

Synthesis of indeno and acenaphtho core containing dihydroxy indolone, pyrrole, coumarin and uracil fused heterocyclic motifs under sustainable condition exploring the catalytic role of SnO₂ quantum dot

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Spectral data of the synthesized compounds:

4b,9b-dihydroxy-7,7-dimethyl-5-phenyl-4b,5,7,8-tetrahydroindeno[1,2-*b*]indole-

9,10(6*H*,9*bH*)-dione (4a): Characteristic: White crystalline solid; Mp: 210-112 °C; IR (KBr): 1458, 1545, 1607, 1720, 2927, 3213 cm⁻¹; ¹H NMR (300 MHz, DMSO-*d*₆): δ 0.86 (3H, s), 0.93 (3H, s), 1.76 (1H, d, *J*= 17.1 Hz), 1.88 (1H, d, 15.9 Hz), 2.12 (1H, d, *J*= 15.6 Hz), 2.38 (1H, d, *J*= 17.1 Hz), 5.96 (1H, s), 6.57-6.59 (1H, m), 7.23-7.28 (3H, m), 7.45-7.55 (5H, m), 7.68-7.71 (1H, m); ¹³C NMR (75 MHz, DMSO-*d*₆): δ 26.6, 29.3, 33.5, 37.1, 51.2, 83.5, 96.8, 105.6, 123.2, 124.9, 128.0, 129.0, 129.4, 130.2, 134.8, 136.1, 147.3, 163.4, 189.3, 197.6; Anal. Calcd for C₂₃H₂₁NO₄: C 73.58, H 5.64, N 3.73%. Found: C 73.55, H 5.60, N 3.75%.

4b,9b-dihydroxy-5-(4-methoxyphenyl)-7,7-dimethyl-4b,5,7,8-tetrahydroindeno[1,2-*b*]indole-

9,10(6*H*,9*bH*)-dione (4b): Characteristic: Pale yellow crystalline solid; Mp: 224 °C; IR (KBr): 1248, 1459, 1510, 1735, 2347, 3407 cm⁻¹; ¹H NMR (300 MHz, CDCl₃): δ 0.94 (3H, s), 1.01 (3H, s), 1.96-2.28 (4H, m), 3.88 (3H, s), 5.40 (1H, s), 5.69 (1H, s), 6.89 (1H, dd, *J*₁= 5.4 Hz, *J*₂= 2.1 Hz), 6.98 (2H, d, *J*= 8.7 Hz), 7.16 (2H, d, *J*= 8.1 Hz), 7.46-7.53 (2H, m), 7.86 (1H, d, *J*= 6.3 Hz); ¹³C NMR (75 MHz, DMSO-*d*₆): δ 21.5, 27.1, 29.7, 33.8, 37.4, 51.7, 55.8, 83.8, 96.9, 105.4, 114.6, 123.6, 125.5, 128.8, 130.6, 131.2, 135.3, 147.8, 159.2, 164.3, 172.4, 189.5, 198.1; Anal. Calcd for C₂₄H₂₃NO₅: C 71.10, H 5.72, N 3.45%. Found: C 71.12, H 5.75, N 3.41%.

5-(3-chloro-4-methoxyphenyl)-4b,9b-dihydroxy-7,7-dimethyl-4b,5,7,8-

tetrahydroindeno[1,2-*b*]indole-9,10(6*H*,9*bH*)-dione (4c): Characteristic: White crystalline solid; Mp: 218-220 °C; IR (KBr): 1458, 1500, 1543, 1605, 1718, 2955, 3393 cm⁻¹; ¹H NMR (300 MHz, CDCl₃): δ 1.20 (3H, s), 1.26 (3H, s), 2.21-2.52 (4H, m), 4.23 (3H, s), 5.63 (1H, s), 5.73 (1H, s), 7.17-7.27 (2H, m), 7.44-7.54 (2H, m), 7.77 (2H, d, *J*= 5.7 Hz), 8.11 (1H, d, *J*= 6.6 Hz); ¹³C NMR (75 MHz, CDCl₃): δ 27.7, 29.3, 34.1, 37.5, 50.9, 56.4, 82.8, 96.9, 105.4, 112.0, 122.7, 124.6, 125.0, 128.5, 129.4, 130.3, 131.4, 135.0, 135.2, 147.6, 155.3, 165.3, 192.2, 197.4; Anal. Calcd for C₂₄H₂₂ClNO₅: C 65.53, H 5.04, N 3.18%. Found: C 65.50, H 5.02, N 3.20%.

4b,9b-dihydroxy-7,7-dimethyl-5-(*p*-tolyl)-4b,5,7,8-tetrahydroindeno[1,2-*b*]indole-

9,10(6*H*,9*bH*)-dione (4d): Characteristic: White crystalline solid; Mp: 214-216 °C; IR (KBr): 1401, 1452, 1514, 1544, 1727, 2962 cm⁻¹; ¹H NMR (300 MHz, CDCl₃): δ 0.90 (3H, s), 0.98 (3H, s), 1.96 (1H, d, *J*= 17.4 Hz), 2.11 (1H, d, *J*= 17.1 Hz), 2.15 (1H, d, *J*= 15.9 Hz), 2.22 (1H, d, *J*=

16.5 Hz), 2.41 (3H, s), 6.83 (1H, d, J= 4.8 Hz), 7.09 (2H, d, J= 7.2 Hz), 7.23 (2H, d, J= 6.9 Hz), 7.44-7.46 (2H, m), 7.82 (1H, d, J= 4.5 Hz); ^{13}C NMR (75 MHz, CDCl_3): δ 18.3, 21.2, 27.6, 29.3, 34.1, 50.8, 82.6, 96.8, 105.3, 124.5, 125.1, 129.4, 129.9, 130.2, 132.9, 134.9, 135.1, 138.7, 147.6, 165.7, 192.0, 197.6; Anal. Calcd for $\text{C}_{24}\text{H}_{23}\text{NO}_4$: C 74.02, H 5.95, N 3.60%. Found: C 74.04, H 5.98, N 3.57%.

5-(4-chlorophenyl)-4b,9b-dihydroxy-7,7-dimethyl-4b,5,7,8-tetrahydroindeno[1,2-*b*]indole-9,10(6*H*,9*bH*)-dione (4e): Characteristic: White crystalline solid; Mp: 238-240 $^{\circ}\text{C}$; IR (KBr): 1449, 1493, 1560, 1716, 3163 cm^{-1} ; ^1H NMR (300 MHz, CDCl_3): δ 0.93 (3H, s), 1.00 (3H, s), 2.02 (1H, d, J= 17.7 Hz), 2.09 (1H, d, J= 17.1 Hz), 2.21 (2H, s), 6.05 (1H, s), 6.31 (1H, s), 6.93 (1H, d, J= 7.8 Hz), 7.31-7.85 (6H, m), 7.89-7.95 (1H, m); ^{13}C NMR (75 MHz, CDCl_3): δ 27.4, 28.9, 33.6, 37.1, 50.3, 83.2, 96.9, 105.0, 124.6, 124.7, 129.1, 130.0, 131.1, 133.8, 134.2, 134.4, 135.2, 147.6, 165.1, 192.5; Anal. Calcd for $\text{C}_{23}\text{H}_{20}\text{ClNO}_4$: C 67.40, H 4.92, N 3.42%. Found: C 67.43, H 4.93, N 3.39%.

5-(4-bromophenyl)-4b,9b-dihydroxy-7,7-dimethyl-4b,5,7,8-tetrahydroindeno[1,2-*b*]indole-9,10(6*H*,9*bH*)-dione (4f): Characteristic: White crystalline solid; Mp: 160-162 $^{\circ}\text{C}$; IR (KBr): 1449, 1490, 1545, 1630, 1726, 2955, 3326 cm^{-1} ; ^1H NMR (300 MHz, CDCl_3): δ 1.18 (3H, s), 1.24 (3H, s), 2.22-2.46 (4H, m), 7.13 (1H, dd, $J_1= 6$ Hz, $J_2= 1.8$ Hz), 7.44 (2H, d, J= 8.4 Hz), 7.71-7.79 (2H, m), 7.85 (2H, d, J= 8.4 Hz), 8.09 (1H, dd, $J_1= 6.3$ Hz, $J_2= 2.4$ Hz); ^{13}C NMR (75 MHz, CDCl_3): δ 27.5, 29.4, 29.7, 34.3, 37.6, 50.8, 82.8, 122.7, 124.6, 124.9, 130.4, 131.2, 132.6, 134.9, 135.3, 147.5, 164.9; Anal. Calcd for $\text{C}_{23}\text{H}_{20}\text{BrNO}_4$: C 60.81, H 4.44, N 3.08%. Found: C 60.83, H 4.41, N 3.10%.

4b,9b-dihydroxy-7,7-dimethyl-5-(3-nitrophenyl)-4b,5,7,8-tetrahydroindeno[1,2-*b*]indole-9,10(6*H*,9*bH*)-dione (4g): Characteristic: Pale yellow crystalline solid; Mp: 170-172 $^{\circ}\text{C}$; IR (KBr): 1448, 1543, 1631, 1728, 3329 cm^{-1} ; ^1H NMR (300 MHz, CDCl_3): δ 0.89 (3H, s), 0.93 (3H, s), 2.01-2.22 (4H, m), 5.70 (1H, s), 6.28 (1H, s), 6.78-6.80 (1H, m), 7.43-7.47 (2H, m), 7.65 (1H, t, J= 8.1 Hz), 7.79 (2H, d, J= 5.4 Hz), 8.12 (1H, d, J= 1.8 Hz), 8.27 (1H, dd, $J_1= 8.1$ Hz, $J_2= 0.9$ Hz); ^{13}C NMR (75 MHz, CDCl_3): δ 27.5, 29.5, 34.4, 37.7, 50.9, 82.9, 97.4, 106.8, 123.2, 124.5, 124.8, 130.3, 130.6, 134.9, 135.5, 135.8, 137.4, 147.4, 148.7, 164.3, 192.7, 197.1; Anal. Calcd for $\text{C}_{23}\text{H}_{20}\text{N}_2\text{O}_6$: C 65.71, H 4.80, N 6.66%. Found: C 65.70, H 4.82, N 6.64%.

5-(9-ethyl-9*H*-carbazol-3-yl)-4*b*,9*b*-dihydroxy-7,7-dimethyl-4*b*,5,7,8-tetrahydroindeno[1,2-*b*]indole-9,10(6*H*,9*bH*)-dione (4*h*): Characteristic: Pale yellow crystalline solid; Mp: 220-222 °C; IR (KBr): 1458, 1490, 1545, 1719, 3352 cm⁻¹; ¹H NMR (300 MHz, DMSO-*d*₆): δ 0.86 (3H, s), 0.94 (3H, s), 1.36 (3H, t, *J* = 6.9 Hz), 1.78-2.45 (4H, m), 4.49 (2H, d, *J* = 6.9 Hz), 5.96 (1H, s), 6.64 (1H, d, *J* = 4.8 Hz), 7.21 (2H, d, *J* = 9.9 Hz), 7.47-7.72 (8H, m), 8.07 (1H, d, *J* = 7.5 Hz); ¹³C NMR (75 MHz, DMSO-*d*₆): δ 14.1, 27.0, 29.7, 33.7, 37.5, 51.6, 83.8, 96.9, 105.1, 109.4, 109.7, 119.4, 120.9, 122.0, 122.3, 122.4, 123.4, 125.5, 126.6, 127.2, 127.6, 130.4, 135.1, 135.2, 139.1, 140.4, 147.8, 164.6, 189.3, 198.1; Anal. Calcd for C₃₁H₂₈N₂O₄ : C 75.59, H 5.73, N 5.69%. Found: C 75.61, H 5.70, N 5.67%.

5-cyclohexyl-4*b*,9*b*-dihydroxy-7,7-dimethyl-4*b*,5,7,8-tetrahydroindeno[1,2-*b*]indole-9,10(6*H*,9*bH*)-dione (4*i*): Characteristic: White crystalline solid; Mp: 202-204 °C; IR (KBr): 1221, 1375, 1491, 1724, 2935, 3531 cm⁻¹; ¹H NMR (300 MHz, CDCl₃): δ 0.95 (3H, s), 1.10 (3H, s), 1.15-2.57 (15H, m), 7.50-7.55 (1H, m), 7.69-7.79 (2H, m), 7.84 (1H, d, *J* = 7.5 Hz); ¹³C NMR (75 MHz, CDCl₃): δ 25.4, 26.5, 26.7, 27.8, 29.1, 33.0, 34.1, 34.4, 39.1, 50.4, 55.1, 82.1, 95.8, 104.3, 123.4, 124.9, 130.4, 135.2, 135.7, 148.2, 164.7, 190.9; Anal. Calcd for C₂₃H₂₇NO₄ : C 72.42, H 7.13, N 3.67%. Found: C 72.40, H 7.15, N 3.70%.

4*b*,9*b*-dihydroxy-7,7-dimethyl-5-(thiophen-2-ylmethyl)-4*b*,5,7,8-tetrahydroindeno[1,2-*b*]indole-9,10(6*H*,9*bH*)-dione (4*j*): Characteristic: Pale yellow crystalline solid; Mp: 184-186 °C; IR (KBr): 1368, 1550, 1603, 1717, 2947, 3383 cm⁻¹; ¹H NMR (300 MHz, CDCl₃): δ 0.85 (3H, s), 0.98 (3H, s), 2.07-2.26 (3H, m), 2.40 (1H, d, *J* = 17.1 Hz), 5.12-5.27 (3H, m), 5.70 (1H, s), 6.80 (1H, d, *J* = 2.7 Hz), 6.90-6.93 (1H, m), 7.19 (1H, dd, *J*₁ = 3.9 Hz, *J*₂ = 0.9 Hz), 7.47-7.62 (3H, m), 7.84 (1H, d, *J* = 7.8 Hz); ¹³C NMR (75 MHz, CDCl₃): δ 28.9, 33.7, 36.9, 41.4, 50.7, 60.4, 83.1, 96.4, 104.8, 124.4, 124.7, 125.0, 125.4, 126.9, 130.3, 134.9, 135.4, 141.3, 148.1, 166.4, 191.4, 197.6; Anal. Calcd for C₂₂H₂₁NO₄S : C 66.82, H 5.35, N 3.54%. Found: C 66.80, H 5.32, N 3.56%.

5-benzyl-4*b*,9*b*-dihydroxy-7,7-dimethyl-4*b*,5,7,8-tetrahydroindeno[1,2-*b*]indole-9,10(6*H*,9*bH*)-dione (4*k*): Characteristic: Pale yellow crystalline solid; Mp: 188-190 °C; IR (KBr): 1438, 1486, 1726, 2951, 3380 cm⁻¹; ¹H NMR (300 MHz, CDCl₃): δ 0.81 (3H, s), 0.93 (3H, s), 1.94-2.27 (4H, m), 5.08 (2H, s), 7.03 (2H, d, *J* = 7.5 Hz), 7.26 (3H, d, *J* = 4.5 Hz), 7.46-7.55 (3H, m), 7.86 (1H, d, *J* = 7.2 Hz); ¹³C NMR (75 MHz, CDCl₃): δ 28.2, 28.7, 33.7, 26.9, 45.6,

50.6, 82.9, 104.5, 124.5, 126.2, 127.4, 128.7, 130.3, 134.9, 135.4, 137.3, 147.9, 191.2, 197.5; Anal. Calcd for C₂₄H₂₃NO₄: C 74.02, H 5.95, N 3.60%. Found: C 74.05, H 5.92, N 3.62%.

4b,9b-dihydroxy-7,7-dimethyl-5-octyl-4b,5,7,8-tetrahydroindeno[1,2-*b*]indole-

9,10(6*H*,9*bH*)-dione (4l): Characteristic: Pale yellow crystalline solid; Mp: 160 °C; IR (KBr): 1497, 1541, 1718, 2927, 3416 cm⁻¹; ¹H NMR (300 MHz, CDCl₃): δ 0.93 (6H, s), 1.08 (3H, s), 1.21-1.34 (11H, m), 1.56-1.77 (2H, m), 2.08-2.39 (3H, m), 3.53-3.75 (2H, m), 7.52 (1H, t, J= 7.2 Hz), 7.72 (1H, t, J= 7.2 Hz), 7.81-7.85 (2H, m); ¹³C NMR (75 MHz, CDCl₃): δ 14.0, 22.6, 27.2, 28.5, 28.7, 29.1, 31.4, 31.7, 33.8, 36.9, 42.8, 50.5, 82.6, 95.9, 103.8, 124.0, 124.7, 130.3, 135.1, 135.6, 148.2, 165.5, 190.7, 197.4; Anal. Calcd for C₂₅H₃₃NO₄: C 72.96, H 8.08, N 3.40%. Found: C 72.94, H 8.10, N 3.43%.

5-(3,3-dimethylbutyl)-4b,9b-dihydroxy-7,7-dimethyl-4b,5,7,8-tetrahydroindeno[1,2-

***b*]indole-9,10(6*H*,9*bH*)-dione (4m):** Characteristic: Pale yellow crystalline solid; Mp: 194-196 °C; IR (KBr): 1492, 1535, 1618, 1707, 2952, 3474 cm⁻¹; ¹H NMR (300 MHz, CDCl₃): δ 0.85-1.05 (15H, m), 1.31-1.41 (1H, m), 1.60-1.70 (1H, m), 2.04-2.30 (4H, m), 3.52-3.73 (2H, m), 4.90 (1H, s), 5.25 (1H, s), 7.46 (1H, t, J= 7.2 Hz), 7.66 (1H, t, J= 7.2 Hz), 7.75-7.79 (2H, m); ¹³C NMR (75 MHz, CDCl₃): δ 28.1, 28.3, 28.8, 29.7, 33.4, 36.4, 38.7, 44.4, 50.1, 82.3, 95.6, 103.5, 123.6, 124.4, 129.9, 134.8, 135.1, 147.9, 164.9, 190.2, 196.9; Anal. Calcd for C₂₃H₂₉NO₄: C 72.04, H 7.62, N 3.65%. Found: C 72.00, H 7.64, N 3.64%.

4b,9b-dihydroxy-5-phenyl-4b,5,7,8-tetrahydroindeno[1,2-*b*]indole-9,10(6*H*,9*bH*)-dione

(4n): Characteristic: Pale brown crystalline solid; Mp: 218-220 °C; IR (KBr): 1458, 1544, 1718, 3650, 3854 cm⁻¹; ¹H NMR (300 MHz, CDCl₃): δ 1.77-1.95 (2H, m), 2.08-2.31 (4H, m), 5.47 (2H, s), 6.77-6.81 (1H, m), 7.19-7.23 (2H, m), 7.39-7.45 (5H, m), 7.80 (1H, dd, J₁= 6.0 Hz, J₂= 3.0 Hz); ¹³C NMR (75 MHz, CDCl₃): δ 21.8, 23.9, 36.7, 60.4, 82.9, 96.5, 106.7, 124.6, 125.1, 128.7, 129.3, 129.6, 130.2, 135.0, 135.2, 135.6, 147.7, 166.6, 193.2, 197.7; Anal. Calcd for C₂₁H₁₇NO₄: C 72.61, H 4.93, N 4.03%. Found: C 72.58, H 4.95, N 4.01%.

4b,9b-dihydroxy-5-(4-methoxyphenyl)-4b,5,7,8-tetrahydroindeno[1,2-*b*]indole-

9,10(6*H*,9*bH*)-dione (4o): Characteristic: Yellow crystalline solid; Mp: 194-196 °C; IR (KBr): 1458, 1508, 1718, 3650, 3747 cm⁻¹; ¹H NMR (300 MHz, CDCl₃): δ 1.86-2.37 (6H, m), 3.88 (3H, s), 5.23 (1H, s), 5.58 (1H, s), 6.91-6.99 (3H, m), 7.16 (2H, d, J= 7.8 Hz), 7.47-7.55 (2H, m),

7.86-7.89 (1H, m); ^{13}C NMR (75 MHz, CDCl_3): δ 21.7, 23.8, 36.7, 55.5, 82.8, 96.3, 106.3, 114.4, 124.5, 125.2, 127.8, 130.2, 130.9, 135.0, 135.2, 147.7, 159.7, 167.2, 193.0, 197.8; Anal. Calcd for $\text{C}_{22}\text{H}_{19}\text{NO}_5$: C 70.02, H 5.07, N 3.71%. Found: C 70.00, H 5.05, N 3.74%.

5-(4-bromophenyl)-4b,9b-dihydroxy-4b,5,7,8-tetrahydroindeno[1,2-*b*]indole-9,10(6*H*,9*bH*)-dione (4p): Characteristic: White crystalline solid; Mp: 190 $^{\circ}\text{C}$; IR (KBr): 1458, 1491, 1542, 1734, 2341, 3650, 3748, 3851 cm^{-1} . ^1H NMR (300 MHz, CDCl_3 +DMSO- d_6): δ 1.81-2.20 (6H, m), 6.62-6.75 (2H, m), 7.04 (2H, d, J = 8.1 Hz), 7.36-7.47 (5H, m), 7.68-7.71 (1H, m); ^{13}C NMR (75 MHz, CDCl_3 +DMSO- d_6): δ 13.4, 21.0, 23.0, 36.2, 59.4, 82.6, 95.9, 121.5, 123.2, 124.1, 129.4, 130.5, 131.4, 134.1, 134.3, 146.9, 164.2, 191.1, 197.1; Anal. Calcd for $\text{C}_{21}\text{H}_{16}\text{BrNO}_4$: C 59.17, H 3.78, N 3.29%. Found: C 59.15, H 3.75, N 3.31%.

5-cyclohexyl-4b,9b-dihydroxy-4b,5,7,8-tetrahydroindeno[1,2-*b*]indole-9,10(6*H*,9*bH*)-dione (4q): Characteristic: Yellow crystalline solid; Mp: 210-212 $^{\circ}\text{C}$; IR (KBr): 1370, 1490, 1560, 1718, 2932 cm^{-1} ; ^1H NMR (300 MHz, CDCl_3): δ 1.04-2.58 (17H, m), 4.49 (1H, s), 5.21 (1H, s), 7.72-7.47 (1H, m), 7.61-7.79 (3H, m); ^{13}C NMR (75 MHz, CDCl_3 +DMSO- d_6): δ 21.9, 25.2, 26.3, 26.4, 32.7, 33.2, 36.4, 54.6, 82.6, 95.8, 105.5, 122.9, 123.6, 124.1, 130.0, 135.1, 135.4, 148.5, 165.1, 190.9, 197.6; Anal. Calcd for $\text{C}_{21}\text{H}_{23}\text{NO}_4$: C 71.37, H 6.56, N 3.96%. Found: C 71.35, H 6.59, N 3.94%.

4b,9b-dihydroxy-5-(thiophen-2-ylmethyl)-4b,5,7,8-tetrahydroindeno[1,2-*b*]indole-9,10(6*H*,9*bH*)-dione (4r): Characteristic: Yellow crystalline solid; Mp: 212-214 $^{\circ}\text{C}$; IR (KBr): 1490, 1542, 1718, 3276, 3748 cm^{-1} ; ^1H NMR (300 MHz, CDCl_3): δ 1.84-1.92 (2H, m), 2.19-2.35 (4H, m), 4.98-5.21 (3H, m), 6.78-6.87 (2H, m), 7.15 (2H, d, J = 4.8 Hz), 7.47 (1H, t, J = 6.9 Hz), 7.56-7.63 (2H, m), 7.81 (1H, d, 7.5 Hz); ^{13}C NMR (75 MHz, CDCl_3 +DMSO- d_6): δ 26.3, 28.1, 41.5, 88.2, 100.3, 111.1, 128.9, 129.2, 130.0, 130.5, 131.6, 135.0, 139.8, 140.2, 145.6, 153.2, 170.6, 196.0, 202.6; Anal. Calcd for $\text{C}_{20}\text{H}_{17}\text{NO}_4\text{S}$: C 65.38, H 4.66, N 3.81%. Found: C 65.41, H 4.64, N 3.83%.

6b,11b-dihydroxy-7-phenyl-8,9,10,11b-tetrahydro-6*bH*-acenaphtho[1,2-*b*]indol-11(7*H*)-one (6a):

Characteristic: White crystalline solid; Mp: 190 $^{\circ}\text{C}$; IR (KBr): 1108, 1461, 1492, 1552, 2929 cm^{-1} ; ^1H NMR (300 MHz, CDCl_3): δ 1.80-2.29 (6H, m), 6.54 (1H, t, J = 7.2 Hz), 7.11-7.35 (7H, m),

7.49-7.53 (1H, m), 7.60-7.65 (2H, m); ¹³C NMR (75 MHz, CDCl₃): δ 22.0, 30.5, 37.0, 86.4, 102.4, 112.0, 119.6, 121.0, 124.4, 125.3, 127.5, 128.2, 128.6, 129.2, 131.3, 136.3, 136.5, 139.4, 142.8, 166.2, 191.5; Anal.Calcd for C₂₄H₁₉NO₃: C 78.03, H 5.18, N 3.79%. Found: C 78.06, H 5.16, N 3.80%.

6b,11b-dihydroxy-9,9-dimethyl-7-(*p*-tolyl)-8,9,10,11b-tetrahydro-6b*H*-acenaphtho[1,2-*b*]indol-11(7*H*)-one (6b): Characteristic: White crystalline solid; Mp: 206 °C; IR (KBr): 781, 1451, 1511, 1554, 2346, 2378, 2957 cm⁻¹; ¹H NMR (300 MHz, CDCl₃): 0.94 (3H, s), 1.07 (3H, s), 1.95-2.23 (4H, m), 2.44 (3H, s), 4.53 (1H, s), 5.06 (1H, s), 6.67 (1H, d, J= 6.9 Hz), 7.10 (2H, d, J= 8.1 Hz), 7.24-7.34 (3H, m), 7.60 (1H, t, J= 7.5 Hz), 7.70-7.74 (2H, m), 8.01 (1H, d, J= 6.9 Hz); ¹³C NMR (75 MHz, CDCl₃): δ 20.9, 27.3, 29.0, 31.2, 37.1, 50.2, 86.4, 102.3, 110.1, 119.4, 120.6, 124.0, 124.9, 127.2, 128.5, 128.7, 129.6, 131.0, 133.4, 136.0, 137.9, 138.9, 142.5, 165.0, 191.7; Anal.Calcd for C₂₇H₂₅NO₃: C 78.81, H 6.12, N 3.40%. Found: C 78.83, H 6.10, N 3.43%.

