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Ultrasound-Assisted Synthesis of Fluorescent Azatetracyclic Derivatives: An Energy-Efficient Approach

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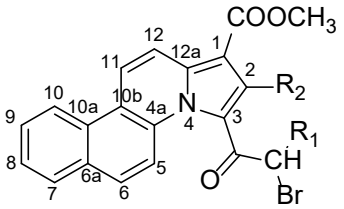
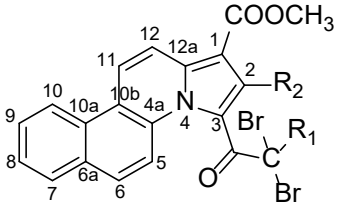
Contents

1. Spectral characterization of the obtained compounds

The following abbreviations were used to designate chemical shift multiplicities: s = singlet, d = doublet, dd = doublet of doublet, t = triplet, m = multiplet. Chemical shifts were reported in delta (δ) units, part per million (ppm) and coupling constants (*J*) in Hz.

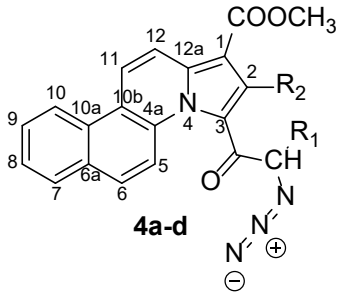


2a-d



3a-c

a - R
b - R^1=H; R_2= $COOCH_3$
c - R^1=CH_3; R_2= H
d - R^1=CH_3; R_2= $COOCH_3$



4a-d

a - R
b - R^1=H; R_2= $COOCH_3$
c - R^1=CH_3; R_2= H
d - R^1=CH_3; R_2= $COOCH_3$

Methyl 3-(2-bromoacetyl)benzo[f]pyrrolo[1,2-a]quinoline-1-carboxylate (2a). *(0.206 g, 52% (under conventional heating) and 0.345 g, 87% (under ultrasounds)) as a straw-yellow crystals, m.p. 194–195 °C); R_f (99.5/0.5 CH_2Cl_2/CH_3OH) 0.70;* ***IR*** *(cm^{-1}): 3067, 3032 (C-H arom.), 2952 (C-H aliph.), 1696 (C=O, ester), 1650 (C=O, keto), 1611, 1547, 1499, 1445, 1406 (aromatic and heteroaromatic ring), 1241, 1194, 1178, 1154, 1088, 1028 (C–O–C, ester), 642 (C–Br);* ***^{1}H NMR*** *(500 MHz, $CDCl_3$): δ 8.63 (1H, d, J = 9.5 Hz, H-11), 8.58 (1H, d, J = 8.0 Hz, H-10), 8.49 (1H, d, J = 9.5 Hz, H-12), 8.13 (1H, s, H-2), 8.01 (2H, m, overlapped peaks, H-5, H-6), 7.98 (1H, d, J = 8.0 Hz, H-7), 7.73 (1H, td, J = 7.0, 8.0 Hz, H-9), 7.65 (1H, t, J = 7.0, 8.0 Hz, H-8), 4.53 (2H, s, CH_2 of bromoacetyl group from 3rd position), 3.98 (3H, s, CH_3 of methoxycarbonyl group from 1st position);* ***^{13}C NMR*** *(125 MHz, $CDCl_3$): δ 180.6 (CO keto group from 3rd position), 164.2 (CO keto ester from 1st position), 141.2 (C-12a), 132.4 (C-4a), 131.1 (C-6a), 129.8 (C-6), 129.6 (C-10a), 129.0 (C-7), 128.6 (C-2), 127.9 (C-9), 127.0 (C-8), 125.8 (C-3), 125.1 (C-11), 123.0 (C-10), 121.4 (C-10b), 119.7 (C-5), 117.4 (C-12), 107.4 (C-1), 51.7 (CH_3 of methoxycarbonyl group from 1st position), 32.3 (CH_2 of bromoacetyl group from 3rd position). Anal. calc. for $C_{20}H_{14}BrNO_3$ (396.24): C 60.62, H 3.56, N 3.53; found: C 60.56, H 3.51, N 3.50.*

Dimethyl 3-(2-bromoacetyl)benzo[f]pyrrolo[1,2-a]quinoline-1,2-dicarboxylate (2b). *(0.209 g, 46% (under conventional heating) and 0.336 g, 74% (under ultrasounds)) as a yellow crystals, m.p. 174–175 °C); R_f (99.5/0.5 CH_2Cl_2/CH_3OH) 0.53;* ***IR*** *(cm^{-1}): 3104, 3024, 3000 (C-H arom.), 2949, 2928 (C-H aliph.), 1727, 1708 (C=O, ester), 1633 (C=O, keto), 1612, 1543, 1484, 1468, 1442, 1399, 1351, 1355 (aromatic and heteroaromatic ring), 1230, 1176, 1157, 1092 (C–O–C, ester), 629 (C–Br);* ***^{1}H NMR*** *(500 MHz, $CDCl_3$): δ 8.46 (2H, m, overlapped peaks, H-10, H-11), 8.31 (1H, d, J = 9.5 Hz, H-12), 7.96 (1H, d, J = 9.0 Hz, H-6), 7.92 (1H, d, J = 8.0 Hz, H-7), 7.69 (1H, td, J = 7.0, 8.0 Hz, H-9), 7.61 (2H, m, overlapped peaks, H-5, H-8), 4.37 (2H, s, CH_2 of bromoacetyl group from 3rd position), 4.06 (3H, s, CH_3 of methoxycarbonyl group from 1st position), 3.94 (3H, s, CH_3 of methoxycarbonyl group from 2nd position);* ***^{13}C NMR*** *(125 MHz, $CDCl_3$): δ 183.5 (CO keto group from 3rd position), 166.5 (CO keto ester from 1st position), 163.3 (CO keto ester from 2nd position), 138.2 (C-12a), 131.4 (C-4a), 130.9 (C-6a), 130.4 (C-6), 130.2 (C-10a), 129.6 (C-2), 128.9 (C-7), 128.2 (C-9), 127.2 (C-8), 124.3 (C-11), 123.8 (C-3), 122.9 (C-10), 121.5 (C-10b), 118.3 (C-5), 117.7 (C-12), 105.4 (C-1), 53.6 (CH_3 of methoxycarbonyl group from 1st position), 52.0 (CH_3 of methoxycarbonyl group from 2nd position), 33.6 (CH_2 of bromoacetyl group*

from 3rd position). Anal. calc. for $C_{22}H_{16}BrNO_5$ (454.28): C 58.17, H 3.55, N 3.08; found: C 58.12, H 3.50, N 3.04.

Methyl 3-(2-bromopropanoyl)benzo[f]pyrrolo[1,2-a]quinoline-1-carboxylate (2c). *(0.217 g, 53% (under conventional heating) and 0.349 g, 85% (under ultrasounds)) as a straw-yellow crystals, m.p. 201–202 °C); R_f (99.5/0.5 CH_2Cl_2/CH_3OH) 0.70;* ***IR*** *(cm^{-1}): 3062, 3053, 3000 (C-H arom.), 2949, 2937 (C-H aliph.), 1709 (C=O, ester), 1641 (C=O, keto), 1609, 1545, 1505, 1447, 1413, 1355 (aromatic and heteroaromatic ring), 1237, 1231, 1158, 1122, 1086 (C–O–C, ester) 609 (C–Br);* ***^{1}H NMR*** *(500 MHz, $CDCl_3$): δ 8.58 (2H, m, overlapped peaks, H-10, H-11), 8.46 (1H, d, J = 9.5 Hz, H-12), 8.08 (1H, s, H-2), 8.01 (1H, d, J = 9.5 Hz, H-6), 7.95 (2H, m, overlapped peaks, H-5, H-7), 7.71 (1H, t, J = 7.5 Hz, H-9), 7.63 (1H, t, J = 7.5 Hz, H-8), 5.48 (2H, q, J = 6.5 Hz, CHBr of bromopropanoyl group from 3rd position), 3.97 (3H, s, CH_3 of methoxycarbonyl group from 1st position), 2.01 (3H, d, J = 6.5 Hz, CH_3 of bromopropanoyl group from 3rd position);* ***^{13}C NMR*** *(125 MHz, $CDCl_3$): δ 183.0 (CO keto group from 3rd position), 164.3 (CO keto ester from 1st position), 141.2 (C-12a), 132.3 (C-4a), 131.0 (C-6a), 129.8 (C-6), 129.6 (C-10a), 128.9 (C-7), 127.9 (C-9), 127.1 (C-2), 126.9 (C-8), 125.9 (C-3), 124.8 (C-11), 123.0 (C-10), 121.3 (C-10b), 119.5 (C-5), 117.4 (C-12), 107.1 (C-1), 51.7 (CH_3 of methoxycarbonyl group from 1st position), 45.1 (CHBr of bromopropanoyl group from 3rd position), 20.7 (CH_3 of bromopropanoyl group from 3rd position). Anal. calc. for $C_{21}H_{16}BrNO_3$ (410.27): C 61.48, H 3.93, N 3.41; found: C 61.42, H 3.88, N 3.37.*

Dimethyl 3-(2-bromopropanoyl)benzo[f]pyrrolo[1,2-a]quinoline-1,2-dicarboxylate (2d). *(0.253 g, 54% (under conventional heating) and 0.328 g, 70% (under ultrasounds)) as a yellow crystals, m.p. 162–163 °C); R_f (99.5/0.5 CH_2Cl_2/CH_3OH) 0.53;* ***IR*** *(cm^{-1}): 3057, 3036, 3007 (C-H arom.), 2952, 2932 (C-H aliph.), 1741, 1708 (C=O, ester), 1659 (C=O, keto), 1604, 1541, 1498, 1470, 1400, 1341 (aromatic and heteroaromatic ring), 1260, 1213,1180, 1133, 1100 (C–O–C, ester), 657 (C–Br);* ***^{1}H NMR*** *(500 MHz, $CDCl_3$): δ 8.26 (1H, d, J = 8.5 Hz, H-10), 8.22 (1H, d, J = 10.0 Hz, H-11), 8.07 (1H, d, J = 10.0 Hz, H-12), 7.86 (1H, d, J = 9.5 Hz, H-6), 7.79 (1H, d, J = 7.5 Hz, H-7), 7.66 (1H, d, J = 9.5 Hz, H-5), 7.55 (1H, t, J = 7.0 Hz, H-9), 7.49 (1H, t, J = 7.0 Hz, H-8), 5.09 (1H, q, J = 7.0 Hz, CHBr of bromopropanoyl group from 3rd position), 4.05 (3H, s, CH_3 of methoxycarbonyl group from 1st position), 3.91 (3H, s, CH_3 of methoxycarbonyl group from 2nd position), 1.95 (3H, d, J = 7.0 Hz, CH_3 of bromopropanoyl group from 3rd position);* ***^{13}C NMR*** *(125 MHz, $CDCl_3$): δ 185.6 (CO keto group from 3rd position), 166.6 (CO keto ester from 1st position), 163.3 (CO keto ester from 2nd position), 138.1 (C-12a), 131.2 (C-4a), 130.6 (C-6a), 130.2 (C-6), 129.6 (C-10a), 129.3 (C-2), 128.6 (C-7), 127.9 (C-9), 126.9 (C-8), 123.9 (C-11), 123.6 (C-3), 122.6 (C-10), 121.1 (C-10b), 117.9 (C-5), 117.3 (C-12), 104.9 (C-1), 53.4 (CH_3 of methoxycarbonyl group from 1st position), 51.9 (CH_3 of methoxycarbonyl group from 2nd position), 46.8 (CHBr of bromopropanoyl group from 3rd position), 20.4 (CH_3 of bromopropanoyl group from 3rd position). Anal. calc. for $C_{23}H_{18}BrNO_5$ (468.30): C 58.99, H 3.87, N 2.99; found: C 58.93, H 3.83, N 2.94.*

Methyl 3-(2,2-dibromoacetyl)benzo[f]pyrrolo[1,2-a]quinoline-1-carboxylate (3a). *(0.048 g, 10% (under conventional heating) and 0 g, 0% (under ultrasounds)) as a yellow crystals, m.p. 170–171 °C); R_f (99.5/0.5 CH_2Cl_2/CH_3OH) 0.68;* ***IR*** *(cm^{-1}): 3113, 3022, 2996 (C-H arom.), 2943(C-H aliph.), 1693 (C=O, ester), 1652 (C=O, keto), 1543, 1504, 1467, 1450, 1334 (aromatic and heteroaromatic ring), 1284, 1256, 1233, 1188, 1163, 1115 (C–O–C, ester), 698, 648 (C–Br);* ***^{1}H NMR*** *(500 MHz, DMSO): δ 9.06 (1H, d, J = 9.5 Hz, H-11), 8.88 (1H, d, J = 8.5 Hz, H-10), 8.66 (1H, s, H-2), 8.46 (1H, d, J = 9.5 Hz, H-12), 8.27 (1H, d, J = 9.5 Hz, H-6), 8.14 (1H, d, J = 7.5 Hz, H-7), 8.09 (1H, s, CH of dibromoacetyl group from 3rd position), 7.82 (2H, m, overlapped peaks, H-9, H-5), 7.76 (1H, t, J = 7.5 Hz, H-8), 3.92 (3H, s, CH_3 of methoxycarbonyl group from 1st position);* ***^{13}C NMR*** *(125 MHz, DMSO): δ 176.3 (CO keto group from 3rd position), 163.3 (CO keto ester from 1st position), 141.1 (C-12a), 131.3 (C-4a), 130.5 (C-6a), 130.2 (C-6), 129.1 (C-10a), 128.8 (C-7), 128.6 (C-2), 128.3 (C-9), 127.4 (C-8), 126.3 (C-11), 123.6 (C-10), 121.4 (C-10b), 120.9 (C-3), 118.5 (C-5), 117.0 (C-12), 106.8 (C-1), 51.6 (CH_3 of methoxycarbonyl group from 1st position), 44.4 (CH of dibromoacetyl group from 3rd position). Anal. calc. for $C_{20}H_{13}Br_2NO_3$ (475.14): C 50.56, H 2.76, N 2.95; found: C 50.51, H 2.73, N 2.90.*

Dimethyl 3-(2,2-dibromoacetyl)benzo[f]pyrrolo[1,2-a]quinoline-1,2-dicarboxylate (3b). *(0.080 g, 15% (under conventional heating) and 0 g, 0% (under ultrasounds)) as a yellow-orange*

crystals, m.p. 178–179 °C); R_f (99.5/0.5 CH_2Cl_2/CH_3OH) 0.60; ***IR*** *(cm^{-1}): 3047, 3037, 3003, (C-H arom.), 2944, 2930 (C-H aliph.), 1733, 1717 (C=O, ester), 1669 (C=O, keto), 1610, 1542, 1468, 1441, 1401, 1356, 1338 (aromatic and heteroaromatic ring), 1251, 1219, 1184, 1123, 1097 (C–O–C, ester), 652, 639 (C–Br);* ***^{1}H NMR*** *(500 MHz, $CDCl_3$): δ 8.56 (2H, m, overlapped peaks, H-10, H-11), 8.39 (1H, d, J = 9.5 Hz, H-12), 8.04 (1H, d, J = 9.5 Hz, H-6), 7.97 (1H, d, J = 7.5 Hz, H-7), 7.73 (2H, m, overlapped peaks, H-9, H-5), 7.66 (1H, t, J = 7.5 Hz, H-8), 6.70 (1H, s, CH of dibromoacetyl group from 3rd position), 4.07 (3H, s, CH_3 of methoxycarbonyl group from 1st position), 3.96 (3H, s, CH_3 of methoxycarbonyl group from 2nd position);* ***^{13}C NMR*** *(125 MHz, $CDCl_3$): δ 178.5 (CO keto group from 3rd position), 166.2 (CO keto ester from 1st position), 163.1 (CO keto ester from 2nd position), 139.1 (C-12a), 131.6 (C-4a), 131.1 (C-6a), 131.0 (C-6), 131.0 (C-10a), 129.7 (C-2), 129.1 (C-7), 128.4 (C-9), 127.4 (C-8), 125.0 (C-11), 123.0 (C-10), 121.7 (C-3), 119.6 (C-10b), 117.8 (C-12), 117.7 (C-5), 105.9 (C-1), 53.8 (CH_3 of methoxycarbonyl group from 1st position), 52.2 (CH_3 of methoxycarbonyl group from 2nd position), 41.6 (CH of dibromoacetyl group from 3rd position). Anal. calc. for $C_{22}H_{15}Br_2NO_5$ (533.17): C 49.56, H 2.84, N 2.63; found: C 49.50, H 2.80, N 2.60.*

Methyl 3-(2,2-dibromopropanoyl)benzo[f]pyrrolo[1,2-a]quinoline-1-carboxylate (3c). *(0.054 g, 11% (under conventional heating) and 0 g, 0% (under ultrasounds)) as a yellow crystals, m.p. 175–176 °C); R_f (99.5/0.5 CH_2Cl_2/CH_3OH) 0.68;* ***IR*** *(cm^{-1}): 3108, 3023 (C-H arom.), 2960, 2928 (C-H aliph.), 1712 (C=O, ester), 1633 (C=O, keto), 1594, 1546, 1495, 1440, 1408 (aromatic and heteroaromatic ring), 1262, 1237, 1150, 1083, 1032 (C–O–C, ester), 667 (C–Br);* ***^{1}H NMR*** *(500 MHz, DMSO): δ 9.02 (1H, d, J = 9.5 Hz, H-11), 8.87 (1H, d, J = 8.0 Hz, H-10), 8.69 (1H, s, H-2), 8.45 (1H, d, J = 9.5 Hz, H-12), 8.17 (1H, d, J = 9.5 Hz, H-6), 8.14 (1H, d, J = 8.0 Hz, H-7), 7.83 (1H, t, J = 7.5 Hz, H-9), 7.75 (1H, t, J = 7.5 Hz, H-8), 7.69 (1H, d, J = 9.5 Hz, H-5) 3.93 (3H, s, CH_3 of methoxycarbonyl group from 1st position), 2.89 (3H, s, CH_3 of dibromopropanoyl group from 3rd position);* ***^{13}C NMR*** *(125 MHz, DMSO): δ 180.6 (CO keto group from 3rd position), 163.3 (CO keto ester from 1st position), 139.7 (C-12a), 131.4 (C-4a), 130.4 (C-6a), 130.0 (C-6), 129.2 (C-10a), 129.1 (C-2), 128.8 (C-7), 128.2 (C-9), 127.3 (C-8), 126.0 (C-11), 123.6 (C-10), 122.4 (C-3), 120.9 (C-10b), 119.6 (C-5), 116.7 (C-12), 106.1 (C-1), 58.6 (CBr_2 of dibromopropanoyl group from 3rd position), 51.7 (CH_3 of methoxycarbonyl group from 1st position), 37.4 (CH_3 of dibromopropanoyl group from 3rd position). Anal. calc. for $C_{21}H_{15}Br_2NO_3$ (489.16): C 51.56, H 3.09, N 2.86; found: C 51.50, H 3.05, N 2.82.*

Methyl 3-(2-azidoacetyl)benzo[f]pyrrolo[1,2-a]quinoline-1-carboxylate (4a). *(0.147 g, 82% (under conventional heating) and 0.167 g, 93% (under ultrasounds)) as a yellow crystals, m.p. 189–190 °C); R_f (99.5/0.5 CH_2Cl_2/CH_3OH) 0.65;* ***IR*** *(cm^{-1}): 3121, 3017 (C-H arom.), 2955, 2924 (C-H aliph.), 2144, 2111 (N_3 azide), 1711 (C=O, ester), 1658 (C=O, keto), 1608, 1557, 1544, 1500, 1450, 1403, 1367 (aromatic and heteroaromatic ring), 1233, 1181, 1129, 1089 (C–O–C, ester);* ***^{1}H NMR*** *(500 MHz, $CDCl_3$): δ 8.65 (1H, d, J = 9.5 Hz, H-11), 8.60 (1H, d, J = 8.5 Hz, H-10), 8.51 (1H, d, J = 9.5 Hz, H-12), 8.12 (1H, d, J = 9.0 Hz, H-6), 8.09 (1H, s, H-2), 8.01 (2H, m, overlapped peaks, H-5, H-7), 7.74 (1H, t, J = 8.0 Hz, H-9), 7.66 (1H, t, J = 8.0 Hz, H-8), 4.60 (2H, s, CH_2 of azidoacetyl group from 3rd position), 3.98 (3H, s, CH_3 of methoxycarbonyl group from 1st position);* ***^{13}C NMR*** *(125 MHz, $CDCl_3$): δ 182.2 (CO keto group from 3rd position), 164.2 (CO keto ester from 1st position), 141.1 (C-12a), 132.5 (C-4a), 131.1 (C-6a), 129.8 (C-6), 129.6 (C-10a), 129.0 (C-7), 128.6 (C-2), 128.0 (C-9), 127.1 (C-8), 125.6 (C-3), 125.2 (C-11), 123.0 (C-10), 121.5 (C-10b), 120.0 (C-5), 117.4 (C-12), 107.6 (C-1), 55.5 (CH_2 of azidoacetyl group from 3rd position), 51.7 (CH_3 of methoxycarbonyl group from 1st position). Anal. calc. for $C_{20}H_{14}N_4O_3$ (358.36): C 67.03, H 3.94, N 15.63; found: C 66.96, H 3.90, N 15.56.*

Dimethyl 3-(2-azidoacetyl)benzo[f]pyrrolo[1,2-a]quinoline-1,2-dicarboxylate (4b). *(0.146 g, 70% (under conventional heating) and 0.179 g, 86% (under ultrasounds)) as a yellow-orange crystals, m.p. 137–138 °C); R_f (99.5/0.5 CH_2Cl_2/CH_3OH) 0.45;* ***IR*** *(cm^{-1}): 3004 (C-H arom.), 2962, 2929 (C-H aliph.), 2115, 2102 (N_3 azide), 1717, 1702 (C=O, ester), 1659 (C=O, keto), 1611, 1547, 1471, 1446, 1404, 1368 (aromatic and heteroaromatic ring), 1262, 1246, 1163, 1132, 1101, 1031 (C–O–C, ester);* ***^{1}H NMR*** *(500 MHz, $CDCl_3$): δ 8.60 (2H, m, overlapped peaks, H-10, H-11), 8.47 (1H, d, J = 9.5 Hz, H-12), 8.05 (1H, d, J = 9.5 Hz, H-6), 8.00 (1H, d, J = 7.5 Hz, H-7), 7.78 (1H, t, J = 7.0 Hz, H-9), 7.69 (1H, t, J = 7.0 Hz, H-8), 7.63 (1H, d, J = 9.5 Hz, H-5), 4.33 (2H,*

s, CH_2 of azidoacetyl group from 3rd position), 4.05 (3H, s, CH_3 of methoxycarbonyl group from 1st position), 3.96 (3H, s, CH_3 of methoxycarbonyl group from 2nd position); ***^{13}C NMR*** *(125 MHz, $CDCl_3$): δ 186.7 (CO keto group from 3rd position), 166.3 (CO keto ester from 1st position), 163.4 (CO keto ester from 2nd position), 138.1 (C-12a), 131.6 (C-4a), 131.0 (C-6a), 130.6 (C-6), 130.3 (C-10a), 129.8 (C-2), 129.1 (C-7), 128.4 (C-9), 127.4 (C-8), 124.3 (C-11), 124.0 (C-3), 123.1 (C-10), 121.7 (C-10b), 118.5 (C-5), 118.0 (C-12), 105.7 (C-1), 56.6 (CH_2 of azidoacetyl group from 3rd position), 53.6 (CH_3 of methoxycarbonyl group from 1st position), 52.1 (CH_3 of methoxycarbonyl group from 2nd position). Anal. calc. for $C_{22}H_{16}N_4O_5$ (416.39): C 63.46, H 3.87, N 13.46; found: C 63.40, H 3.84, N 13.40.*

