Bronsted acid-type biosurfactant for heterocyclization: a green protocol for benzopyran synthesis

Smita T. Morbale,[a] Swati D. jadhav,[a] Madhukar B. Deshmukh,[b] Suresh S. Patil [a*]

[a]Synthetic Research Laboratory, PG Department of Chemistry, P.D.V.P. College, Tasgaon, Dist. Sangli ,

India - 416312.

[b] Department of chemistry, Shivaji University, Kolhapur-416 004, India.

*Email: sanyujapatil@yahoo.com

Supporting Information

-S1-

General: All chemicals were commercially sourced from Sigma Aldrich and used without further purification. Melting points were determined on DBK programmable melting point apparatus and are uncorrected. Infrared spectra were measured with a Bruker FT-IR spectrophotometer. ^{1}H NMR and ^{13}C NMR spectra were recorded on a Bruker AC (300 MHz for ^{1}H NMR and 300 MHz for ^{13}C NMR) spectrometer using $CDCl_3$ as solvent. Chemical shifts are expressed in δ parts per million (ppm) values with tetramethylsilane (TMS) as the internal sreference and coupling constants are expressed in Hertz (Hz). Mass spectra were recorded on Shimadzu (QP 2010 GCMS). Equiptronics (Model EQ-664A) digital auto ranging conductivity meter was used for the measurement of critical micellar concentration. Optical micrograph was taken using ordinary light microscope (Leica DM 2000) under 100x magnifications.

Typical procedure for synthesis of 9-(2-hydroxy-4,4-dimethyl-6-oxo-cyclohex-1-enyl)-3,3-dimethyl-2,3,4,9-tetrahydroxanthen-1-one:

In a 25 mL round bottom flask, salicylaldehyde (1.1 mmol), 5,5-dimethyl 1,3-cyclohexanedione (2.2 mmol) were placed in lemon extract:water (6 mL, 1:1, v/v) and reaction mixture was stirred at 80^{o}C temperature in preheated oil-bath till the completion of reaction as indicated by TLC (ethylacetate:hexane 4:6). The solid products was separated by simple filtration through a Buckner funnel, washed with cold water, and recrystalyzed from 96% ethanol (5 mL). The identity of the compound was ascertained on the basis of ^{1}H NMR, ^{13}C NMR, and FT-IR spectroscopy.

-S2-

9-(2-Hydroxy-4,4-dimethyl-6-oxo-cyclohex-1-enyl)-3,3-Dimethyl-2,3,4,9-tetrahydroxanthen-1-one (Table 3,Entry 1)

Yield: 85 %; mp 215–218 ^{o}C; ^{1}H NMR (300 MHz, $CDCl_3$): d 10.50(s, 1H, -OH), 7.08–7.16 (m, 1H, Ar-H), 6.93–7.01 (m, 3H, Ar-H), 4.65 (s, 1H, -CH), 2.54 (q, J=17.7, 20.0 Hz, 2H, -CH_2), 2.35 (s, 2H, -CH_2), 2.30(s, 2H, -CH_2), 1.93 (q, J=6.0, 16.4 Hz, 2H, -CH_2), 1.14 (s, 3H, -CH_3), 1.03 (s, 3H, -CH_3), 1.00 (s, 6H, 2-CH_3); ^{13}C NMR (300 MHz, $CDCl_3$): d 200.40, 196.13, 170.53, 168.78, 151.04, 127.98, 127.52, 124.53, 118.31, 115.78, 111.07, 96.20, 50.58, 49.93, 43.24, 41.60, 32.33, 31.02, 29.85, 29.43, 27.79, 27.21,26.42; IR (cm^{-1}): 3153, 2958, 1622, 1488, 1376, 1312, 1233, 1185, 1151, 1077, 1019, 762, 655, 582, 475; MS : 367 (M + 1), 389 (M + Na). Anal. calcd. for $C_{23}H_{26}O_4$: C, 75.38; H, 7.15; O, 17.46. Found: C, 75.33; H, 7.15; HRMS m/z calcd. for $C_{23}H_{26}O_4$: 366.0000, found 367.1918(M+H), 389.1737 (M+Na).

-S3-

3-methoxy-9-(2-hydroxy-4,4-dimethyl-6-oxo-cyclohex-1-enyl)-3,3-dimethyl-2,3,4,9-tetrahydro-xanthen-1-one (Table 3,Entry 2)

Yield: 80 %; mp 224-227 ^{o}C; ^{1}H NMR (300 MHz, $CDCl_3$): d 10.50 (s, 1H, -OH), 7.08–7.21 (m, 1H, Ar-H), 6.93–7.01 (m, 3H, Ar-H), 4.63 (s, 1H, -CH), 2.54 (q, J=17.7, 20.0 Hz, 2H, -CH_2), 2.35 (s, 2H, -CH_2), 2.30 (s, 2H, -CH_2), 1.93 (q, J=6.0, 16.4 Hz, 2H, -CH_2), 3.88 (s, 1H, -OCH_3) , 1.14(s, 3H, -CH_3), 0.93 (s, 9H, 3CH_3); ^{13}C NMR (300 MHz, $CDCl_3$): 200.40, 196.521, 170.554, 168.800, 147.081, 140.658, 125.203, 124.203, 119.760, 118.149, 110.887, 110.370, 56.058, 50.623, 49.930, 43.167, 41.533, 32.288, 30.887, 29.852, 29.051, 27.755 , 27.162, 26.421.

-S3-

-S4-

7-Bromo-9-(2-hydroxy-4,4-dimethyl-6-oxo-cyclohex-1-enyl)-3,3-dimethyl-2,3,4,9-tetrahydro-xanthen-1-one (Table 3,Entry 3)

Yield: 92 %; mp 248-251^{o}C; 1H NMR (300 MHz, $CDCl_3$): d 10.15 (s, 1H, -OH), 7.21–7.24 (dd, J=1.9, 6.8 Hz, 1H, Ar-H), 7.08 (s, 1H, Ar-H), 6.87 (d, J=8.7 Hz, 1H, Ar-H), 5.02 (s, 1H, -CH-), 2.28–2.59 (m, 6H, 3-CH_2), 1.95 (s, 2H, -CH_2), 1.33 (s, 3H, -CH_3), 0.99–1.05 (m, 9H, 3-CH_3); ^{13}C NMR (300 MHz, $CDCl_3$ + DMSO): d 195.65, 164.328, 148.794, 130.563, 129.103, 127.741, 116.932, 115.413, 110.34, 50.27, 40.65, 40.33, 40.05, 39.78, 39.22, 38.94, 38.66, 31.35, 31.27, 28.93,27.56, 26.30; IR (cm^{-1}): 3103, 2963, 1618, 1475, 1374, 1302, 1231, 1178, 1075, 1037, 884, 817, 657, 590, 478; MS : 445 (M^{+1}), 447 (M+2). Anal. calcd. for $C_{23}H_{25}BrO_4$: C, 62.03; H, 5.66; Br,17.94; O, 14.37. Found: C, 62.03; H, 5.65. HRMS m/z calcd for: $C_{23}H_{25}BrO_4$: 445.0000, found 445.1003 $(M)^{+}$.

-S5-

7-Chloro-9-(2-hydroxy-4,4-dimethyl-6-oxo-cyclohex-1-enyl)-3,3-dimethyl-2,3,4,9-tetrahydro-xanthen-1-one (Table 3,Entry 5)

Yield: 91 %; mp 232–234 ^{o}C; ^{1}H NMR (300 MHz, $CDCl_3$): d 10.50 (s, 1H, -OH), 7.09 (dd, J=2.2, 2.6 Hz, 1H, Ar-H), 6.91–6.97 (m, 2H, Ar-H), 4.61 (s, 1H, -CH), 2.52 (q, J= 17.3, 18.5 Hz, 2H, -CH_2), 2.37 (d, J=4.9 Hz, 2H, -CH_2), 2.30 (s, 2H, -CH_2), 1.96 (s, 2H, -CH_2), 1,14 (s, 3H, -CH_3), 1.00–1.05 (m, 9H, 3-CH_3); IR (cm^{-1}): 3102, 2965, 2710, 1624, 1571, 1476,1374, 1301, 1233, 1179, 1077, 1038, 1015, 879, 819, 657, 618, 591, 549, 469; MS : 401 (M^{+1}), 403 (M+2). Anal. calcd. for $C_{23}H_{25}ClO_4$: C, 68.91; H, 6.29; Cl, 8.84; O, 15.96. Found: C, 68.89; H, 6.24. HRMS m/z calcd. for $C_{23}H_{25}ClO_4$: 400.0000, found 401.1529 (M + H), 423.1328 (M + Na).

