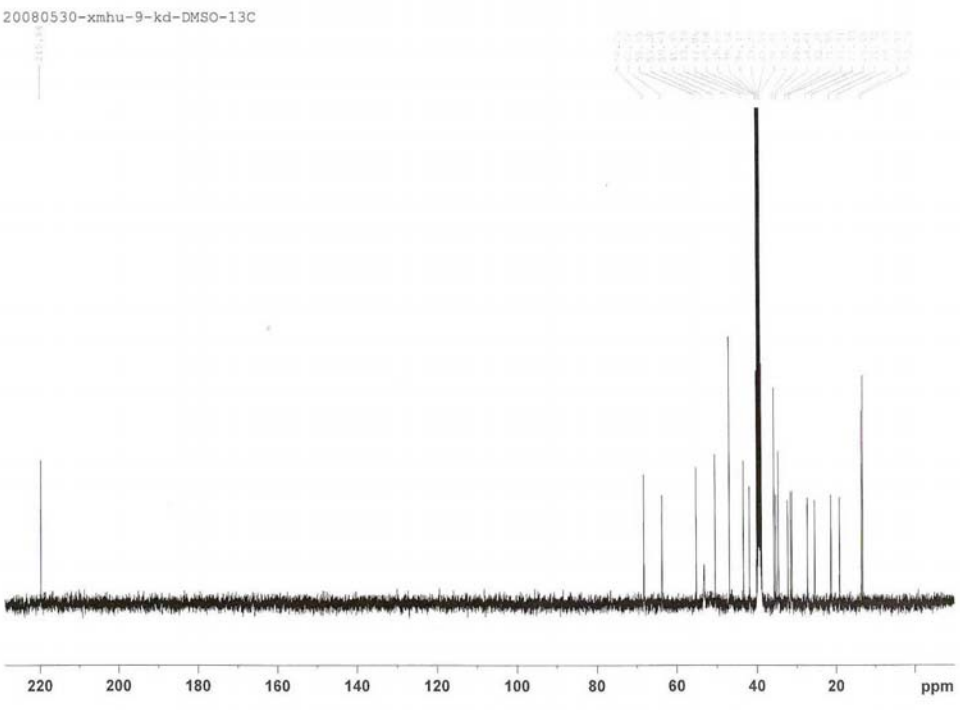




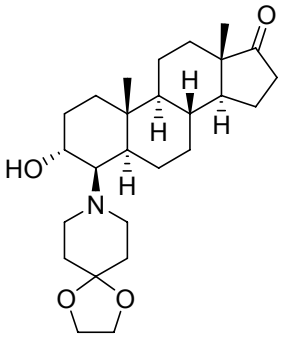
^{1}H NMR and ^{13}C NMR Spectra of 5f

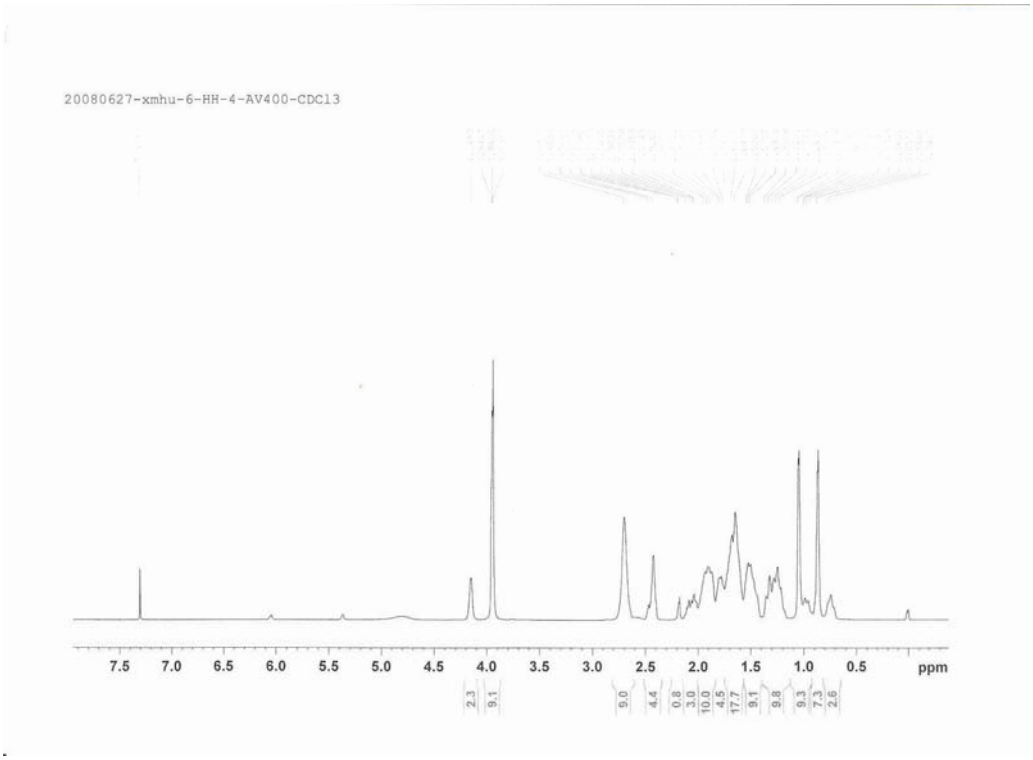


