Electronic Supplementary Material (ESI) for Photochemical & Photobiological Science

Synthesis, photophysical, photochemical, DNA cleavage/binding and cytotoxic properties of pyrene oxime ester conjugates

Nilanjana Chowdhury[1], Sansa Dutta[1], Swagata Dasgupta[1] and N. D. Pradeep Singh[1]*

Mithu Baidya[2] and S. K. Ghosh[2]

[1]*Department of Chemistry,* [2] *Department of Biotechnology*

Indian Institute of Technology Kharagpur, Kharagpur-721302, India

Phone: (+) 91-3222-282324; Fax: (+) 91-3222-282252

E-mail: ndpradeep@chem.iitkgp.ernet.in (*NDPS*)

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General information:

General

^{1}H-NMR (200 MHz) spectra were recorded on a BRUKER-AC 200MHz spectrometer. Chemical shifts are reported in ppm from tetramethylsilane with the solvent resonance as the internal standard (deuterochloroform: 7.26 ppm). Data are reported as follows: chemical shifts, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, dd = doublet of doublet, m = multiplet), coupling constant (Hz). ^{13}C-NMR (50 MHz) spectra were recorded on a BRUKER-AC 200 MHz Spectrometer with complete proton decoupling. Chemical shifts are reported in ppm from tetramethylsilane with the solvent resonance as the internal standard (deuterochloroform: 77.0 ppm). Chromatographic purification was done with 60-120 mesh silica gel (Merck). For reaction monitoring, precoated silica gel 60 F254 TLC sheets (Merck) were used. UV/vis absorption spectra were recorded on a Shimadzu UV-2450 UV/vis spectrophotometer. FT-IR spectra were recorded on a Perkin Elmer RXI spectrometer. High-resolution mass spectra were recorded using LCT micro mass spectrometer. HPLC was performed using Shimadzu Prominence (LC 20 AT) liquid chromatography on a C18 column (4.5 mm × 250 mm) with a UV/ vis detector. Photolysis of all the ester were carried out using 125 W medium pressure mercury lamp supplied by SAIC (India).

NMR data

(E)-1-(pyren-1-yl)ethanone *O*-benzoyl oxime (4a):

White solid, mp: 126-130 °C. IR (KBr): 945, 1665, 1735 cm^{-1}. ^{1}H NMR (200 MHz, $CDCl_3$): δ 2.78 (s, 3H), 7.46-7.70 (m, 3H), 8.01-8.26 (m, 10H), 8.46 (d, *J* = 9.2 Hz, 1H). ^{13}C NMR (50 MHz, $CDCl_3$): δ 19.5, 124.3, 124.5, 124.8, 125.6, 125.8, 126.0, 126.2, 127.2, 128.4, 128.6, 128.7 (2C), 129.2, 129.7 (2C), 130.1, 130.4, 130.7, 131.2, 132.2, 133.4, 133.6, 163.9, 166.3. HRMS (ES+) calcd for $C_{25}H_{17}NO_2$, 386.1157 $(M+Na)^+$ *m/z* ; found, 386.1153 *m/z*; Anal. calcd for $C_{25}H_{17}NO_2$: C, 82.63; H, 4.72; N, 3.85. Found: C,

82.82; H, 4.81; N, 3.69.

(*E*)-4-((1-(pyren-1-yl)ethylideneaminooxy)carbonyl)benzonitrile (4b) :

White solid, mp: 138-142 °C. IR (KBr): 955, 1670, 1750 cm^{-1}. ^{1}H NMR (400 MHz, $CDCl_3$): δ 2.78 (s, 3H), 7.84 (d, 2H, J = 8.0 Hz), 8.04-8.25 (m, 8H), 8.30 (d, *J* = 8.0 Hz, 2H), 8.42 (d, *J* = 9.2 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 19.6, 116.9, 117.9, 124.2, 124.58, 124.6, 124.9, 125.7, 125.9 (3C), 126.4, 127.2, 128.7, 128.9, 129.9, 130.2 (2C), 130.7, 131.2, 132.5 (2C), 133.1, 162.3, 167.2. ESI-MS *m/z*: 389 (MH^+). Anal. calcd for $C_{26}H_{16}N_2O_2$: C, 80.40; H, 4.15; N, 7.21. Found: C, 80.67; H, 4.31; N, 7.10.

(*E*)-1-(pyren-1-yl)ethanone *O*-3,4-dimethoxybenzoyl oxime (4c):

yellow solid, mp: 145-148 °C. IR (KBr): 935, 1660, 1745cm^{-1}. ^{1}H NMR (400 MHz, $CDCl_3$): δ 2.77 (s, 3H), 3.99 (s, 3H), 4.00 (s, 3H), 6.98 (d, *J* = 8.4 Hz, 1H), 7.72 (s, 1H), 7.87 (d, *J* = 8.4 Hz, 1H), 8.02-8.24 (m, 8H), 8.46 (d, *J* = 9.2 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 19.7, 56.3 (2C), 110.7, 112.6, 121.8, 123.9, 124.6, 124.8 (2C), 125.1, 125.8, 125.9, 126.2, 126.5, 127.4, 128.7, 128.9, 128.92, 130.8, 130.9, 131.4, 132.4, 149.2, 153.7, 163.8, 166.2. HRMS (ES+) calcd for $C_{27}H_{21}NO_4$, 446.1369 $(M+Na)^+$ *m/z* ; found, 446.1359 *m/z*; Anal. calcd for $C_{27}H_{21}NO_4$: C, 76.58; H, 5.00; N, 3.31. Found: C, 76.42; H, 5.26; N, 3.25.

(*E*)-1-(pyren-1-yl)ethanone *O*-furan-2-carbonyl oxime (4d):

White solid, mp: 92-95 °C. IR (KBr): 930, 1652, 1753 cm^{-1}. ^{1}H NMR (400 MHz, $CDCl_3$): δ 2.75 (s, 3H), 6.62 (dd, *J* = 1.6, 3.6 Hz, 1H), 7.41 (d, *J* = 3.6 Hz, 1H), 7.70 (s, 1H), 8.02-8.24 (m, 8H), 8.40 (d, *J* = 9.2 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 19.5, 112.0, 118.8, 124.3, 124.5, 124.6, 125.6, 125.8, 125.9, 126.0, 126.2, 127.2, 128.0, 128.3, 128.5, 130.2, 130.7, 131.2, 132.2, 143.3, 146.8, 156.2, 166.5; ESI-MS *m/z*: 354 (MH^+). Anal. calcd for $C_{23}H_{15}NO_3$: C, 78.17; H, 4.28; N, 3.96. Found: C, 78.31; H, 4.31; N, 3.88.

(*E*)-1-(pyren-1-yl)ethanone *O*-2-(1H-indol-3-yl)acetyl oxime (4e):

yellow solid, mp: 100-103 °C. IR (KBr): 960, 1681, 1748 cm^{-1}. ^{1}H NMR (200 MHz, $CDCl_3$): δ 2.53 (s, 3H), 4.06 (s, 2H), 7.14-7.25 (m, 3H,), 7.36 (d, *J* = 8.0 Hz, 1H), 7.95(d, *J* = 8.0 Hz, 1H), 8.02-8.29 (m, 8H), 8.36 (d, *J* = 8.8 Hz, 1H). ^{13}C NMR (50 MHz, $CDCl_3$): δ 19.6, 30.5,

107.9, 111.5, 119.0, 119.9, 122.4, 123.7, 124.5, 124.7, 125.0, 125.8, 125.9, 126.1, 126.5, 127.4, 127.5, 128.6, 128.7,128.8 (2C), 130.7, 130.9,131.4, 132.3 , 136.4, 165.9, 169.8. ESI-MS *m/z*: 417 (MH^+). Anal. calcd for $C_{28}H_{20}N_2O_2$: C, 80.75; H, 4.84; N, 6.73. Found: C, 80.88; H, 4.81; N, 6.55.

3,3-dimethyl-1-(2-((1-(pyren-1-yl)ethylideneaminooxy)carbonyl)pyrrolidin-1-yl)butan-1-one (E/Z 165:1) (4f):

^1H NMR (400 MHz, $CDCl_3$): δ 1.52 (s, 9H), 1.94-2.00 (m, 1H), 2.08-2.12 (m, 1H), 2.21-2.31 (m, 1H), 2.35-2.42 (m, 1H), 2.63 (s, 1.89H), 2.64 (s, 1.11H), 3.54-3.70 (m, 2H), 4.53-4.56 (m, 0.63H), 4.65-4.68 (m, 0.37H), 7.98-8.22 (m, 8H), 8.30 (d, *J* = 9.2 Hz, 0.63H), 8.39 (d, *J* = 9.2 Hz, 0.37H). ESI-MS *m/z*: 457 (MH^+).

(*E*)-tert-butyl 1-oxo-3-phenyl-1-(1-(pyren-1-yl)ethylideneaminooxy)propan-2-ylcarbamate (4g):

White solid, mp: 100-104 °C. IR (KBr): 945, 1670, 1695, 1748 cm^{-1}. ^1H NMR (200 MHz, $CDCl_3$): δ 1.47 (s, 9H), 2.37 (s, 3H), 3.21 (t, *J* = 7.4 Hz, 2H), 4.88 (dd, *J* = 7.4, 14.6 Hz, 1H), 5.20-5.30 (m, 1H), 7.34-7.38 (m, 5H), 7.93-8.25 (m, 9H). ^{13}C NMR (50 MHz, $CDCl_3$): δ 19.3, 28.4 (3C), 39.4, 54.1, 80.2, 124.2, 124.54, 124.56, 124.8, 125.6, 125.8 (2C), 126.3, 127.2, 127.22, 128.5, 128.6, 128.7 (3C), 129.5 (2C), 130.1, 130.7, 131.2, 132.3, 136.1, 155.2, 166.8, 169.9. HRMS (ES+) calcd for $C_{32}H_{30}N_2O_4$, 529.2104 $(M+Na)^+$ *m/z* ; found, 529.2104 *m/z*; Anal. calcd for $C_{32}H_{30}N_2O_4$: C, 75.87; H, 5.97; N, 5.53. Found: C, 75.98; H, 6.07; N, 5.44.