-S6-

5-Bromo-7-chloro-9-(2-hydroxy-4,4-dimethyl-6-oxo-cyclohex-1-enyl)-3,3-dimethyl-2,3,4,9-tetrahydro-xanthen-1-one (Table 3,Entry 6)

Yield: 90 %; mp 241-243 ^{o}C; ^{1}H NMR (300 MHz, $CDCl_3$): d 10.34 (s, 1H, -OH), 7.36 (d, J=2.2 Hz, 1H,Ar-H), 6.90 (d, J=2.0 Hz, 1H, Ar-H), 4.60 (s, 1H, -CH), 2.62 (q, J=17.7,18.5 Hz, 2H, -CH_2), 2.38 (d, J=4.5 Hz, 2H, -CH_2), 2.31 (s, 2H, -CH_2), 1.97 (s, 2H, -CH_2), 1.16 (s, 3H, -CH_3), 1.00–1.05 (m, 9H, 3-CH_3); ^{13}C NMR (300 MHz, $CDCl_3$): d 196.47, 195.10, 163.43, 144.77, 128.68, 127.79, 127.41,

126.35, 112.78,109.93, 108.78, 94.79, 49.58, 49.03, 39.81, 30.77, 28.24, 26.92, 26.03, 25.64, 25.17; IR (cm $^{-1}$): 3184, 2940, 1647, 1599, 1452, 1375,1313, 1257, 1207, 1183, 1150, 1017, 887, 855, 803, 722, 662, 587, 475; MS: 479 (M^+), 481 (M+2). Anal. calcd. for $C_{23}H_{24}BrClO_4$: C, 57.58; H,5.04; Br, 16.65; Cl, 7.39; O, 13.34. Found: C, 57.57; H, 5.04; HRMS m/z calcd. for $C_{23}H_{23}ClBrO_4$: 478.0000, found 479.0618 (M + H), 481.0602 (M + 2) 501.0421 (M + Na), 503.0415 (M + Na + 2)

-S7-

9-(2-Hydroxy-6-oxo-cyclohex-1-enyl)-2,3,4,9-tetrahydro-xanthen-1-one(Table 3, Entry 7)

Yield: 87 %; mp 240-243 ^{o}C; ^{1}HNMR (300 MHz, $CDCl_3$): d 10.00 (s, 1H, -OH), 6.80–7.14 (m, 4H, Ar-H), 4.84(s, 1H, -CH), 1.60–2.40 (m, 12H, 6-CH_2); IR (cm $^{-1}$): 2951, 2538, 1830, 1641, 1553, 1485,1421, 1372, 1294, 1235, 1192, 1142, 1071, 993, 924, 850, 773, 564, 493 MS : 311 (M+1). Anal. calcd. for $C_{19}H_{18}O_4$: C, 73.53; H, 5.85; O, 20.62. Found: C, 73.52; H, 5.84; HRMS m/z calcd. for $C_{19}H_{18}O_4$: 310.0000, found 311.1295 (M + H), 333.1081 (M + Na).

-S8-

7-Bromo-9-(2-hydroxy-6-oxo-cyclohex-1-enyl)-2,3,4,9-tetrahydro-xanthen-1-one(Table 3, Entry 9)

Yield: 88 %; mp 238-240 ^{o}C; 1H NMR (300 MHz): d 10.75 (s, 1H, -OH), 7.25 (d, J=3.0 Hz, 1H, Ar-H), 7.09 (d, J=2.2 Hz, 1H, Ar-H), 6.89 (dd, J=5.2, 6.0 Hz, 1H, Ar-H), 4.57(s, 1H, -CH), 1.76–2.85 (m, 12H, 6-CH_2); ^{13}C NMR (300 MHz, $CDCl_3$) : 202.18, 193.99, 167.43, 166.15, 148.45, 129.74, 129.28, 128.61, 126.86, 116.51, 116.10, 115.09, 47.57, 35.57, 35.02, 33.26, 26.02, 22.80, 18.95; IR (cm^{-1}): 3105, 2955, 1640, 1596, 1477, 1374,1279, 1233, 1186, 1144, 1070, 981, 819, 763, 620, 530, 470; MS : 389 (M^{+1}) 391 (M +2); Anal. calcd. For $C_{19}H_{17}BrO_4$: C, 58.63; H, 4.40; Br, 20.53; O, 16.44, found:C, 58.63; H, 4.39; HRMS m/z calcd. for $C_{19}H_{17}BrO_4$: 389.0000, found 391.0551 (M + 2).

-S9-

7-Chloro-9-(2-hydroxy-6-oxo-cyclohex-1-enyl)-2,3,4,9-tetrahydro-xanthen-1-one (Table 3, Entry 11)

Yield: 94 %; mp 242-244 ^{o}C; ^{1}H NMR (500MHz, $CDCl_3$): d 10.76(s, 1H, -OH), 7.09 (d, J=6.3 Hz, 1H, Ar-H), 6.91–6.96 (m, 2H, Ar-H), 4,57(s, 1H, -CH), 1.77–2.81 (m, 12H, 6-CH_2); ^{13}C NMR (300MHz, $CDCl_3$+DMSO-d6): 201.86, 193.94, 167.23, 165.96, 147.56, 127.13, 126.76, 125.61, 124.53,

115.52, 110.65, 99.74, 47.08, 35.47, 34.82, 33.05, 26.35, 22.69, 19.03; IR (cm $^{-1}$): 3110, 2954, 1645, 1596, 1477, 1416, 1375, 1280, 1239, 1188, 1141, 1068, 984, 917, 824, 576, 460; MS : 345 (M^+), 347 (M + 2). Anal. calcd. for $C_{19}H_{17}ClO_4$: C, 66.19; H, 4.97; Cl, 10.28; O, 18.56, found: C, 66.18; H, 4.97.

-S10-

5-Bromo-7-chloro-9-(2-hydroxy-6-oxo-cyclohex-1-enyl)-2,3,4,9-tetrahydro-xanthen-1-one(Table 3, Entry 12)

Yield: 91 %; mp 238–240 ^{o}C; ^{1}H NMR (300MHz, $CDCl_3$): d 10.44 (s, 1H, -OH), 7.30 (d, J=2.6 Hz, 1H, Ar-H), 6.95 (d, J=1.7 Hz, 1H, Ar-H), 5.04 (s, 1H, -CH), 1.93–2.12 (m, 4H, 2-CH_2),2.25–2.51(m,8H,4CH_2);^{13}CNMR(300MHz,$CDCl_3$):195.44,163.90,145.45,129.31,128.72,127.93,110.62,109.50,50.29,40.33,40.05,39.77,39.50,39.2,38.94.38.76,31.45,31.3,28.97,27.56,26.69,26.20,25.75 29; IR (cm^{-1}): 49, 2887, 2526, 1651, 1560, 1452, 1363, 1279, 1245, 1185, 1133, 1063, 1007, 857, 765, 707, 538, 500, 438; MS: 423 (M^+),425 (M+2) Anal. calcd. for $C_{19}H_{16}BrClO_4$: C, 53.86; H, 3.81; Br, 18.86; Cl, 8.37; O, 15.11, found: C, 53.85; H, 3.81.

