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Supporting information

Fabrication and characterization of inorganic-organic hybrid copper ferrite anchored on chitosan Schiff base as a reusable green catalyst for synthesis of indeno[1,2-b]indolone derivatives

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General procedure for the synthesis of indeno indolone

Exact amounts of aromatic amine(1mmol), 1mmol of dimedone and $CuFe_2O_4$@CS-SB catalyst were stirred in distilled water under tidy condition at 75 ^{0}C. Subsequently, 1mmol of ninhydrine was added and the reaction mixture was all over again stirred for the suitable time. After the reaction was supplemented (TLC). The reaction mixture was filtered off. In order that with the aim of achieving $CuFe_2O_4$@CS-SB catalyst from the products, the $CuFe_2O_4$@CS-SB catalyst was separated from the reaction mixture by a strong magnet and washed several times with acetone and ethanol to be used as a catalyst in other reactions. Ultimately, precipitate was washed by petroleum ether and recrystallized from ethanol, if required, to give absolute target products. Every single product was confirmed by

adjusting its melting point and applying spectroscopic methods such as FT-IR, ^{1}H NMR and ^{13}C NMR**.**

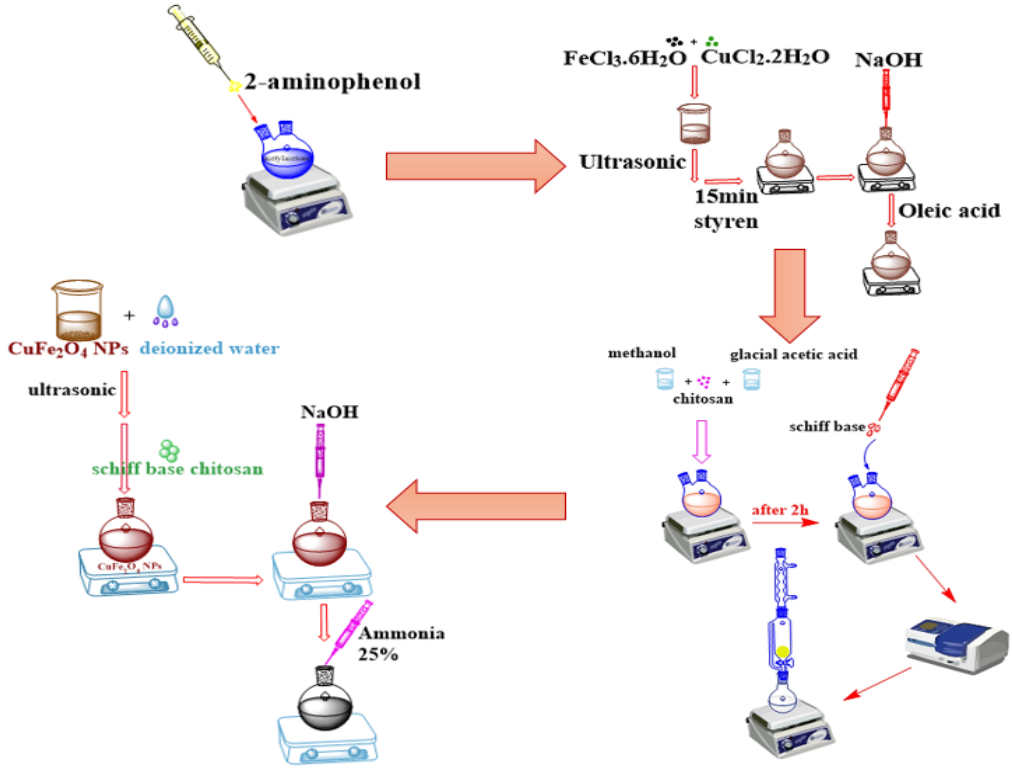

Figure S1. Stepwise of preparation of the $CuFe_2O_4$@CS-SB catalyst

4b,9b-dihydroxy-7,7-dimethyl-5-phenyl-4b,5,6,7,8,9b-hexahydroindeno[1,2-b]indole-9,10-dione (4a): White solid (93%yield); $m.p_{rep}.(^0C) = 260\text{-}265\ ^0C$; $m.p_{lit}.(^0C) = 210\text{-}212\ ^0C$[1]; IR (KBr): ϑ 3475, 3232, 2931, 2876, 1723, 1606, 1547, 1452, 1277, 1159cm^{-1} . ^1H NMR (400MHz, DMSO) (ppm)= 7.72 (d, *J*= 4.0 Hz, 1H, ArH), 7.58-7.45 (m,5H, ArH), 7.30 (s, 2H, ArH), 7.28 (s, 1H,), 6.60 (d, *J*=8.0 Hz, 1, ArH), 6.01 (s,1H,), 2.41 (d, *J*=16.0 Hz,1H), 2.15 (d, *J*=16.0 Hz,1H), 1.91 (d, *J*=16.0 Hz,1H), 1.79 (d, *J*=16.0 Hz,1H), 0.96 (s, 3H, Me), 0.89 (s, 3H, Me).