(*E*)-tert-butyl 2-oxo-1-phenyl-2-(1-(pyren-1-yl)ethylideneaminooxy)ethylcarbamate (4h):

white solid, mp: 114-119 °C; IR (KBr): 964, 1681, 1698, 1750 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$): δ 1.48 (s, 9H), 2.52 (s, 3H), 5.68-5.75 (m, 2H), 7.38-7.45 (m, 3H,), 7.52-7.54(m, 2H), 7.93 (d, *J* = 8.0 Hz, 1H), 8.01-8.26 (m, 8H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 19.3, 28.3 (3C), 56.8, 80.3, 124.1, 124.3, 124.4, 124.7, 125.6, 125.8, 125.9, 126.2, 127.1, 127.4 (4C), 128.5, 128.6, 129.0 (2C), 129.8, 130.6, 131.1, 132.2, 136.7, 154.9, 166.9, 169.0. HRMS (ES+) calcd for $C_{31}H_{28}N_2O_4$, 515.1947 $(M+Na)^+$ *m/z* ; found, 515.1942 *m/z*;Anal. calcd for $C_{31}H_{28}N_2O_4$: C, 75.59; H, 5.73; N, 5.69. Found: C, 75.68; H, 5.81; N,

5.57.

(*E*)-tert-butyl 2-oxo-2-(1-(pyren-1-yl)ethylideneaminooxy)ethylcarbamate (4i):

White solid, mp: 52-54 °C. IR (KBr): 9957, 1648, 1691 1758 cm^{-1}. ^{1}H NMR (200 MHz, $CDCl_3$): δ 1.46 (s, 9H), 2.63 (s, 3H), 4.23 (d, *J* = 5.4Hz, 2H), 5.14 (bs, 1H,), 7.94-8.29 (m, 9H). ^{13}C NMR (50 MHz, $CDCl_3$): δ 19.5, 28.4 (3C), 42.0, 80.3, 124.0, 124.48, 124.5, 124.8, 125.7, 125.9 (2C), 126.0, 126.3, 127.2, 128.6, 128.8, 130.0, 130.6, 131.2, 132.3, 156.0, 166.2, 169.1. HRMS (ES+) calcd for $C_{25}H_{24}N_2O_4$, 439.1634 $(M+Na)^+$ *m/z* ; found, 439.1624 *m/z*; Anal. calcd for $C_{25}H_{24}N_2O_4$: C, 72.10; H, 5.81; N, 6.73. Found: C, 72.16; H, 5.91; N, 6.70.

(*E*)-tert-butyl 4-oxo-4-(1-(pyren-1-yl)ethylideneaminooxy)butylcarbamate (4j):

yellow solid, mp: 60-65 °C; IR (KBr): 943, 1641, 1681, 1735 cm^{-1}; ^{1}H NMR (200 MHz, $CDCl_3$): δ 1.45 (s, 9H),), 1.99 (t, 2H, *J* = 6.8 Hz, 2H), 2.56 (s, 3H), 2.59-2.66 (m, 2H,), 3.23 (dd, *J* = 6.2, 12.4 Hz, 2H), 4.75 (bs, 1H,), 7.93-8.19 (m, 8H), 8.33 (d, *J* = 9.2 Hz, 1H). ^{13}C NMR (50 MHz, $CDCl_3$): δ 19.4, 25.3, 28.4 (3C), 30.4, 39.9, 79.3, 124.2, 124.52, 124.54, 124.8, 125.6, 125.62, 125.8, 125.9, 126.3, 127.2, 128.4, 128.7, 130.5, 130.7, 131.2, 132.1, 156.0, 165.4, 171.0. ESI-MS *m/z*: 445 (MH^+). Anal. calcd for $C_{27}H_{28}N_2O_4$: C, 72.95; H, 6.35; N, 6.30. Found: C, 72.78; H, 6.47; N, 6.27.

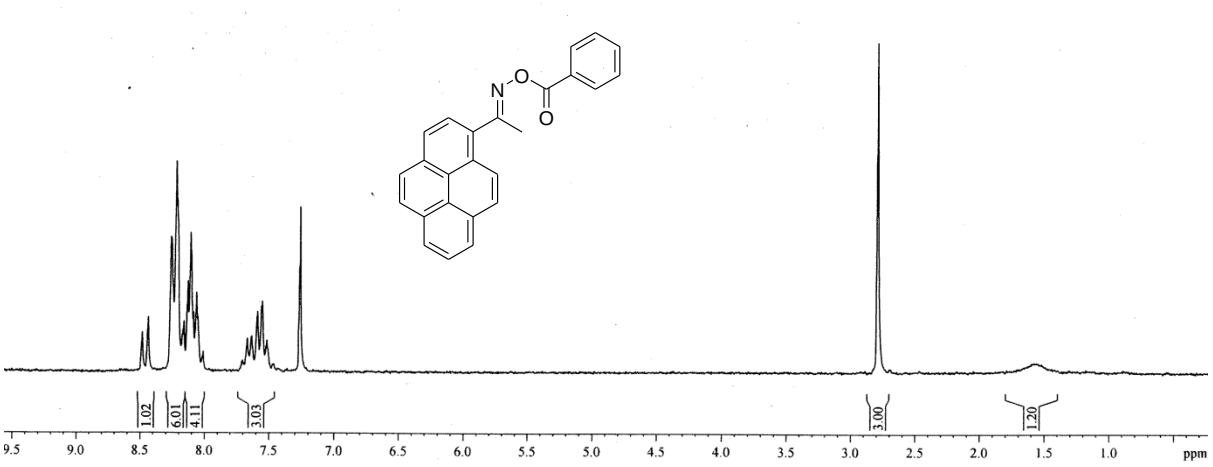
***N*-acetyl-*N*-(pyren-6-yl)benzamide (8a)**

^{1}H NMR (200 MHz, $CDCl_3$): δ 2.45 (s, 3H), 7.22-7.32 (m, 3H), 7.64 (d, *J* = 8.2 Hz, 2H), 7.77 (d, *J* = 8.2 Hz, 1H), 7.97-8.22 (m, 8H). ^{13}C NMR (50 MHz, $CDCl_3$): δ 25.8, 121.3, 124.6, 125.4, 125.6, 126.1, 126.3, 126.6, 127.1, 127.2, 128.3 (2C), 128.5, 128.71, 128.74 (2C), 129.5, 130.8, 131.2, 131.7, 132.0. 132.8, 135.3, 173.5, 174.5.

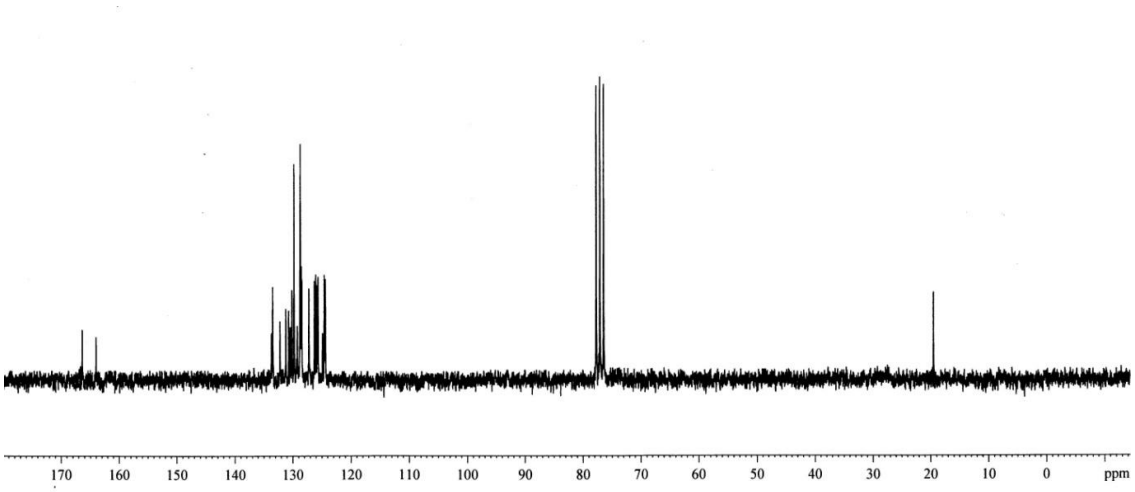
***N*-acetyl-3,4-dimethoxy-*N*-(pyren-6-yl)benzamide (8c)**

^{1}H NMR (400 MHz, $CDCl_3$): δ 2.57 (s, 3H), 3.51 (s,3H), 3.86 (s, 3H), 6.61 (d, *J* = 8.8 Hz, 1H), 7.19 (s, 1H), 7.36 (d, *J* = 8.4Hz, 1H), 7.76 (d, *J* = 8.4Hz, 1H). 8.00-8.23 (m, 8H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 25.6, 55.5, 55.7, 109.9, 111.8, 121.3, 123.4, 124.4, 125.1, 125.4, 125.8, 126.1, 126.5, 126.4, 126.6, 127.0, 127.1, 128.2, 129.4, 130.5, 130.9, 131.3, 133.1, 148.2, 152.2, 172.5, 174.4

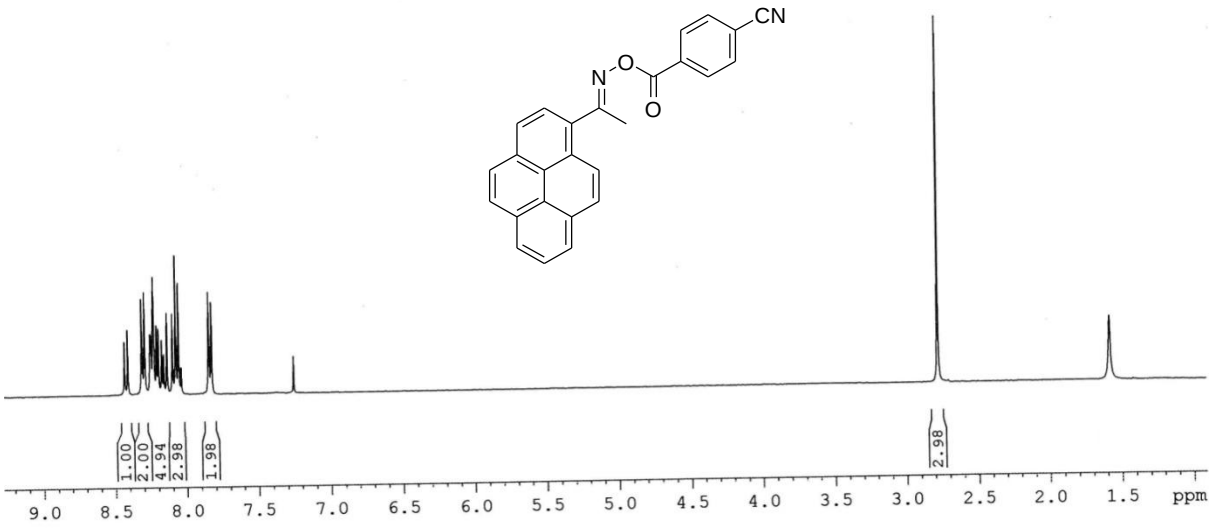
NMR spectra:



^{1}H-NMR Spectra of (*E*)-1-(pyren-1-yl)ethanone O-benzoyl oxime (**4a) (**200 MHz, $CDCl_3$**).**

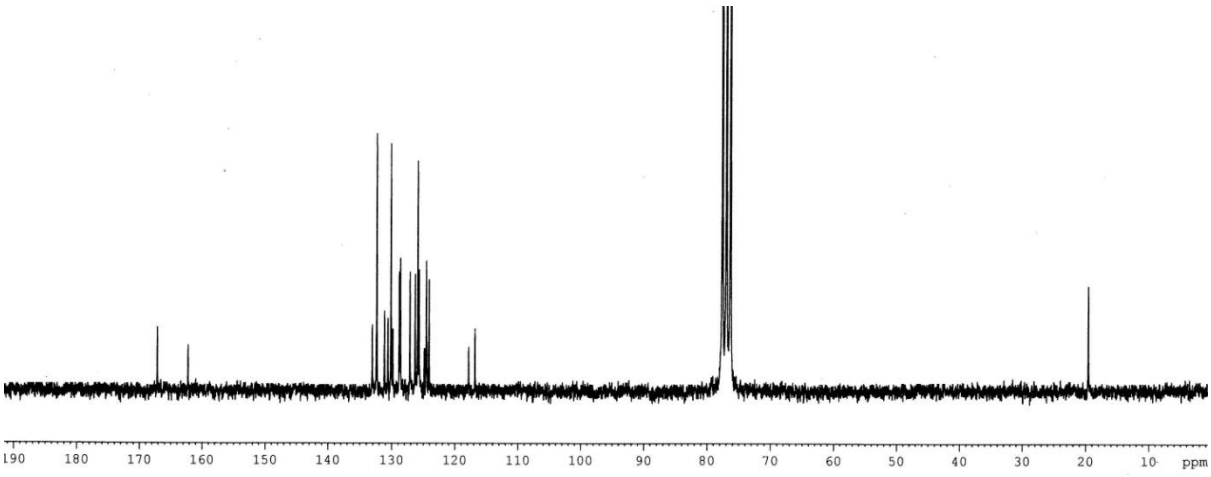


^{13}C -NMR Spectra of (*E*)-1-(pyren-1-yl)ethanone O-benzoyl oxime (**4a) (**50 MHz, $CDCl_3$**).**



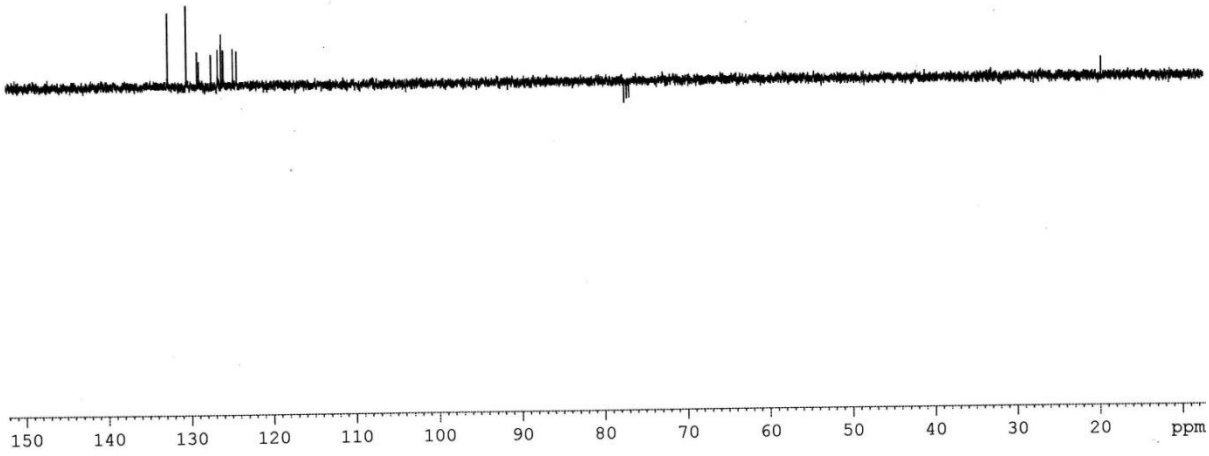
^{1}H-NMR Spectra of (*E*)-4-((1-(pyren-1-yl)ethylideneaminooxy)carbonyl)benzonitrile

(**4b) (**400 MHz, $CDCl_3$**)**



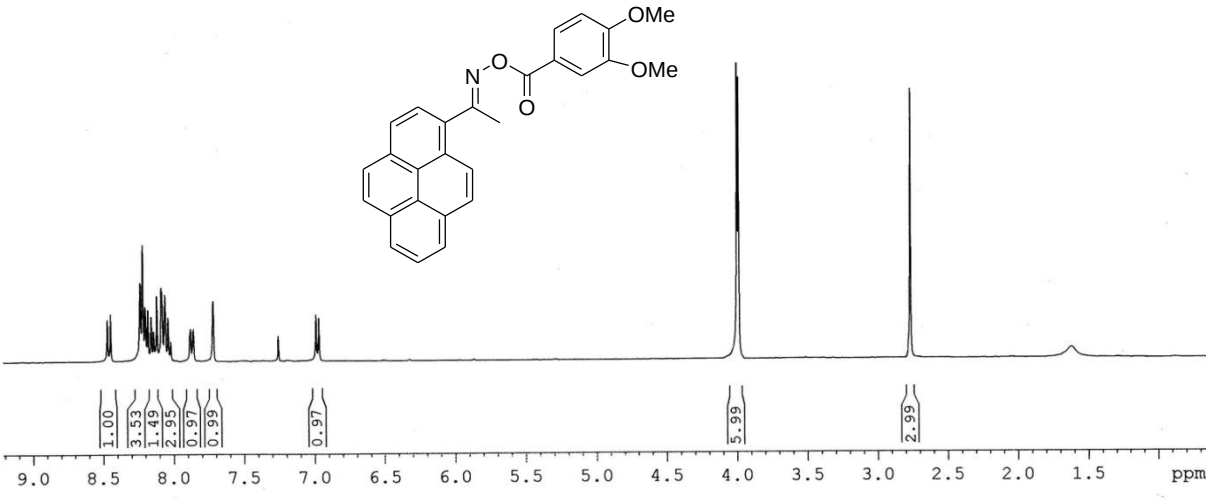
^{13}C-NMR Spectra of (*E*)-4-((1-(pyren-1-yl)ethylideneaminooxy)carbonyl)benzonitrile

(**4b) (**100 MHz, $CDCl_3$**)**



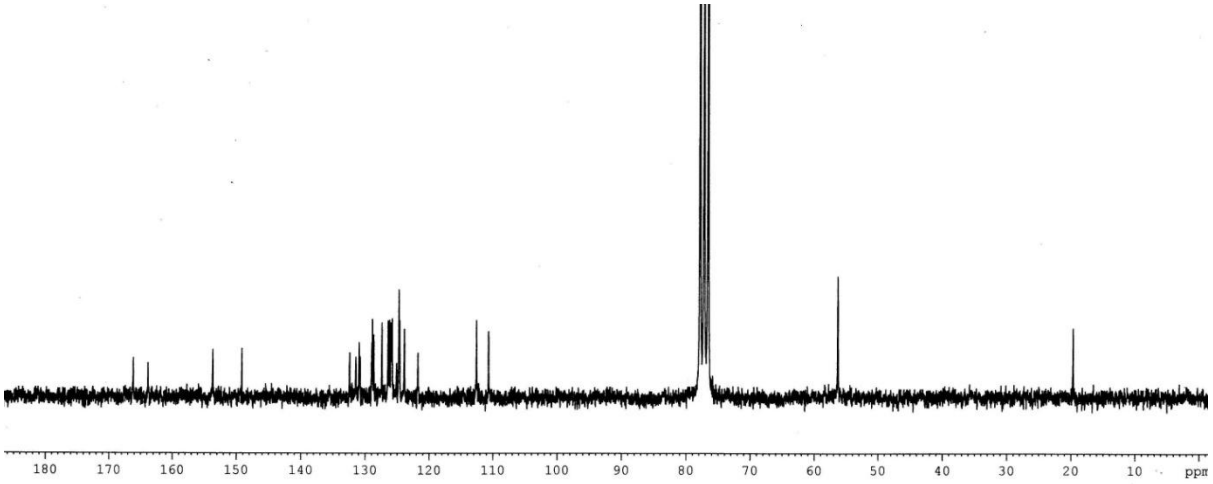
DEPT-135 Spectra of (*E*)-4-((1-(pyren-1-yl)ethylideneaminooxy)carbonyl)benzonitrile

(**4b) (**100 MHz, $CDCl_3$**).**



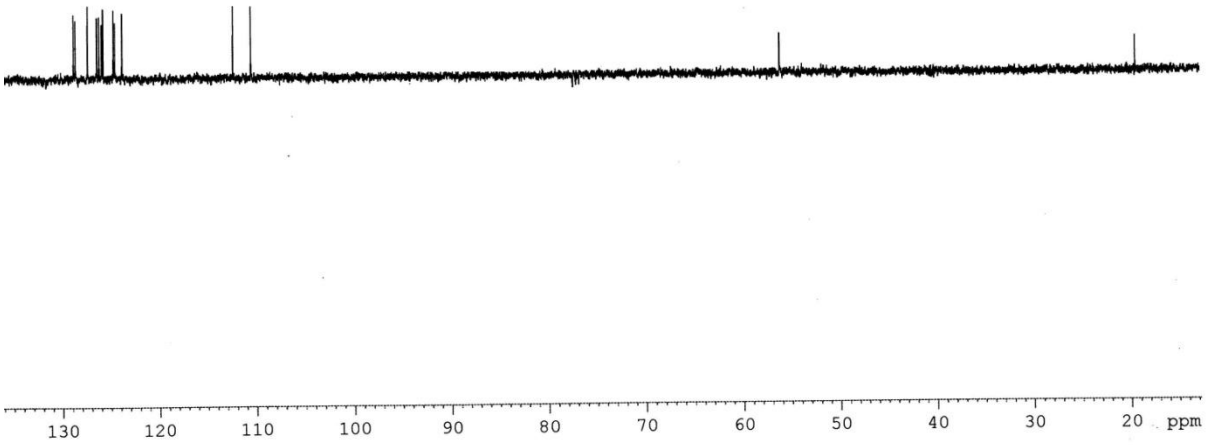
^{1}H-NMR Spectra of (*E*)-1-(pyren-1-yl)ethanone O-3,4-dimethoxybenzoyl oxime