Methyl 3-(2-azidopropanoyl)benzo[f]pyrrolo[1,2-a]quinoline-1-carboxylate (4c). *(0.155 g, 83% (under conventional heating) and 0.177 g, 95% (under ultrasounds)) as a yellow crystals, m.p. 167–168 °C); R_f (99.5/0.5 CH_2Cl_2/CH_3OH) 0.65;* ***IR*** *(cm^{-1}): 3078, 3025 (C-H arom.), 2974. 2949, 2921 (C-H aliph.), 2110, 2088, 2063 (N_3 azide), 1693 (C=O, ester), 1645 (C=O, keto), 1609, 1544, 1507, 1494, 1439, 1414, 1404, 1322 (aromatic and heteroaromatic ring), 1238, 1176, 1085, 1051, 1031 (C–O–C, ester);* ***^{1}H NMR*** *(500 MHz, $CDCl_3$): δ 8.44 (2H, m, overlapped peaks, H-10, H-11), 8.33 (1H, d, J = 9.5 Hz, H-12), 8.04 (1H, s, H-2), 7.92 (1H, d, J = 9.5 Hz, H-6), 7.89 (1H, d, J = 8.0 Hz, H-7), 7.84 (1H, d, J = 9.5 Hz, H-5), 7.63 (1H, t, J = 7.5 Hz, H-9), 7.57 (1H, t, J = 7.5 Hz, H-8), 4.71 (2H, q, J = 7.0 Hz, CHN_3 of azidopropanoyl group from 3rd position), 3.95 (3H, s, CH_3 of methoxycarbonyl group from 1st position), 1.73 (3H, d, J = 7.0 Hz, CH_3 of azidopropanoyl group from 3rd position);* ***^{13}C NMR*** *(125 MHz, $CDCl_3$): δ 185.6 (CO keto group from 3rd position), 164.0 (CO keto ester from 1st position), 141.1 (C-12a), 132.1 (C-4a), 130.8 (C-6a), 129.6 (C-6), 129.4 (C-10a), 128.8 (C-7), 128.6 (C-9), 127.8 (C-2), 126.9 (C-8), 125.6 (C-3), 124.8 (C-11), 122.8 (C-10), 121.2 (C-10b), 119.6 (C-5), 117.2 (C-12), 107.4 (C-1), 59.6 (CHN_3 of azidopropanoyl group from 3rd position), 51.6 (CH_3 of methoxycarbonyl group from 1st position), 17.3 (CH_3 of azidopropanoyl group from 3rd position). Anal. calc. for $C_{21}H_{16}N_4O_3$ (372.38): C 67.73, H 4.33, N 15.05; found: C 67.67, H 4.29, N 14.99.*

Dimethyl 3-(2-azidopropanoyl)benzo[f]pyrrolo[1,2-a]quinoline-1,2-dicarboxylate (4d). *(0.146 g, 68% (under conventional heating) and 0.179 g, 83% (under ultrasounds)) as a yellow-orange crystals, m.p. 160–161 °C); R_f (99.5/0.5 CH_2Cl_2/CH_3OH) 0.45;* ***IR*** *(cm^{-1}): 3034, 3014 (C-H arom.), 2950, 2930 (C-H aliph.), 2131, 2114, 2100 (N_3 azide), 1732, 1697 (C=O, ester), 1665 (C=O, keto), 1610, 1544, 1503, 1468, 1442, 1408 (aromatic and heteroaromatic ring), 1264, 1228, 1189, 1159, 1094, 1074 (C–O–C, ester);* ***^{1}H NMR*** *(500 MHz, $CDCl_3$): δ 8.57 (1H, d, J = 8.0 Hz, H-10), 8.53 (1H, d, J = 9.5 Hz, H-11), 8.43 (1H, d, J = 9.5 Hz, H-12), 8.04 (1H, d, J = 9.0 Hz, H-6), 7.98 (1H, d, J = 8.0 Hz, H-7), 7.75 (1H, t, J = 7.5, 8.0 Hz, H-9), 7.66 (1H, t, J = 7.5, 8.0 Hz, H-8), 7.58 (1H, d, J = 9.0 Hz, H-5), 4.30 (1H, q, J = 7.0 Hz, CHN_3 of azidopropanoyl group from 3rd position), 4.03 (3H, s, CH_3 of methoxycarbonyl group from 1st position), 3.95 (3H, s, CH_3 of methoxycarbonyl group from 2nd position), 1.56 (3H, d, J = 7.0 Hz, CH_3 of azidopropanoyl group from 3rd position);* ***^{13}C NMR*** *(125 MHz, $CDCl_3$): δ 190.7 (CO keto group from 3rd position), 166.1 (CO keto ester from 1st position), 163.4 (CO keto ester from 2nd position), 137.7 (C-12a), 131.4 (C-4a), 130.9 (C-6a), 130.7 (C-6), 130.0 (C-10a), 129.7 (C-2), 129.1 (C-7), 128.4 (C-9), 127.3 (C-8), 123.9 (C-3), 123.8 (C-11), 123.0 (C-10), 121.5 (C-10b), 118.2 (C-5), 118.1 (C-12), 105.5 (C-1), 60.9 (CHN_3 of azidopropanoyl group from 3rd position), 53.4 (CH_3 of methoxycarbonyl group from 1st position), 52.1 (CH_3 of methoxycarbonyl group from 2nd position), 16.7 (CH_3 of azidopropanoyl group from 3rd position). Anal. calc. for $C_{23}H_{18}N_4O_5$ (430.42): C 64.18, H 4.22, N 13.02; found: C 64.13, H 4.18, N 12.97.*

2. NMR spectra of the obtained compounds

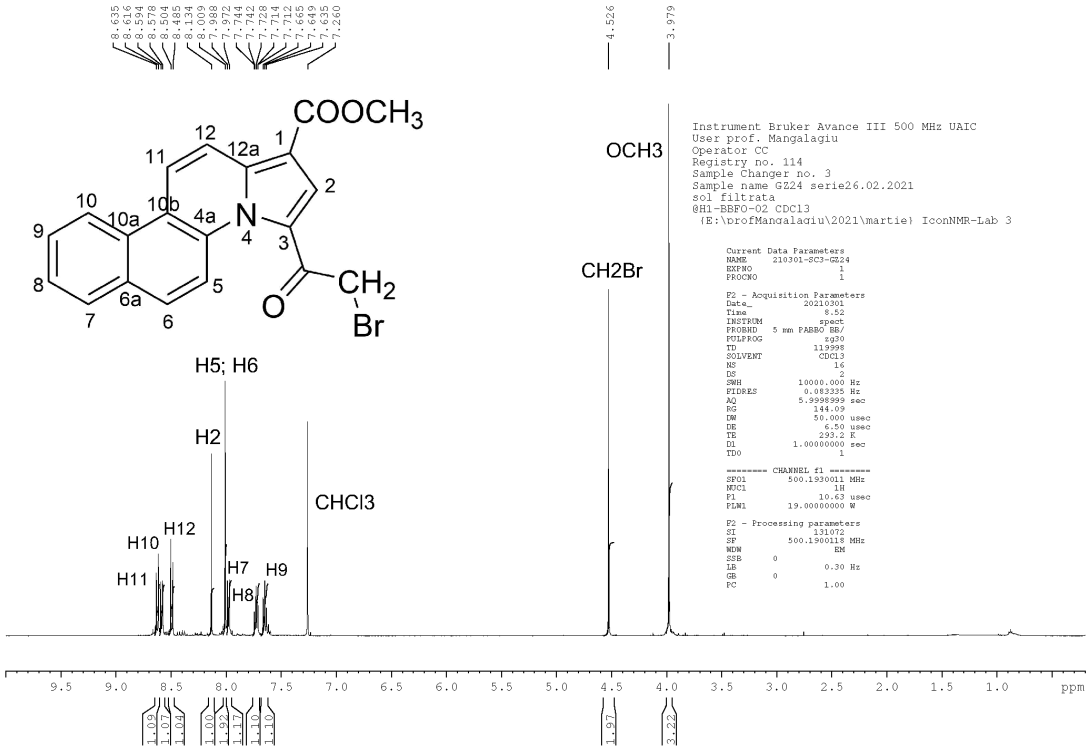


Figure S1a. [1]H NMR spectrum of the compound **2a.**

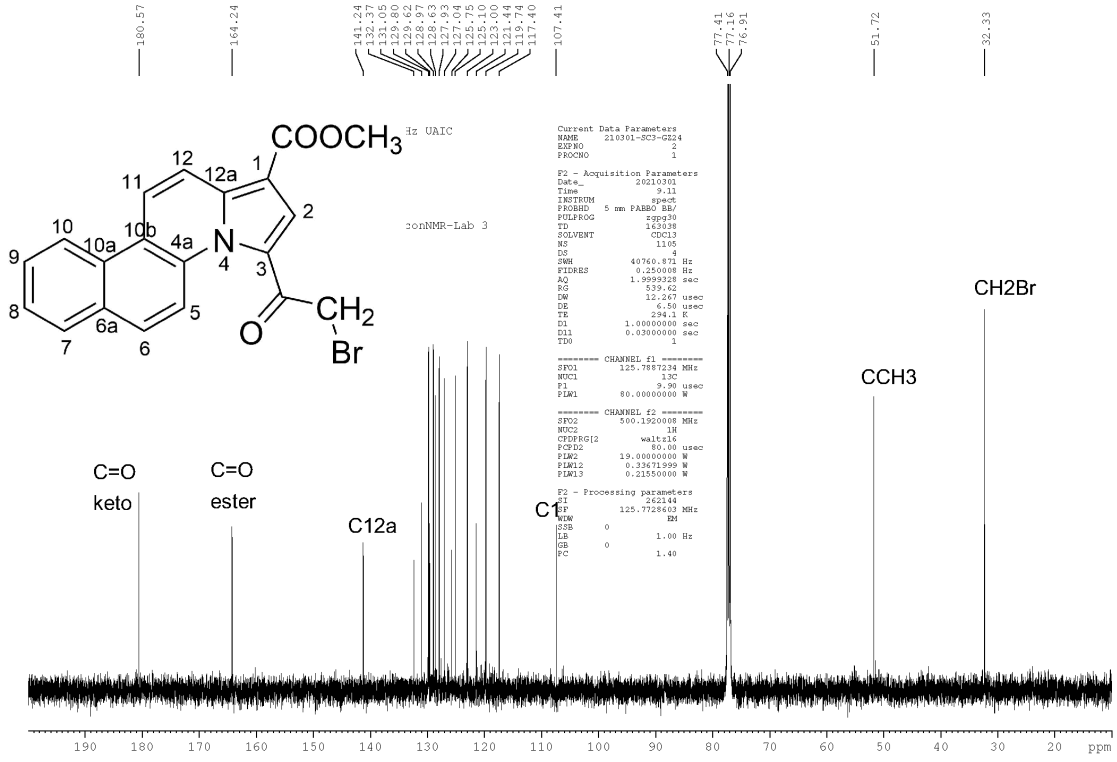


Figure S1b. ^{13}C NMR spectrum of the compound **2a.**

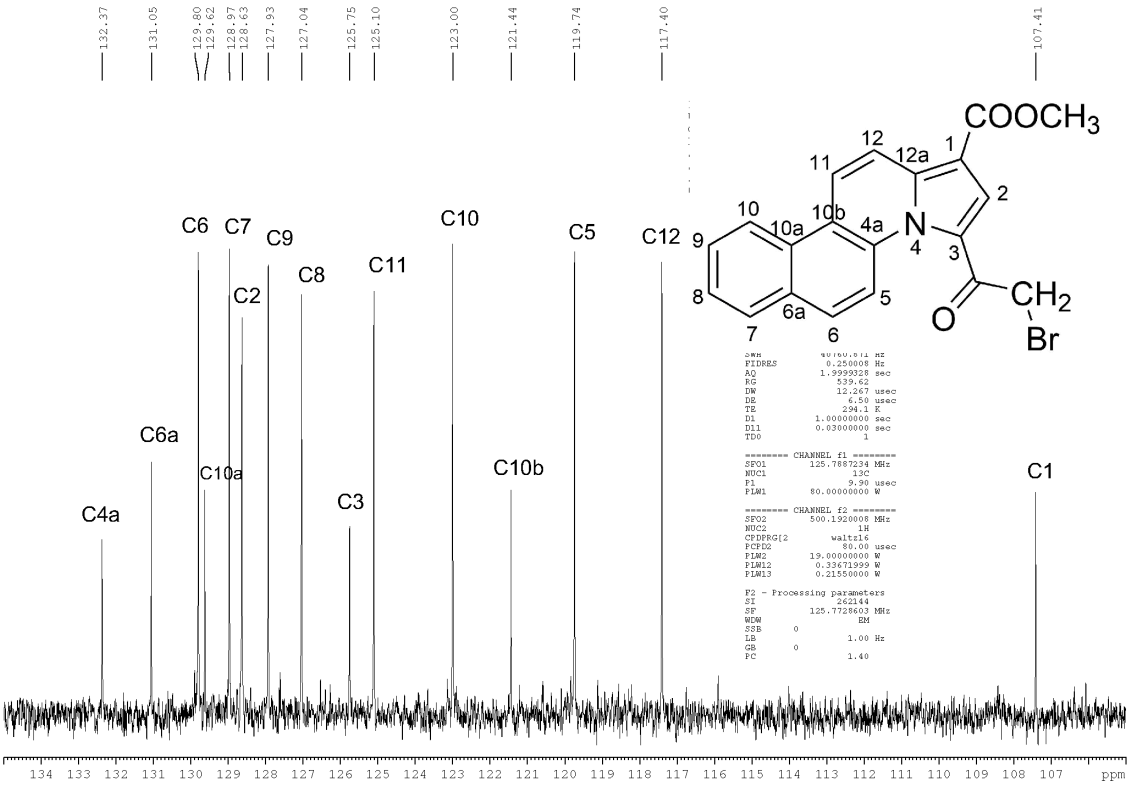


Figure S1c. Detail in the aromatic area of the ^{13}C NMR spectrum of the compound **2a.**

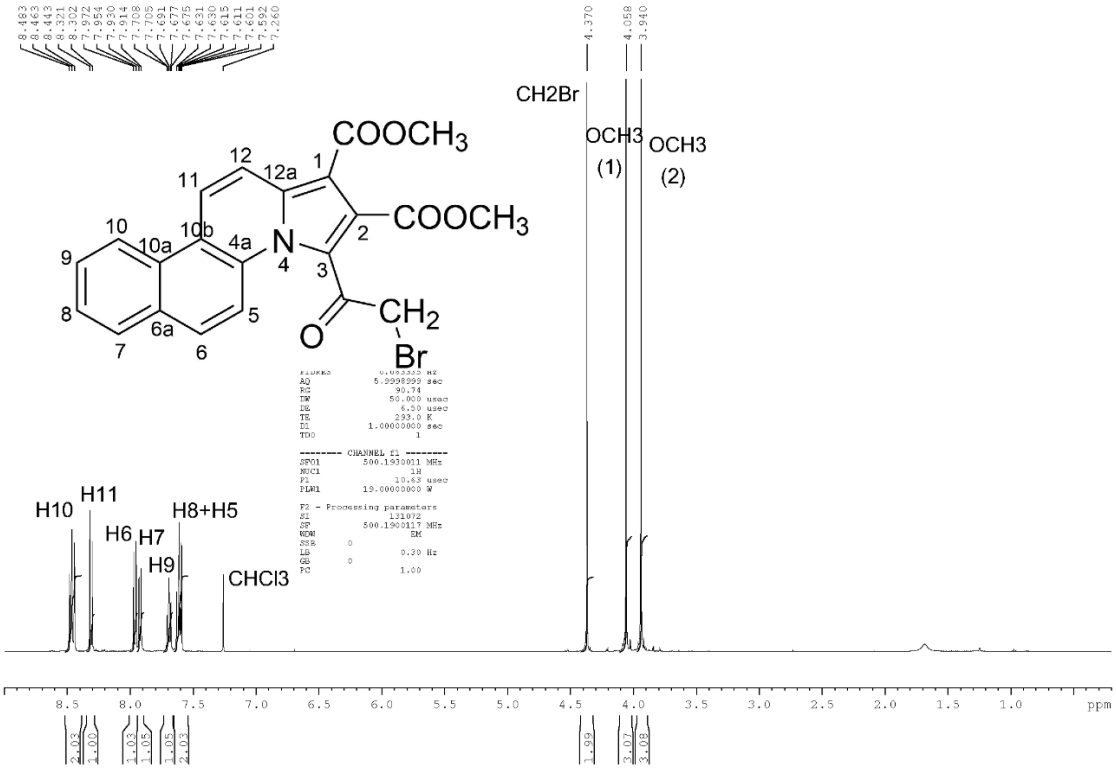


Figure S2a. [1]H NMR spectrum of the compound **2b.**

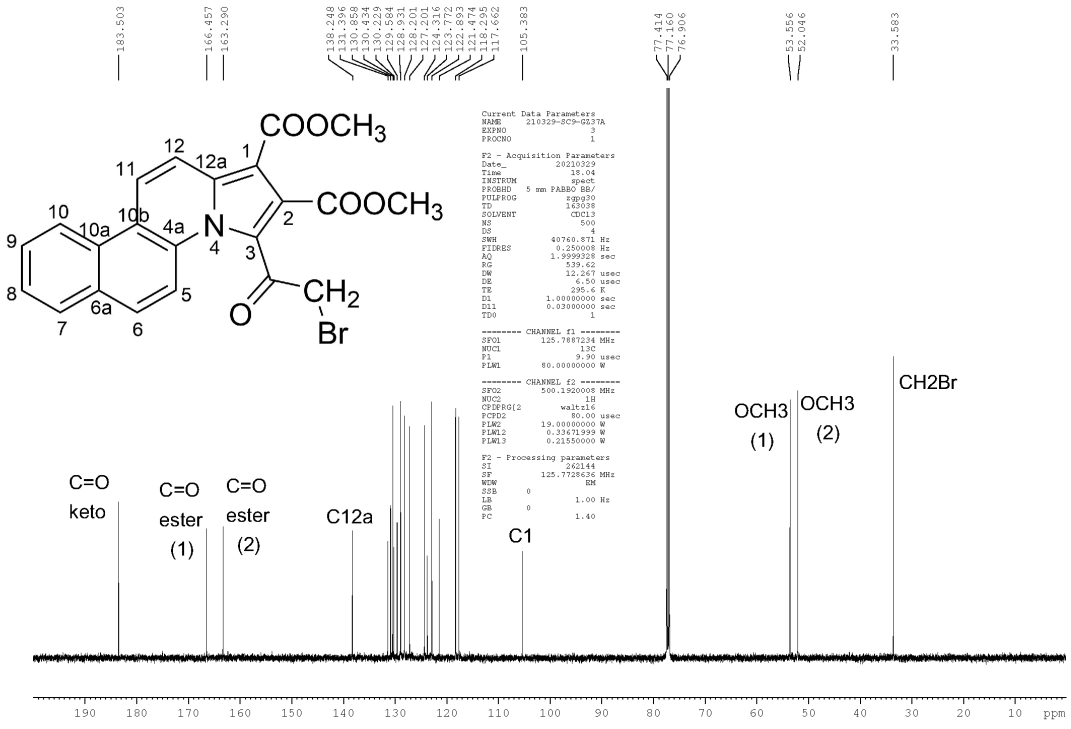


Figure S2b . [13]C NMR spectrum of the compound **2b.**

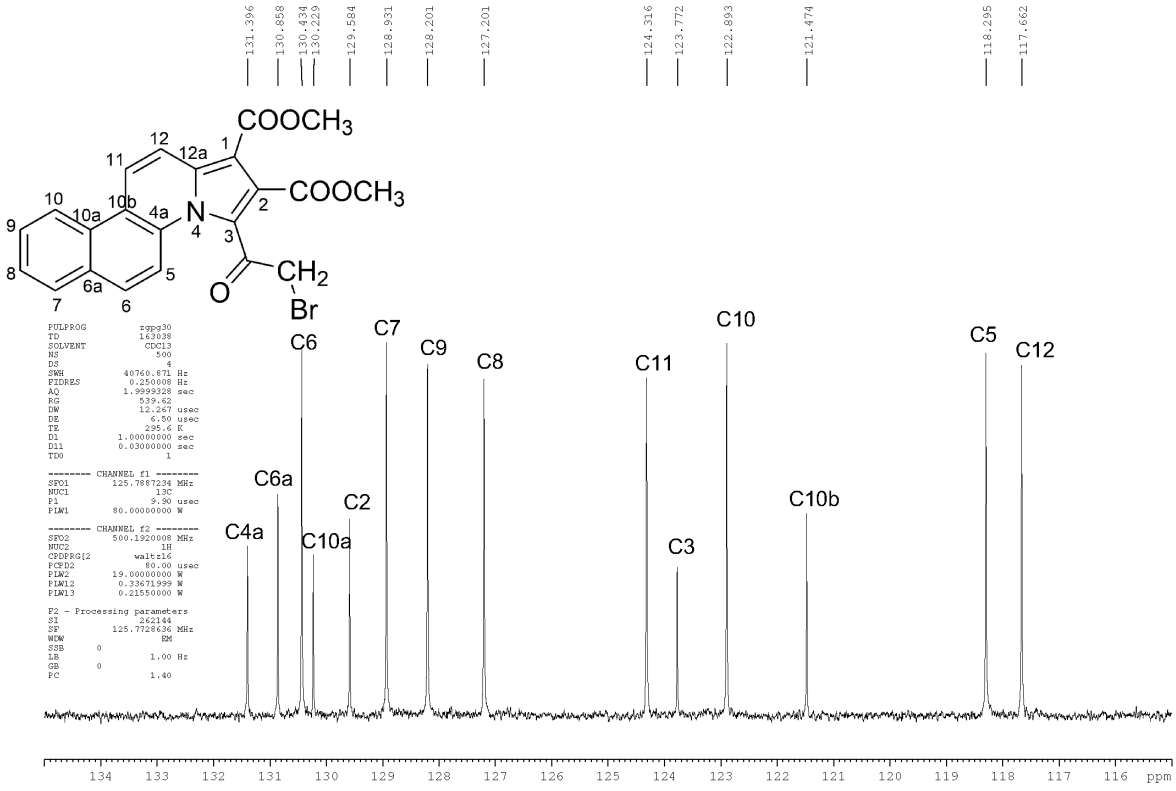


Figure.S2c Detail in the aromatic area of the ^{13}C NMR spectrum of the compound **2b.**

