Supplementary Material (ESI) for Chemical Communications


# Enantiopure Cycloalkane Fused Tetrahydro Pyrans Through Domino Michael–Ketalizations With Organocatalysis.

## Supporting Information

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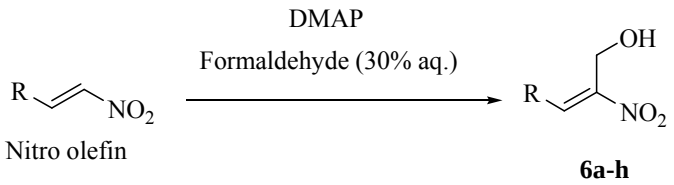
**General**: Reactions were monitored by thin layer chromatography using 0.25 mm E. Merck silica gel coated glass plates (60F-254) using UV light, β-napthol or *p* anisaldehyde to visualize the course of reaction. Column chromatography was performed on siliga gel (60, particle size 0.040–0.063 mm) using ethyl acetate and hexanes as eluent. Chemical yields refer to pure isolated substances. $^{1}H$ and $^{13}C$ NMR spectra were obtained using either a Bruker DPX-300 or AV- 200 or 400 spectrometer. Chemical shifts are reported in ppm from tetramethylsilane with the solvent resonance as the internal standard. The following abbreviations were used to designate chemical shift mutiplicities: s = singlet, d = doublet, t = triplet, q = quartet, h = heptet, m = multiplet, dd = doublet of doublet, td = triplet of doublet, br = broad. The enantiopurity was determined by HPLC on chiral Eurocel column (250 X 4.6 mm) using *i*PrOH/hexane as mobile phase.

All reactions were run in the air except noted. Secondary amine catalysts **2-5** were prepared according to literature.[1] Hydroxy methyl nitro olefins (**6a** to **6h**) were prepared from atom economic – organocatalyzed Baylis–Hillman reaction between nitro olefin and formaldehyde[2].

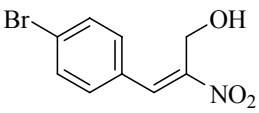
**Preparation of Substrates (6a - 6h)**:




Nitro olefin **6a-h**

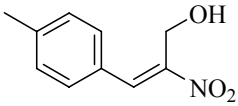
**General Procedure:** A mixture of nitro olefin (1mmol) and 0.2 eq of DMAP in THF (3 mL) were heated at 60 $^{o}$C. Formaldehyde solution (30% aq. 6 equiv.) was added slowly at 60 $^{o}$C, stirred for 12 h at same temperature. The reaction mixture was acidified with 1.5N hydrochloric acid at 0 $^{o}$C, extracted with methylene dichloride, washed with sat. sodium bicarbonate and brine. Methylene dichloride was removed in vacuum and the crude product was purified by silica gel (60 mesh) chromatography using hexane and ethyl acetate as mobile phase to afford the hydroxyl methyl nitro olefins (**6a** to **6h**, entries 1-8, Table 2) with moderate yields (40 - 60%).

The data of **6a**, **6b** and **6h** were in agreement with reported in the literature[3].



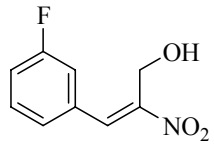

**6c**

**Hydroxyl methyl nitro olefin 6c**: $^{1}$H NMR (400 MHz, $CDCl_3$): δ = 8.13 (s, 1H), 7.63 (d, *J* = 8.0 Hz, 2H), 7.44 (d, *J* = 8.0 Hz, 2H), 4.66 (s, 2H) 2.66(br s, 1H); $^{13}$C NMR (100 MHz, $CDCl_3$): δ = 149.6, 136.4, 132.4, 131.5, 130.0, 125.7, 56.5; ESIMS: *m/z* 255.92 $[M-1]^-$.



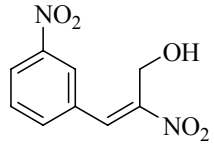

**6d**

**Hydroxyl methyl nitro olefin 6d**: $^{1}$H NMR (400 MHz, $CDCl_3$): δ = 8.20 (s, 1H), 7.48 (d, *J* = 8.1 Hz, 2H), 7.29 (d, *J* = 8.1 Hz, 2H), 4.72 (s, 2H), 2.62 (br s, 1H), 2.42 (s, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$): δ = 148.6, 141.8, 138.0, 137.9, 130.4, 129.9, 56.8, 21.6; ESIMS: *m/z* 192 $[M-1]^-$.