(**4C) (**400 MHz, $CDCl_3$**).**



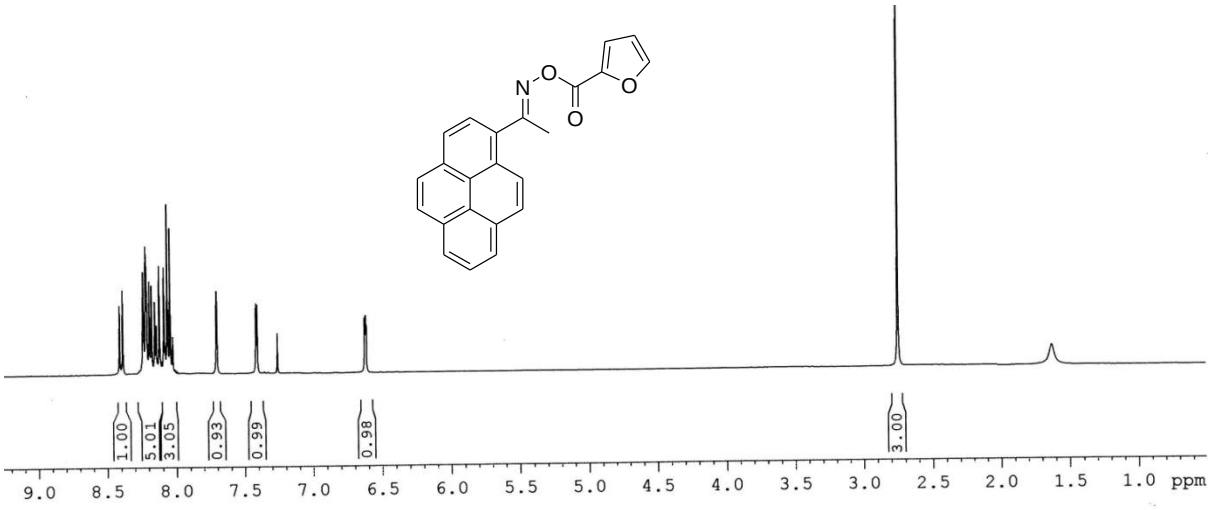
^{13}C-NMR Spectra of (*E*)-1-(pyren-1-yl)ethanone O-3,4-dimethoxybenzoyl oxime

(**4C) (**100 MHz, $CDCl_3$**)**



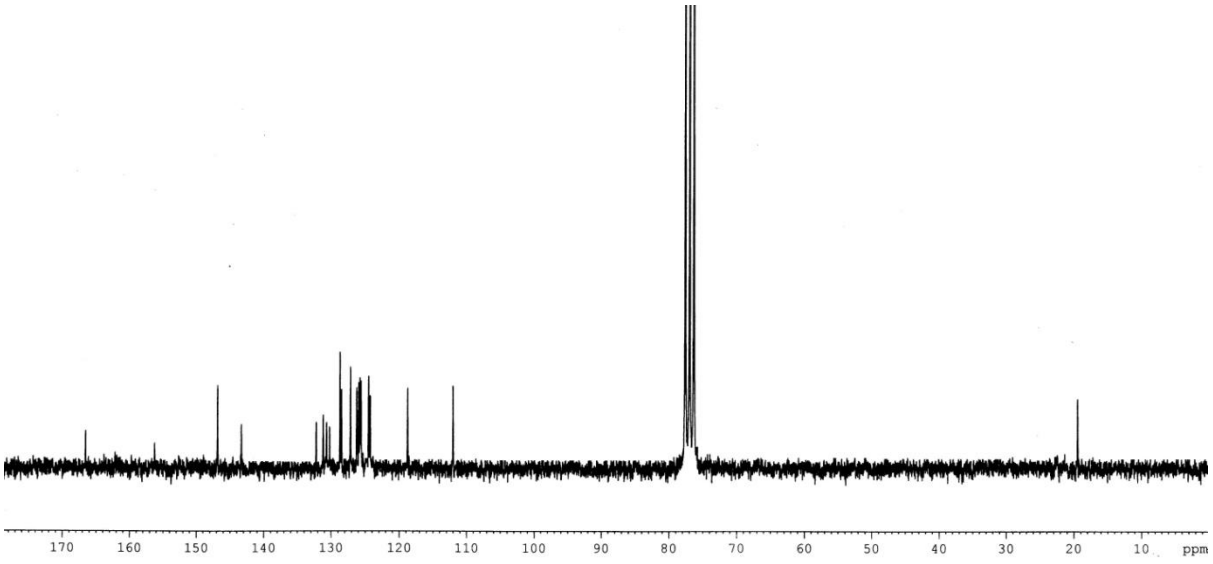
DEPT-135 Spectra of (*E*)-1-(pyren-1-yl)ethanone O-3,4-dimethoxybenzoyl oxime

(**4C)(**100 MHz, $CDCl_3$**).**



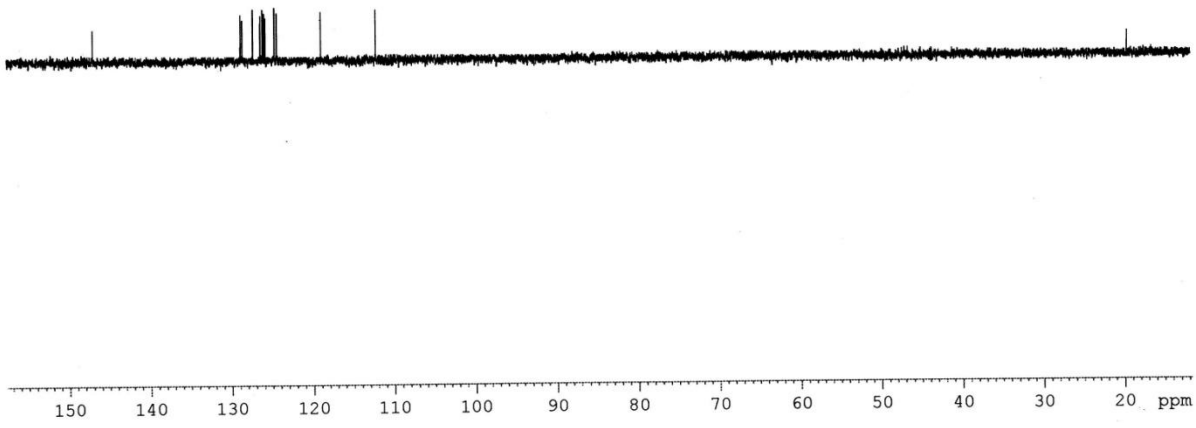
^{1}H-NMR Spectra of (*E*)-1-(pyren-1-yl)ethanone O-furan-2-carbonyl oxime

(**4d) (**400 MHz, $CDCl_3$**)**



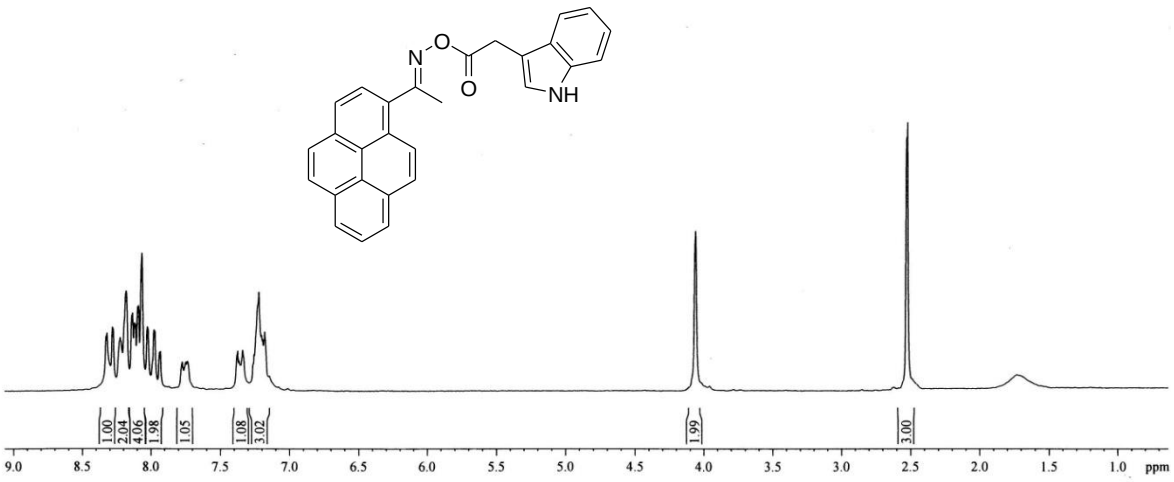
^{13}C-NMR Spectra of (*E*)-1-(pyren-1-yl)ethanone O-furan-2-carbonyl oxime