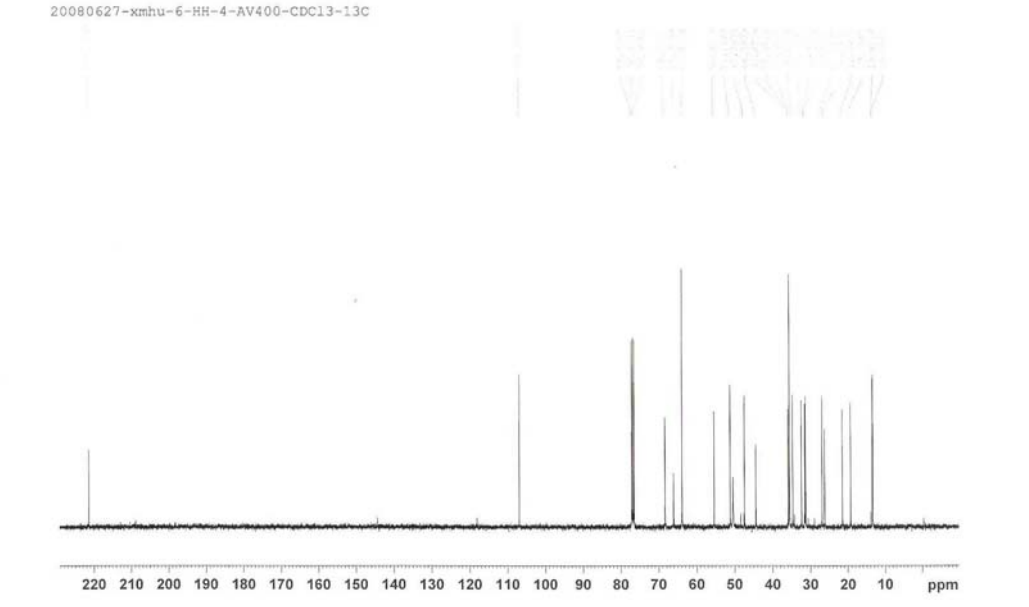




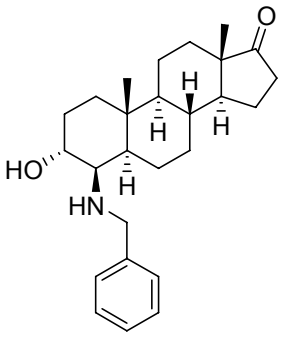
^{1}H NMR and ^{13}C NMR Spectra of 5g

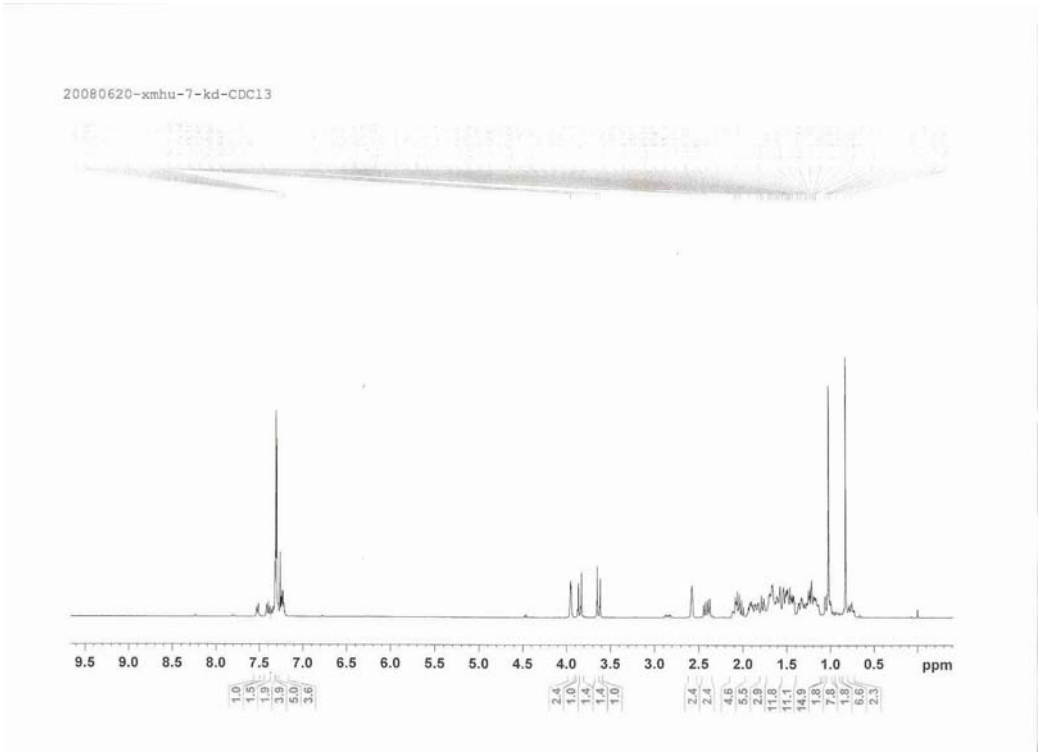


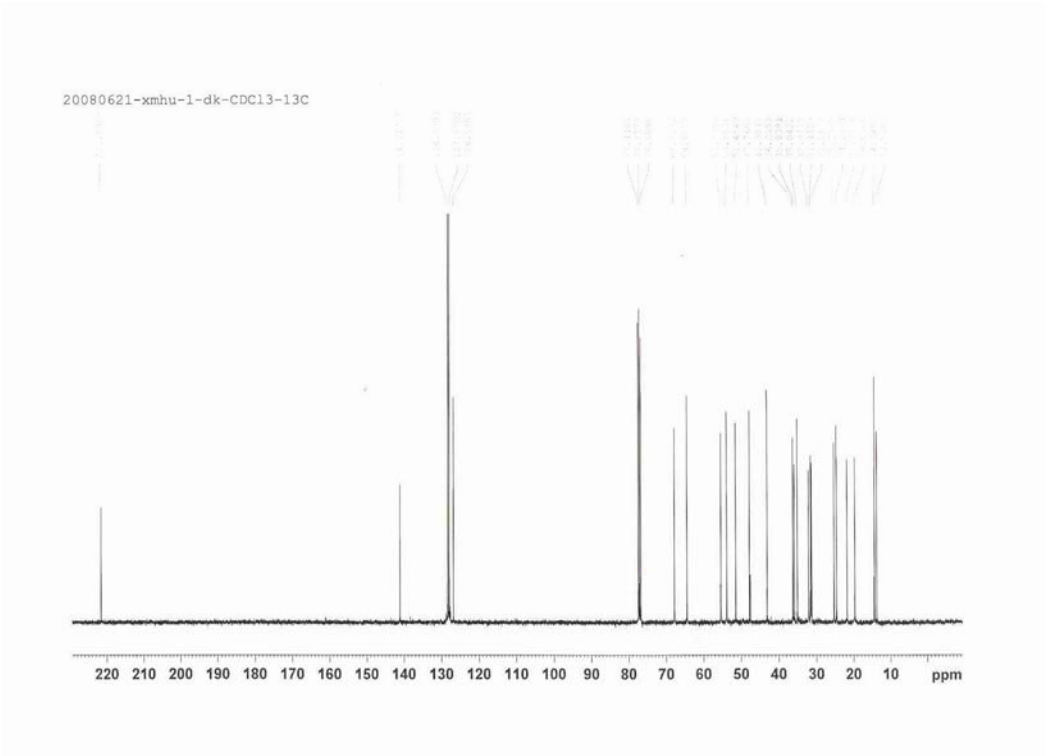