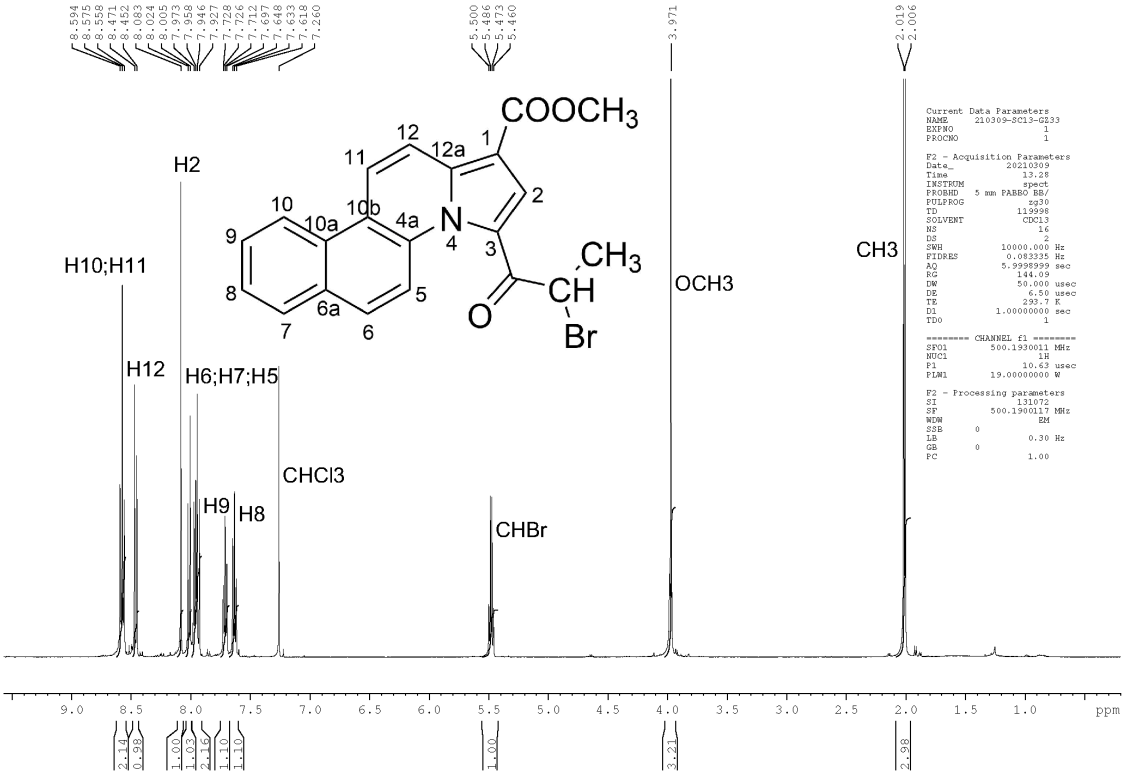


Figure S3a. ^{1}H NMR spectrum of the compound **2c.**

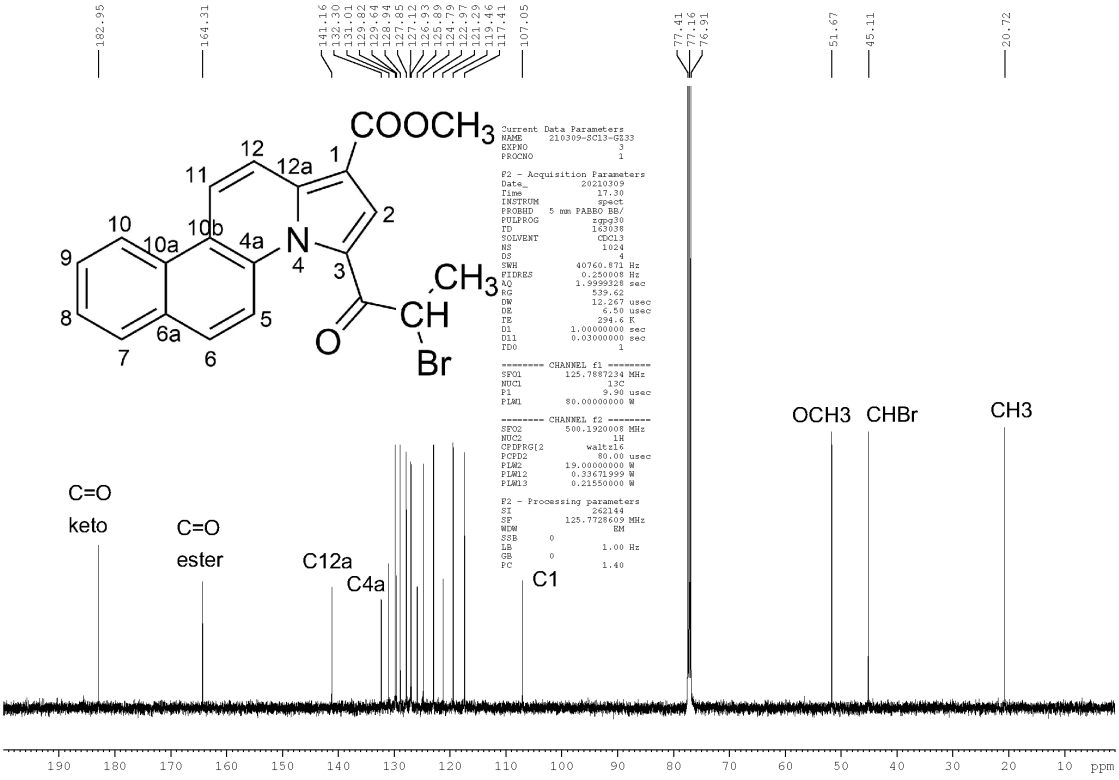


Figure S3b. ^{13}C NMR spectrum of the compound **2c.**

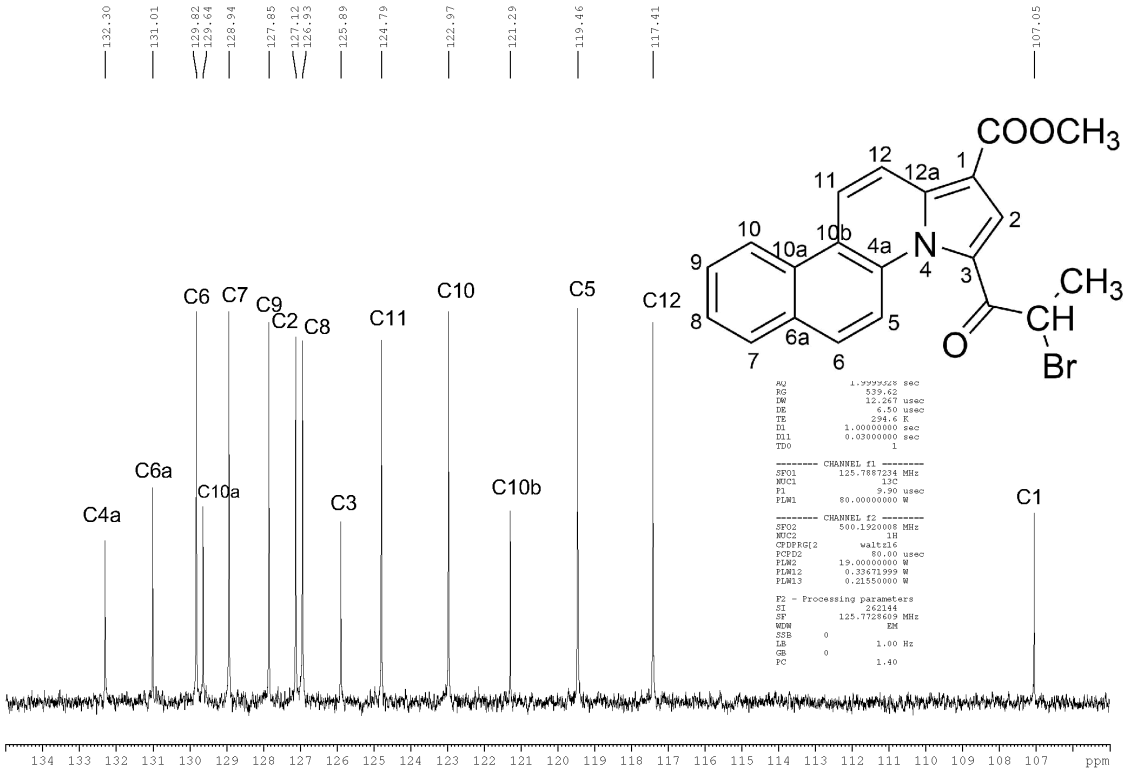


Figure S3c. Detail in the aromatic area of the ^{13}C NMR spectrum of the compound **2c.**

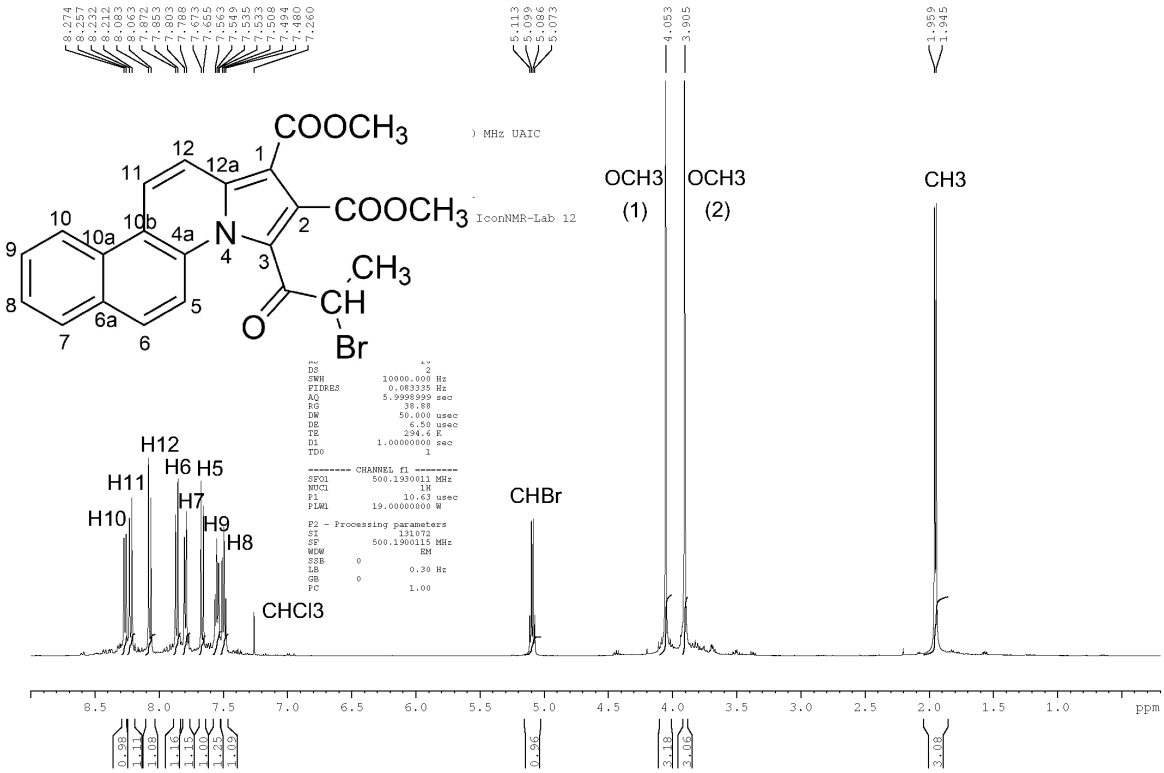


Figure S4a. [1]H NMR spectrum of the compound **2d.**

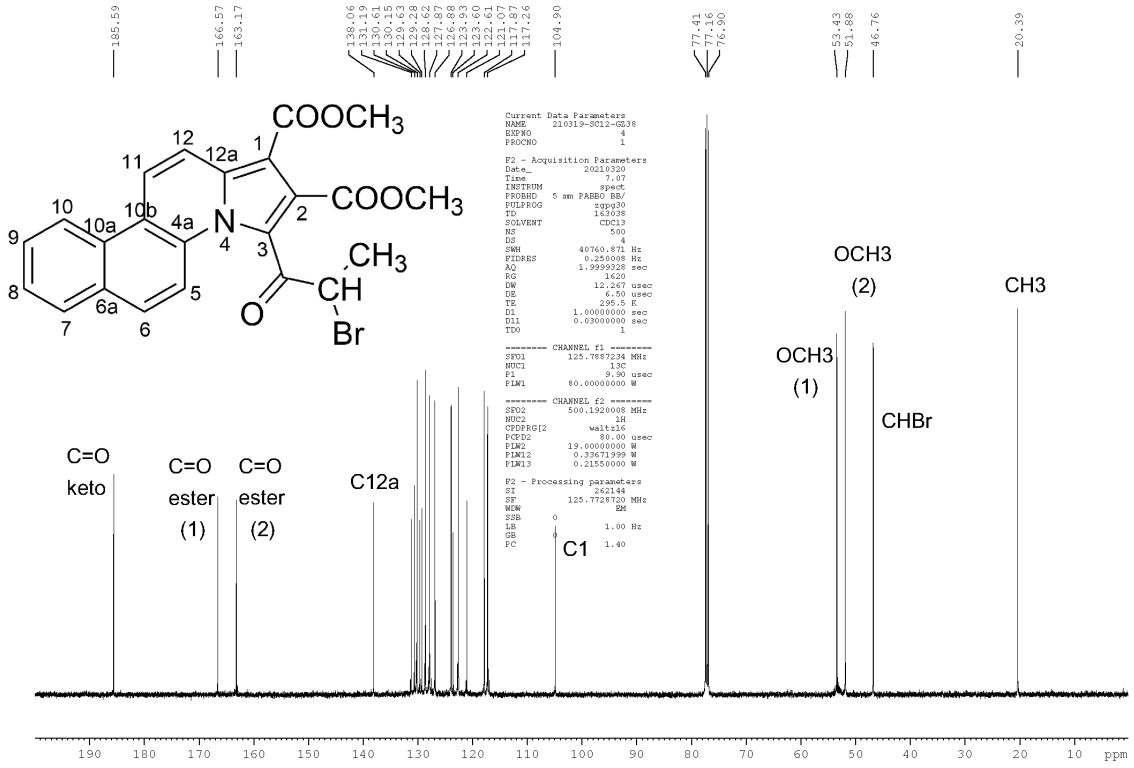


Figure S4b. ^{13}C NMR spectrum of the compound **2d.**

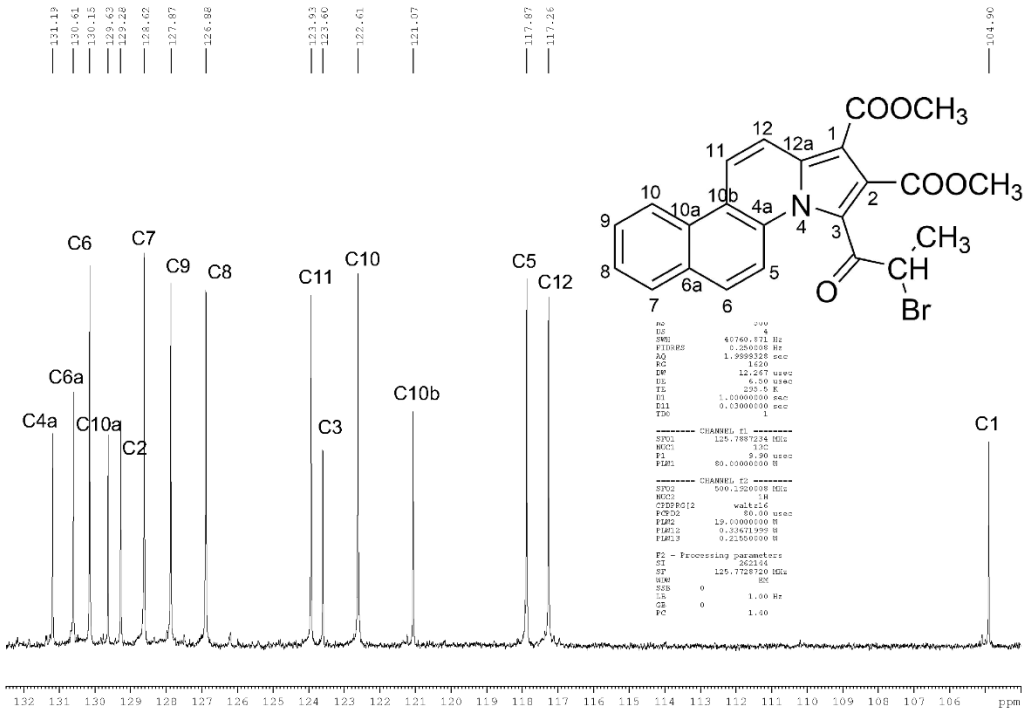


Figure S4c. Detail in the aromatic area of the ^{13}C NMR spectrum of the compound **2d.**

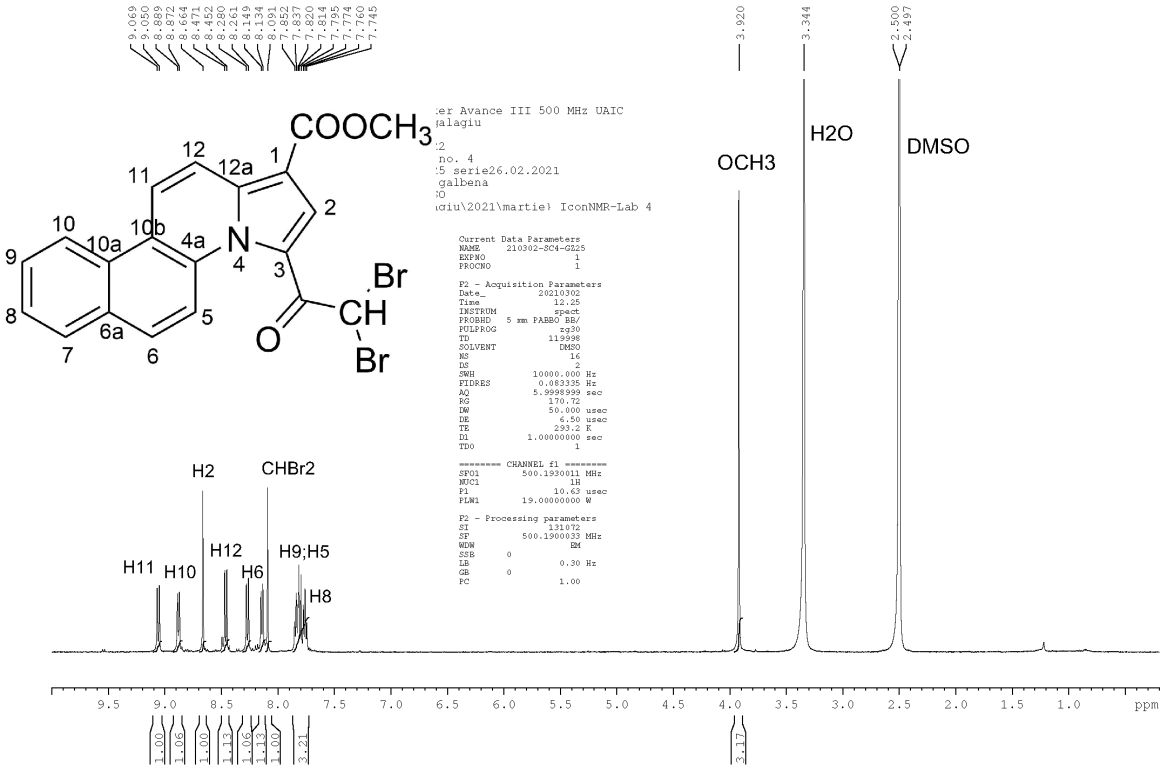


Figure S5a. [1]H NMR spectrum of the compound **3a.**

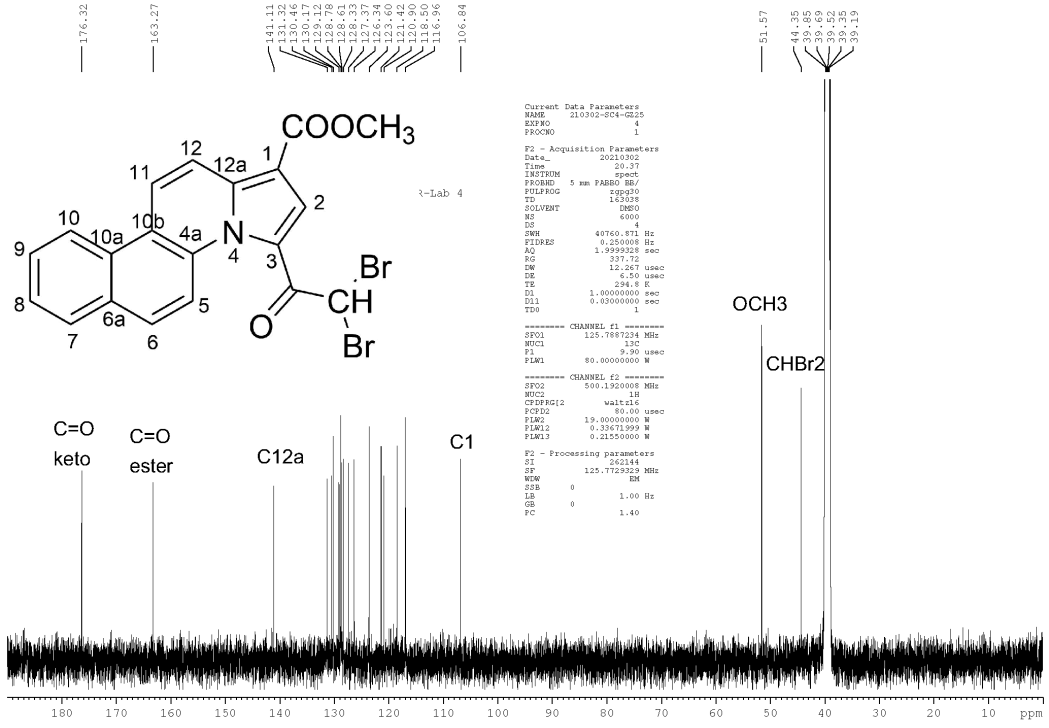


Figure S5b. [13]C NMR spectrum of the compound **3a.**

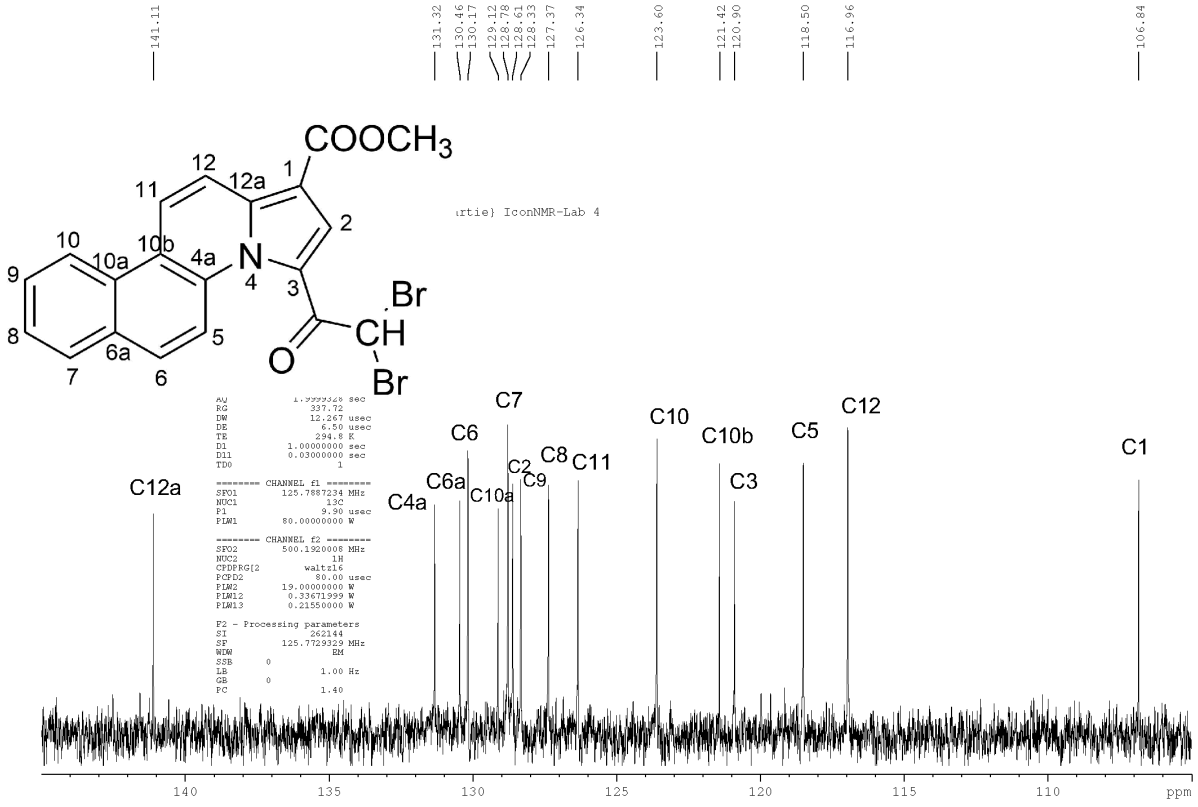


Figure S5c. Detail in the aromatic area of the ^{13}C NMR spectrum of the compound **3a.**