7-(4-chlorophenyl)-6b,11b-dihydroxy-9,9-dimethyl-8,9,10,11b-tetrahydro-6b*H*-acenaphtho[1,2-*b*]indol-11(7*H*)-one (6c): Characteristic: White crystalline solid; Mp: 208 °C; IR (KBr): 1438, 1491, 1551, 1600, 2953 cm⁻¹; ¹H NMR (300 MHz, CDCl₃): δ 0.87 (3H, s), 1.00 (3H, s), 1.86-2.08 (2H, m), 2.14 (2H, s), 6.61 (1H, d, J= 7.2 Hz), 7.13 (2H, d, J= 8.4 Hz), 7.26 (1H, t, J= 7.5 Hz), 7.36 (2H, d, J= 8.4 Hz), 7.51 (1H, t, J= 7.5 Hz), 7.65 (2H, d, J= 8.1 Hz), 7.92 (1H, d, J= 6.9 Hz); ¹³C NMR (75 MHz, CDCl₃): δ 27.3, 29.1, 34.0, 37.1, 50.1, 86.4, 102.5, 110.8, 119.2, 120.8, 124.0, 125.1, 127.2, 128.7, 129.2, 129.9, 131.0, 133.7, 134.9, 135.9, 138.7, 142.3, 164.4, 192.0; Anal.Calcd for C₂₆H₂₂ClNO₃: C 72.30, H 5.13, N 3.24%. Found: C 72.32, H 5.11, N 3.27%.

7-(4-bromophenyl)-6b,11b-dihydroxy-9,9-dimethyl-8,9,10,11b-tetrahydro-6b*H*-acenaphtho[1,2-*b*]indol-11(7*H*)-one (6d): Characteristic: White crystalline solid; Mp: 216 °C; IR (KBr): 1113, 1438, 1515, 2341, 3308 cm⁻¹; ¹H NMR (300 MHz, CDCl₃): δ 0.94 (3H, s), 1.07 (3H, s), 1.94-2.21 (4H, m), 4.93 (1H, s), 5.44 (1H, s), 6.69 (1H, d, J= 6.9 Hz), 7.15 (2H, d, J= 8.4 Hz), 7.33 (1H, t, J= 7.5 Hz), 7.55-7.60 (3H, m), 7.72 (2H, d, J= 8.4 Hz), 7.99 (1H, d, J= 6.9 Hz); ¹³C NMR (75 MHz, CDCl₃): δ 27.5, 29.5, 34.5, 37.4, 50.5, 86.8, 102.7, 111.4, 119.4, 120.9, 122.1, 124.5, 125.5, 127.6, 129.0, 130.3, 131.3, 132.5, 135.7, 136.2, 138.9, 142.5, 164.4, 192.4; Anal.Calcd for C₂₆H₂₂BrNO₃: C 65.56, H 4.66, N 2.94%. Found: C 65.58, H 4.64, N 2.96%.

2-hydroxy-2-(5-oxo-2-(phenylamino)cyclopent-1-en-1-yl)-1H-indene-1,3(2H)-dione (8a):

Characteristic: Yellow crystalline solid; Mp: 194-196 °C; IR (KBr): 1575, 1598, 1706, 1748, 3511 cm⁻¹; ¹H NMR (300 MHz, CDCl₃): δ 2.01-2.04 (2H, m), 2.49-2.53 (2H, m), 3.45 (1H, s), 7.05-7.23 (5H, m), 7.62-7.65 (2H, m), 7.80-7.83 (2H, m), 8.82 (1H, s); ¹³C NMR (75 MHz, CDCl₃): δ 26.7, 32.5, 109.0, 123.7, 124.0, 126.3, 129.5, 136.0, 138.1, 140.6, 175.0, 197.1, 198.2; Anal. Calcd for C₂₀H₁₅NO₄: C 72.06, H 4.54, N 4.20%. Found: C 72.04, H 4.55, N 4.23%.

2-hydroxy-2-(2-((4-methoxyphenyl)amino)-5-oxocyclopent-1-en-1-yl)-1H-indene-1,3(2H)-dione (8b):

Characteristic: Yellow crystalline solid; Mp: 208-210 °C; IR (KBr): 1509, 1560, 1596, 1703, 3327, 3363 cm⁻¹; ¹H NMR (300 MHz, CDCl₃): δ 1.97-2.00 (2H, m), 2.35-2.38 (2H, m), 3.34 (1H, s), 3.62 (3H, s), 6.71 (2H, d, J = 8.7 Hz), 6.98 (2H, d, J = 8.7 Hz), 7.62-7.64 (2H, m), 7.80-7.83 (2H, m), 8.61 (1H, s); ¹³C NMR (75 MHz, DMSO-d₆): δ 26.0, 32.0, 55.4, 76.9, 108.0, 114.6, 123.2, 125.2, 131.2, 136.1, 140.2, 157.2, 174.7, 197.7, 198.6; Anal. Calcd for C₂₁H₁₇NO₅: C 69.41, H 4.72, N 3.85%. Found: C 69.38, H 4.75, N 3.81%.

2-(2-((4-chlorophenyl)amino)-5-oxocyclopent-1-en-1-yl)-2-hydroxy-1H-indene-1,3(2H)-dione (8c):

Characteristic: Yellow crystalline solid; Mp: 216-218 °C; IR (KBr): 1440, 1567, 1603, 1708, 3325, 3388 cm⁻¹; ¹H NMR (300 MHz, CDCl₃): δ 2.01-2.05 (2H, m), 2.46-2.50 (2H, m), 3.34 (1H, s), 7.00 (2H, d, J = 8.7 Hz), 7.17 (2H, d, J = 8.7 Hz), 7.63-7.66 (2H, m), 7.80-7.83 (2H, m), 8.76 (1H, s); ¹³C NMR (75 MHz, CDCl₃): δ 26.6, 32.5, 109.7, 124.0, 125.0, 129.7, 131.8, 136.1, 136.6, 140.6, 174.6, 197.0, 198.2; Anal. Calcd for C₂₀H₁₄ClNO₄: C 65.32, H 3.84, N 3.81%. Found: C 65.34, H 3.81, N 3.83%.

2-(2-(cyclohexylamino)-5-oxocyclopent-1-en-1-yl)-2-hydroxy-1H-indene-1,3(2H)-dione (8d):

Characteristic: Yellow crystalline solid; Mp: 198-200 °C; IR (KBr): 1560, 1706, 1747, 2920, 3568 cm⁻¹; ¹H NMR (300 MHz, CDCl₃): δ 1.27-2.54 (15H, m), 7.15-7.19 (2H, m), 7.72-7.74 (2H, m), 7.90-7.92 (2H, m); ¹³C NMR (75 MHz, DMSO-d₆): δ 23.8, 24.3, 24.9, 31.9, 33.2, 51.6, 77.1, 104.8, 123.2, 135.9, 140.1, 175.3, 196.2, 198.1; Anal. Calcd for C₂₀H₂₁NO₄: C 70.78, H 6.24, N 4.13%. Found: C 70.75, H 6.22, N 4.16%.

2-hydroxy-2-(5-oxo-2-((thiophen-2-ylmethyl)amino)cyclopent-1-en-1-yl)-1H-indene-

1,3(2H)-dione (8e): Characteristic: Yellow crystalline solid; Mp: 212-214 °C; IR (KBr): 1559, 1578, 1709, 3098, 3362 cm⁻¹; ¹H NMR (300 MHz, CDCl₃): δ 1.99-2.03 (2H, m), 2.43-2.46 (2H,

m), 3.02 (1H, s), 4.51 (2H, d, J= 6.0 Hz), 6.80-6.87 (2H, m), 7.08-7.10 (1H, m), 7.39 (1H, s), 7.60-7.64 (2H, m), 7.78-7.81 (2H, m); ¹³C NMR (75 MHz, CDCl₃ + DMSO-d₆): δ 29.5, 36.6, 47.2, 111.6, 127.7, 129.7, 130.1, 131.5, 139.9, 144.7, 144.9, 180.7, 201.9, 202.9; Anal. Calcd for C₁₉H₁₅NO₄S : C 64.58, H 4.28, N 3.96%. Found: C 64.61, H 4.30, N 3.94%.

4b,9b-dihydroxy-9b,10-dihydroindeno[2',1':4,5]pyrrolo[2,3-d]pyrimidine-

2,4,5(1H,3H,4bH)-trione (11a): Characteristic: White crystalline solid; Mp:>250 °C; IR (KBr): 1607, 1647, 1717, 3067 cm⁻¹; ¹H NMR (300 MHz, CDCl₃+DMSO-d₆): δ 5.78 (1H, s), 6.49 (1H, s), 7.50 (1H, t, J= 7.5 Hz), 7.62 (1H, d, J= 7.5 Hz), 7.72 (1H, t, J= 7.2 Hz), 7.92 (1H, d, J= 7.8 Hz), 8.65 (1H, s), 10.00 (1H, s), 11.07 (1H, s); ¹³C NMR (75 MHz, CDCl₃+DMSO-d₆): δ 82.8, 83.6, 93.0, 123.1, 125.7, 130.3, 134.6, 135.7, 149.9, 151.7, 154.5, 159.7, 197.8; Anal. Calcd for C₁₃H₉N₃O₅: C 54.36, H 3.16, N 14.63%. Found: C 54.39, H 3.18, N 14.60%.

4b,9b-dihydroxy-1,3-dimethyl-9b,10-dihydroindeno[2',1':4,5]pyrrolo[2,3-d]pyrimidine-

2,4,5(1H,3H,4bH)-trione (11b): Characteristic: Yellow crystalline solid; Mp:>250 °C; IR (KBr): 1560, 1637, 1724, 3221 cm⁻¹; ¹H NMR (300 MHz, DMSO-d₆): δ 2.96 (3H, s), 3.12 (3H, s), 5.85 (1H, s), 6.70 (1H, s), 7.49 (1H, t, J= 7.2 Hz), 7.61 (1H, d, J= 7.5 Hz), 7.75 (1H, t, J= 7.2 Hz), 7.84 (1H, d, J= 7.8 Hz), 9.20 (1H, s); ¹³C NMR (75 MHz, DMSO-d₆): δ 27.4, 30.8, 83.6, 83.9, 92.9, 123.1, 125.5, 130.5, 134.7, 136.0, 149.9, 151.7, 153.8, 157.8, 197.6; Anal. Calcd for C₁₅H₁₃N₃O₅: C 57.14, H 4.16, N 13.33%. Found: C 57.17, H 4.15, N 13.30%.

6b,11b-dihydroxy-11b,12-dihydro-6H-chromeno[4,3-b]indeno[2,1-d]pyrrole-6,7(6bH)-dione

(11c): Characteristic: White crystalline solid; Mp:>250 °C; IR (KBr): 753, 1529, 1619, 1663, 1723, 3102 cm⁻¹; ¹H NMR (300 MHz, DMSO-d₆): δ 6.18 (1H, s), 6.98 (1H, s), 7.29 (2H, t, J= 7.8 Hz), 7.54-7.62 (2H, m), 7.61 (1H, d, J= 7.8 Hz), 7.82-7.93 (3H, m), 9.90 (1H, s); ¹³C NMR (75 MHz, DMSO-d₆): δ 84.1, 93.7, 94.0, 111.6, 117.1, 123.3, 123.9, 124.5, 125.5, 130.6, 133.6, 134.9, 136.4, 150.1, 154.4, 155.4, 157.2, 197.7; Anal. Calcd for C₁₈H₁₁NO₅: C 67.29, H 3.45, N 4.36%. Found: C 67.26, H 3.47, N 4.35%.

6b,11b-dihydroxy-10,11b-dihydro-6bH-acenaphtho[1',2':4,5]pyrrolo[2,3-d]pyrimidine-

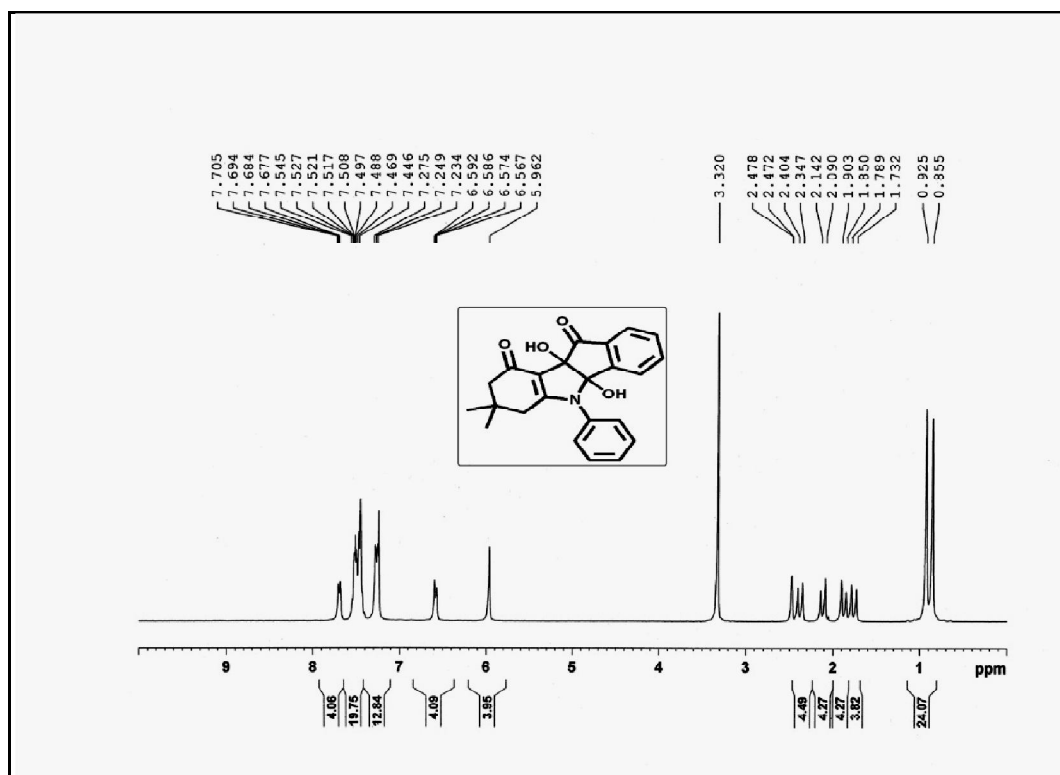
9,11(7H,8H)-dione (11d): Characteristic: Pale brown crystalline solid; Mp:>250 °C; IR (KBr): 1591, 1707, 3167, 3371 cm⁻¹; ¹H NMR (300 MHz, DMSO-d₆): δ 6.18 (1H, s), 7.29-8.07 (5H, m), 8.35 (1H, d, J= 8.1 Hz), 9.75 (1H, s), 9.78 (2H, s), 10.65 (1H, s); ¹³C NMR (75 MHz, DMSO-

d₆): δ 62.5, 101.9, 121.7, 124.7, 128.5, 128.9, 129.3, 132.8, 150.4, 151.8, 153.2, 159.8, 164.0; Anal.Calcd for C₁₆H₁₁N₃O₄: C 62.14, H 3.59, N 13.59%. Found: C 62.11, H 3.61, N 13.57%.

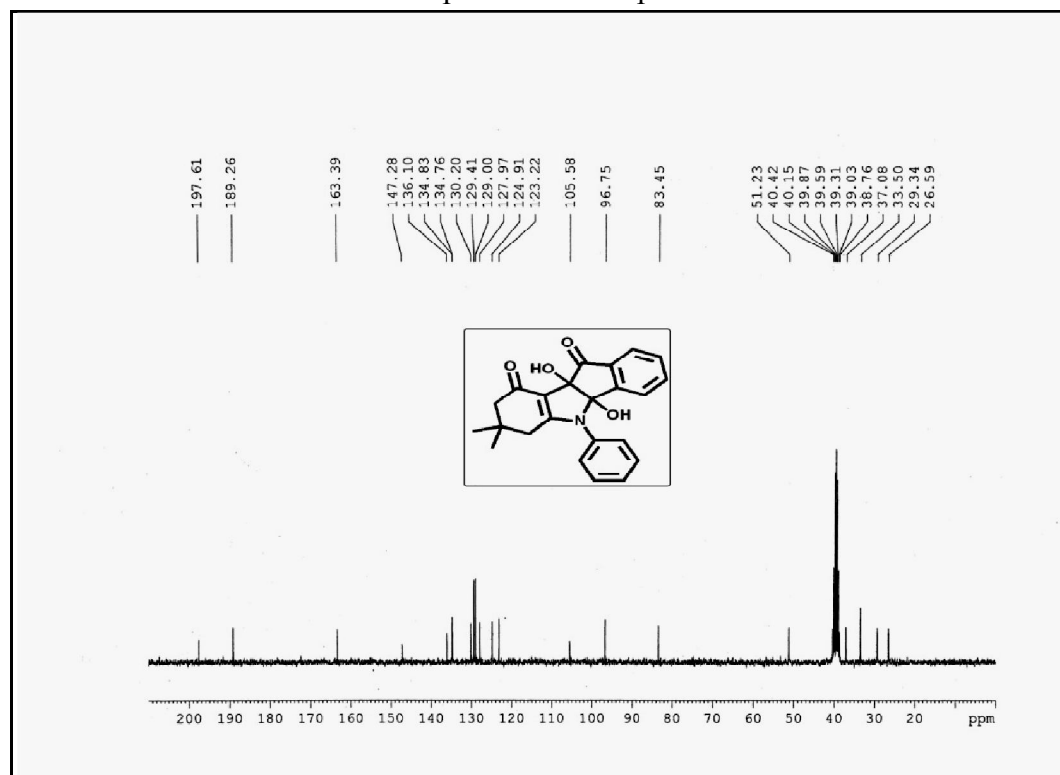
6b,11b-dihydroxy-8,10-dimethyl-10,11b-dihydro-6bH-acenaphtho[1',2':4,5]pyrrolo[2,3-d]pyrimidine-9,11(7H,8H)-dione (11e): Characteristic: White crystalline solid; Mp:178-180 °C; IR (KBr): 1560, 1637, 2342, 2365, 3650, 3748, 3851 cm⁻¹; ¹H NMR (300 MHz, DMSO-d₆): δ 2.99 (3H, s), 3.10 (3H, s), 5.68 (1H, s), 6.50 (1H, s), 7.48-7.79 (6H, m), 8.88 (1H, s); ¹³C NMR (75 MHz, DMSO-d₆): δ 27.3, 30.6, 86.8, 88.2, 98.4, 119.8, 121.2, 123.8, 125.1, 128.4, 128.8, 131.0, 135.8, 143.2, 144.7, 151.8, 154.5, 158.2; Anal.Calcd for C₁₈H₁₅N₃O₄: C 64.09, H 4.48, N 12.46%. Found: C 64.12, H 4.46, N 12.48%.

6b,12b-dihydroxy-12b,13-dihydroacenaphtho[1,2-b]chromeno[3,4-d]pyrrol-6(6bH)-one (11f): Characteristic: White crystalline solid; Mp:200-202 °C; IR (KBr): 1527, 1685, 3650, 3736, 3854 cm⁻¹; ¹H NMR (300 MHz, DMSO-d₆): δ 6.04 (1H, s), 6.80 (1H, s), 7.28 (2H, d, J= 8.4 Hz), 7.56-7.63 (4H, m), 7.73-7.88 (4H, m), 9.55 (1H, s); ¹³C NMR (75 MHz, DMSO-d₆): δ 87.2, 98.6, 99.5, 112.0, 117.0, 119.7, 121.1, 123.7, 124.0, 124.3, 125.0, 128.5, 128.8, 131.0, 133.0, 136.0, 143.2, 144.2, 154.9, 155.1, 158.1; Anal.Calcd for C₂₁H₁₃NO₄: C 73.46, H 3.82, N 4.08%. Found: C 73.43, H 3.80, N 4.11%.

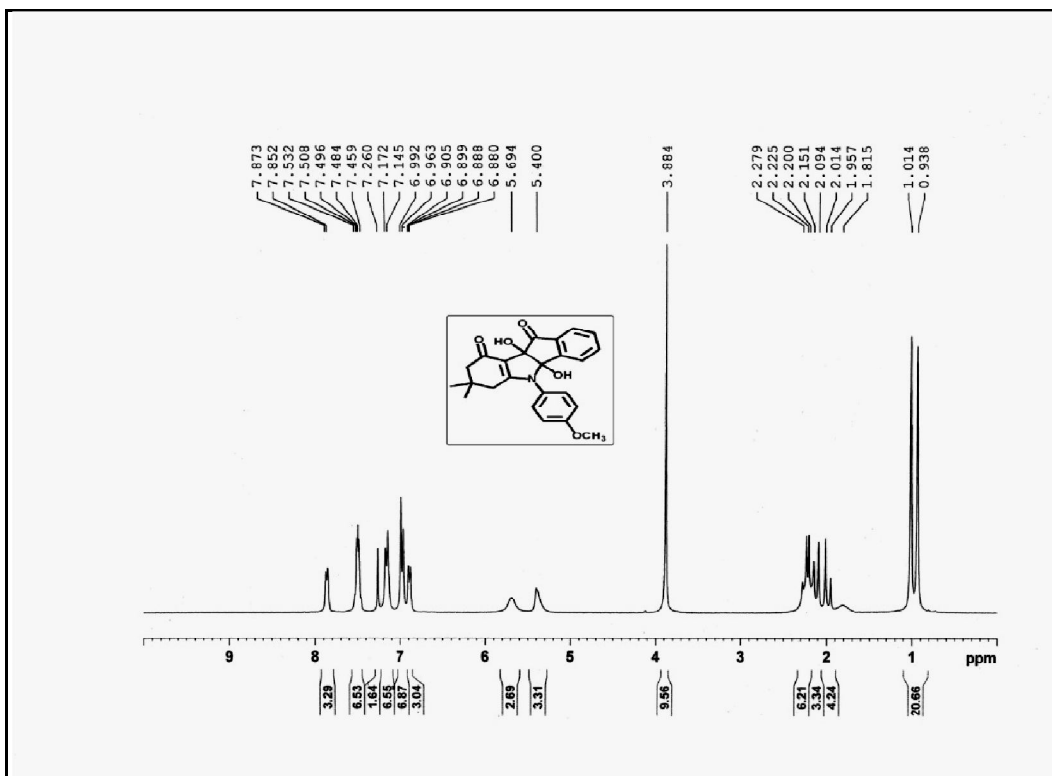
Spectral data of the synthesized compounds:



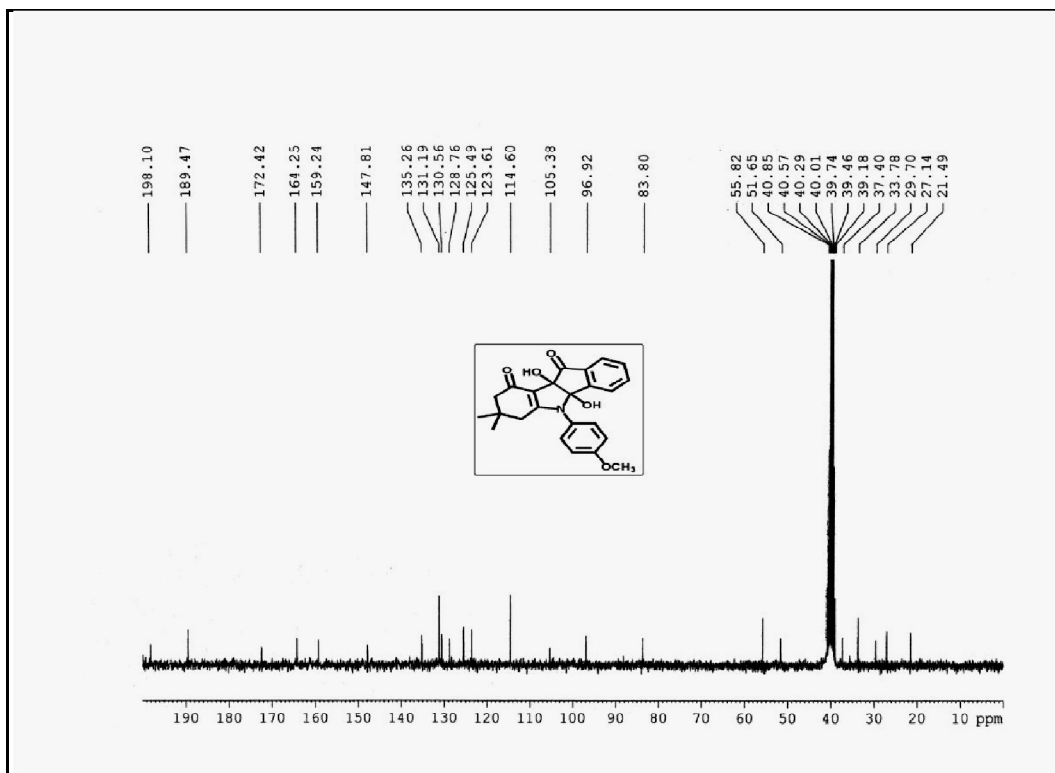
¹H NMR spectrum of the product 4a



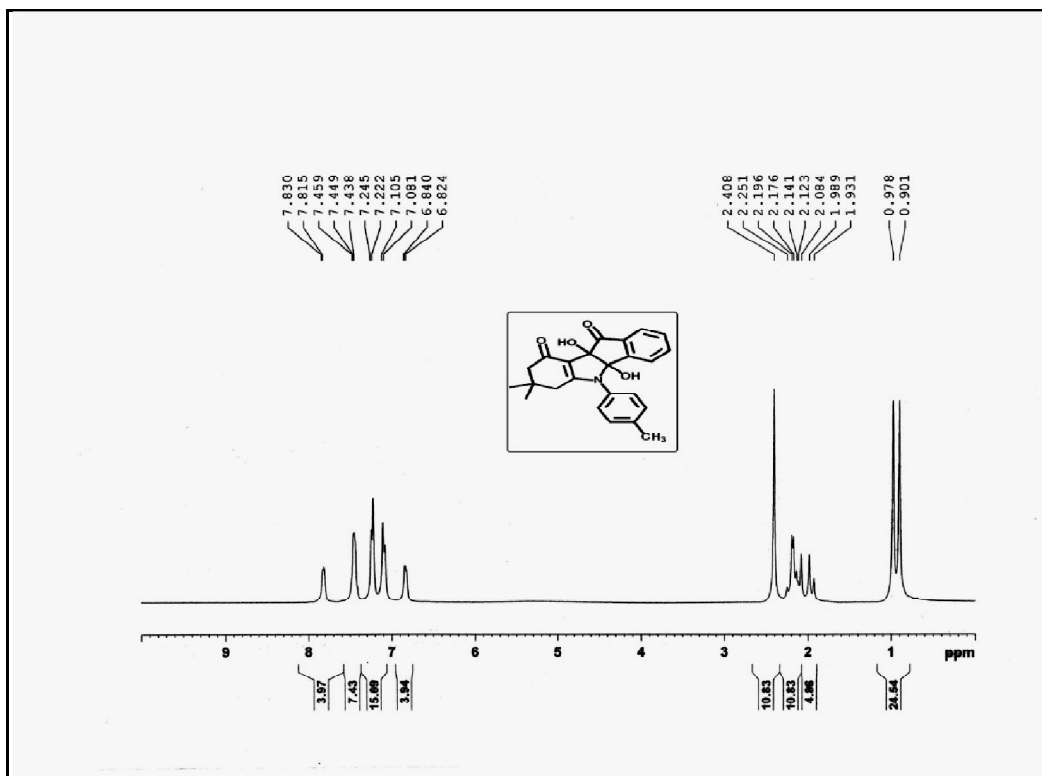
¹³C NMR spectrum of the product 4a



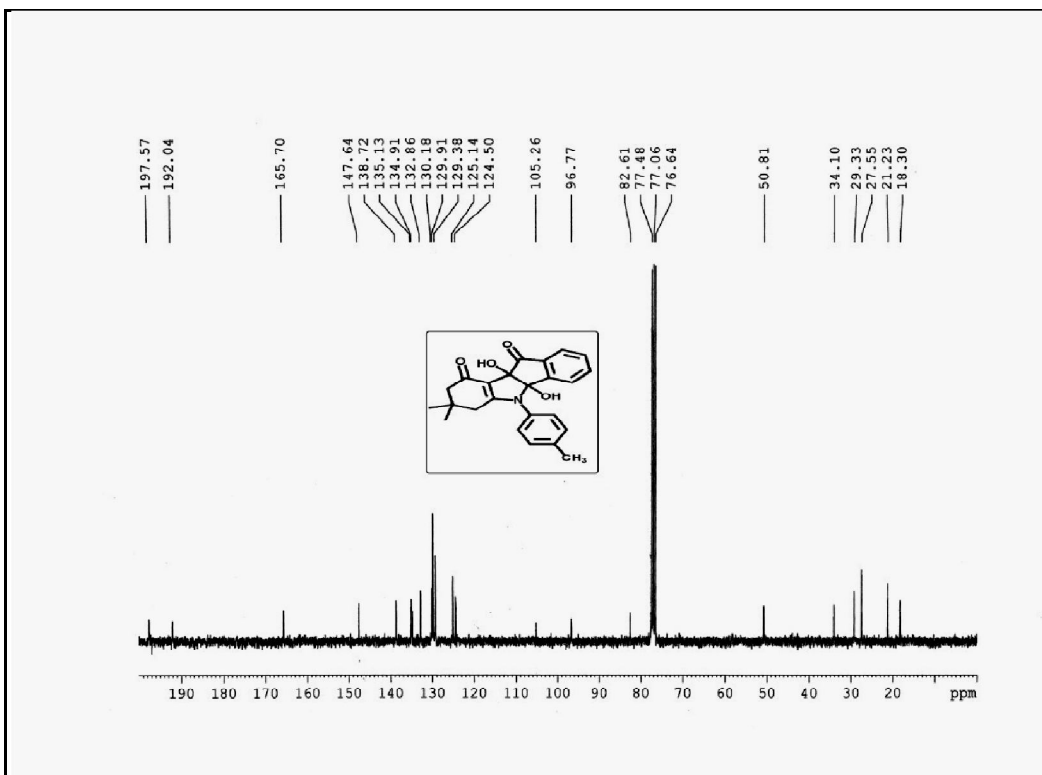
¹H NMR spectrum of the product 4b



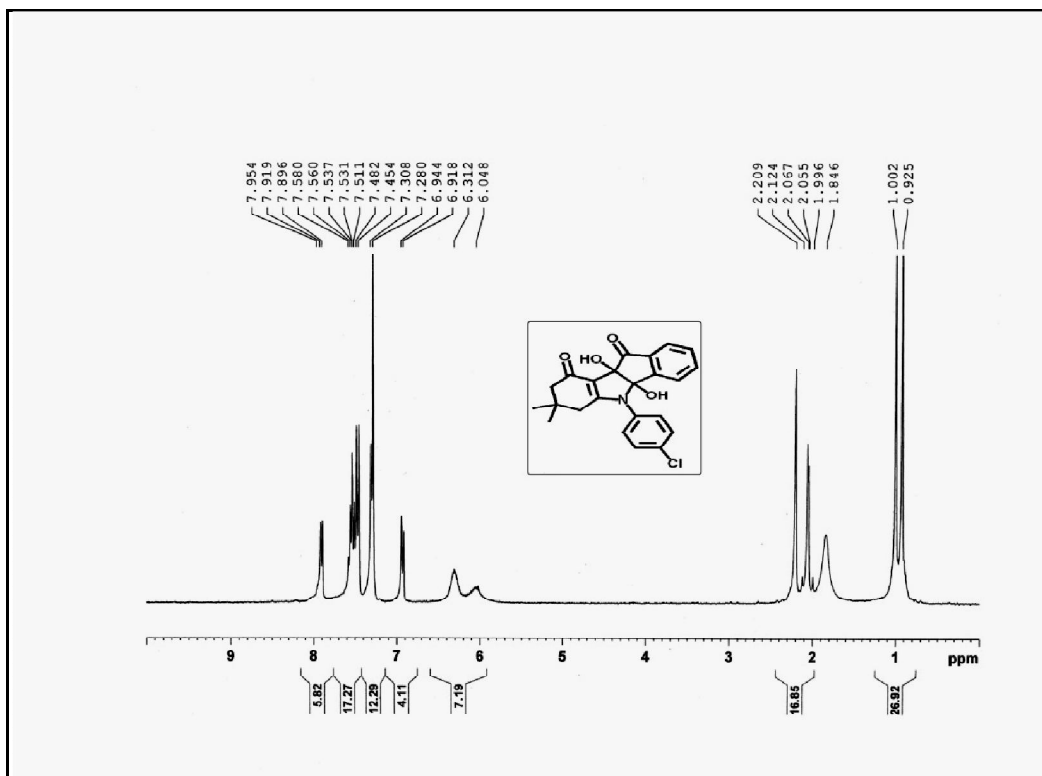
¹³C NMR spectrum of the product 4b



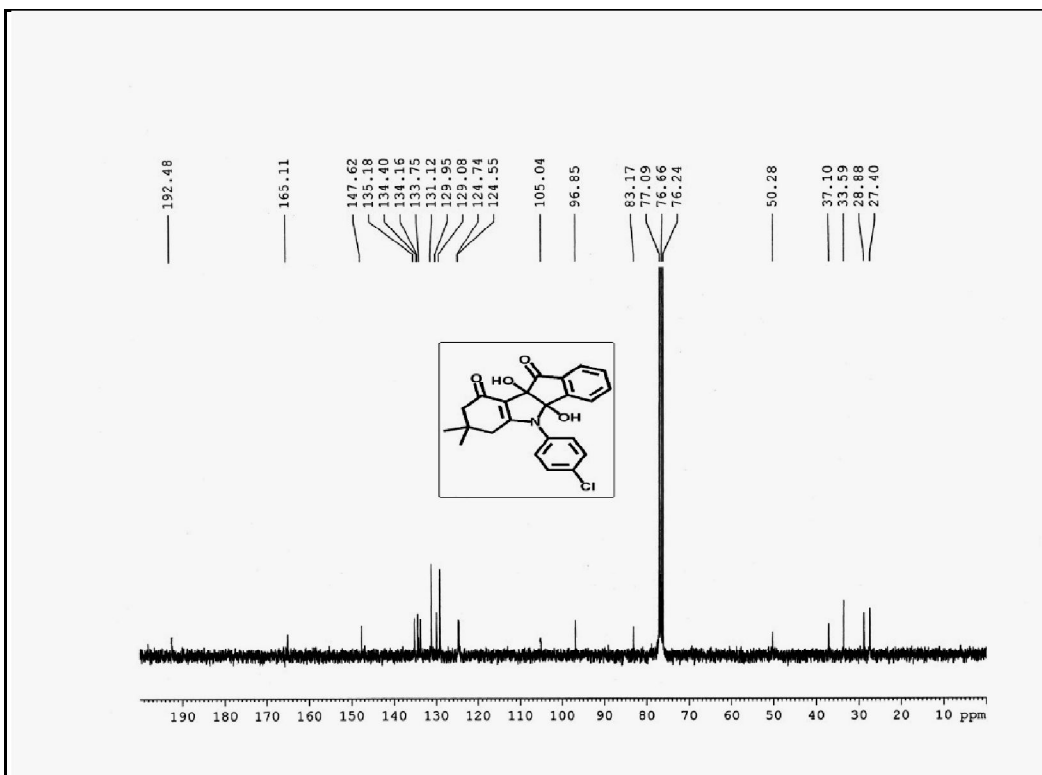
¹H NMR spectrum of the product 4d



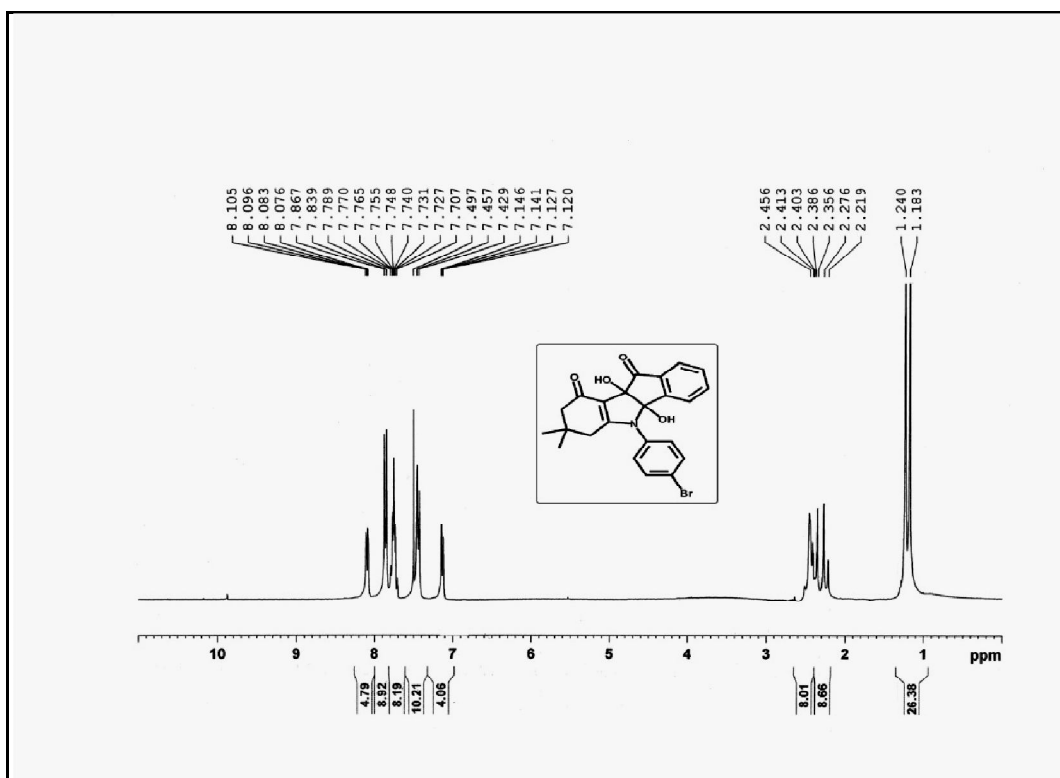
¹³C NMR spectrum of the product 4d



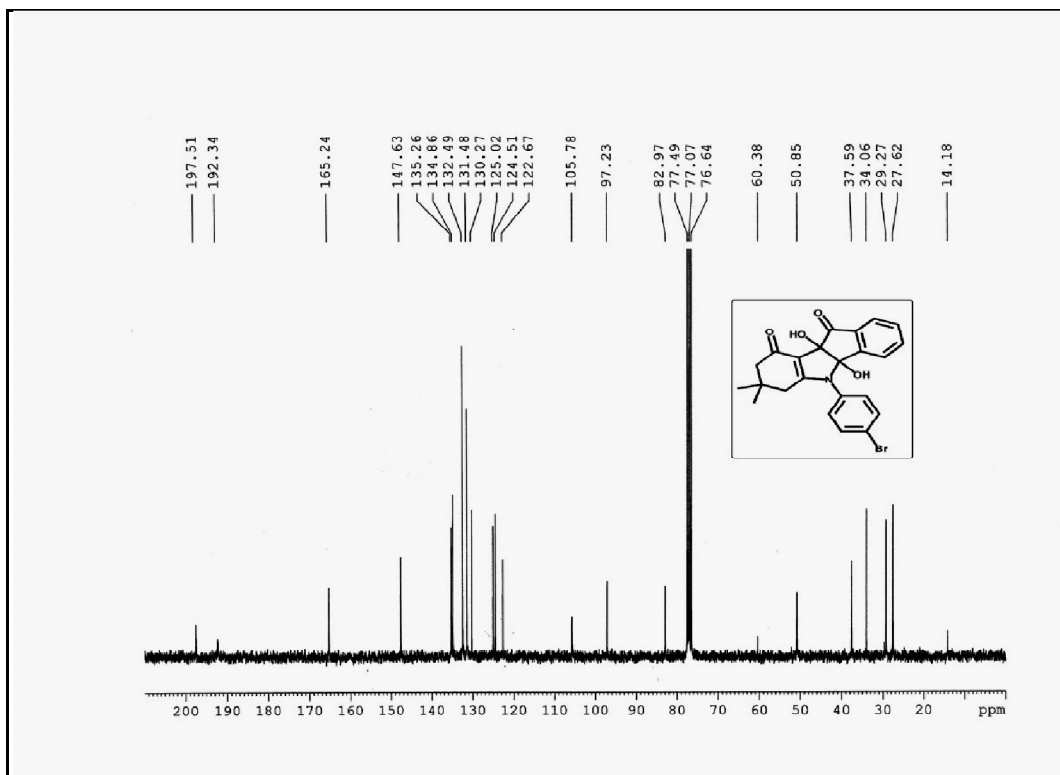
¹H NMR spectrum of the product 4e



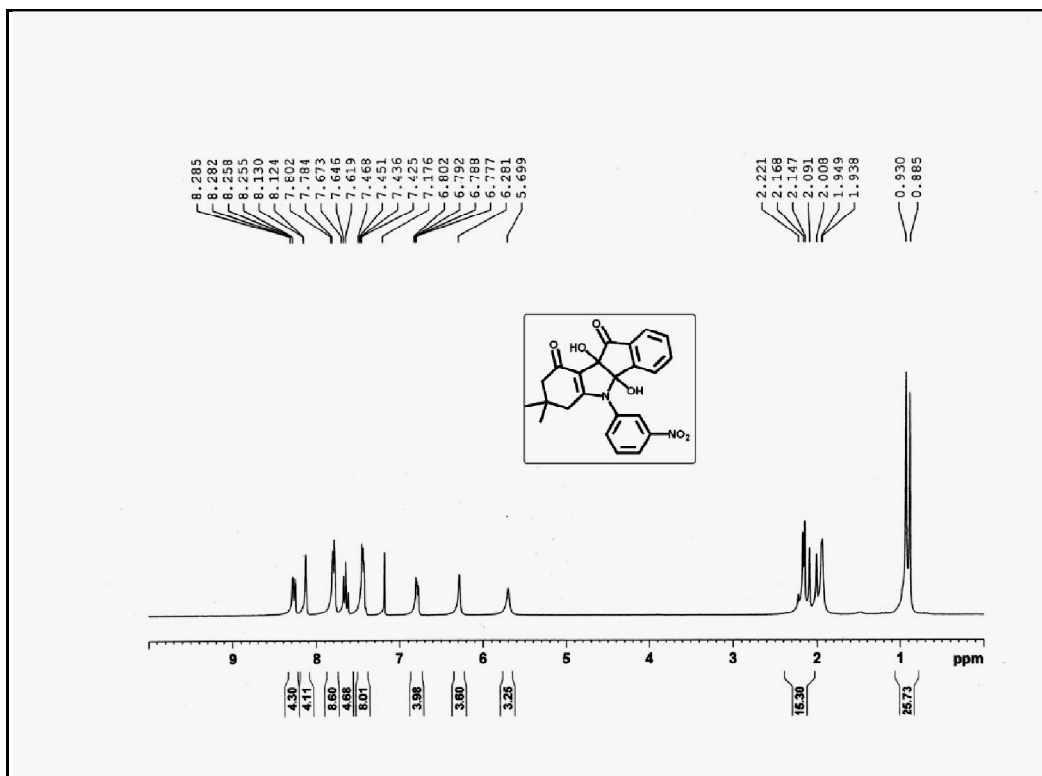
¹³C NMR spectrum of the product 4e



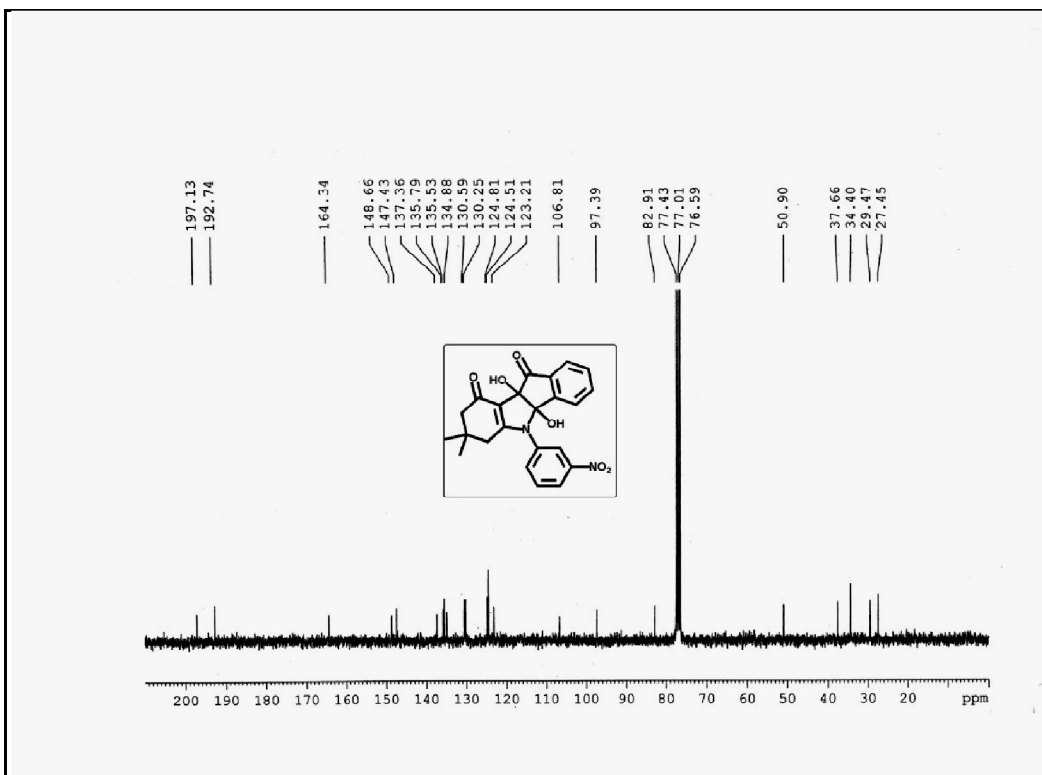
¹H NMR spectrum of the product 4f