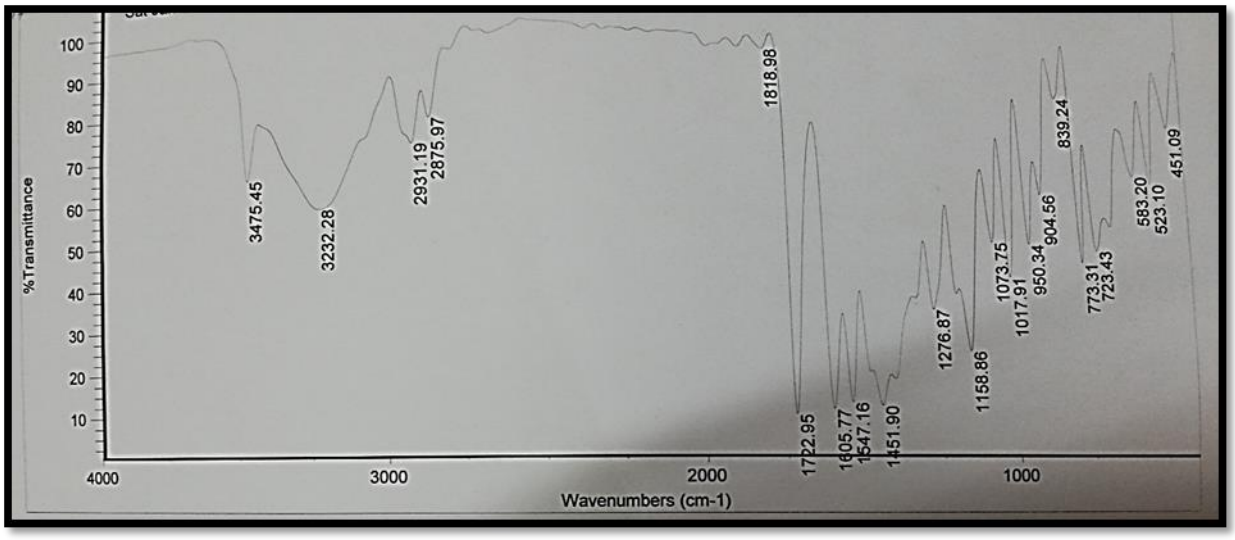

Figure S2. The FT-IR of **4a**

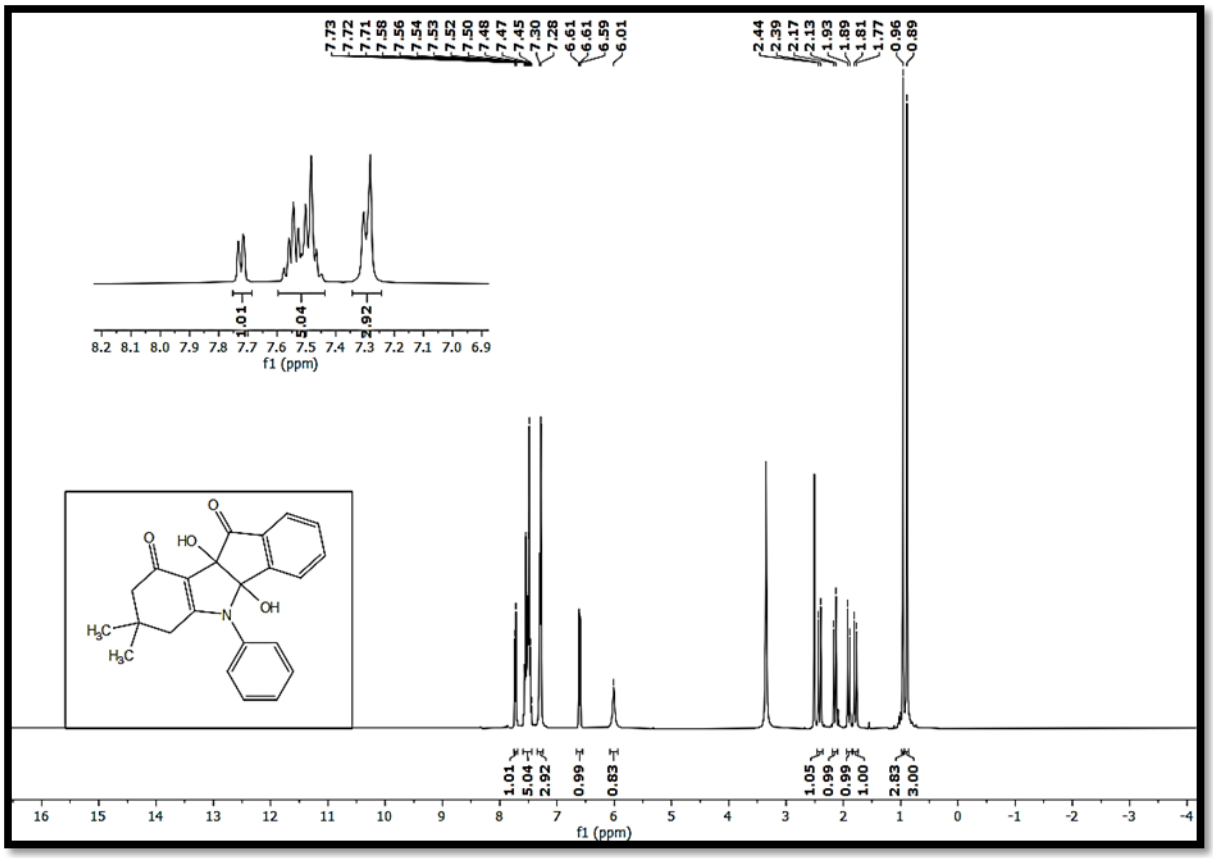

Figure S3. The ^1H NMR of **4a**

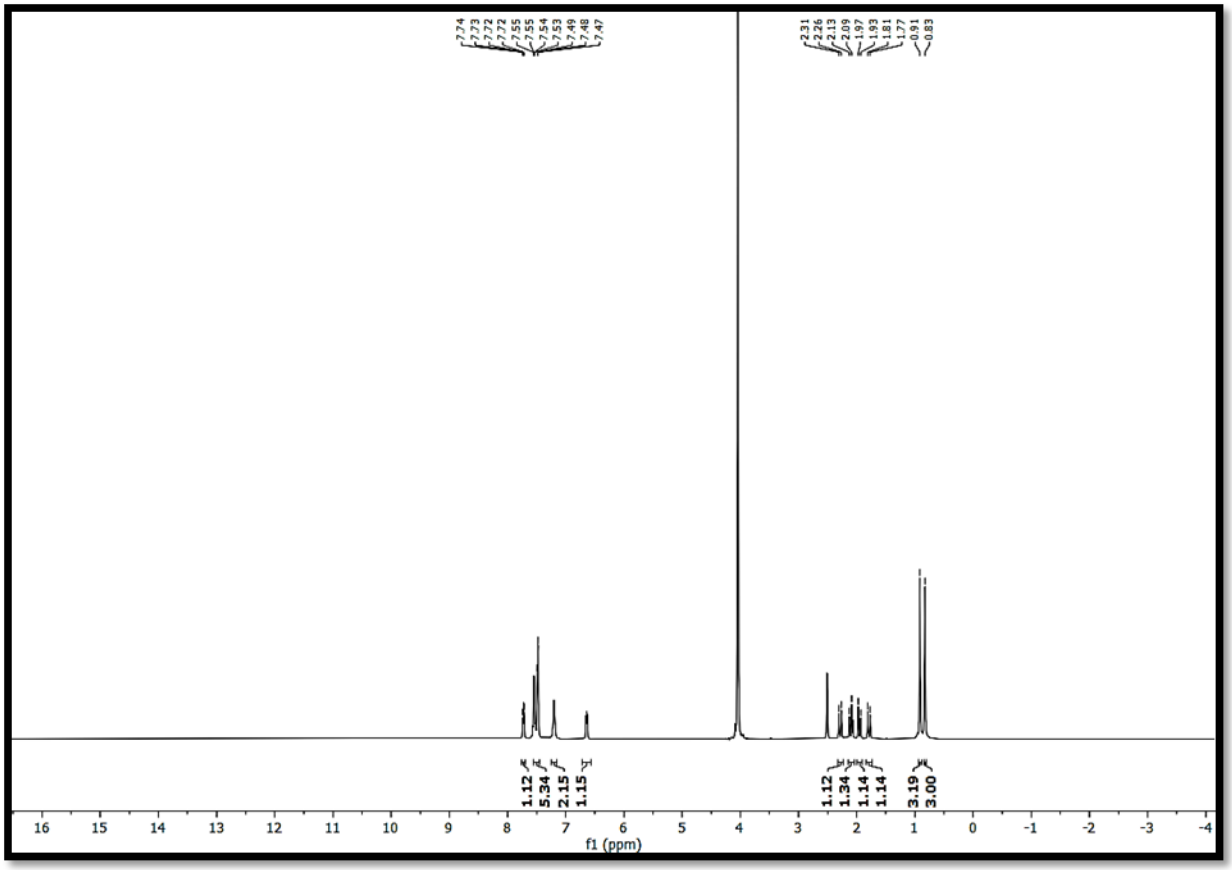

Figure S4. The ^{1}H NMR of **4a** in D_2O

5-(4-ethylphenyl)-4b,9b-dihydroxy-7,7-dimethyl-4b,5,6,7,8,9b-hexahydroindeno[1,2-b]indole-9,10-dione (4b): light brown solid (92%yield); $m.p_{rep.}$(^{0}C)= 145-150 ^{0}C, IR(KBr): ϑ 3398, 2956, 2876, 1724, 1610, 1551, 1156 cm^{-1} . H^{1} NMR (400MHZ, DMSO) (ppm)= 7.72 (d, *J*=4.0 Hz, 1H, ArH), 7.59-7.51 (m, 2H, ArH), 7.33 (d, *J*=8.0 Hz, 3H, ArH), 7.21 (s, 2H, ArH), 7.19 (s, 1H) , 6.66 (d, *J*=8.0 Hz, 1H, ArH), 5.97 (s, 1H), 2.7 (d, *J*=8.0 Hz, 2H, CH_2), 2.37 (d, *J*=16.0 Hz, 1H), 2.13 (d, *J*=16.0 Hz, 1H), 1.90 (d, *J*=16.0 Hz, 1H), 1.79 (d, *J*=16.0 Hz, 1H), 1.25 (t, *J*=8.0 Hz, 3H, Me), 0.88 (s, 3H, Me), 0.86 (s, 3H, Me); ^{13}C NMR (100 MHz, DMSO-d_6) δ (ppm)= 198.07, 189.57, 147.73, 144.01, 135.30, 135.20, 133.97, 130.62, 129.76, 128.72, 125.41, 123.62, 105.68, 97.10, 83.87, 51.66, 37.47, 33.87, 29.78, 28.27, 27.03, 15.85.

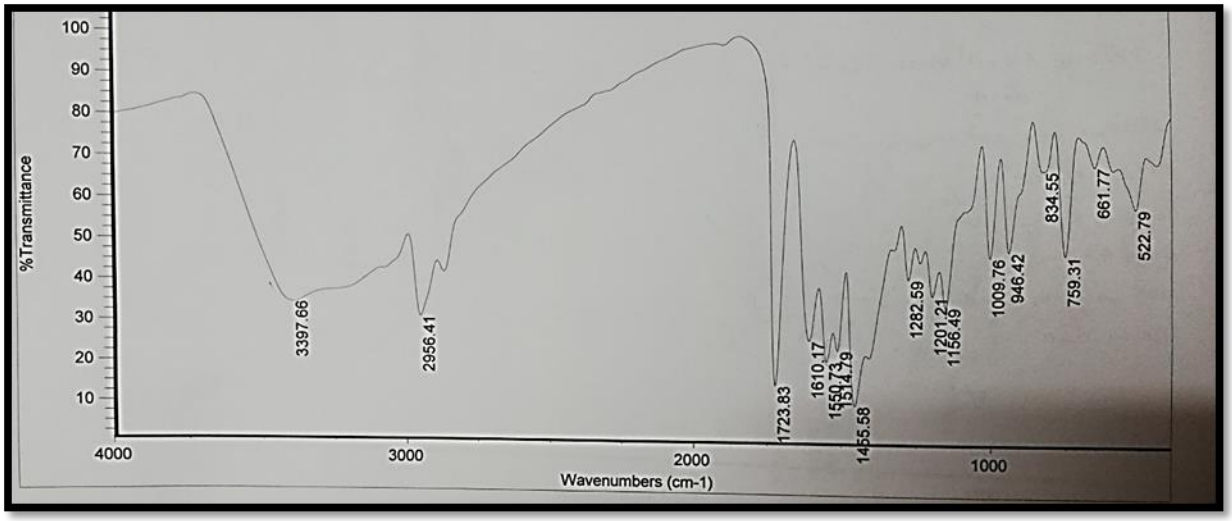

Figure S5. The FT-IR of **4b**

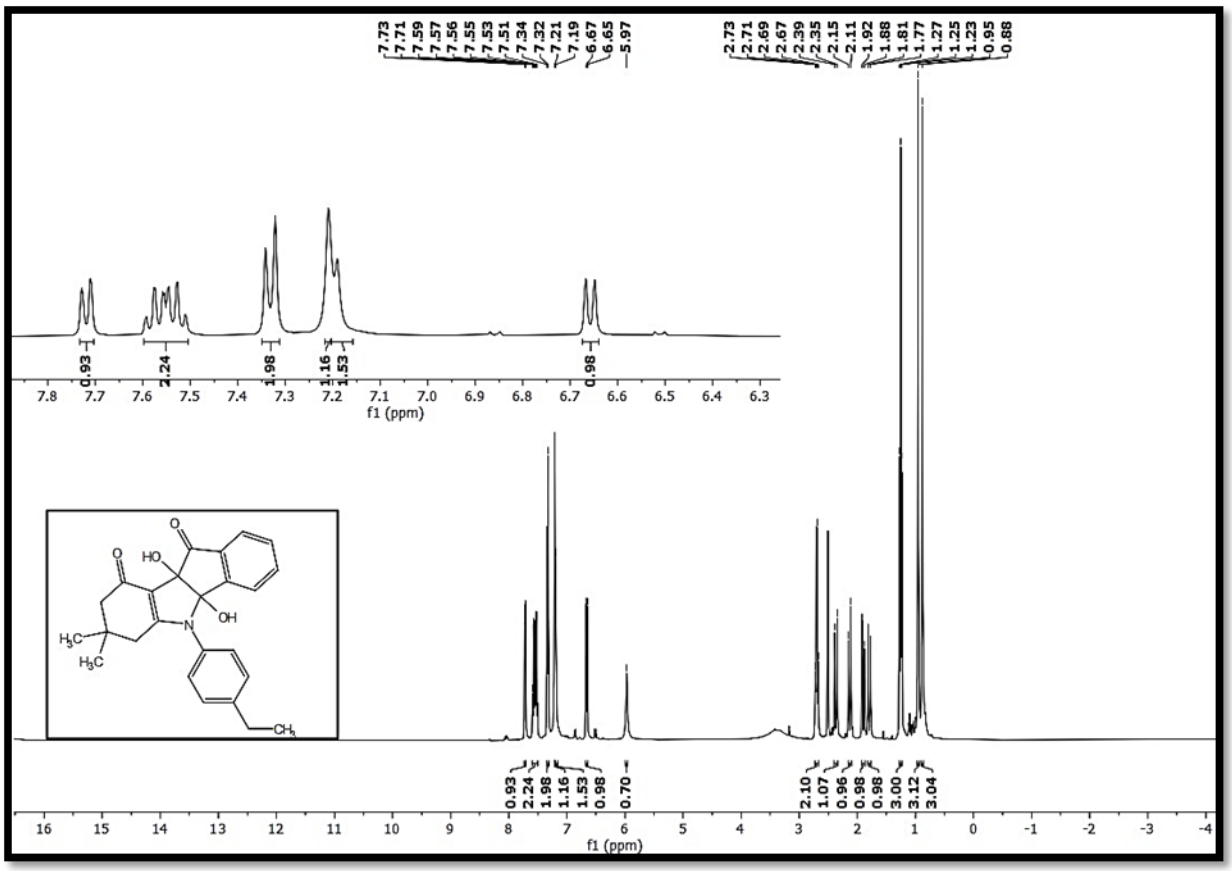

Figure S6. The ^{1}H NMR of **4b**

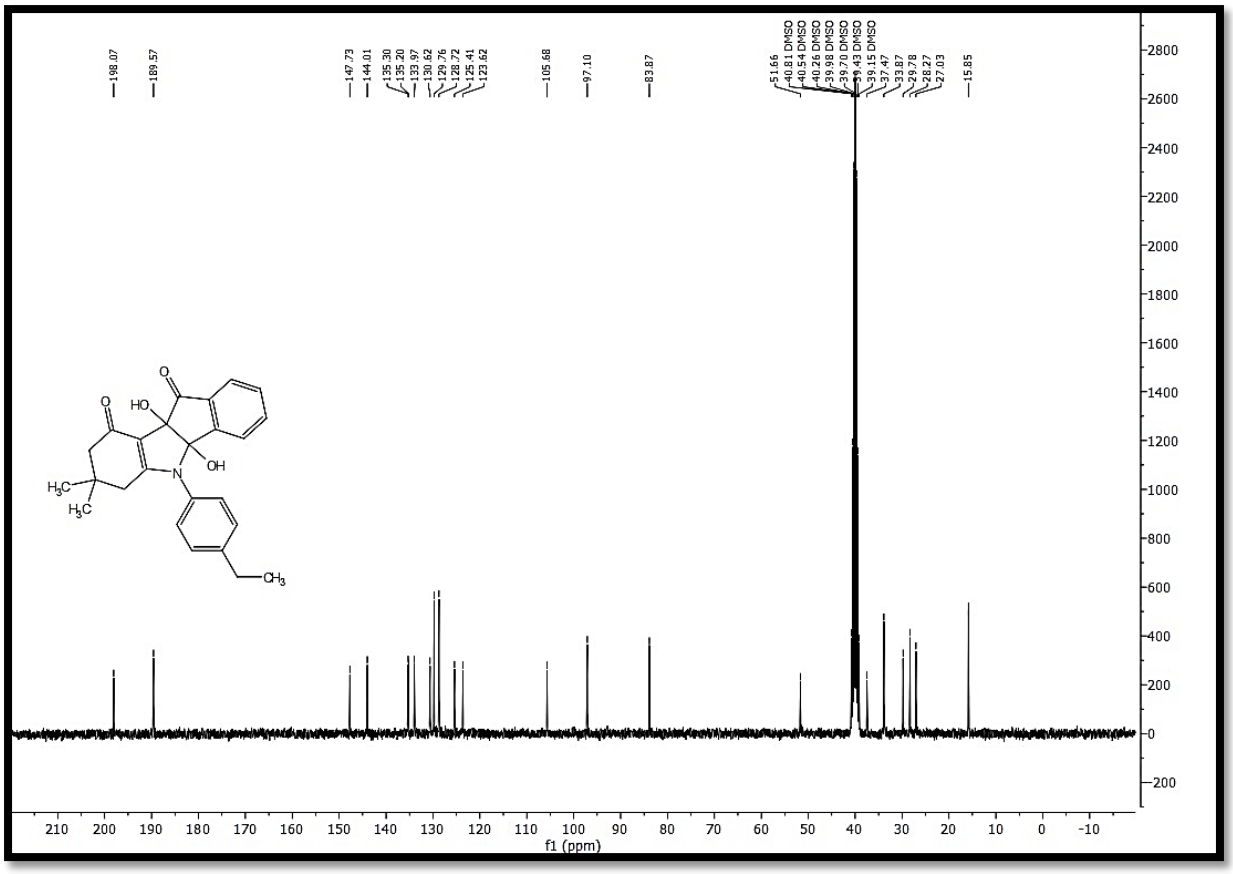

Figure S7. The ^{13}C NMR of **4b**

5-(3-chlorophenyl)-4b,9b-dihydroxy-7,7-dimethyl-4b,5,6,7,8,9b-hexahydroindeno [1,2-b] indole-9,10-dione (4c): white solid (90%yield); $m.p_{rep}.(\ ^0C\ )$=200-205 ^0C; $m.p_{lit}.(\ ^0C\ )$= 223-226 ^0C [19]; IR(KBr): ϑ 3564, 3391, 2947, 2873, 1719, 1641, 1480, 1159, 731 cm^{-1}. ^{1}HNMR (400MHz.DMSO) (ppm)= 7.61 (d, *J*=4.0 Hz, 1H, ArH), 7.51-7.56 (m, 5H, ArH), 7.30 (s, 1H, ArH), 7.18 (d, *J*=8.0, 1H, ArH), 2.48 (d, *J*=16.0 Hz, 1H), 2.15 (d, *J*=16.0 Hz, 1H), 1.90 (d, *J*=16.0 Hz,1H), 1.81 (d, *J*=16.0 Hz,1H), 0.96 (s, 3H, Me), 0.91 (s, 3H, Me)

