

Apoptosis and DNA intercalating activities of novel Emodin derivatives

T. Narender* P. Sukanya,^a Komal Sharma,^b and Surendar Reddy Bathula^{b*}

Supporting data

Supporting data

Figure S1

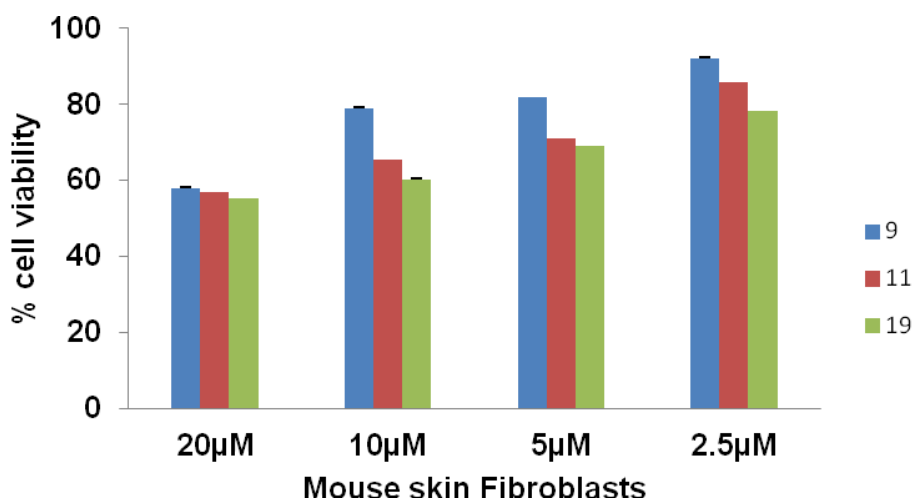


Figure S1: We have evaluated the Cytotoxicity of compounds 9, 11 and 19 against mouse skin fibroblasts using MTT assay.

1, 3, 8-trihydroxy-6-methylanthracene-9-10-dione (1):

IR (KBr) 3613, 2925, 1625, 1461, 1373, 1277, 1029, 767, 672 cm^{-1} ; ^1H NMR (DMSO- d_6 , 300 MHz) δ 12.03 (s, OH), 11.95 (s, OH), 7.41 (s, 1H), 7.10 (s, 1H), 7.06 (s, 1H), 6.55 (s, 1H), 2.38 (s, 3H); ^{13}C NMR(DMSO- d_6 , 75 MHz) δ 189.40, 180.92, 165.51, 164.35, 161.30, 148.04, 134.77, 132.47, 123.91, 120.25, 113.04, 108.09, 107.75, 21.45; MS (ESI) m/z 270.

1, 8-dihydroxy-3-methyl-6-(nonyloxy) anthracene-9, 10-dione (2)

IR (KBr) 3365, 2359, 1628, 1461, 1217, 1020, 769, 671 cm^{-1} ; ^1H NMR (CDCl_3 , 300 MHz) δ 12.27 (s, OH), 12.10 (s, OH), 7.59 (s, 1H), 7.32 (s, 1H), 7.05 (s, 1H), 6.64 (s, 1H), 4.07 (t, 2H), 2.43 (s, 3H), 1.82 - 1.78 (m, 2H), 1.58 (s, 2H), 1.45 (s, 2H), 1.25 (s, 6H), 0.85 (t, 3H); MS (ESI) m/z 382; Yield: 66% .

1, 8-dihydroxy-3-methyl-6-(undecyloxy) anthracene-9, 10-dione (3):

IR (KBr) 3761, 3414, 2952, 1624, 1318, 1216, 766, 671 cm^{-1} ; ^1H NMR (CDCl_3 , 300 MHz,) δ 12.49 (s, OH), 12.32 (s, OH), 7.81 (s, 1H), 7.54 (s, 1H), 7.46 (s, 1H), 6.84 (s, 1H), 4.27 (t, 2H), 2.64 (s, 3H), 2.02 - 1.99 (m, 2H), 1.76 (s, 2H), 1.66 (s, 2H), 1.45 (s, 16H), 1.07 (t, 3H)); ^{13}C NMR(CDCl_3 , 75 MHz) δ 191.06, 183.04, 167.18, 166.19, 163.45, 149.31, 140.27, 136.16, 134.23, 125.44, 122.21, 115.06, 114.70, 111.00, 109.72, 108.10, 70.04, 34.02, 32.93, 32.63, 30.70, 30.50, 30.53, 30.36, 30.29, 30.16, 29.96, 29.89, 26.89, 23.69, 23.13, 15.11; MS (ESI) m/z 438; Yield: 65%.

3-(dodecyloxy)-1, 8-dihydroxy-6-methyl anthracene-9, 10-dione (4):

IR (KBr) 3429, 1627, 1473, 1386, 1303, 1264, 1218, 1032, 769, 670 cm^{-1} ; ^1H NMR (CDCl_3 , 300 MHz,) δ 12.30 (s, OH), 12.13 (s, OH), 7.62 (s, 1H), 7.35 (s, 1H), 7.07 (s, 1H), 6.85 (s, 1H), 4.08 (t, 2H), 2.44 (s, 3H), 2.05 (s, 2H), 1.85 - 1.80(m, 2H), 1.57 (s, 2H), 1.45 - 1.41 (m, 4H), 1.29 (s, 2OH), 0.86 (t, 3H); ^{13}C NMR(CDCl_3 , 75 MHz) δ 190.65, 182.01, 166.16, 165.17, 162.44, 148.31, 136.12, 133.19, 124.43, 121.21, 106.71, 107.08, 69.03, 31.92, 31.62, 29.66, 29.36, 28.88, 25.88, 22.69, 22.13, 14.12; MS (ESI) m/z 452; Yield: 65%.

1, 8-dihydroxy-3-methyl-6-(pentadecyloxy) anthracene-9, 10-dione (5):

IR (KBr) 3490, 2924, 1627, 1452, 1217, 769, 670 cm^{-1} ; ^1H NMR (CDCl_3 , 300 MHz,) δ 7.61 (s, 1H), 7.34 (s, 1H), 7.06 (s, 1H), 6.65 (s, 1H), 4.07 (t, 2H), 2.44 (s, 3H), 2.02 (t, 2H), 1.84 - 1.79 (m, 2H), 1.56 (s, 2H), 1.25 (s, 24H), 0.87 (t, 3H); ^{13}C NMR(CDCl_3 , 75 MHz) δ 190.69, 182.05, 166.19, 166.20, 162.47, 148.32, 139.27, 135.17, 133.24, 124.45, 121.22, 114.06, 113.70, 110.03, 108.72, 107.10, 69.04, 33.83, 31.93, 31.63, 29.70, 29.54, 29.37, 29.30, 29.16, 28.96, 28.89, 25.89, 22.70, 22.13, 14.12; MS (ESI) m/z 494; Yield: 62%.

1, 8-dihydroxy-3-methyl-6-(octadecyloxy) anthracene-9, 10-dione (6)

IR (KBr) 3407, 2952, 1631, 1363, 1217, 1012, 769, 670 cm^{-1} ; ^1H NMR (CDCl_3 , 300 MHz,) δ 12.29 (s, OH), 12.12 (s, OH), 7.61 (s, 1H), 7.34 (s, 1H), 7.07 (s, 1H), 6.66 (s, 1H), 4.09 (t, 2H), 2.45 (s, 3H), 1.86 - 1.82 (m, 2H), 1.60 (s, 2H), 1.47 - 1.43 (m, 2H), 1.27 (s, 28H), 0.87 (t, 3H); MS (ESI) m/z 522; Yield: 65%.

1, 8-dihydroxy-3-methyl-6-(icosyloxy) anthracene-9, 10-dione (7):

IR (KBr) 3289, 2368, 1658, 1584, 1458, 1218, 769, 670 cm^{-1} ; ^1H NMR (CDCl_3 , 300 MHz,) δ 12.31 (s, OH), 12.15 (s, OH), 7.64 (s, 1H), 7.37 (s, 1H), 7.09 (s, 1H), 6.68 (s, 1H), 4.10 (t, 2H), 2.46 (s, 3H), 2.05 (t, 2H), 1.87 - 1.82 (m, 2H), 1.59 (s, 2H), 1.34 (s, 31H), 0.88 (t, 3H); ^{13}C NMR(CDCl_3 , 75 MHz) δ 190.11, 181.47, 165.61, 164.62, 161.89, 147.74, 138.69, 134.59, 132.66, 123.87, 120.54, 113.48, 113.12, 109.45, 108.14, 106.52, 68.45, 32.25, 31.35, 31.05, 29.12, 29.0, 28.79, 28.72, 28.59, 28.38, 28.31, 25.31, 22.12, 21.55, 13.54; MS (ESI) m/z 550; Yield: 63%.

3-(docosyloxy)-1, 8-dihydroxy-6-methyl anthracene-9, 10-dione (8):

IR(KBr) 3388, 2362, 1624, 1365, 1217, 767, 672 cm^{-1} ; ^1H NMR (CDCl_3 , 300 MHz,) δ 12.29 (s, OH), 12.12 (s, OH), 7.61 (s, 1H), 7.34 (s, 1H), 7.06 (s, 1H), 6.65 (s, 1H), 4.08 (t, 2H), 2.44 (s, 3H), 2.05 (t, 2H), 1.82 (s, 2H), 1.25 (s, 34H), 0.88 (t, 3H); MS (ESI) m/z 578; Yield: 64%.

(E)-3-(3, 7-dimethylocta-2, 6-dienyloxy) 1, 8-dihydroxy-6-methyl anthracene-9, 10-dione (9):

IR (KBr) 3349, 2367, 1718, 1624, 1364, 1218, 770, 650 cm^{-1} ; ^1H NMR (CDCl_3 , 300 MHz,) δ ^1H 12.32 (s, OH), 12.16 (s, OH), 7.64 (s, 1H), 7.28 (s, 1H), 7.10 (s, 1H), 6.70 (s, 1H), 5.51 (t, 1H), 5.11 (s, 1H), 4.71 (t, 2H), 2.47 (s, 3H), 2.14 (s, 4H), 1.80 (s, 6H), 1.73 (s, 3H); MS (ESI) m/z 406; Yield: 62%.

1, 8-dihydroxy-3-methyl-6-(prop-2-ynyloxy) anthracene-9, 10-dione (10):

IR (KBr) 3282, 2922, 2125, 2357, 1717, 1631, 1390, 1218, 1078, 766, 680 cm^{-1} ; ^1H NMR (CDCl_3 , 300 MHz) δ 12.12 (s, OH), 12.01 (s, OH), 7.80 (s, 1H), 7.66 (s, 1H), 7.64 (s, 1H), 7.096 (s, 1H), 4.03 (s, 2H), 2.85 (s, 1H), 2.46 (s, 3H); MS (ESI) m/z 308; Yield: 60%.

3-(2-(dimethylamino) ethoxy)-1, 8-dihydroxy-6-methylanthracene-9, 10-Dione (11):

IR (KBr) 3413, 2924, 1630, 1433, 1216, 1028, 925, 764, 672 cm^{-1} ; ^1H NMR (CDCl_3 , 300 MHz,) δ 12.27 (s, OH), 12.09 (s, OH), 7.61 (s, 1H), 7.35 (s, 1H), 7.07 (s, 1H), 6.68 (s, 1H), 4.25 (t, 2H), 2.86 (t, 2H), 2.62 (s, 6H), 2.45 (s, 3H); MS (ESI) m/z 341; Yield: 75%.

3-(2-(diisopropylamino) ethoxy)-1, 8-dihydroxy-6-methylanthracene-9, 10-Dione (12):

IR (KBr) 3349, 2360, 1615, 1452, 1217, 1020, 769, 672 cm^{-1} ; ^1H NMR (CDCl_3 , 300 MHz,) δ 12.10 (br, 2H), 7.58 (s, 1H), 7.31 (s, 1H), 7.04 (s, 1H), 6.64 (s, 1H), 4.04 (t, 2H), 3.10 (t, 2H), 2.89 (t, 2H), 2.42 (s, 3H), 1.08 (d, 12H); ^{13}C NMR(CDCl_3 , 75 MHz) δ 190.60, 181.95, 165.91, 165.12, 162.41, 148.32, 135.10, 133.15, 124.42, 121.20, 113.63, 108.65, 107.20, 69.76, 49.91, 44.14, 22.1, 20.61; MS (ESI) m/z 397; Yield: 80%.

4, 5 di hydroxyl-7-methyl-9, 10-dioxo-9, 10-dihydroanthracene-2-yl 2-acetobenzoate (13):

IR (KBr) 3493, 3142, 1715, 1629, 1451, 1189, 762, 662; ^1H NMR (CDCl_3 , 300 MHz) 12.22 (s, OH), 11.95 (s, OH), 8.23 (d, 1H), 7.70 -7.65 (m, 3H), 7.41 (s, 1H), 7.21 (s, 1H), 7.16 (s, 1H), 7.11 (s, 1H), 2.46 (s, 3H), 2.33 (s, 3H); MS (ESI) m/z 432; Yield: 65%.

(S)-4, 5-dihydroxy-7-methyl-9, 10-dioxo-9, 10-dihydroanthracen-2-yl 2-(7-methoxynaphthalen-2-yl) propanoate (14):

IR (KBr) 3369, 1713, 1629, 1451, 1373, 1217, 1059, 765, 665; ^1H NMR (CDCl_3 , 300 MHz) 12.13 (s, OH), 11.92 (s, OH), 7.75 (t, 3H), 7.60 (s, 1H), 7.45 (d, 2H), 7.14 (d, 2H), 7.07 (s, 1H), 6.94 (s, 1H), 4.11 (q, 1H), 3.92 (s, 3H), 2.43 (s, 3H), 1.72 (d, 3H); MS (ESI) m/z 482; Yield: 62%.

4, 5-dihydroxy-7-methyl-9, 10-dioxo-9, 10-dihydroanthracen-2-yl cinnamate (15):

IR (KBr) 3322, 1733, 1623, 1464, 1375, 1216, 1134, 1023, 767; ¹H NMR (CDCl₃, 300 MHz) 12.22 (s, OH), 11.98 (s, OH), 7.96 (d, 1H), 7.66-7.61 (m, 4H), 7.47-7.45 (m, 3H), 7.18 (s, 1H), 7.12 (s, 1H), 6.66 (d, 1H), 2.48 (s, 3H); MS (ESI) m/z 400; Yield: 64%.

4, 5-dihydroxy-7-methyl-9, 10-dioxo-9, 10-dihydroanthracen-2-yl isonicotinate (16):

IR (KBr) 3439, 3023, 2928, 1773, 1718, 1620, 1388, 1220, 1077, 972, 758, 521 cm⁻¹; ¹H NMR (CDCl₃, 300 MHz) 8.43 (s, 2H), 7.80 (s, 2H), 7.59 (s, 1H), 7.19 (s, 1H), 7.03 (s, 1H), 6.58 (s, 1H), 2.43 (s, 3H); MS (ESI) m/z 375; Yield: 60%.

6-methyl-9, 10-dioxo-9, 10-dihydroanthracene-1, 3, 8-triyl triacetate (17):

IR (KBr) 3407, 2927, 1761, 1668, 1605, 1457, 1324, 1206, 1029, 908, 766, 674 cm⁻¹; ¹H NMR (CDCl₃, 300 MHz) 8.01 (s, 1H), 7.95 (s, 1H), 7.23 (s, 1H), 7.22 (s, 1H), 2.50 (s, 3H), 2.43 (s, 6H), 2.35 (s, 3H); MS (ESI) m/z 396; Yield: 98%.

4, 5, 7-triacetoxy-9, 10-dioxo-9, 10-dihydroanthracene-2-carboxylic acid (18):

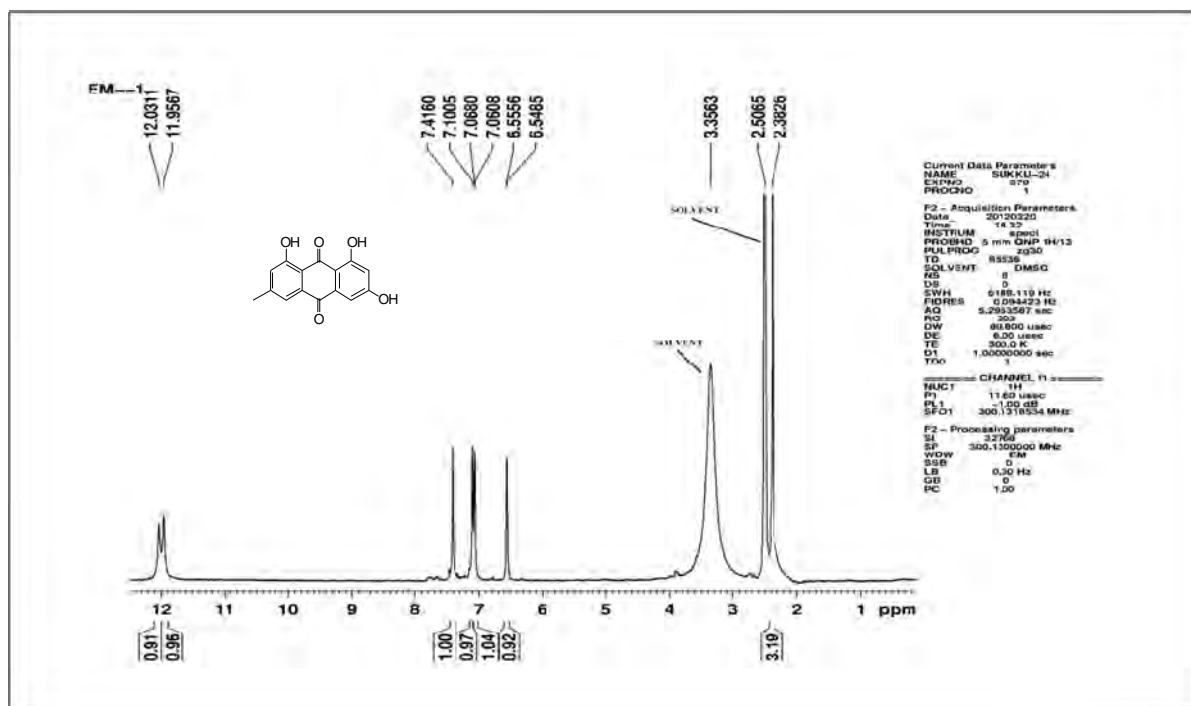
IR (KBr) 3416, 3024, 2927, 2367, 1770, 1648, 1460, 1372, 1215, 1029, 923, 761, 672 cm⁻¹; ¹H NMR (DMSO-d⁶, 300 MHz) 8.12 (s, 1H), 7.95 (s, 1H), 7.93 (s, 1H), 7.63 (s, 1H), 2.39 (s, 9H); ¹³C NMR (DMSO-d⁶, 75 MHz) δ 180.14, 179.37, 168.40, 166.29, 165.02, 154.69, 150.99, 149.81, 136.56, 135.26, 134.43, 132.51, 124.98, 123.96, 123.08, 121.93, 120.39, 20.88; MS (ESI) m/z 426; Yield: 80%.