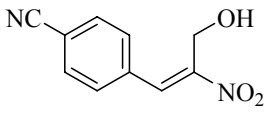

**6f**

**Hydroxyl methyl nitro olefin 6f**: $^{1}$H NMR (400 MHz, $CDCl_3$): δ = 8.15 (s, 1H), 7.56 – 7.14 (m, 4H), 4.69 (s, 2H), 2.82 (br s, 1H); $^{13}$C NMR (100 MHz, $CDCl_3$): δ = 136.1, 130.8, 130.7, 125.9, 117.9, 117.7, 116.8, 116.8, 56.3; ESIMS: *m/z* 196 $[M-1]^-$.




**6g**

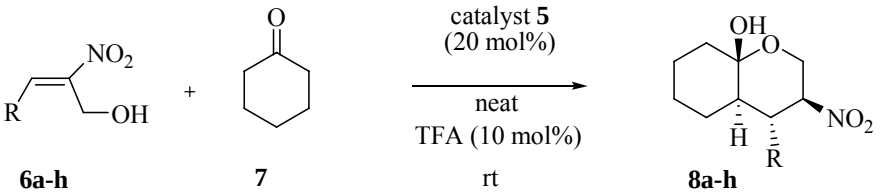
**Hydroxyl methyl nitro olefin 6g**: $^{1}$H NMR (300 MHz, $CDCl_3$): δ = 8.45 (s, 1H), 8.35 (d, *J* = 8.1 Hz, 1H), 8.23 (s, 1H), 7.94 (d, *J* = 7.7 Hz, 1H), 7.72 (t, *J* = 8.1 Hz, *J* = 7.7 Hz, 1H), 4.69 (s, 2H), 2.92 (br s, 1H); $^{13}$C NMR (75 MHz, $CDCl_3$): δ = 151.2, 148.5, 135.5, 134.7, 132.8, 130.2, 125.1,124.7, 56.2; HRMS: exact mass calculated for $[M-H]^-$ ($C_9H_7N_2O_5$) requires *m/z* 223.036, found *m/z* 223.0351.




**6e**

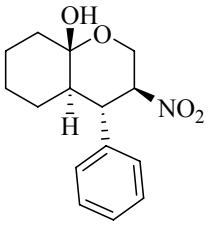
**Hydroxyl methyl nitro olefin 6e**: $^{1}$H NMR (300 MHz, $CDCl_3$): δ = 8.17 (s, 1H), 7.79 (d, *J* = 8.1Hz, 2H), 7.69 (d, *J* = 8.1Hz, 2H),4.64 (d, *J* = 6.9 Hz, 2H), 2.78 (t, *J* = 6.9 Hz, 1H); $^{13}$C NMR (75 MHz, $CDCl_3$): δ = 151.2, 135.6, 135.1, 132.7, 130.4, 117.8, 114.2, 56.3; HRMS: exact mass calculated for $[M-H]^-$ ($C_{10}H_7N_2O_3$) requires *m/z* 203.0462, found *m/z* 203.0471.

**General procedure for Catalytic asymmetric Michael – ketalization reaction of cyclohexanone with various hydroxy methyl nitro olefins.**



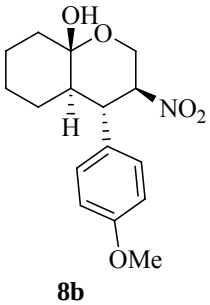

**6a-h** **7** **8a-h**

Hydroxy methyl nitro olefins (**6a – 6h,** 0.27 mmol) and catalyst **5** (0.054 mmol) were mixed with cyclohexanone **7** (5.5 mmol) in the presence of TFA (0.027 mmol) at room temperature. The homogeneous reaction mixture was stirred at room temperature for several days mentioned in Table 2 (still starting material disappears). The reaction mixture was directly loaded onto silica gel column to afford the Michael adducts (**8a – 8h,** 41 - 62% yield) as solids.