(**4d) (**100 MHz, $CDCl_3$**)**

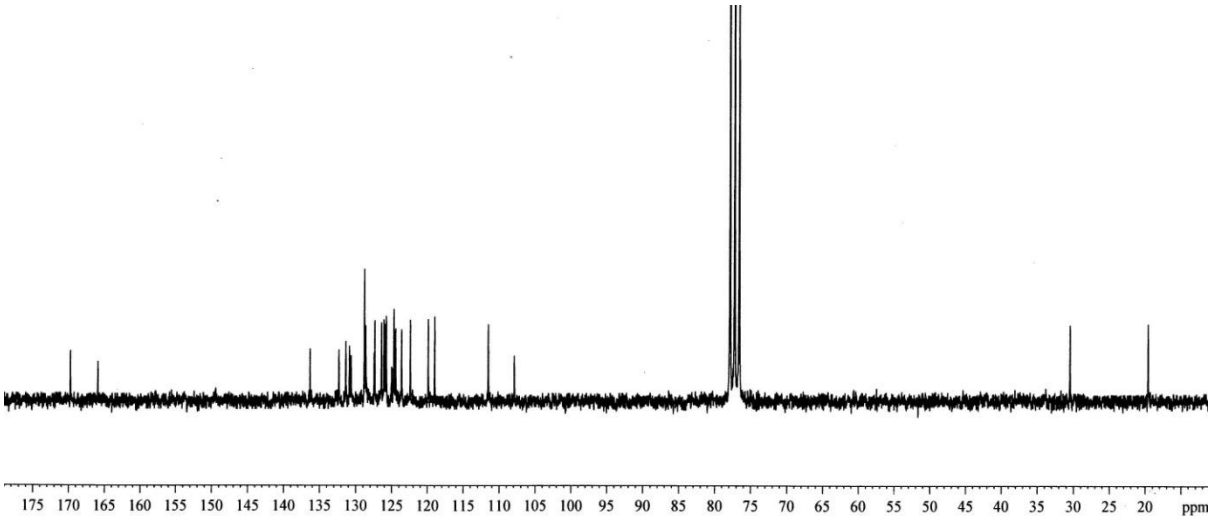


DEPT-135 Spectra of (*E*)-1-(pyren-1-yl)ethanone O-furan-2-carbonyl oxime

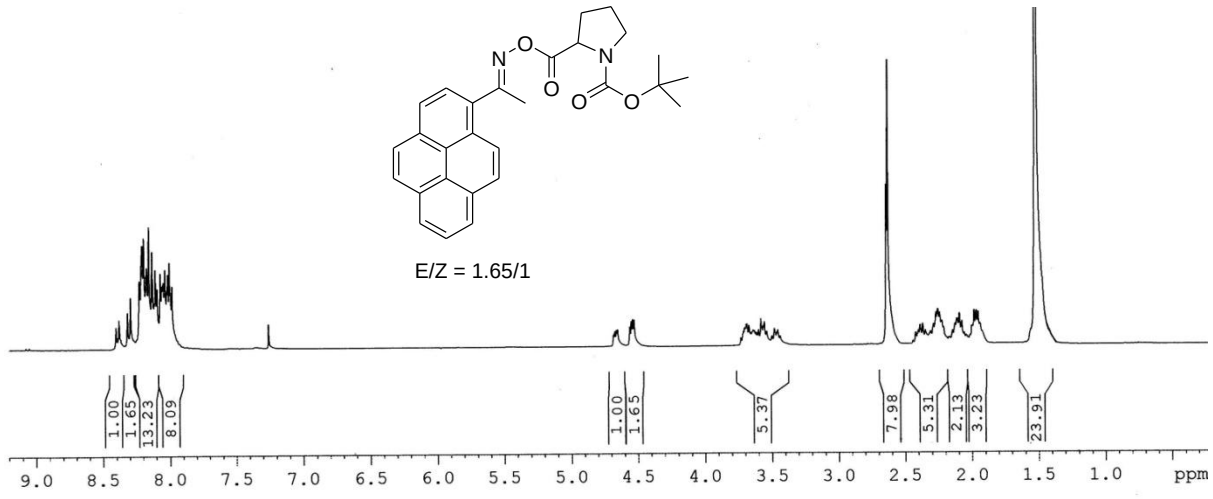
(**4d) (**100 MHz, $CDCl_3$**)**



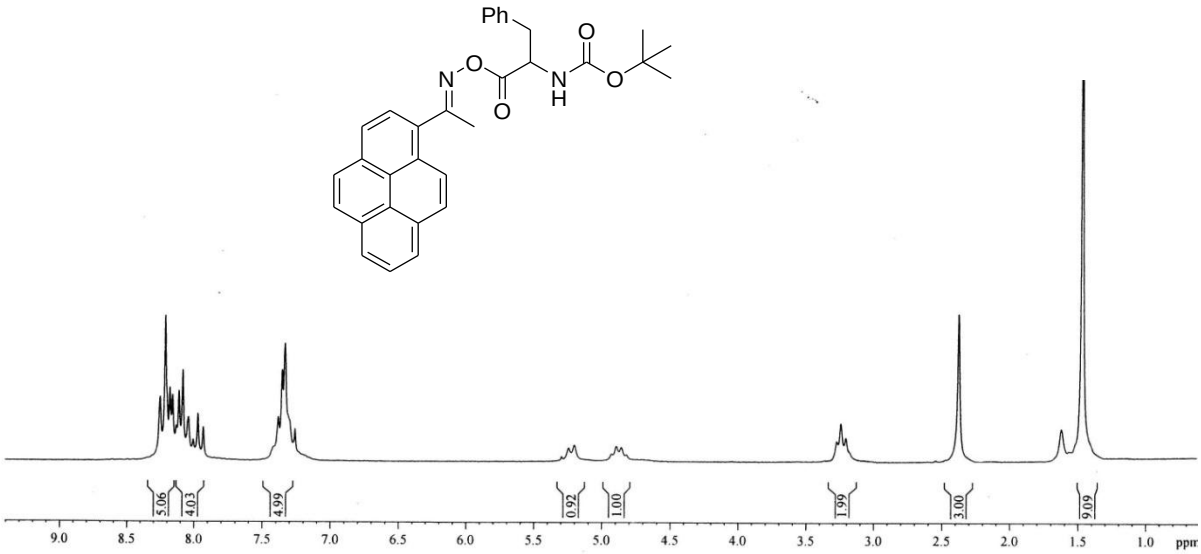
^{1}H-NMR Spectra of (*E*)-1-(pyren-1-yl)ethanone O-2-(1H-indol-3-yl)acetyl oxime (**4e**) (200 MHz, $CDCl_3$).



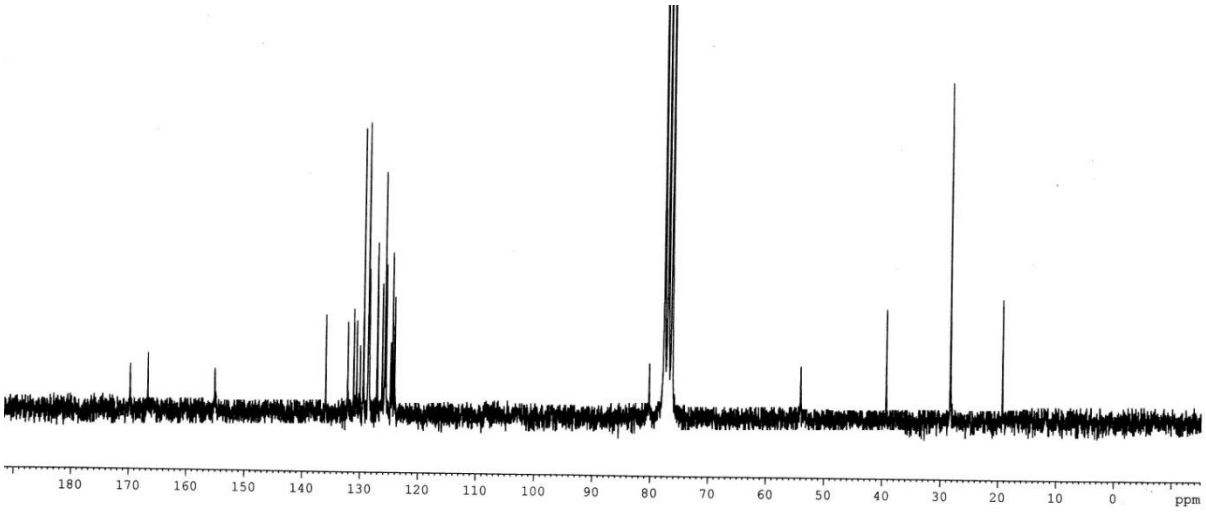
^{13}C-NMR Spectra of (*E*)-1-(pyren-1-yl)ethanone O-2-(1H-indol-3-yl)acetyl oxime (**4e**) (50 MHz, $CDCl_3$).



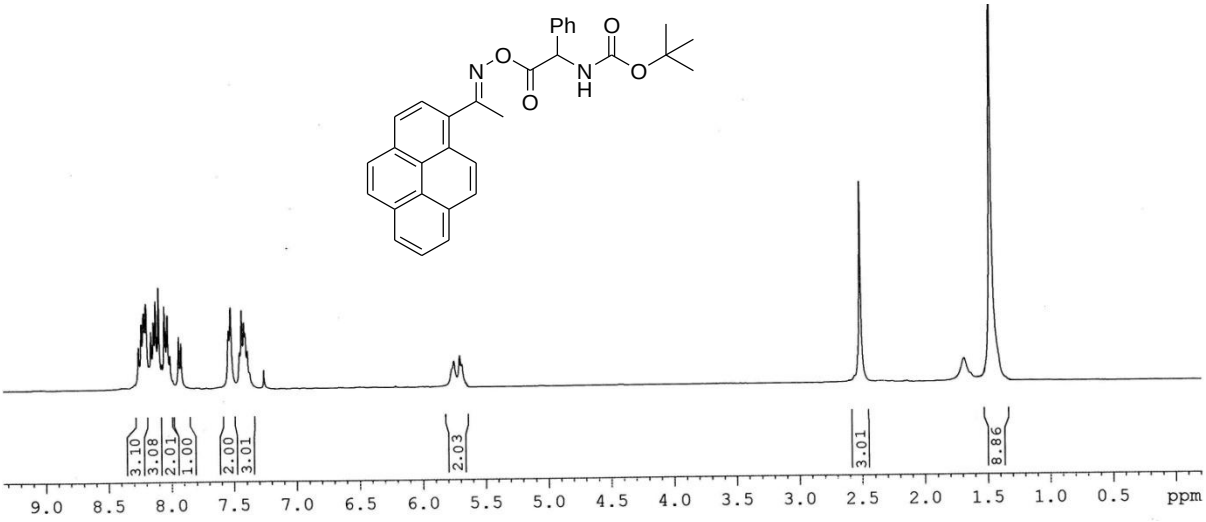
^{1}H-NMR Spectra of compound **4f (**400 MHz, $CDCl_3$**)**



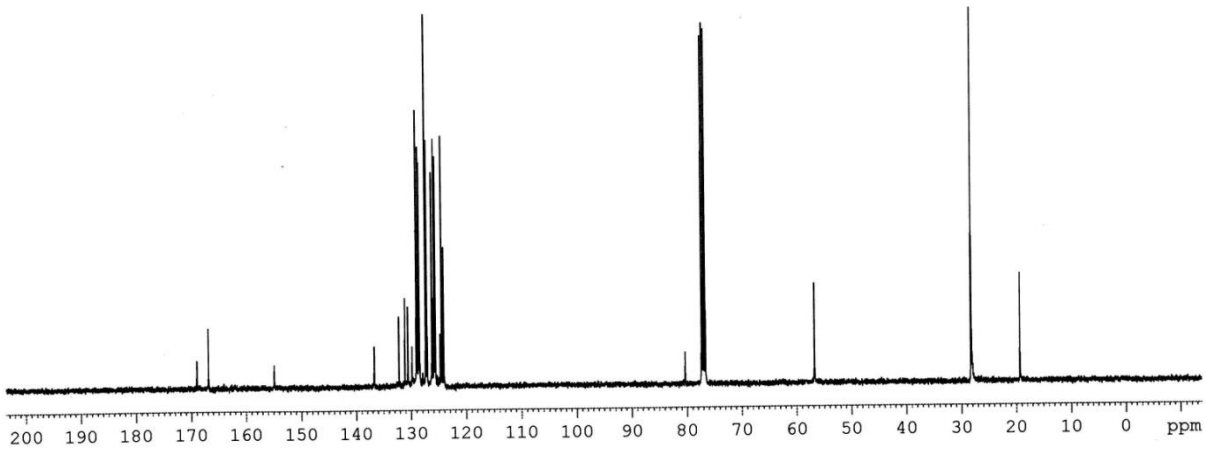
^{1}H-NMR Spectra of (*E*)-tert-butyl 1-oxo-3-phenyl-1-(1-(pyren-1-yl)ethylideneaminooxy)propan-2-ylcarbamate (**4g**) (200 MHz, $CDCl_3$).