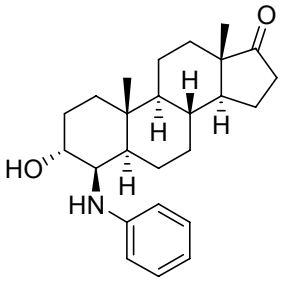
^{1}H NMR and ^{13}C NMR Spectra of 5h

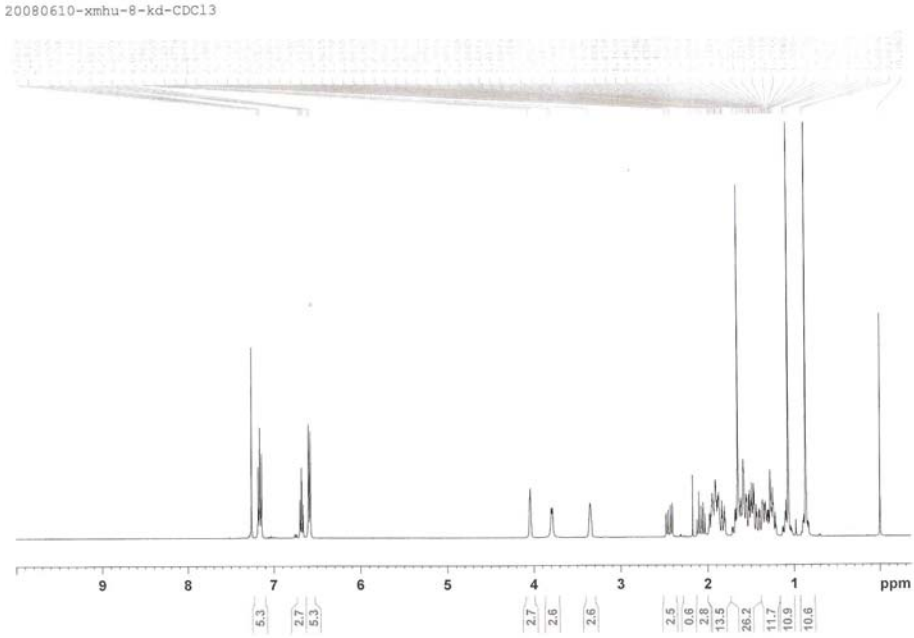


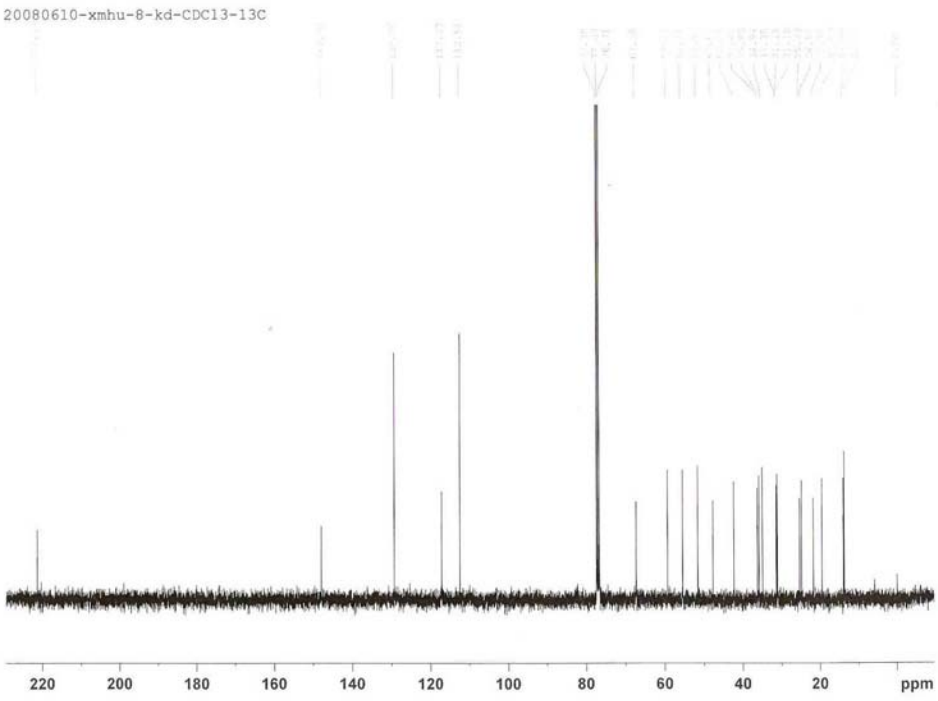