4, 5, 7-trihydroxy-9, 10-dioxo-N-(2-(piperidin-1-yl) ethyl)-9, 10-dihydroanthracene-2-carboxamide (19)

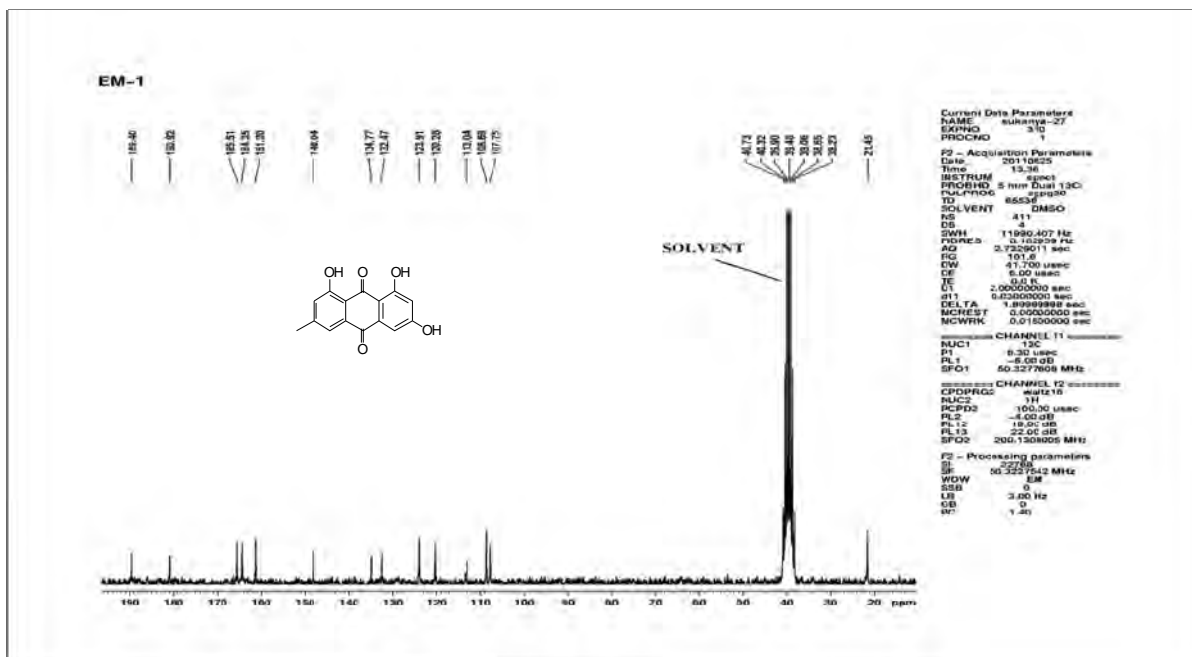
IR (KBr) 3452, 3229, 2920, 1720, 1525, 1452, 1217, 765, 630 cm⁻¹; ¹H NMR (DMSO-d⁶, 300 MHz) 8.38 (s, 1H), 7.99 (s, 1H), 7.86 (s, 1H), 7.41 (s, 1H), 6.77 (s, 1H), 4.03 (t, 2H), 3.27 (t, 2H), 3.19 (s, 4H), 2.13 (t, 4H), 1.96 (t, 2H); MS (ESI) m/z 408; Yield: 85%.

4, 5, 7-trihydroxy-N-(2-morpholinoethyl)-9, 10-dioxo-9, 10-dihydroanthracene-2-carboxamide (20):

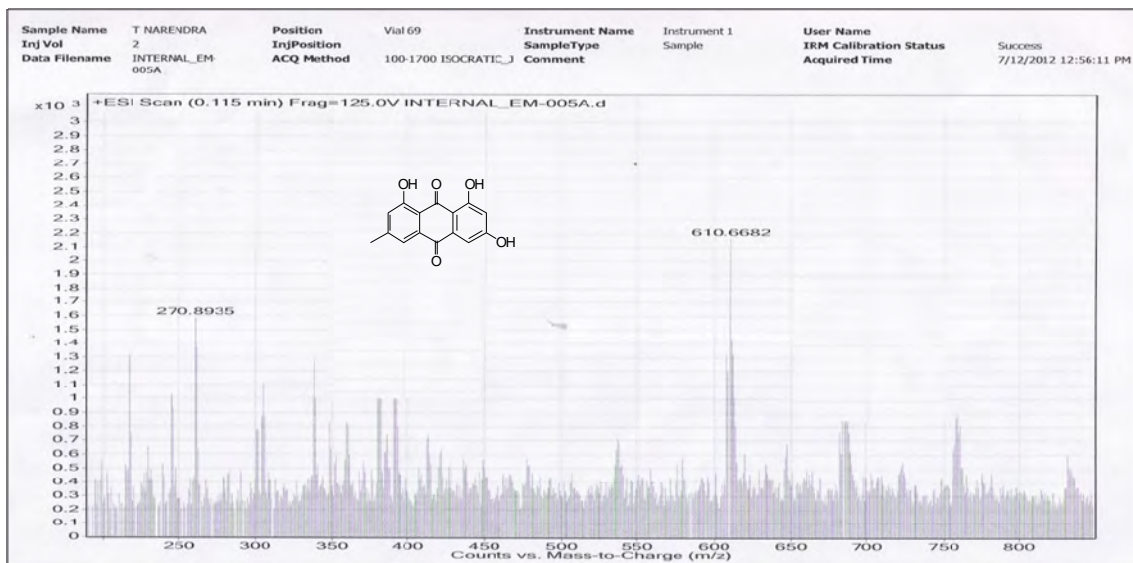
IR (KBr) 3594, 3229, 2360, 1720, 1520, 1452, 1212, 767, 640 cm^{-1} ; ^1H NMR (DMSO- d_6 , 300 MHz) 8.11 (s, 1H), 7.70 (s, 1H), 7.42 (s, 1H), 7.24 (s, 1H), 6.60 (s, 1H), 3.78 (t, 2H), 3.59 (t, 2H), 2.67 (t, 2H), 2.59 (s, 4H); MS (ESI) m/z 410; Yield: 85%.