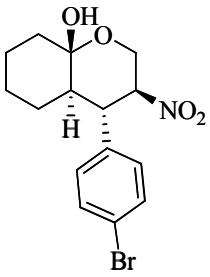

**8a**

**(3S, 4S, 4aR, 8aS)-3-nitro-4-phenyl-octahydro-2H-chromen-8a-ol (8a):** $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ = 7.37-7.23 (m, 3H), 7.18 (m, 2H), 4.94 (td, $J$ = 5.3 Hz, $J$ = 11.1 Hz, 1H), 4.48 (t, $J$ = 10.9 Hz, $J$ = 10.5 Hz, 1H), 4.10 (dd, $J$ = 5.1 Hz, $J$ = 10.3 Hz, 1H), 3.55 (t, $J$ = 11.5 Hz, 1H), 1.85 (m, 1H), 1.78-1.60 (m, 5H), 1.30-1.06 (m, 4H); $^{13}$C NMR (50 MHz, $CDCl_3$) $\delta$ = 137.3, 128.9, 127.7, 96.5, 87.8, 61.7, 46.7, 45.5, 38.4, 26.0, 25.5, 22.8; $[\alpha]_D^{27}$ +20.0 ($c$ = 0.25); HRMS: exact mass calculated for $[M+Na]^+$ ($C_{15}H_{19}NNaO_4$) requires $m/z$ 300.1206, found $m/z$ 300.1209. The enantiomeric excess was determined to be 97% by HPLC on a chiral Eurocel column (250X4.6 mm, 5µ), λ = 225 nm, $i$PrOH/hexane (10:90), 1 ml/min; $t_R$ = 5.8 min (minor), $t_R$ = 6.8 min (major); mp. 178-179 $^o$C.



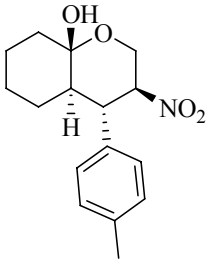

**8b**

**(3S, 4S, 4aR, 8aS)-4-(4-methoxy phenyl)-3-nitro-octahydro-2H-chromen-8a-ol (8b):** $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ = 7.01 (d, $J$ = 7.6 Hz, 2H), 6.84 (d, $J$ = 7.6 Hz, 2H), 6.84, (d, $J$ = 7.6 Hz, 2H), 4.88 (td, $J$ = 5.9 Hz, $J$ = 11.0 Hz, $J$ = 11.8 Hz, 1H), 4.47 (t, $J$ = 10.2 Hz, $J$ = 11.0 Hz, 1H), 4.08 (dd, $J$ = 5.1 Hz, $J$ = 11.0 Hz, 1H), 3.77 (S, 3H), 3.49 (t, $J$ = 11.8 Hz, 1H), 1.89 (s, 1H), 1.78-1.54 (m, 5H), 1.29-1.03 (m, 4H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ = 158.8, 129.1, 114.2, 96.4, 88.0, 61.7, 55.2, 46.8, 44.7, 38.5, 26.0, 25.5, 22.9; $[\alpha]_D^{27}$ +30.0 ($c$ = 0.25, $CHCl_3$); HRMS: exact mass calculated for $[M+Na]^+$ ($C_{16}H_{21}NNaO_5$) requires $m/z$ 330.1312, found $m/z$ 330.1308. The enantiomeric excess was determined to be 99% by HPLC on a chiral Erocel column (250X4.6 mm, 5µ), λ = 225 nm, $i$PrOH/hexane (10:90), 1 ml/min; $t_R$ = 6.7 min (minor), $t_R$ = 7.8 min (major); mp. 187-188 $^o$C.



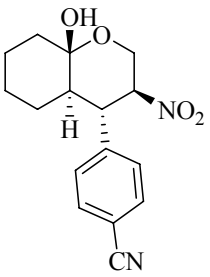

**8c**

**(3S, 4S, 4aR, 8aS)-4-(4-bromo phenyl)-3-nitro-octahydro-2H-chromen-8a-ol (8c):** $^{1}$H NMR (400 MHz, $CDCl_3$) $\delta$ = 7.45 (d, $J$ = 8.0 Hz, 2H), 7.06 (d, $J$ = 8.0Hz, 2H), 4.88 (td, $J$ = 5.1 Hz, $J$ = 10.9 Hz, $J$ = 11.7 Hz, 1H), 4.46 (t, $J$ = 10.9 Hz, 1H), 4.09 (dd, $J$ = 5.1 Hz, $J$ = 10.9 Hz, 1H), 3.54 (t, $J$ = 10.9, $J$ = 11.7 Hz, 1H), 1.90 (s, 1H), 1.78-1.60 (m, 5H), 1.30-1.05 (m, 4H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ = 136.3, 131.9, 131.7, 121.5, 96.3, 87.4, 61.5, 46.6, 45.0, 38.4, 26.4, 25.5, 22.8; $[\alpha]_D^{27}$ +10.00 ($c$ = 0.25, $CHCl_3$); HRMS: exact mass calculated for $[M-H]^-$ ($C_{15}H_{17}BrNO_4$) requires $m/z$ 354.0346, found $m/z$ 354.0348. The enantiomeric excess was determined to be 91% by HPLC on a chiral Eurocel column (250X4.6 mm, 5µ), λ = 225 nm, $i$PrOH/hexane (10:90), 1 ml/min; $t_R$ = 5.9 min (minor), $t_R$ = 7.1 min (major); mp. 189-190 $^{o}$C.