-S11-

5-methoxy-2,3-Dihydro-9-(2-hydroxy-5-oxocyclopent-1-enyl)-cyclopenta[*b*]chromen-1(9*H*)-one (Table 3, Entry 14)

Yield: 84 %; mp 257-260 ^{o}C; ^{1}H NMR (300 MHz DMSO): 2.29~2.36 (m, 6H, 3CH2), 2.72~2.74 (m, 2H, CH_2), 3.82 (s, 3H, CH_3O), 4.58 (s, 1H, CH), 6.58~6.60 (m, 1H, ArH), 6.92 (dd, *J* = 8.0 Hz, *J* = 1.2 Hz, 1H, ArH), 6.99~7.03 (m, 1H, ArH), 11.80 (b, 1H, OH); IR (cm^{-1}): 3438, 3024, 2971, 2939, 1682, 1637, 1579, 1480, 1445, 1380, 1322, 1273, 1255, 1237, 1170, 1125, 1076, 825, 788, 739, 716.

-S12-

7-Bromo-2,3-dihydro-9-(2-hydroxy-5-oxocyclopent-1-enyl)cyclopenta[*b*]chromen-1(9*H*)-one(Table 3, Entry 15)

Yield: 86 %; mp 280-282^{o}C; ^{1}H NMR (300 MHz DMSO): 2.26~2.43 (m, 6H, 3CH_2), 2.56~3.34(m, 2H, CH_2), 5.01(s, 1H, CH), 7.01~7.24 (m, 2H, ArH), 7.27 (d, *J* = 8.4 Hz, 1H, ArH), 10.60 (b, 1H, OH); IR (cm $^{-1}$): 3505, 2932 , 2910, 1699, 1653, 1585, 1474, 1383, 1276, 1259, 1240,1198, 1160, 1126, 1071, 1018, 818, 707, 659.

-S13-

7-nitro-2,3-Dihydro-9-(2-hydroxy-5-oxocyclopent-1-enyl)cyclopenta[*b*]chromen-1(9*H*)-one (Table 3, Entry 16)

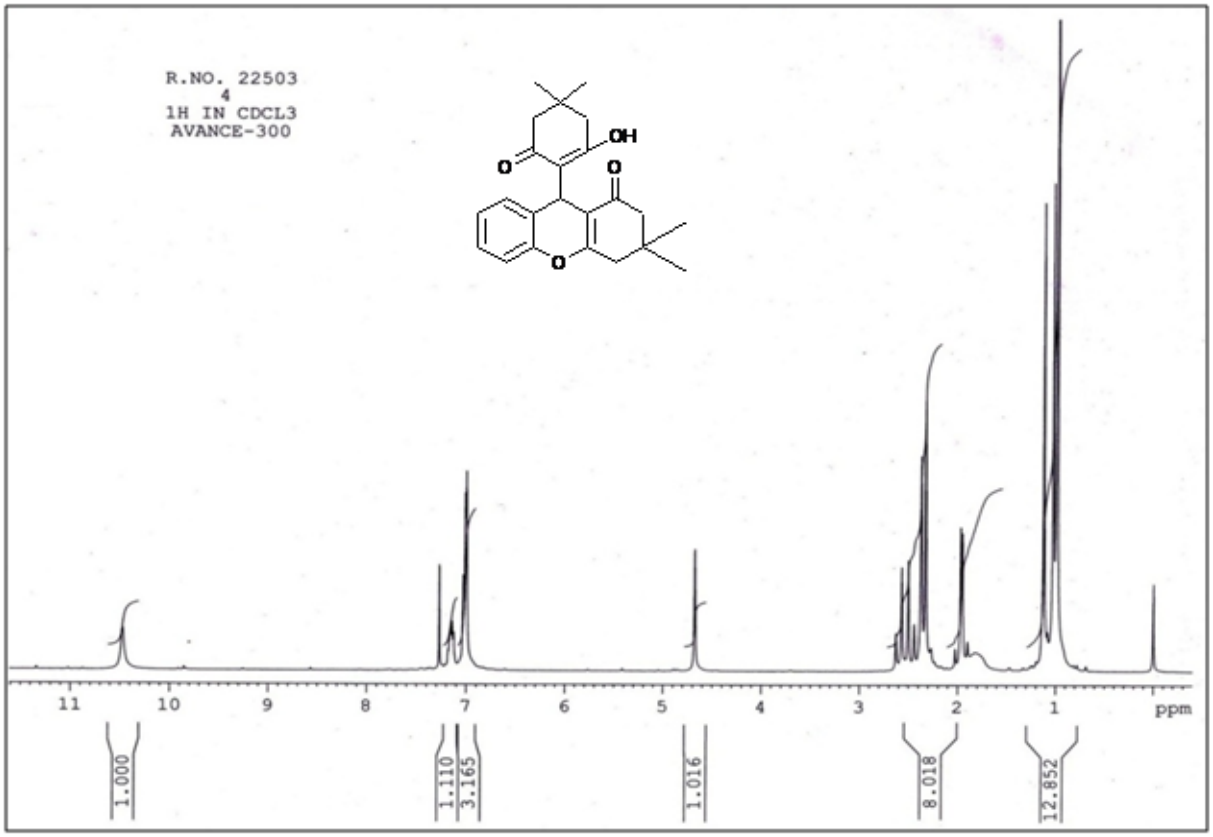
Yield: 89 %; mp 265-268C ^{o}C; ^{1}H NMR (300 MHz DMSO): 2.34~2.41 (m, 6H, 3CH_2), 2.74~2.76 (m, 2H, CH_2), 4.72(s, 1H, CH), 7.41 (d, *J* = 8.8 Hz, 1H, ArH), 7.87 (d, *J* =2.4Hz, 1H, ArH), 8.11 (dd, *J*=8.8 Hz, *J*= 2.4 Hz, 1H, ArH), 12.06 (b, 1H, OH). IR (cm^{-1}): 3512, 2943, 2926, 1698, 1656, 1581, 1528, 1481, 1458, 1379, 1277, 1253, 1168, 1134, 1020, 929, 912, 840, 805, 748, 666.

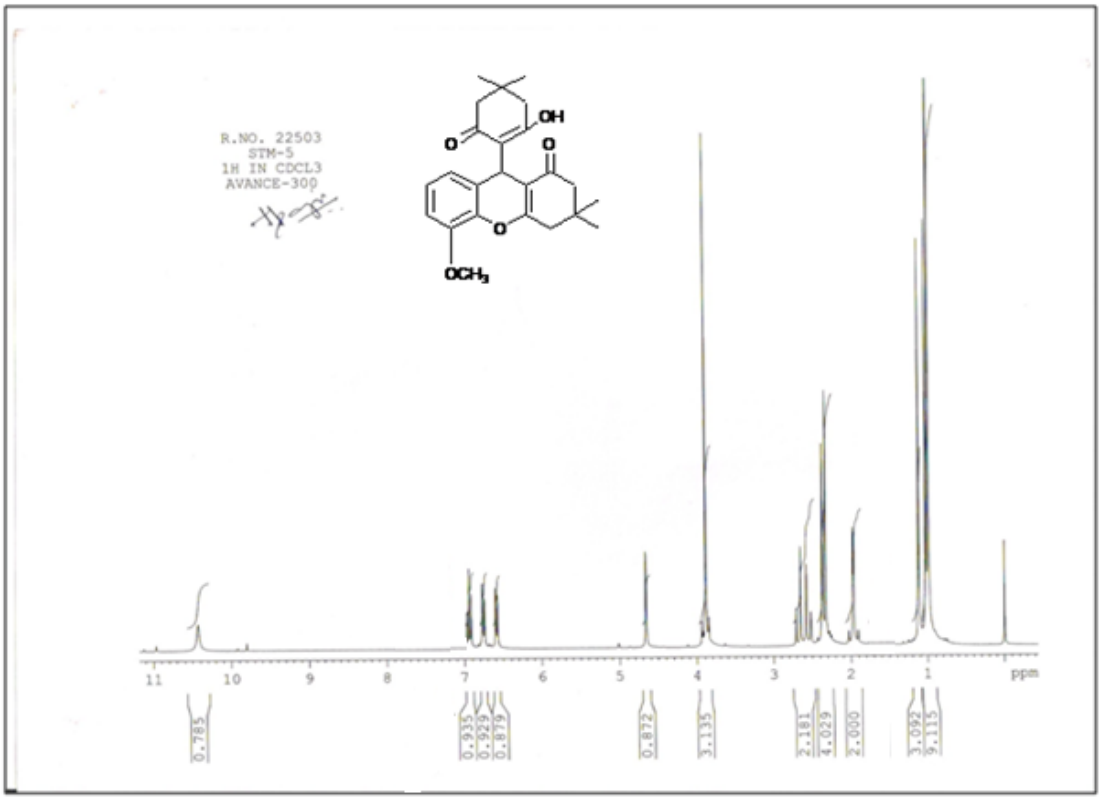
7-Chloro-2,3-dihydro-9-(2-hydroxy-5-oxocyclopent-1-enyl)cyclopenta[*b*]chromen-1(9*H*)-one (Table 3, Entry 17)