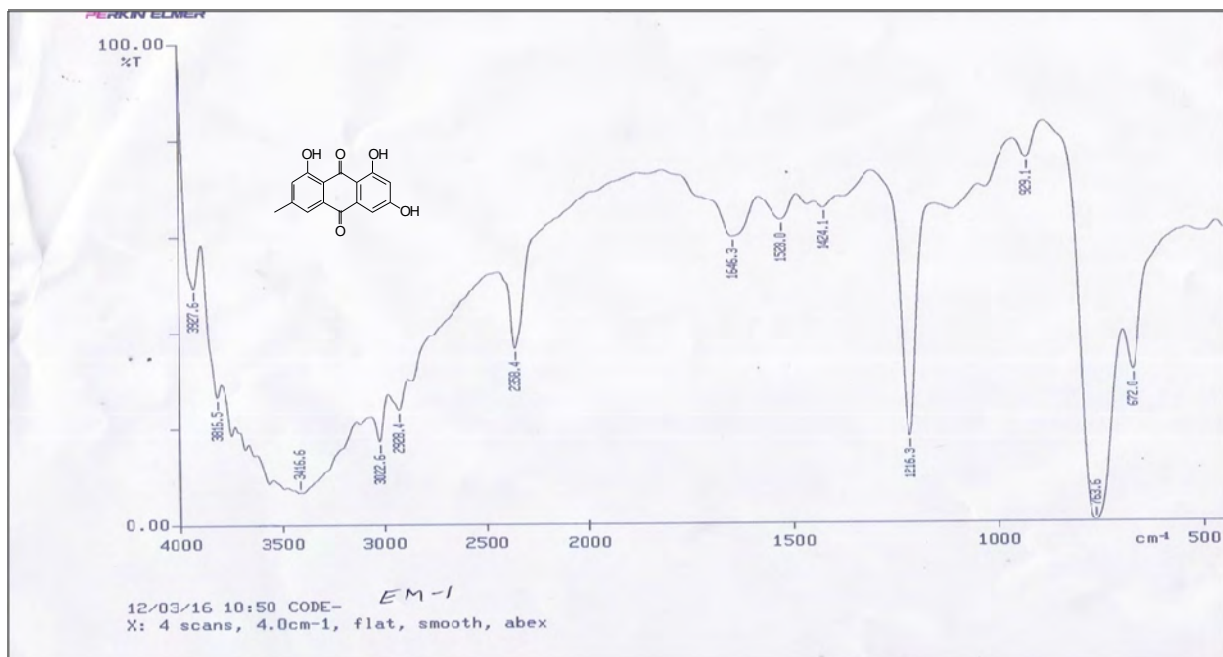
Proton NMR spectrum of compound 1



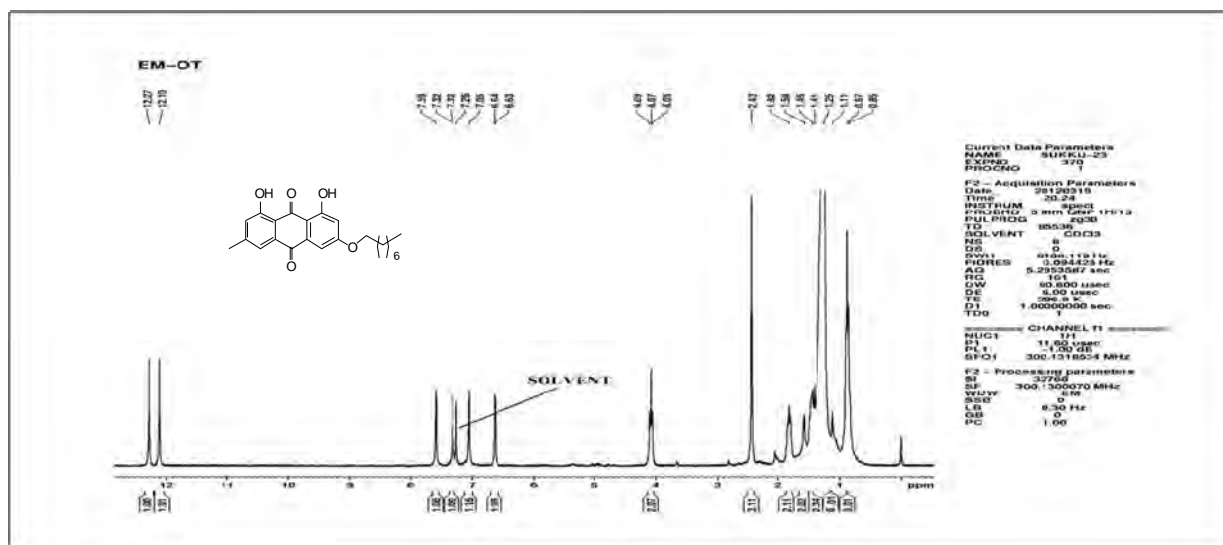
Carbon-13 NMR spectrum of compound 1



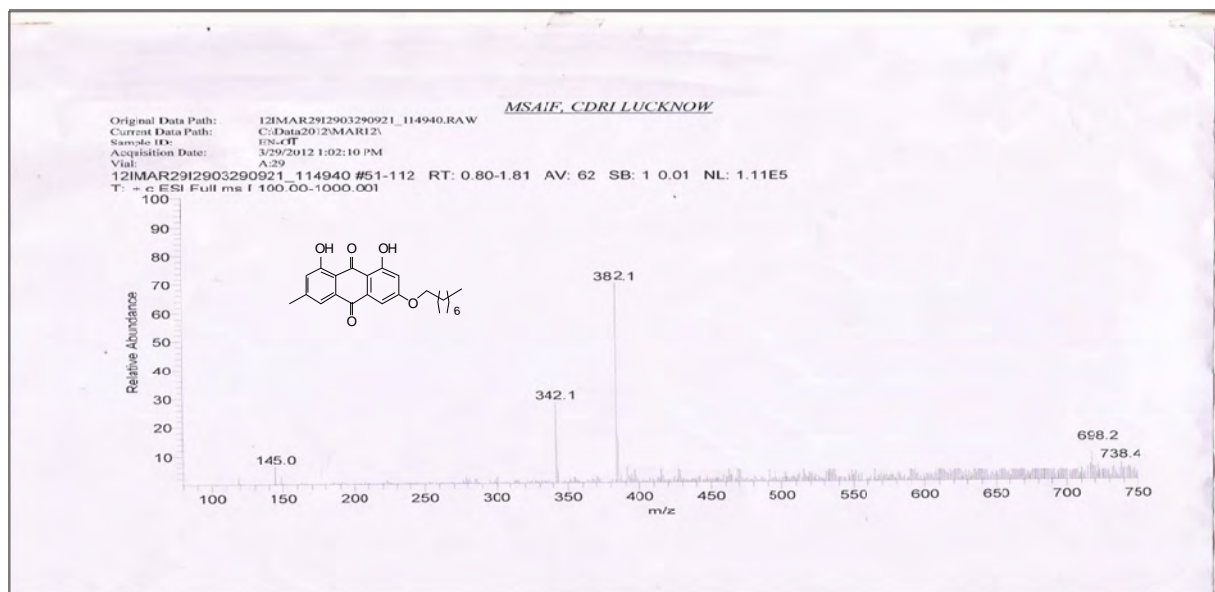
Mass spectrum of compound 1



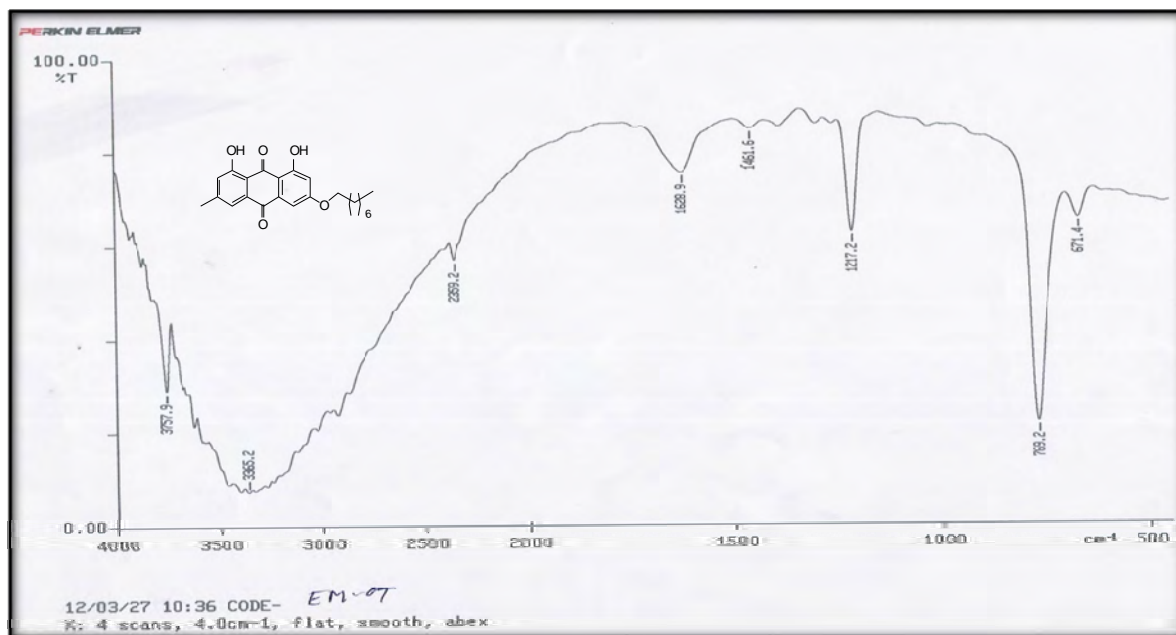
IR spectrum of compound 1



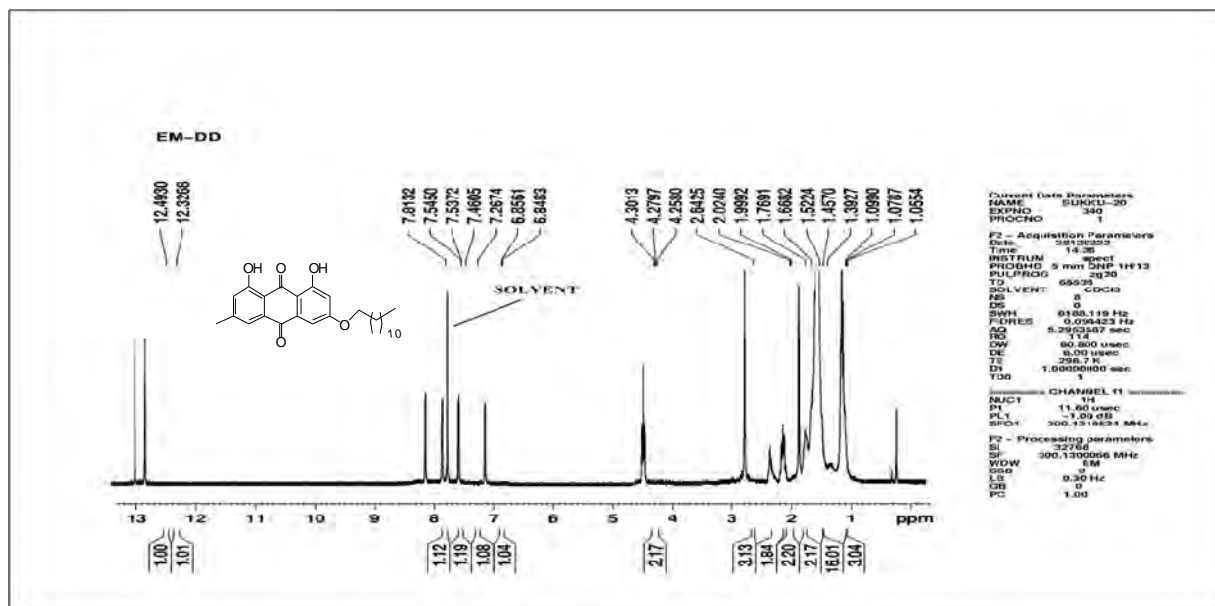
Proton NMR spectrum of compound 2



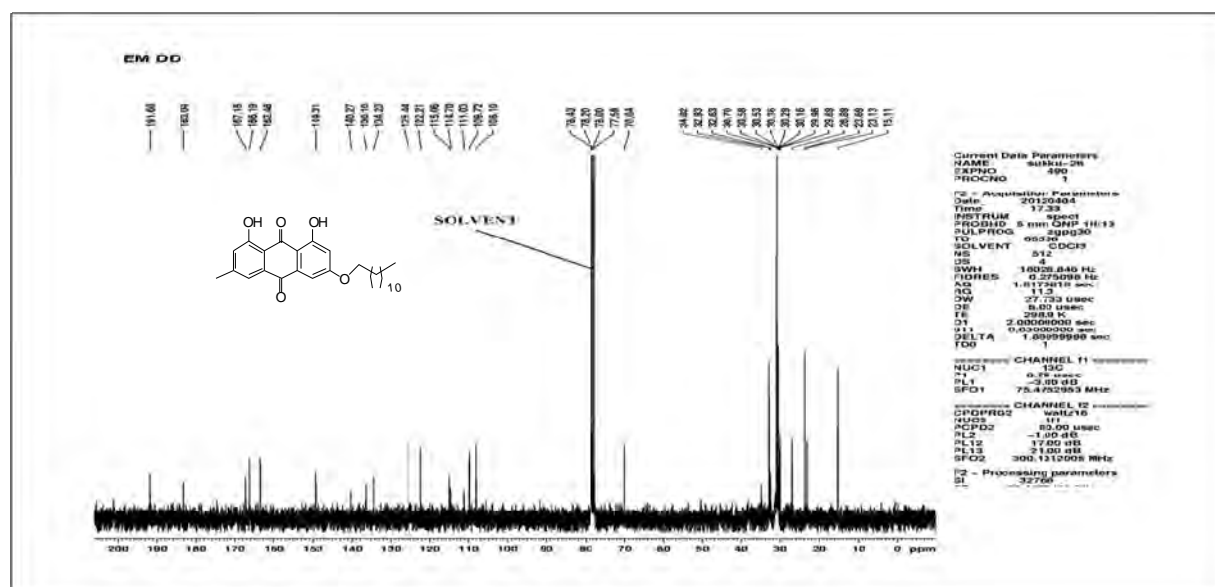
Mass spectrum of compound 2



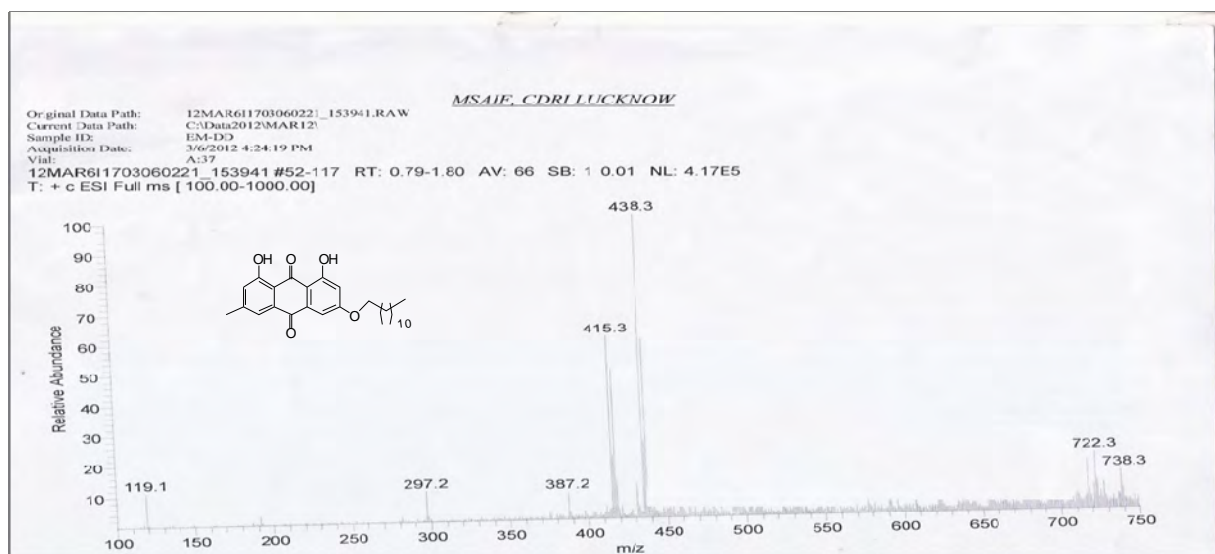
IR spectrum of compound 2



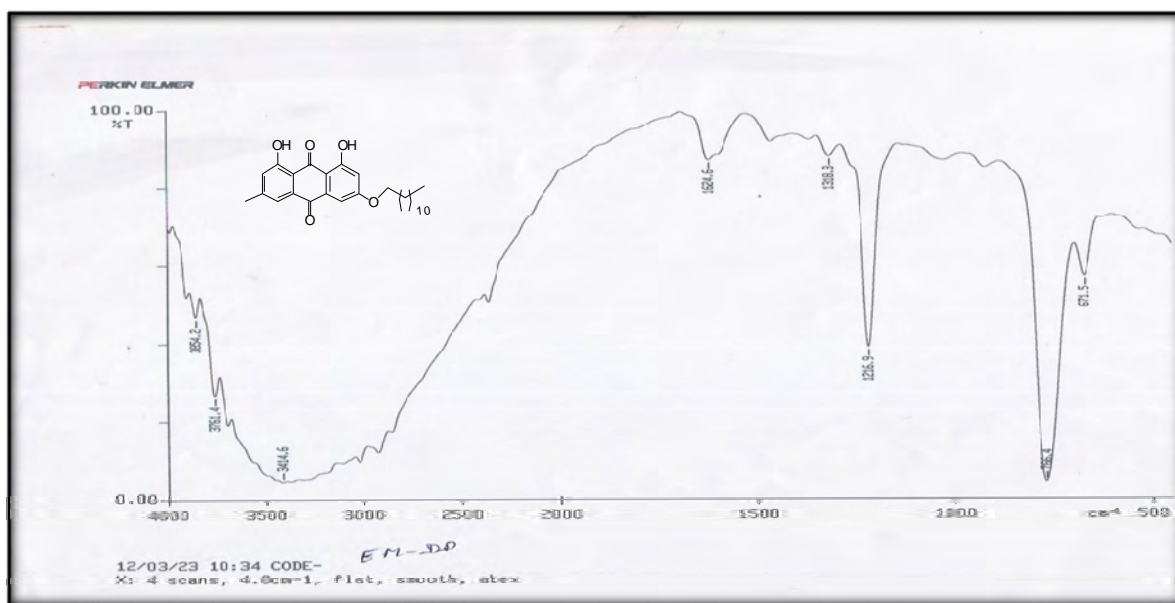
Proton NMR spectrum of compound 3



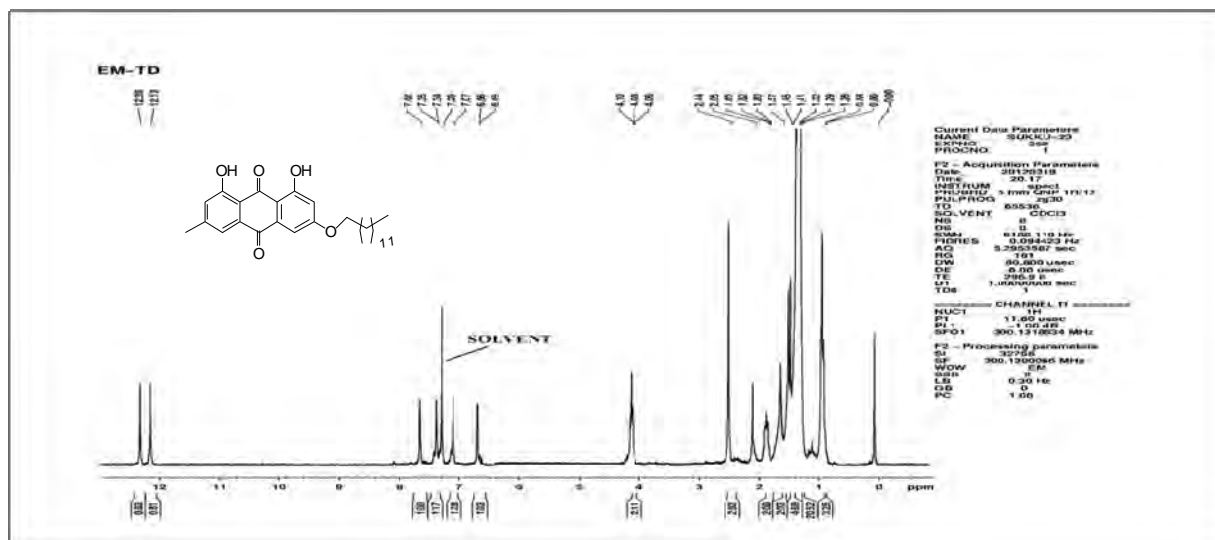
Carbon-13 NMR spectrum of compound 3



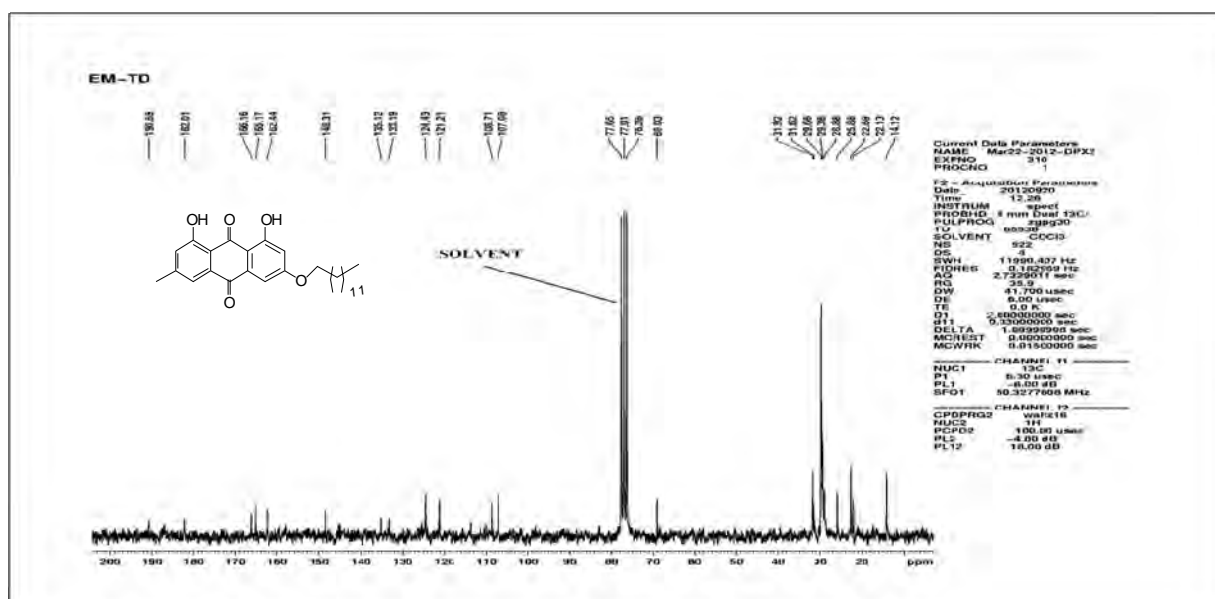
Mass spectrum of compound 3



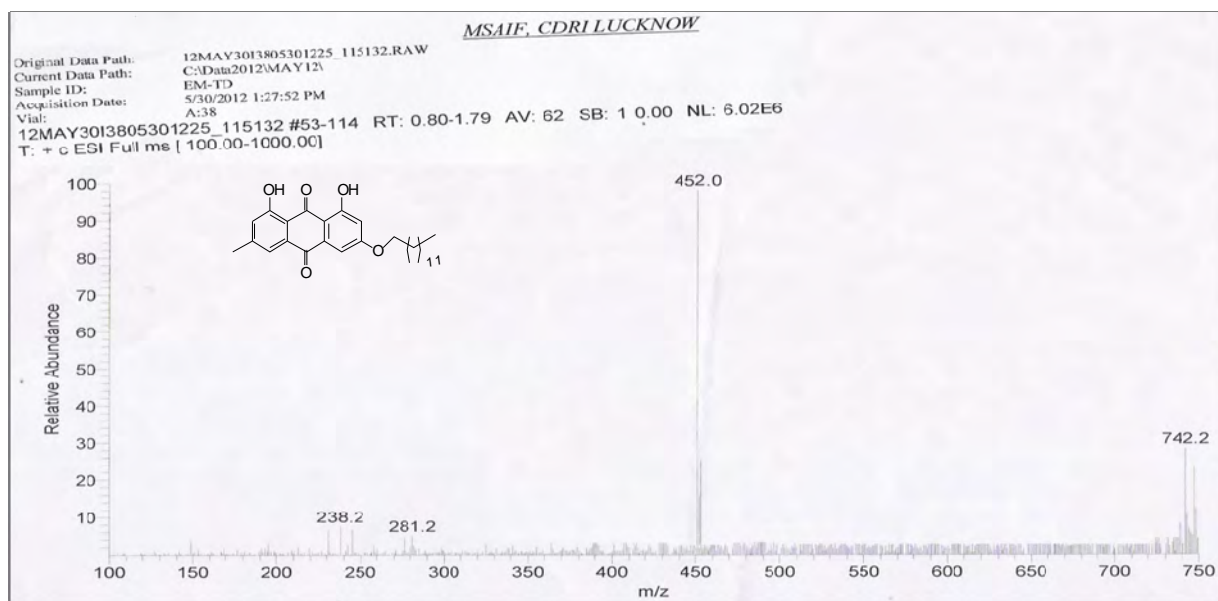