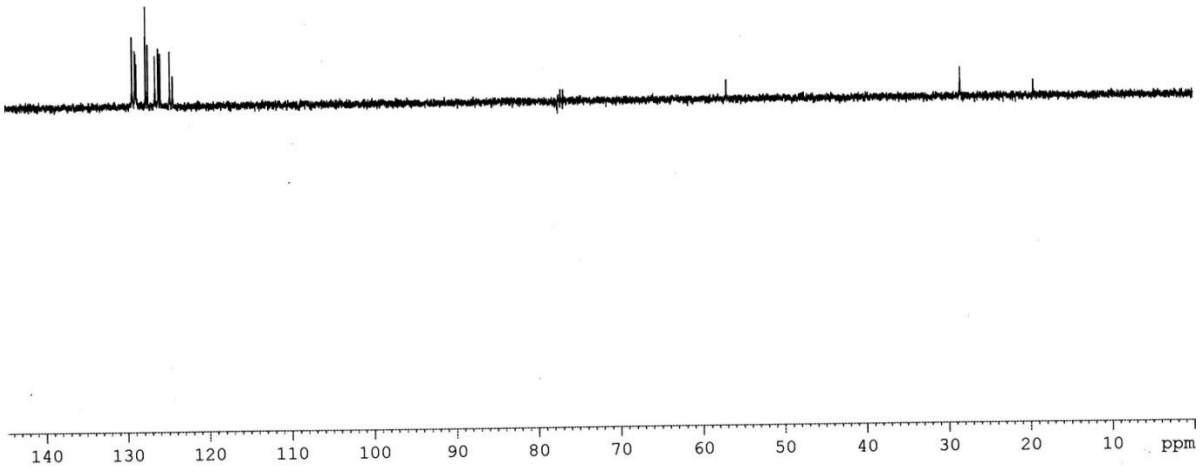
^{13}C-NMR Spectra of (*E*)-tert-butyl 1-oxo-3-phenyl-1-(1-(pyren-1-yl)ethylideneaminooxy)propan-2-ylcarbamate (**4g**) (200 MHz, $CDCl_3$).



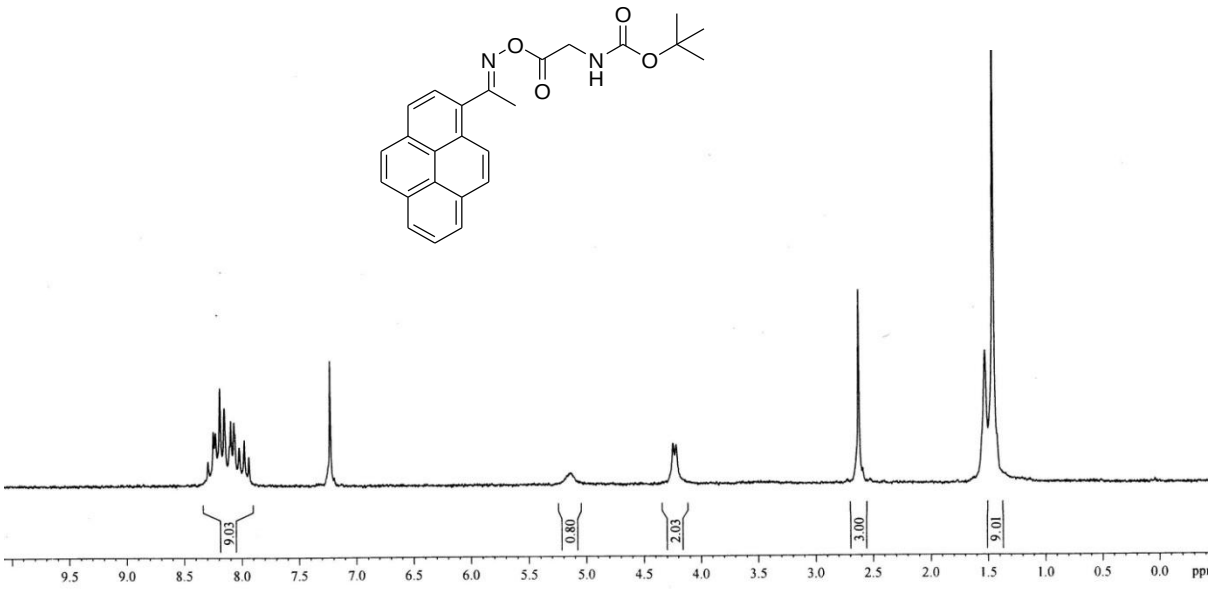
^{1}H-NMR Spectra of (*E*)-tert-butyl 2-oxo-1-phenyl-2-(1-(pyren-1-yl)ethylideneaminooxy)ethylcarbamate(**4h**) (400 MHz, $CDCl_3$).



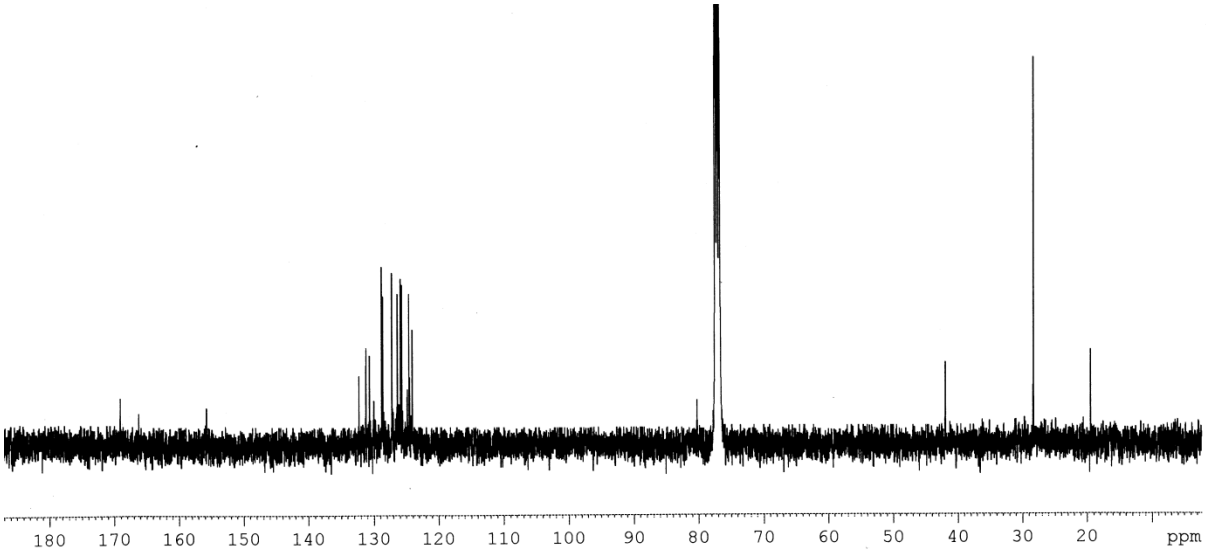
^{13}C-NMR Spectra of (*E*)-tert-butyl 2-oxo-1-phenyl-2-(1-(pyren-1-yl)ethylideneaminooxy)ethylcarbamate (**4h**) (100 MHz, $CDCl_3$).



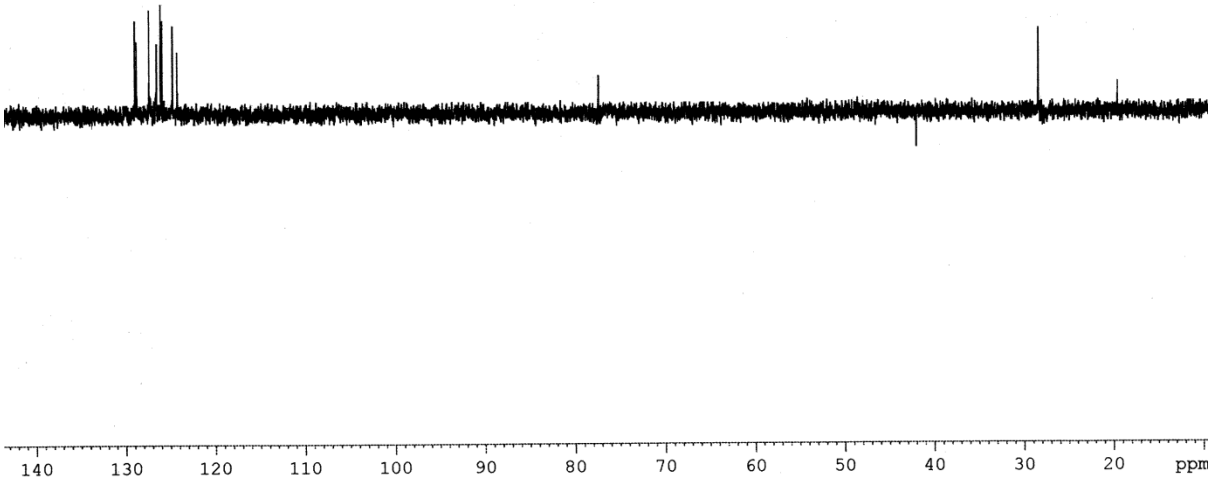
DEPT-135 Spectra of (*E*)-tert-butyl 2-oxo-1-phenyl-2-(1-(pyren-1-yl)ethylideneaminooxy)ethylcarbamate(**4h**) (100 MHz, $CDCl_3$).