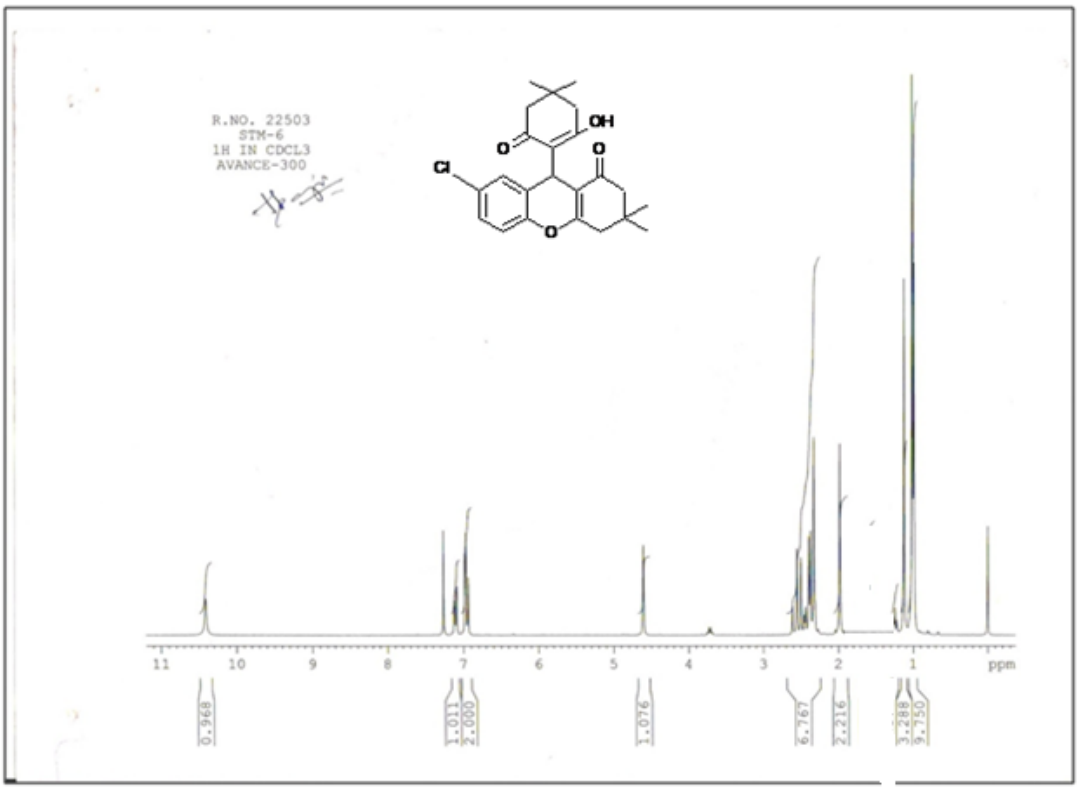
Yield: 90 %; mp 271-273 ^{o}C; ^{1}H NMR (300 MHz DMSO): 2.33~2.38 (m, 6H, 3CH_2), 2.71~2.73 (m, 2H, CH_2), 4.60(s, 1H, CH), 7.01 (dd, *J* = 2.4 Hz, *J* = 1.2 Hz, 1H, ArH),7.18 (d, *J* = 8.8 Hz, 1H, ArH), 7.27~7.30 (m, 1H, ArH),12.00 (b, 1H, OH); IR (cm^{-1}): 3508, 2935, 2914, 1699, 1654, 1583, 1477, 1409, 1384, 1277, 1259, 1240, 1162,1126, 1018, 819, 677.

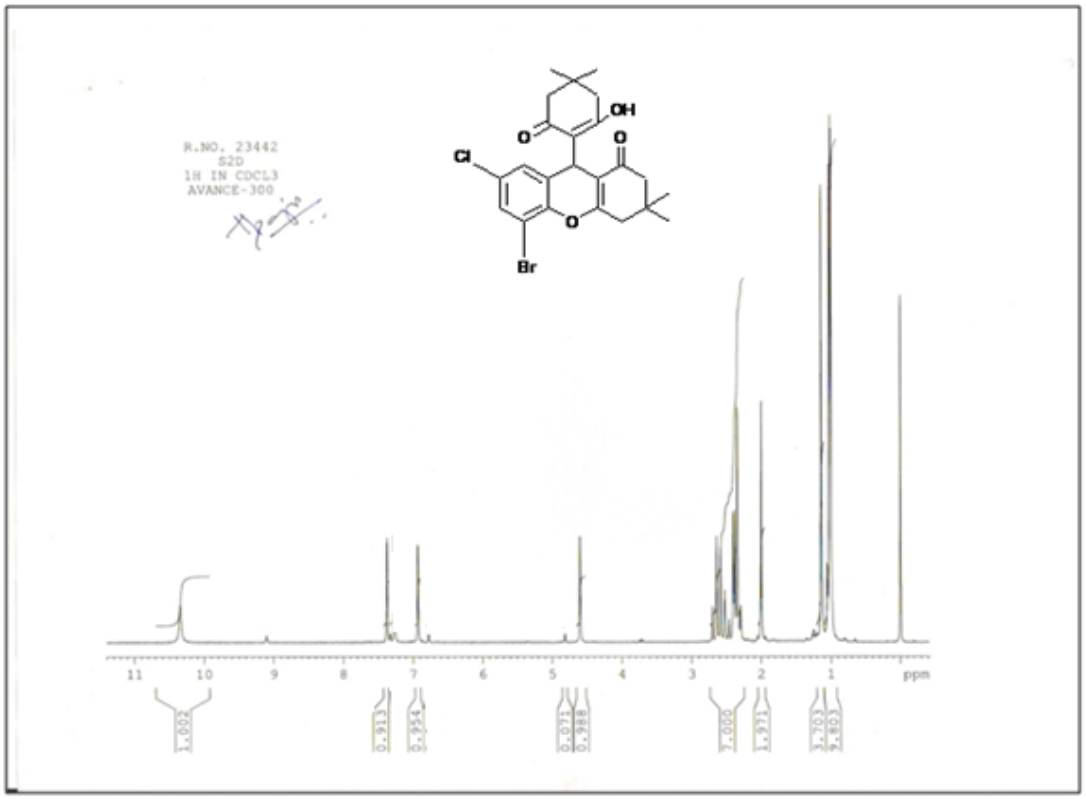
7,8-h-ph-9-(2-hydroxy-4,4-dimethyl-6-oxocyclohex-1-enyl)-3,3-dimethyl-2,3,4,9-tetrahydro-1H-xanthen-1-one (3h) (Table 4, Entry 1)