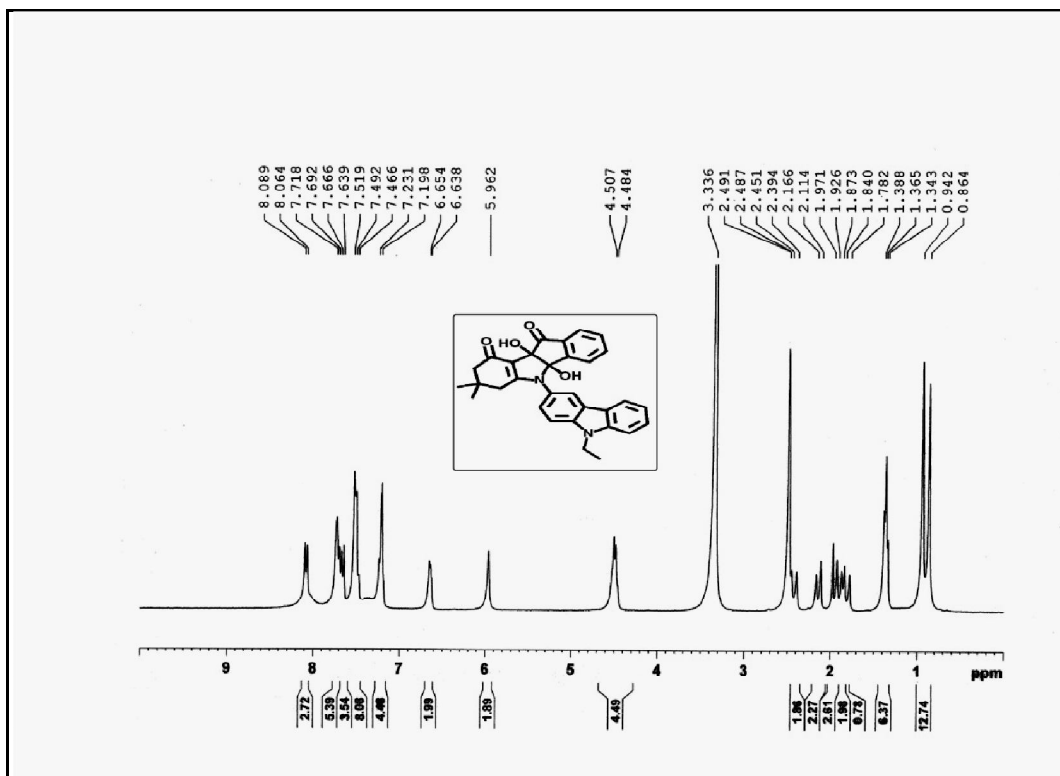
¹³C NMR spectrum of the product 4f



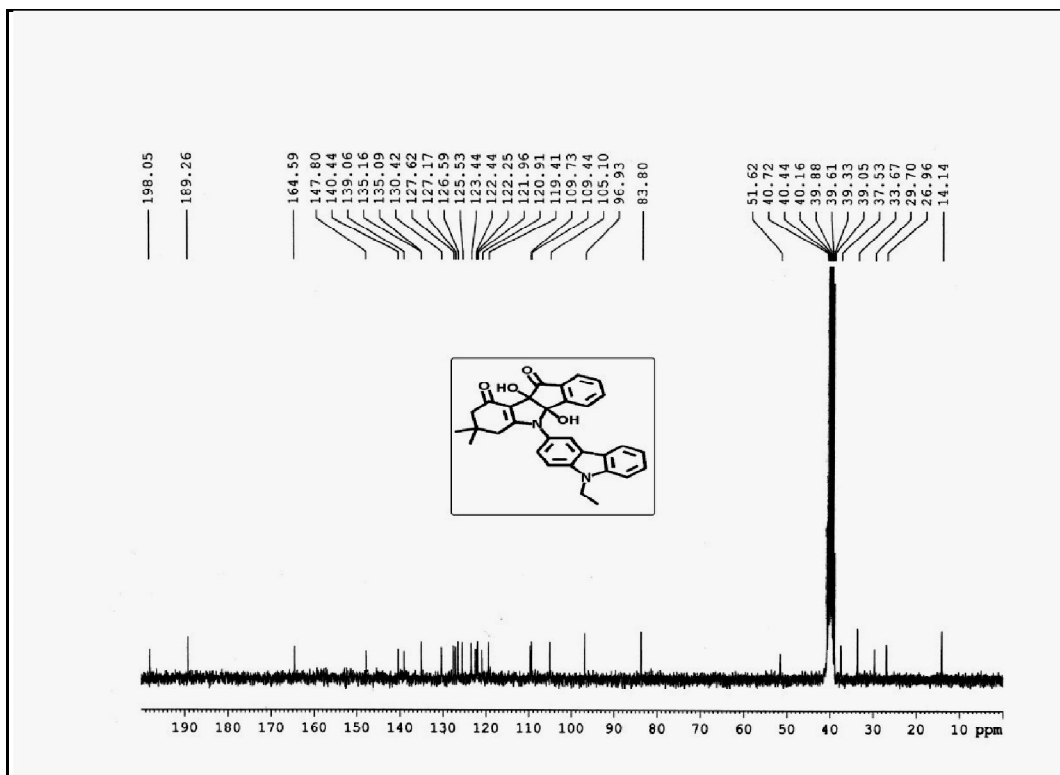
¹H NMR spectrum of the product 4g



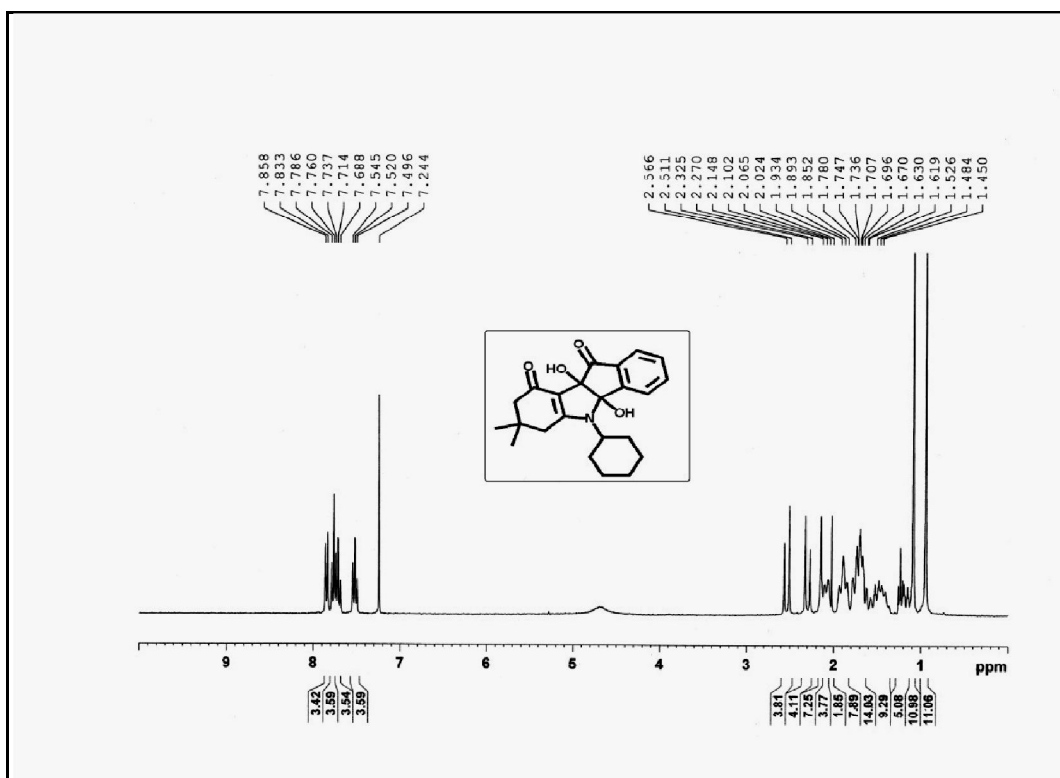
¹³C NMR spectrum of the product 4g



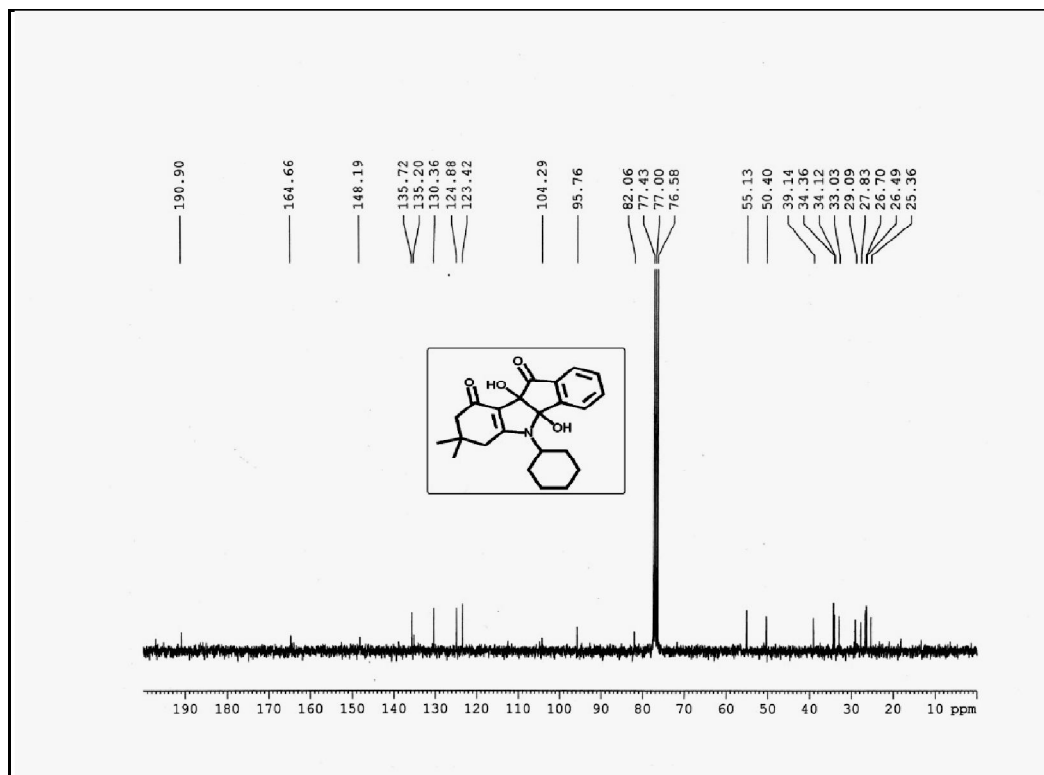
¹H NMR spectrum of the product 4h



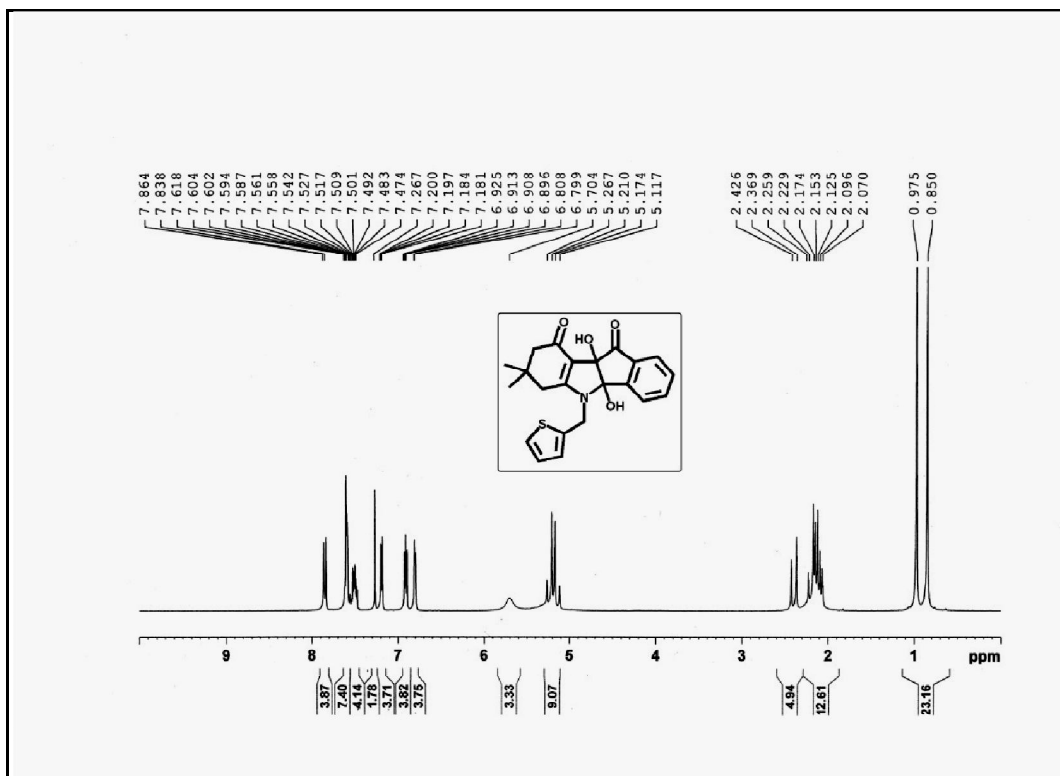
¹³C NMR spectrum of the product 4h



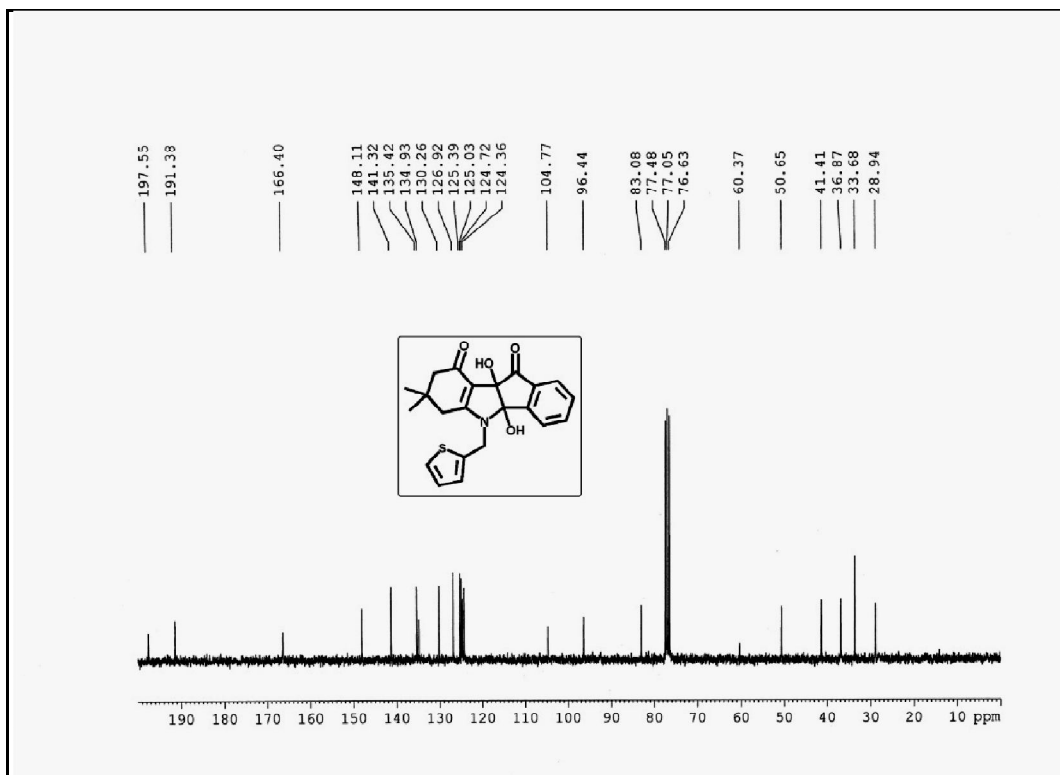
¹H NMR spectrum of the product 4i



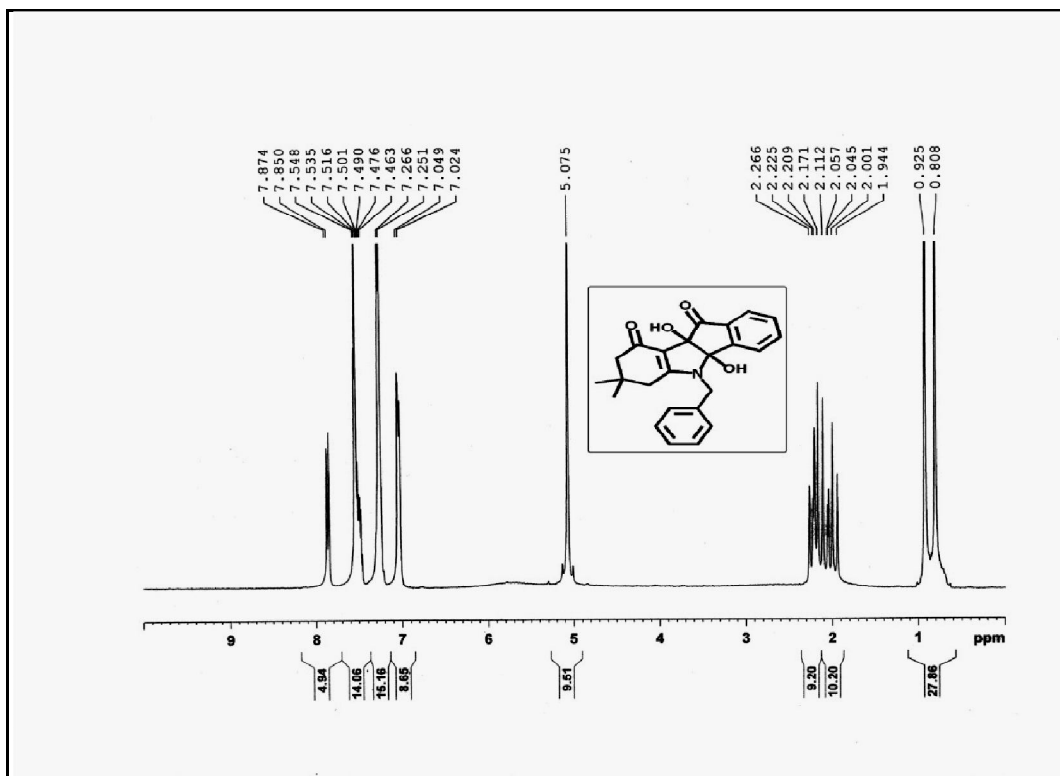
¹³C NMR spectrum of the product 4i



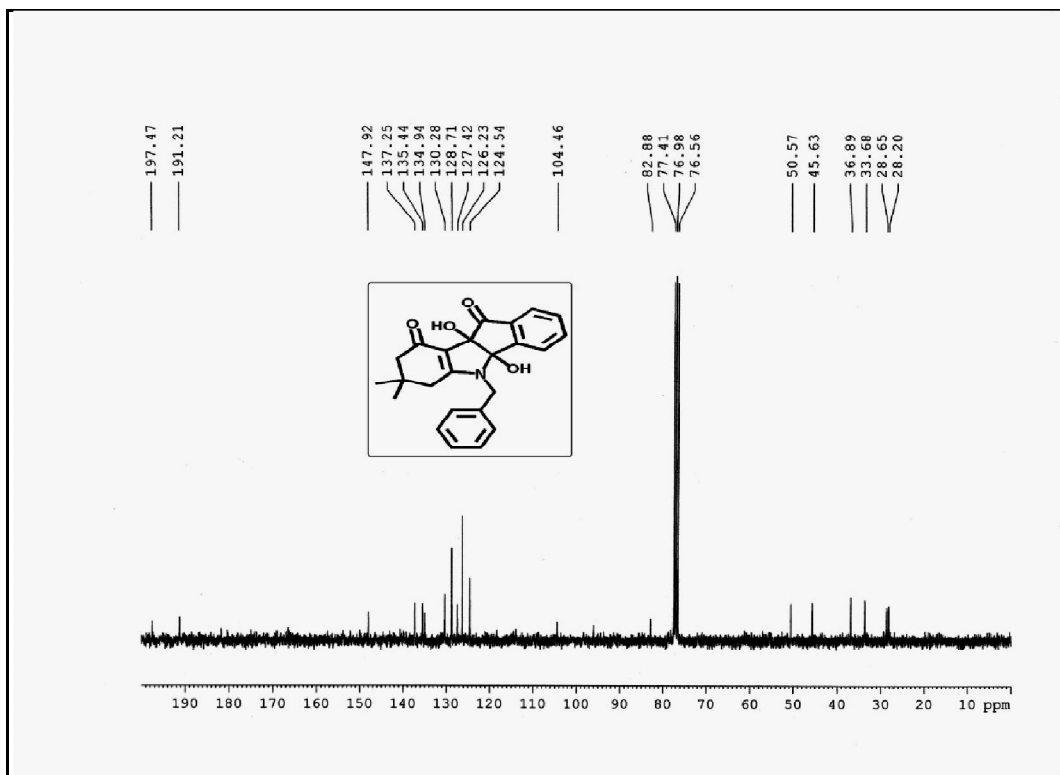
¹H NMR spectrum of the product 4j



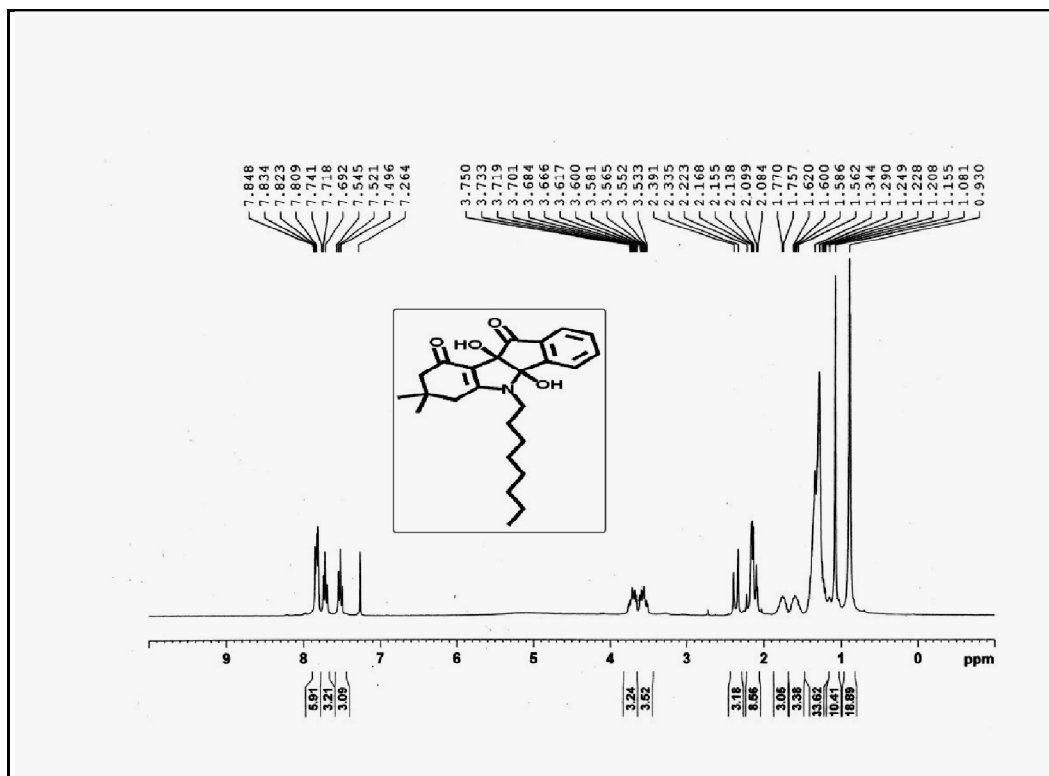
¹³C NMR spectrum of the product 4j