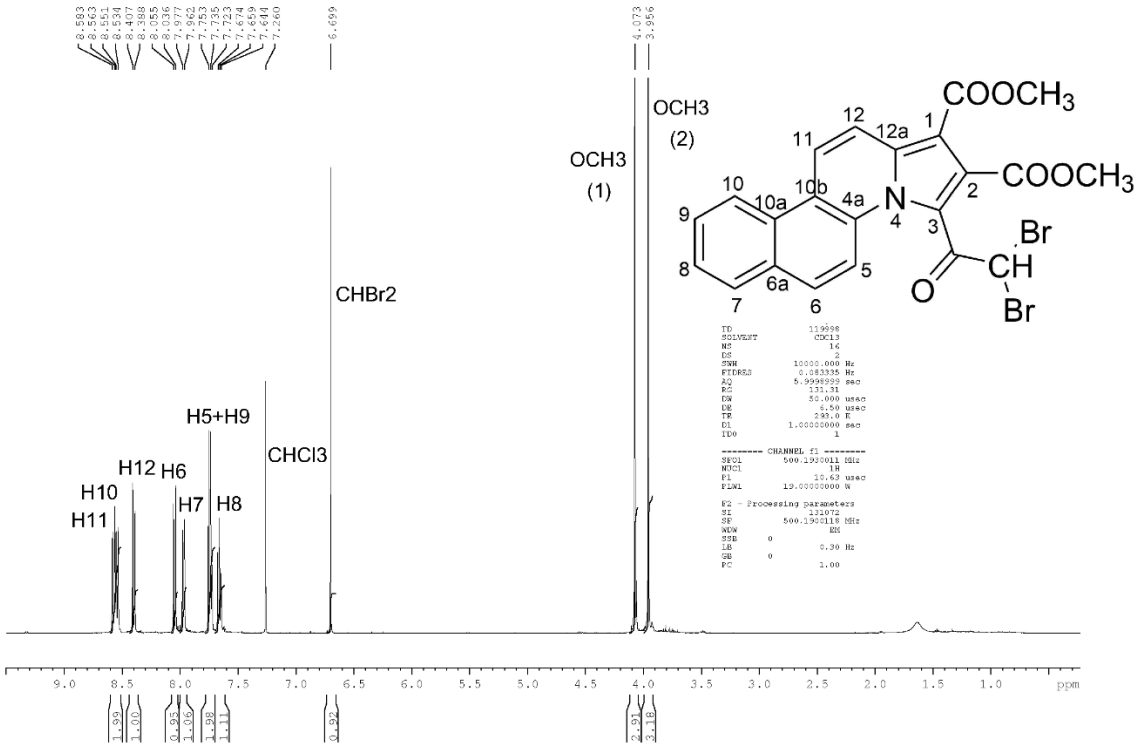


Figure S6a. [1]H NMR spectrum of the compound **3b.**

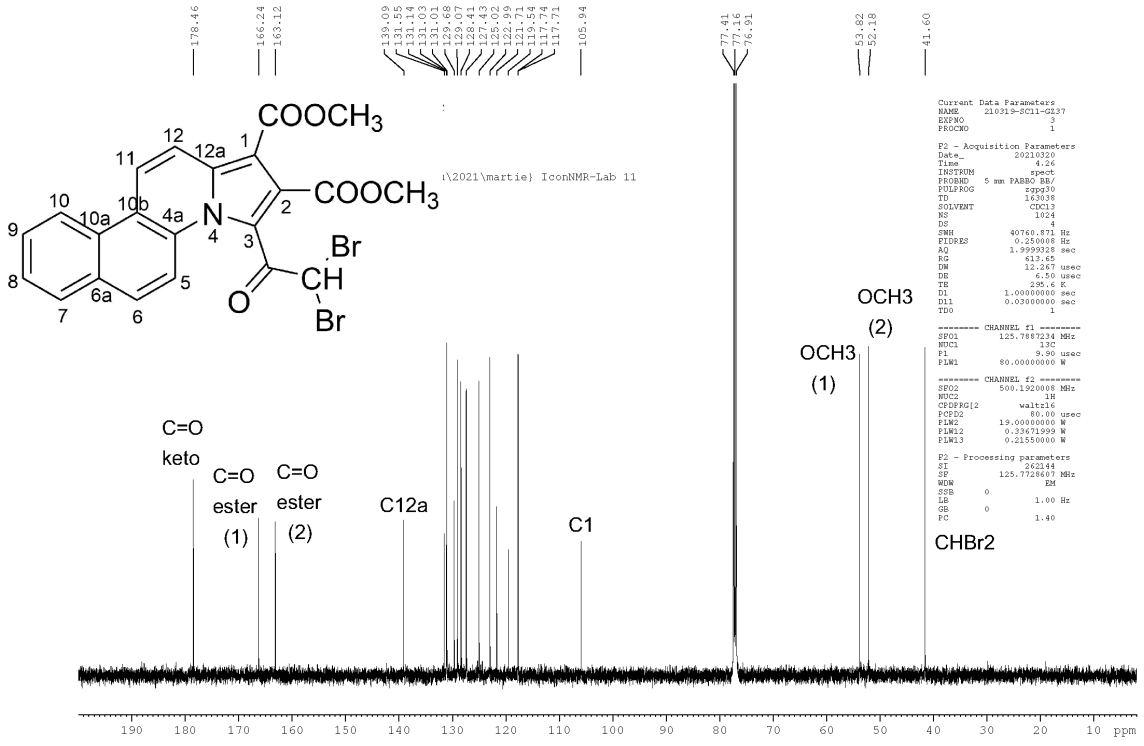


Figure S6b. [13]C NMR spectrum of the compound **3b.**

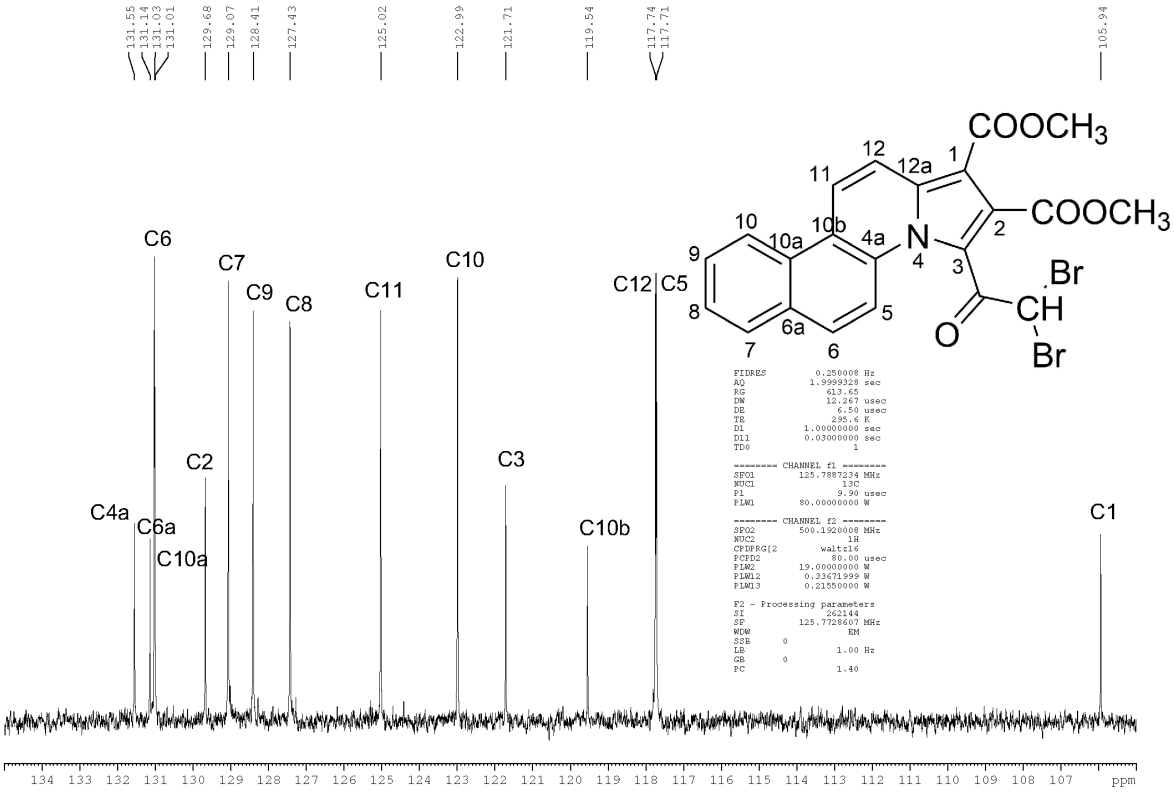


Figure S6c. Detail in the aromatic area of the ^{13}C NMR spectrum of the compound **3b.**

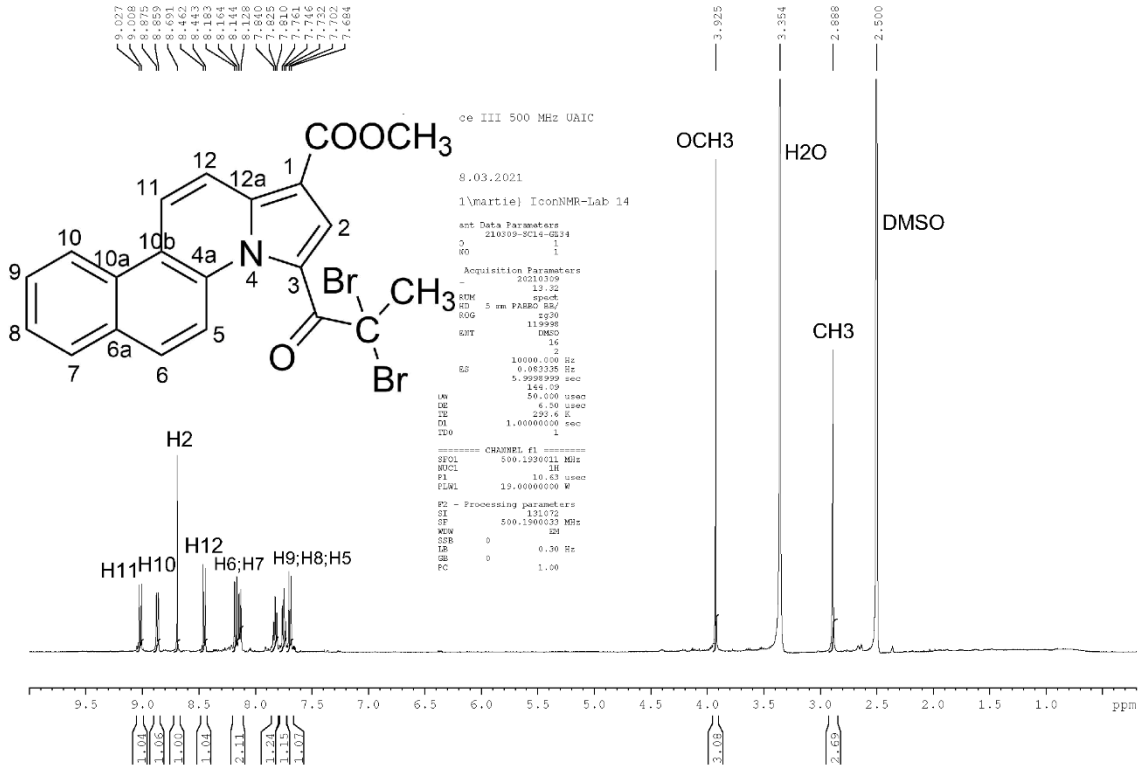


Figure S7a. ^{1}H NMR spectrum of the compound **3c.**

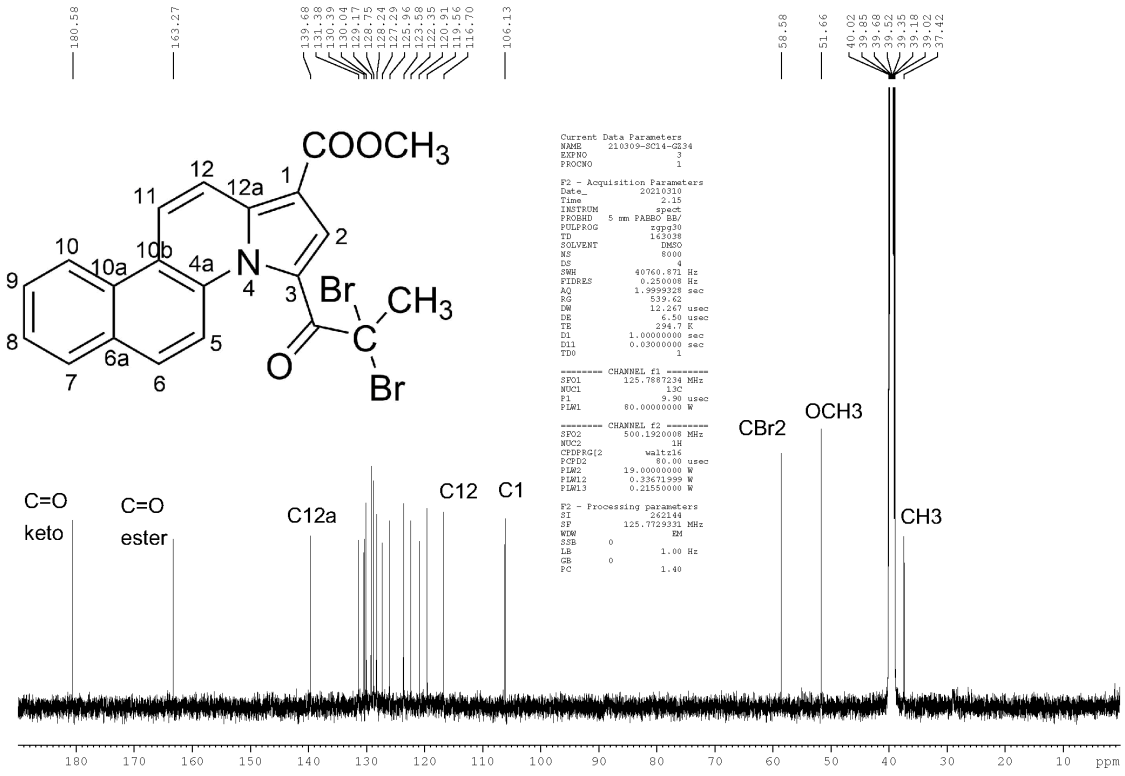


Figure S7b. ^{13}C NMR spectrum of the compound **3c.**

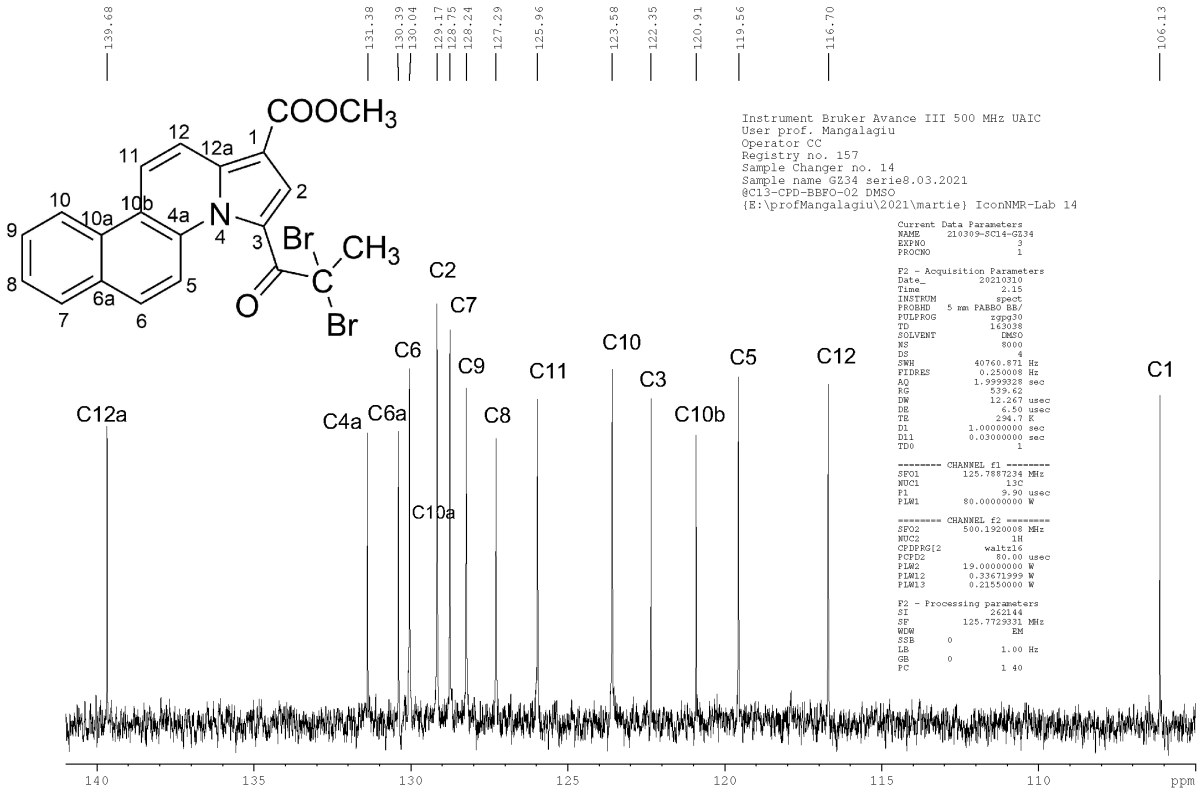


Figure S7c. Detail in the aromatic area of the ^{13}C NMR spectrum of the compound **3c.**

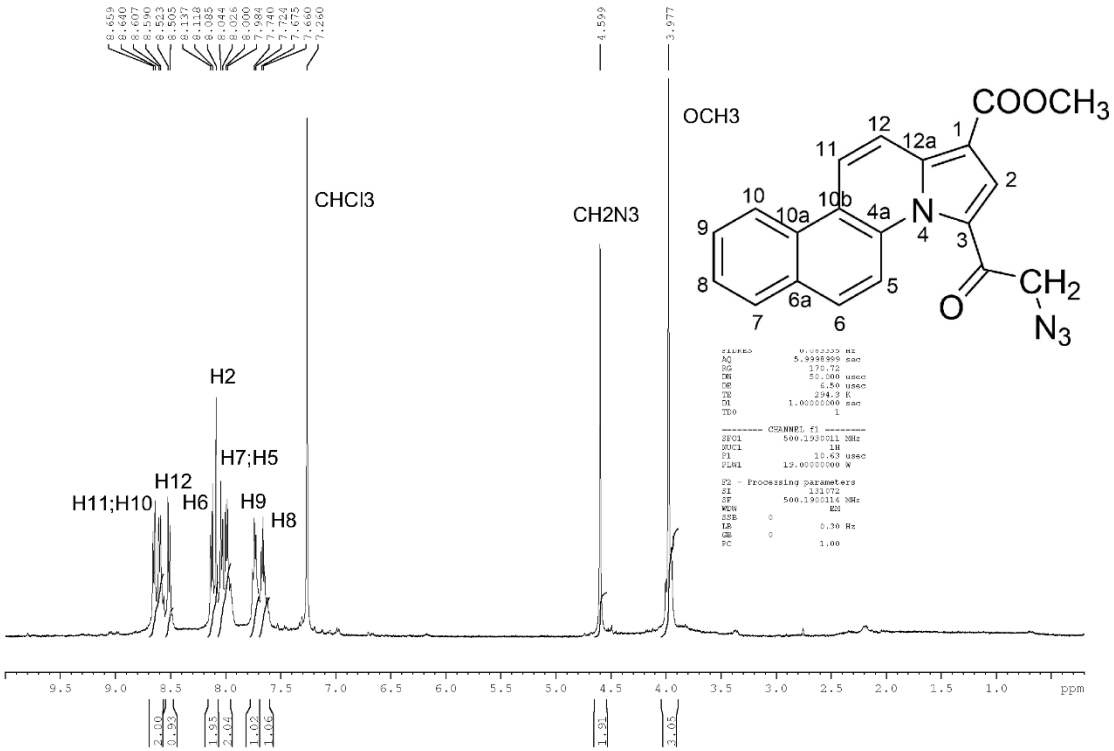


Figure S8a. [1]H NMR spectrum of the compound **4a.**

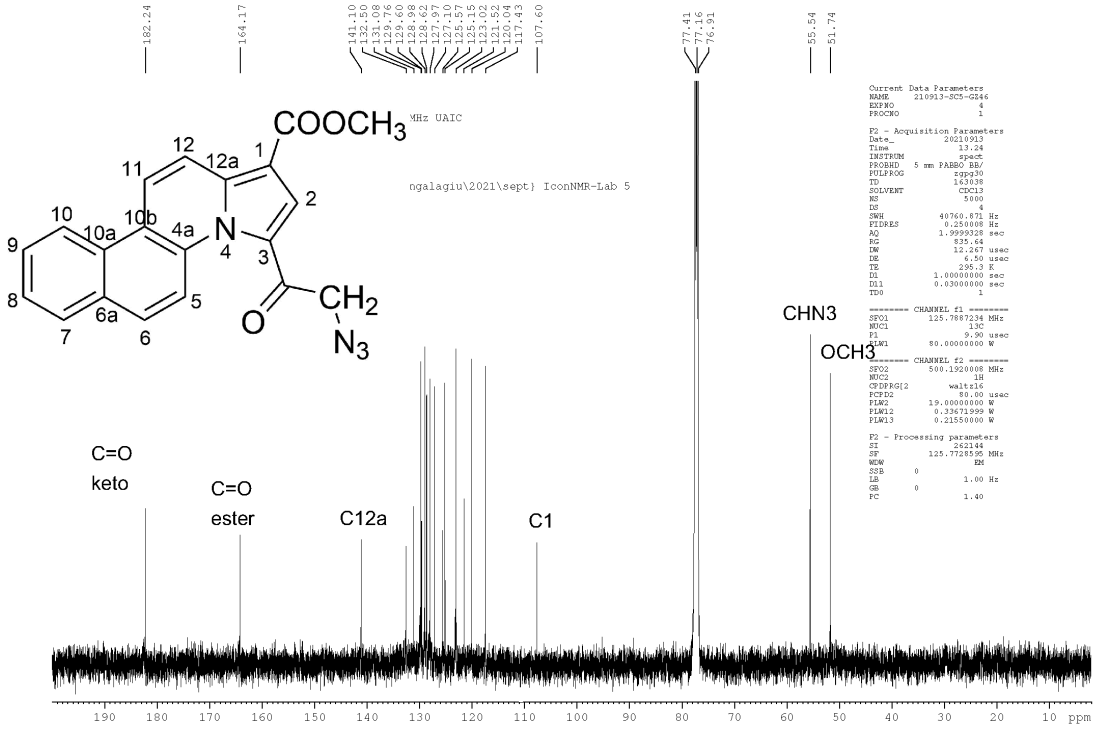


Figure S8b. [13]C NMR spectrum of the compound **4a.**

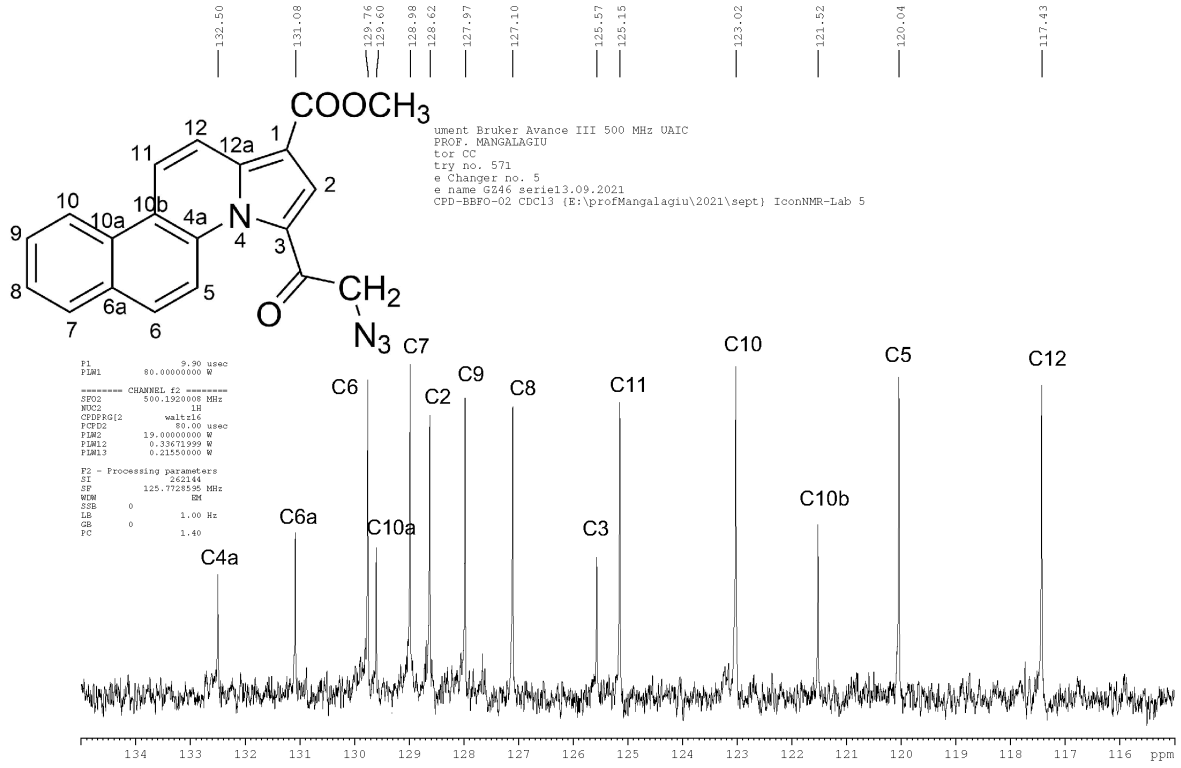


Figure S8c. Detail in the aromatic area of the ^{13}C NMR spectrum of the compound **4a.**