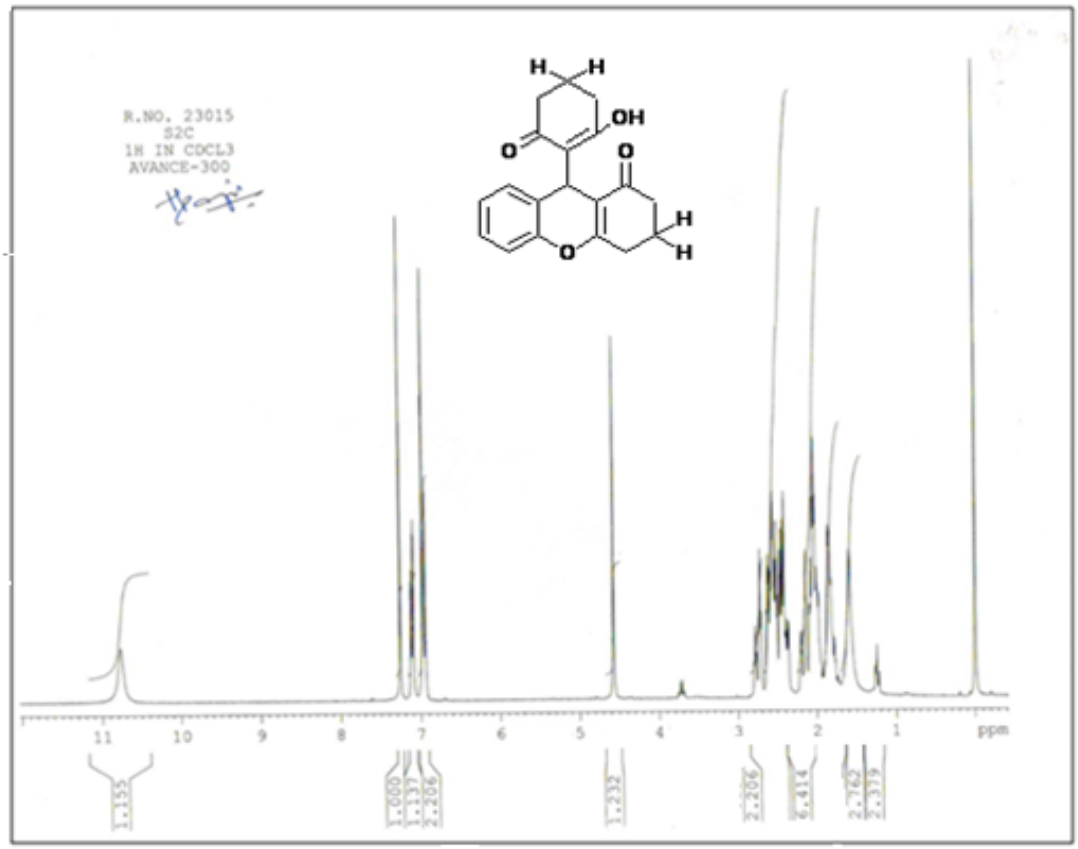
Yield: 95 % mp 235-237 °C. ^{1}H NMR (300 MHz, $CDCl_3$) δ = 10.70 (s, 1H, OH), 7.78 (d, 1H, ArH), 7.73 (d, 2H, ArH), 7.48 (t, 1H, ArH), 7.39 (t, 1H, ArH), 7.27 (d, 1H, ArH), 5.27 (s, 1H, CH), 2.68 (AB_q, J = 17.6 Hz, 1H, CH_2), 2.57 (AB_q, J = 17.6 Hz, 1H, CH_2), 1.96 (AB_q, J = 16.4 Hz, 1H, CH_2), 1.83 (AB_q, J = 16.4 Hz, 1H, CH_2),2.36-2.41 (m, 4H, 4CH_2), 1.17 (s, 3H, CH_3), 1.08 (s, 3H, CH_3), 0.95 (s, 3H, CH_3), 0.72 (s, 3H, CH_3) ppm;^{13}C NMR (300 MHz, $CDCl_3$) δ = 201.11, 196.85, 170.22, 169.09, 148.89, 131.26, 130.96, 158.54, 128.50, 126.71, 124.64, 122.87, 117.68, 116.59, 116.14, 111.08, 50.71, 49.98, 43.18, 41.37, 32.42, 30.62, 29.92, 29.33, 27.10, 26.37, 25.38 ppm; IR (KBr): 3182, 2941, 2862, 1643, 1593, 1464, 1373, 1315, 1261, 1235, 1061, 1026, 888, 813 cm^{-1}.