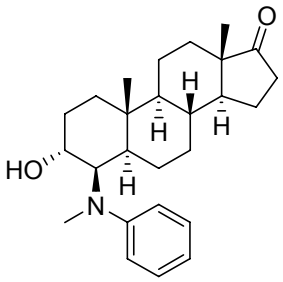
^{1}H NMR and ^{13}C NMR Spectra of 5i

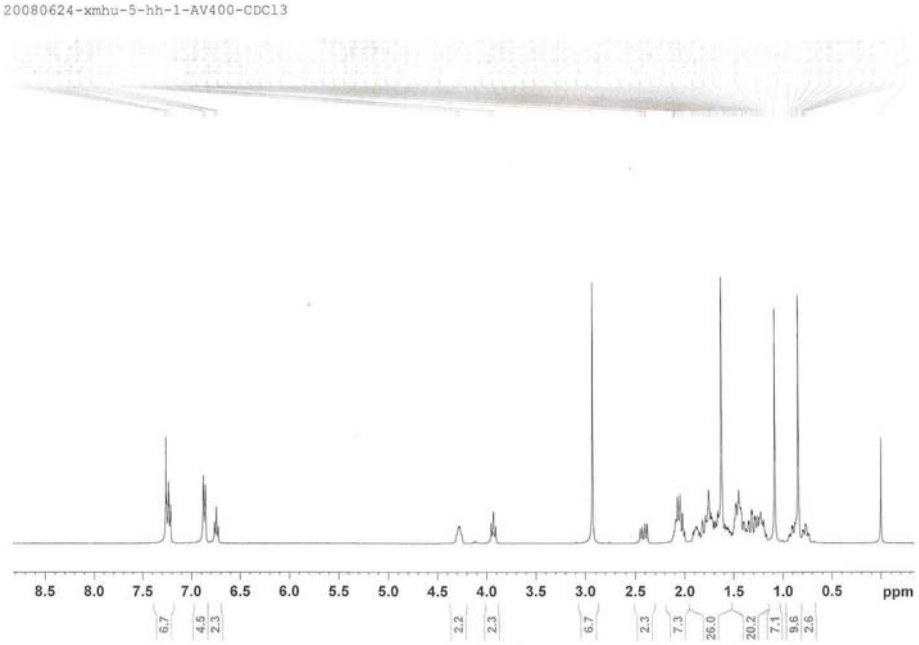


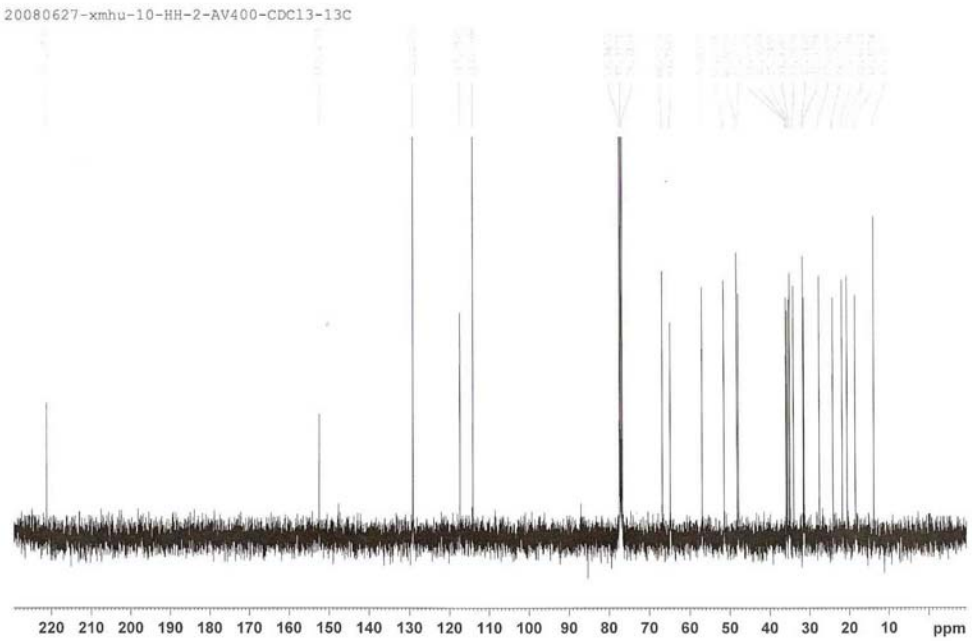