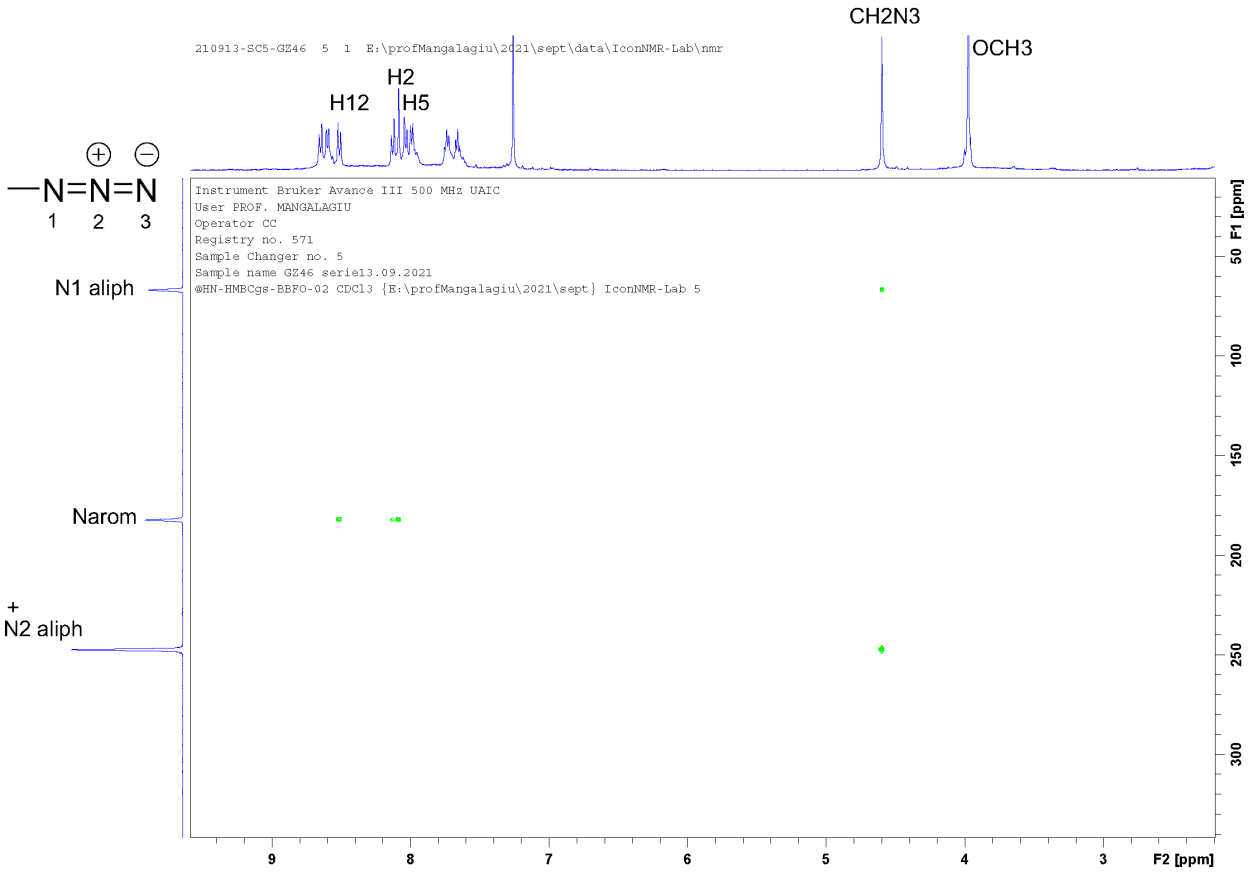


Figure S8d. Long range ^{1}H-^{15}N correlation HMBC spectrum of the compound **4a.**

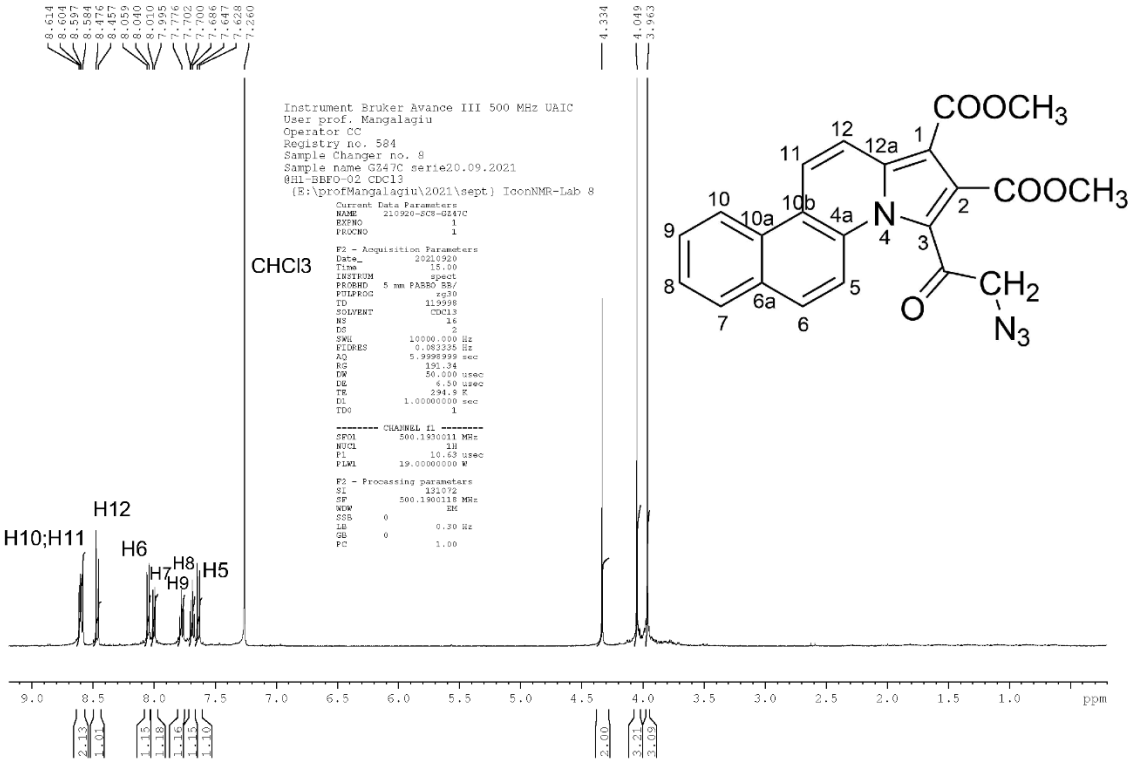


Figure S9a. [1]H NMR spectrum of the compound **4b.**

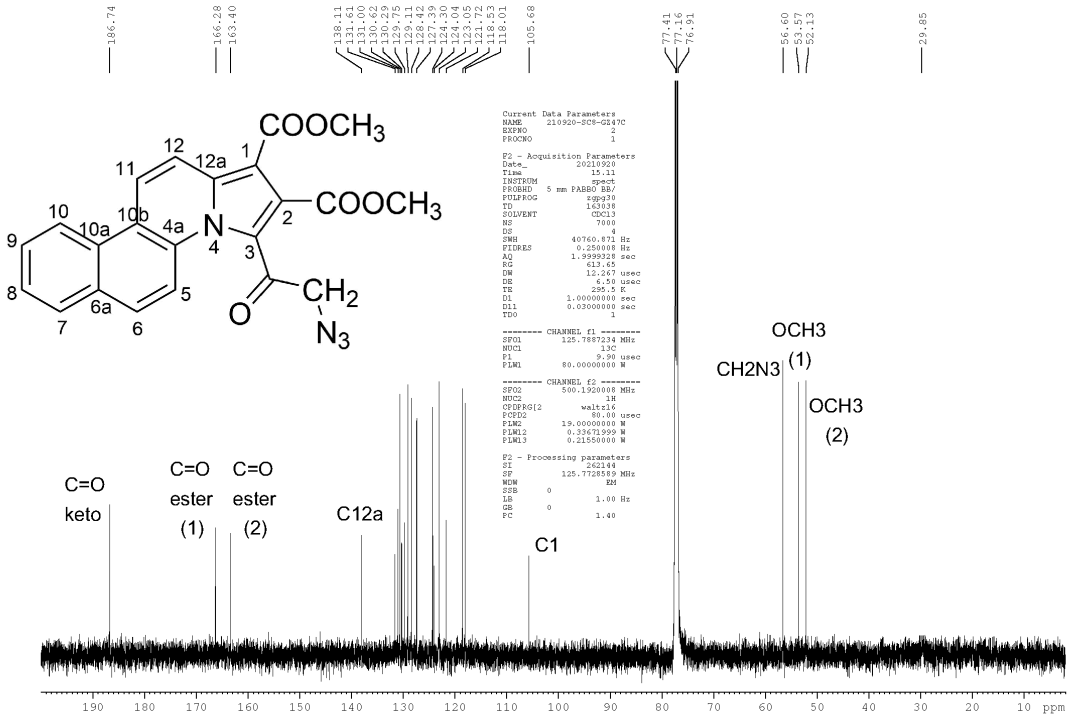


Figure S9b. [13]C NMR spectrum of the compound **4b.**

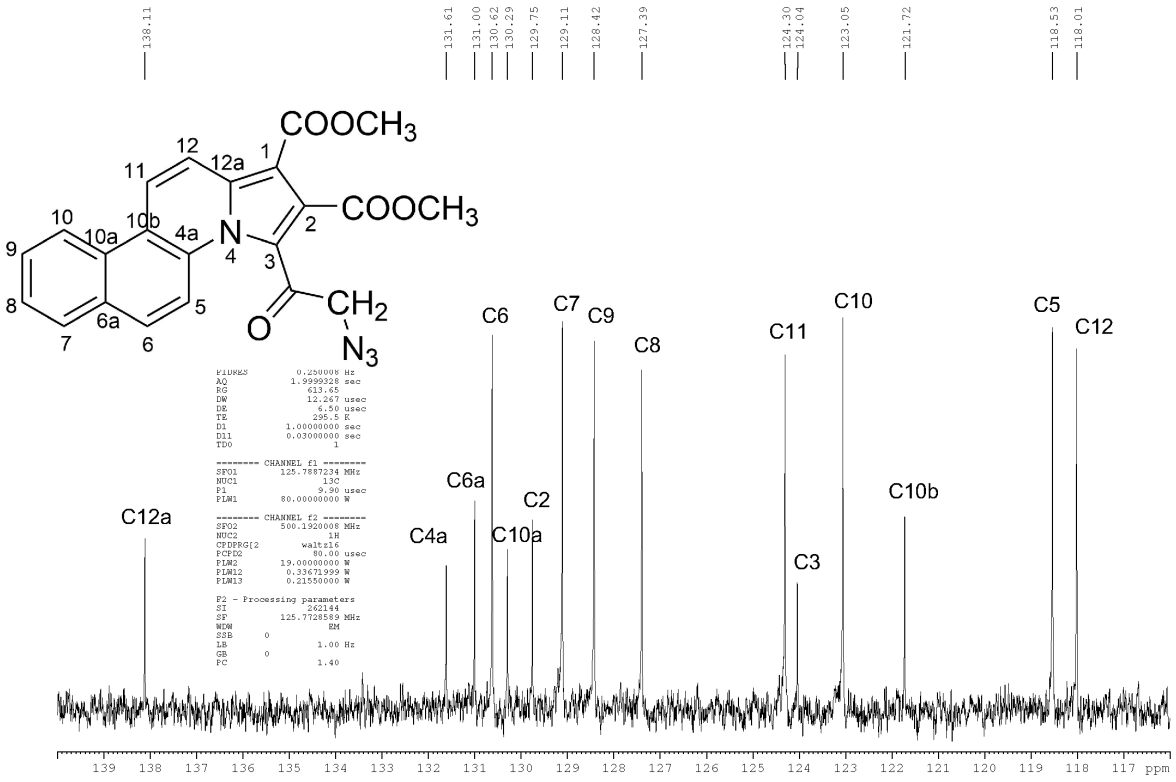


Figure S9c . Detail in the aromatic area of the ^{13}C NMR spectrum of the compound **4b.**

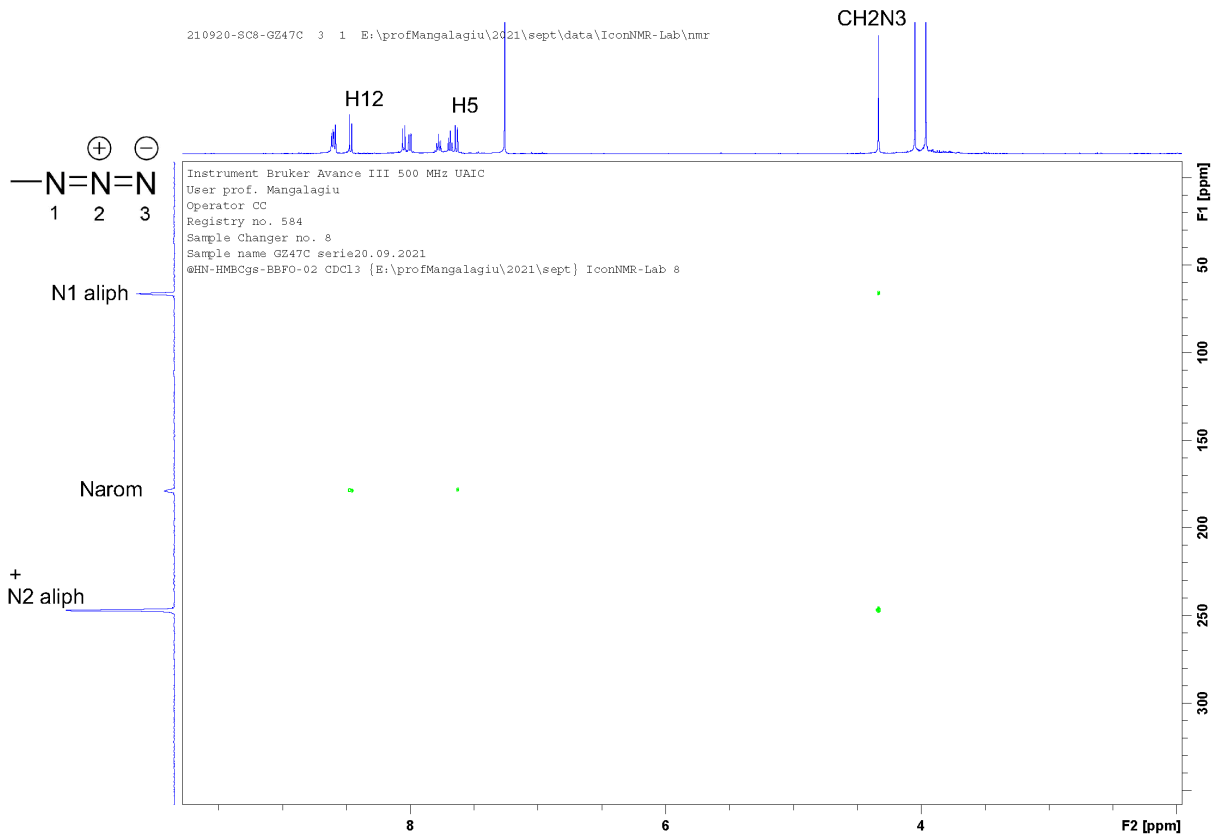


Figure S9d. Long range ^{1}H-^{15}N correlation HMBC spectrum of the compound **4b.**

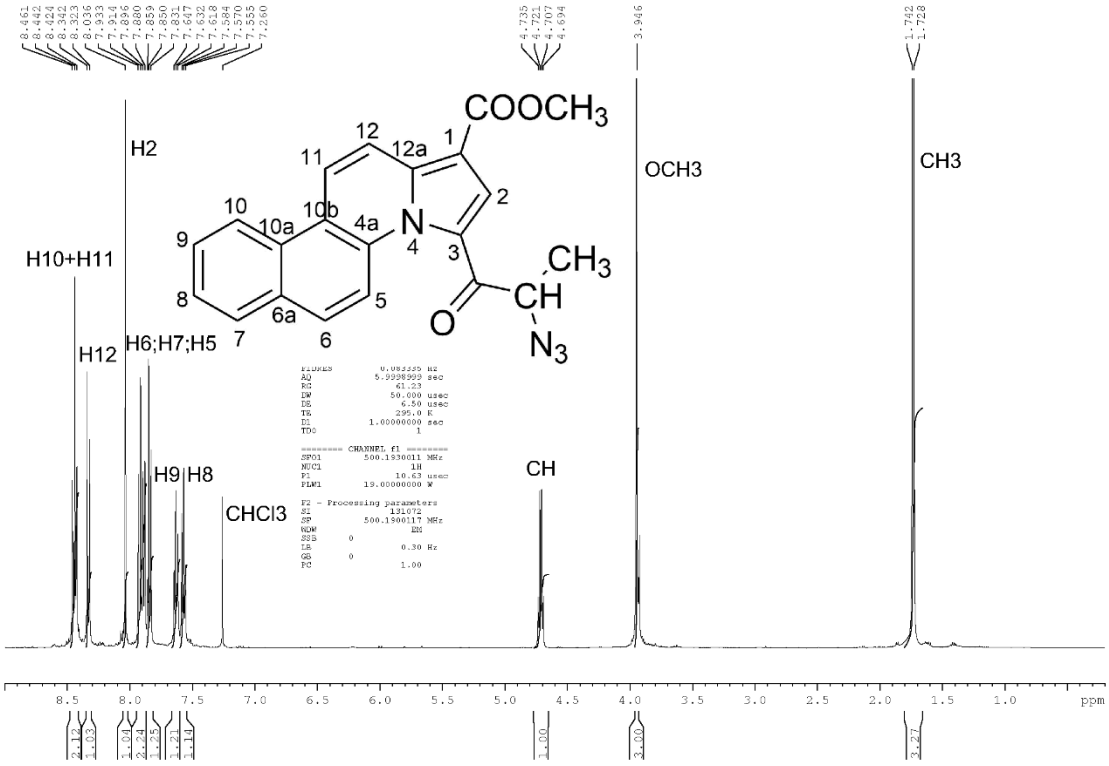


Figure S10a. [1]H NMR spectrum of the compound **4c.**

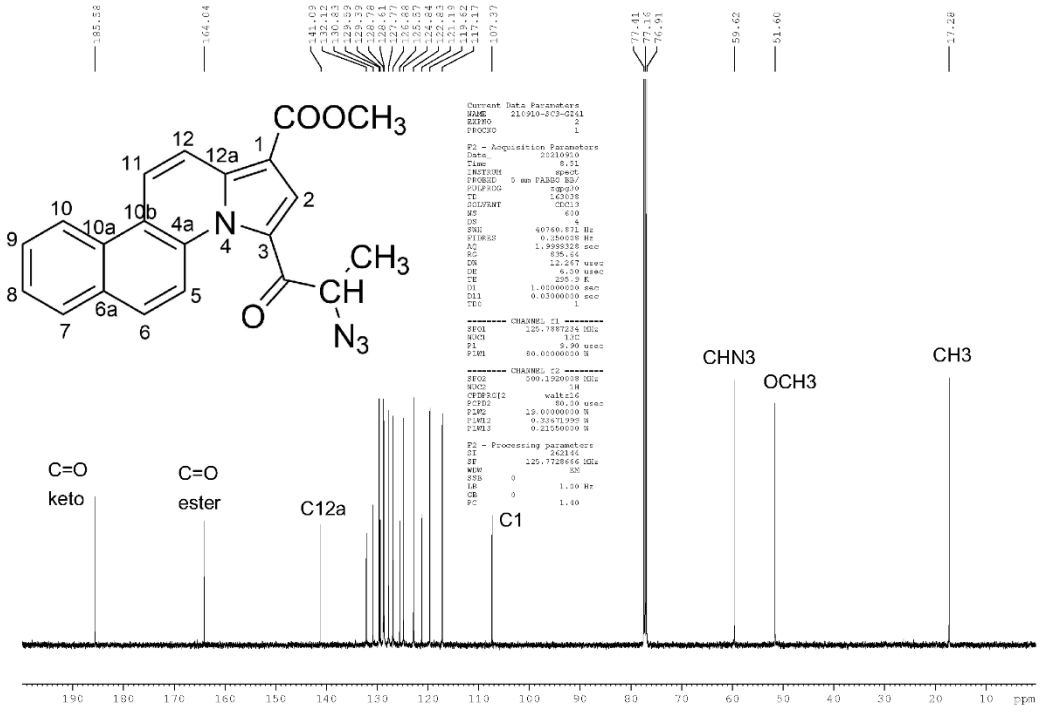


Figure S10b. [13]C NMR spectrum of the compound **4c.**

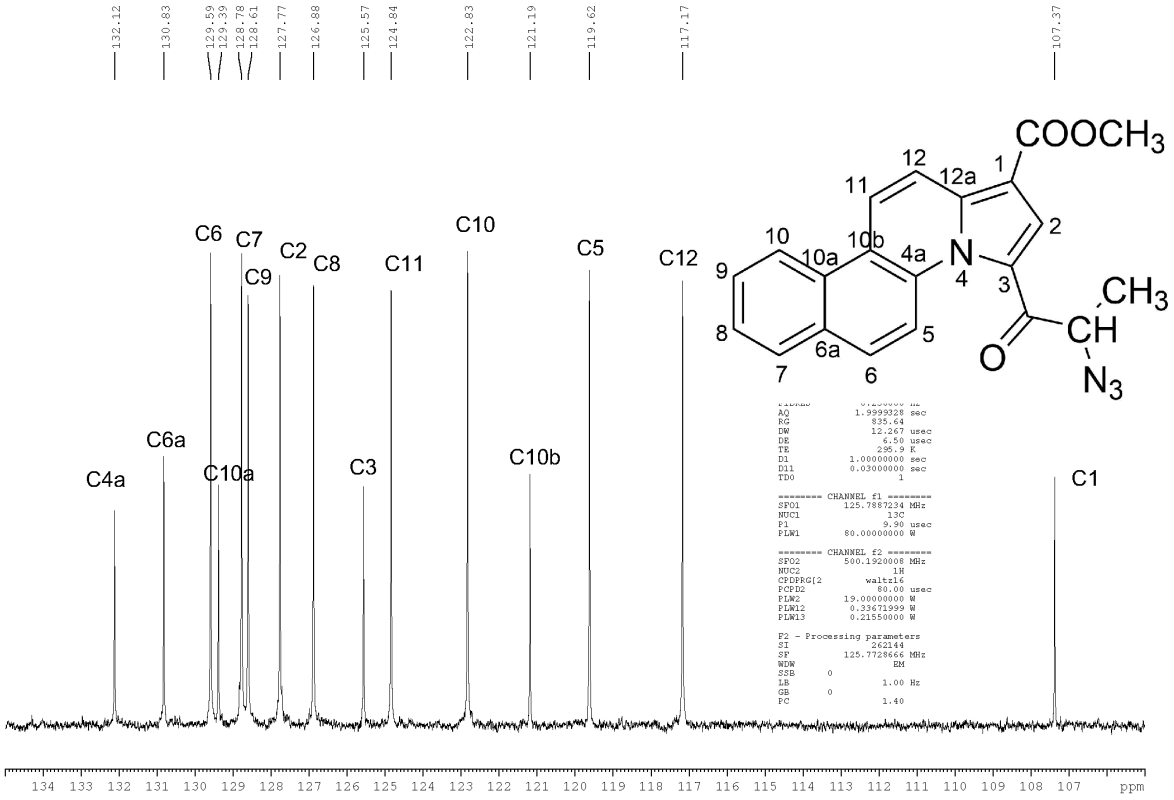


Figure S10c. Detail in the aromatic area of the ^{13}C NMR spectrum of the compound **4c.**