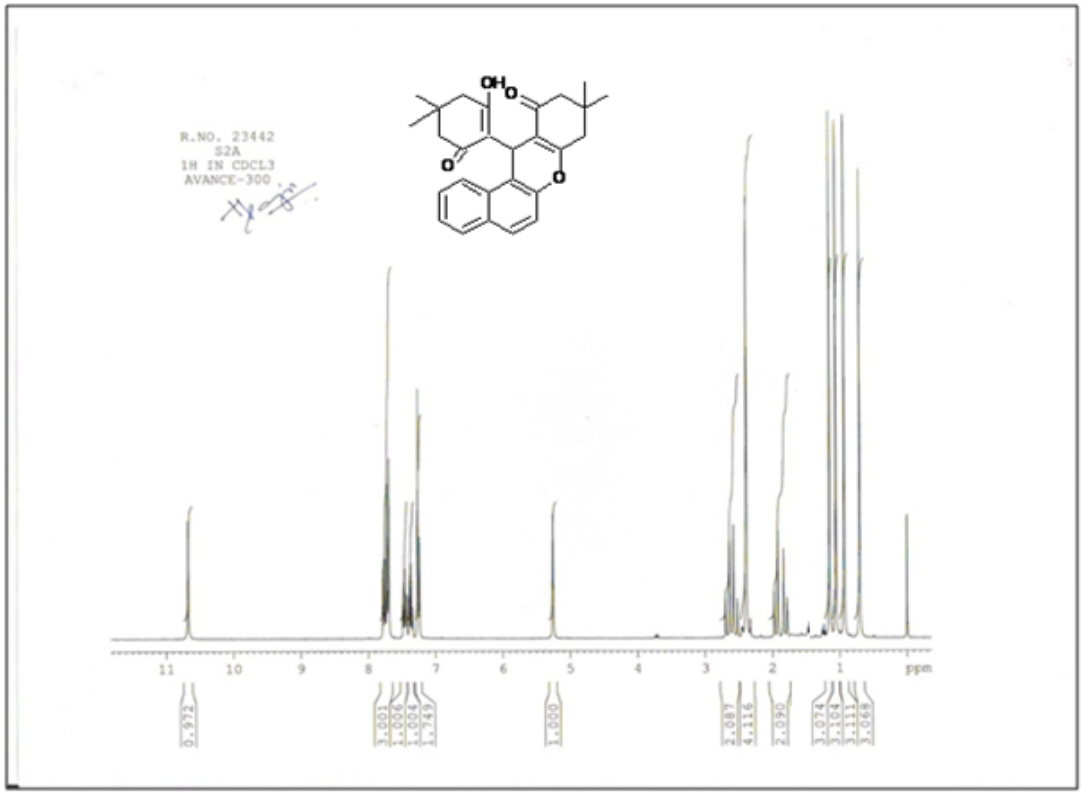

R.NO. 22503
4
1H IN CDCL3
AVANCE-300
OH
O
O
O
11
10
9
8
7
6
5
4
3
2
1
ppm
1.000
1.110
3.165
1.016
8.018
12.852

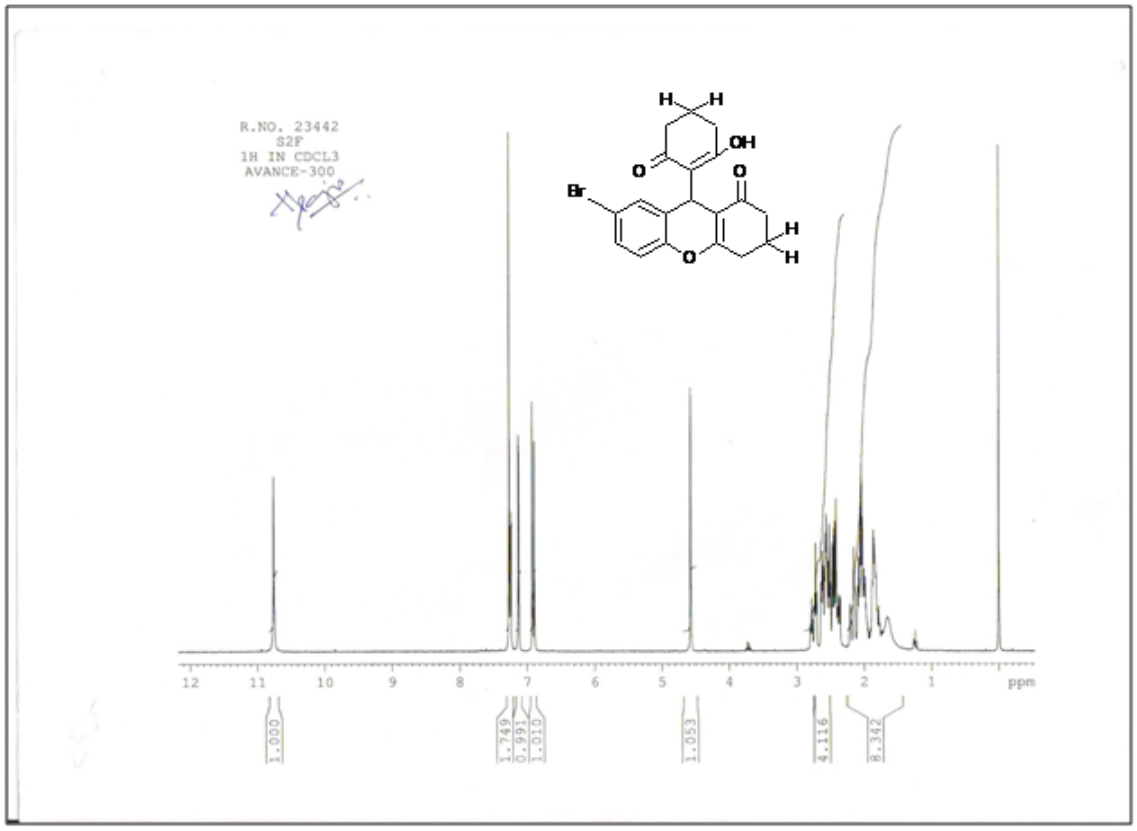

R.NO. 22503
STM-5
1H IN CDCL3
AVANCE-300
OH
O
O
O
OCH3
11
10
9
8
7
6
5
4
3
2
1
ppm
0.785
0.935
0.929
0.879
0.872
3.135
2.181
4.029
2.000
3.092
9.115

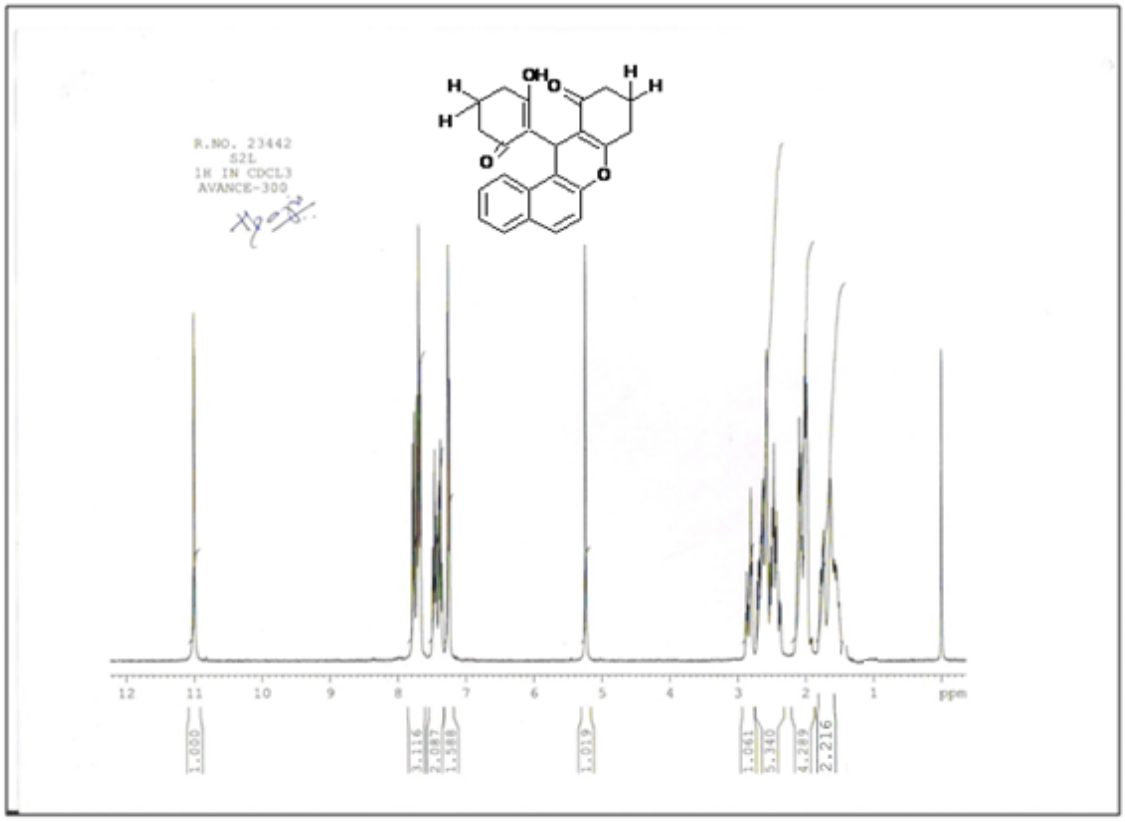

R.NO. 22503
STM-6
1H IN CDCL3
AVANCE-300
OH
O
O
Cl
O
11
10
9
8
7
6
5
4
3
2
1
ppm
0.968
1.011
2.000
1.076
6.767
2.216
3.288
9.750


R.NO. 23442
S2D
1H IN CDCL3
AVANCE-300
OH
O
O
Cl
O
Br
11
10
9
8
7
6
5
4
3
2
1
ppm
1.002
0.913
0.954
0.071
0.998
7.000
1.971
2.703
2.803

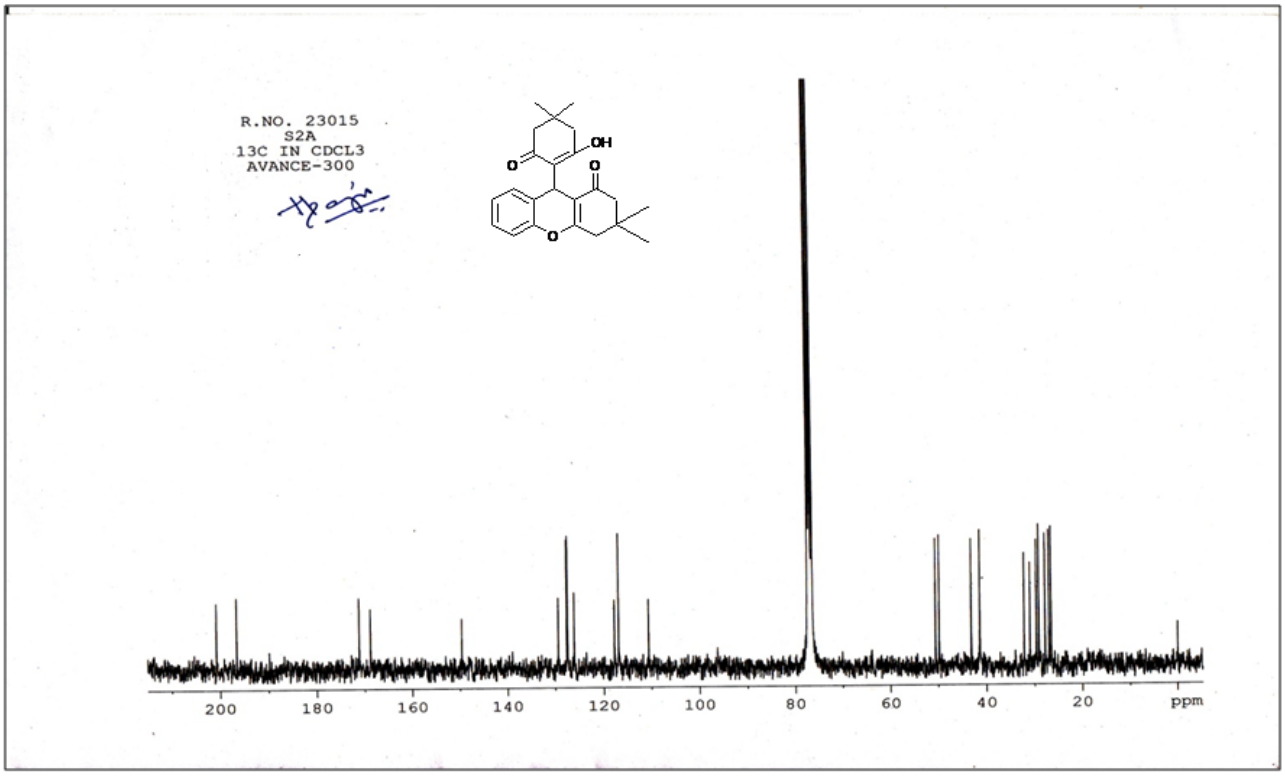

R.NO. 23015
S2C
1H IN CDCL3
AVANCE-300
H
H
OH
O
O
H
H
O
11
10
9
8
7
6
5
4
3
2
1
ppm
1.155
1.000
1.137
2.206
1.232
2.206
6.414
2.762
2.379