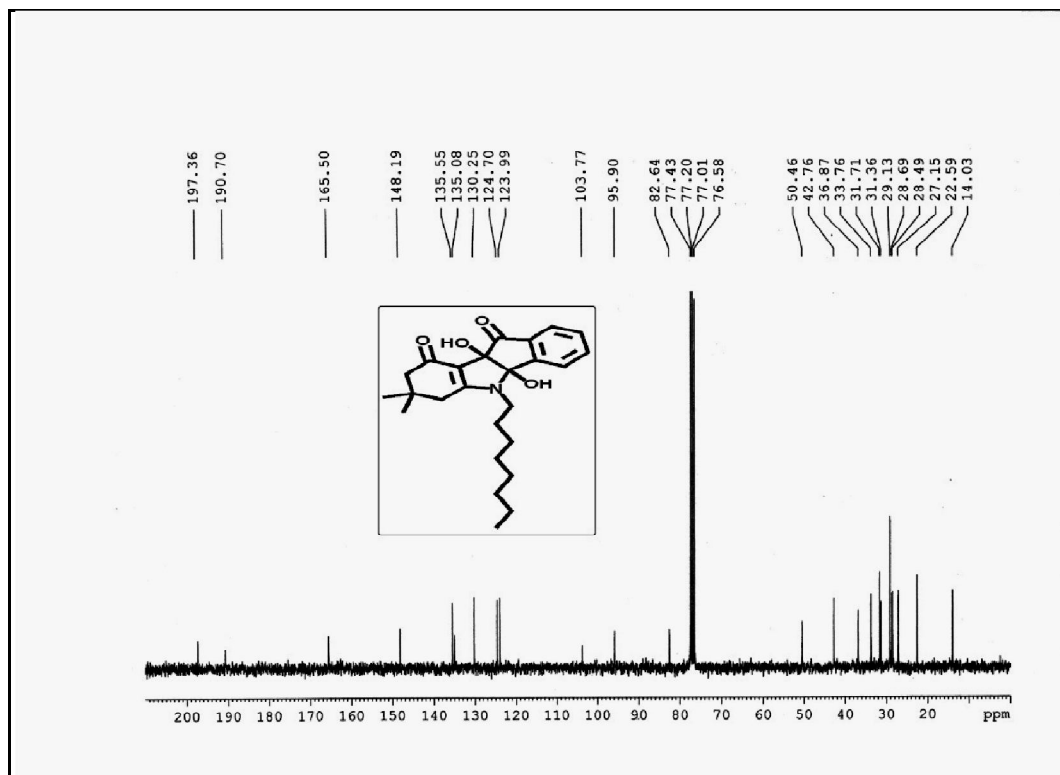
¹H NMR spectrum of the product 4k



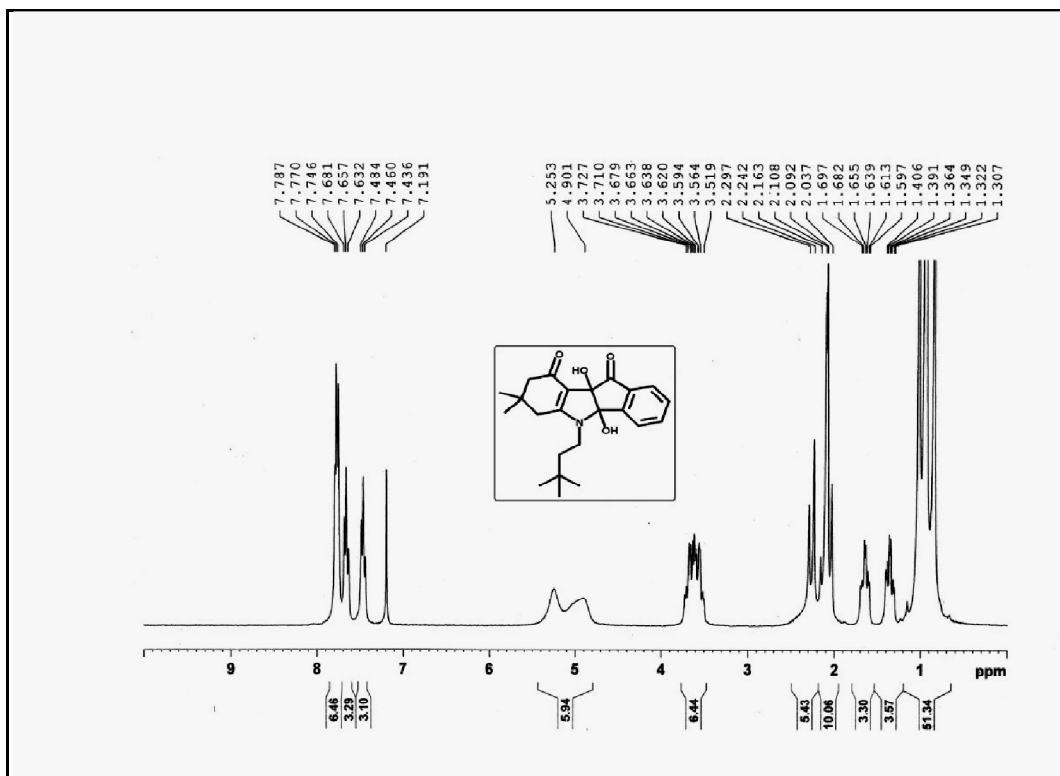
¹³C NMR spectrum of the product 4k



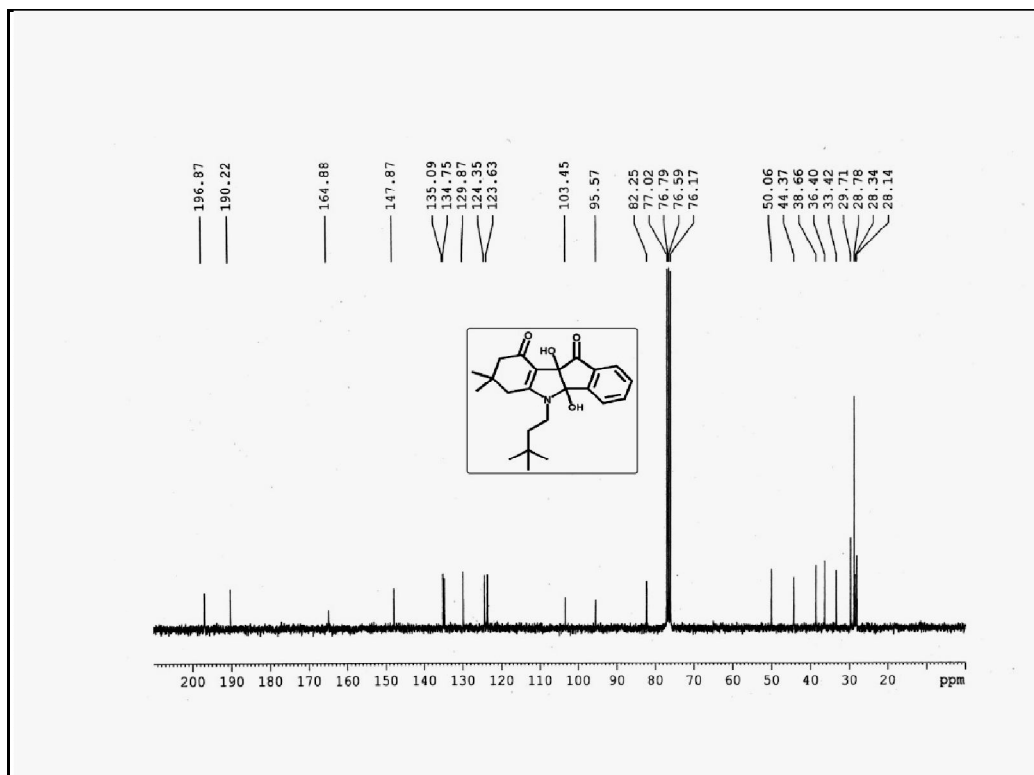
¹H NMR spectrum of the product 41



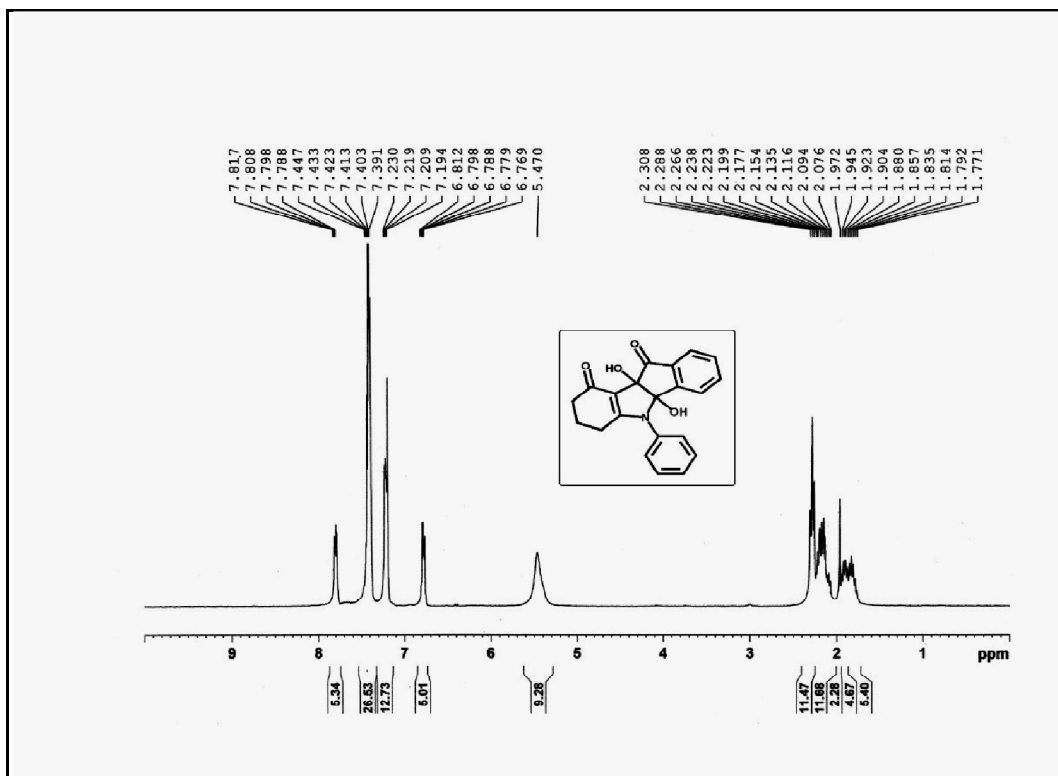
¹³C NMR spectrum of the product 41



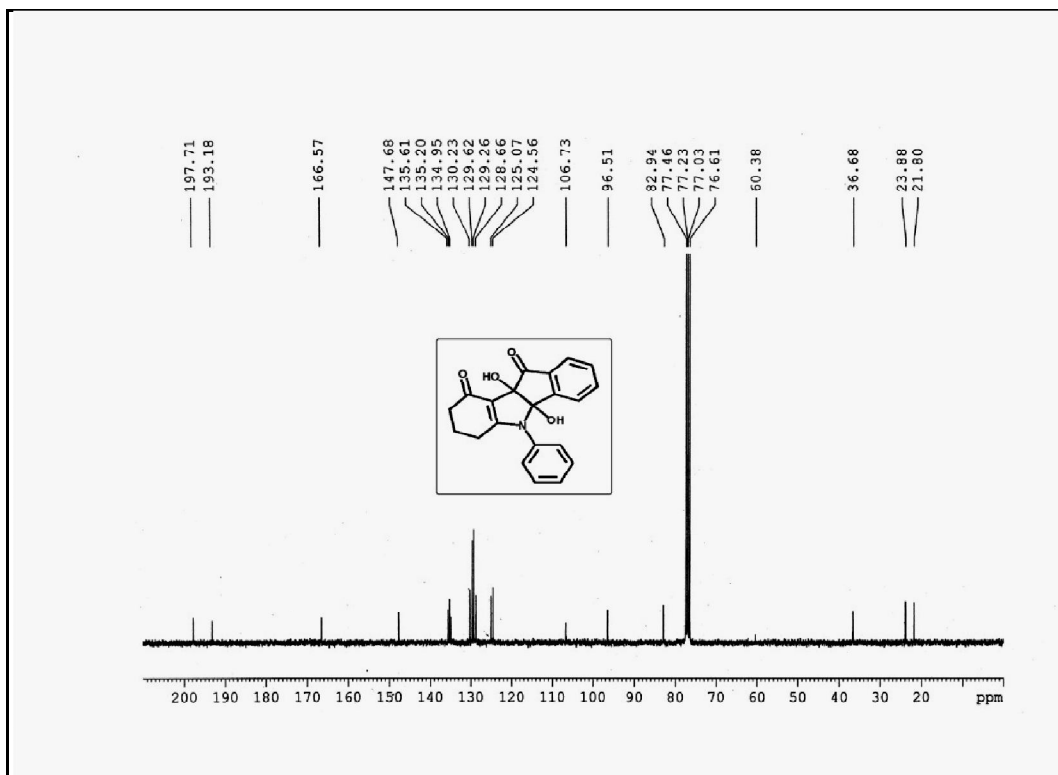
¹H NMR spectrum of the product 4m



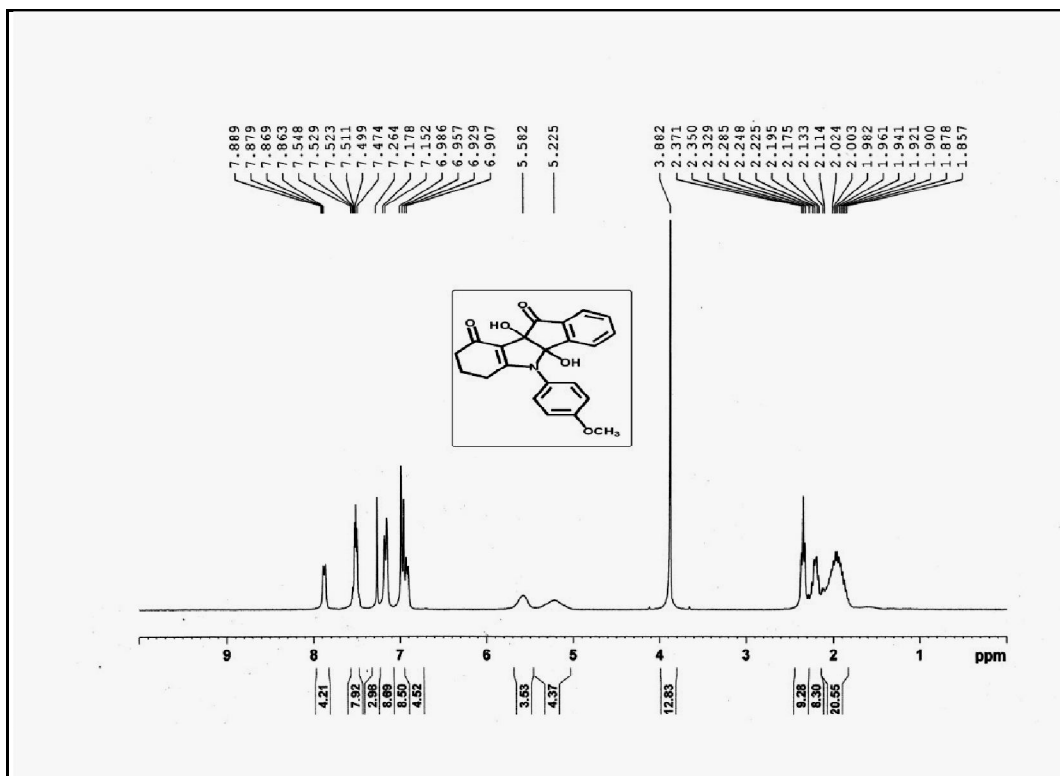
¹³C NMR spectrum of the product 4m



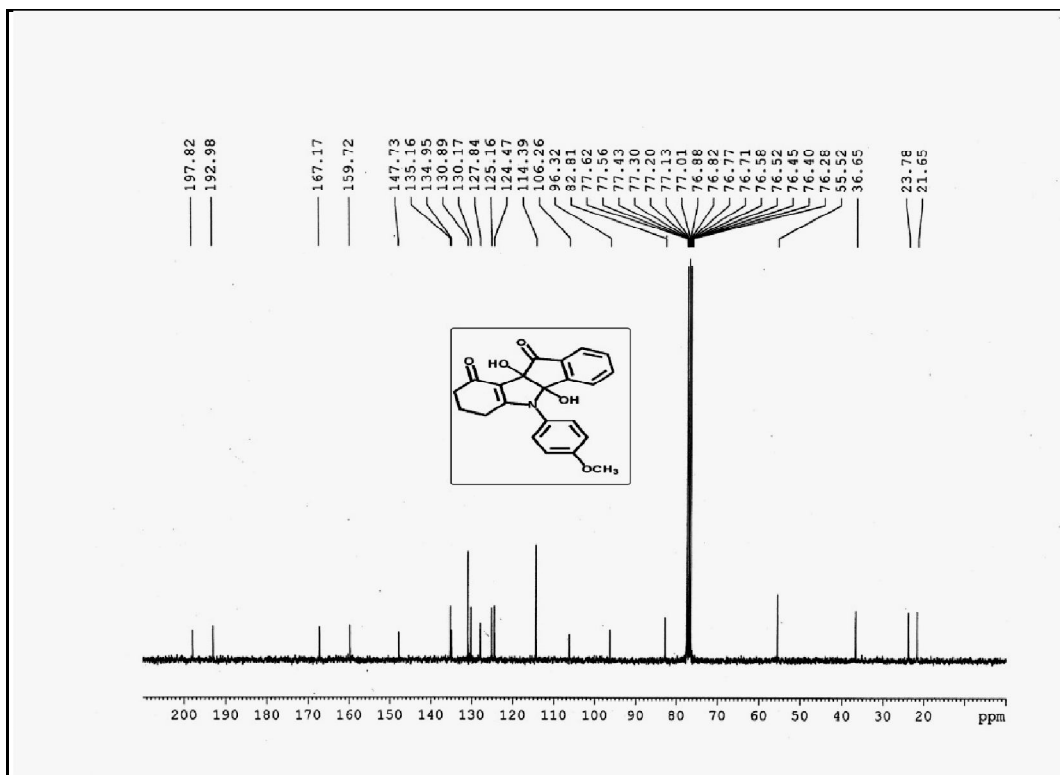
¹H NMR spectrum of the product 4n



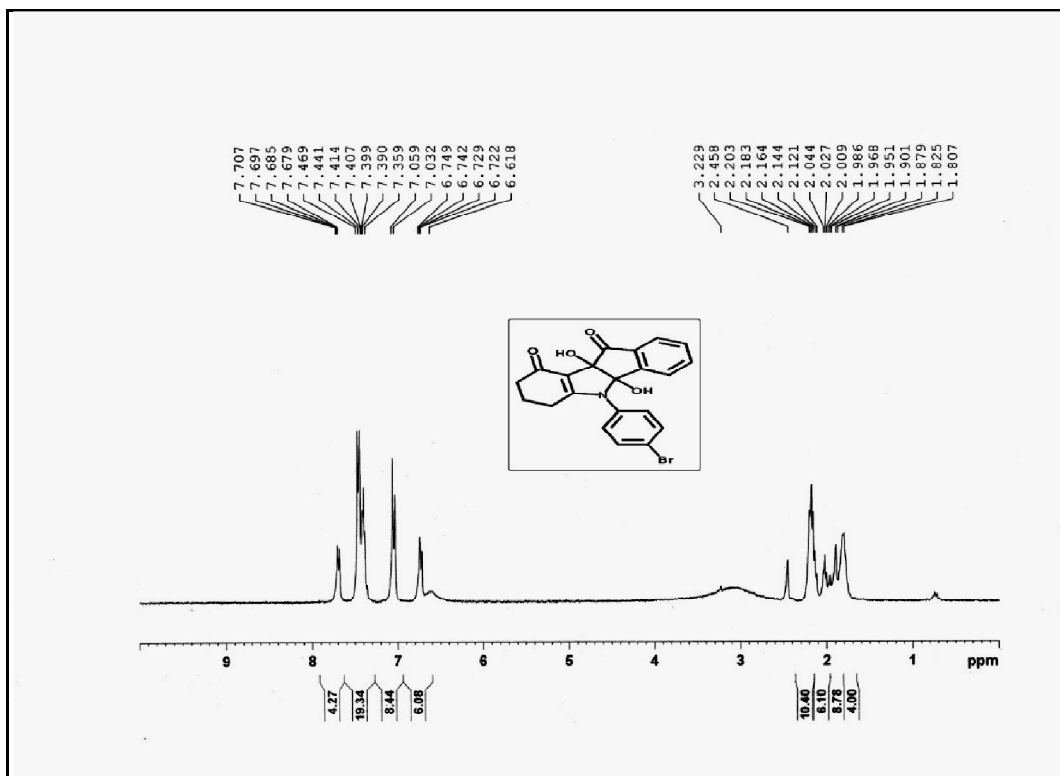
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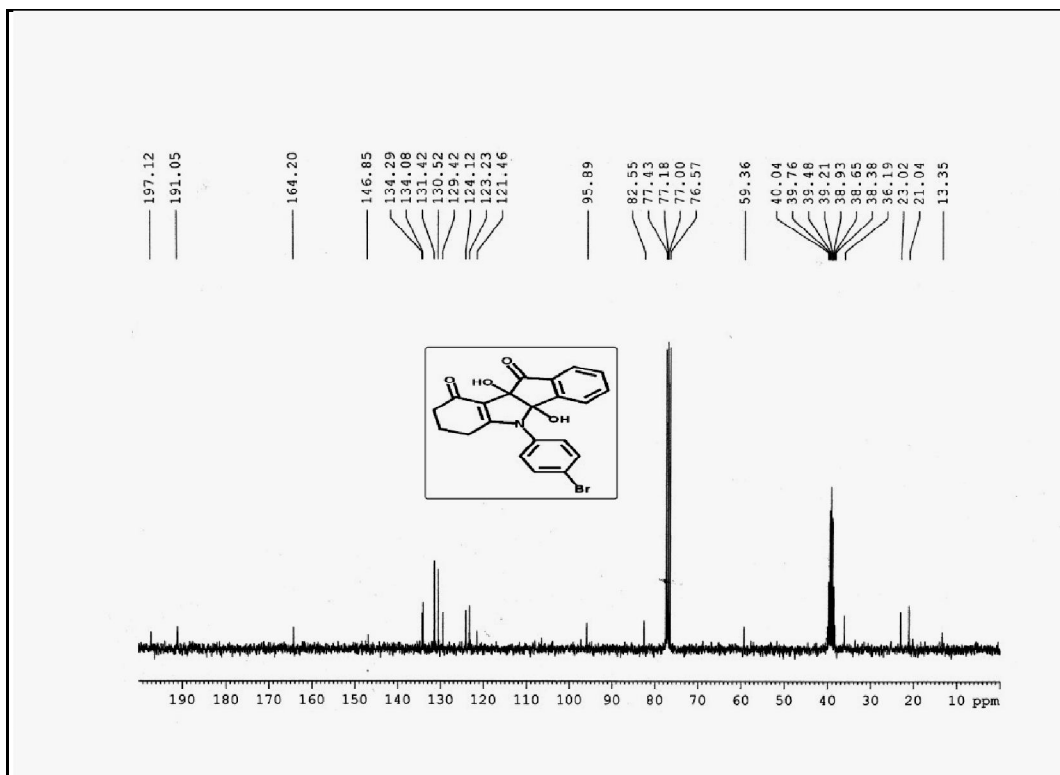
¹H NMR spectrum of the product 4o