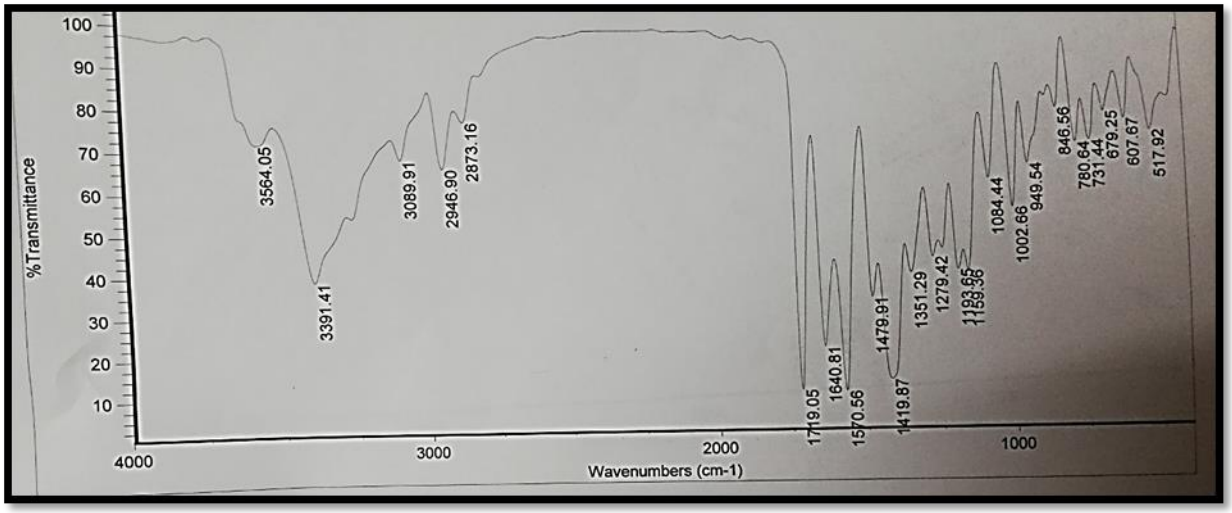

Figure S8. The FT-IR of **4c**

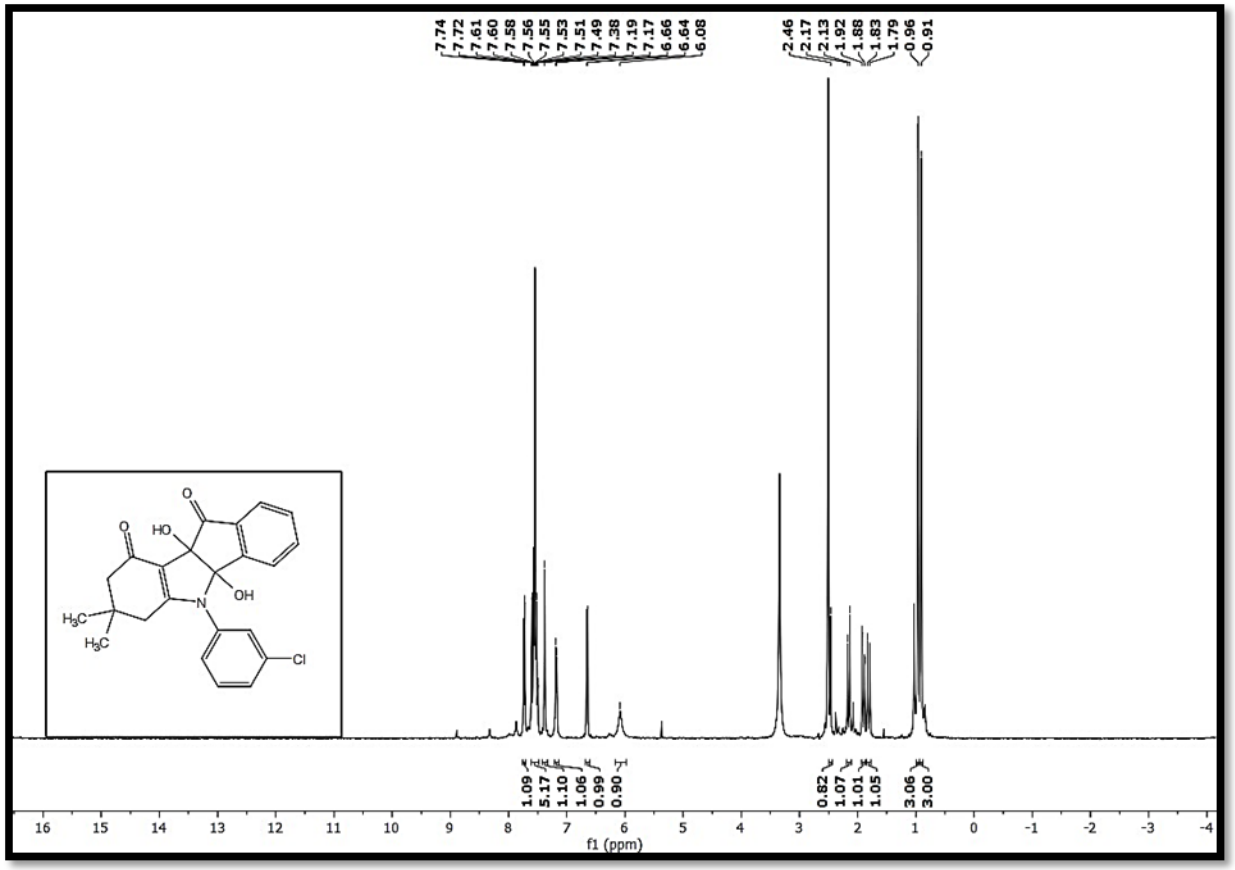

Figure S9. The ^{1}H NMR of **4c**

5-(4-bromophenyl)-4b,9b-dihydroxy-7,7-dimethyl-4b,5,6,7,8,9b-hexahydroindeno [1,2-b] indole-9,10-dione (4d): white solid (92% yield); m.p$_{rep}$.(^{0}C)= 195-200 ^{0}C; m.p$_{lit}$.(^{0}C)= 160-162 ^{0}C [2]; IR (KBr): ϑ 3465, 2957, 2883, 1722, 1602, 1489, 1148, 518 cm^{-1}. ^{1}H NMR (400 MHz, DMSO-d$_6$) (ppm)= 7.72 (t, *J*=8.0 Hz, 3H, ArH), 7.61 (t, *J*=8.0 Hz, 1H, ArH), 7.54 (t, *J*=8.0 Hz, 1H),7.35 (s, 1H), 7.26 (d, *J*=8.0 Hz, 2H, ArH, OH), 6.68 (d, *J*=8.0 Hz, 1H, ArH), 6.05 (s, 1H, OH), 2.42 (d, *J*=16.0 Hz, 1H), 2.15 (d, *J*=16.0 Hz, 1H), 1.90 (d, *J*=16.0 Hz, 1H), 1.81 (d, *J*=16.0 Hz, 1H), 0.95 (s, 3H, Me), 0.90 (s, 3H, Me)

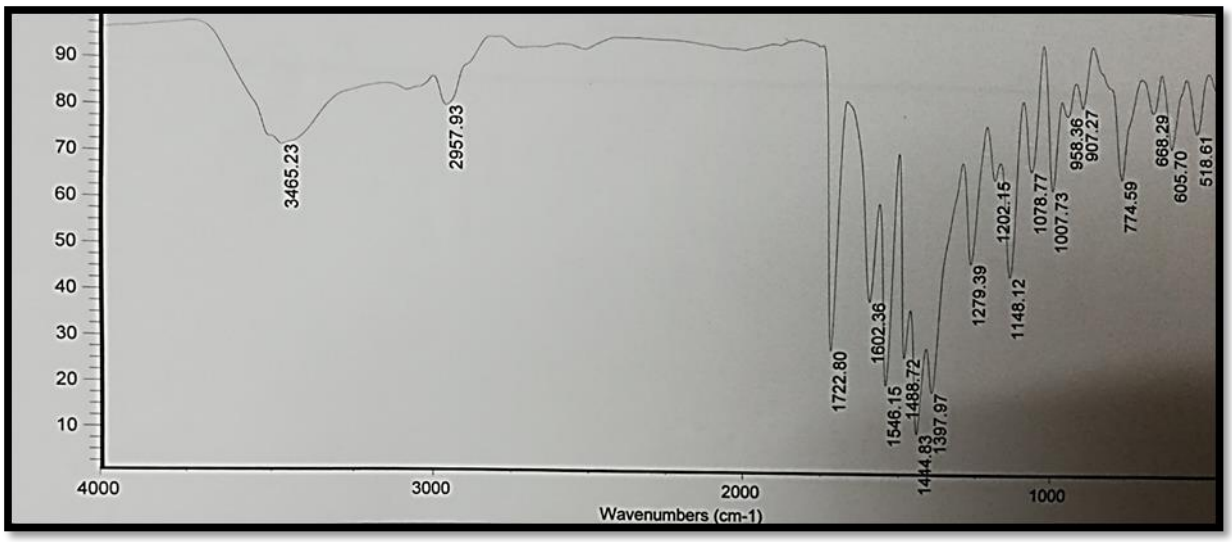

Figure S10. The FT-IR of **4d**

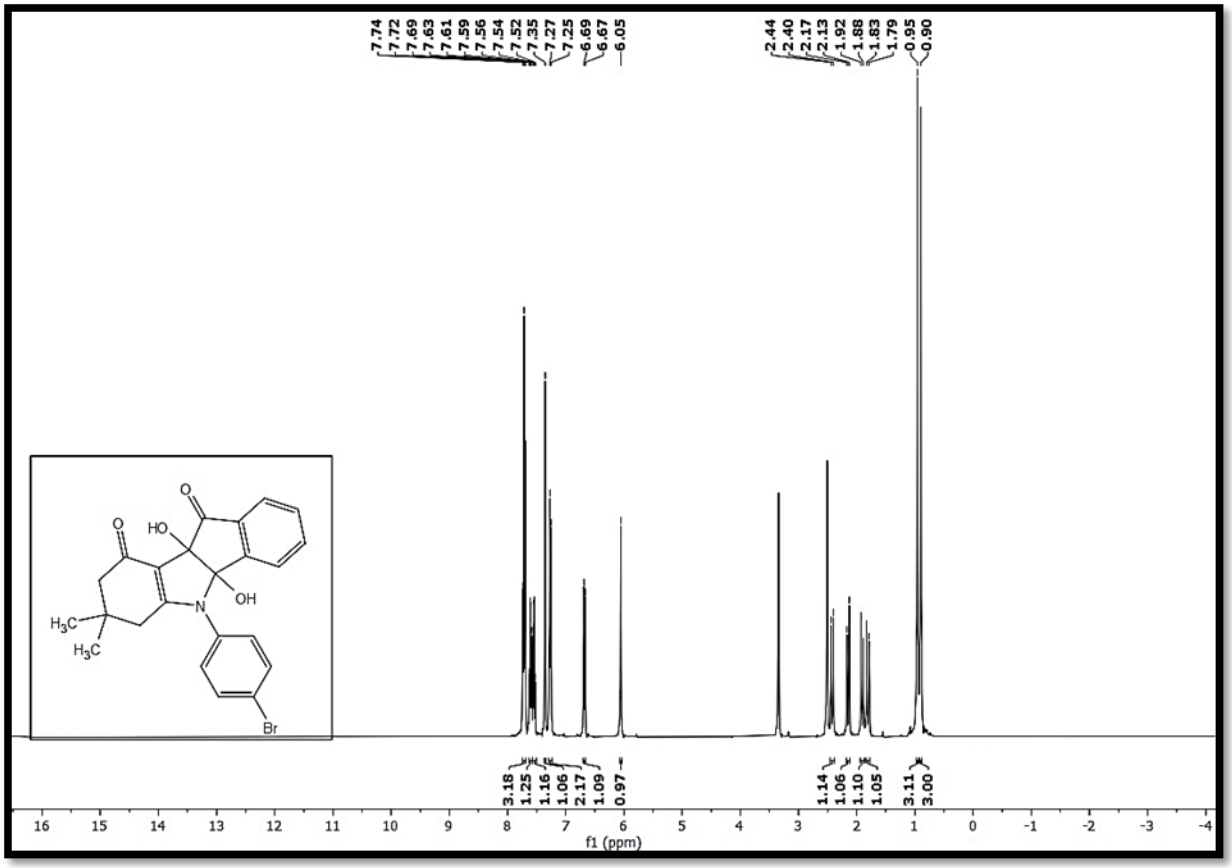

Figure S11. The ^{1}H NMR of **4d**

4b,9b-dihydroxy-7,7-dimethyl-5-(naphthalene-1-yl)-4b,5,6,7,8,9b-hexahydroindeno [1,2-b] indole-9,10-dione(4e): light yellow solid: (93%yield); m.p$_{rep}$.(^{0}C)= 205-210 ^{0}C; m.p$_{lit}$.(^{0}C)=186-188 ^{0}C [20]; IR(KBr): ϑ 3381, 2931, 1712, 1608, 1448, 1157 cm^{-1}. ^{1}HNMR (400 MHz, DMSO-d$_6$) (ppm)= 8.04-8.13 (m, 1H), 7.99 (d, *J*=8.0Hz, 1H, ArH), 7.93 (d, *J*=8.0Hz, 1H, ArH), 7.70-7.81 (m, 2H, ArH), 7.57-7.63 (m, 1H, ArH), 7.40-7.45 (m, 2H, ArH), 7.05-7.17 (m, 2H, ArH, OH), 6.36 (d, *J*=8.0 Hz, 1H, ArH), 6.29 (d, *J*=4.0 Hz, 1H, ArH), 6.02 (s, 1H, OH), 1.79-2.16 (m, 4H), 0.90 (s, 3H, Me), 0.78 (s, 3H, Me)