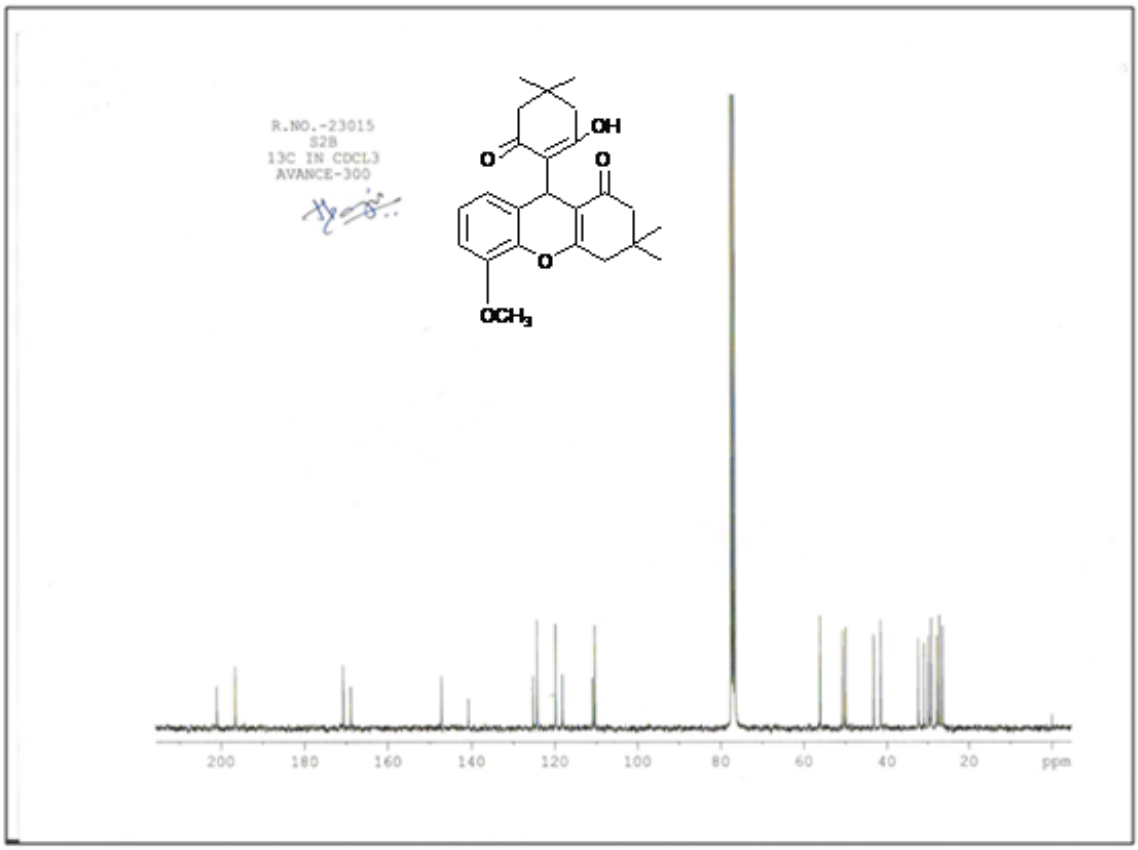

R.NO. 23442
S2A
1H IN CDCL3
AVANCE-300
OH
O
O
O
11
10
9
8
7
6
5
4
3
2
1
ppm
0.972
3.001
1.006
1.004
1.749
1.000
2.087
4.116
2.090
3.074
3.164
3.111
3.046

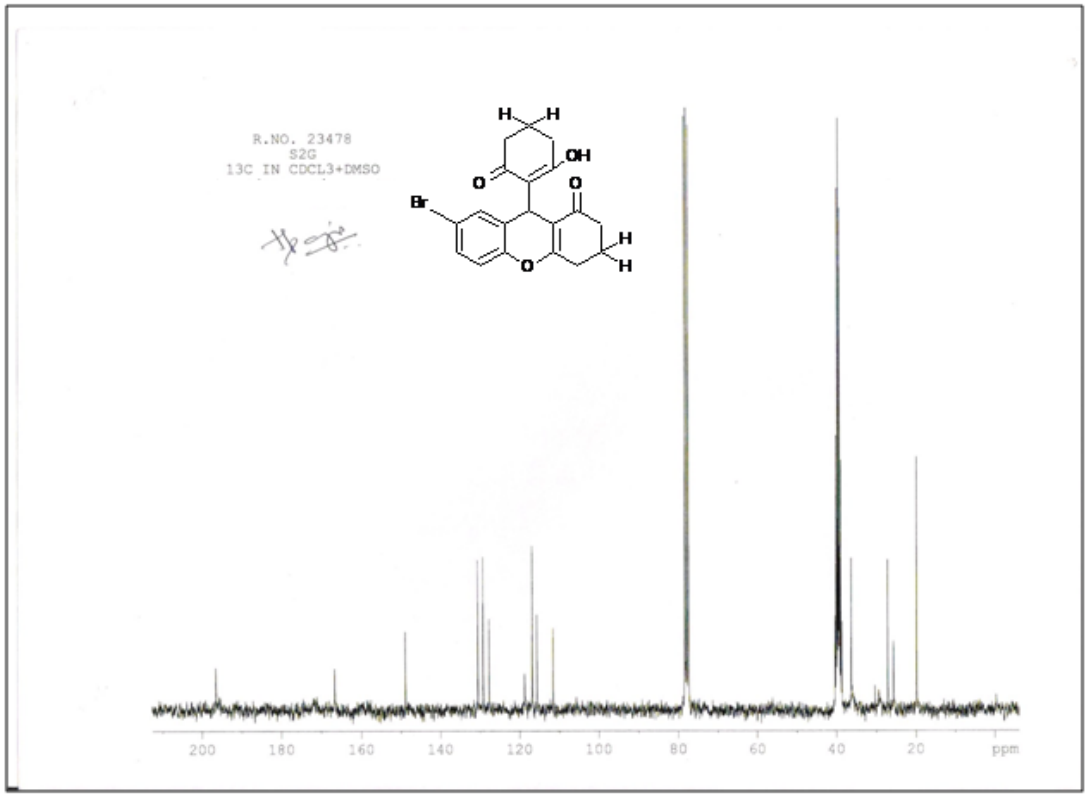

R.NO. 23442
S2F
1H IN CDCL3
AVANCE-300
H
H
OH
O
O
Br
H
H
O
12
11
10
9
8
7
6
5
4
3
2
1
ppm
1.000
1.749
0.991
1.010
1.053
4.116
8.342