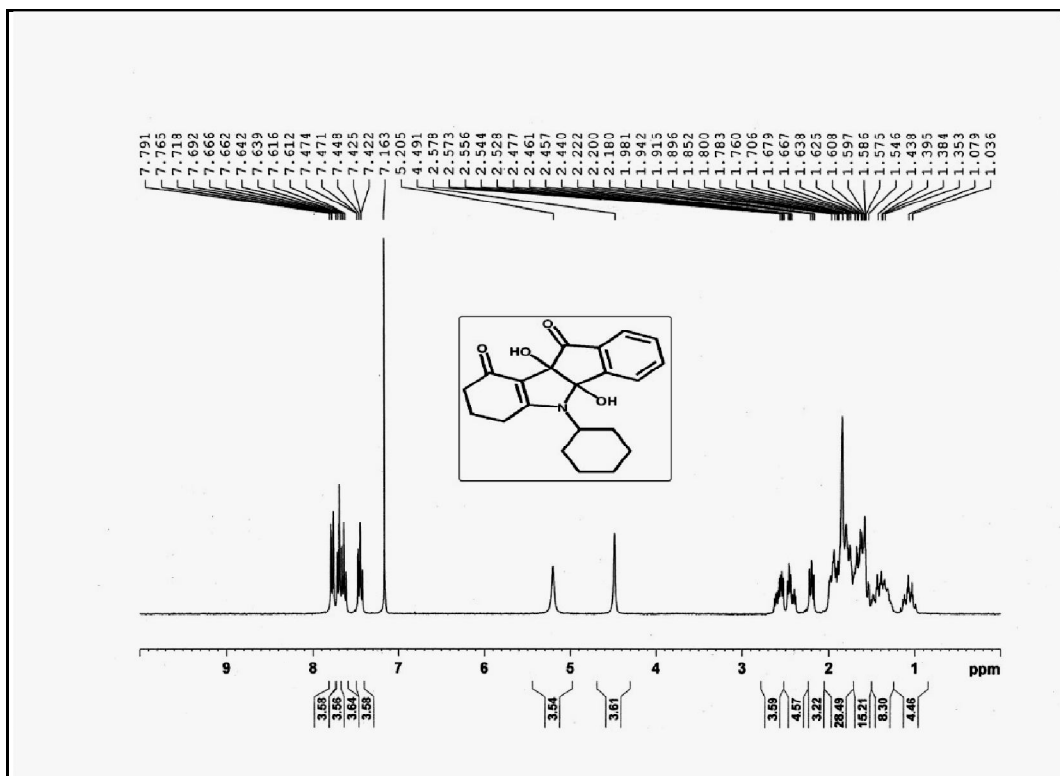
¹³C NMR spectrum of the product 4o



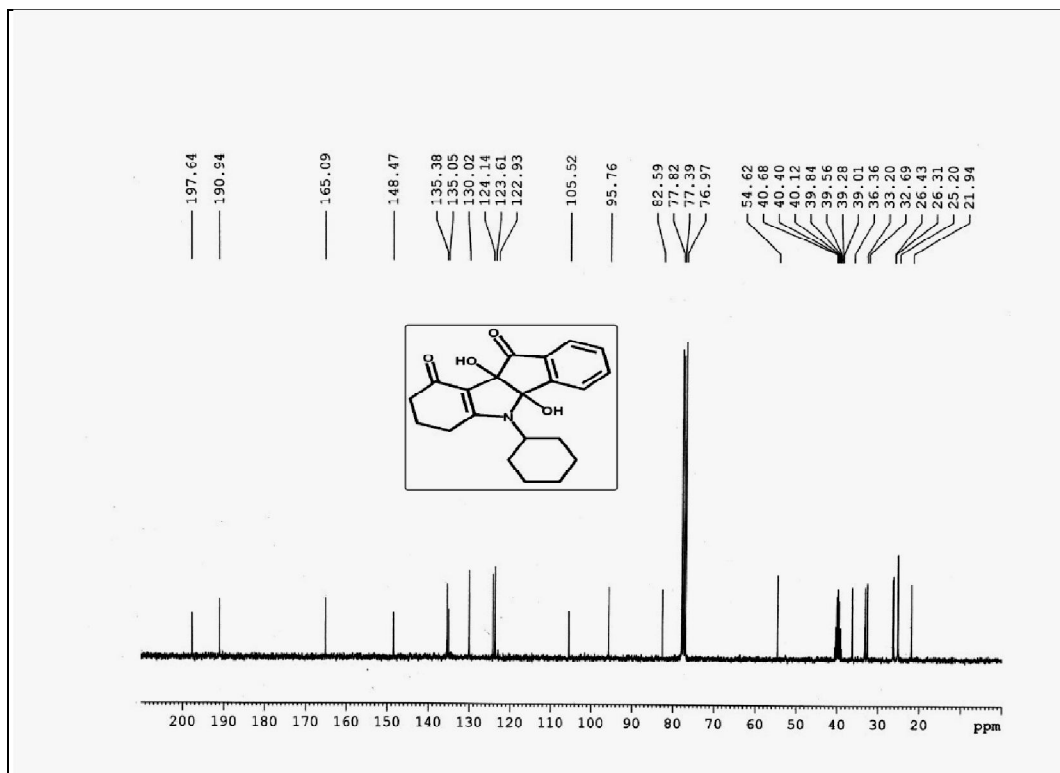
¹H NMR spectrum of the product 4p



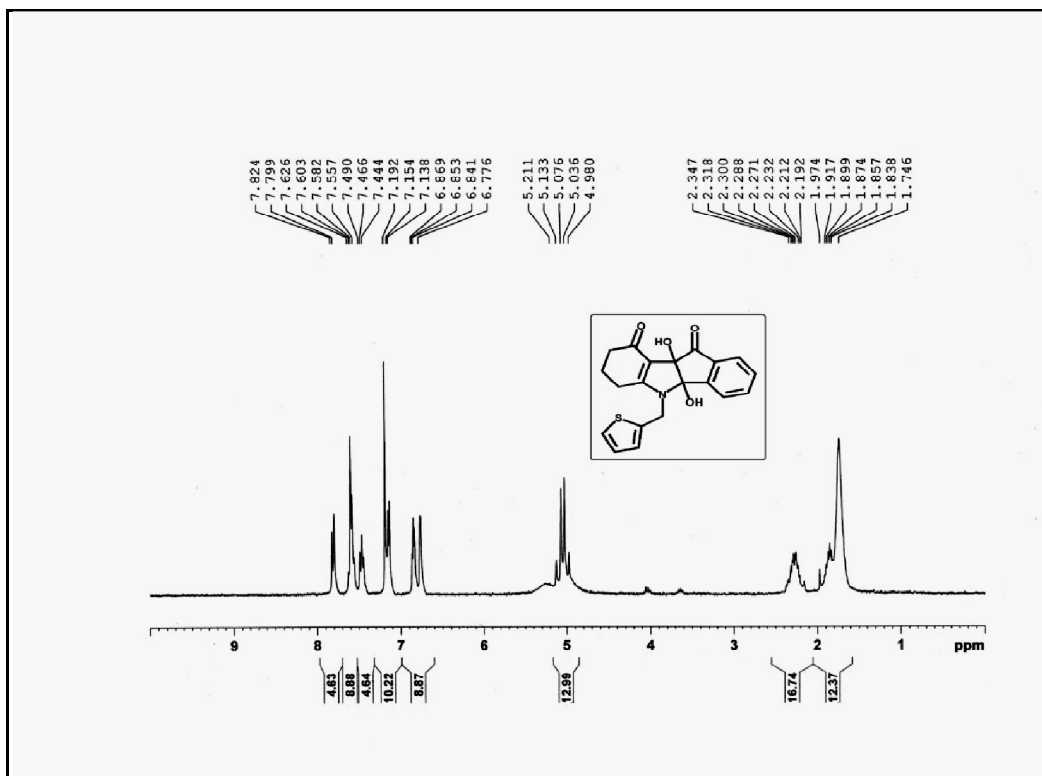
¹³C NMR spectrum of the product 4p



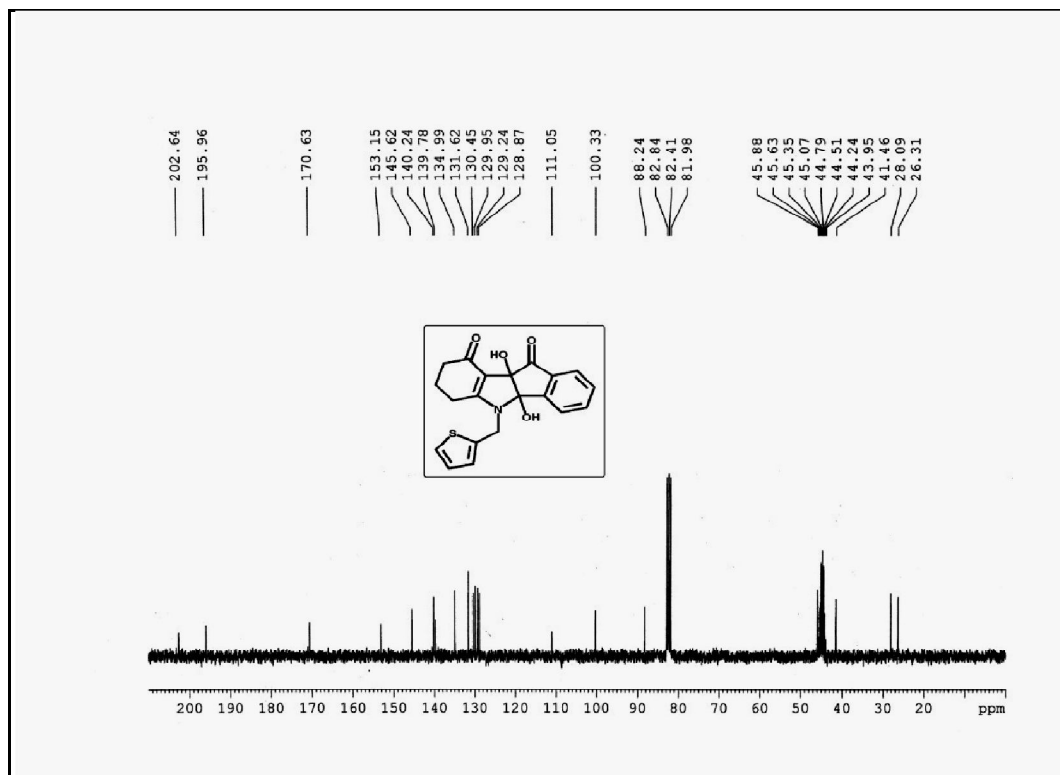
¹H NMR spectrum of the product 4q



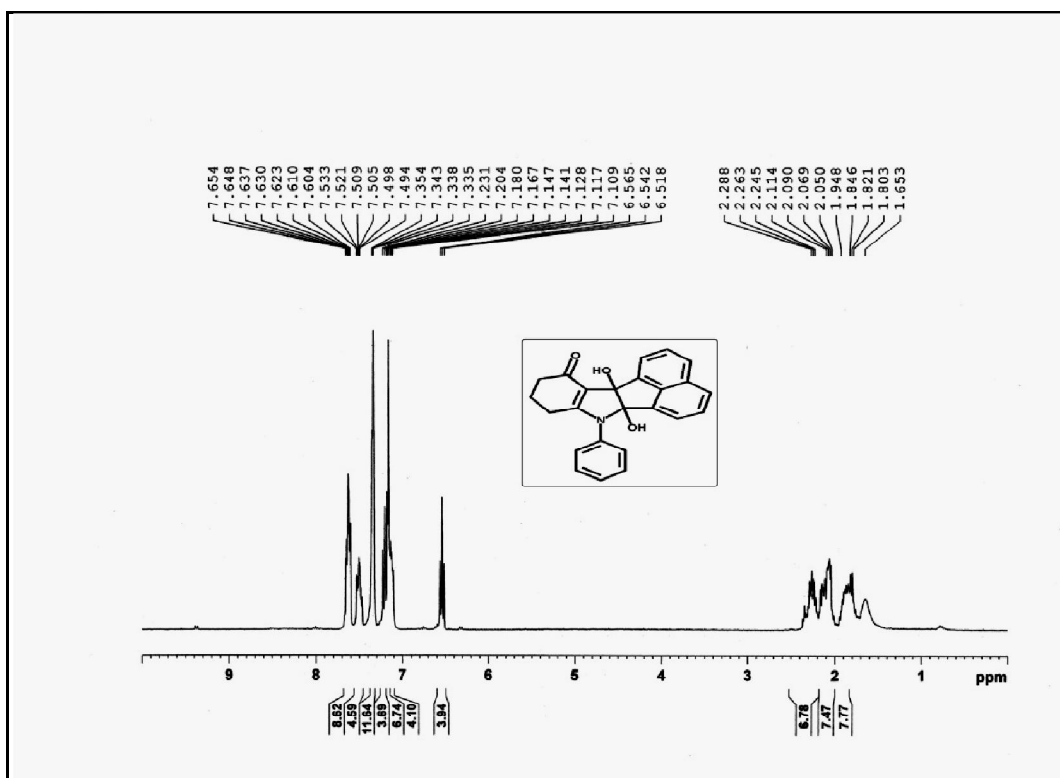
¹³C NMR spectrum of the product 4q



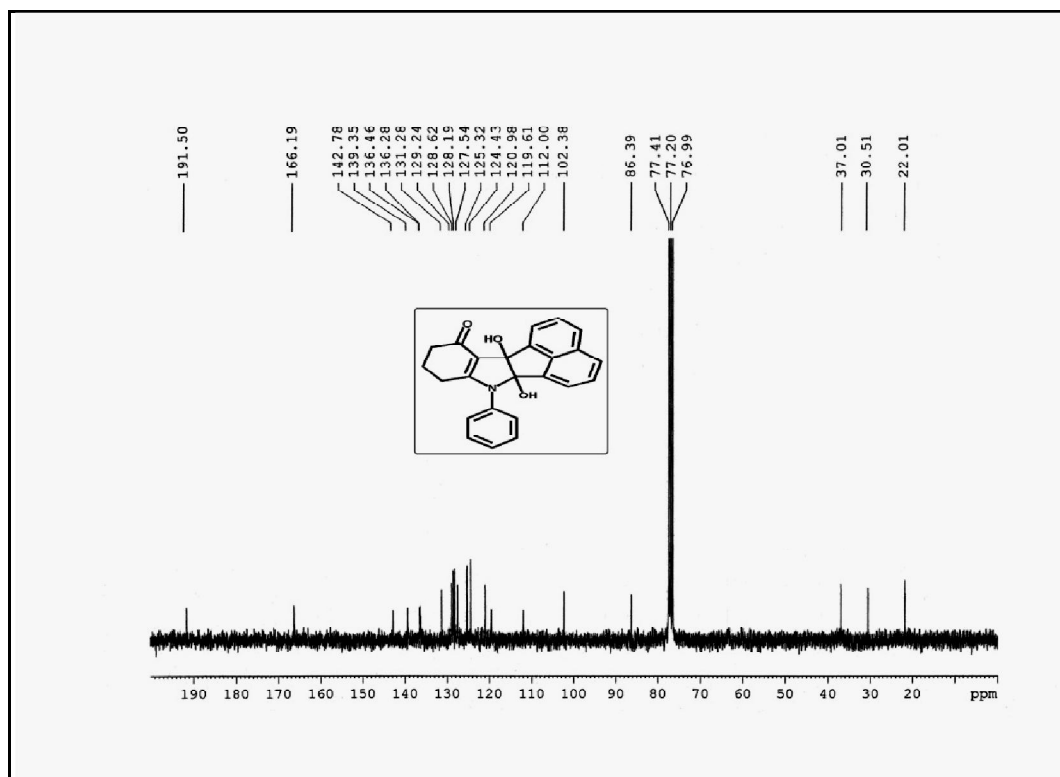
¹H NMR spectrum of the product 4r



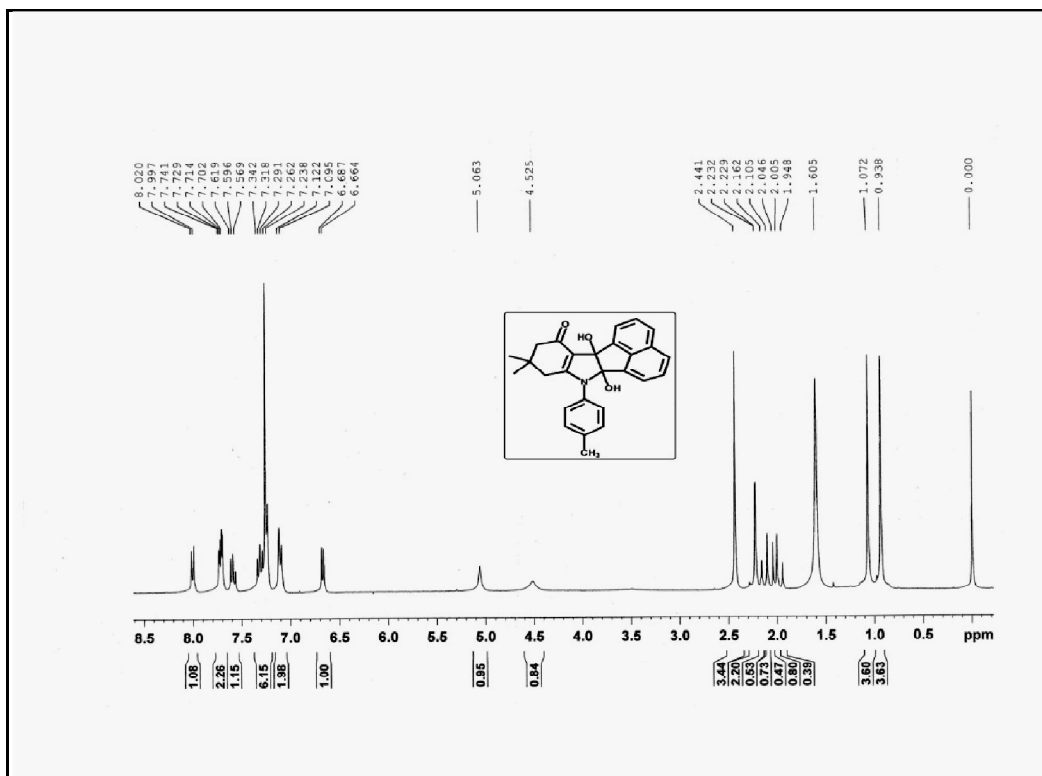
¹³C NMR spectrum of the product 4r



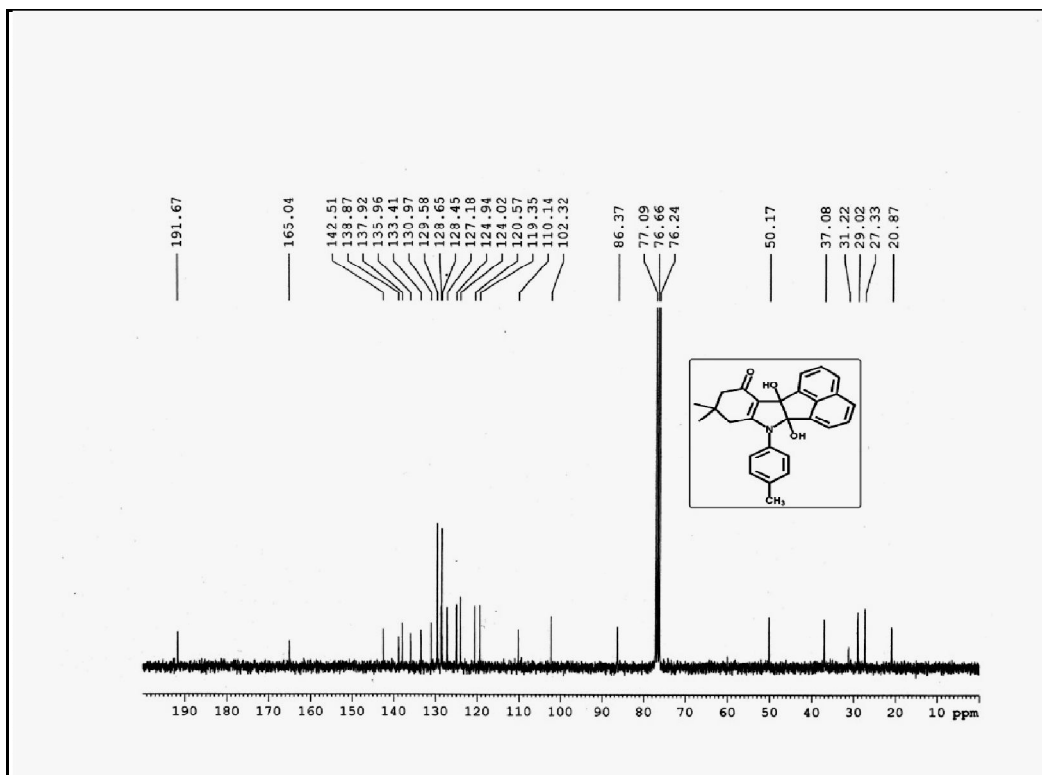
¹H NMR spectrum of the product 6a



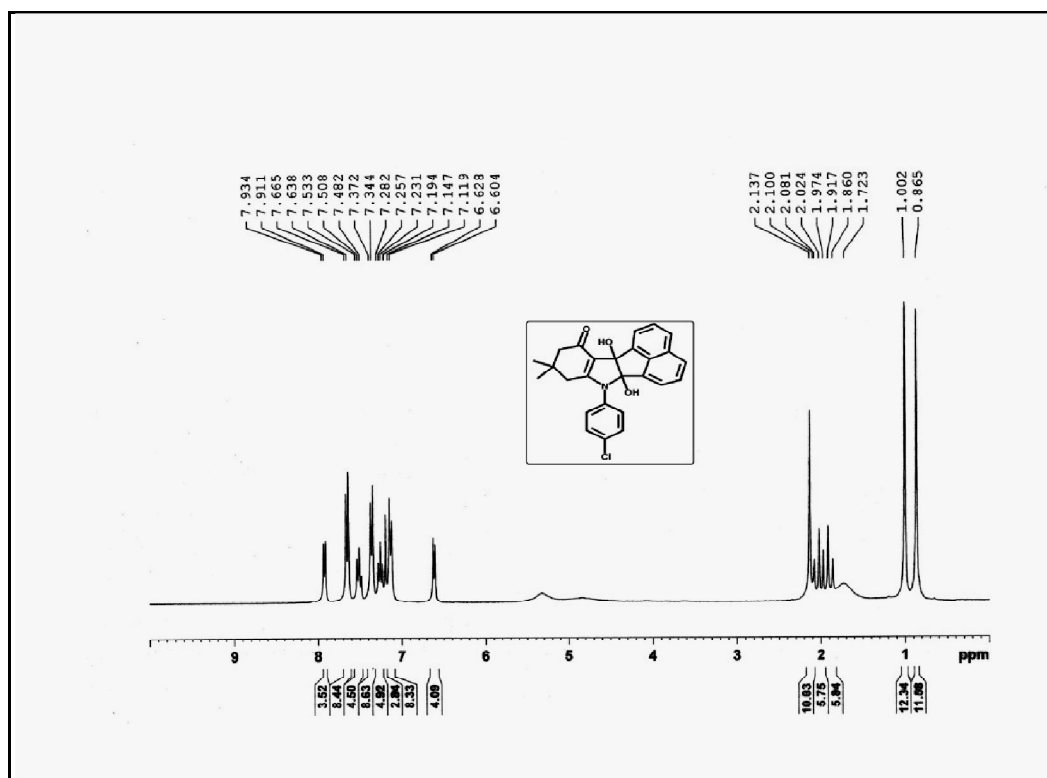
¹³C NMR spectrum of the product 6a



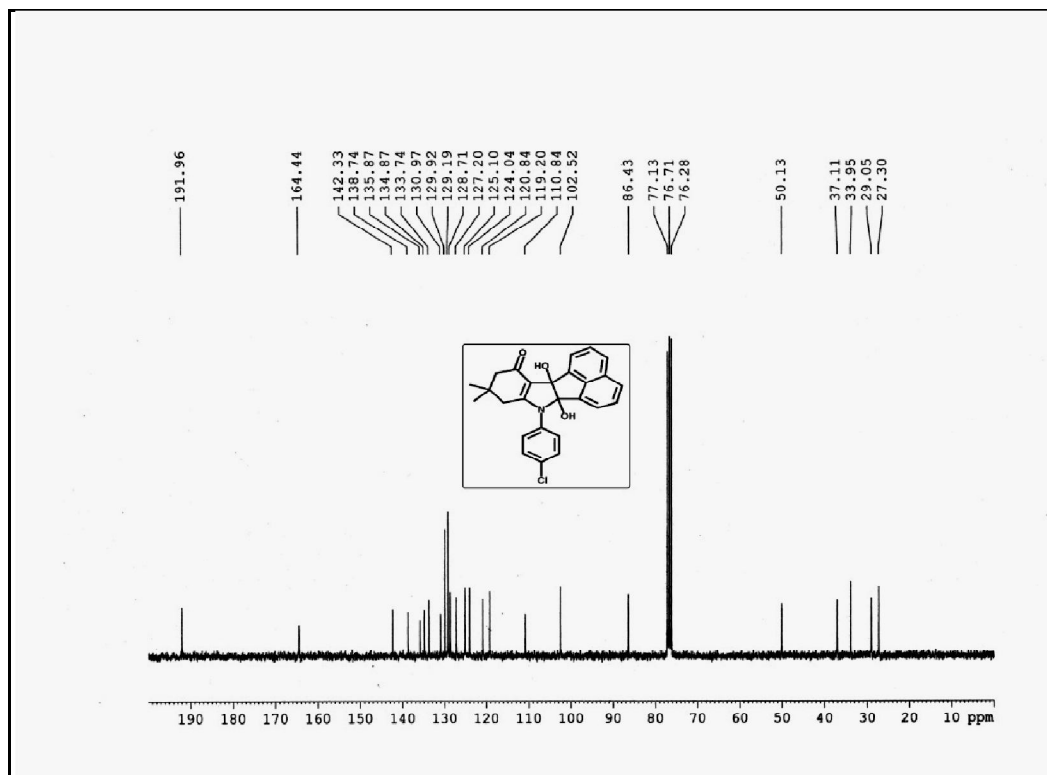
¹H NMR spectrum of the product 6b



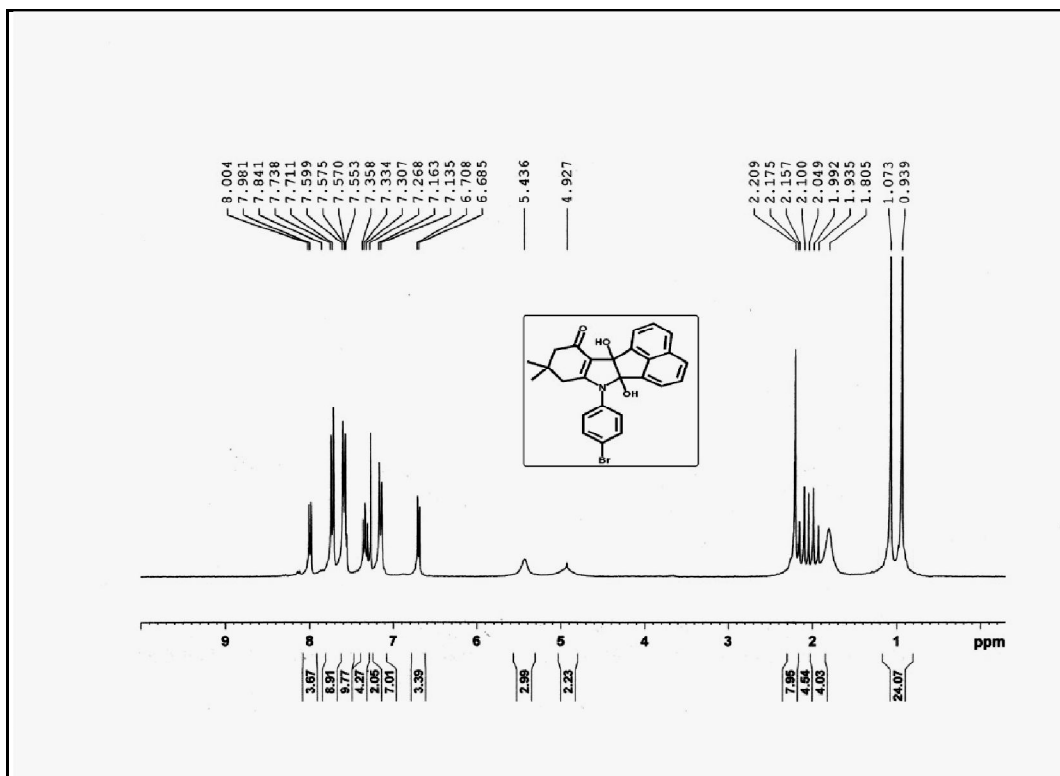
¹³C NMR spectrum of the product 6b



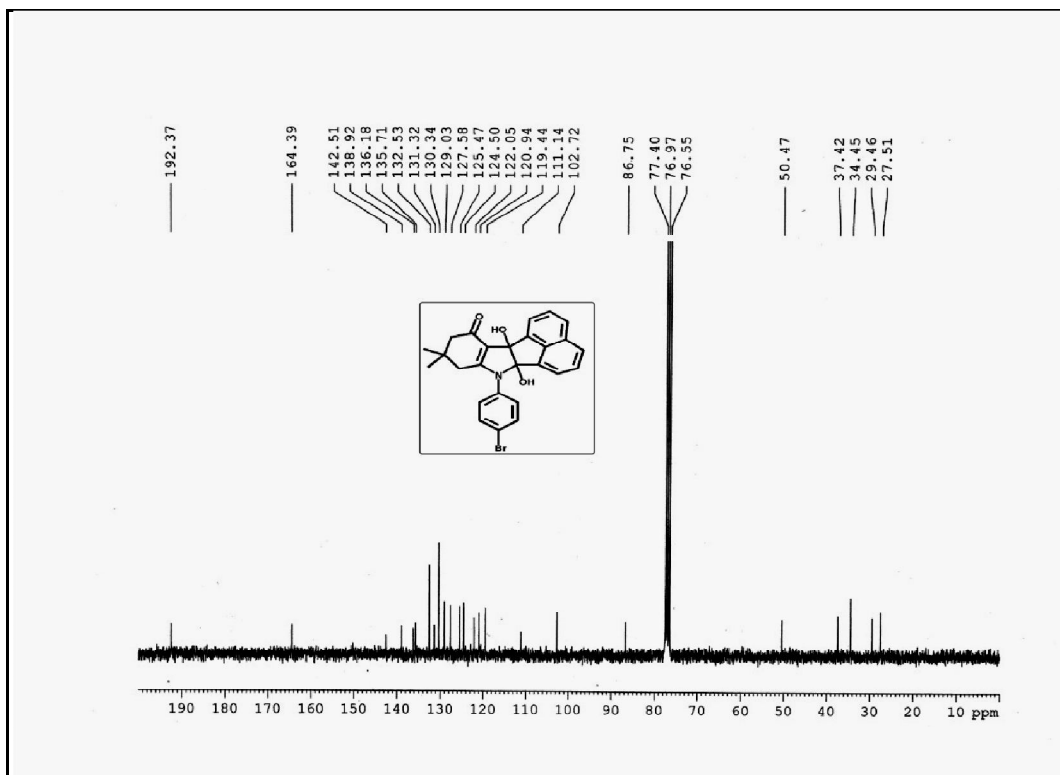
¹H NMR spectrum of the product 6c