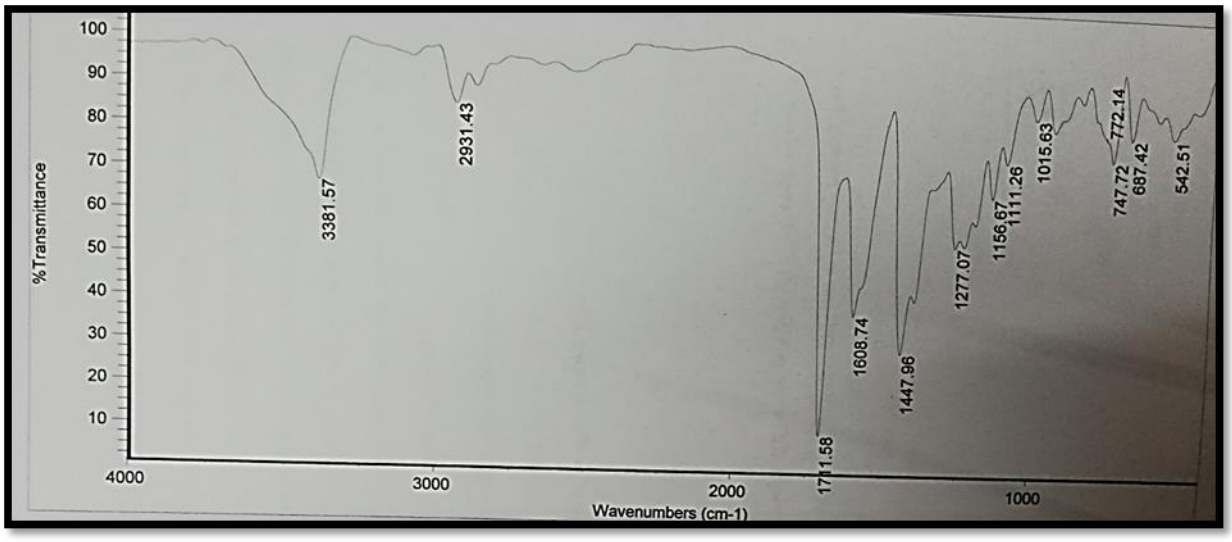

Figure S12. The FT-IR of **4e**

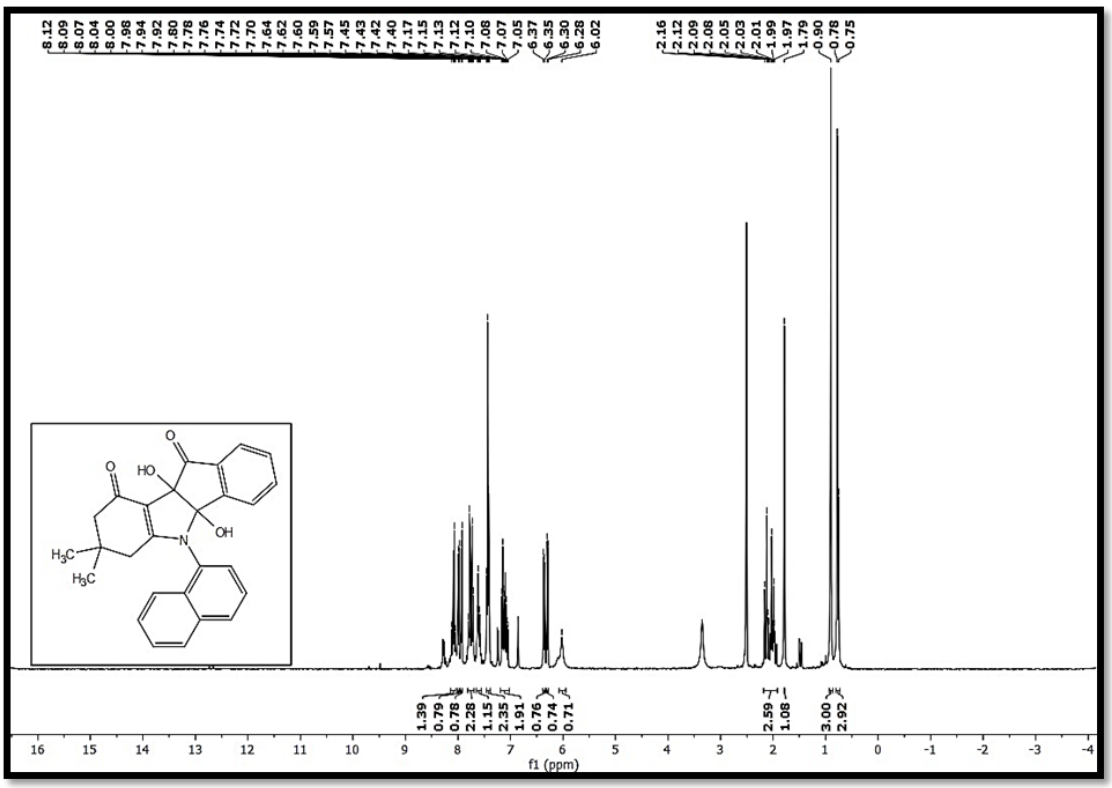

Figure S13. The ^{1}H NMR of **4e**

5,5'-(1,4-phenylene)bis(4b,9b-dihydroxy-7,7-dimethyl-4b,5,6,7,8,9b-hexahydroindeno [1,2-b] indole-9,10-dione) (4f): smoky solid (95%yield); m.p$_{rep}$.(^{0}C)= 305-310^{0}C; IR (KBr): ϑ 3357, 3176, 2960, 1719, 1567, 1507, 1449, 1380, 1157 cm^{-1}. ^{1}HNMR (400MHz.DMSO) (ppm)= 7.77(d ,*J*=8.0Hz, 2H, ArH), 7.68 -7. 56 (m, 4H, ArH), 7.45-7.39 (m, 6H, ArH, OH), 6.75-6.79 (m,2H,ArH), 6.09 (s, 2H, OH), 2.56 (d, *J*=16.0 Hz, 2H), 2.18 (d, *J*=16.0 Hz, 2H), 1.95 (d, *J*=4.0 Hz, 2H), 1.92 (d, *J*=16.0 Hz ,2H), 1.02 (s, 6H, Me), 0.95 (s, 6H, Me); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ (ppm)= 198.06, 189.93, 163.66, 147.75, 136.13, 135.31, 130.93, 130.06, 129.81, 123.93, 106.68, 97.40, 83.91, 51.75, 37.56, 34.17, 34.13, 30.05.