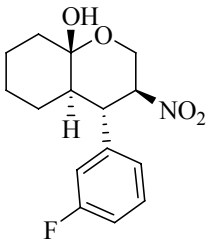

**8d**

**(3S, 4S, 4aR, 8aS)-3-nitro-4-*p*-tolyl-octahydro-2H-chromen-8a-ol (8d):** $^{1}$H NMR (400 MHz, $CDCl_3$) $\delta$ = 7.16-7.02 (m, 4H), 4.90 (td, $J$ = 5.4 Hz, $J$ = 10.9 Hz, $J$ = 11.7 Hz, 1H), 4.47 (t, $J$ = 10.9 Hz, J = 10.1 Hz, 1H), 4.08 (dd, $J$ = 5.4 Hz, $J$ = 10.1 Hz, 1H), 3.50 (t, $J$ = 11.7 Hz, 1H), 2.31 (s, 3H), 1.87 (s, 1H), 1.78-1.59 (m, 5H), 1.27-1.08 (m, 4H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ = 137.3, 134.1, 129.5, 96.4, 87.9, 61.6, 46.6, 45.1, 38.4, 25.9, 25.4, 22.7, 21.0; $[\alpha]_D^{27}$ +18.00 ($c$ = 0.25, $CHCl_3$); HRMS: exact mass calculated for $[M+Na]^+$ ($C_{16}H_{21}NNaO_4$) requires $m/z$ 314.1363, found $m/z$ 314.1366. The enantiomeric excess was determined to be 94% by HPLC on a chiral Eurocel column (250X4.6 mm, 5µ), λ = 225 nm, $i$PrOH/hexane (10:90), 1 ml/min; $t_R$ = 5.1 min (minor), $t_R$ = 5.8 min (major); mp. 187-188.5 $^{o}$C.



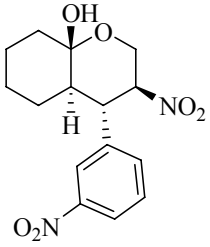

**8e**

**4-((3S, 4S, 4aR, 8aS)-8a-hydroxy-3-nitro-octahydro-2H-chromen-4-yl)benzonitrile (8e):** $^{1}$H NMR (400 MHz, $CDCl_3$) $\delta$ = 7.63 (d, $J$ = 7.8 Hz, 2H), 7.32 (d, $J$ = 7.8 Hz, 2H), 4.90 (dd, $J$ = 5.5 Hz, $J$ = 10.9 Hz, 1H), 4.48 (t, $J$ = 10.9 Hz, 1H), 4.11 (dd, $J$ = 4.7 Hz, $J$ = 10.9 Hz, 1H), 3.67 (t, $J$ = 11.7 Hz, 1H), 2.2 (s, 1H), 1.85-1.56 (m, 6H), 1.32-0.97 (m, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ = 143.1, 132.6, 118.3, 111.7, 96.1, 87.0, 61.3, 46.5, 45.5, 38.0, 26.0, 25.3, 22.6; $[\alpha]_D^{27}$ +12.50 ($c$ = 0.25, $CHCl_3$); HRMS: exact mass calculated for $[M-H]^-$ ($C_{16}H_{17}N_2O_4$) requires $m/z$ 301.1194, found $m/z$ 301.1192. The enantiomeric excess was determined to be 88% by HPLC on a chiral Eurocel column (250X4.6 mm, 5µ), λ = 225 nm, $i$PrOH/hexane (10:90), 1 ml/min; $t_R$ = 11.6 min (minor), $t_R$ = 14.6 min (major); mp. 205-207 $^{o}$C.