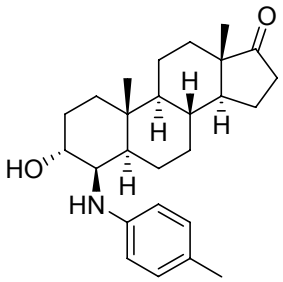
^{1}H NMR and ^{13}C NMR Spectra of 5j

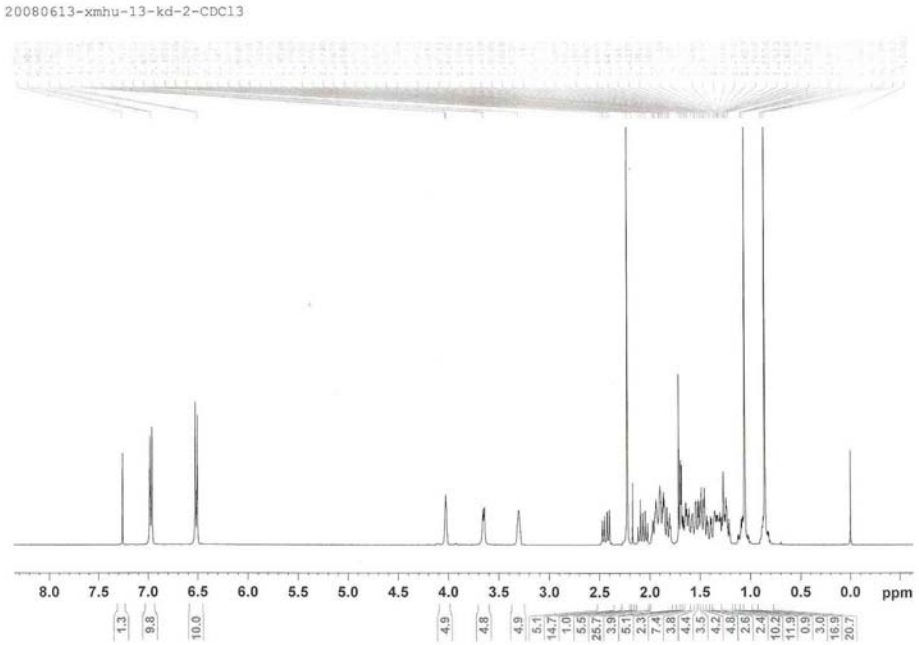


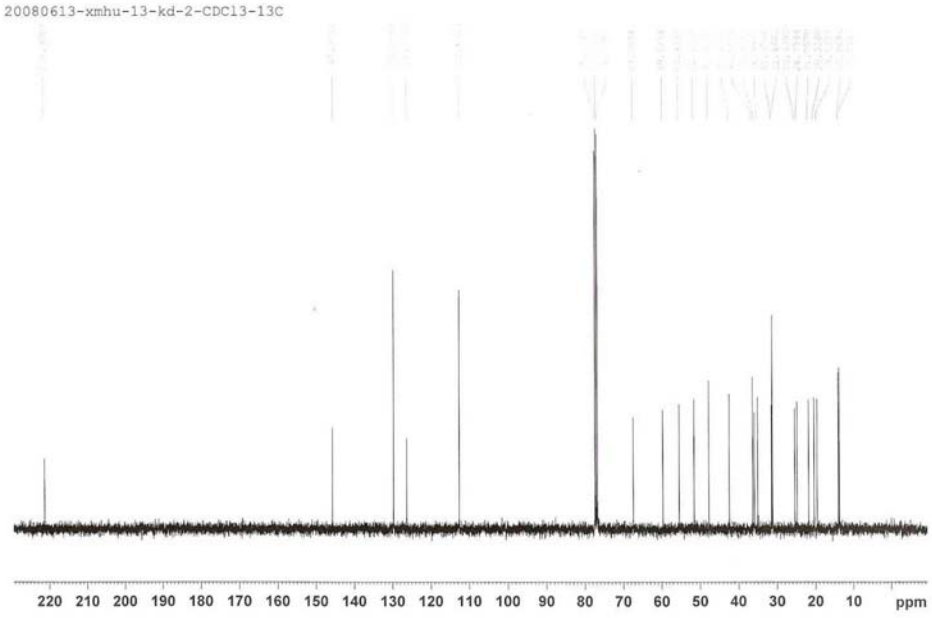




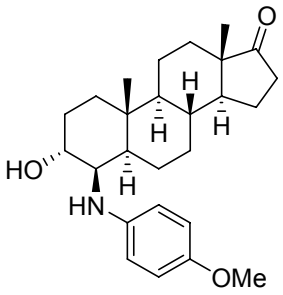