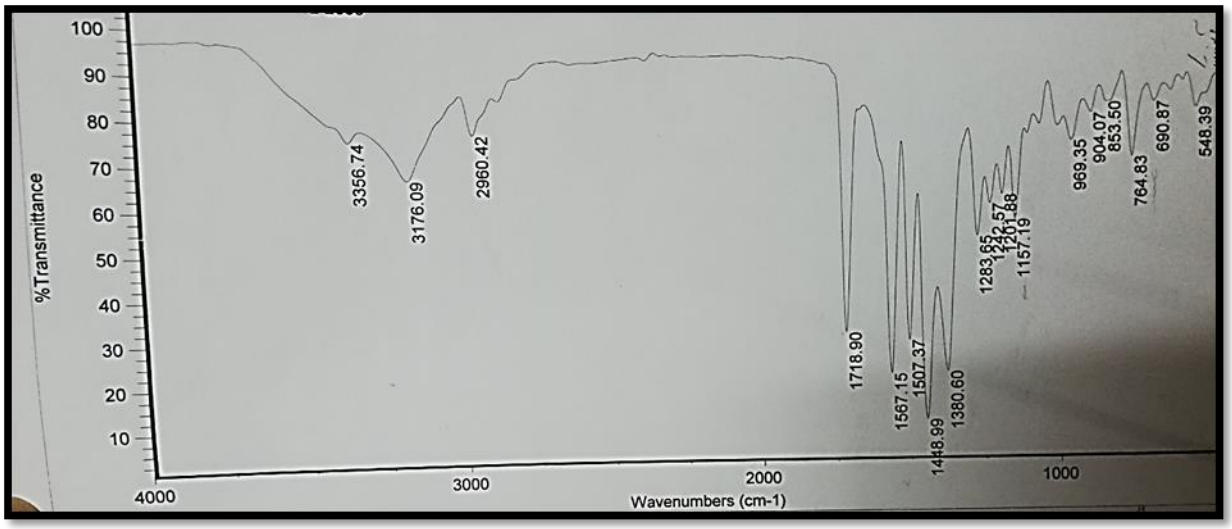

Figure S14. The FT-IR of **4f**

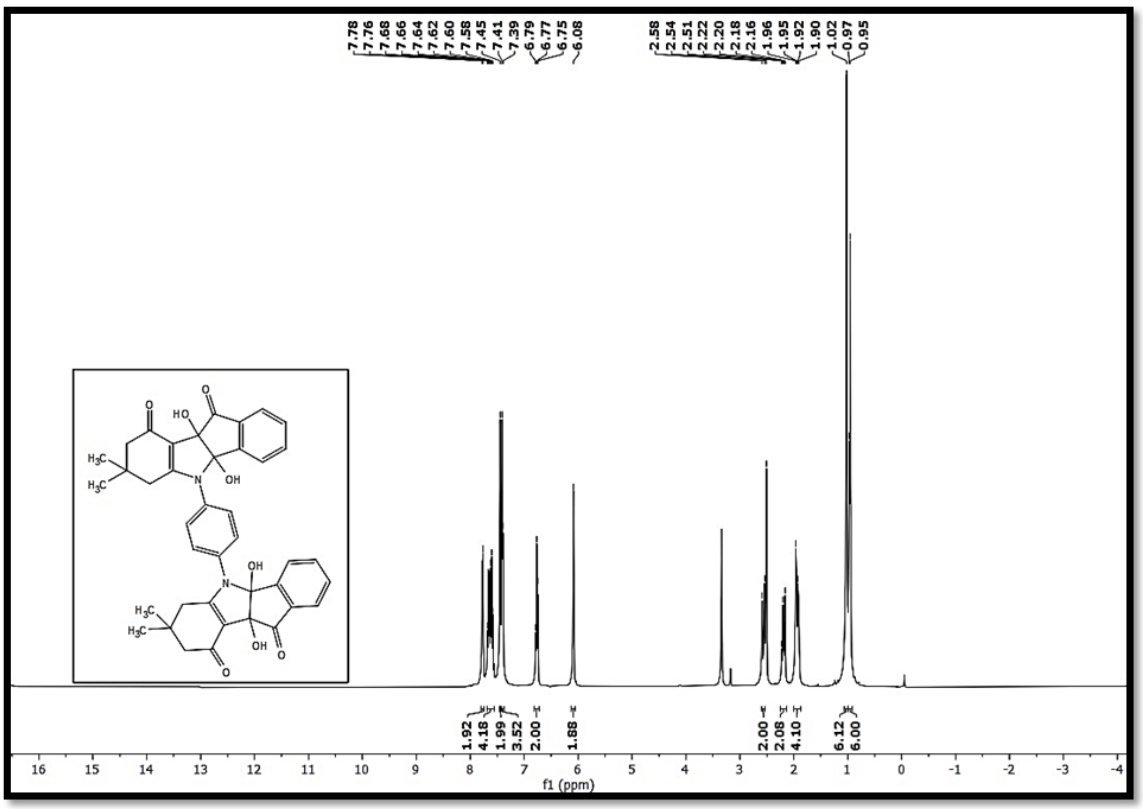

Figure S15. The ^{1}H NMR of **4f**

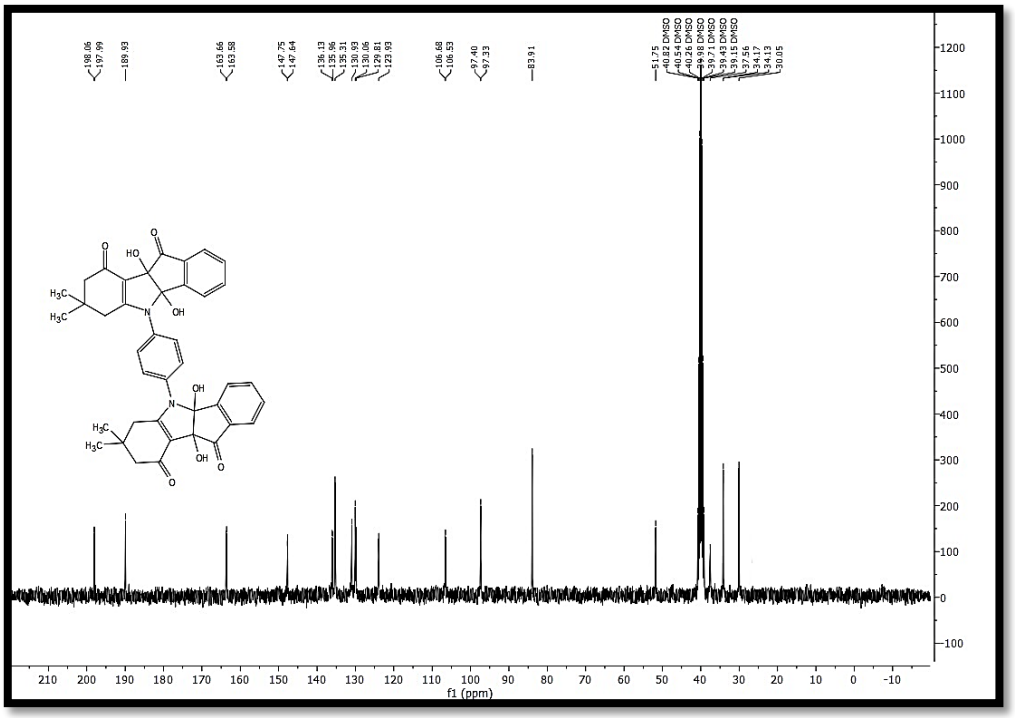

Figure S16. The ^{13}C NMR of **4f**

5-(2-chlorophenyl)-4b,9b-dihydroxy-7,7-dimethyl-4b,5,6,7,8,9b-hexahydroindeno [1,2-b] indole-9,10-dione (4g): white solid (92%yield); $m.p_{rep}.(\ ^0C\ )$= 240-245 ^0C; $m.p_{lit}.(\ ^0C\ )$= 230-231 ^0C [1]; IR (KBr): ϑ 3417, 2955, 2874, 1714, 1571, 1446, 1155, 772 cm^{-1}. ^{1}HNMR (400MHz.DMSO) (ppm)= 2.83 (d, *J*=4.0Hz, 1H, ArH), 7.74 (d, *J*=8.0Hz, 1H, ArH), 7.53-7.55 (m,5H,ArH), 7.38 (s, 1H, OH), 6.66(d, *J*=4.0 Hz, ArH), 5.96 (s, 1H, OH), 2.08-1.95 (m, 4H), 0.97 (s, 3H, Me), 0.87 (s, 3H, Me)

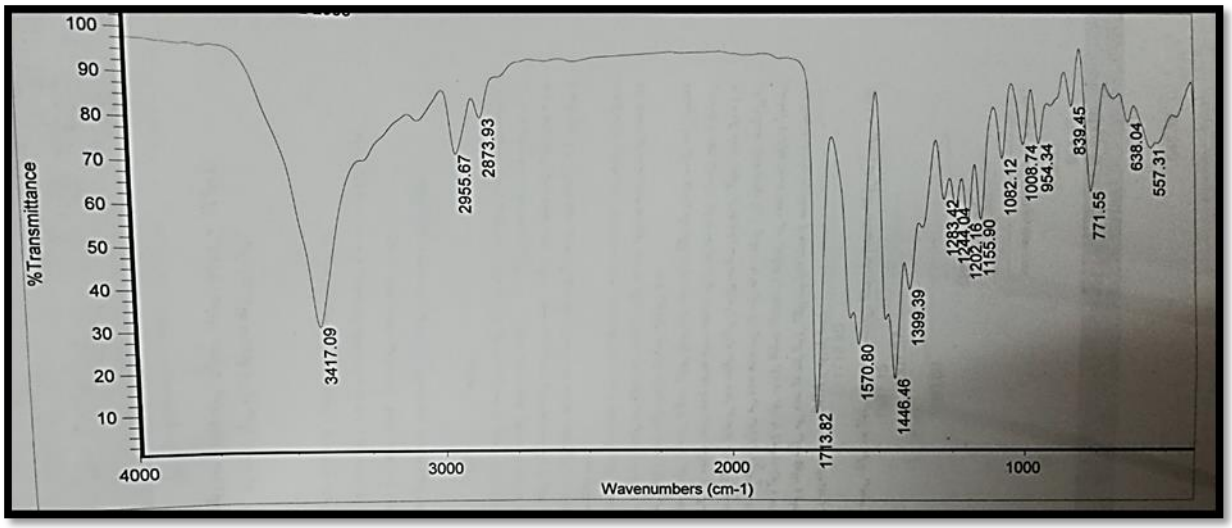

Figure S17. The FT-IR of **4g**

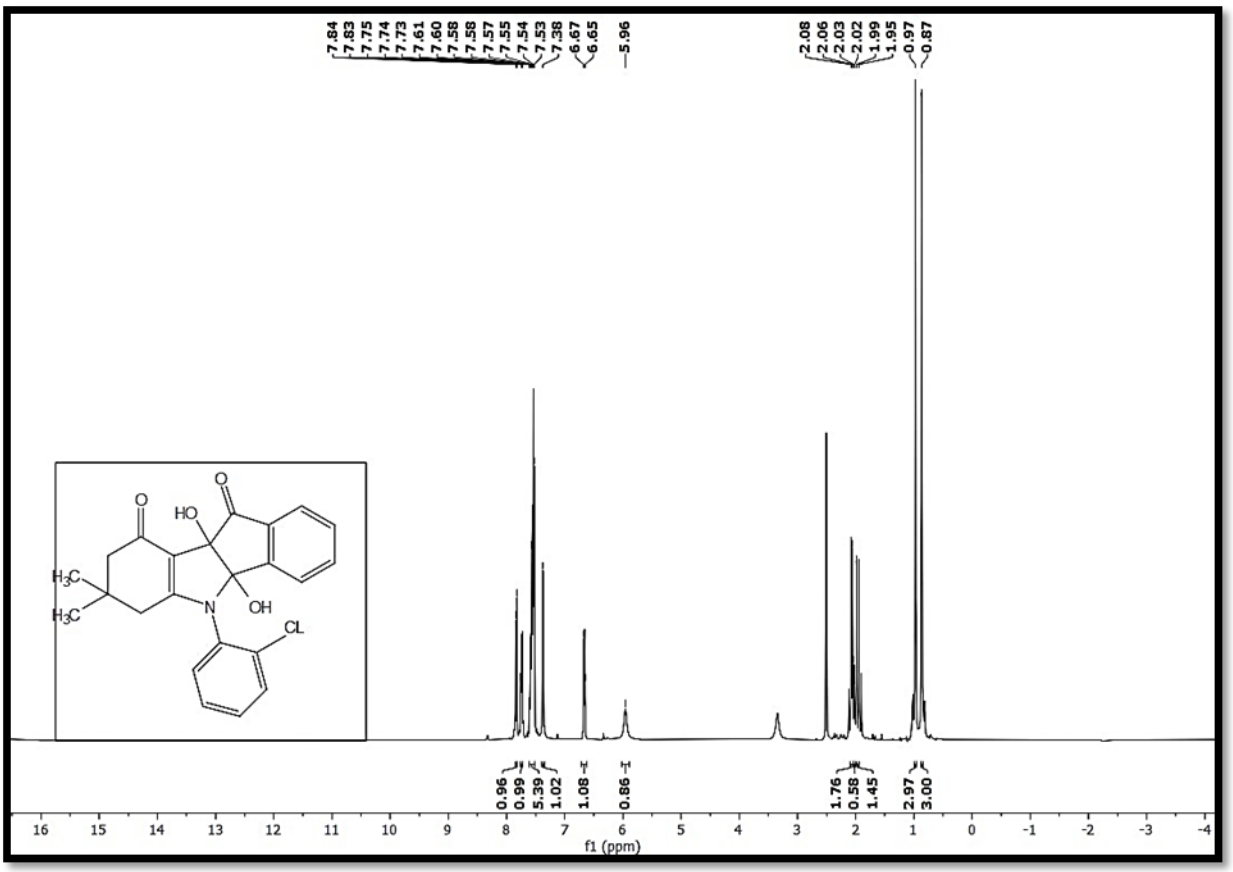

Figure S18. The ^{1}H NMR of **4g**

4b,9b-dihydroxy-5-(4-methoxyphenyl)-7,7-dimethyl-4b,5,6,7,8,9b-hexahydroindeno [1,2-b] indole-9,10-dione (4h): gray solid (91%yield); $m.p_{rep}.(\ ^0C\ )$= 210-215 ^0C; $m.p_{lit}.(\ ^0C\ )$= 224-226 ^0C [1];

IR (KBr): ϑ 3410, 3037, 2951, 2715, 1728, 1607, 1512, 1441, 1149 cm^{-1}. ^{1}HNMR (400MHz.DMSO) (ppm)= 7.72(d, *J*=8.0Hz, 1H, ArH), 7.60-7.51 (m, 2H, ArH), 7.31-7.16 (m, 5H, ArH, OH), 6.66 (d, *J*=8.0Hz, 1H, ArH), 5.98 (s, 1H, OH), 2.39 (s, 3H, OMe), 2.35 (s, 1H), 2.13 (d, *J*=16.0 Hz, 1H), 1.89 (d, *J*=16.0 Hz, 1H), 1.77 (d, *J*=16.0 Hz, 1H), 0.91 (s, 3H, Me), 0.88 (s, 3H, Me)