IR spectrum of compound 3



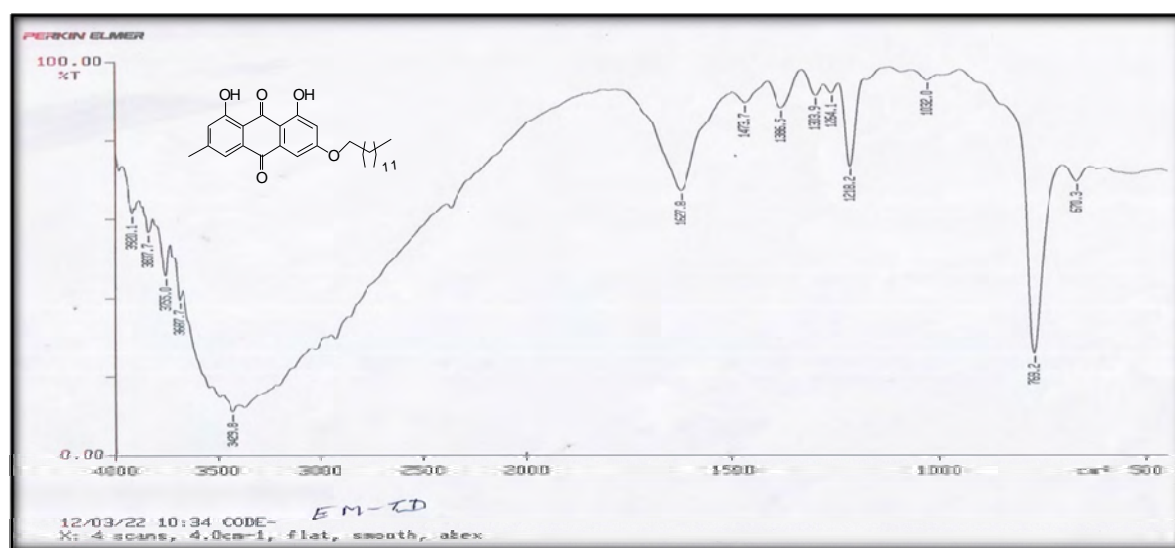
Proton NMR spectrum of compound 4



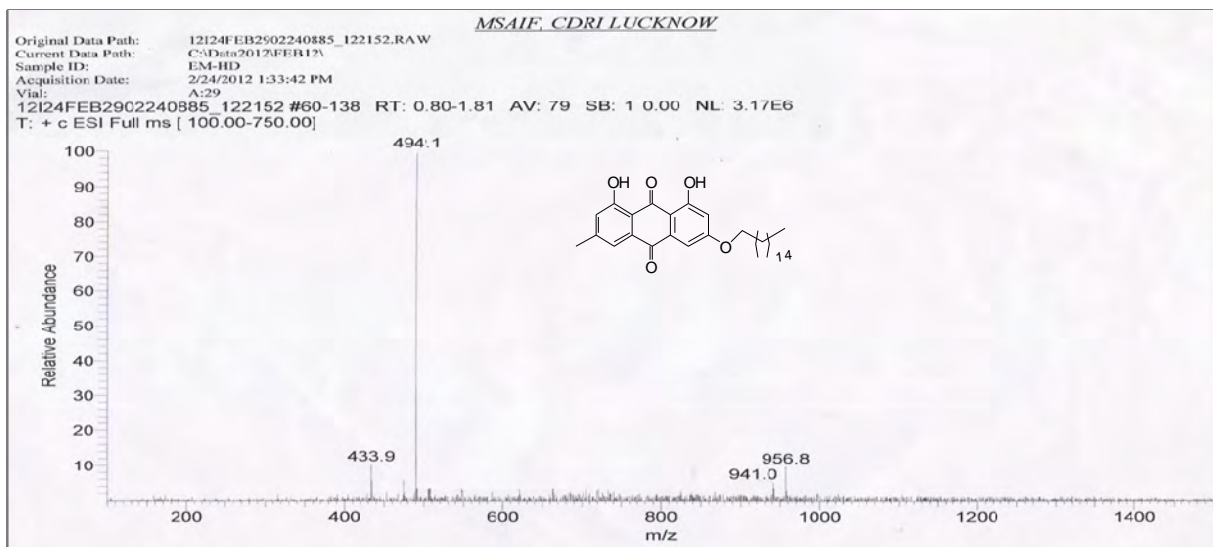
Carbon-13 NMR spectrum of compound 4



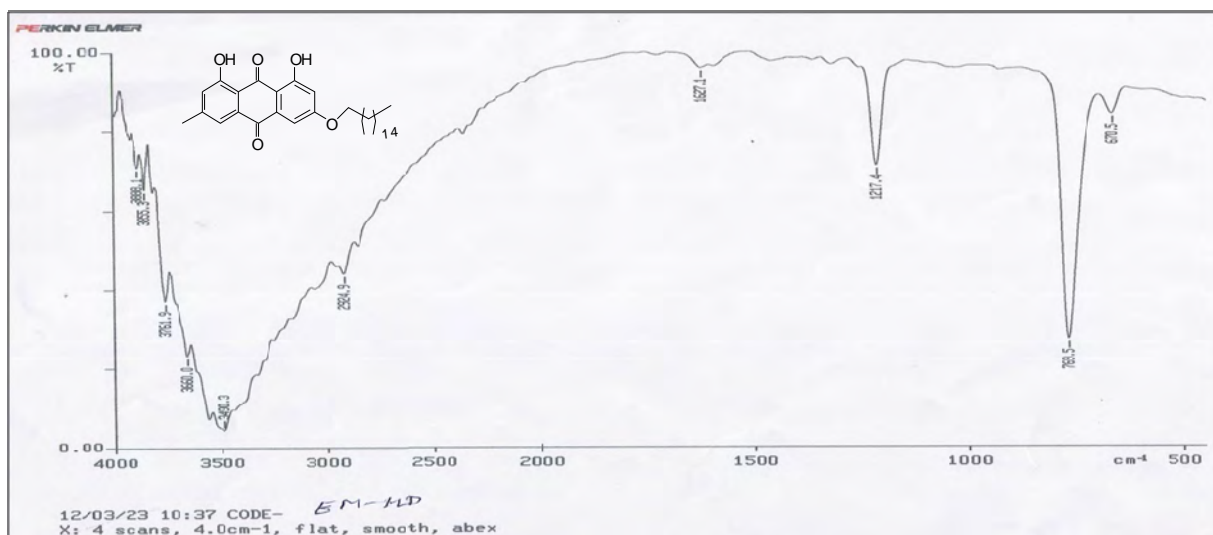
Mass spectrum of compound 4



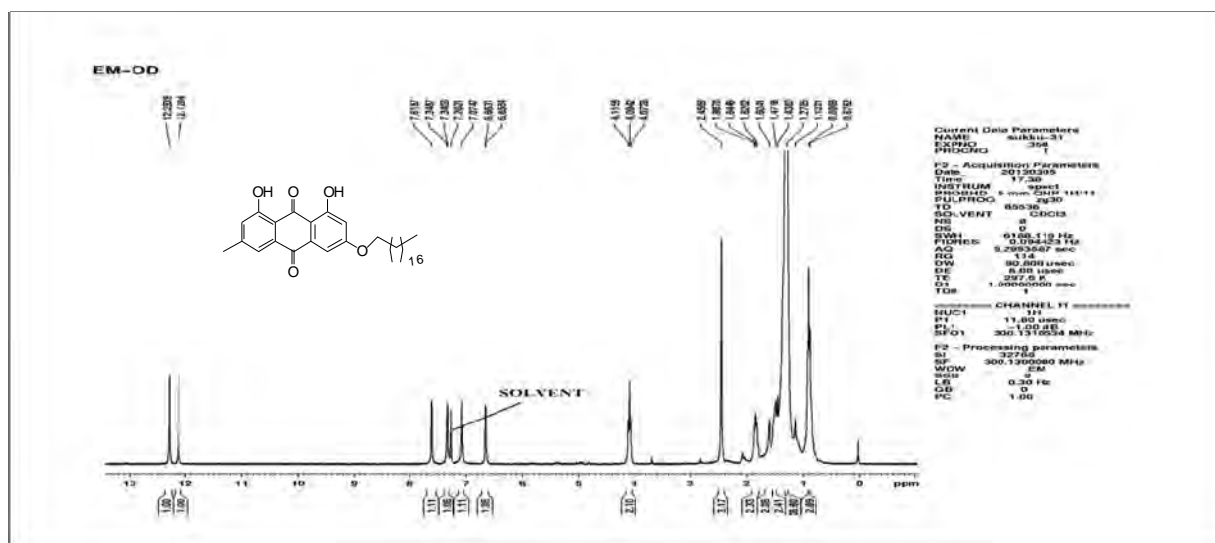
IR spectrum of compound 4



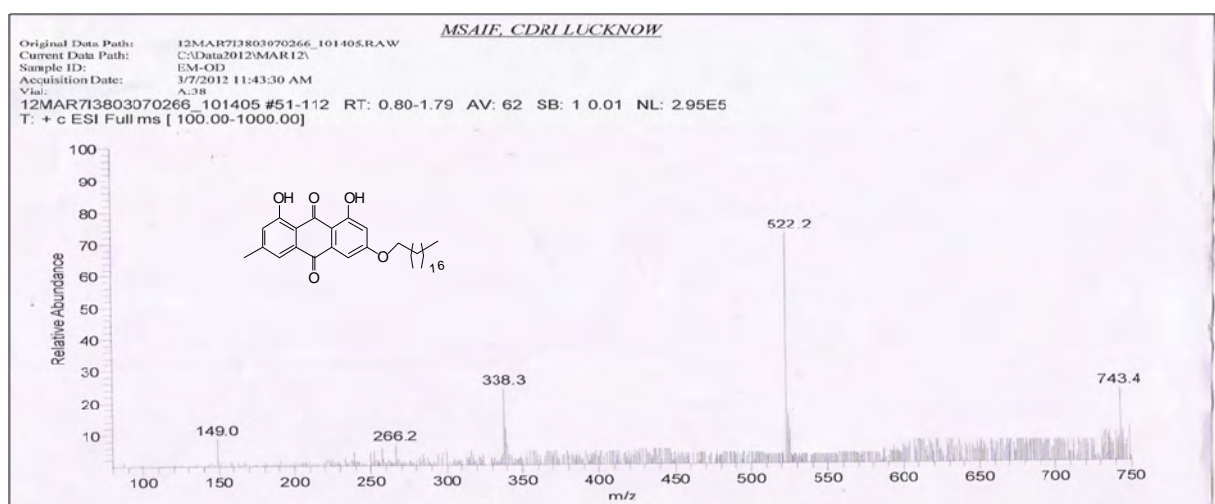
Mass spectrum of compound 5



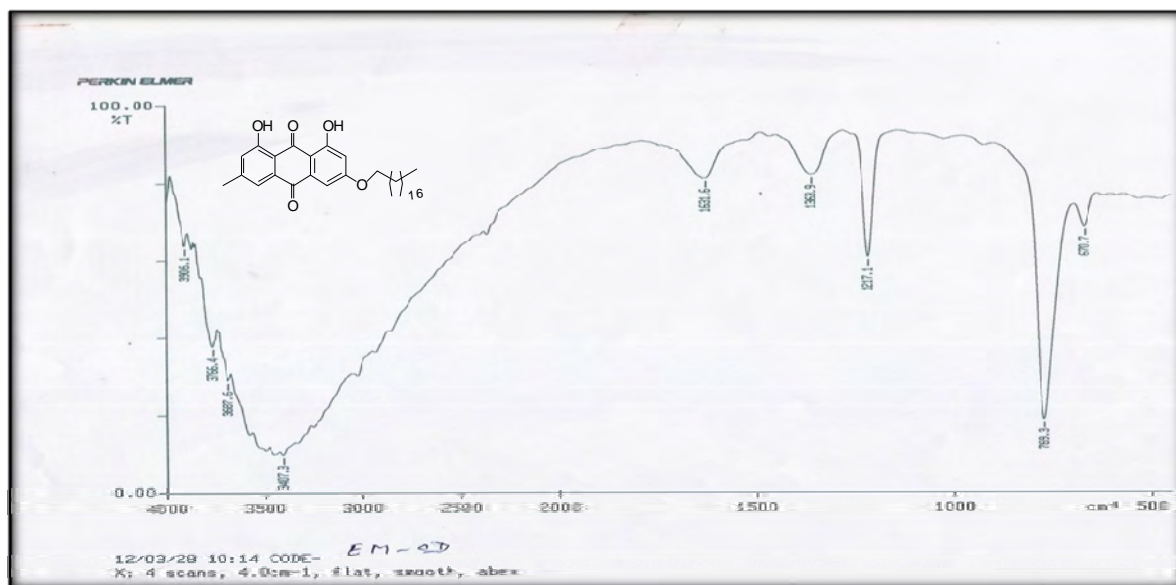
IR spectrum of compound 5



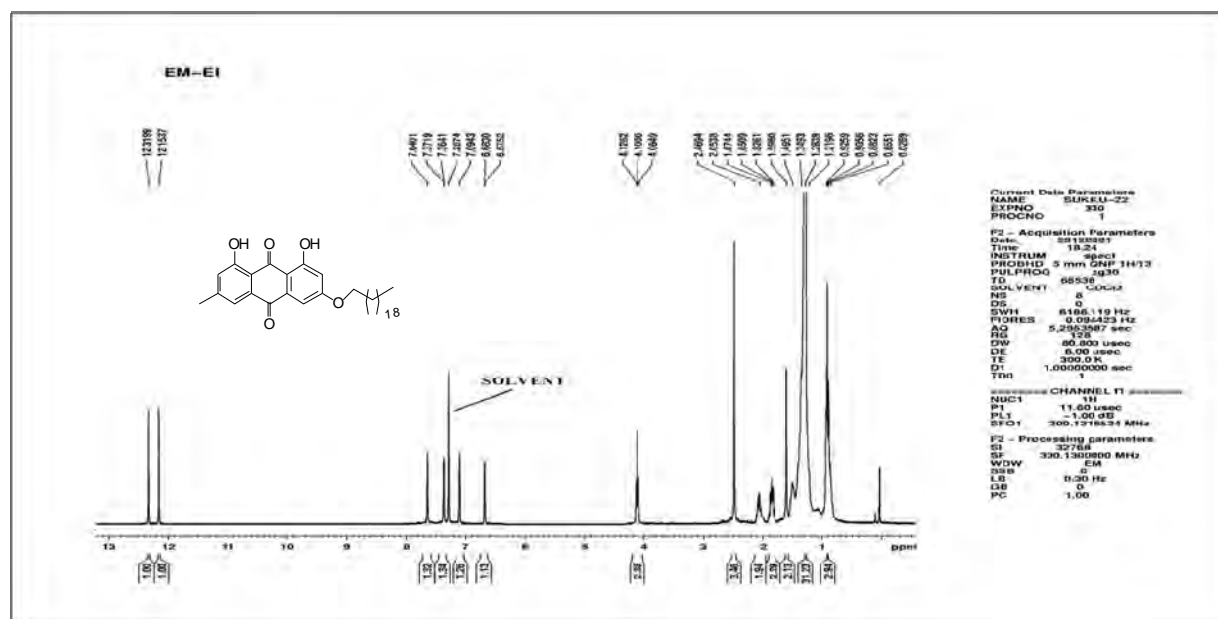
Proton NMR spectrum of compound 6



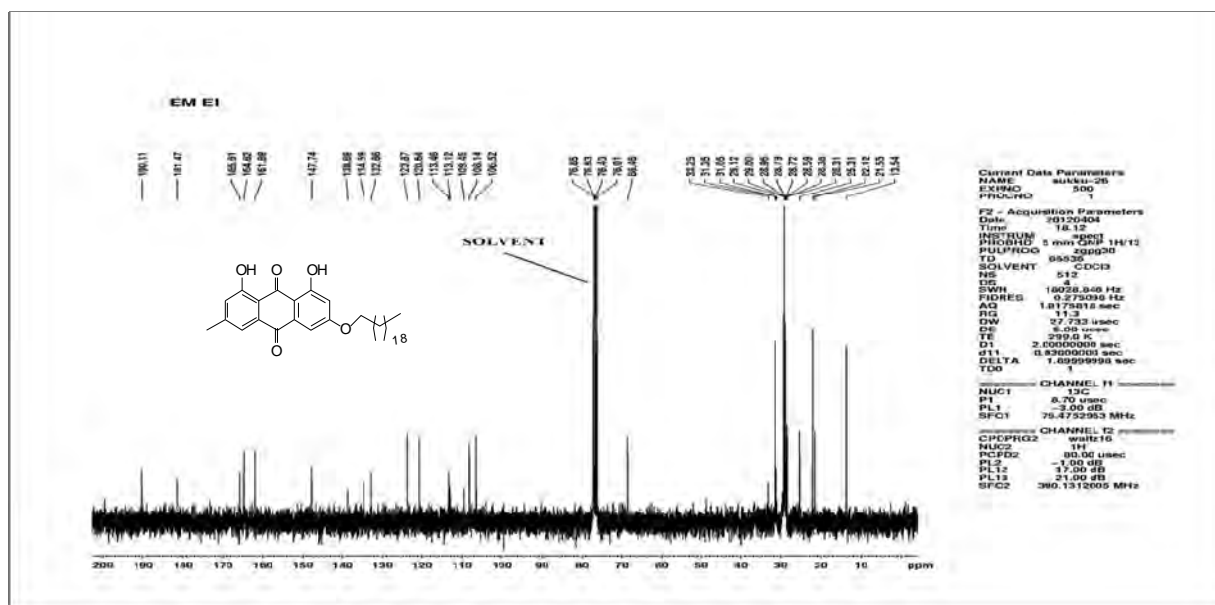
Mass spectrum of compound 6



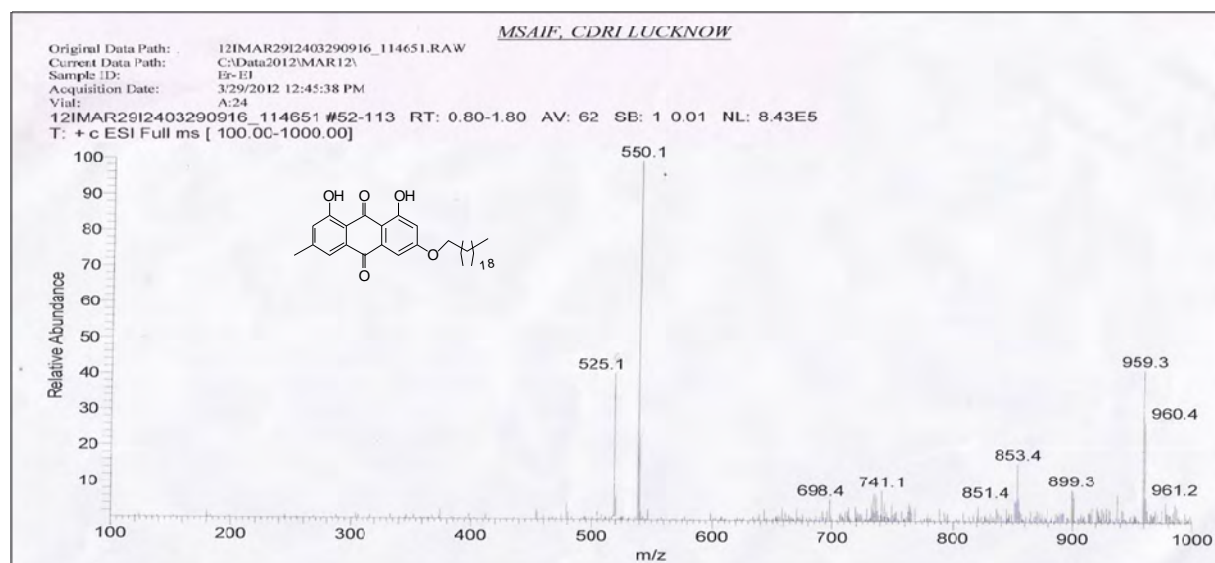
IR spectrum of compound 6



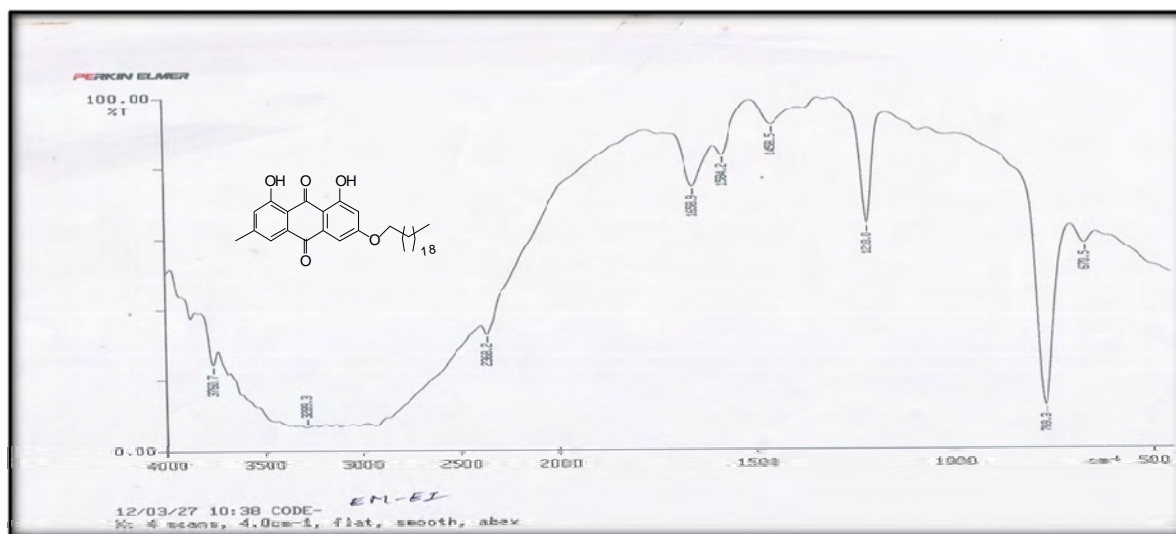
Proton NMR spectrum of compound 7