^{1}H NMR and ^{13}C NMR Spectra of 5k

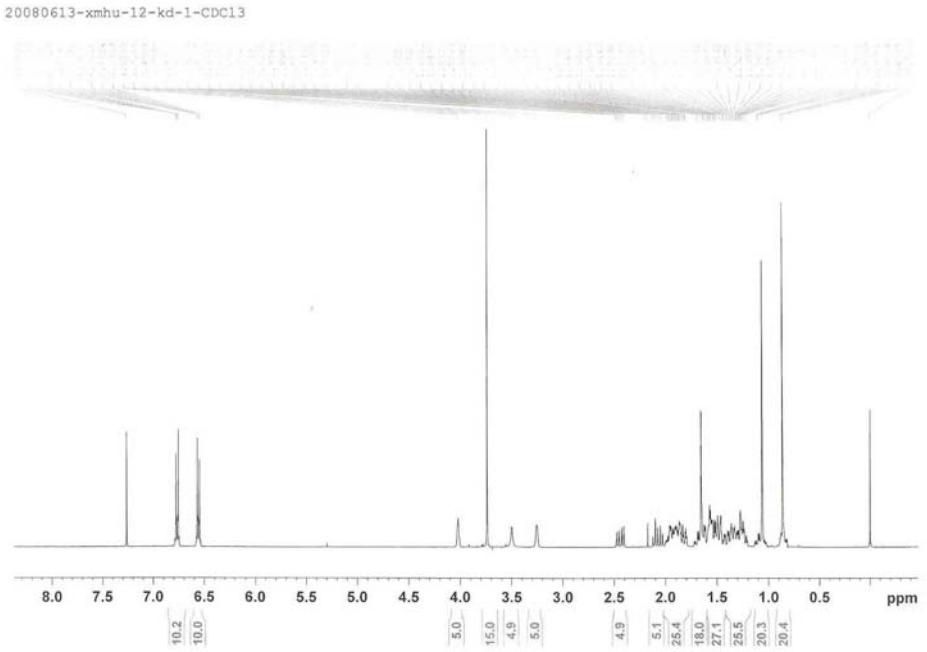


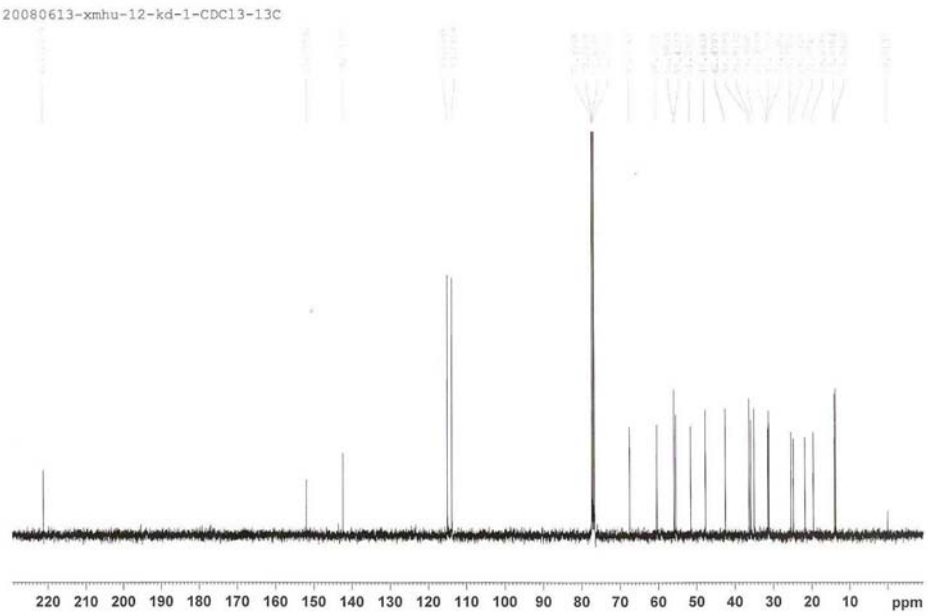




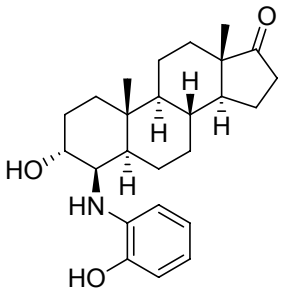