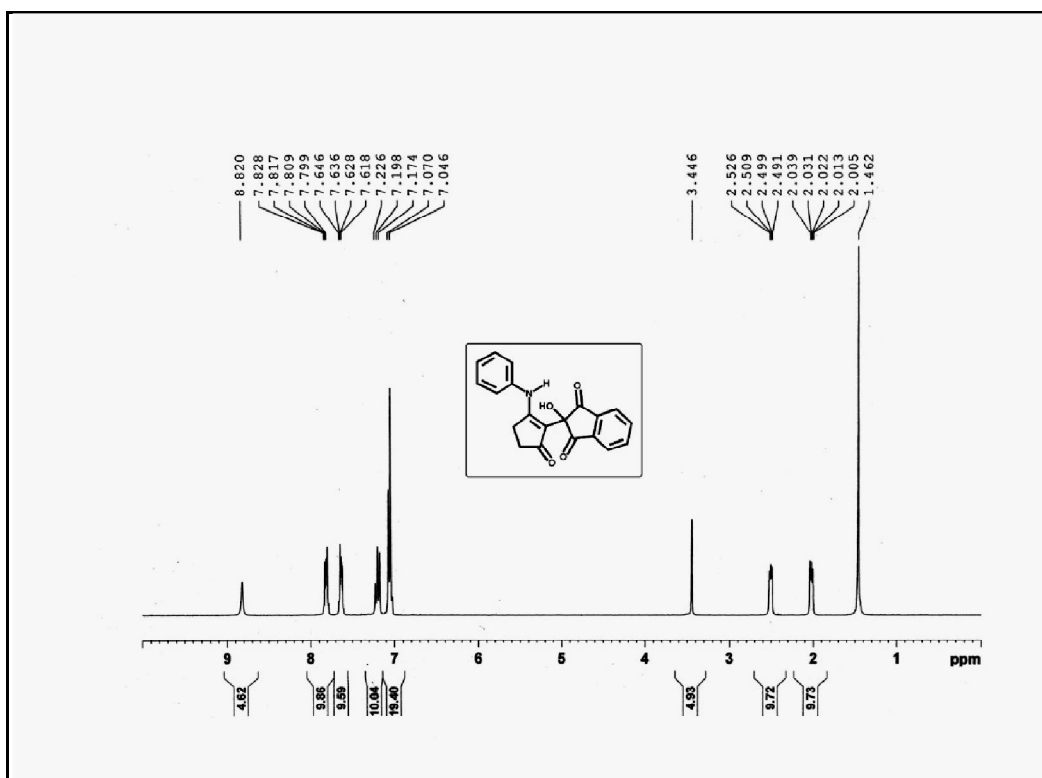
¹³C NMR spectrum of the product 6c



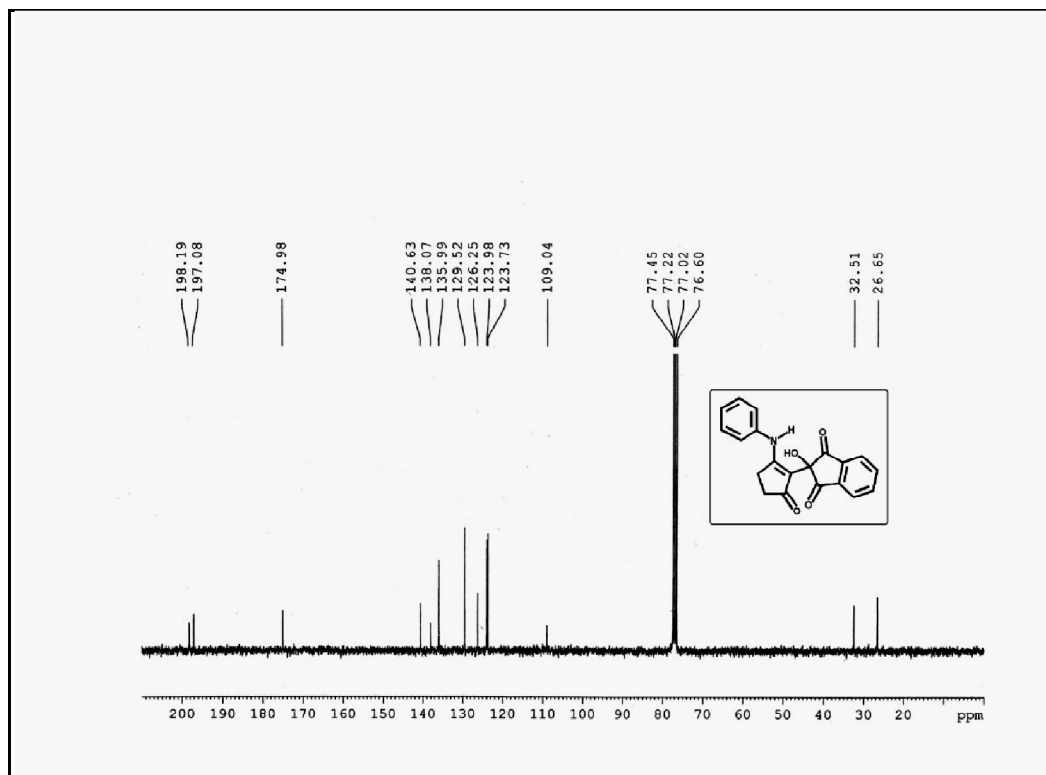
¹H NMR spectrum of the product 6d



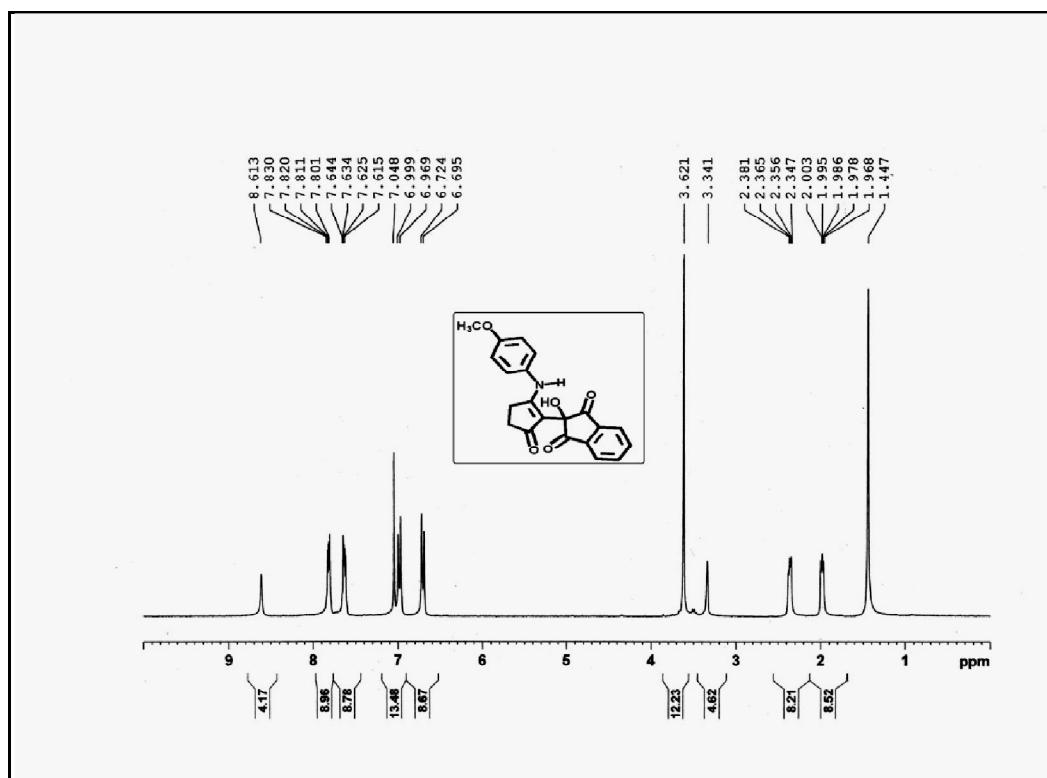
¹³C NMR spectrum of the product 6d



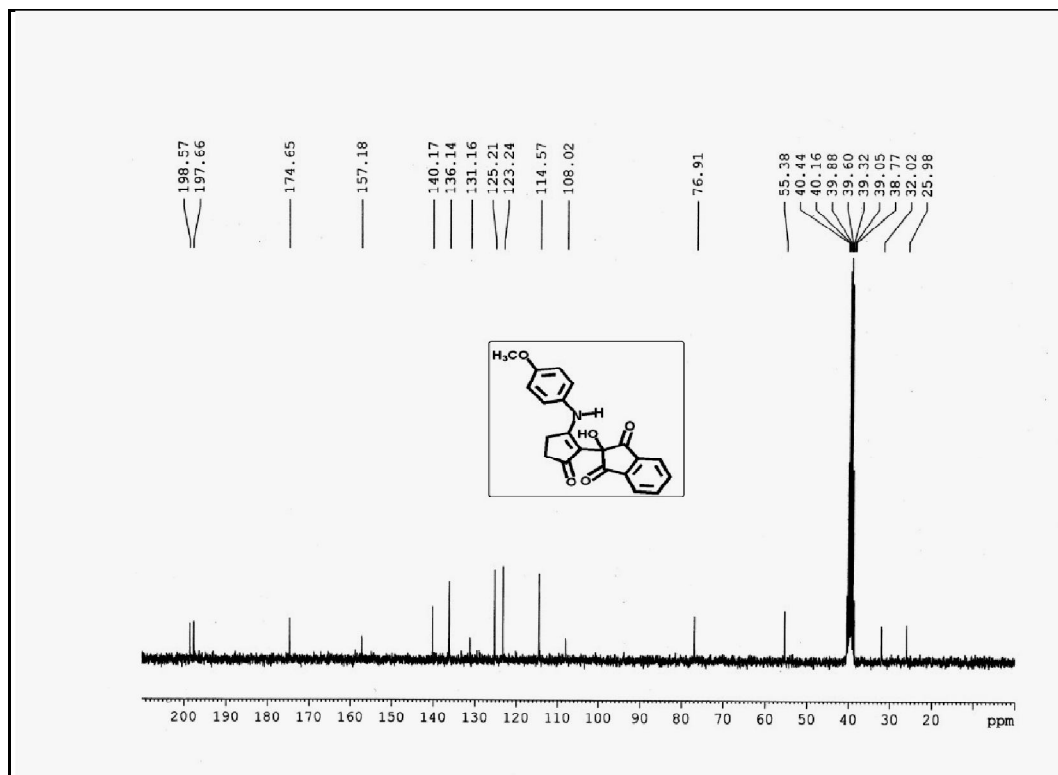
¹H NMR spectrum of the product 8a



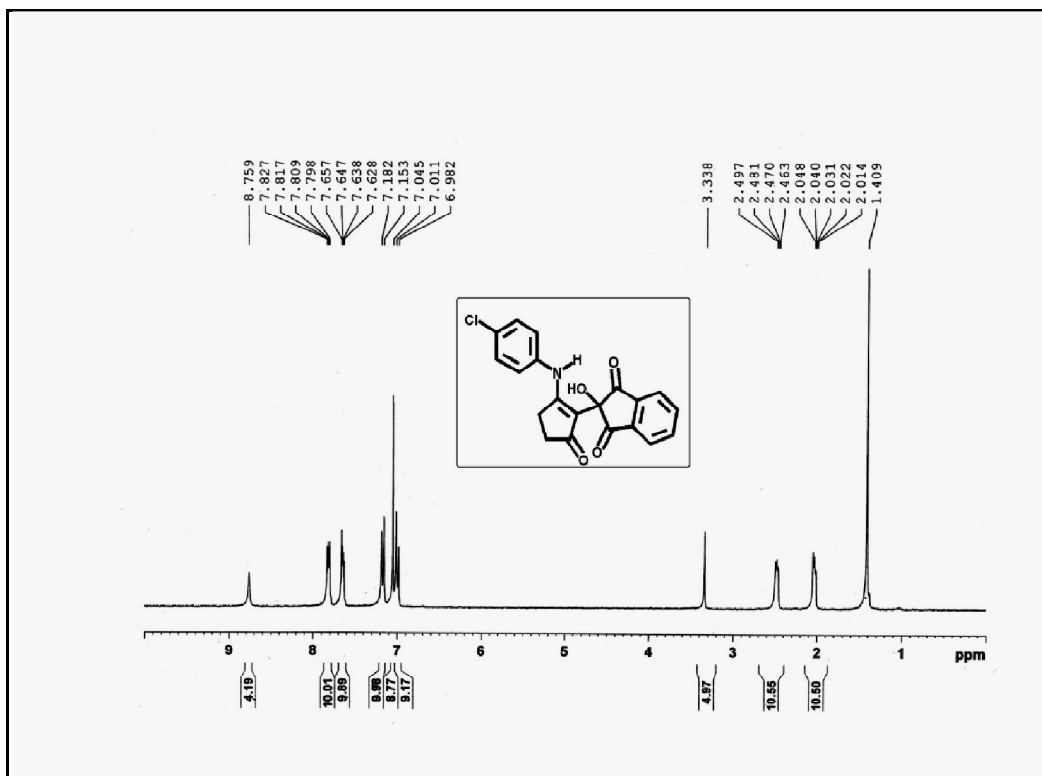
¹³C NMR spectrum of the product 8a



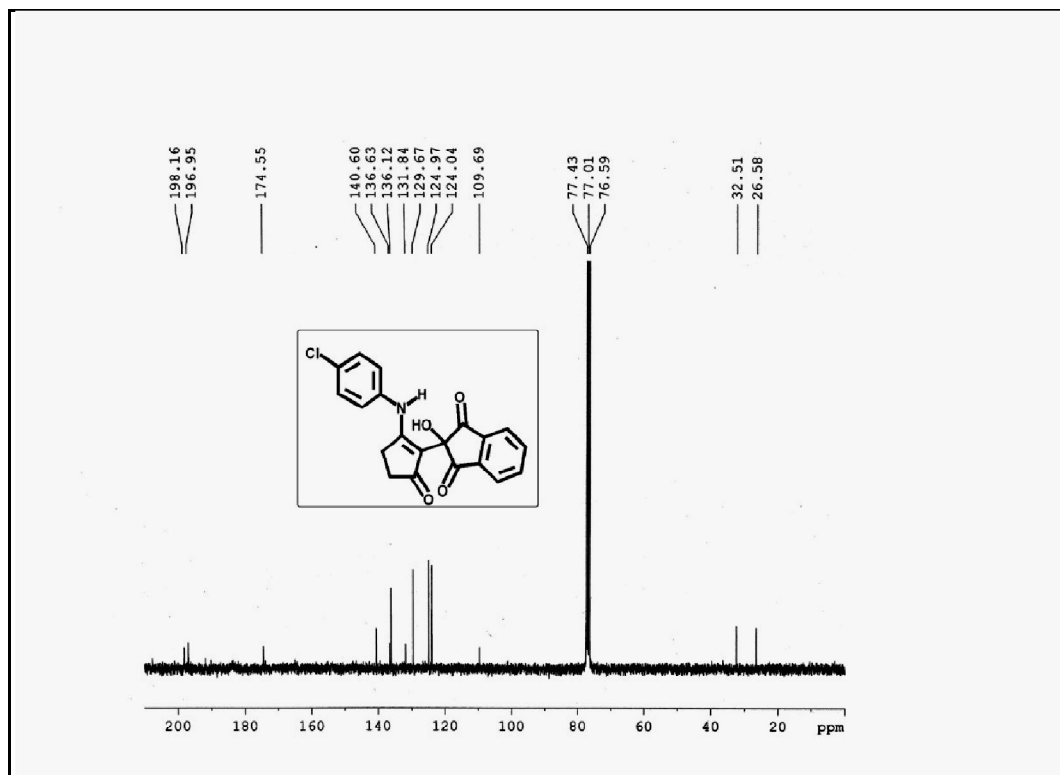
¹H NMR spectrum of the product 8b



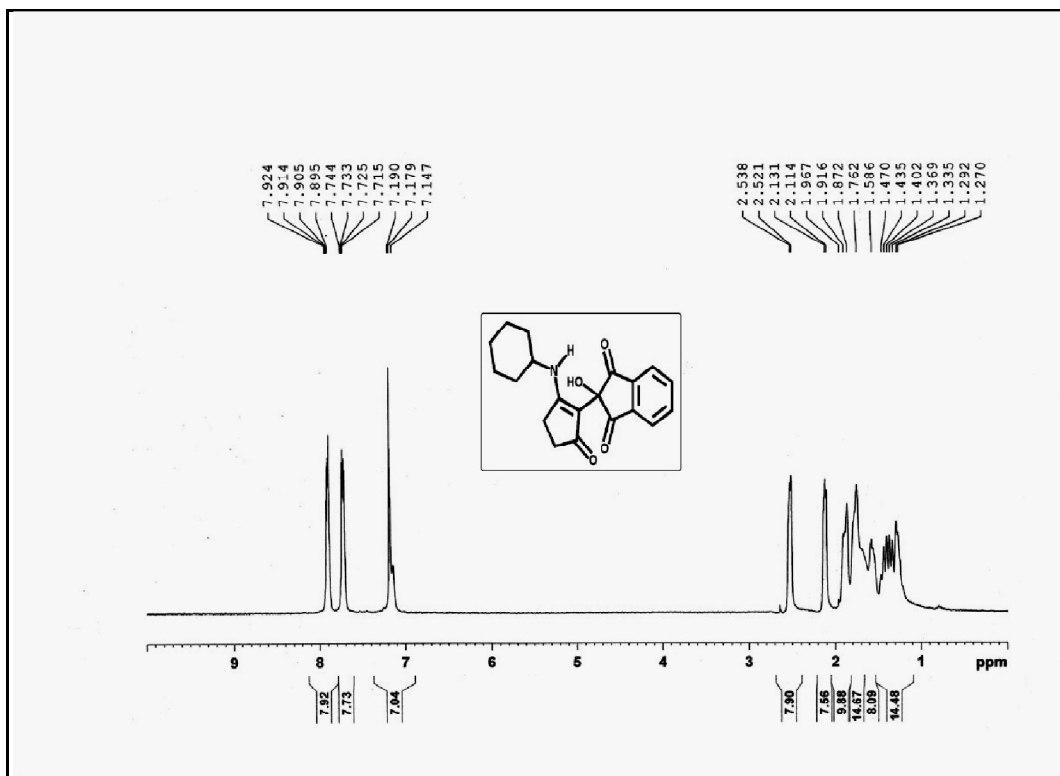
¹³C NMR spectrum of the product 8b



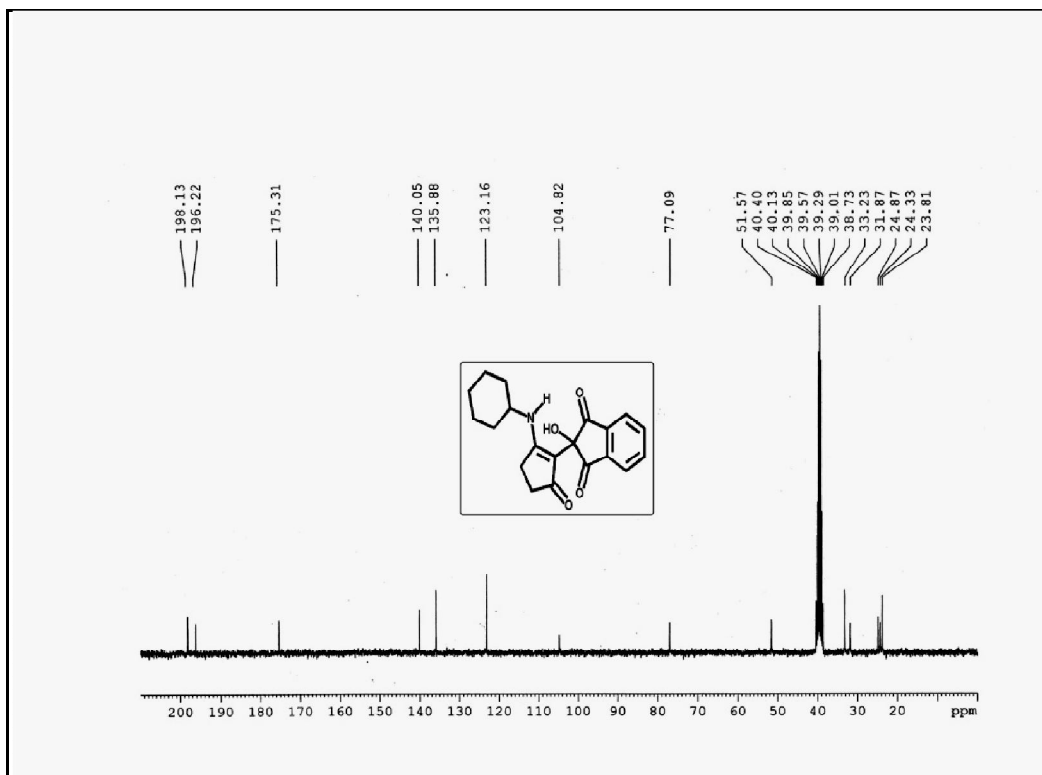
¹H NMR spectrum of the product 8c



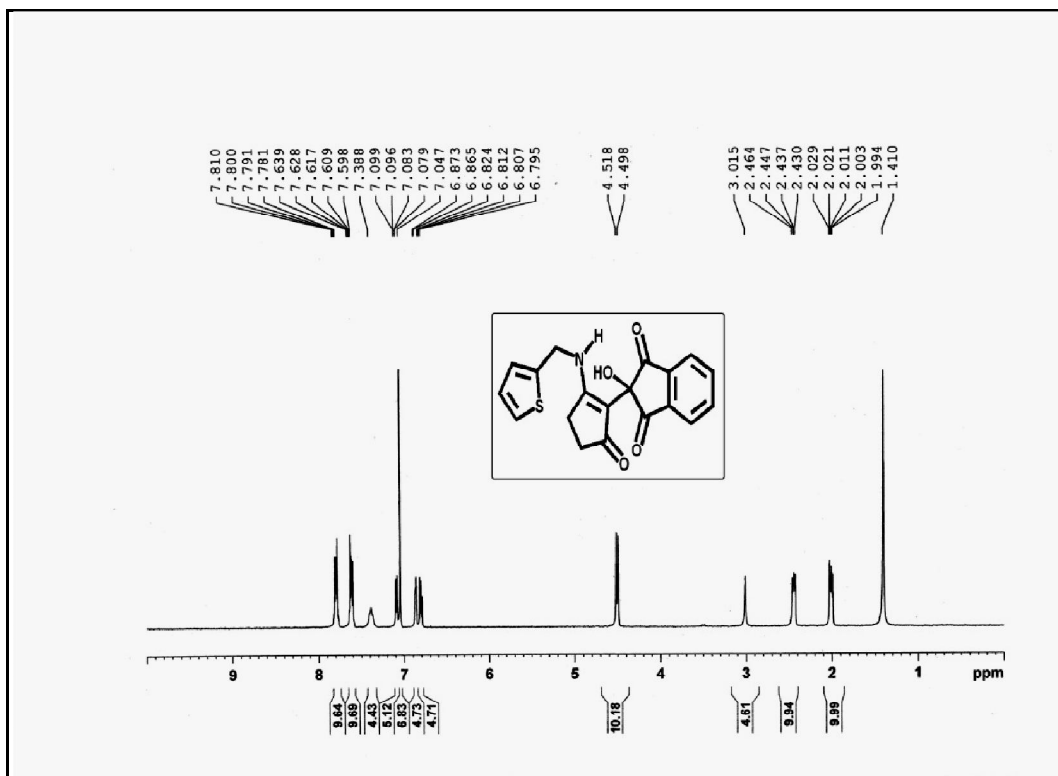
¹³C NMR spectrum of the product 8c



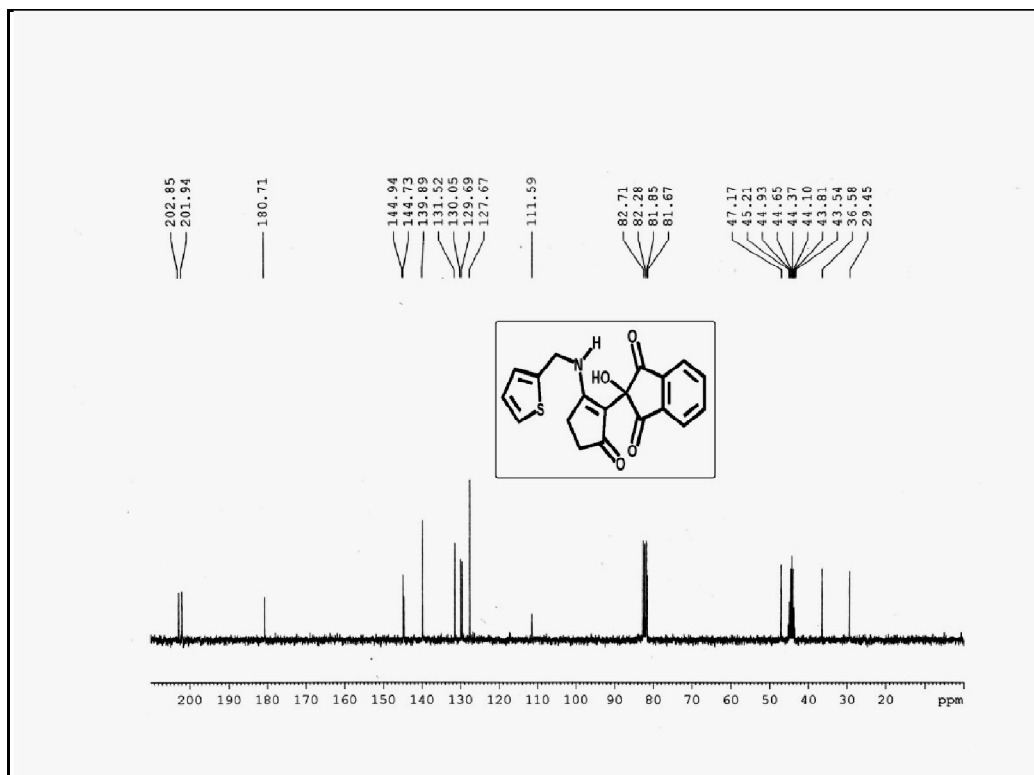
¹H NMR spectrum of the product 8d



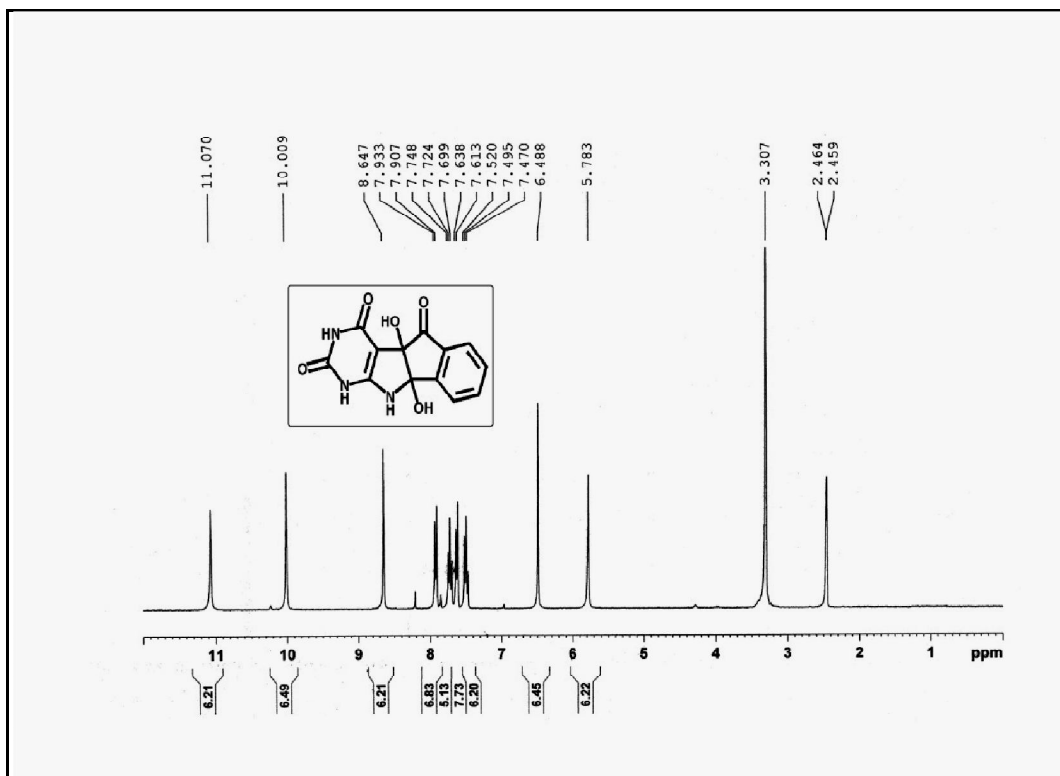
¹³C NMR spectrum of the product 8d



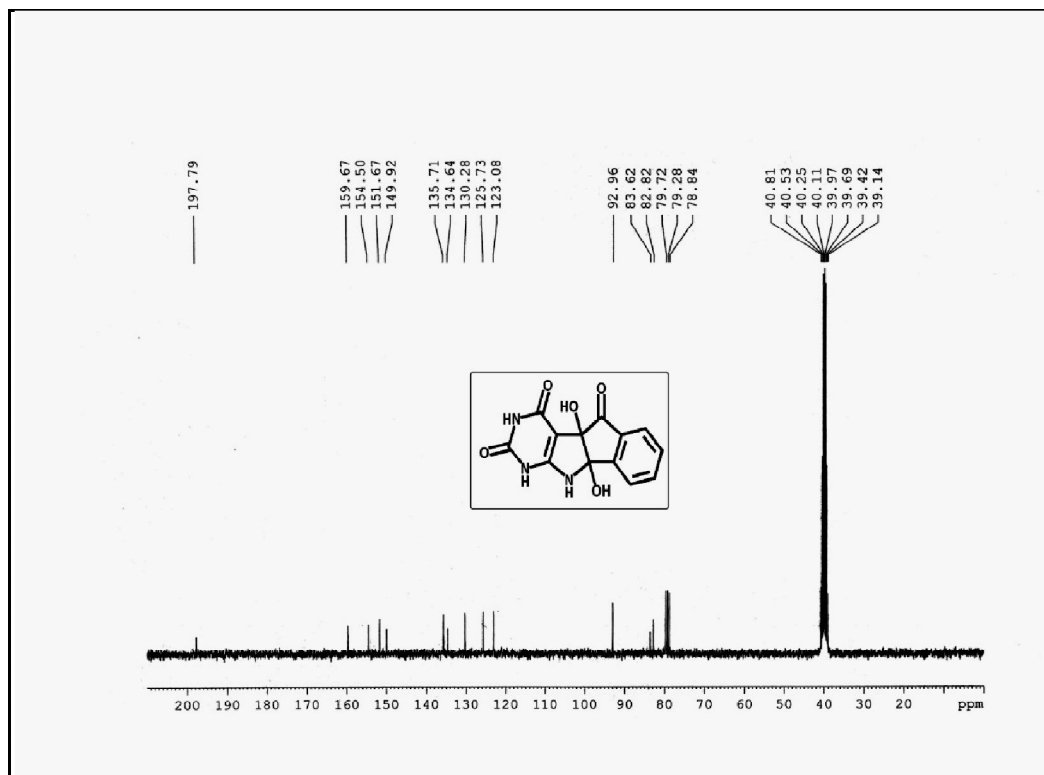
¹H NMR spectrum of the product 8e