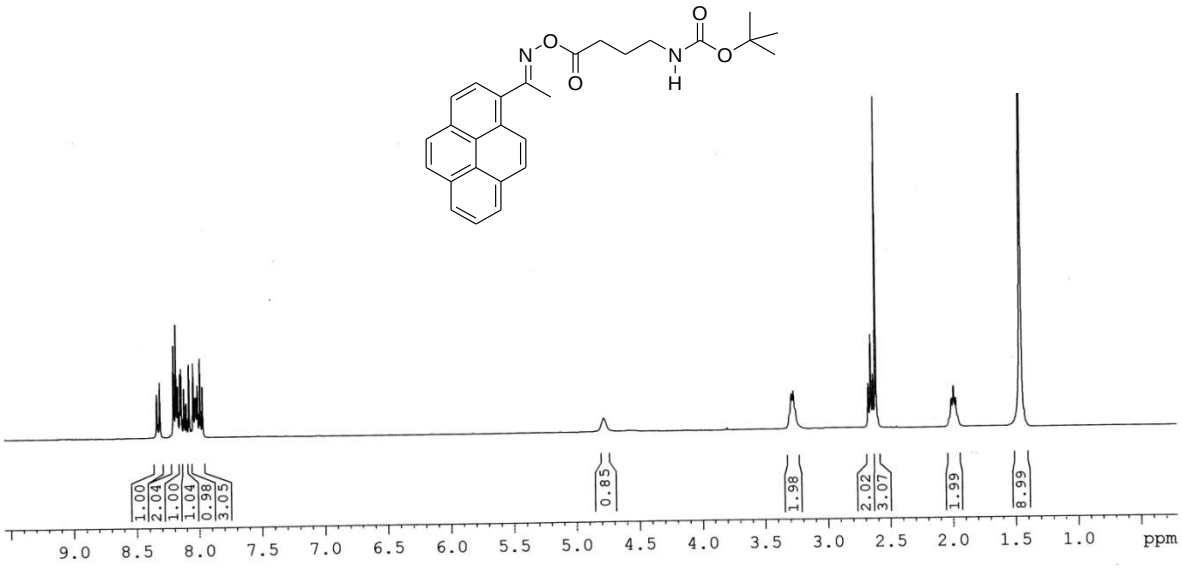
^{1}H-NMR Spectra of (*E*)-tert-butyl 2-oxo-2-(1-(pyren-1yl)ethylideneaminooxy)ethylcarbamate (**4i**) (200 MHz, $CDCl_3$).



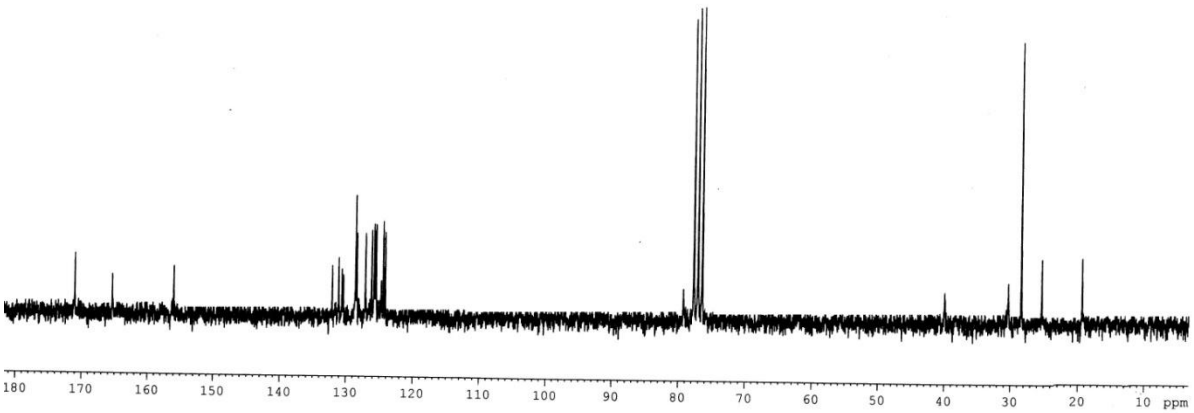
^{13}C -NMR Spectra of (*E*)-tert-butyl 2-oxo-2-(1-(pyren-1yl)ethylideneaminooxy)ethylcarbamate (**4i**) (50 MHz, $CDCl_3$).



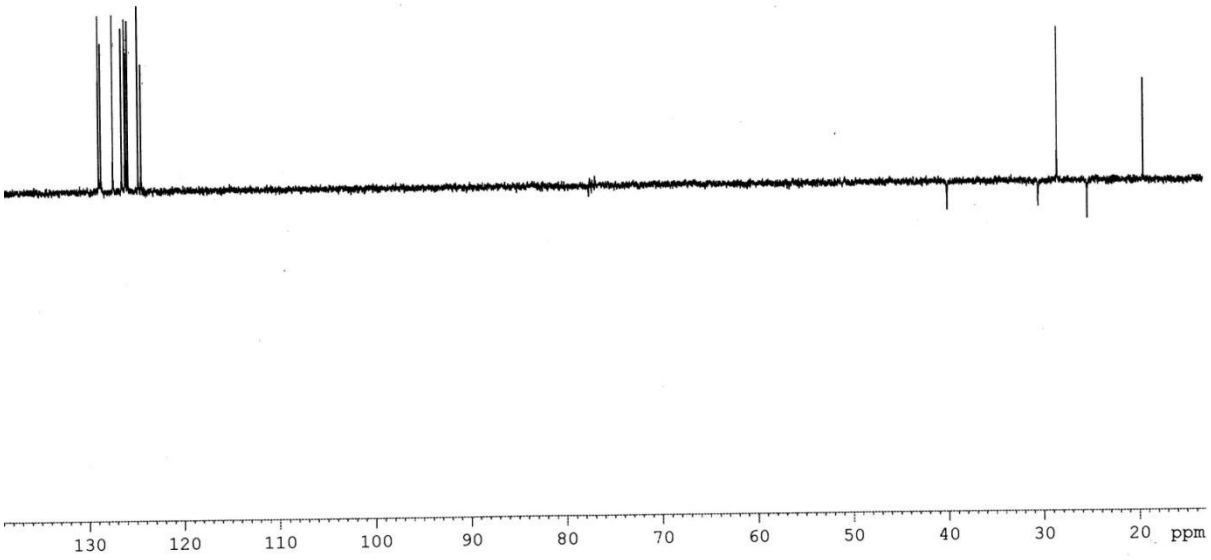
DEPT-135 Spectra of (*E*)-tert-butyl 2-oxo-2-(1-(pyren-1yl)ethylideneaminooxy)ethylcarbamate (**4i**) (50 MHz, $CDCl_3$).



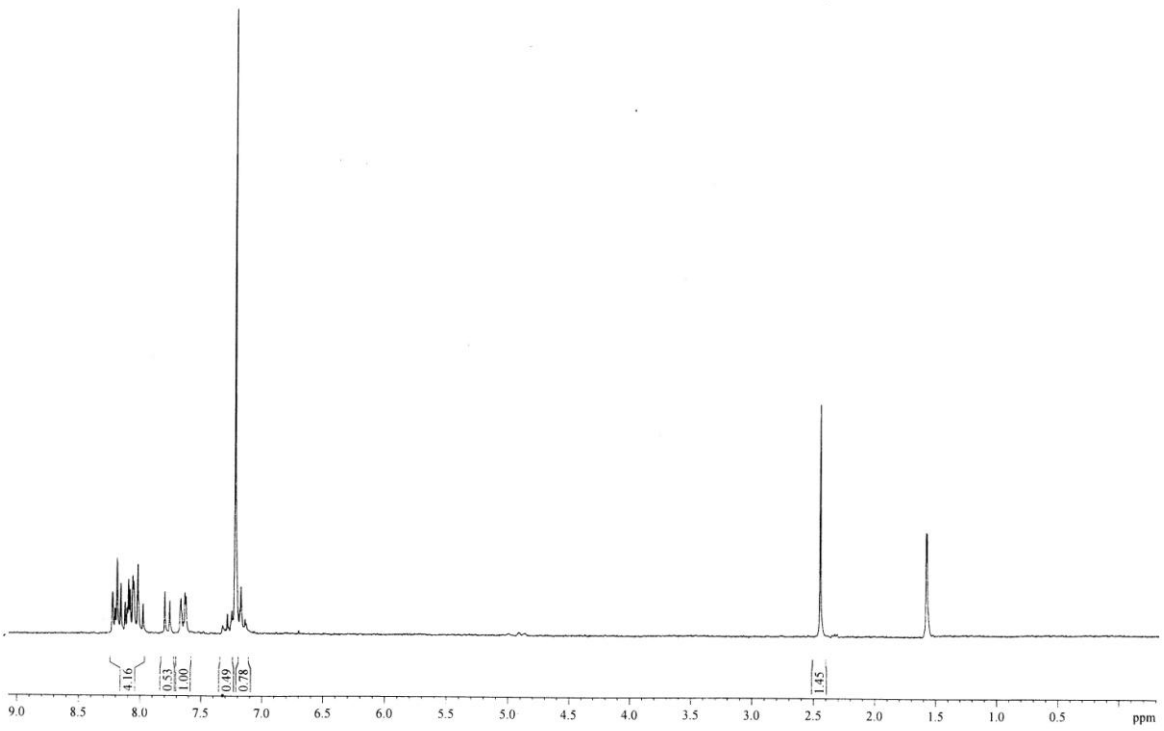
^{1}H-NMR Spectra of (*E*)-tert-butyl 4-oxo-4-(1-(pyren-1-yl)ethylideneaminooxy)butylcarbamate (**4j**) (400 MHz, $CDCl_3$).