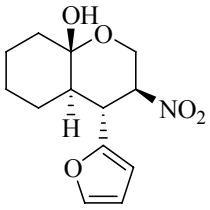
**8f**

**(3S, 4S, 4aR, 8aS)-4-(3-fluoro phenyl)-3-nitro-octahydro-2H-chromen-8a-ol (8f):** $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ = 7.34-7.23 (m, 1H), 7.02-6.87 (m, 3H), 4.90 (td, $J$ = 5.2 Hz, $J$ = 11.2 Hz, 1H), 4.46 (t, $J$ = 11.2 Hz, $J$=10.4 Hz, 1H), 4.10 (dd, $J$ = 5.2 Hz, $J$ = 10.4 Hz, 1H), 3.57 (t, $J$ = 11.9 Hz, $J$ = 11.2 Hz, 1H), 1.94-1.90 (s, 1H), 1.78-1.61 (m, 5H), 1.30-1.06(m, 4H); $^{13}$C NMR (50 MHz, $CDCl_3$) $\delta$ = 139.9, 139.8, 130.4, 130.3, 114.7, 114.5, 96.2, 87.4, 61.5, 46.5, 45.2, 38.4, 26.0, 25.4, 22.8; $[\alpha]_D^{27}$ +24.00 ($c$ = 0.25, $CHCl_3$); HRMS: exact mass calculated for $[M-H]^-$($C_{15}H_{17}FNO_4$) requires $m/z$ 294.1147, found $m/z$ 294.1146. The enantiomeric excess was determined to be 89% by HPLC on a chiral Eurocel column (250X4.6 mm, 5µ), λ = 225 nm, $i$PrOH/hexane (5:95), 1 ml/min; $t_R$ = 9.3 min (minor), $t_R$ = 11.3 min (major); mp. 165-167 $^o$C.



**8g**

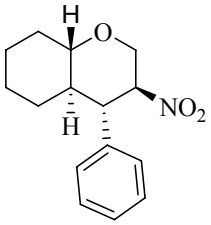
**(3S, 4S, 4aR, 8aS)-3-nitro-4-(3-nitro phenyl)-octahydro-2H-chromen-8a-ol (8g):** $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ = 8.20-8.06 (m, 2H), 7.59-7.49 (m, 2H), 4.95 (td, $J$ = 5.1 Hz, $J$ = 11.0 Hz, 1H), 4.49 (t, $J$ = 10.2Hz, $J$ = 11.0Hz, 1H), 4.14 (dd, $J$ = 5.1Hz, $J$ = 11.3 Hz, 1H), 3.73 (t, $J$ = 11.8 Hz, $J$ = 11.0 Hz, 1H), 1.96-1.57 (m, 7H), 1.35-0.98 (m, 3H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ = 148.5, 139.7, 129.8, 122.8, 96.2, 87.0, 61.4, 46.6, 45.3, 38.3, 26.1, 25.3, 22.7; $[\alpha]_D^{27}$ +6.00 ($c$ = 0.25, $CHCl_3$); ESIMS: $m/z$ 322 $[M-1]^-$; The enantiomeric excess was determined to be 92% by HPLC on a chiral Eurocel column (250X4.6 mm, 5µ), λ = 225 nm, $i$PrOH/hexane (10:90), 1 ml/min; $t_R$ = 9.9 min (minor), $t_R$ = 11.5 min (major); mp. 190-192 $^o$C.



**8h**

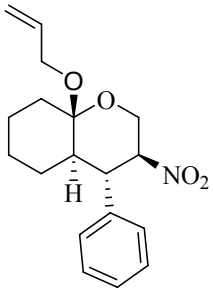
**(3S, 4R, 4aR, 8aS)-4-(furan-2-yl)-3-nitro-octahydro-2H-chromen-8a-ol (8h):** $^1$H NMR (400 MHz, $CDCl_3$) $\delta$ = 7.34 (m, 1H), 6.25 (m, 1H), 6.14 (m, 1H), 4.92 (td, $J$ = 5.2 Hz, $J$ = 11.4 Hz, $J$ = 10.5 Hz, 1H), 4.39 (t, $J$ = 11.4 Hz, $J$ = 10.5, 1H), 4.05 (dd, $J$ = 5.2 Hz, $J$ = 10.5 Hz, 1H), 3.65 (t, $J$ = 11.4 Hz, 1H), 1.86-1.55 (m, 6H), 1.34-1.14 (m, 4H); $^{13}$C NMR (100 MHz, $CDCl_3$) $\delta$ = 150.5, 142.3, 110.3, 109.2, 96.2, 85.2, 61.2, 44.9, 39.5, 38.5, 26.4, 25.6, 22.9; $[\alpha]_D^{27}$ +26.00 ($c$ = 0.25, $CHCl_3$); HRMS: exact mass calculated for $[M-H]^-$ ($C_{13}H_{16}FNO_5$) requires $m/z$ 266.1034, found $m/z$ 266.1023. The enantiomeric excess was determined to be 98% by HPLC on a chiral Eurocel column (250X4.6 mm, 5µ), λ = 225nm, $i$PrOH/hexane (5:95), 1 ml/min; $t_R$ = 7.8 min (minor), $t_R$ = 9.2 min (major); mp. 125-126 $^o$C.