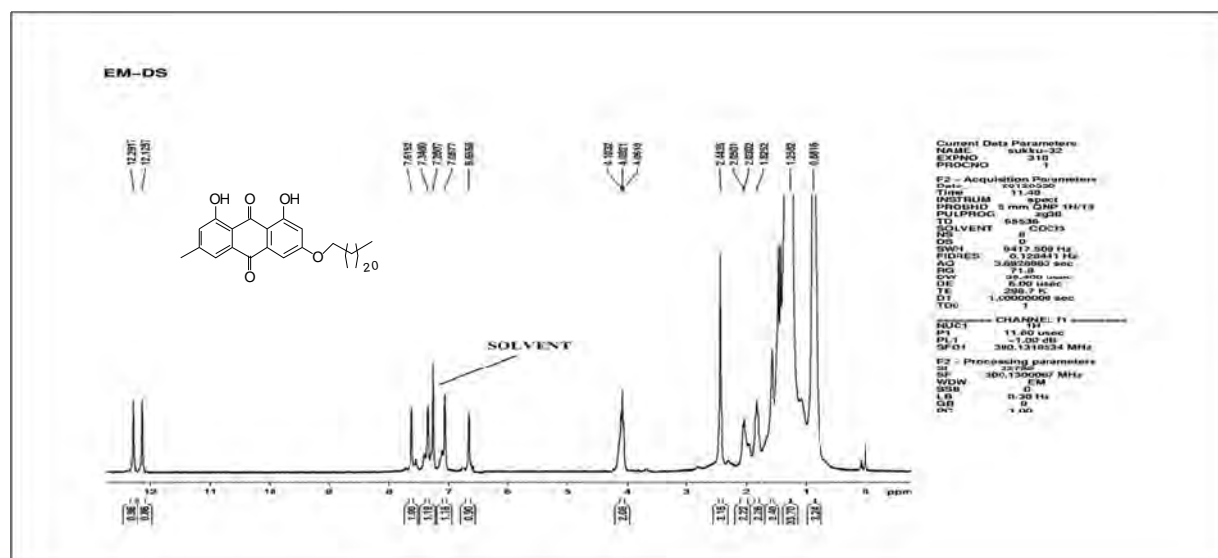
Carbon-13 NMR spectrum of compound 7



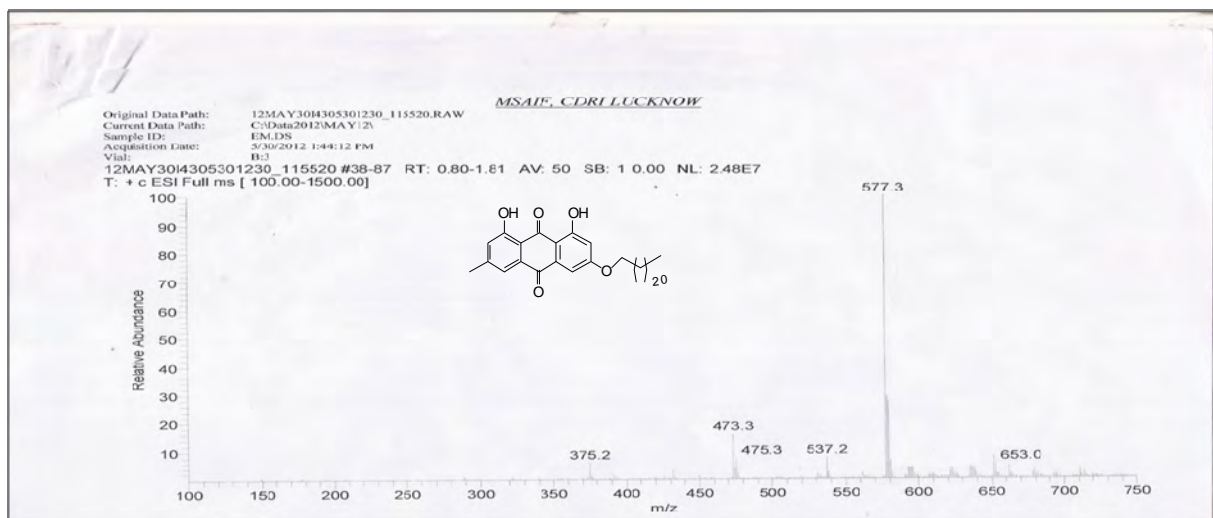
Mass spectrum of compound 7



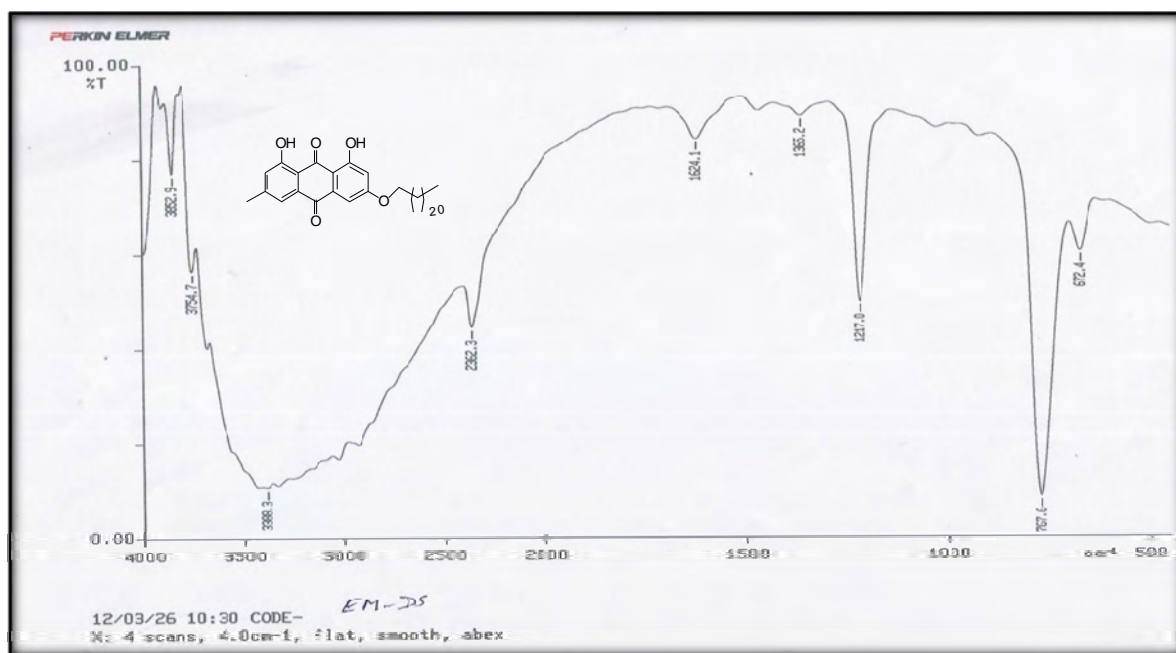
IR spectrum of compound 7



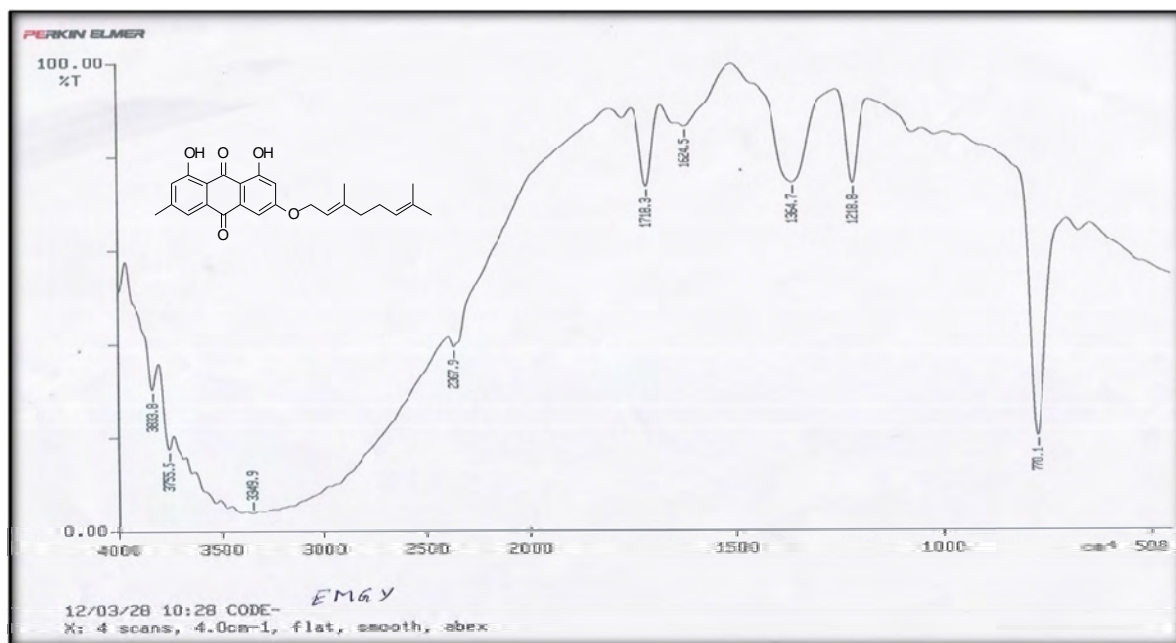
Proton NMR spectrum of compound 8



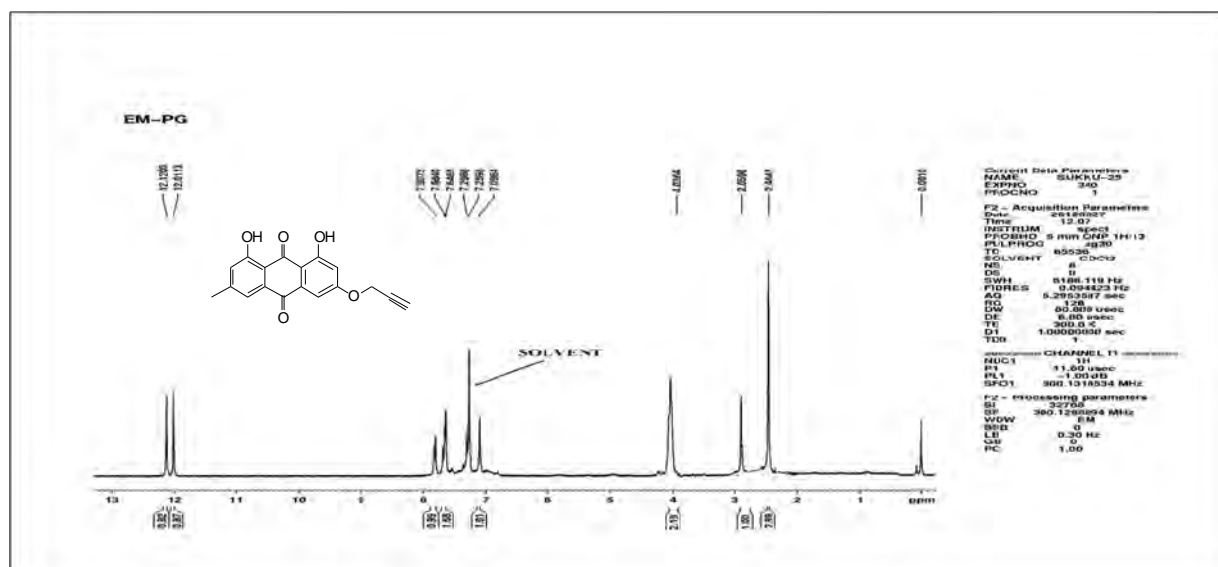
Mass spectrum of compound 8



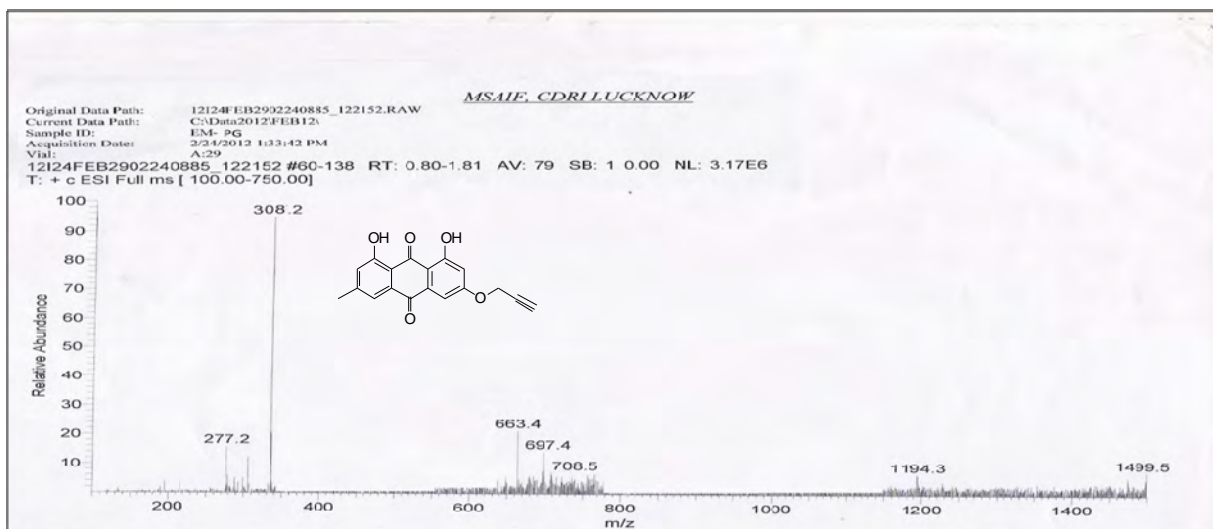
IR spectrum of compound 8



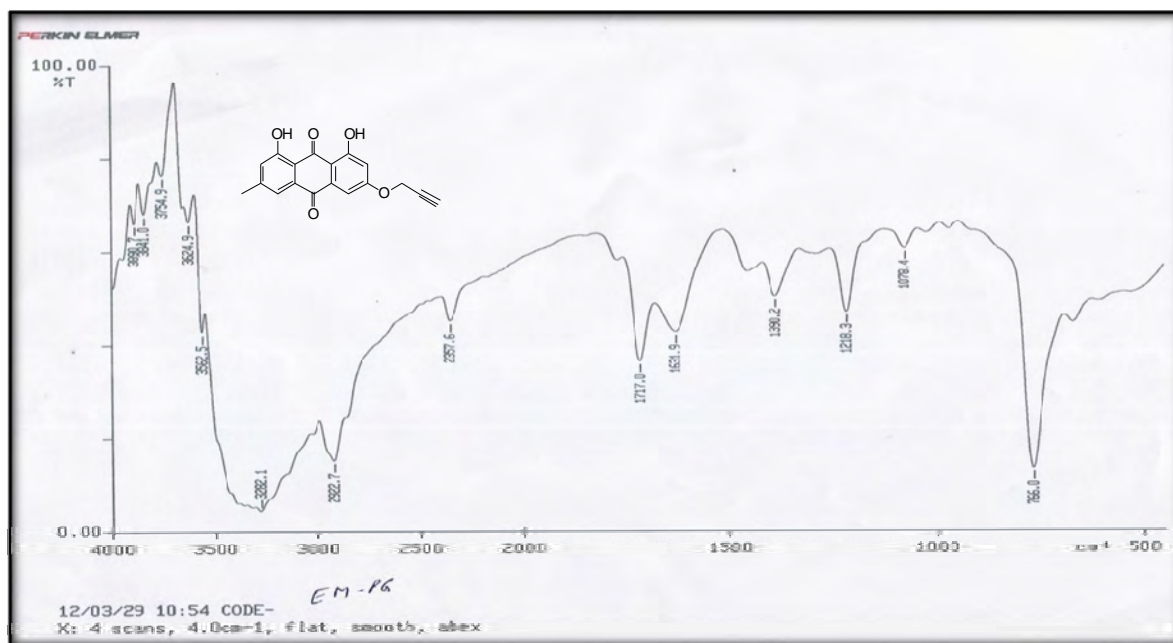
IR spectrum of compound 9



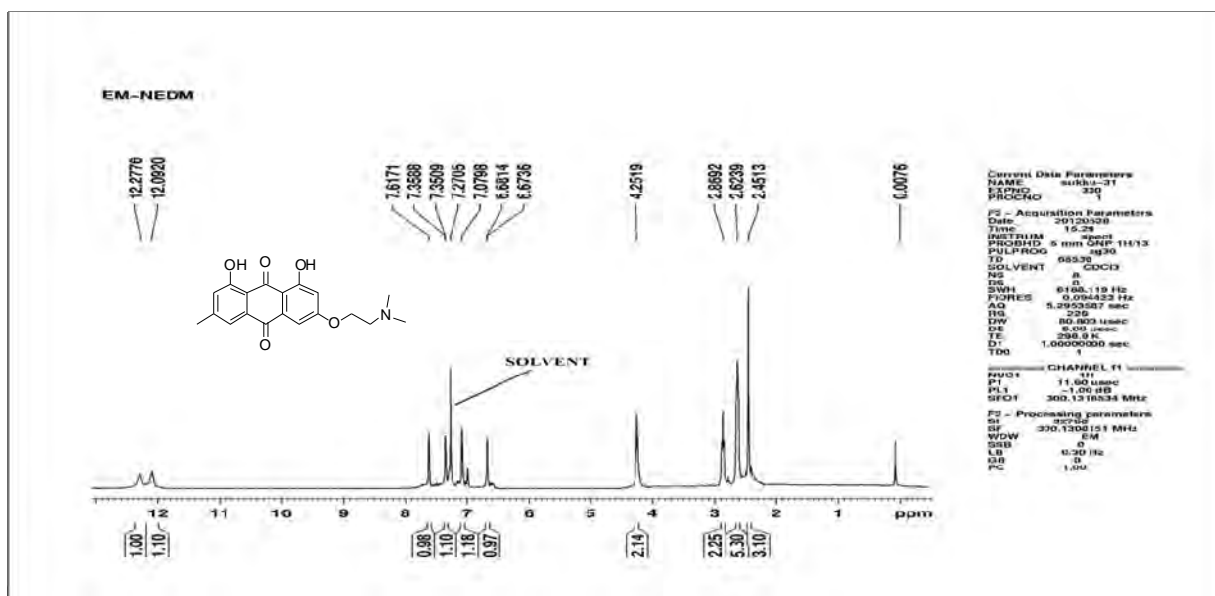
Proton NMR spectrum of compound 10



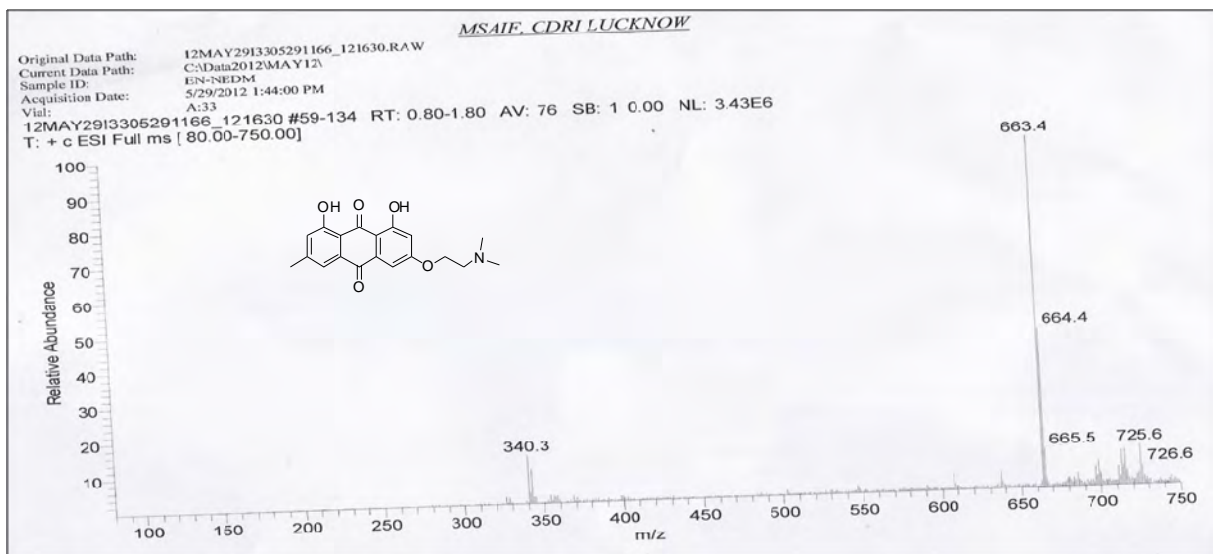
Mass spectrum of compound 10



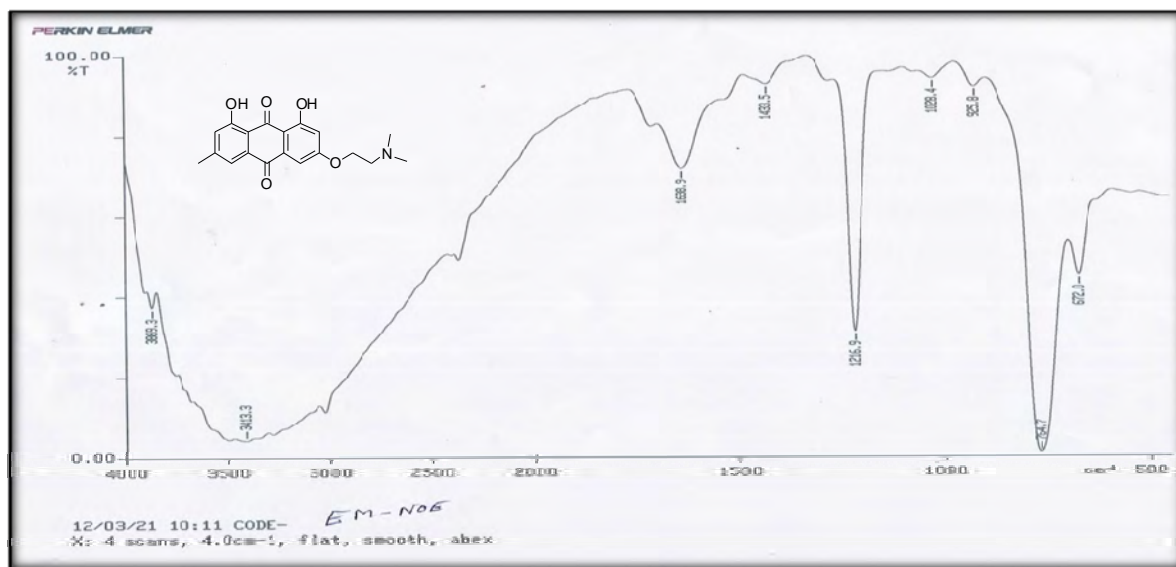
IR spectrum of compound 10



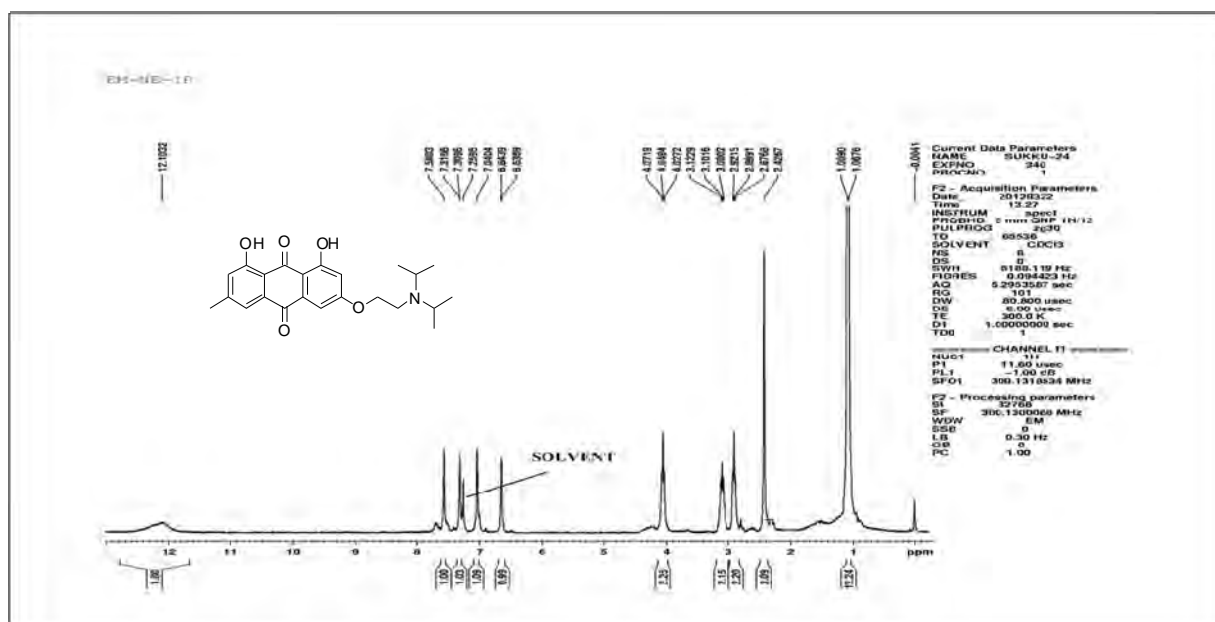