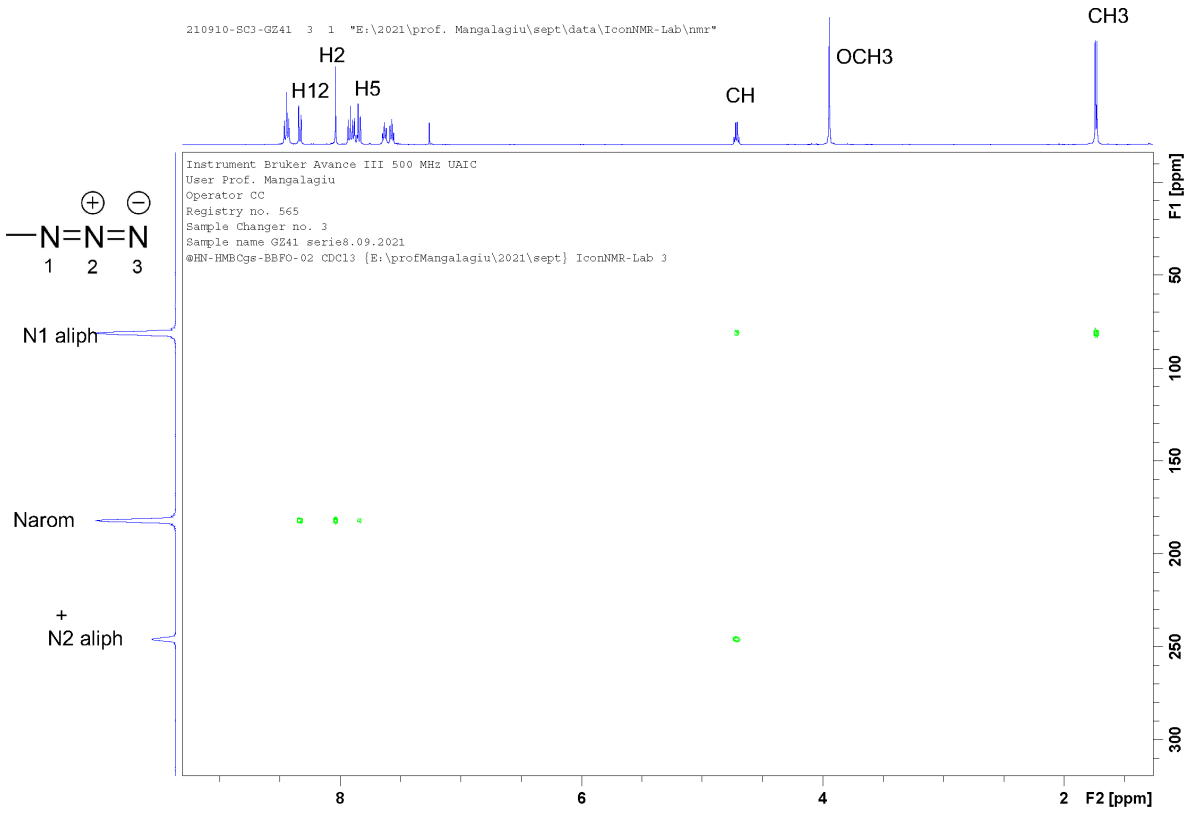


Figure S10d . Long range ^{1}H-^{15}N correlation HMBC spectrum of the compound **4c.**

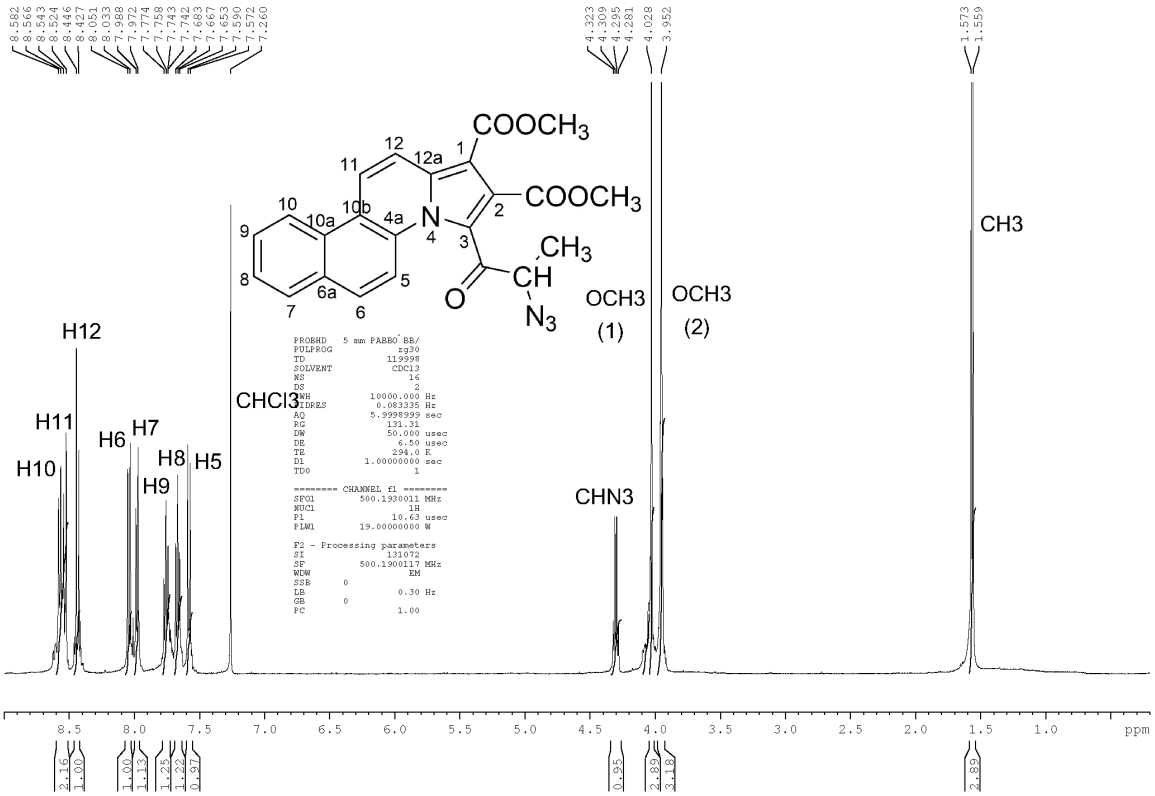


Figure S11a. ^{1}H NMR spectrum of the compound **4d.**

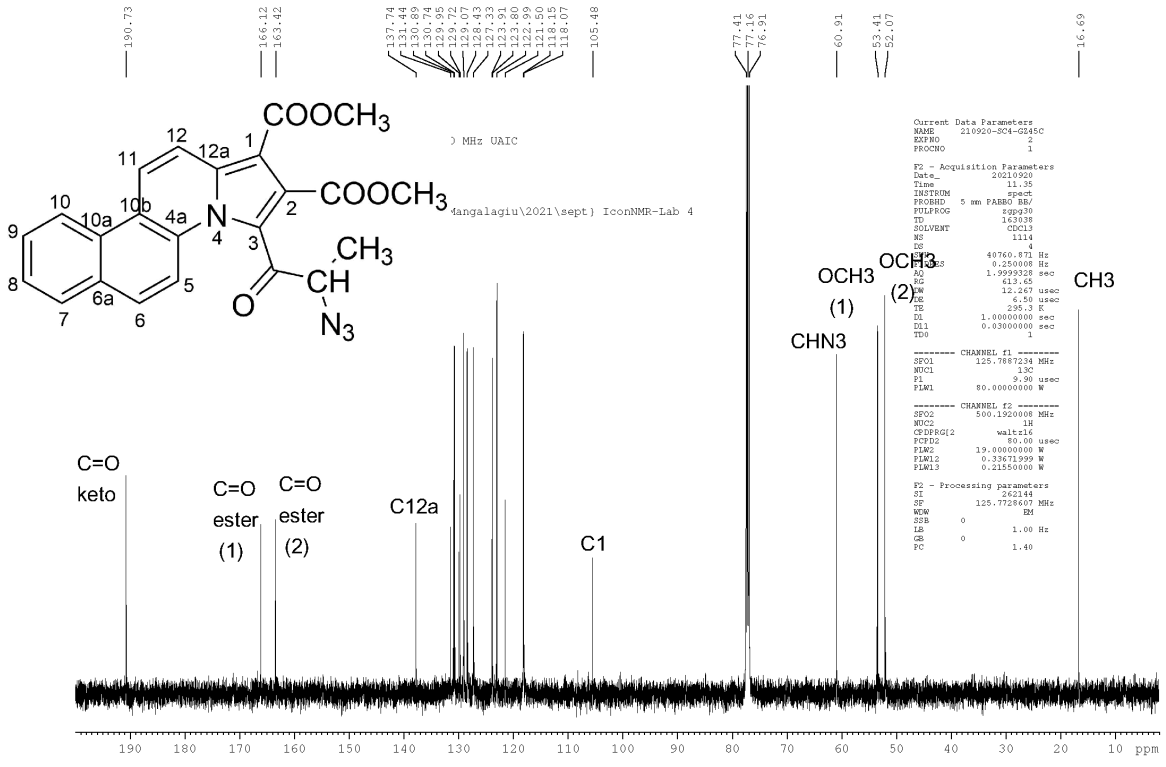


Figure S11b. ^{13}C NMR spectrum of the compound **4d.**

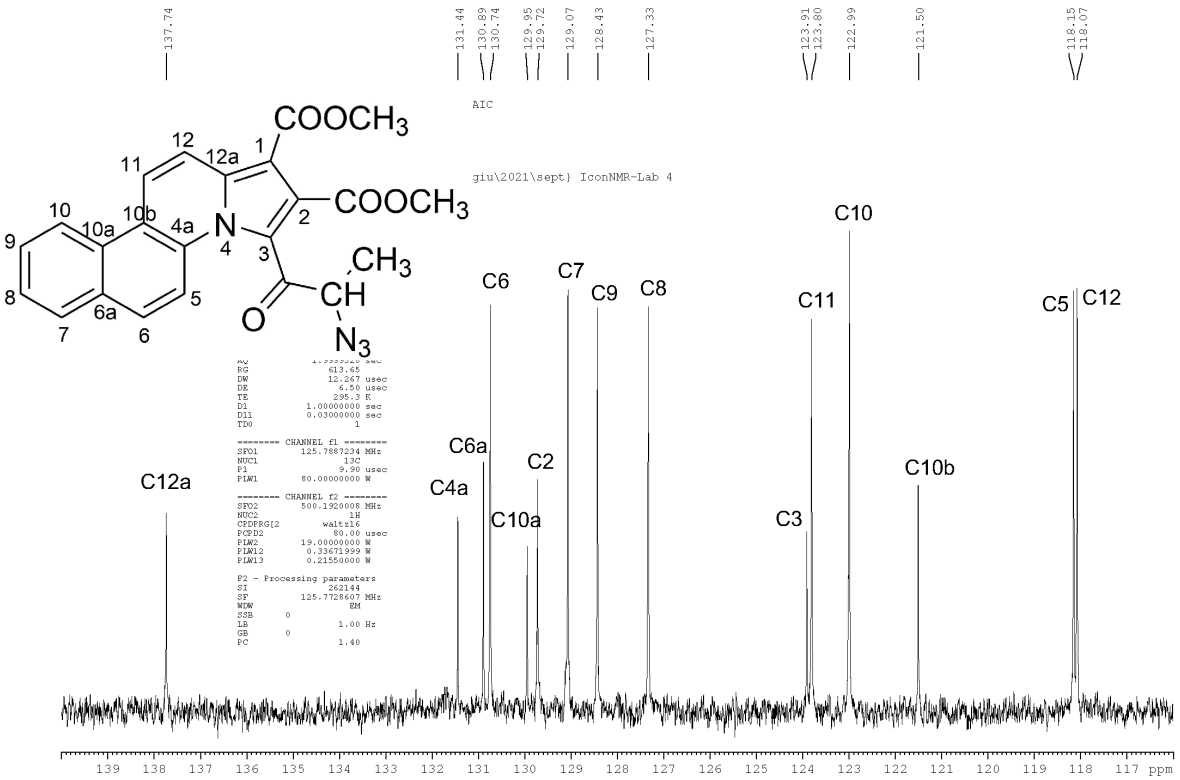


Figure S11c. Detail in the aromatic area of the ^{13}C NMR spectrum of the compound **4d.**

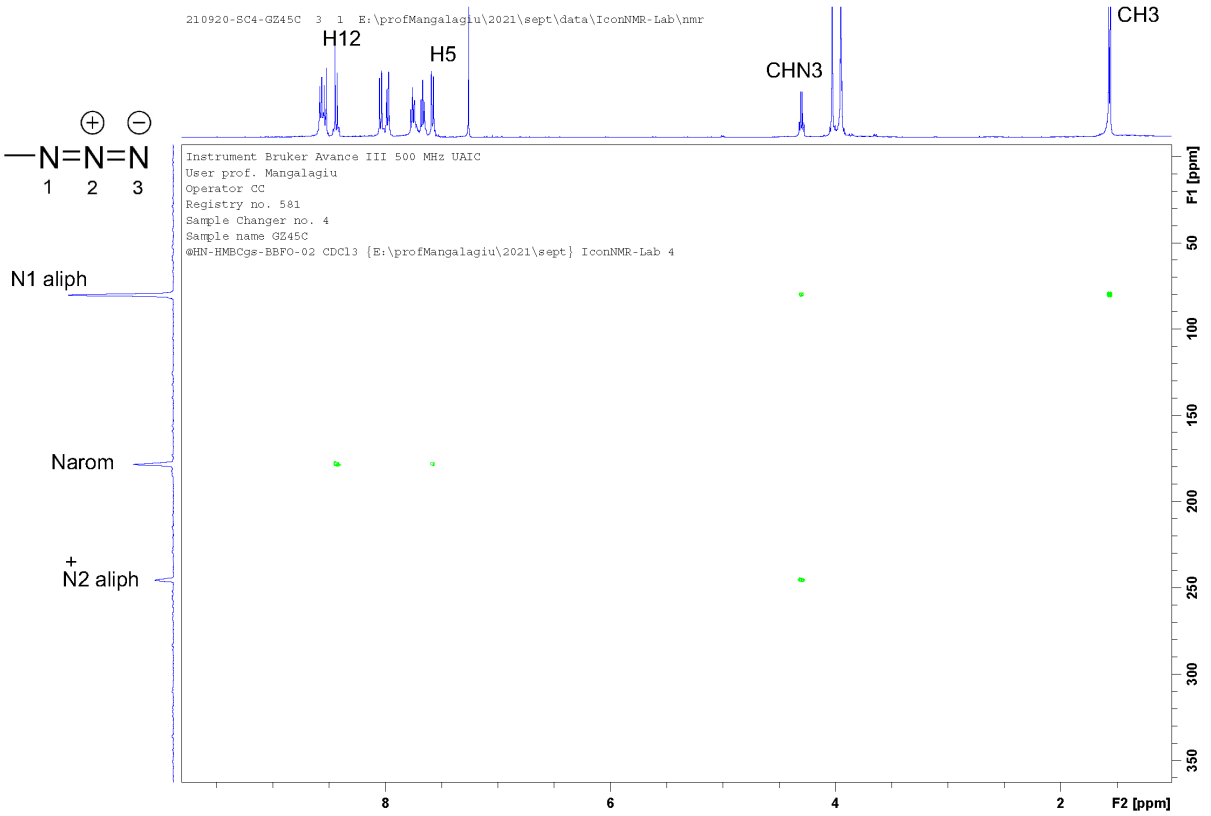


Figure S11d. Long range ^{1}H-^{15}N correlation HMBC spectrum of the compound **4d.**