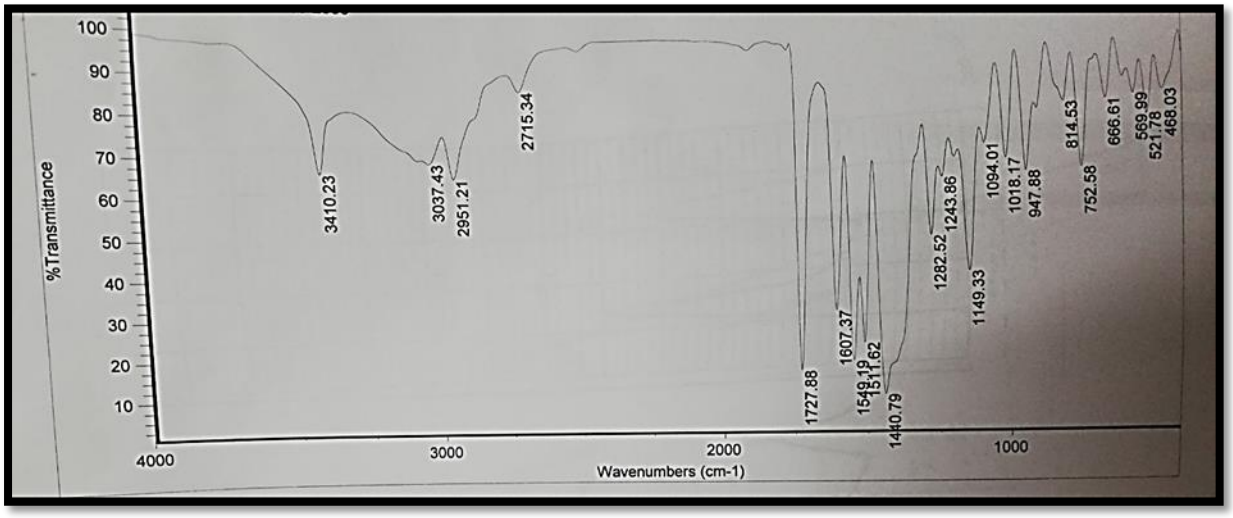

Figure S19. The FT-IR of **4h**

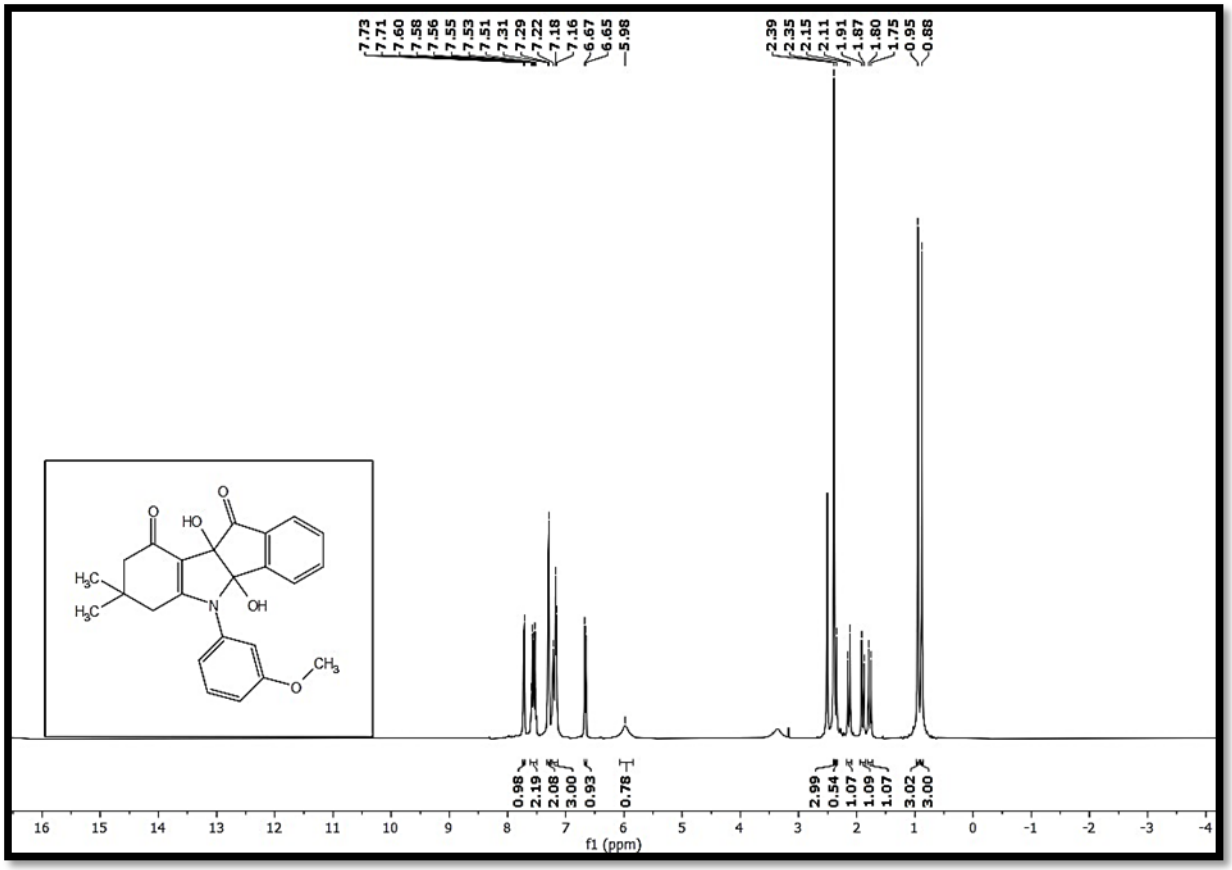

Figure S20. The ^{1}H NMR of **4h**

5-(4-chlorophenyl)-4b,9b-dihydroxy-7,7-dimethyl-4b,5,6,7,8,9b-hexahydroindeno [1,2-b]indole-9,10-dione (4i): white solid (93%yield); m.p_{rep}.(^{0}C)= 223-228 ^{0}C; m.p_{lit}.(^{0}C)= 235-236 ^{0}C [1]; IR (KBr): ϑ 3423, 2952, 1713, 1621, 1553, 1449, 1183, 771 cm^{-1}. ^{1}HNMR (400MHz.DMSO) (ppm)= 7.73

(d, *J*=8.0Hz, 1H ,ArH), 7.62-7.52 (m, 4H, ArH), 7.36 (s, 1H, OH), 7.33 (d, *J*=8.0Hz, 2H, ArH), 6.67 (d, *J*=8.0Hz ,1H, ArH), 6.06 (S, 1H, OH), 2.42 (d, *J*=20.0 Hz, 1H), 2.15 (d, *J*=16.0 Hz, 1H), 1.90 (d, *J*=16.0 Hz, 1H), 1.80 (d, *J*=20.0 Hz, 1H), 0.96 (s, 3H, Me), 0.90 (s, 3H, Me)

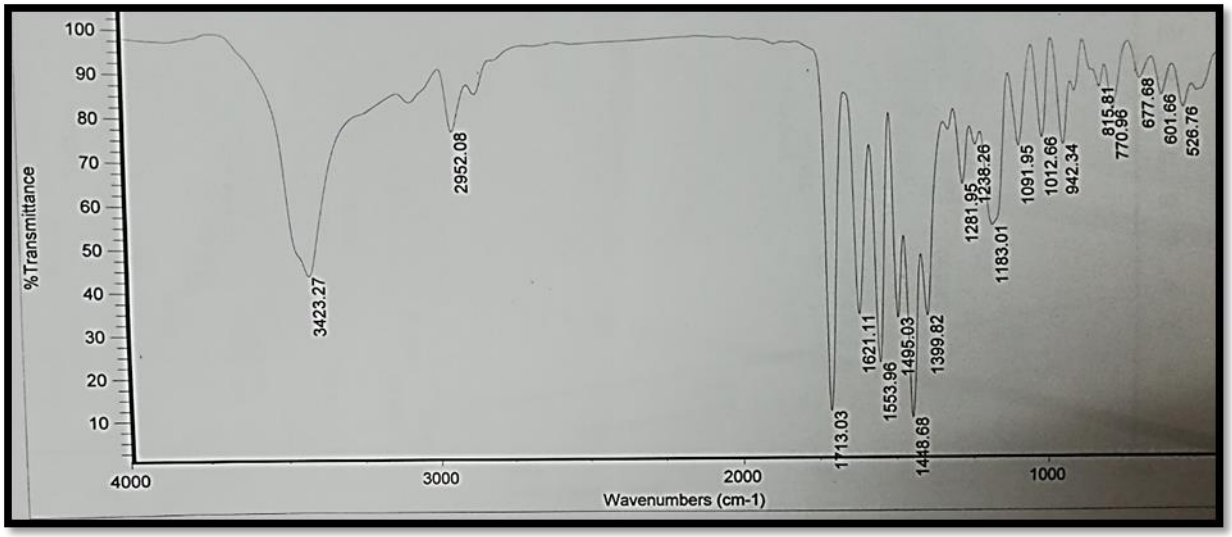

Figure S21. The FT-IR of **4i**

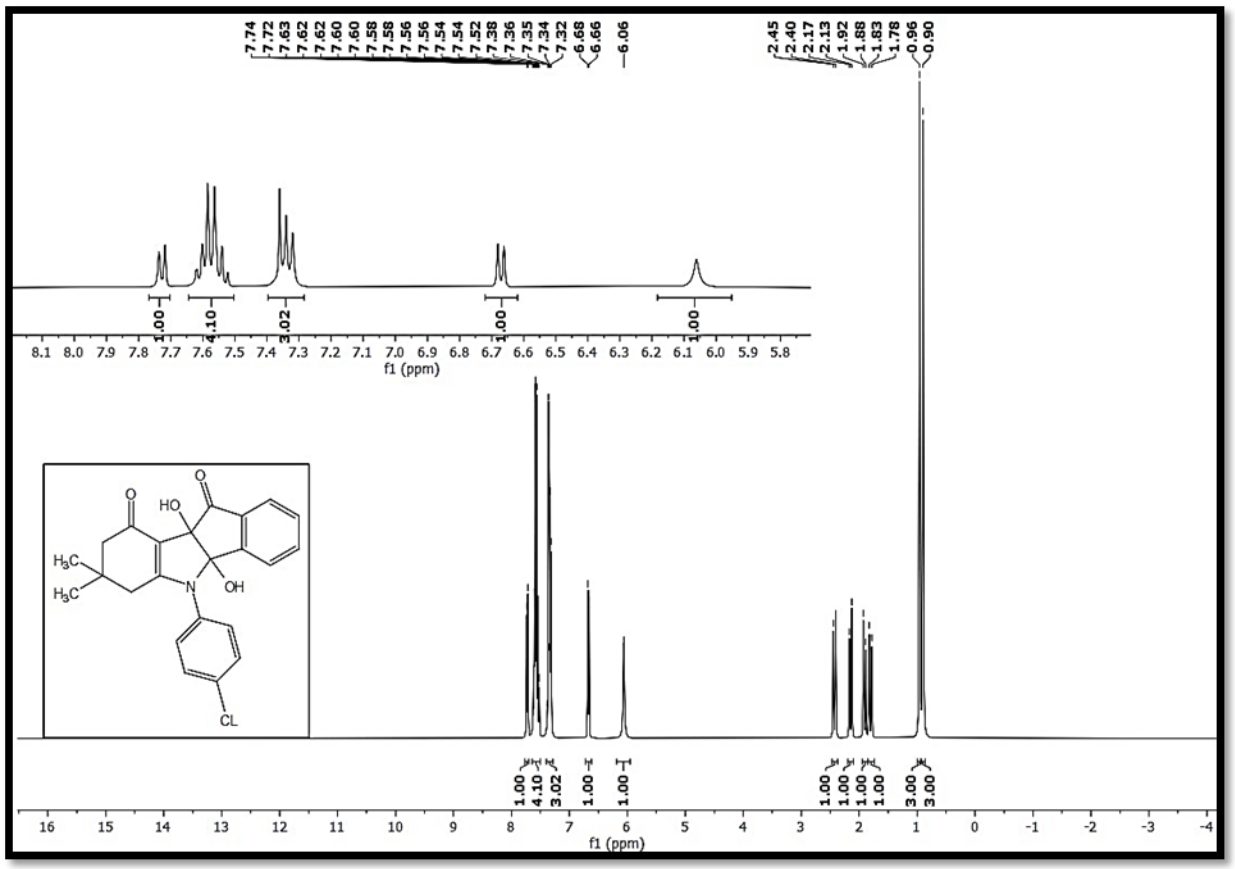

Figure S22. The ^{1}H NMR of **4i**

5,5'-(pyridine-2,6-diyl)bis(4b,9b-dihydroxy-7,7-dimwthyl-4b,5,6,7,8,9b-hexahydroindeno [1,2-b] indole-9,10-dione) (4j): pale yellow (94%yield); m.p$_{rep}$.(^{0}C)= 215-220 ^{0}C; IR (KBr): ϑ 3389, 3254, 2943, 2879, 1713, 1660, 1607, 1464, 1255, 1164 cm^{-1}. ^{1}HNMR (400MHz.DMSO) (ppm)= 8.34-8.21 (m, 2H, ArH), 8.87-7.43 (m, 11H, ArH, OH), 6.28 (s, 2H , OH), 2.37-1.99 (m, 8H), 1.03 (s, 6H, Me),

0.85 (s, 6H, Me); ^{13}C NMR (100 MHz, DMSO-d_6) δ (ppm)= 197.55, 193.18, 175.94, 152.58, 147.25, 136.62, 134.70, 131.88, 125.30, 123.47, 112.94, 111.67, 91.09, 90.91, 82.60, 51.58, 37.63, 33.45,27.81.