**The data of diverse skeletons:**



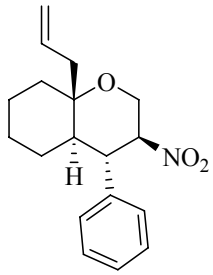
**9**

**(3S, 4S, 4aR, 8aS)-3-nitro-4-phenyl-octahydro-2H-chromene 9:** $^{1}$H NMR (400 MHz, $CDCl_3$) $\delta$ = 7.36-7.23 (m, 3H), 7.20-7.14 (m, 2H), 4.92 (td $J$ = 4.3 Hz, $J$ = 10.9 Hz, 1H), 4.41 (dd, $J$ = 4.3 Hz, $J$ = 10.9 Hz, 1H), 3.86 (t, $J$ = 10.2 Hz, $J$ = 10.9 Hz, 1H), 3.21 (td, $J$ = 3.6Hz, $J$ = 10.2 Hz, 1H), 3.06 (t, $J$ = 10.9 Hz, 1H) 2.07-2.00 (m, 1H), 1.84-1.76 (m, 1H), 1.64-1.48 (m, 2H), 1.40-1.24 (m, 4H), 1.15-0.82 (m, 2H); $^{13}$C NMR (100 MHz, $CDCl_3$) δ = 137.2, 128.8, 127.8, 87.8, 82.0, 69.3, 51.6, 45.6, 31.9, 28.3, 25.2, 24.5; ESIMS: *m/z* 284.3 $[M+Na]^+$; mp. 125-126 $^{o}$C.



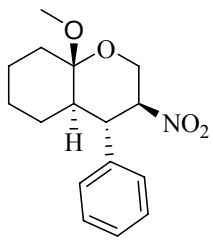
**10**

**(3S, 4S, 4aR, 8aS)-8a-(allyloxy)-3-nitro-4-phenyl-octahydro-2H-chromene 10:** $^{1}$H NMR (400MHz, $CDCl_3$) $\delta$ = 7.36-7.15 (m, 5H), 6.09-5.97 (m, 1H), 5.45 (dd, $J$ = 1.6 Hz, $J$ = 16.9 Hz, 1H), 5.24 (dd, $J$ = 1.6 Hz, $J$ = 10.1 Hz, 1H), 4.93 (td, $J$ = 5.0 Hz, $J$ = 11.0 Hz, 1H), 4.10-3.93 (m, 4H), 3.62 (t, $J$ = 11.0 Hz, $J$ = 11.8 Hz, 1H), 2.13-2.06 (m, 1H), 1.73 (td, $J$ = 3.3 Hz, $J$ = 11.8 Hz, 1H), 1.67-1.58 (m, 2H), 1.47-1.24 (m, 4H), 1.17-1.03 (m, 2H); $^{3}$C NMR (100 MHz, $CDCl_3$) δ = 137.3, 134.2, 128.7, 127.5, 116.0, 98.8, 87.7, 61.8, 60.4, 47.8, 45.2, 32.1, 25.8, 25.5, 22.5; ESIMS: *m/z* 340.0 $[M+Na]^+$; mp. 62-63 $^{o}$C.



**11**

**(3S, 4S, 4aR, 8aR)-8a-allyl-3-nitro-4-phenyl-octahydro-2H-chromene 11:** $^{1}$H NMR (400 MHz, $CDCl_3$) $\delta$ = 7.35-7.16 (m, 5H), 6.01-5.89 (m, 1H), 5.15 (dd, $J$ = 2.0 Hz, $J$ = 10.0 Hz, 1H), 5.10 (dd, $J$ = 2.0 Hz, $J$ = 16.9 Hz, 1H), 4.89-4.81 (m, 1H), 4.14-4.10 (m, 2H), 3.66 (t, $J$ = 12.1 Hz, 1H), 2.55-2.42 (m, 2H), 2.30-2.22 (m, 1H), 2.18-2.17 (m, 1H), 2.00-1.95 (m, 1H), 1.86-1.79 (m, 1H), 1.46-1.36 (m, 4H), 1.20-1.13 (m, 1H); $^{13}$C NMR (100 MHz, $CDCl_3$) δ = 137.8, 133.2, 128.9, 127.7, 117.9, 88.8, 76.9, 62.0, 44.4, 42.3, 42.2, 26.3, 24.2, 23.1, 19.2; ESIMS: *m/z* 324.3 $[M+Na]^+$; mp. 79-80 $^{o}$C.