3. IR spectra of the obtained compounds

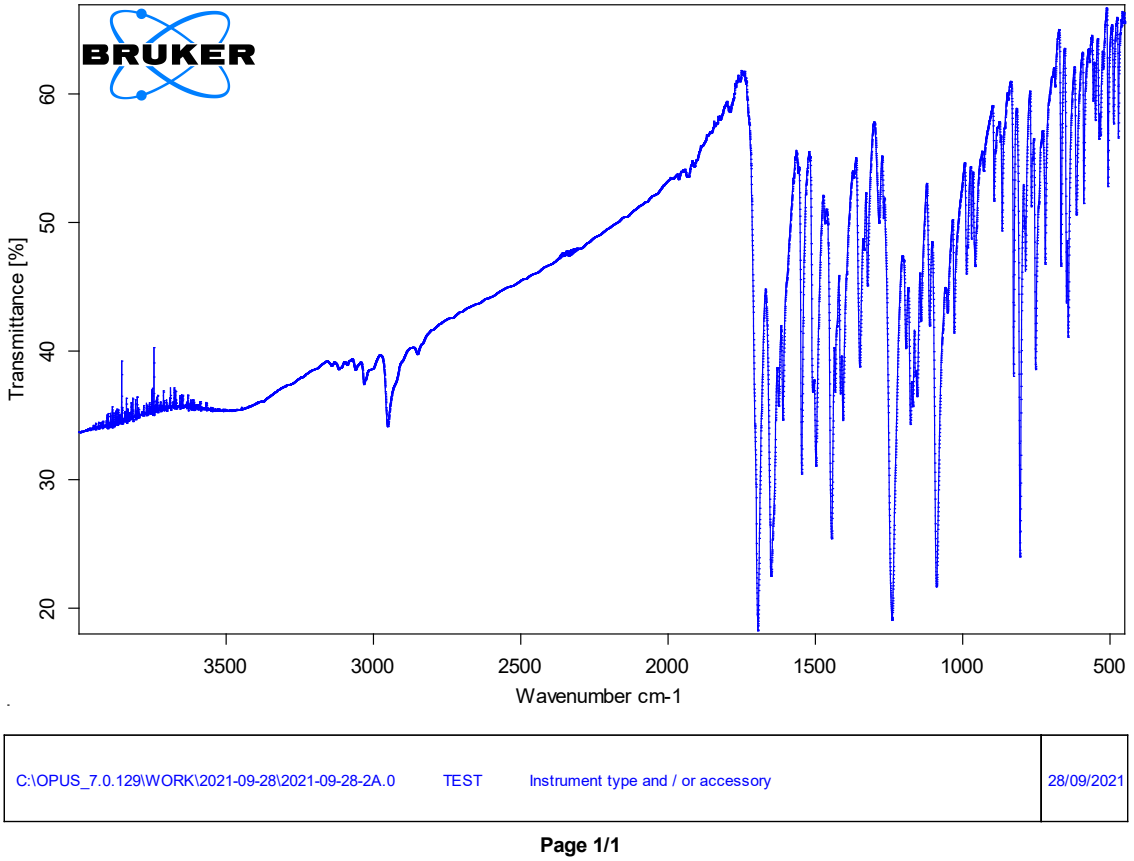


Figure S12. IR spectrum of the compound **2a.**

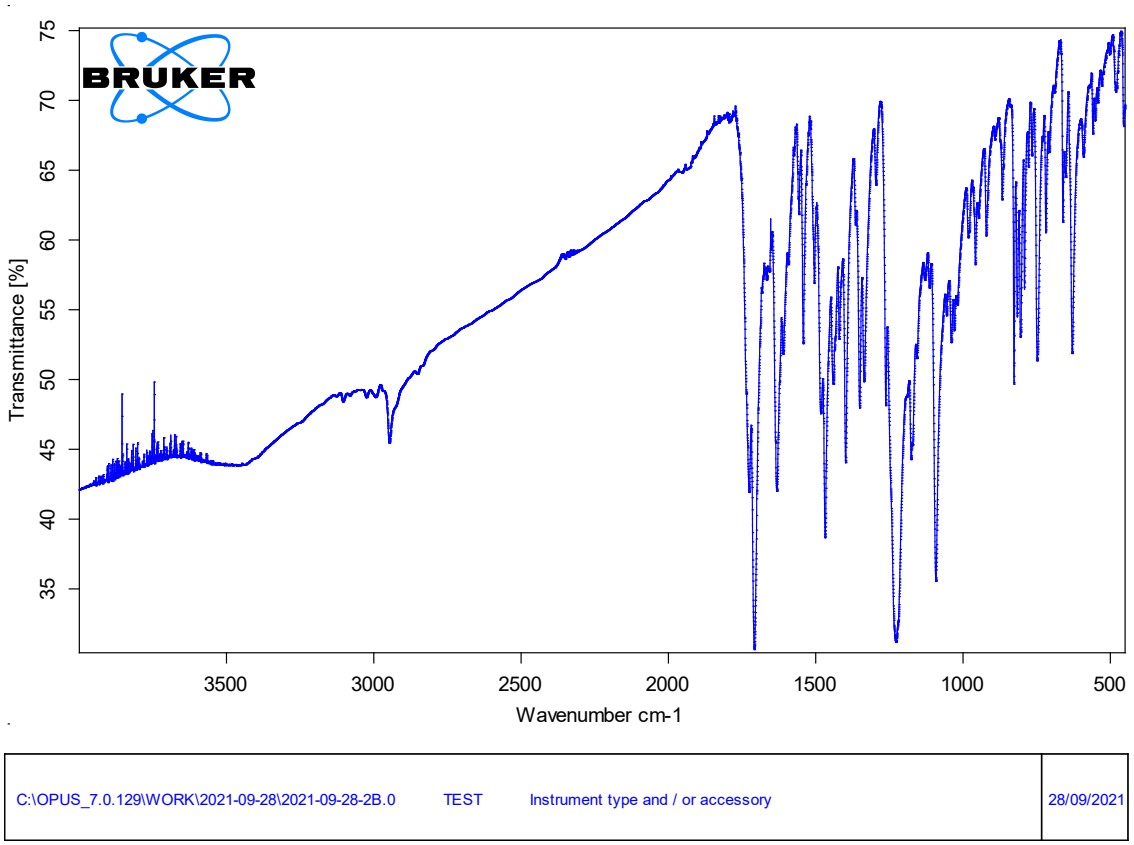


Figure S13. IR spectrum of the compound **2b.**

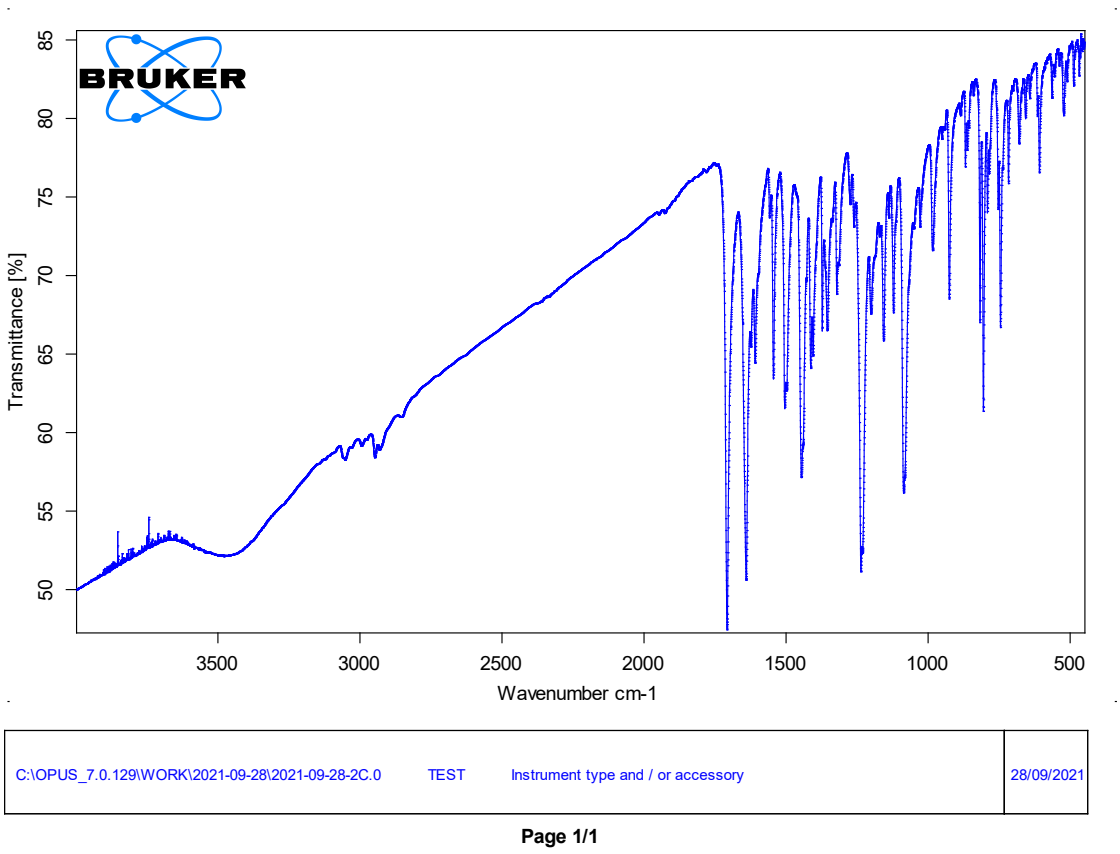


Figure S14. IR spectrum of the compound **2c.**

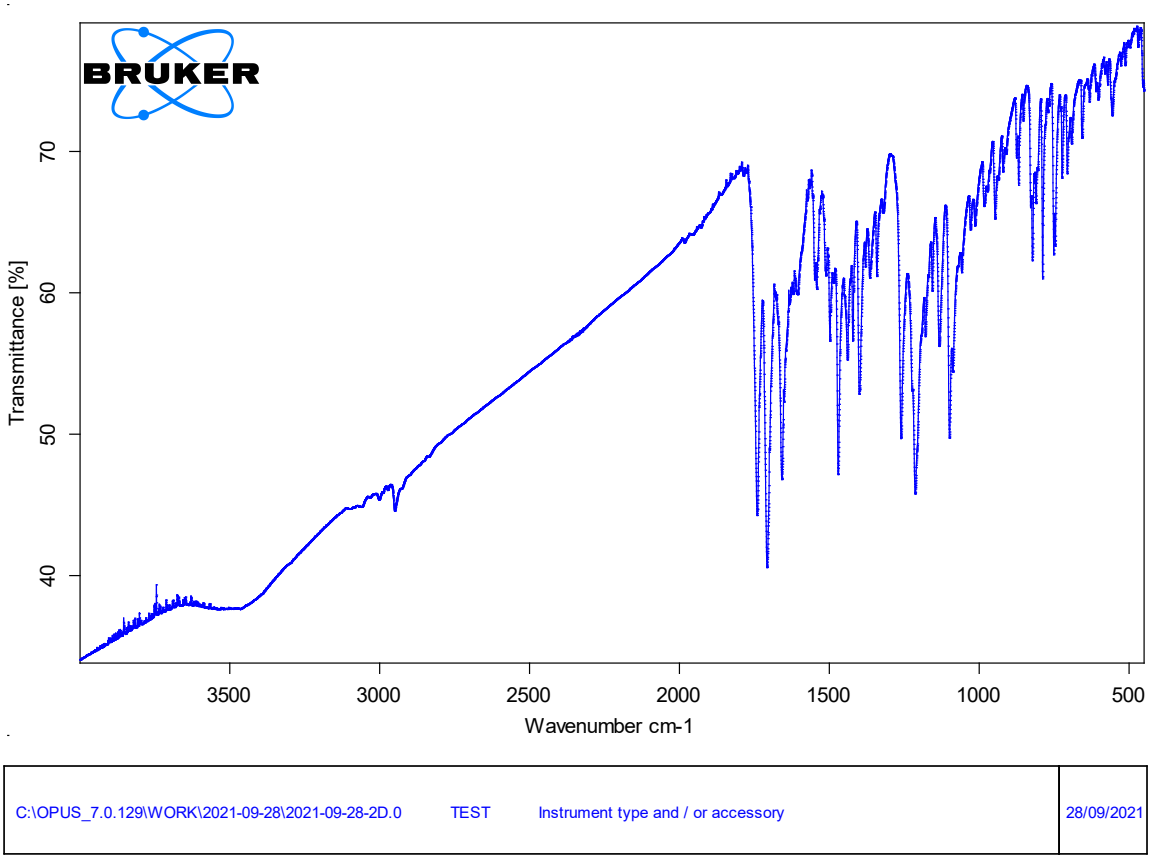


Figure S15. IR spectrum of the compound **2d.**

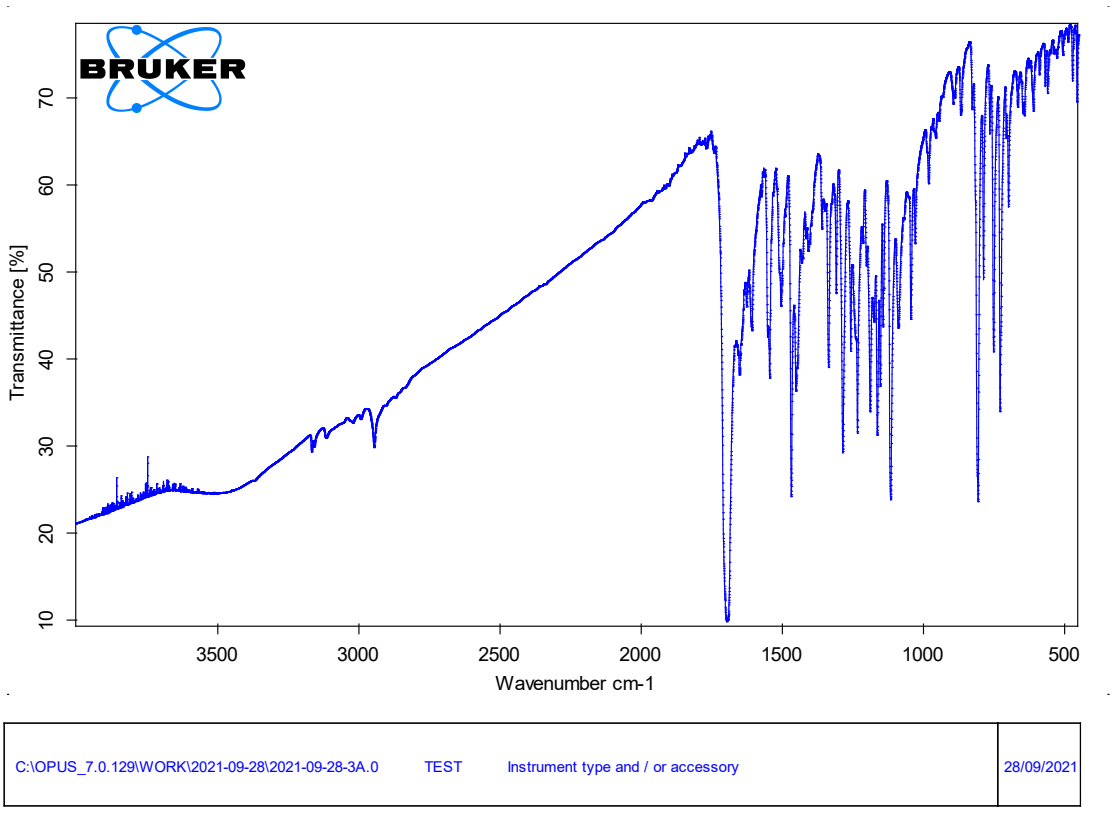


Figure S16. IR spectrum of the compound **3a.**

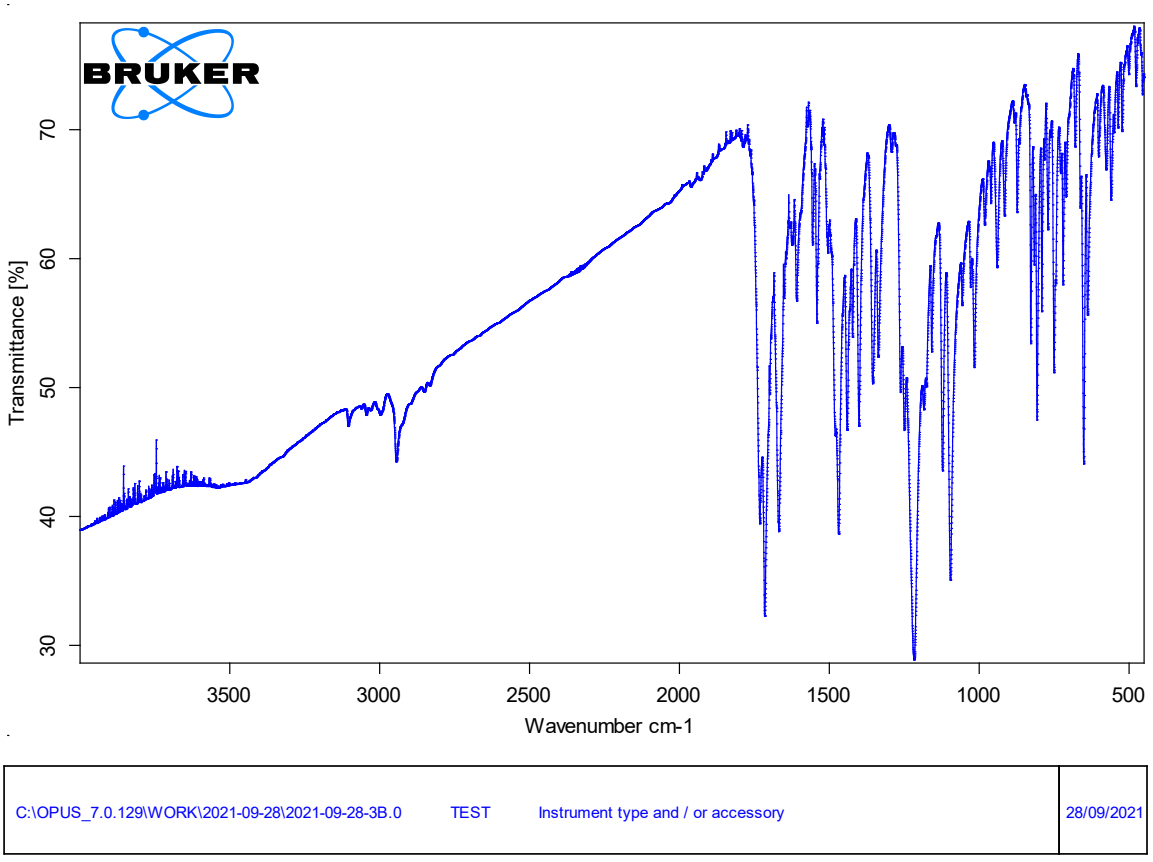


Figure S17. IR spectrum of the compound **3b.**

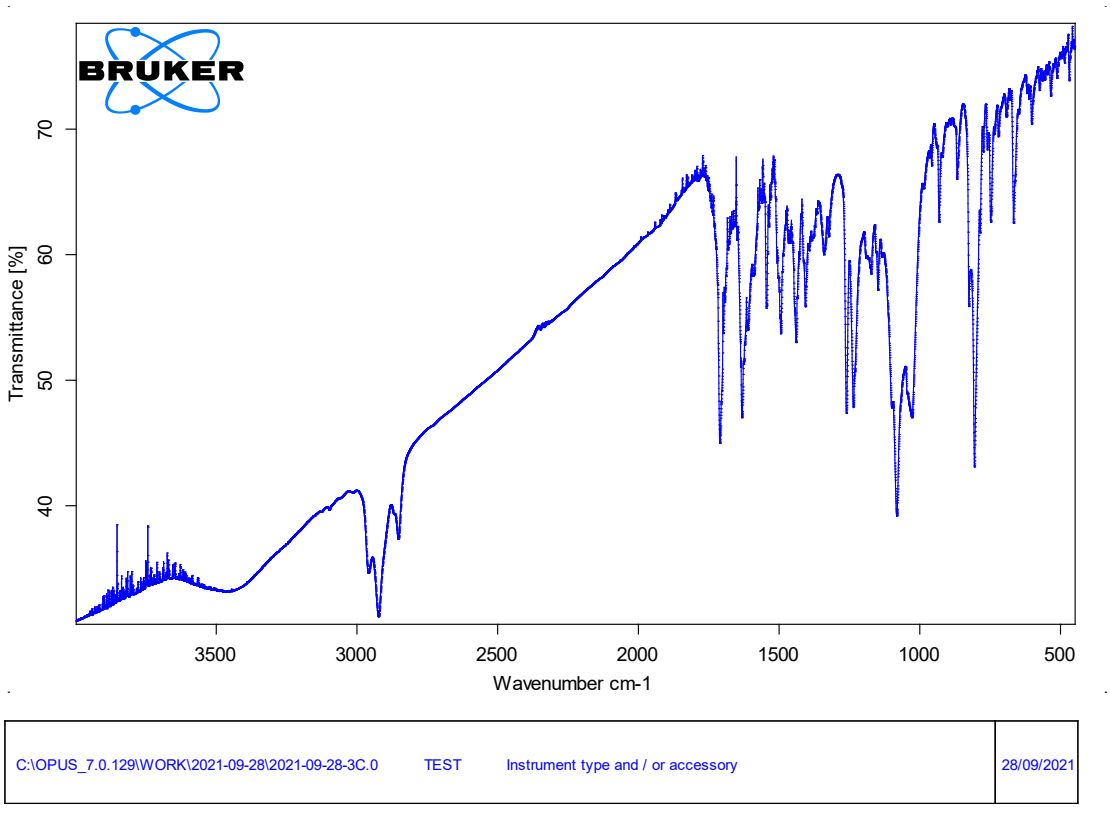


Figure S18. IR spectrum of the compound **3c.**

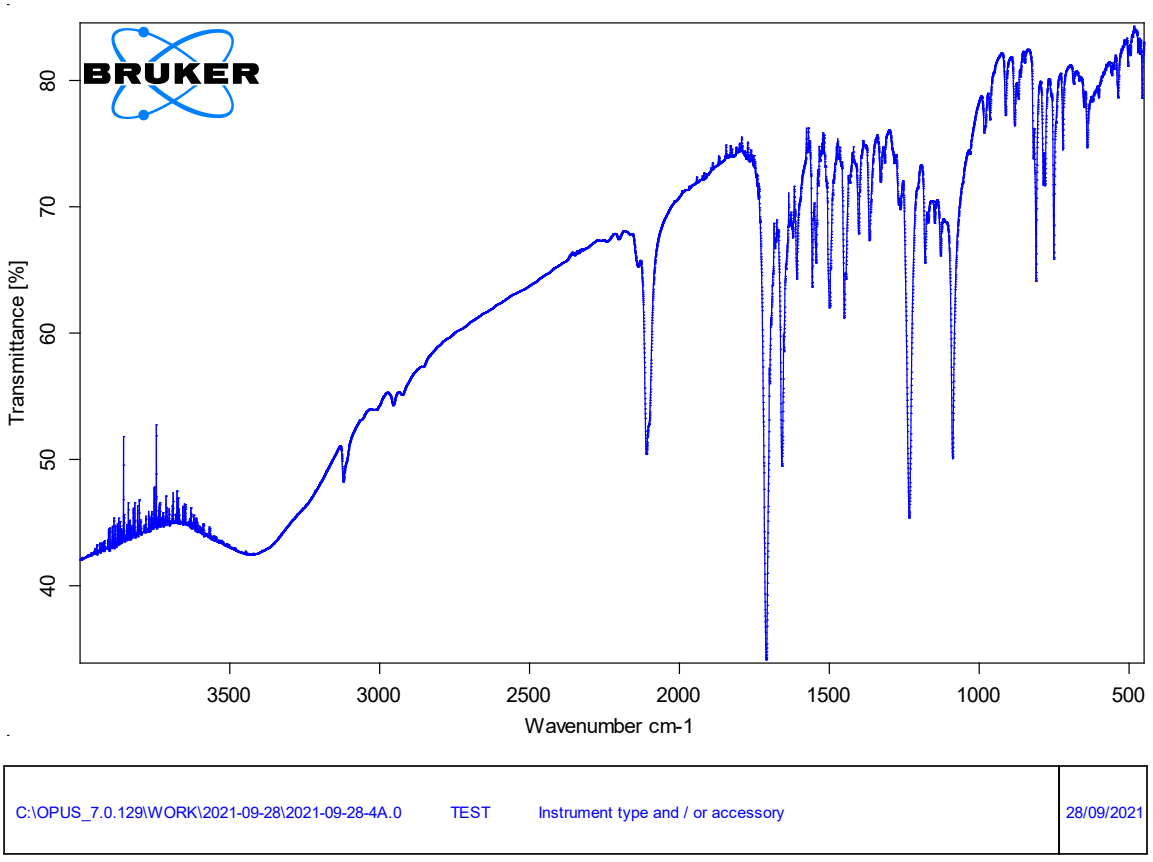


Figure S19. IR spectrum of the compound **4a.**

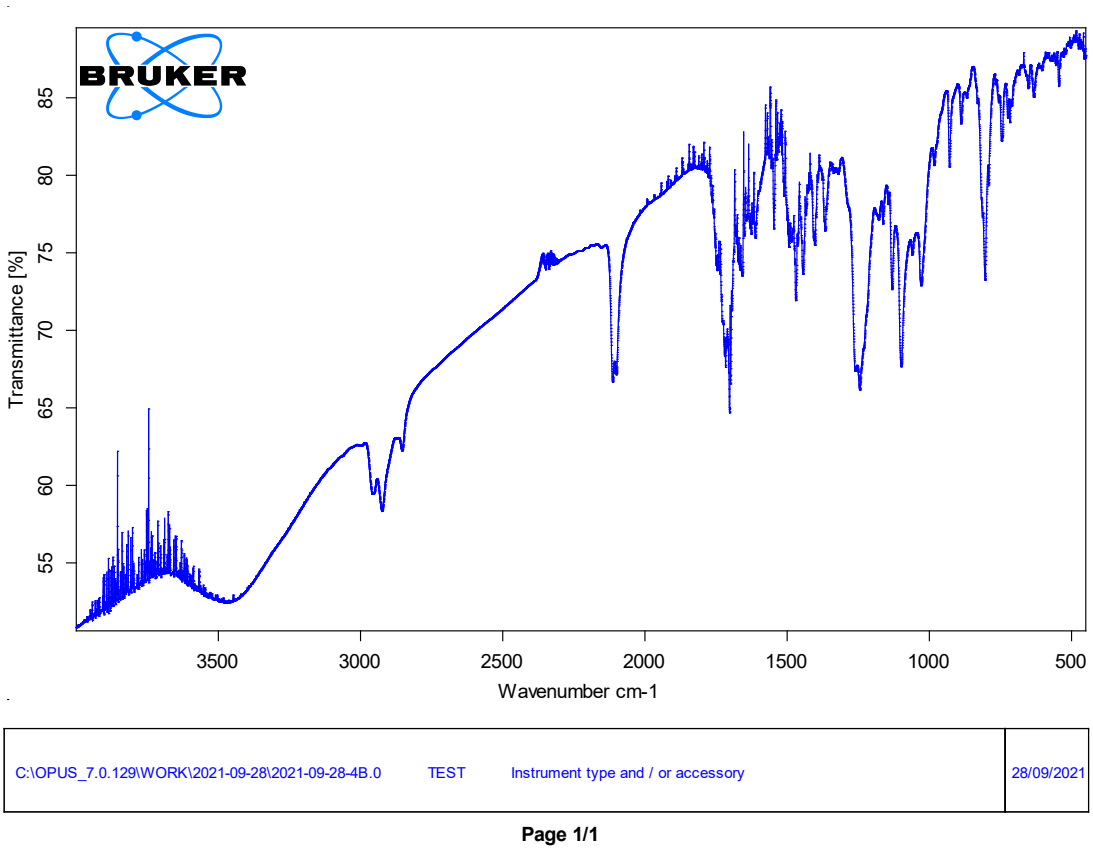


Figure S20. IR spectrum of the compound **4b.**

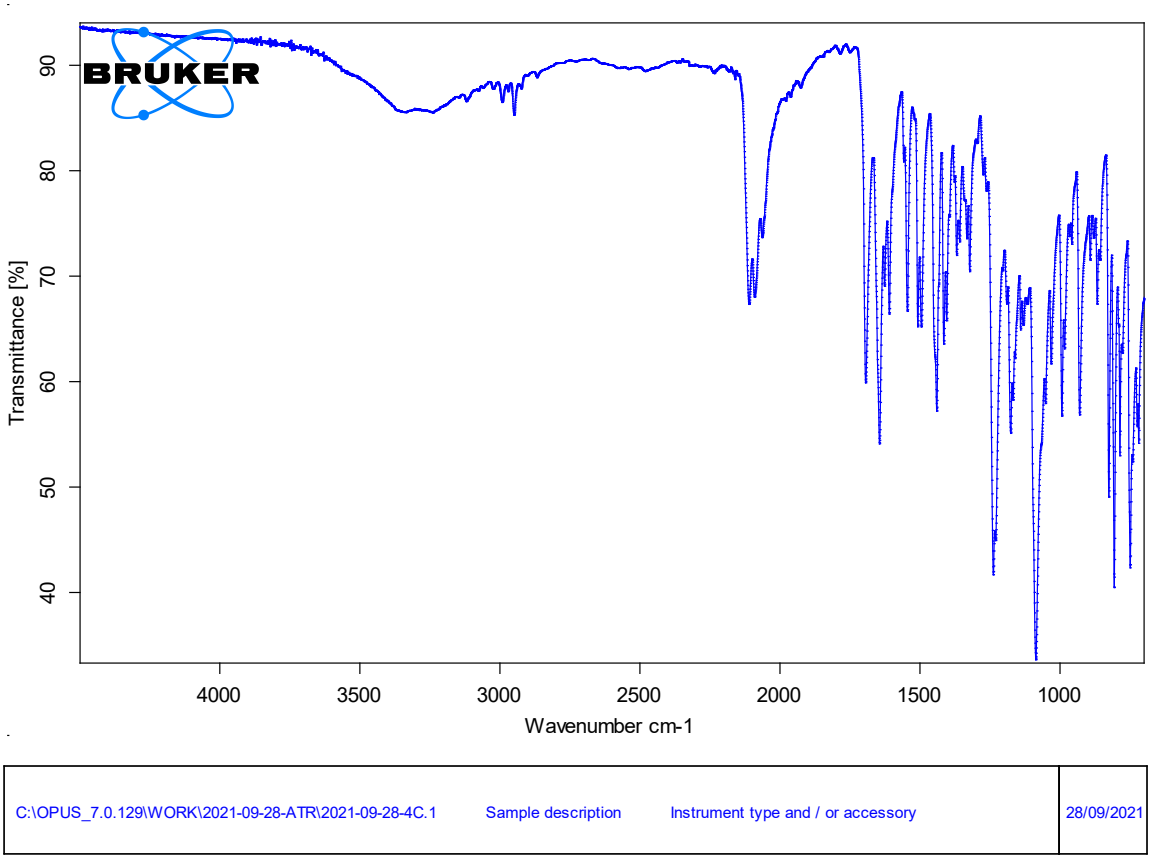


Figure S21. IR spectrum of the compound **4c.**

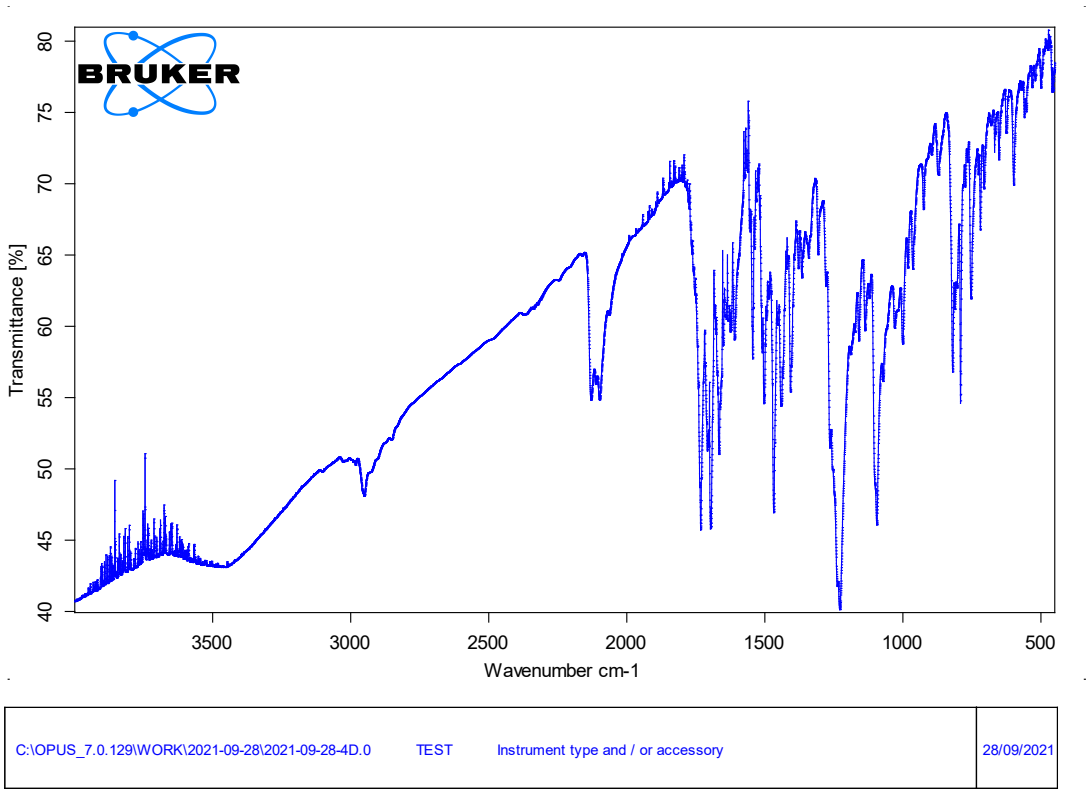


Figure S22. IR spectrum of the compound **4d.**

4. UV spectra of the obtained compounds

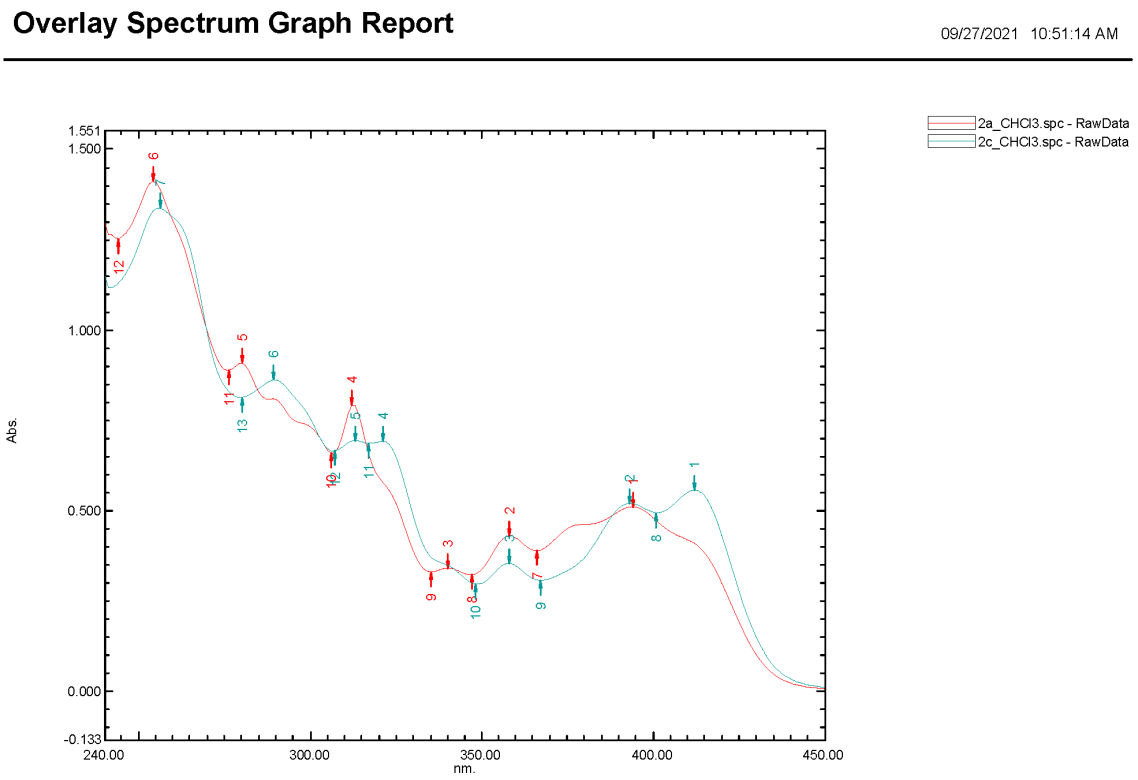


Figure S23. Overlayed UV-Vis spectra of the compounds **2a** and **2c** in chloroform.

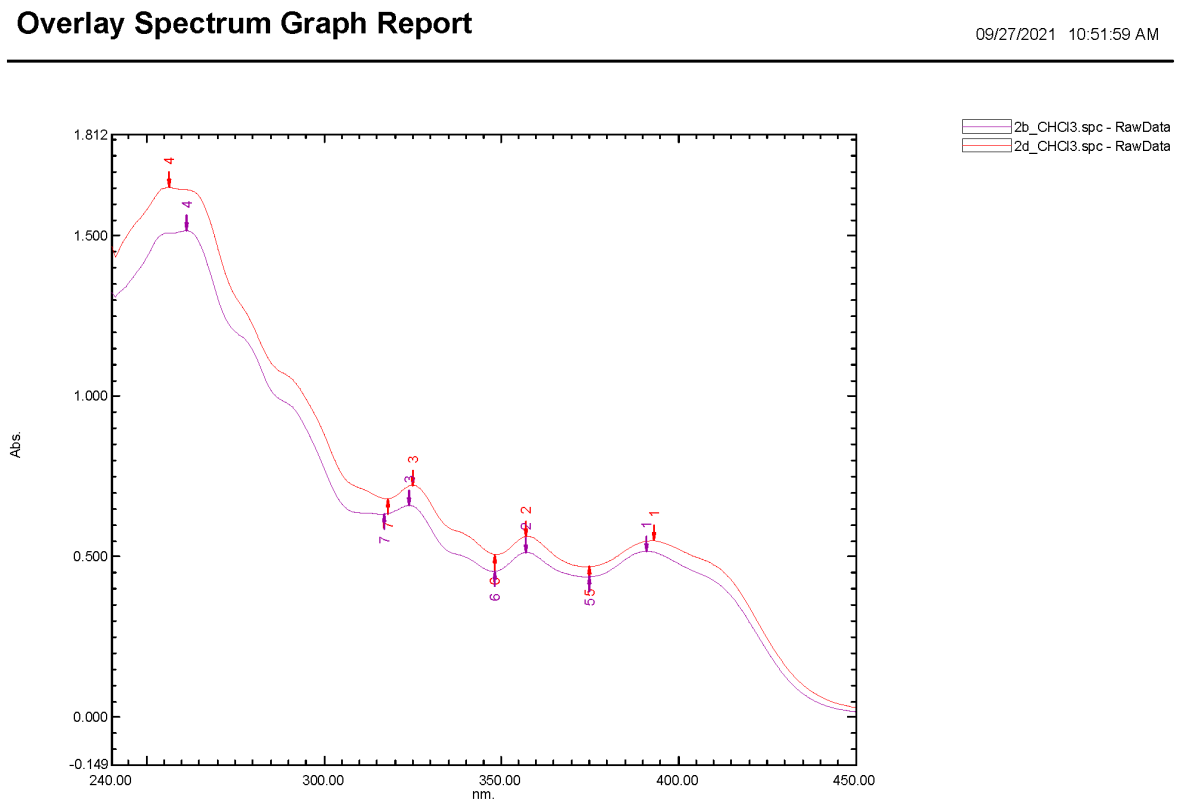


Figure S24. Overlayed UV-Vis spectra of the compounds **2b** and **2d** in chloroform.

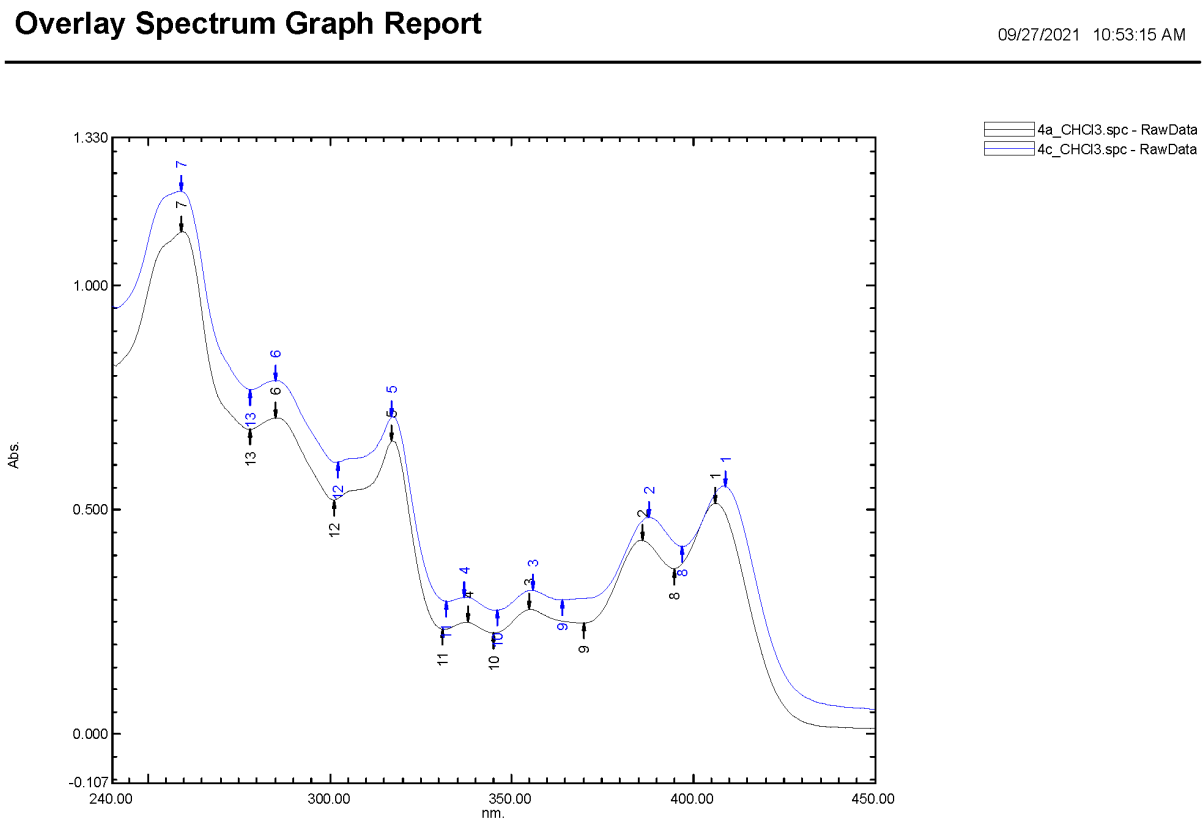


Figure S25. Overlayed UV-Vis spectra of the compounds **4a** and **4c** in chloroform.

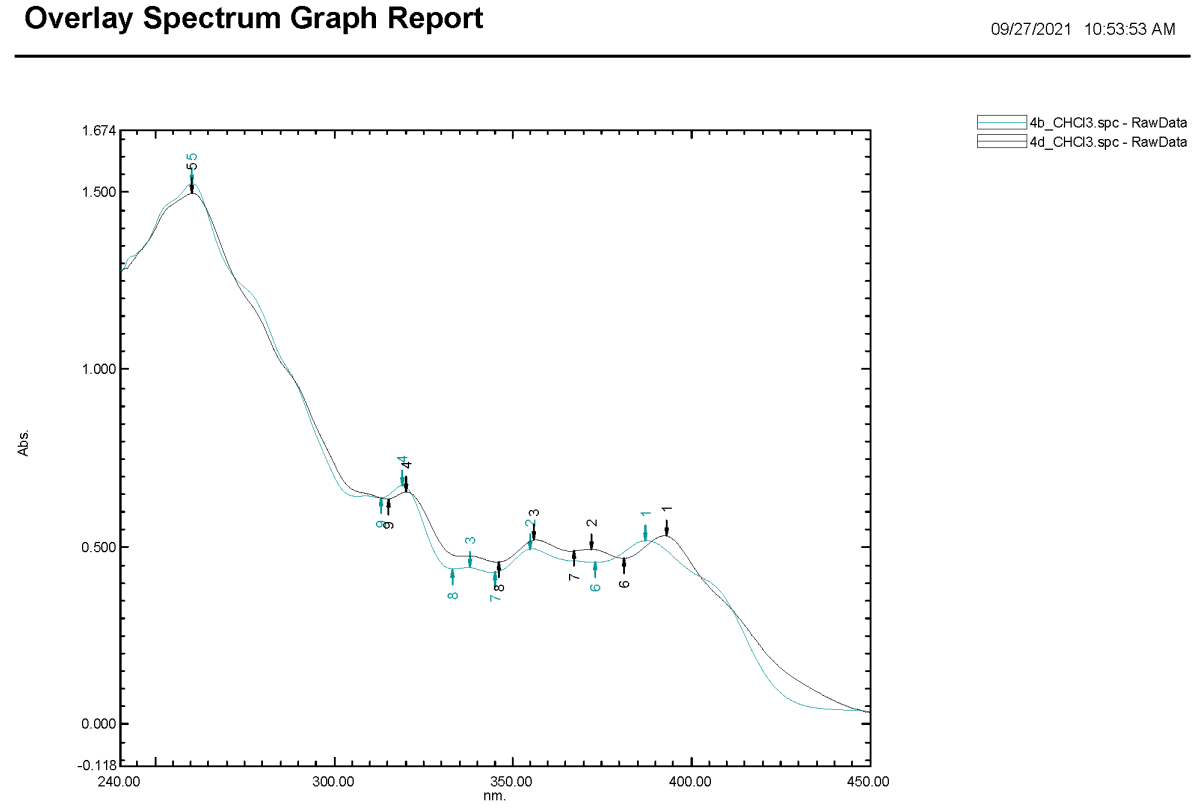


Figure S26. Overlayed UV-Vis spectra of the compounds **4b** and **4c** in chloroform.

In the case of the samples **2a-d** the profile of the third absorption region and the absorption maxima are similar for the samples **2a**, **2b** and **2d** (394 nm for **2a**, 391 nm for **2b** and 393 nm for **2d**), while for the sample **2c** the maximum of the absorption is situated on 412 nm. Sample **2c** present the same absorption bands like **2a**, **2b** and **2d** with a small bathochromic shift.