^{1}H NMR and ^{13}C NMR Spectra of 5l

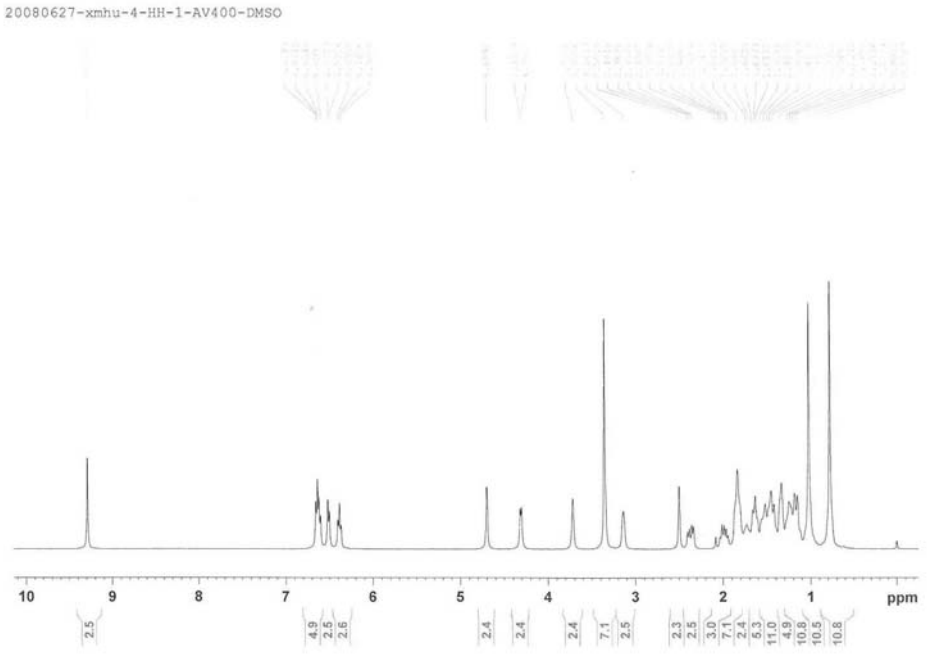


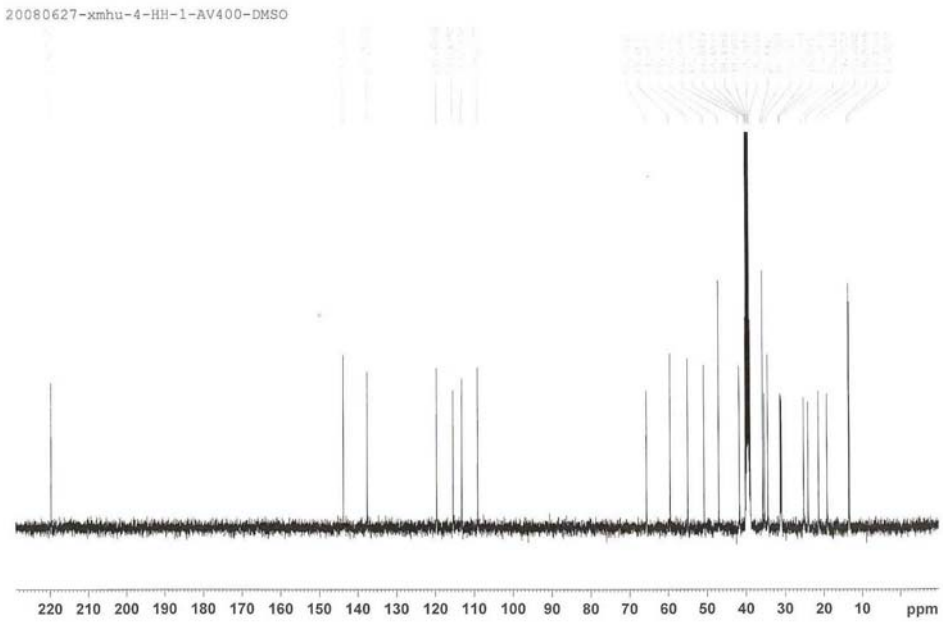




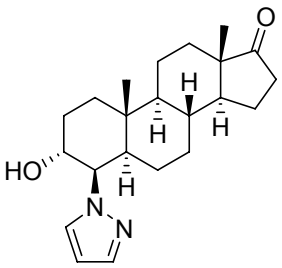
^{1}H NMR and ^{13}C NMR Spectra of 5m