**12**

**(3S, 4S, 4aR, 8aS)-8a-methoxy-3-nitro-4-phenyl-octahydro-2H-chromene 12:** $^{1}$H NMR (400 MHz, $CDCl_3$) $\delta$ = 7.35-7.12 (m, 5H), 4.96-4.86 (m, 1H), 4.10-4.04 (m, 2H), 3.56 (t, $J$ = 11.6 Hz, 1H), 3.26 (S, 3H), 2.15-2.07 (m, 1H), 1.72 (td, $J$ = 3.1 Hz, $J$ = 11.6 Hz, 1H), 1.66-1.56 (m, 2H), 1.43-1.01 (m, 5H); $^{13}$C NMR (100 MHz, $CDCl_3$) δ = 137.4, 128.8, 127.6, 98.7, 87.7, 61.5, 47.6, 47.0, 45.2,31.2, 25.8, 25.4, 22.2, 19.2; ESIMS: *m/z* 314.7 $[M+Na]^+$; mp. 175-176 $^{o}$C.

**Relative stereochemistry analysis of compound 8a and 9 by NOE experiments:**

**Compound-8a**

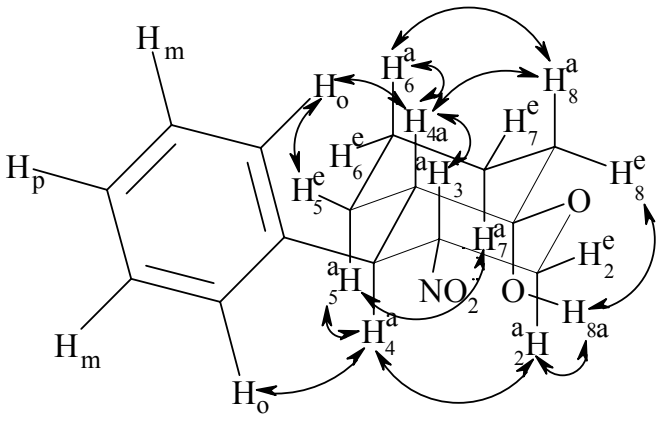



Figure-1

$^1$H NMR DATA

7.36-7.15 [ m, aromatic, 5H ]

4.94 [ td, 1H, *J* ( $H_3^a$- $H_4^a$ , $H_3^a$- $H_2^a$ ) =11.0 Hz, *J* ( $H_3^a$- $H_2^e$ ) = 5.1 Hz , $H_3^a$ ]

4.48 [ t, 1H, *J* ( $H_2^a$- $H_3^a$, $H_2^a$- $H_2^e$ ) = 11.0 Hz, $H_2^a$ ]

4.10 [dd, 1H, *J* ( $H_2^e$- $H_2^a$ ) = 11.0 Hz, *J* ( $H_2^e$- $H_3^a$ ) = 5.1 Hz , $H_2^e$ ]

3.55 [ t, 1H, *J* ( $H_4^a$- $H_3^a$ , $H_4^a$- $H_{4a}$ ) = 11.0 Hz, $H_4^a$ ]

1.88 [ bs, 1H, $H_{8a}$ ]

1.78-1.59 [ m, 5H, $H_{4a}$, $H_5^a$, $H_7^a$, $H_8^a$, $H_8^e$ ]

1.29-1.08 [ m, 4H, $H_5^e$, $H_6^a$, $H_6^e$, $H_7^e$ ]

This compound has been analysed by using 1D- $^1$H decoupling and 2D NMR techniques such as DQF- COSY, TOCSY and NOESY.

The conformation of the molecule is fixed by considering the observed coupling constants and NOEs.

The strong NOE cross peaks between $H_6^a$-$H_8^a$, $H_6^a$- $H_4^a$, $H_8^a$- $H_{4a}$ and $H_3^a$- $H_4^a$ suggested that these protons are in same plane. Furthermore, the strong NOE cross peaks between $H_5^a$-$H_4^a$, $H_5^a$-$H_7^a$ and $H4^a$-$H_2^a$ suggested that these protons are in same plane. In addition to these NOEs other NOE cross-peaks, $H_2^a$-$H_8^a$, $H_8^a$- $H_8^e$, $H_o$- $H_4^a$, $H_o$- $H_5^e$ and $H_o$- $H_4^a$ confirm the structure of the molecule as shown in figure-1.