In the case of the samples **4a** and **4c** the profile of the third absorption region and the absorption maxima are similar (406 nm for **4a** and 409 nm for **4c**), while the samples **4b** and **4d** have similar profile of the third absorption region and the absorption maxima (387 nm for **4b** and 393 nm for **4d**). Samples **4a** and **4c** present the same absorption bands like **4b** and **4d** with a small bathochromic shift. The similar absorption behaviour of the samples **4a** with **4c** and of the samples **4b** with **4d** can be explained by their similar structure (samples **b** and **d** having a supplementary carbomethoxy group in the 2nd position of the azatetracyclic skeleton in comparison with the samples **a** and **c**).

5. Absorption vs emission spectra of the obtained compounds

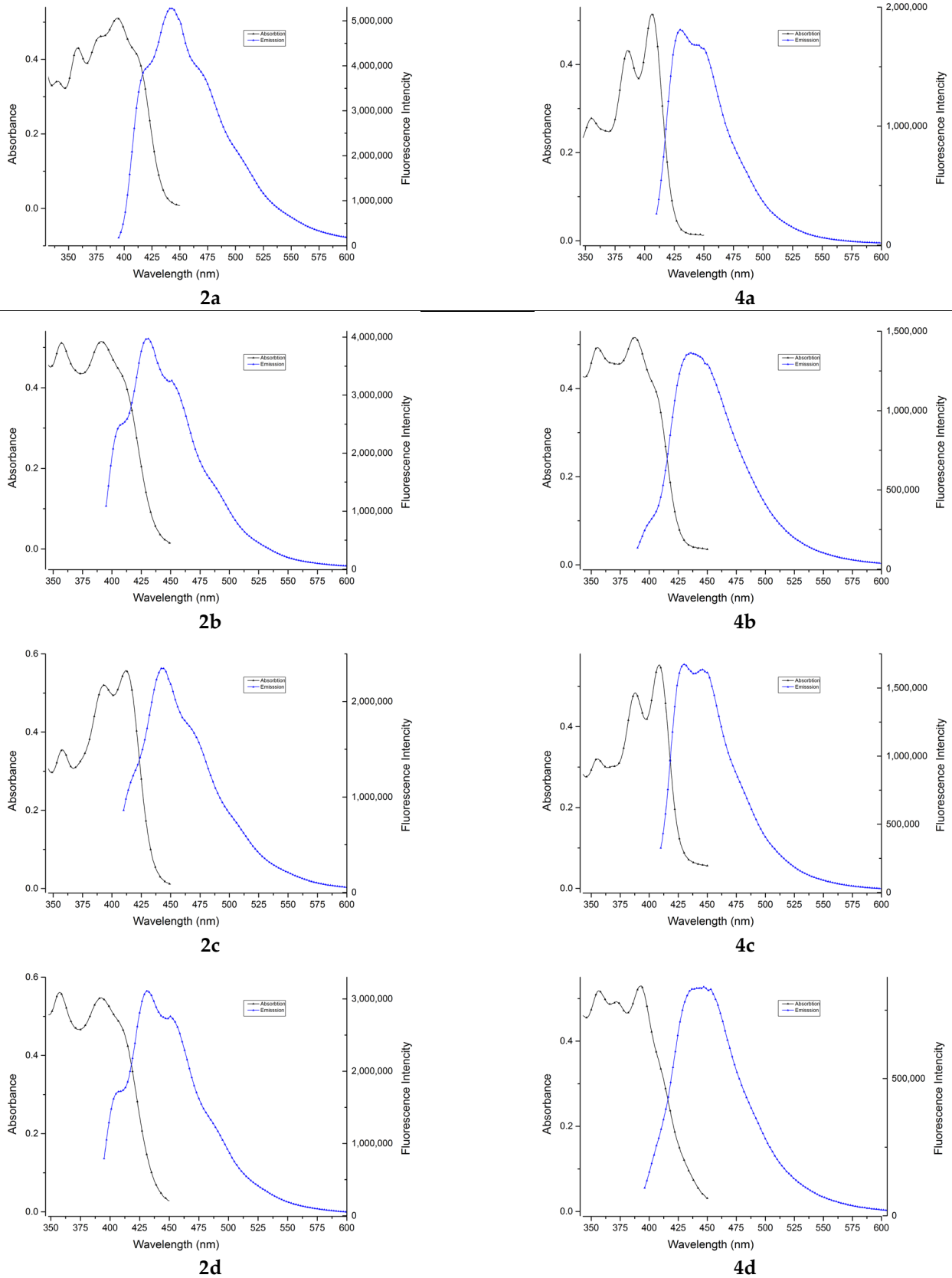


Figure S27. The absorption (black line) and emission (blue line) spectra of functionalized derivatives: bromides **2a-d** (left column) and azides **4a-d** (right column). Excitation wavelength was: 380 nm for sample **4b**; 385 nm for samples **2a**, **2b**, **2d** and **4d**; and 400 nm for samples **2c**, **4a** and **4c**.

In the case of the bromides **2a-d**, the samples **2a** and **2c** have similar peak profile with λ_{max} = 443 nm for sample **2a** and respectively λ_{max} = 444 nm for sample **2c**. The fluorescence intensity of the sample **2a** is higher than the fluorescence intensity of the sample **2c**. The samples **2b** and **2d** have similar peak profile having λ_{max} = 431 nm for sample **2b** and respectively λ_{max} = 433 nm for sample **2d**. The fluorescence intensity of the sample **2b** is higher than the fluorescence intensity of the sample **2d**, but lower than the fluorescence intensity of the sample **2c**. The fluorescence intensity of all bromides **2a-d** is higher than the fluorescence of the corresponding azides **4a-d**.

In the case of the azides **4a-d**, the samples **4a** and **4c** have structured band with similar peak profile (λ_{max} = 430 nm for both sample **4a** and **4c**) and intensity. The azides **4b** and **4d** have similar peak profile (λ_{max} = 435 nm for sample **4b** and respectively λ_{max} = 445 nm for sample **4d**) with unstructured band. The fluorescence intensity of the sample **4d** is lower (almost a half) than the intensity of the sample **4b**. Sample **4a** have the highest fluorescence intensity from all the azides.