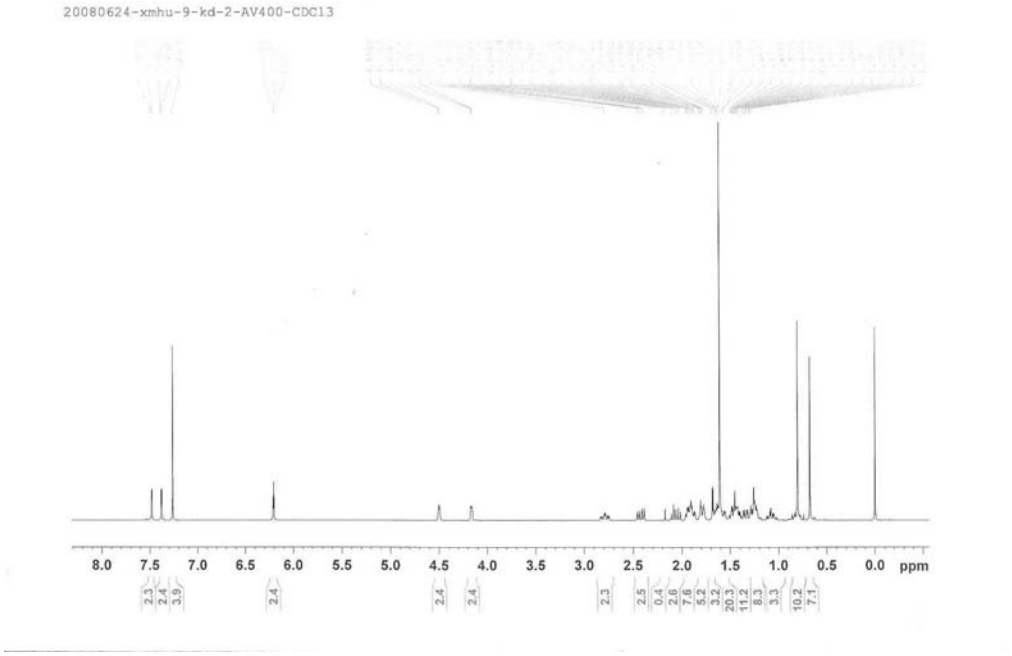


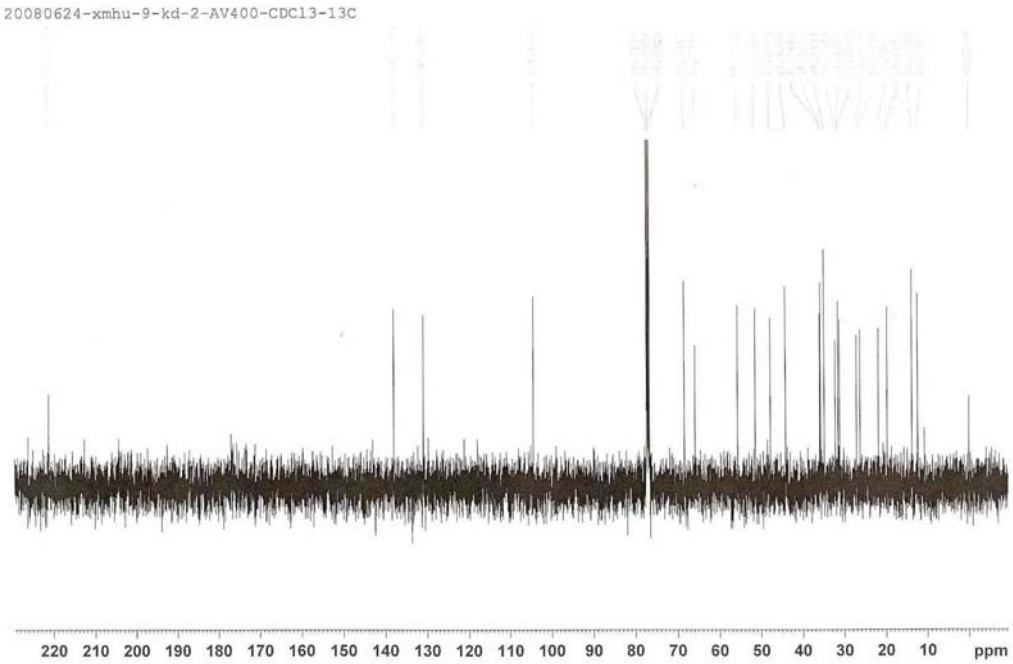




^{1}H NMR and ^{13}C NMR Spectra of 5n







^{1}H NMR and ^{13}C NMR Spectra of 5o