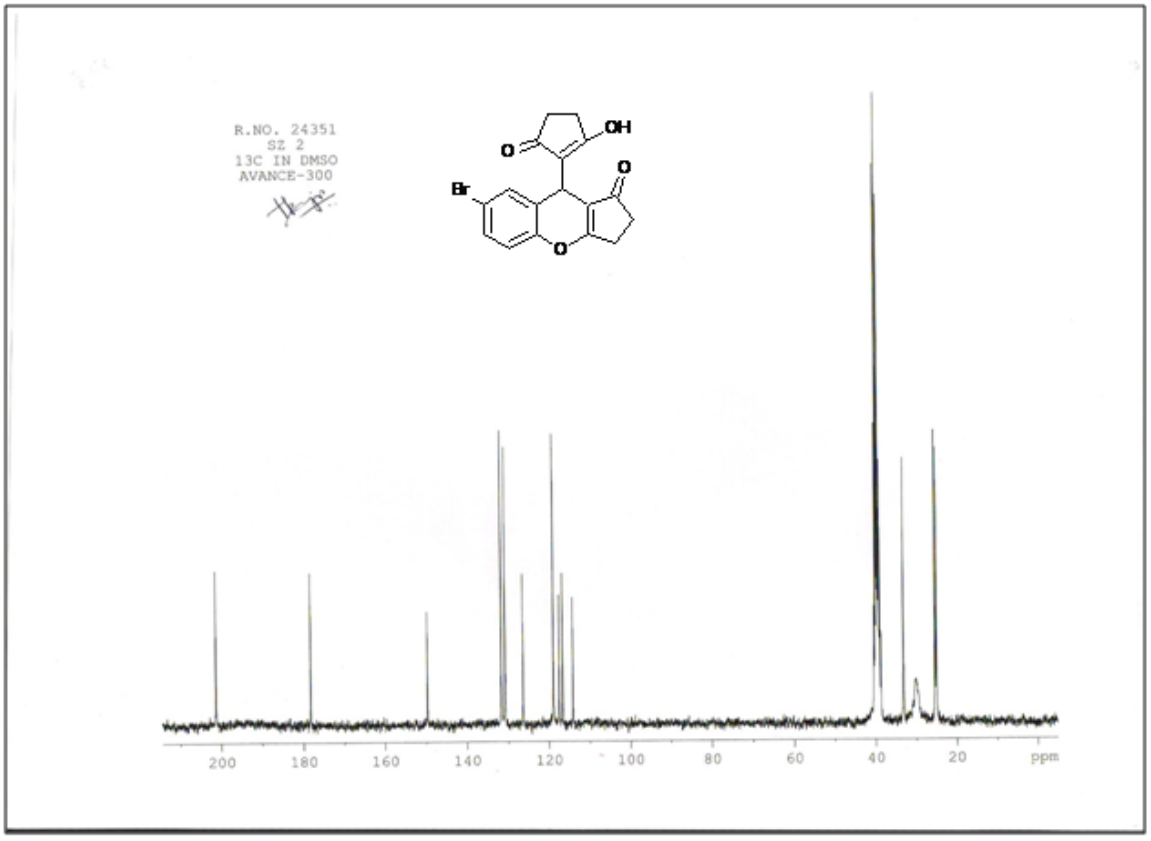

R.NO. 23442
S2L
1H IN CDCL3
AVANCE-300
OH
O
H
H
H
H
O
O
12
11
10
9
8
7
6
5
4
3
2
1
ppm
1.000
3.116
2.087
1.588
1.019
1.041
5.340
4.289
2.216

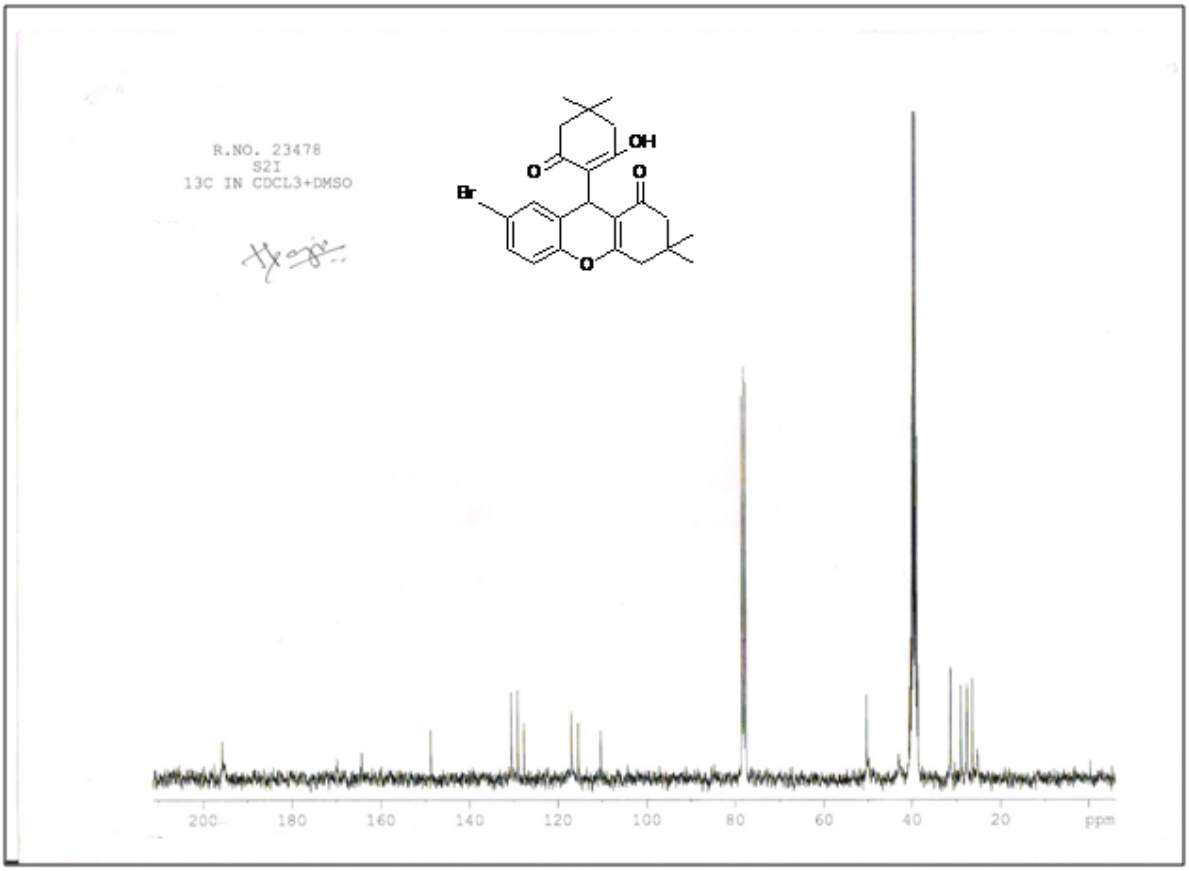

R.NO. 24351
SZ 1
1H IN DMSO
AVANCE-300
OH
O
O
Br
O
13
12
11
10
9
8
7
6
5
4
3
2
1
ppm
0.928
1.018
2.000
1.022
2.128
6.112


R.NO. 23015
S2A
13C IN CDCL3
AVANCE-300
OH
O
O
O
200
180
160
140
120
100
80
60
40
20
ppm


R.NO.-23015
S2B
13C IN CDCL3
AVANCE-300
OH
O
O
O
OCH3
200
180
160
140
120
100
80
60
40
20
ppm


R.NO. 23478
S2G
13C IN CDCL3+DMSO
H
H
OH
O
O
Br
H
H
O
200
180
160
140
120
100
80
60
40
20
ppm


R.NO. 24351
SZ 2
13C IN DMSO
AVANCE-300
OH
O
O
Br
O
200
180
160
140
120
100
80
60
40
20
ppm


R.NO. 23478
S2I
13C IN CDCL3+DMSO
OH
O
O
Br
O
200
180
160
140
120
100
80
60
40
20
ppm

Determination of Critical micellar concentration (CMC) of lemon extract by conductivity method

To maintain better lemon extract:water composition i.e above CMC for this protocol, we employed electrical conductivity method to determine the critical micelle concentration (CMC) of reaction medium. The conductivity experiments were carried using Equiptronics (Model EQ-664 A) digital auto ranging conductivity meter. Different composition of solutions of Lemon extract was prepared in deionized water having specific conductance 7.0 μs cm^{-1}. A step-by step dilution method was adopted for the measurements of specific conductance of the various compositions to avoid dilution error. The conductance was plotted as a function of percentage composition of lemon extract:water (v/v) and the inflection point gives the value (40 %) of CMC which is indicated in the figure.