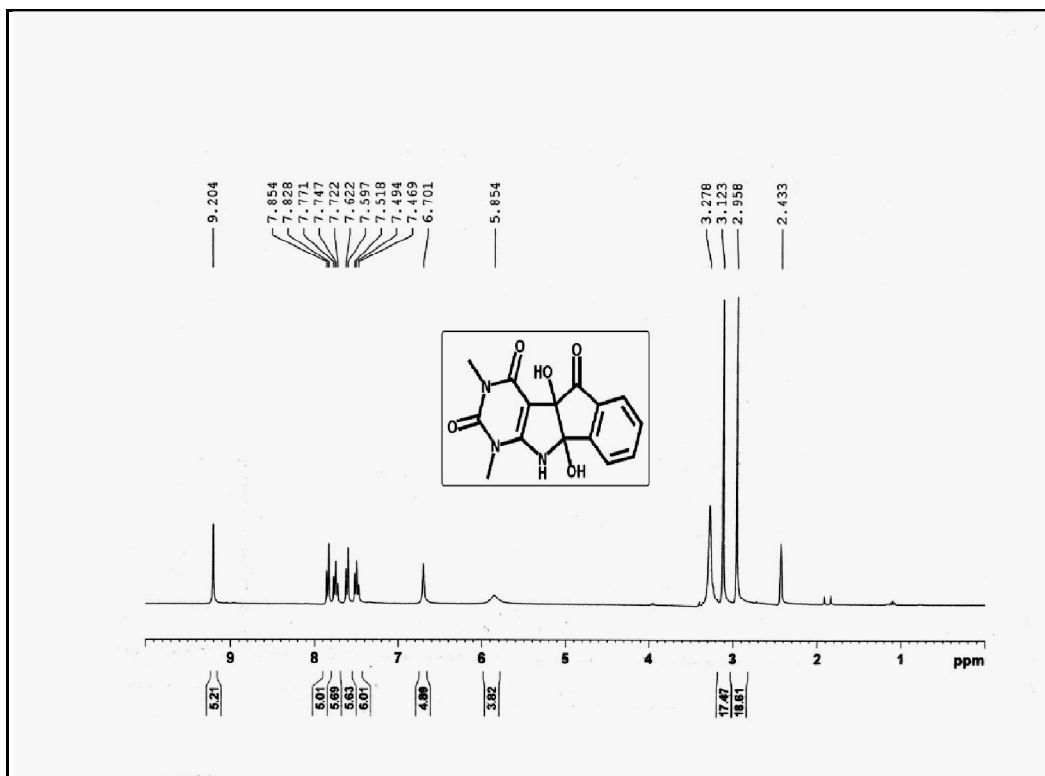
¹³C NMR spectrum of the product 8e



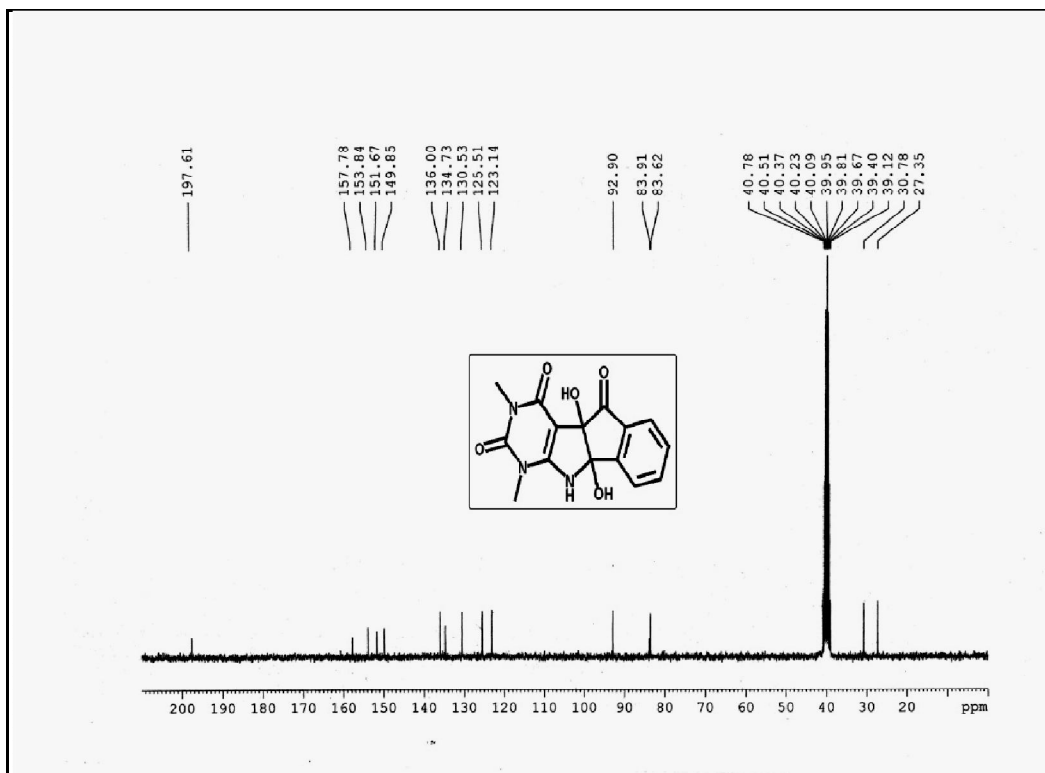
^1H NMR spectrum of the product 11a



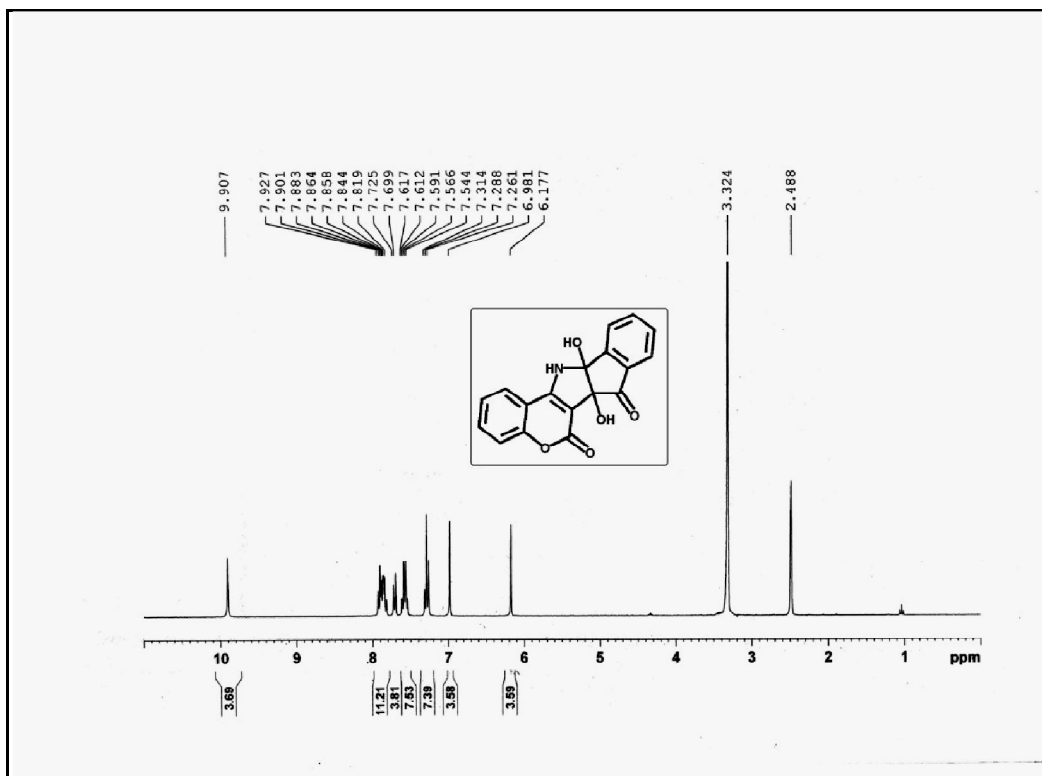
^{13}C NMR spectrum of the product 11a



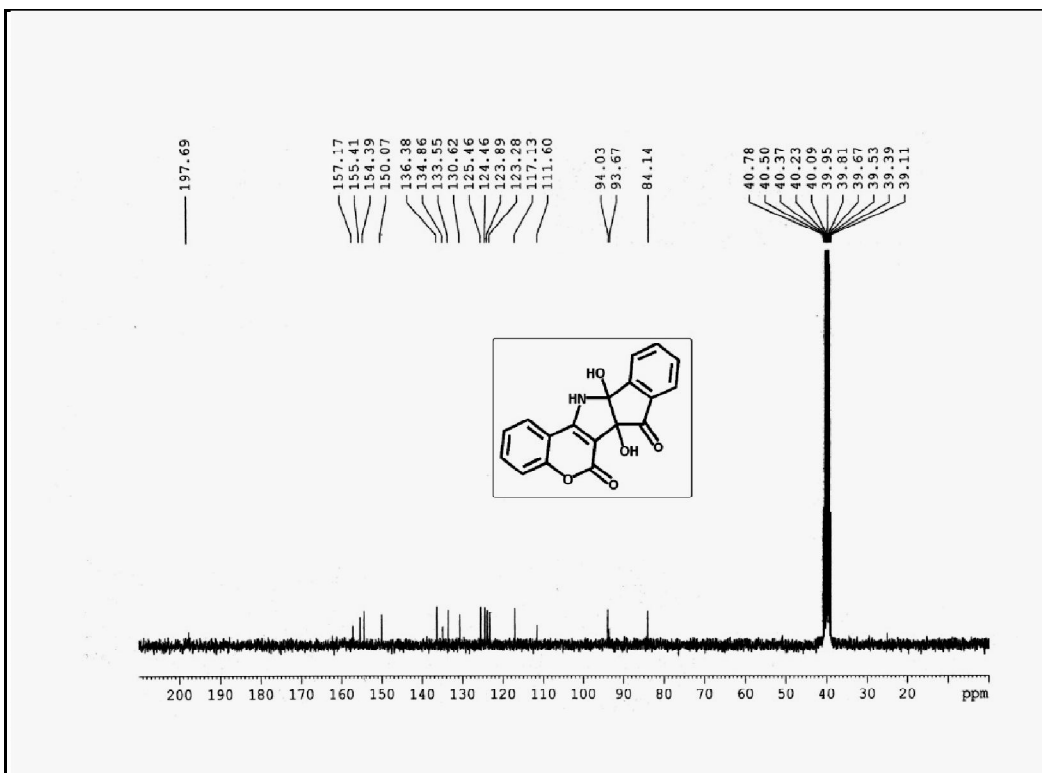
^1H NMR spectrum of the product 11b



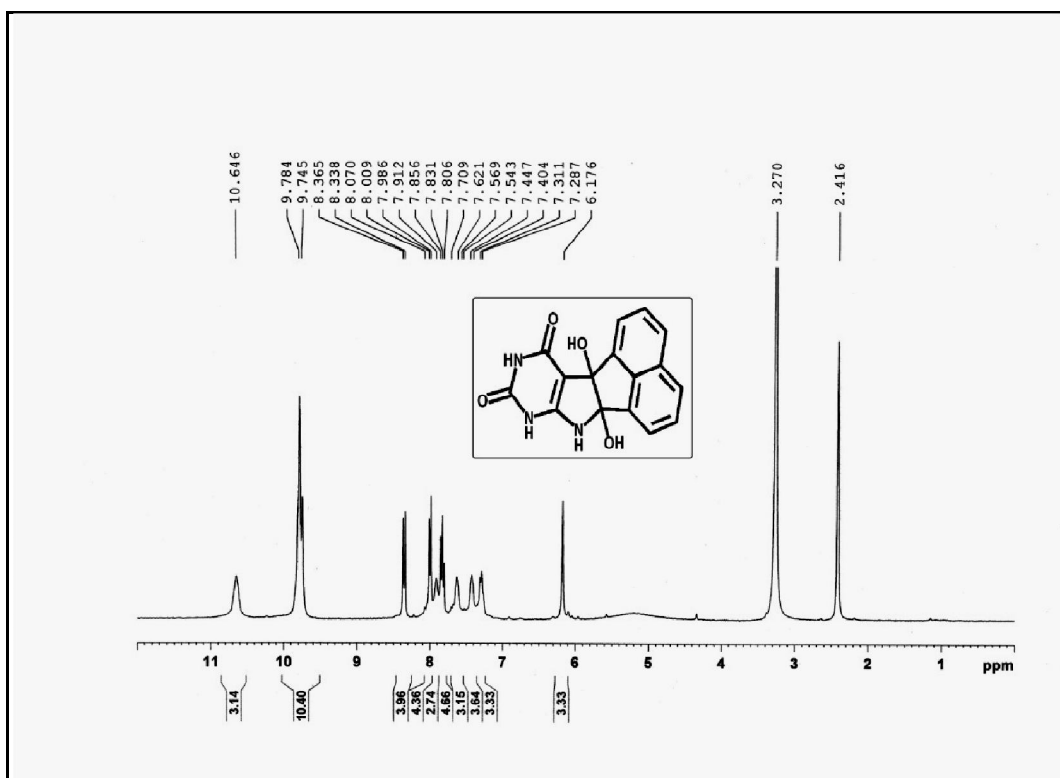
^{13}C NMR spectrum of the product 11b



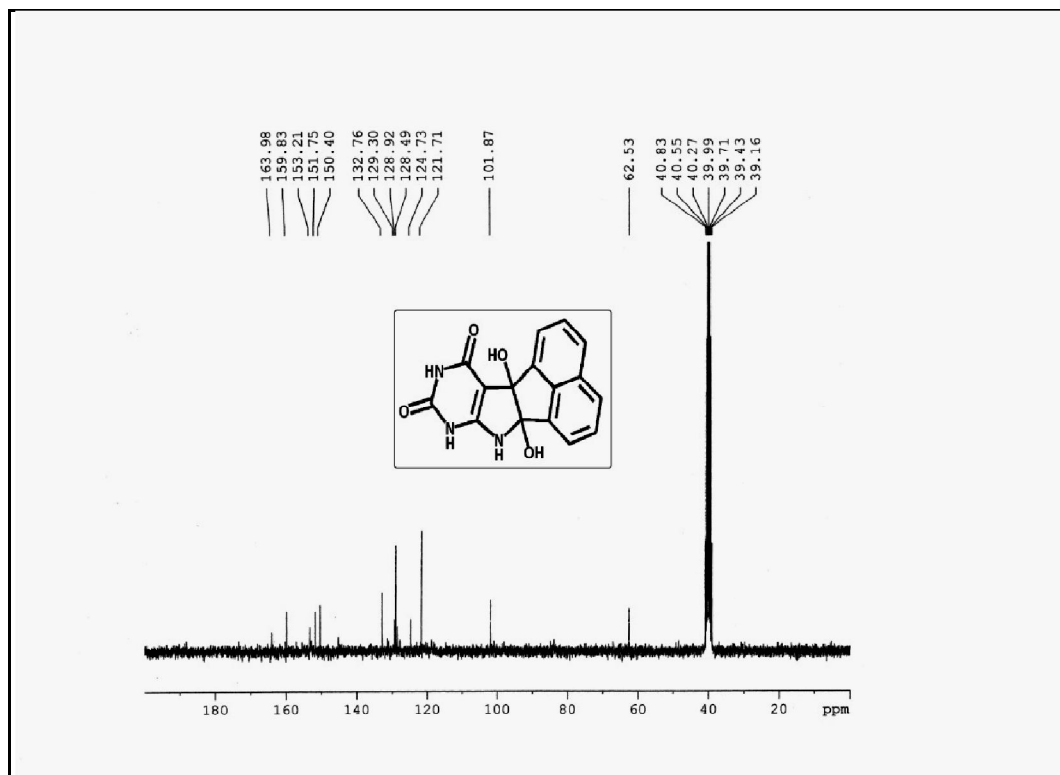
^1H NMR spectrum of the product 11c



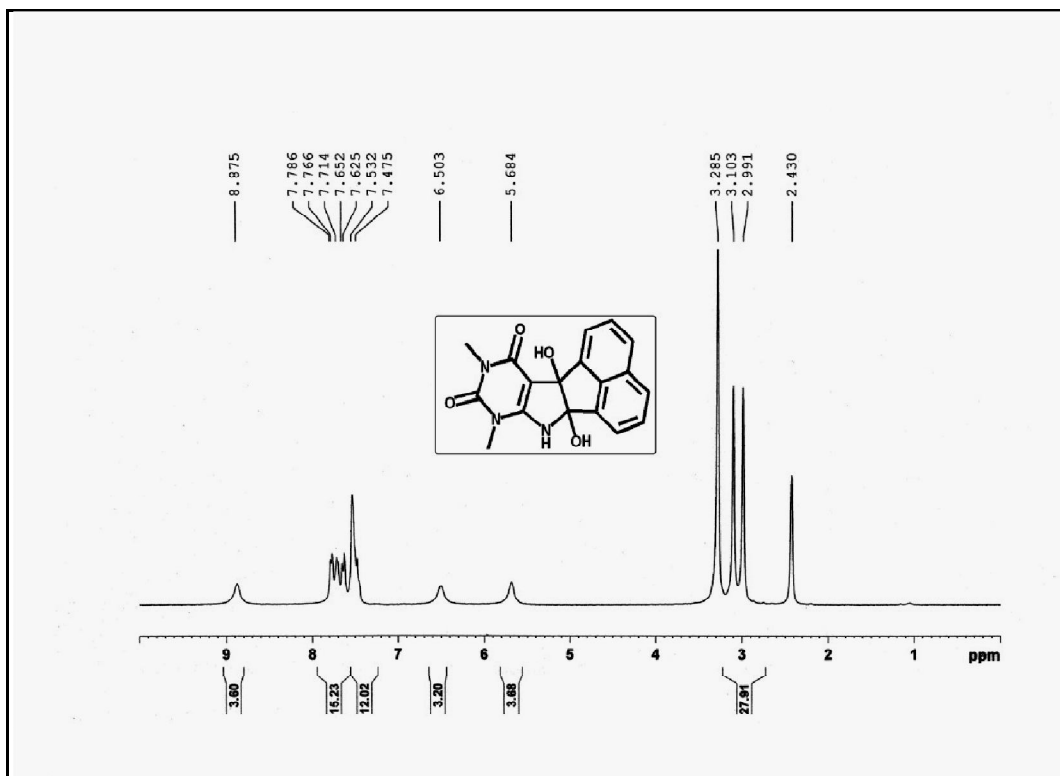
^{13}C NMR spectrum of the product 11c



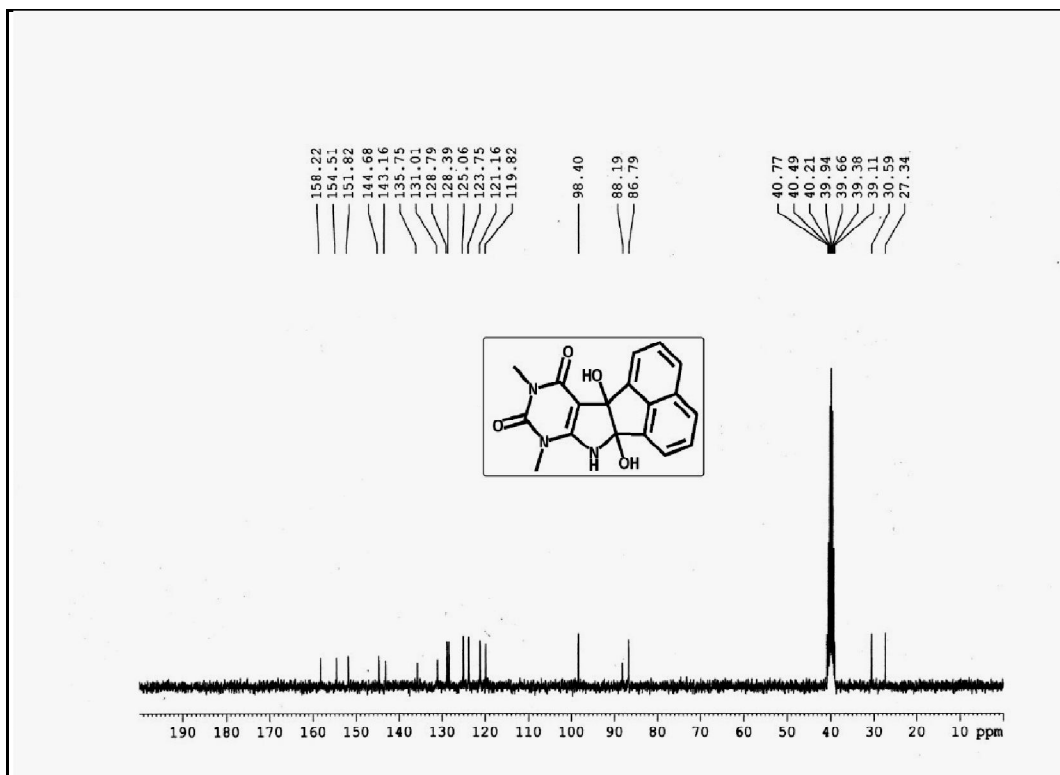
¹H NMR spectrum of the product 11d



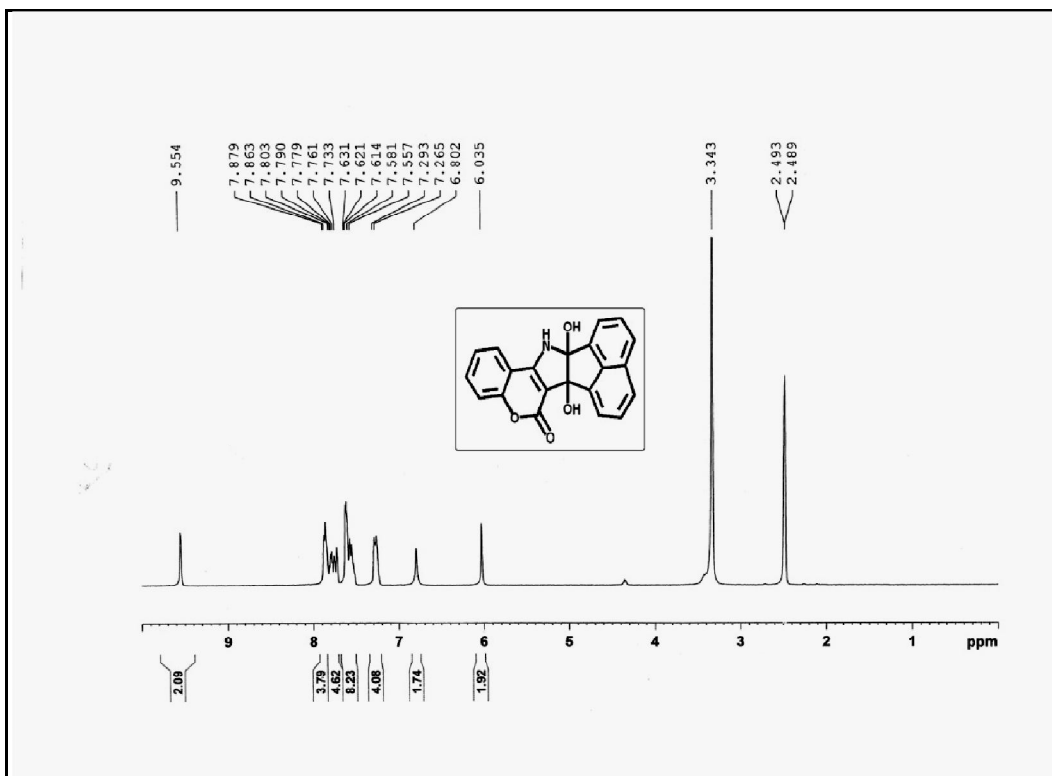
¹³C NMR spectrum of the product 11d



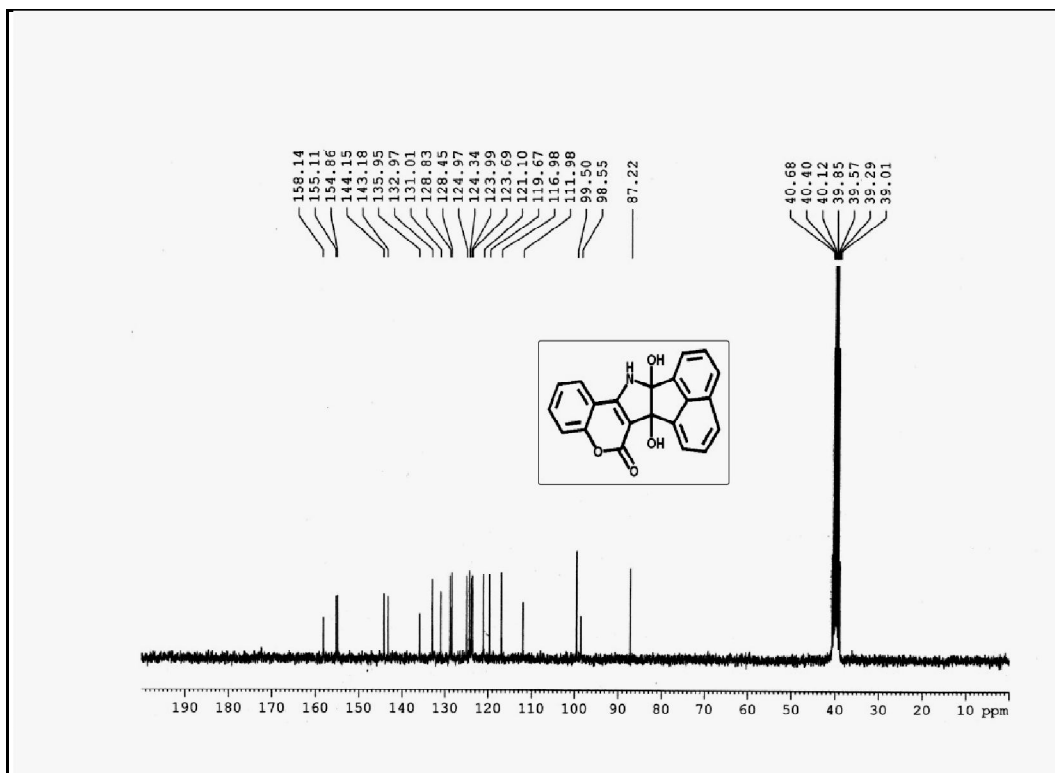
^1H NMR spectrum of the product 11e



^{13}C NMR spectrum of the product 11e



^1H NMR spectrum of the product 11f



^{13}C NMR spectrum of the product 11f