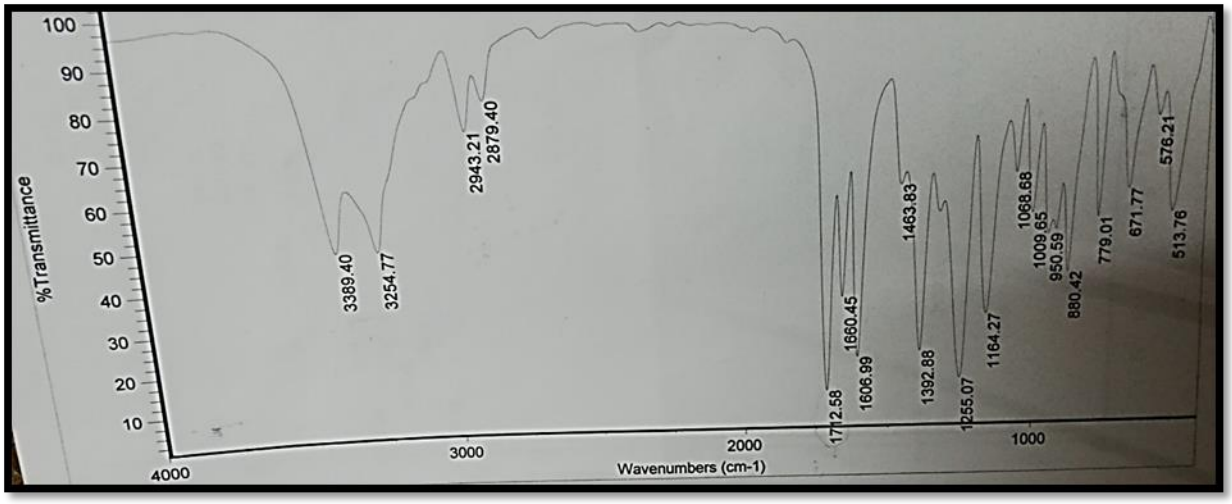

Figure S23. The FT-IR of **4j**

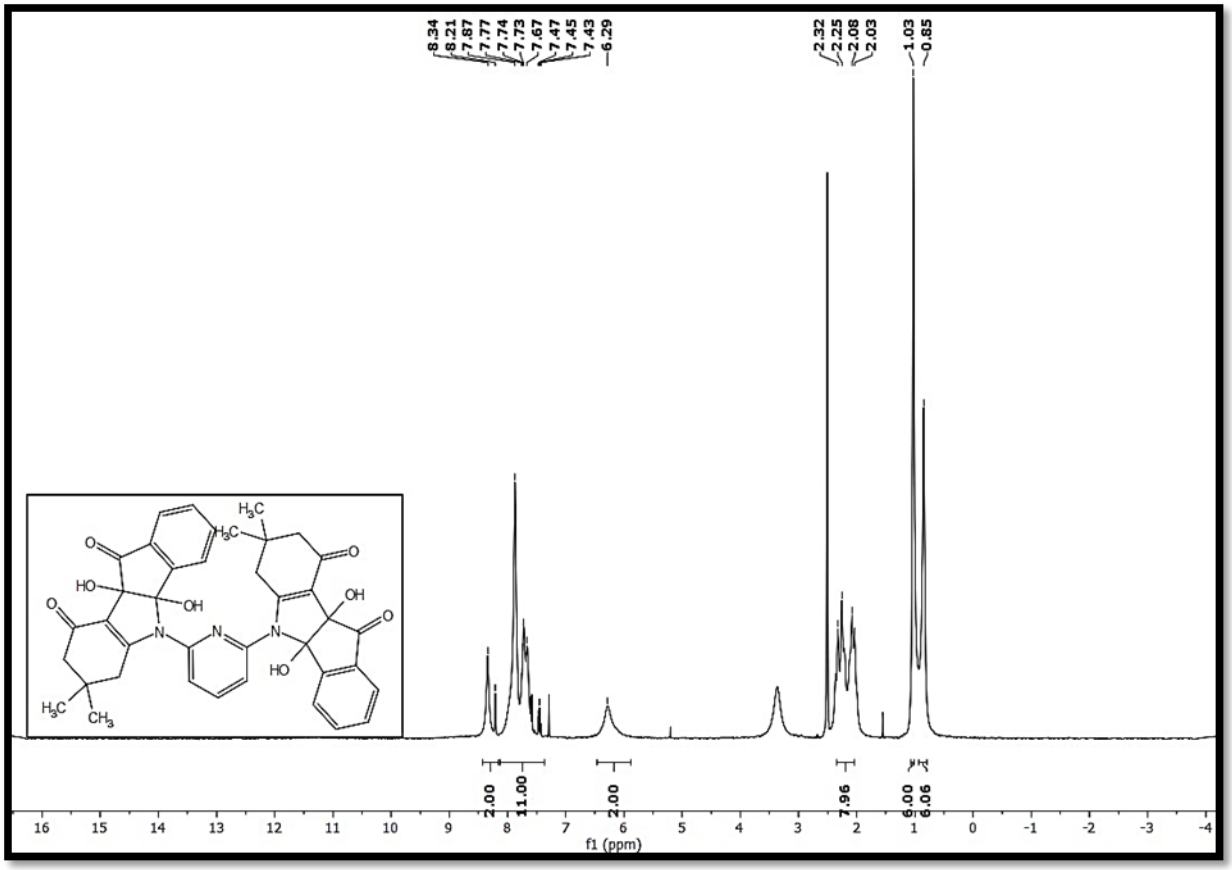

Figure S24. The ^{1}H NMR of **4j**

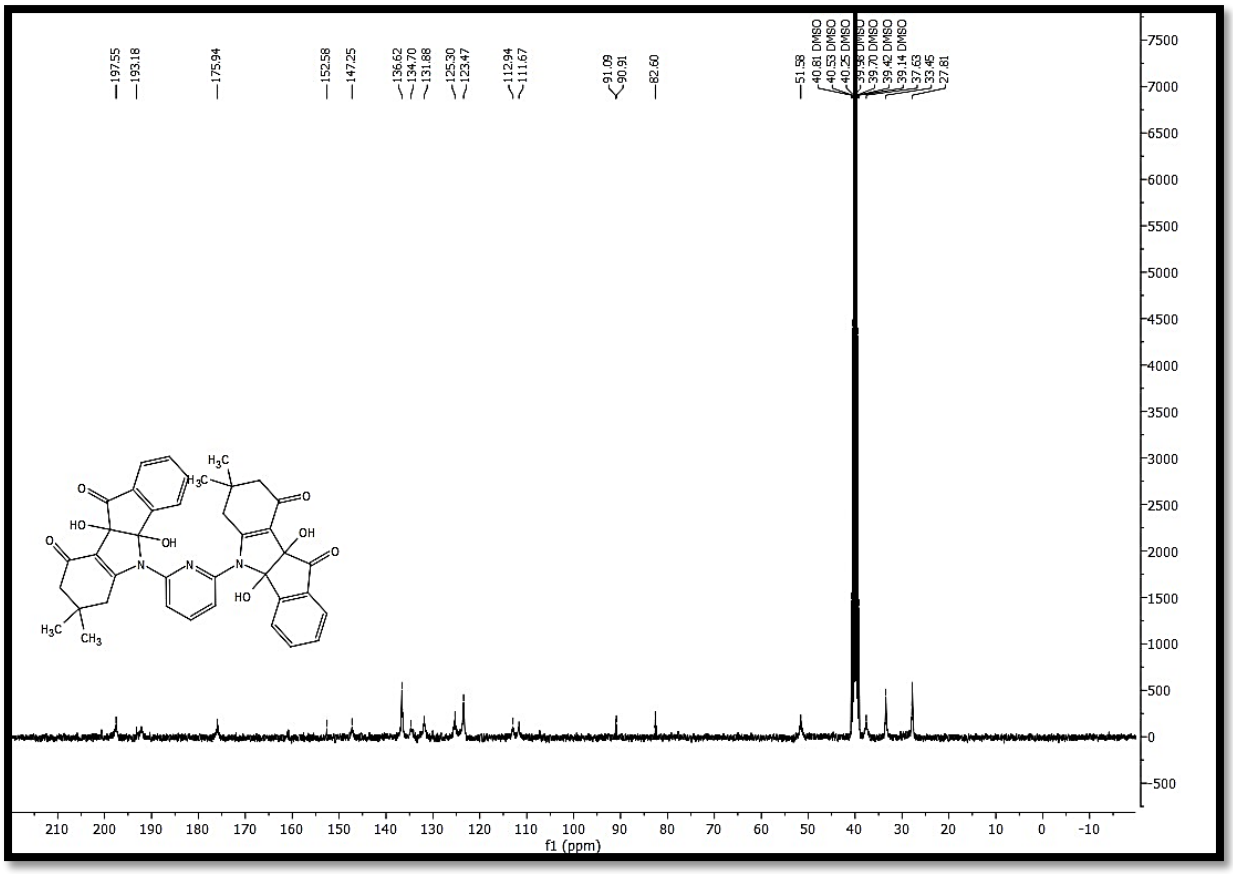

Figure S25. The ^{1}C NMR of **4j**

5,5'-(sulfonylbis(4,1-phenylene))bis(4b,9b-dihydroxy-7,7-dimethyl-4b,5,6,7,8,9b-hexahydroindeno [1,2-b] indole-9,10-dione) (4k): white solid (95%yield); m.p$_{rep.}$(^{0}C)= 290-295 ^{0}C; FT-IR (KBr): ϑ 3393, 2959, 2879, 1724, 1624, 1560, 1493, 1432, 1289 cm^{-1}. ^{1}H NMR (400MHz.DMSO) (ppm)= 8.16-8.19 (m, 3H), 7.72 (d, *J*=4Hz, 2H), 7.65 (d, *J*=8Hz, 4H), 7.58 (s, 2H), 7.49-7.55 (m, 5H), 6.54-6.58 (m, 2H), 6.19 (s, 2H), 2.53-2.57 (m, 2H), 2.12-2.19 (m, 2H), 1.86-1.94 (m, 4H), 0.94 (s,6H,Me), 0.88 (s, 6H, Me); ^{13}C NMR (100 MHz, DMSO-d$_6$) δ (ppm)= 197.75, 190.35, 147.37, 142.04, 139.80, 135.51, 135.13, 130.89, 130.04, 129.03, 124.91, 123.85, 113.61, 108.00, 97.82, 83. 98, 51.68, 37.55, 34.25, 29.86.