**Compound 9:**

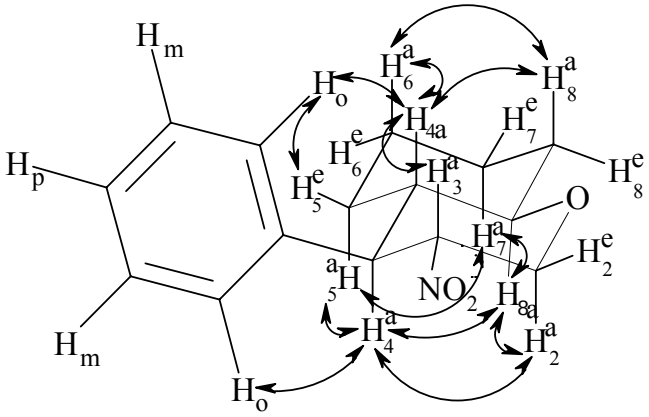



Figure -2

$^1$H NMR DATA

7.35-7.15 [ m, aromatic, 5H ]

4.92 [ td, 1H, *J* ( $H_3^a$- $H_4^a$ , $H_3^a$- $H_2^a$ ) =10.8 Hz, *J* ( $H_3^a$- $H_2^e$ ) = 4.7 Hz , $H_3^a$ ]

4.41 [ dd, 1H, *J* ( $H_2^e$- $H_2^a$ ) = 10.8 Hz , *J* ($H_2^e$- $H_3^a$ ) = 4.7 Hz, $H_2^e$ ]

3.86 [ t, 1H, *J* ( $H_2^a$- $H_2^e$ , $H_2^a$- $H_3^a$ ) = 10.8 Hz, $H_2^a$ ]

3.21 [ td, 1H, *J* ( $H_{8a}$ - $H_3^a$ , $H_{8a}$ – $H_8^a$ ) = 10.8 Hz, *J* ($H_{8a}$- $H_8^e$ ) , $H_{8a}$ ]

3.07 [ t, 1H, *J* ($H_4^a$- $H_3^a$ , $H_4^a$ – H4a) = 10.8 Hz, $H_4^a$ ]

2.07-2.00 [ m, 1H, $H_8^e$ ]

1.84-1.77 [ m, 1H, $H_7^e$ ]

1.64-1.49 [ m, 2H, $H_6^e$, $H_{4a}$ ]

1.42-1.24 [ m, 3H, $H_8^a$, $H_7^a$, $H_5^e$ ]

1.14-1.02 [ m, 1H, $H_6^a$ ]

0.99-0.84 [ m, 1H, $H_5^a$]

This compound has been analysed by using 1D- $^1$H decoupling and 2D NMR techniques such as DQF- COSY, TOCSY and NOESY.

The conformation of the molecule is fixed by considering the observed coupling constants and NOEs.

The strong NOE cross peaks between $H_4^a$- $H_2^a$, $H_4^a$- $H_5^a$, $H_4^a$- $H_8^a$, $H_8^a$ – $H_7^a$, $H_8^a$ – $H_7^a$ and $H_7^a$- $H_5^a$ suggested that these protons are in same plane. Furthermore, the strong NOE cross peaks between $H_4^a$ – $H_3^a$, $H_4^a$ – $H_6^a$, $H_4^a$ – $H_8^a$ and $H_6^a$- $H_8^a$ suggested that these protons are in same plane. In addition to these NOEs other NOE cross-peaks, $H_o$- $H_5^e$, $H_o$- $H_4^a$ and $H_o$- $H_4^a$ confirm the structure of the molecule as shown in figure-2.

**References:**

(1) (a) S. Luo, H. Xu, X. Mi, J.Li, X. Zeng, J. P. Cheng, *J. Org . Chem.* **2006**, *71*, 9244; (b) S. Chandrasekhar, B. Tiwari, B. B. Parida, Ch. Rajireddy, *Tetrahedron: Asymmetry* **2008**, *19*, 495.
(2) F. Rezgui, M. M. E. Gaied, *Tetrahedron Lett.* **1998**, *39*, 5965.
(3) R. Mohan, N. Rostogi, I. N. N. Namboothiri, *Bio. Org. Med. Chem.* **2006**, *14*, 8073.