Proton NMR spectrum of compound 11



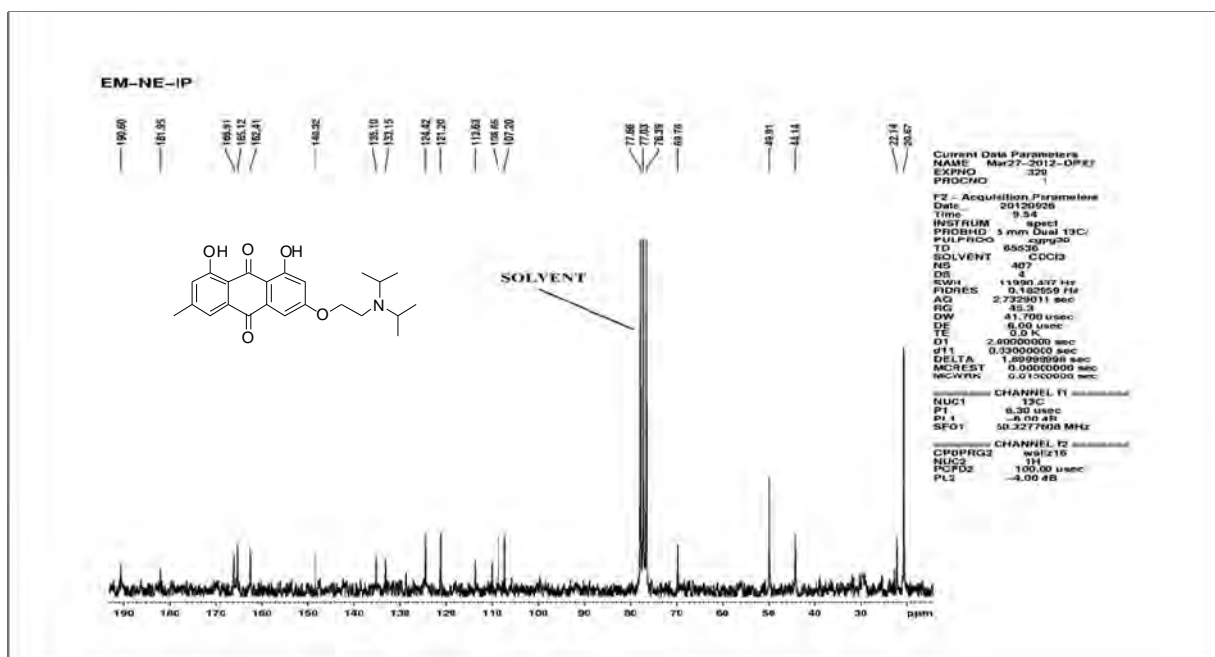
Mass spectrum of compound 11



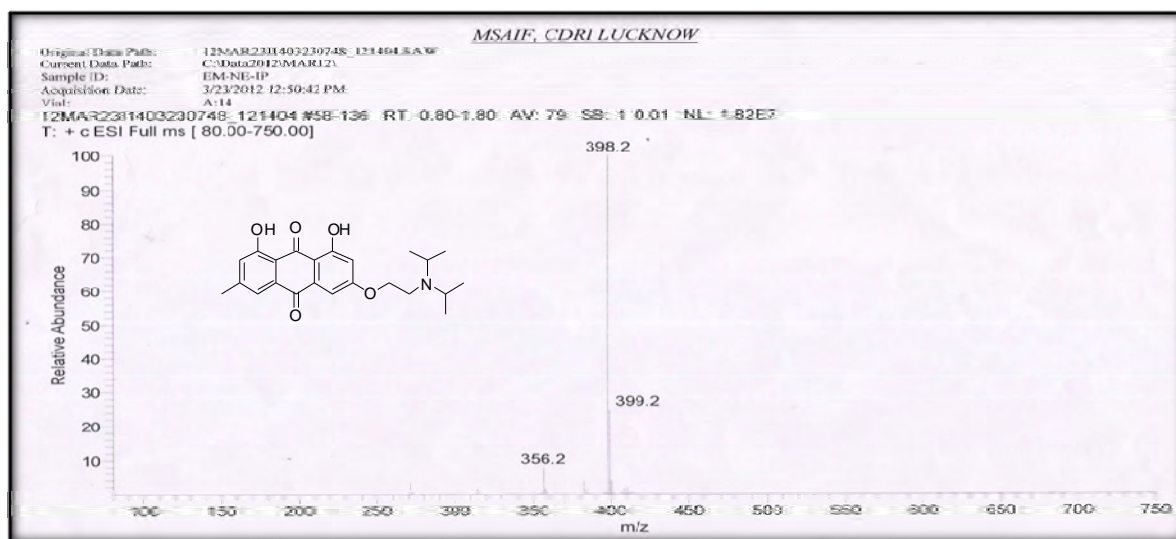
IR spectrum of compound 11



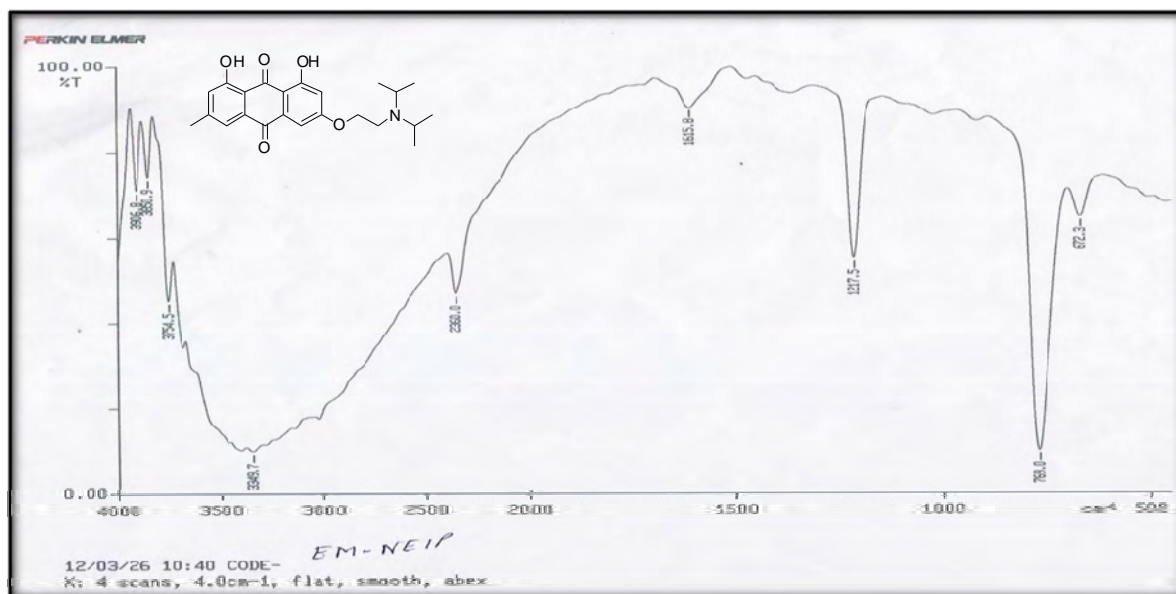
Proton NMR spectrum of compound 12



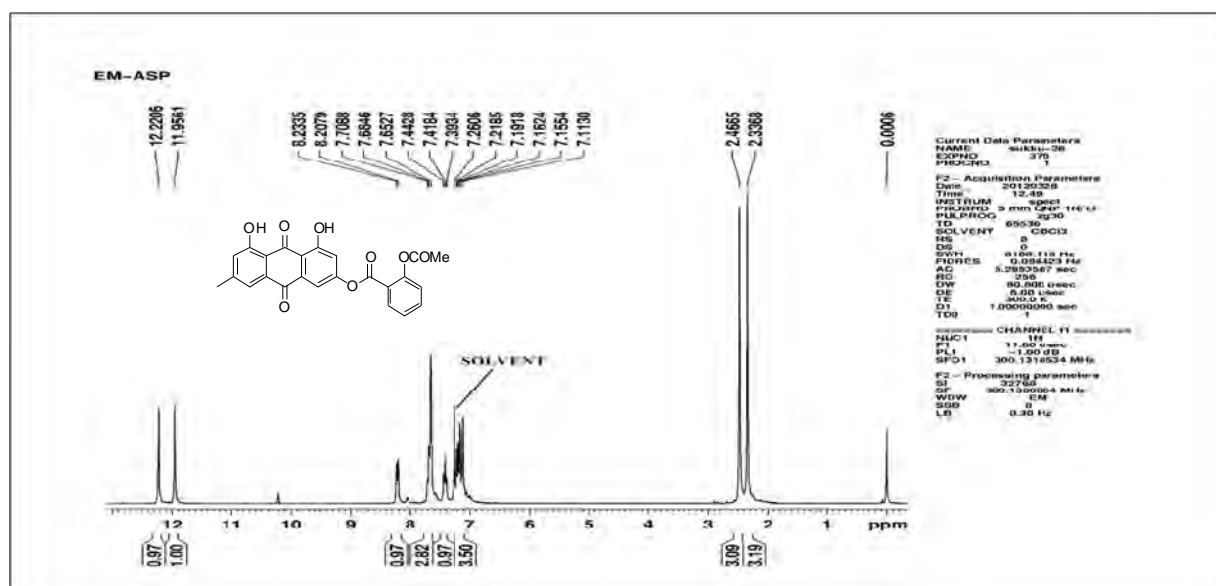
Carbon-13 NMR spectrum of compound 12



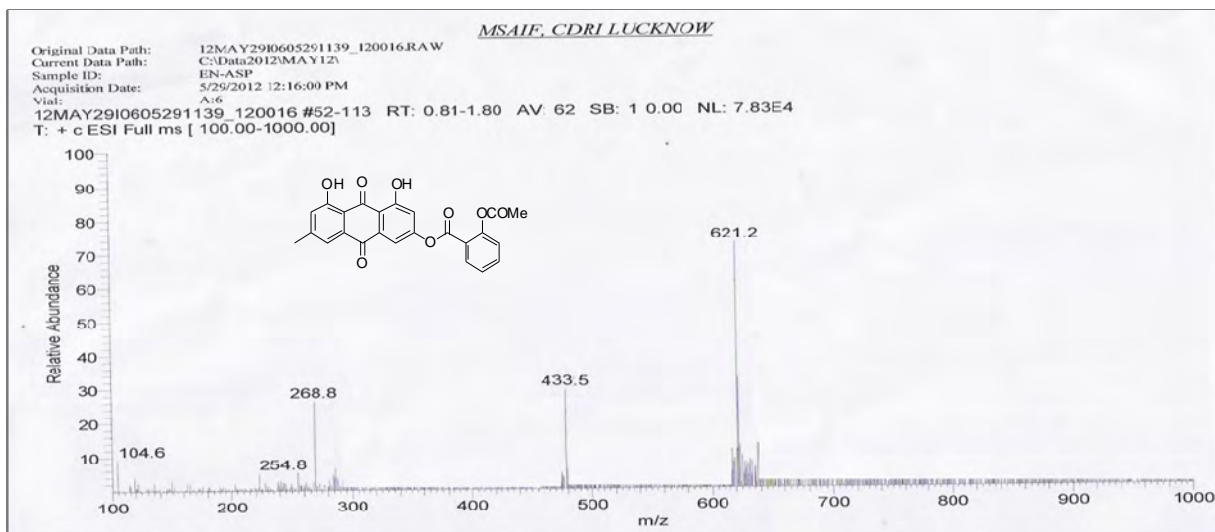
Mass spectrum of compound 12



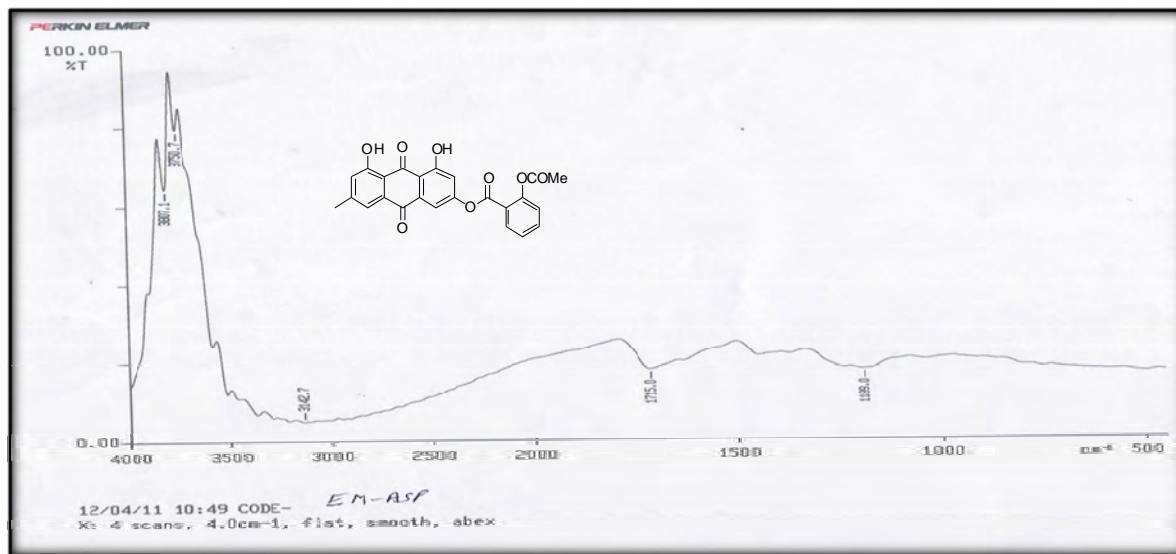
IR spectrum of compound 12



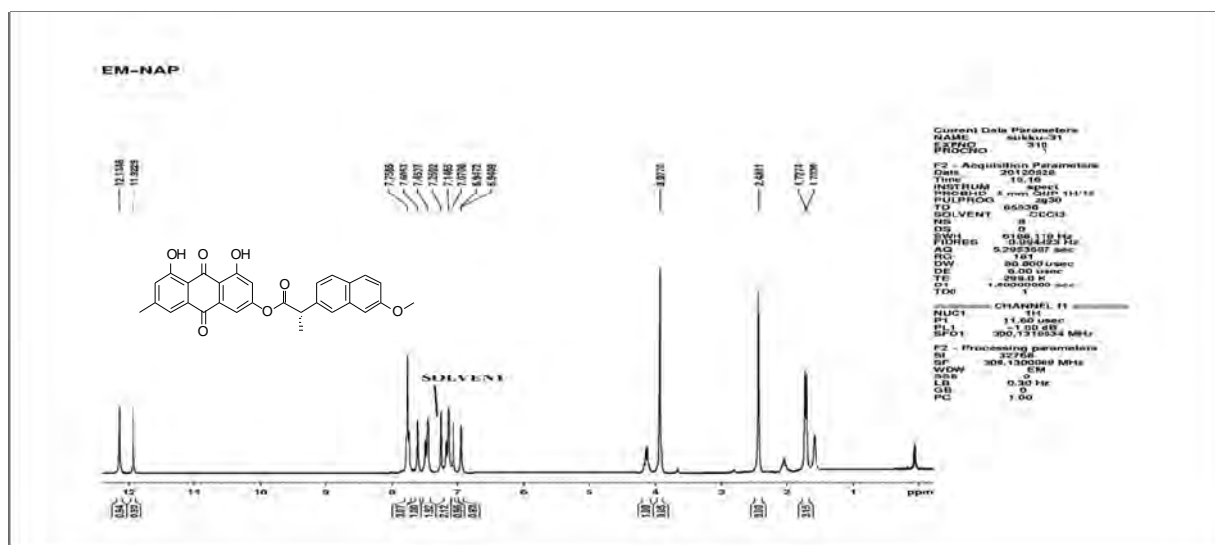
Proton NMR spectrum of compound 13



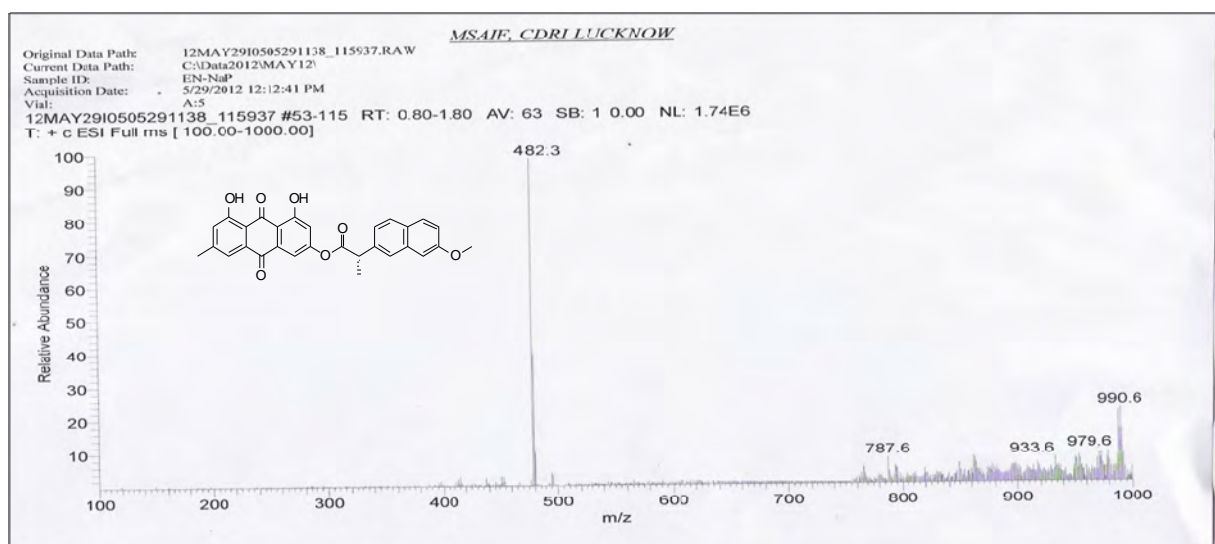
Mass spectrum of compound 13



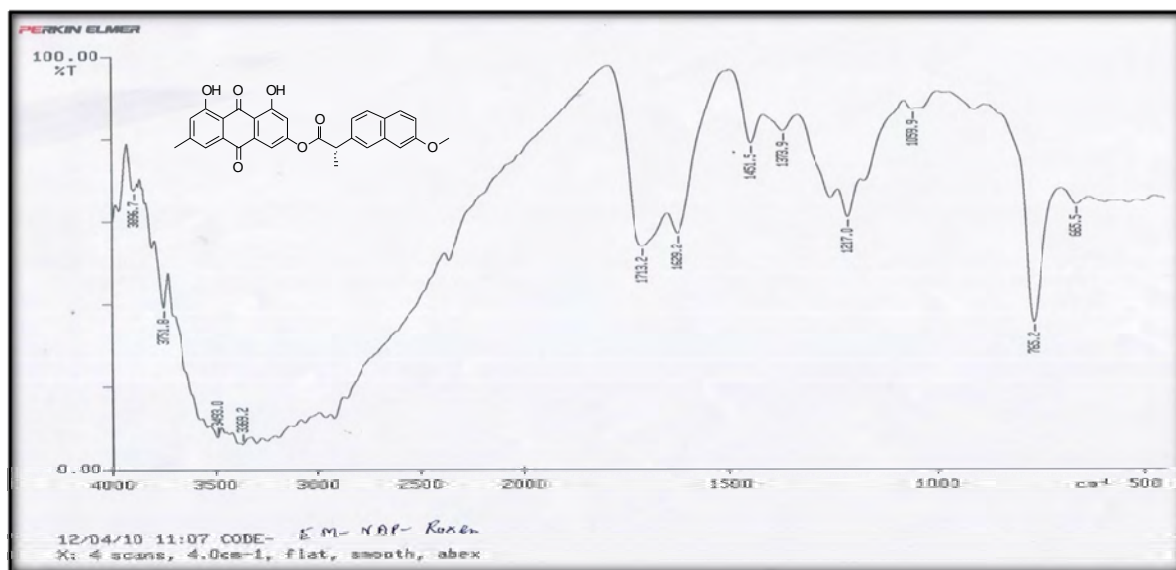
IR spectrum of compound 13



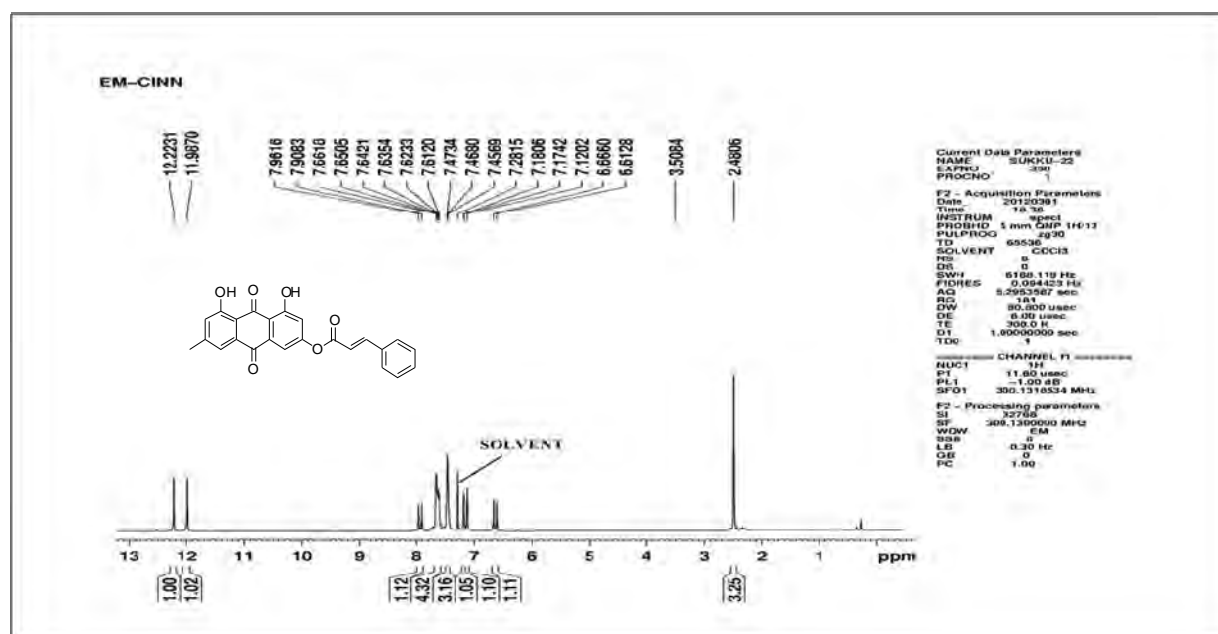
Proton NMR spectrum of compound 14