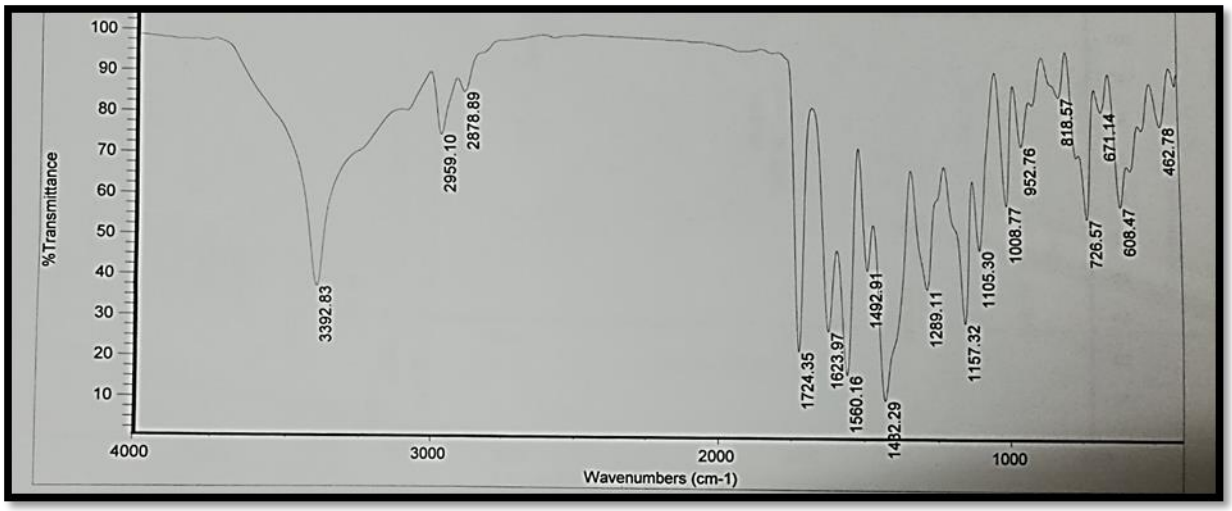

Figure S26. The FT-IR of **4k**

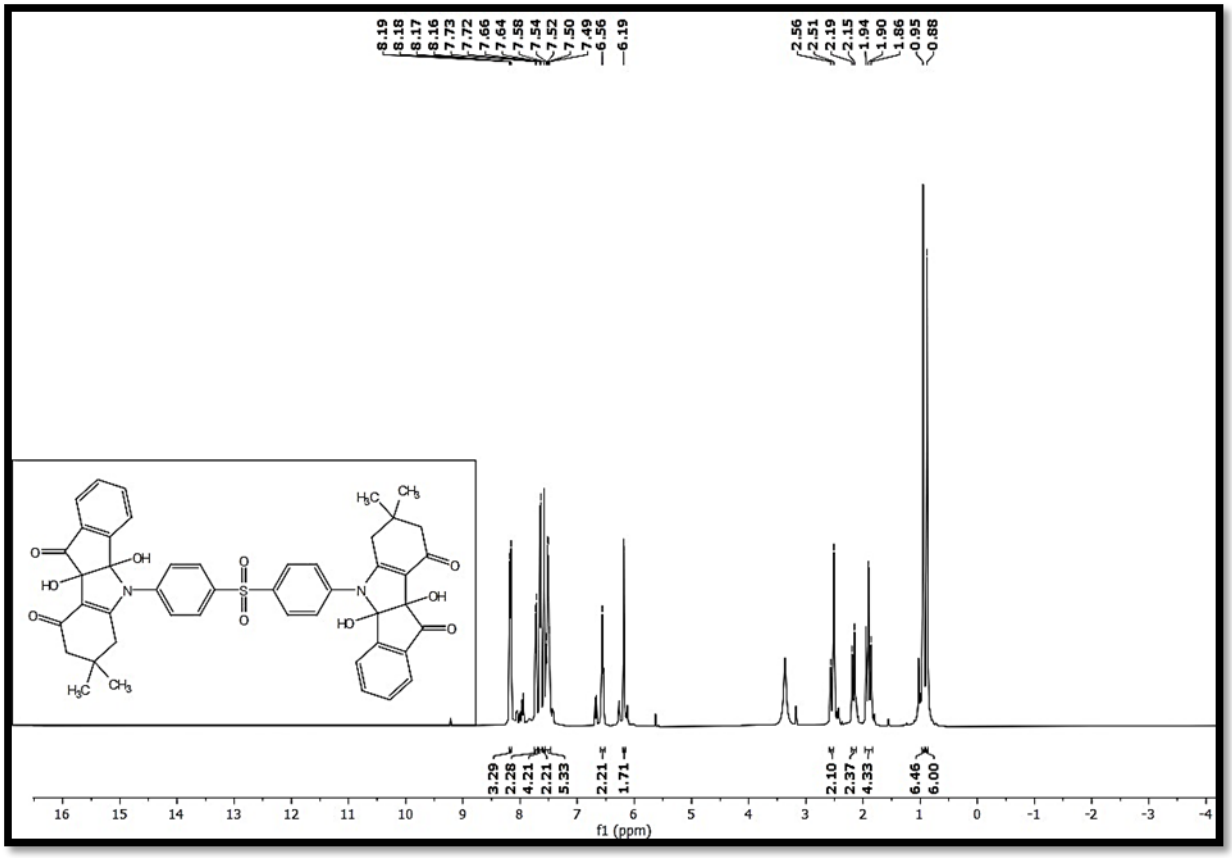

Figure S27. The ^{1}H NMR of **4k**

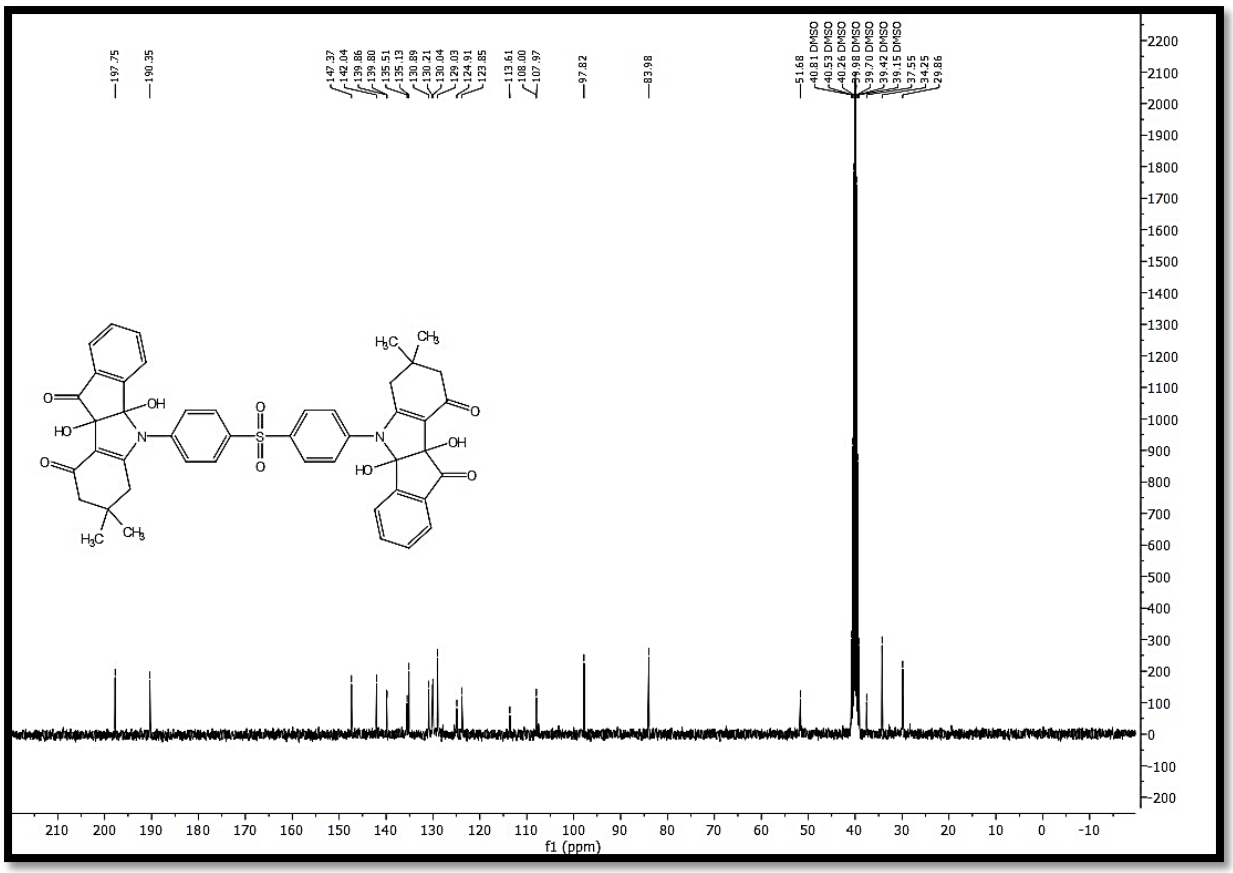

Figure S28. The ^{1}C NMR of **4k**

4b,9b-dihydroxy-7,7-dimethyl-5-(o-tolyl) -4b,5,6,7,8,9b- hexahydroindeno [1,2-b] indole-9,10-dione (4l): white solid (92%yield); m.p_{rep}.(^{0}C)= 215-220 ^{0}C; m.p_{lit}.(^{0}C)= 217-216 ^{0}C[1]; FT-IR (KBr): ϑ 3392, 2959, 1724, 1624, 1493, 1289, 1157 cm^{-1}. ^{1}H NMR (400MHz.DMSO) (ppm)= 8.34 (s, 1H), 7,66-7.88 (m, 8H), 6.29 (s, 1H), 2.33 (s, 1H), 2.00-2.12 (m, 3H), 1.03 (s, 6H, Me), 0.85 (s, 3H, Me).

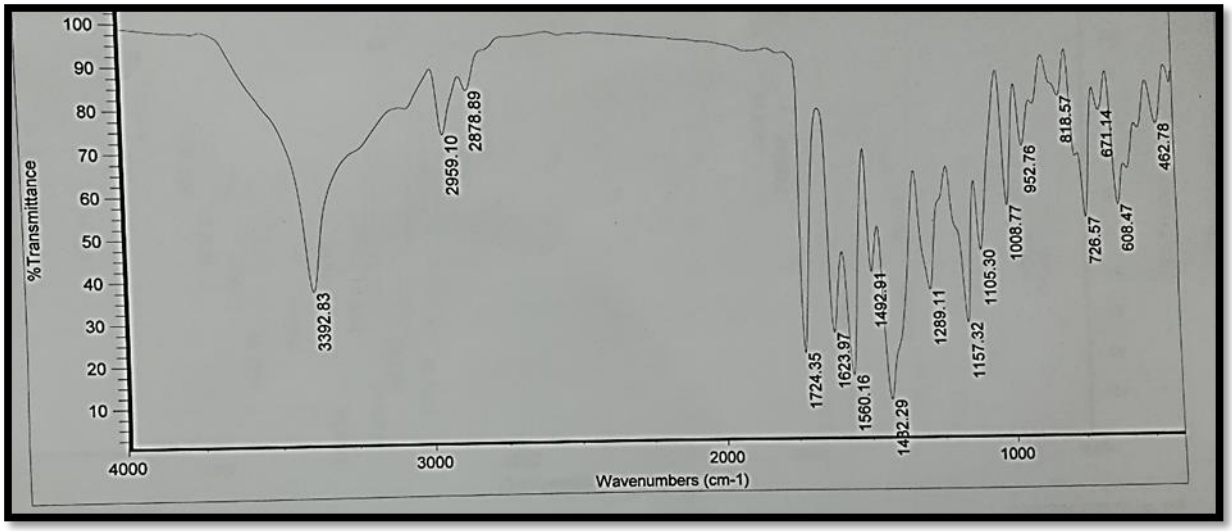

Figure S29. The FT-IR of **4l**

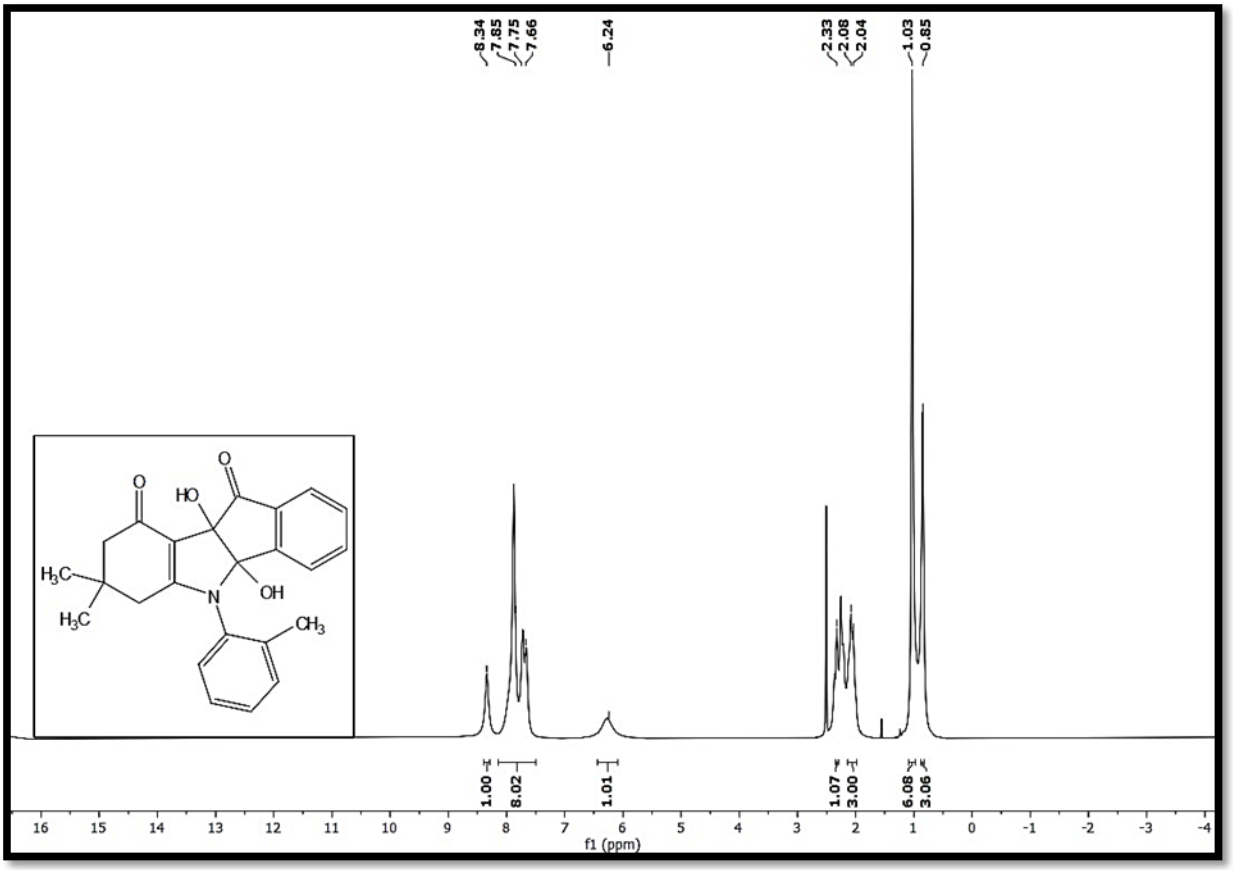

Figure S30. The ^{1}H NMR of **4l**