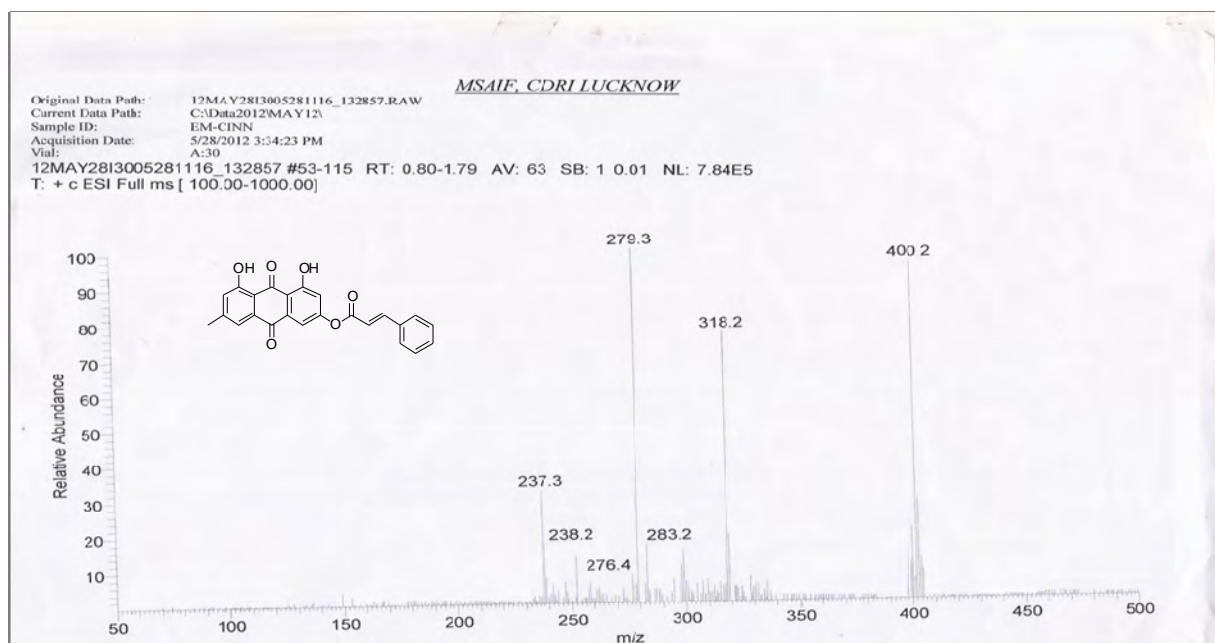
Mass spectrum of compound 14



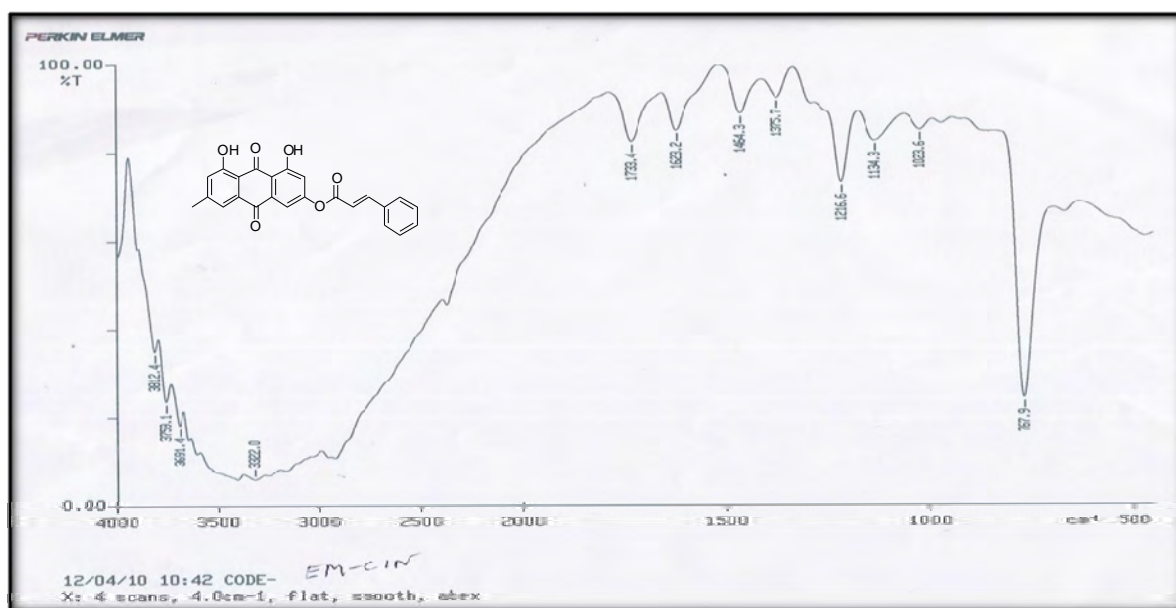
IR spectrum of compound 14



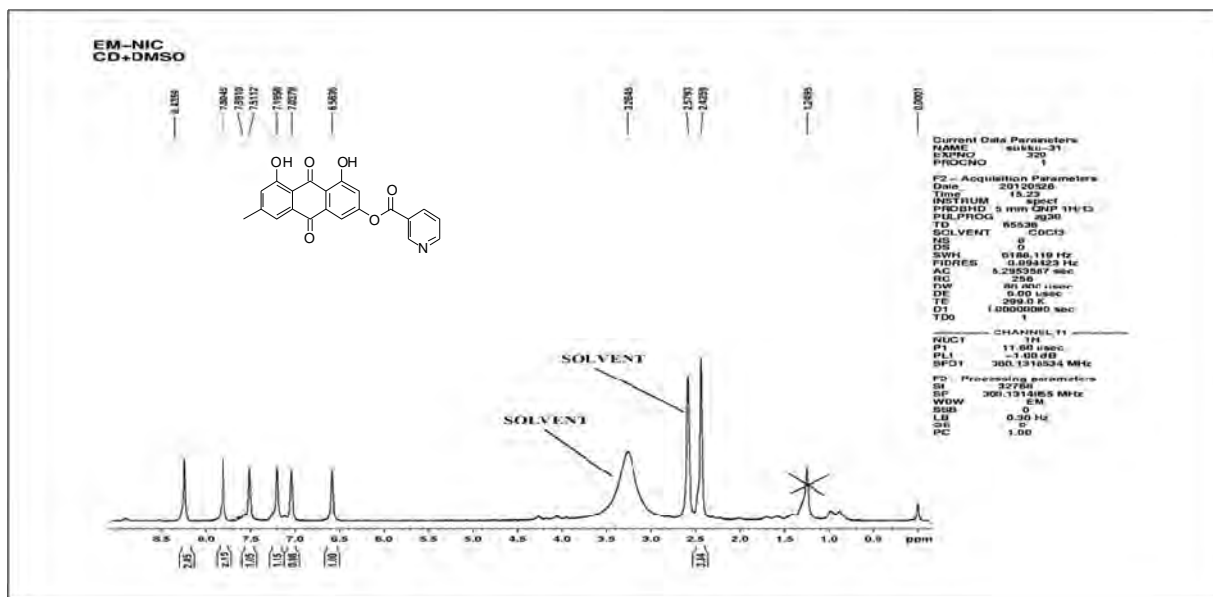
Proton NMR spectrum of compound 15



Mass spectrum of compound 15

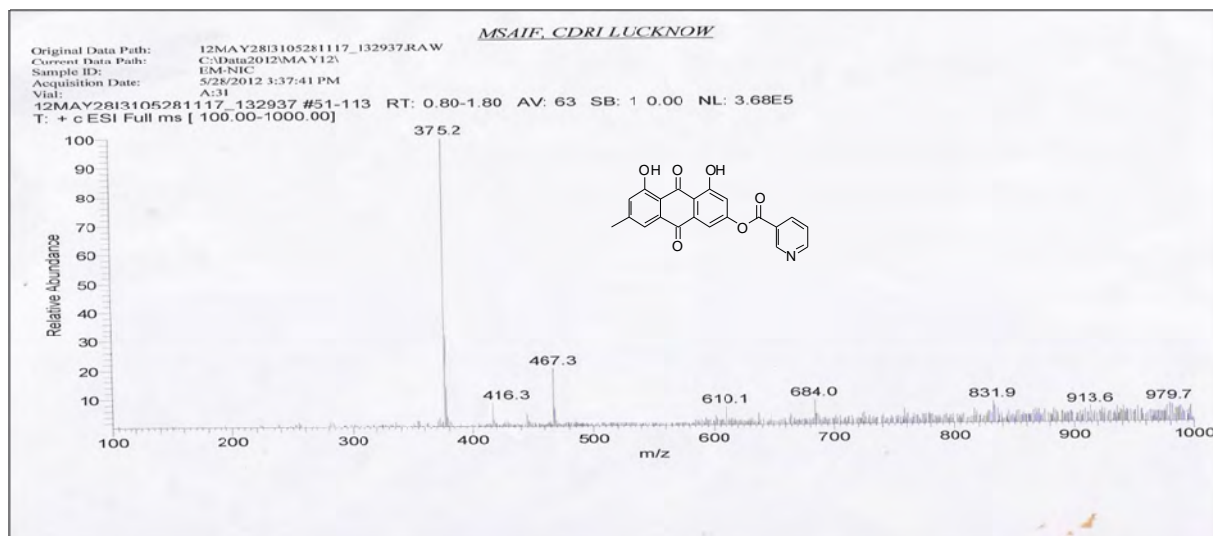


IR spectrum of compound 15

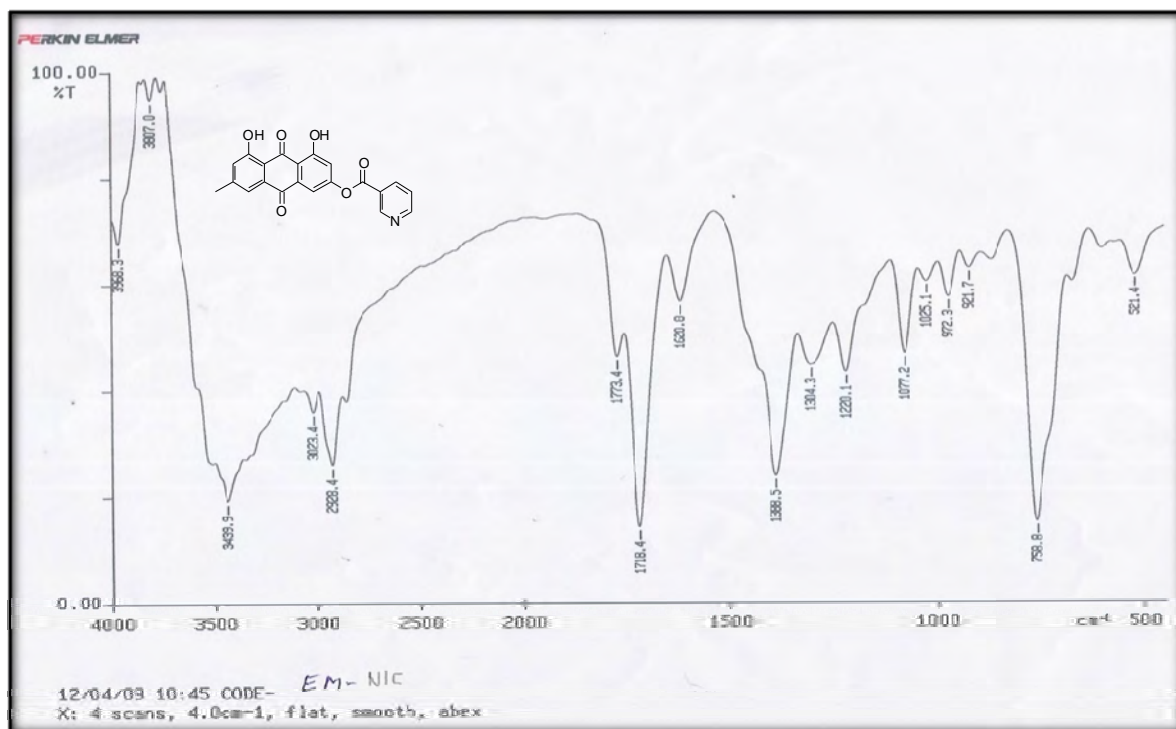


Proton NMR spectrum of compound 16

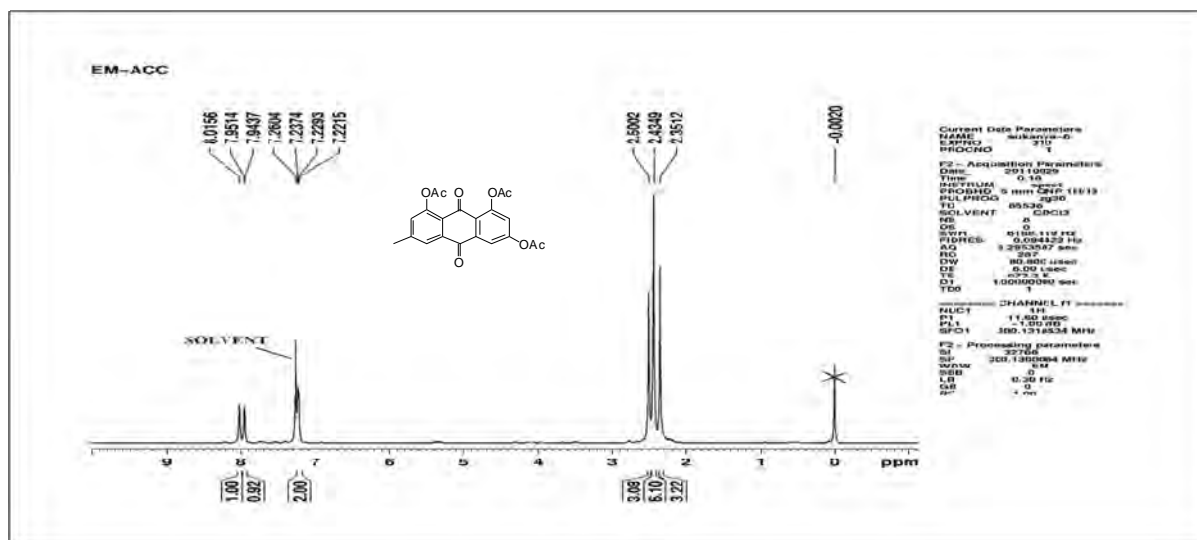
X= Indicates grease impurities in the spectrum



Mass spectrum of compound 16

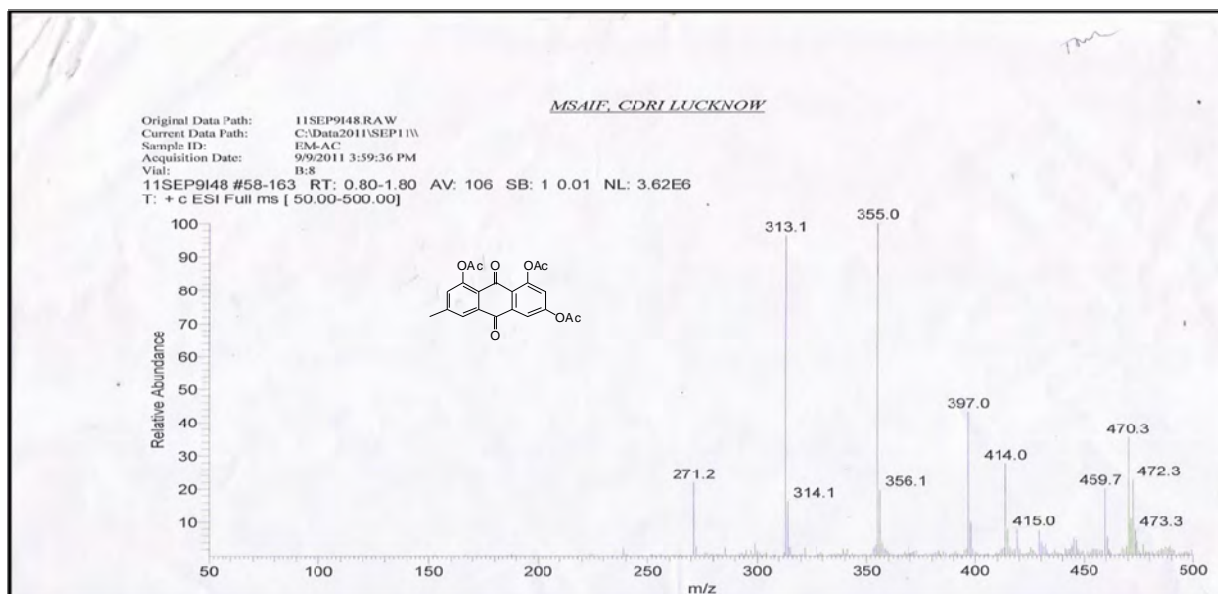


IR spectrum of compound 16

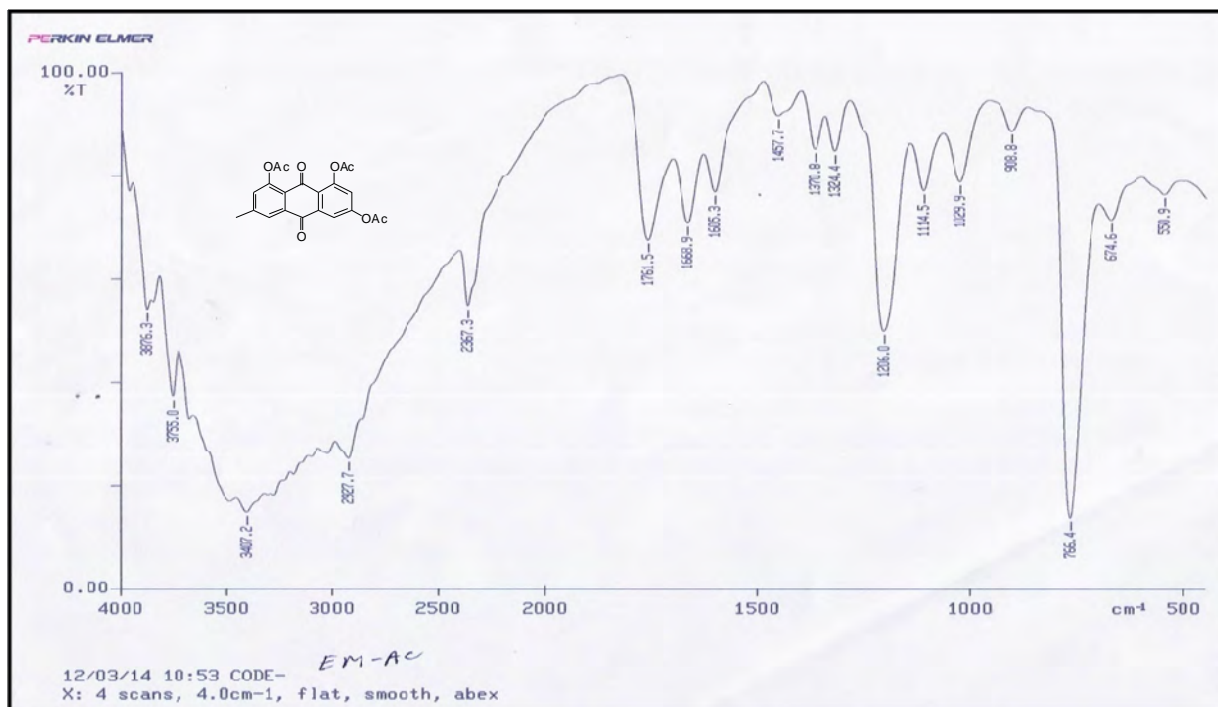


Proton NMR spectrum of compound 17

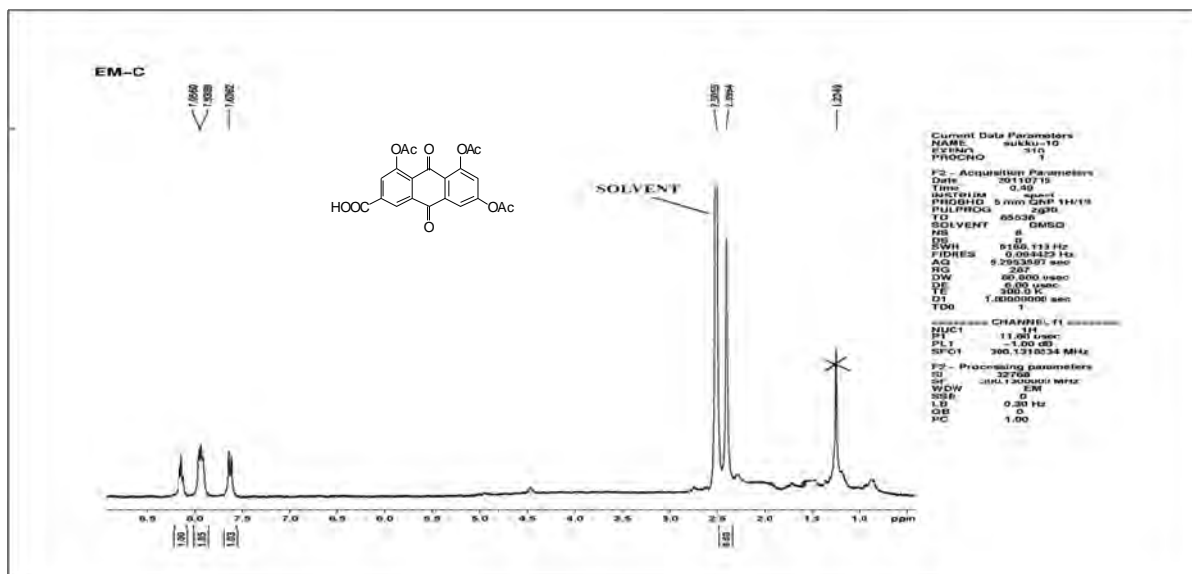
X= Indicates grease impurities in the spectrum



Mass spectrum of compound 17

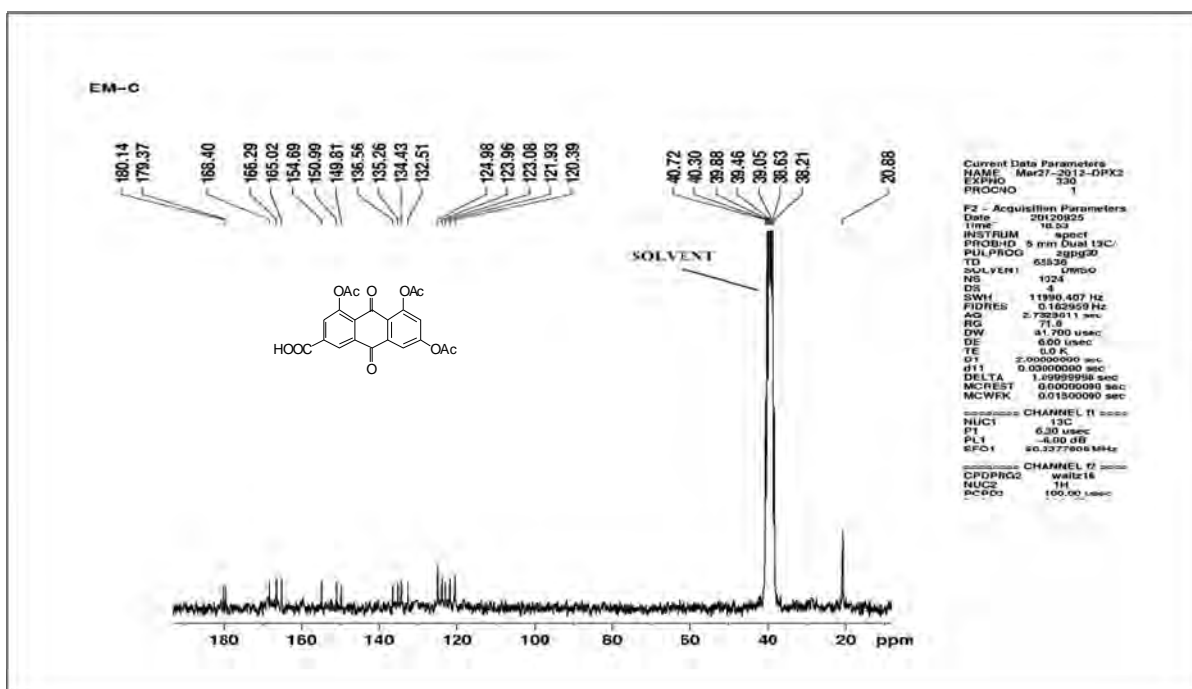


IR spectrum of compound 17

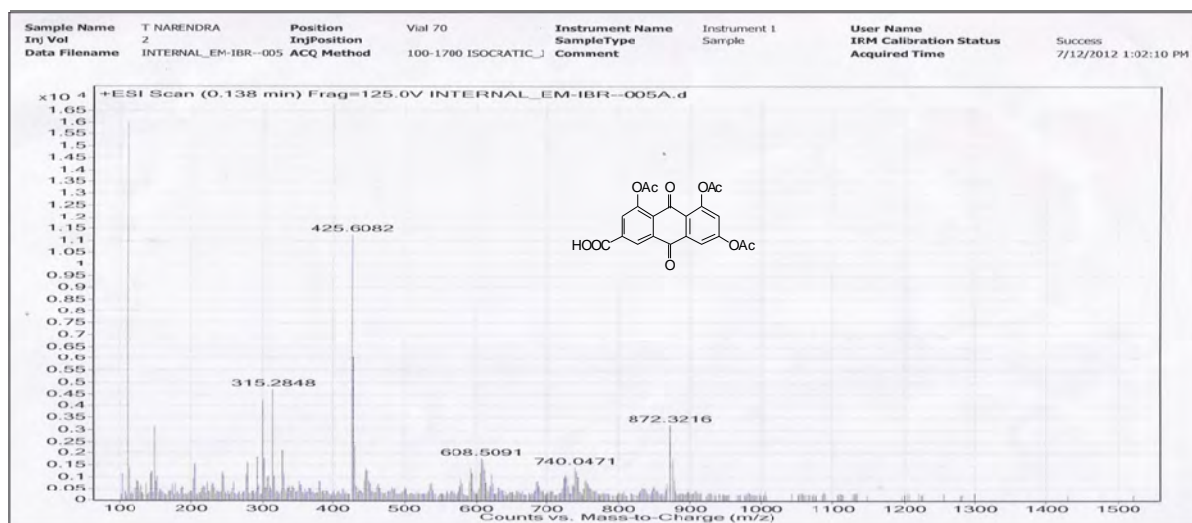


Proton NMR spectrum of compound 18

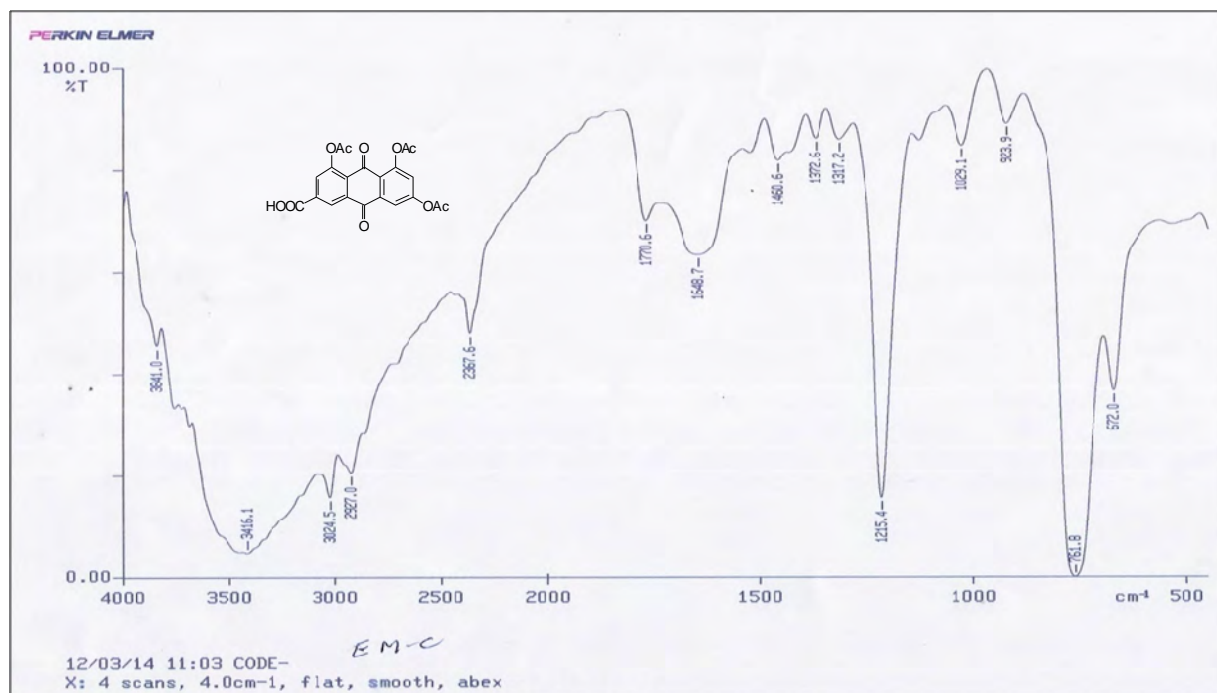
X= Indicates grease impurities in the spectrum



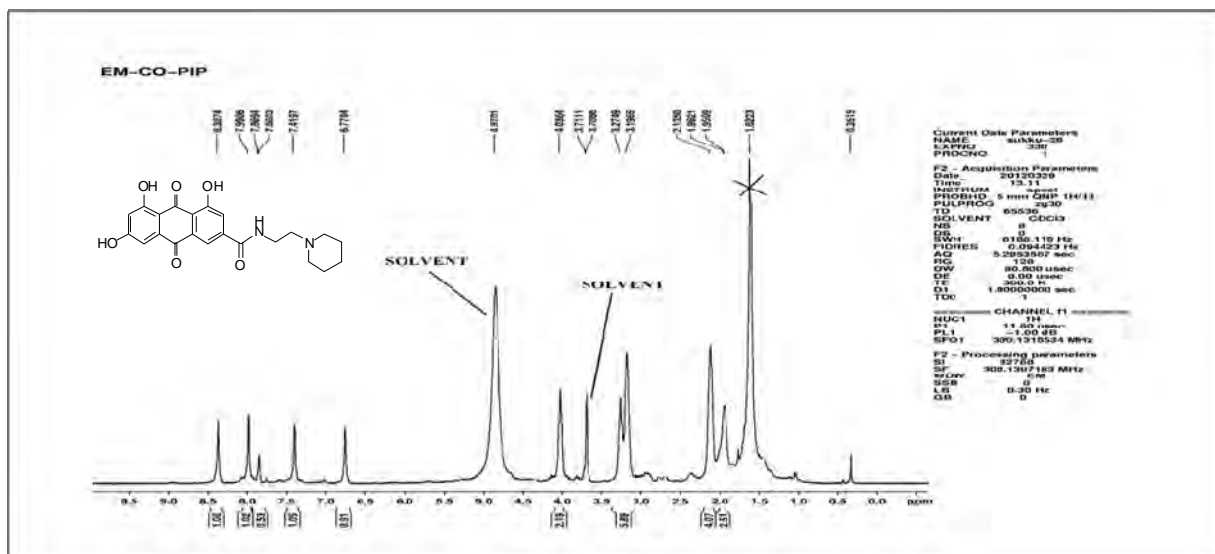
Carbon-13 NMR spectrum of compound 18



Mass spectrum of compound 18

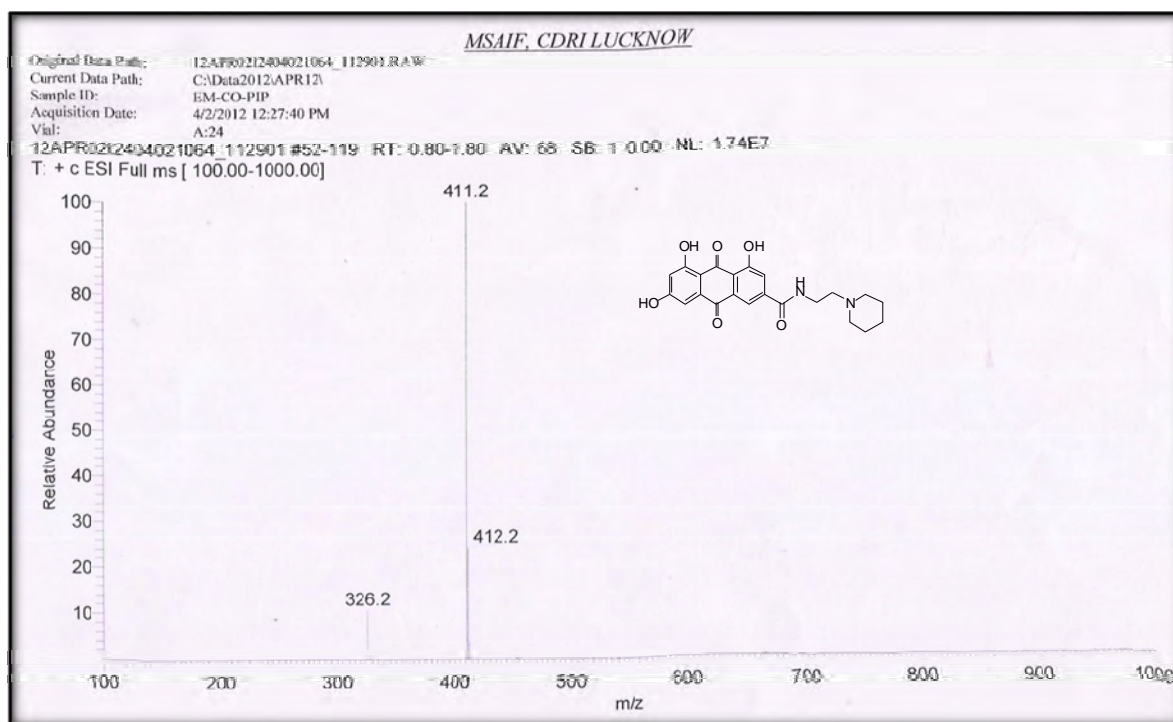


IR spectrum of compound 18

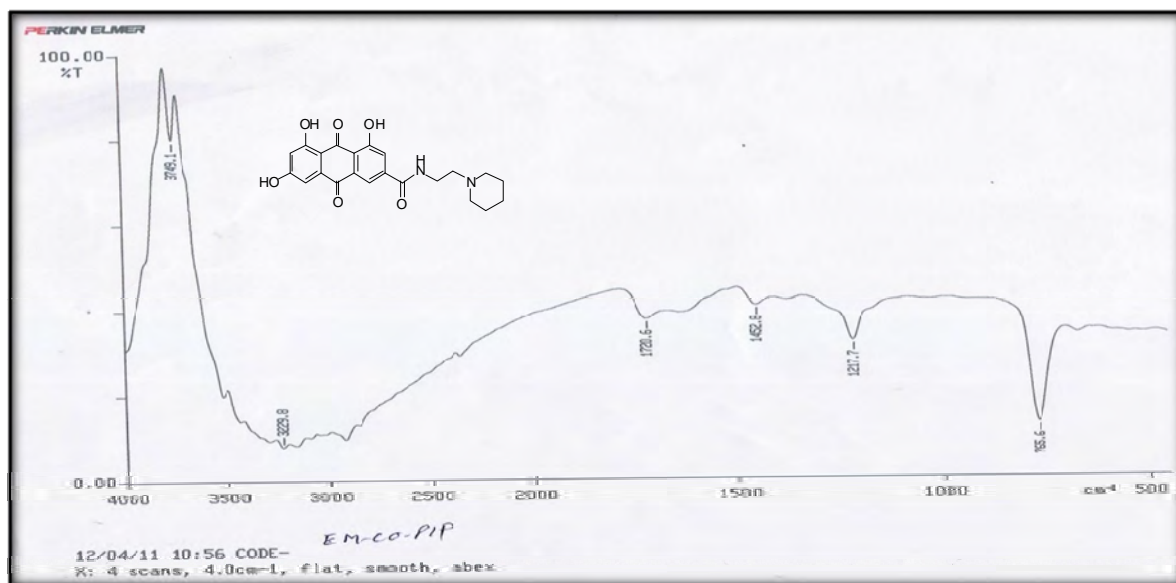


Proton NMR spectrum of compound 19

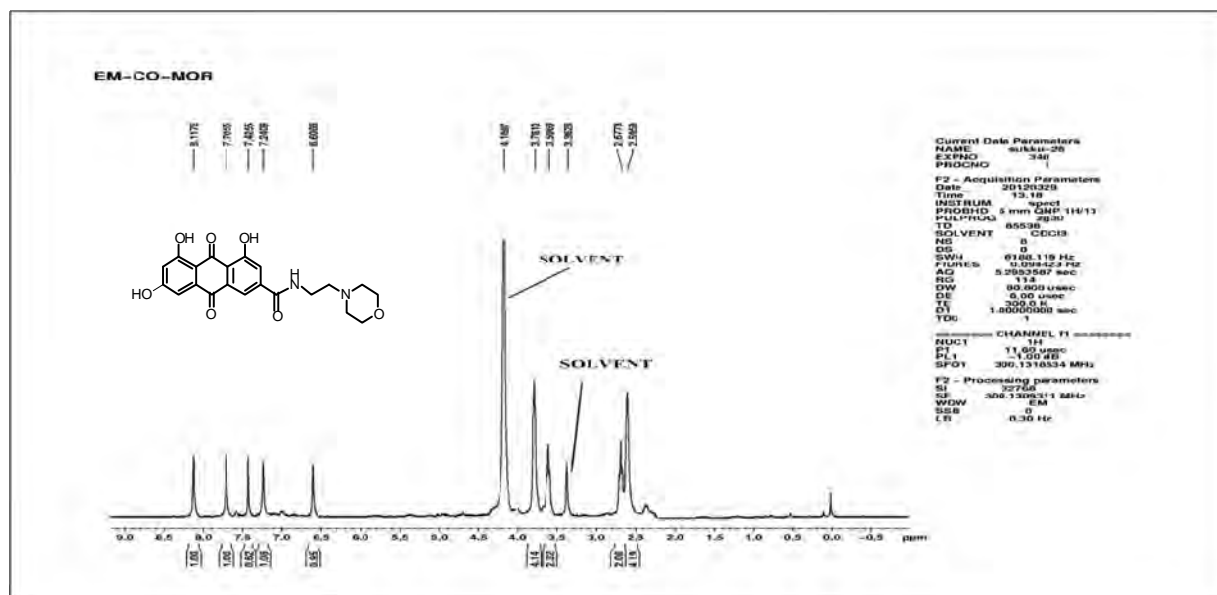
X= Indicates grease impurities in the spectrum



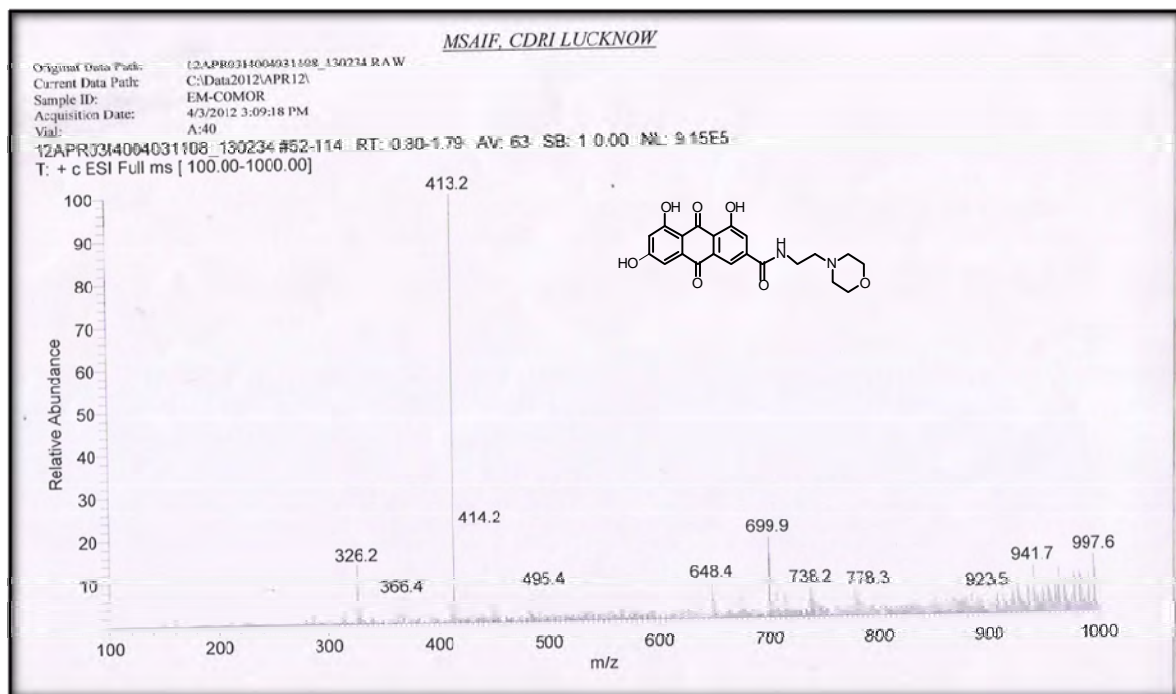
Mass spectrum of compound 19



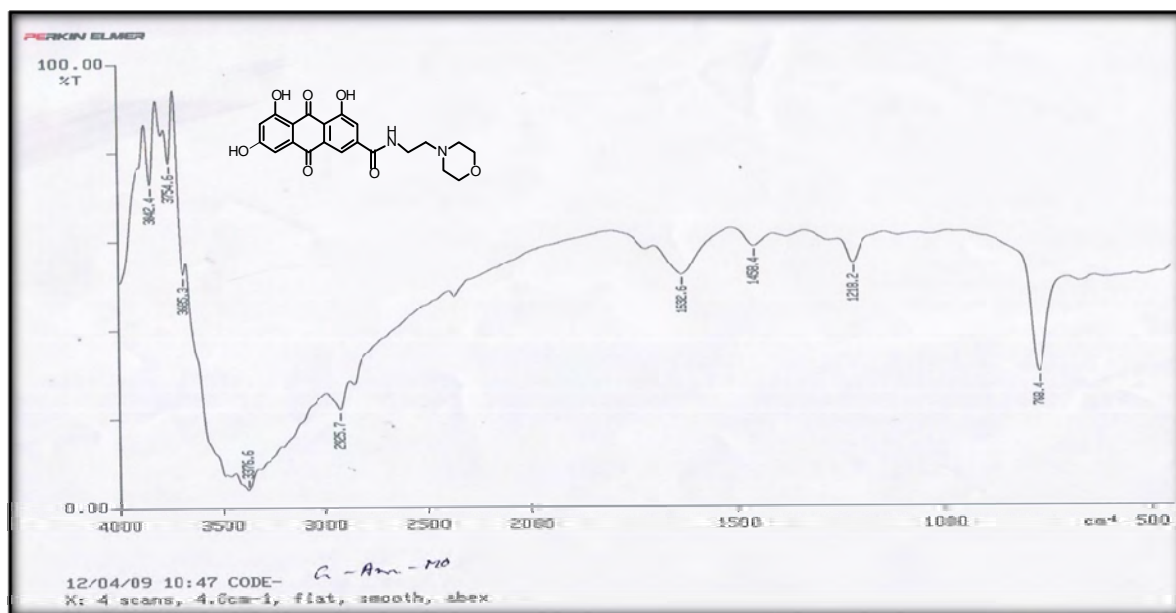
IR spectrum of compound 19



Proton NMR spectrum of compound 20



Mass spectrum of compound 20



IR spectrum of compound 20