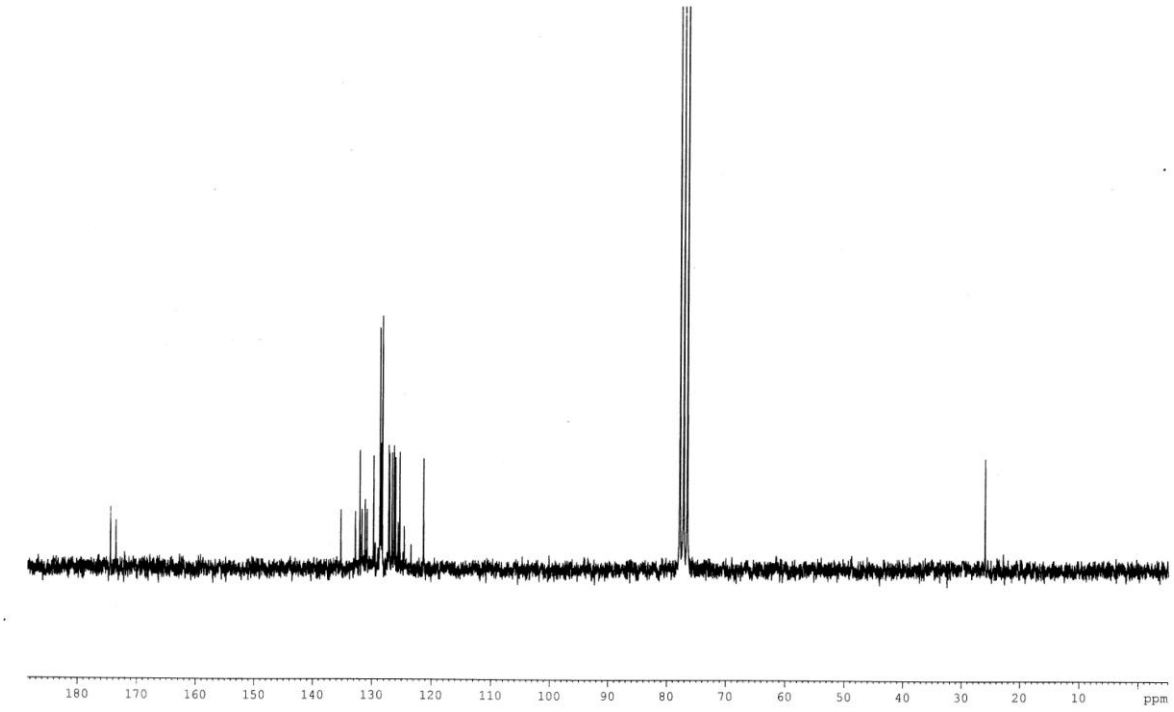
^{13}C -NMR Spectra of (*E*)-tert-butyl 4-oxo-4-(1-(pyren-1-yl)ethylideneaminooxy)butylcarbamate (**4j**) (100 MHz, $CDCl_3$).



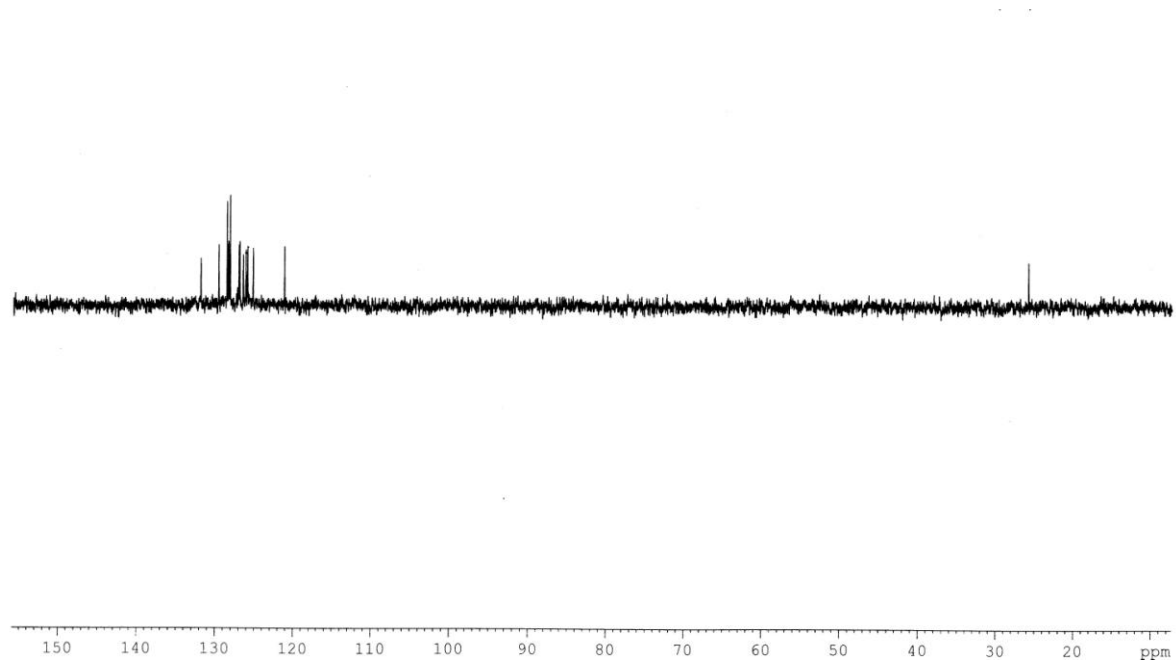
DEPT-135 Spectra of (*E*)-tert-butyl 4-oxo-4-(1-(pyren-1-yl)ethylideneaminooxy)butylcarbamate (**4j**) (100 MHz, $CDCl_3$).



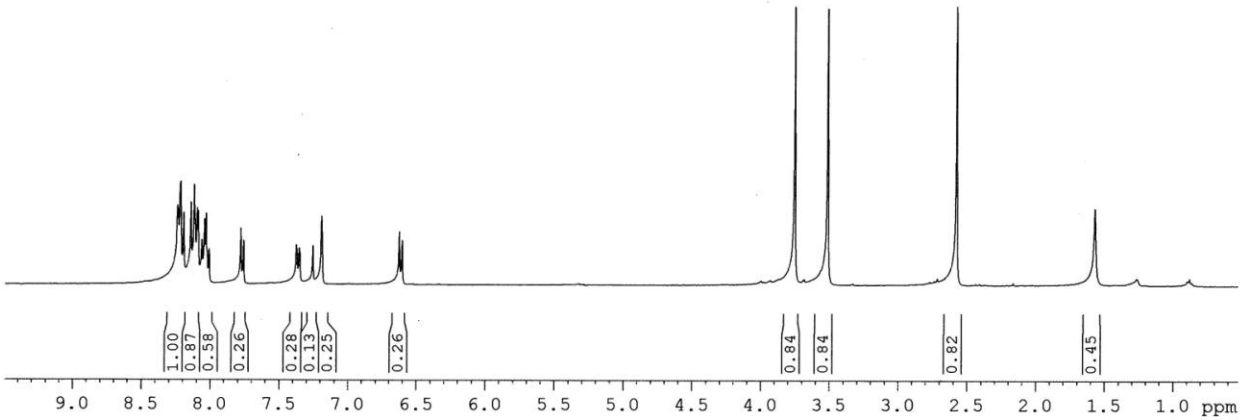
^{1}H-NMR Spectra of *N*-acetyl-*N*-(pyren-1-yl)benzamide (**8a**) (200 MHz, $CDCl_3$).



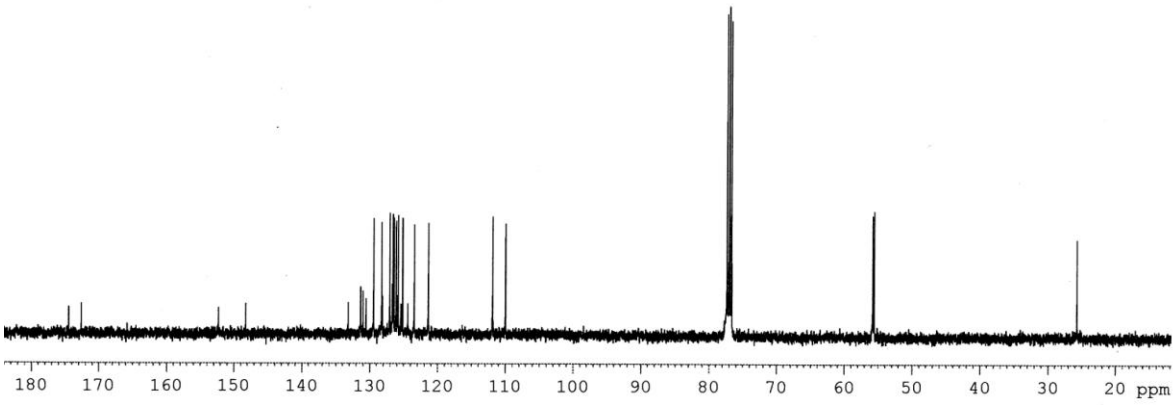
^{13}C-NMR Spectra of *N*-acetyl-*N*-(pyren-1-yl)benzamide (**8a**) (50 MHz, $CDCl_3$).



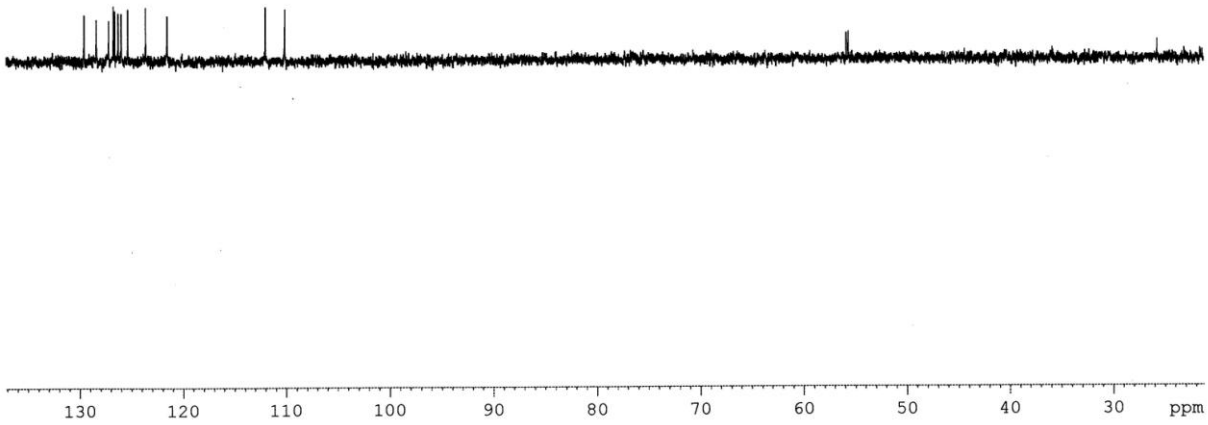
DEPT-135 Spectra of *N*-acetyl-*N*-(pyren-1-yl)benzamide (**8a**) (50 MHz, $CDCl_3$).



^{1}H-NMR Spectra of *N*-acetyl-3,4-dimethoxy-*N*-(pyren-1-yl)benzamide (**8c**) (400 MHz, $CDCl_3$).



^{13}C-NMR Spectra of *N*-acetyl-3,4-dimethoxy-*N*-(pyren-1-yl)benzamide (**8c**) (100 MHz, $CDCl_3$).



DEPT-135 Spectra of *N*-acetyl-3,4-dimethoxy-*N*-(pyren-1-yl)benzamide (**8c**) (100 MHz, $CDCl_3$).

HPLC Chromatogram:

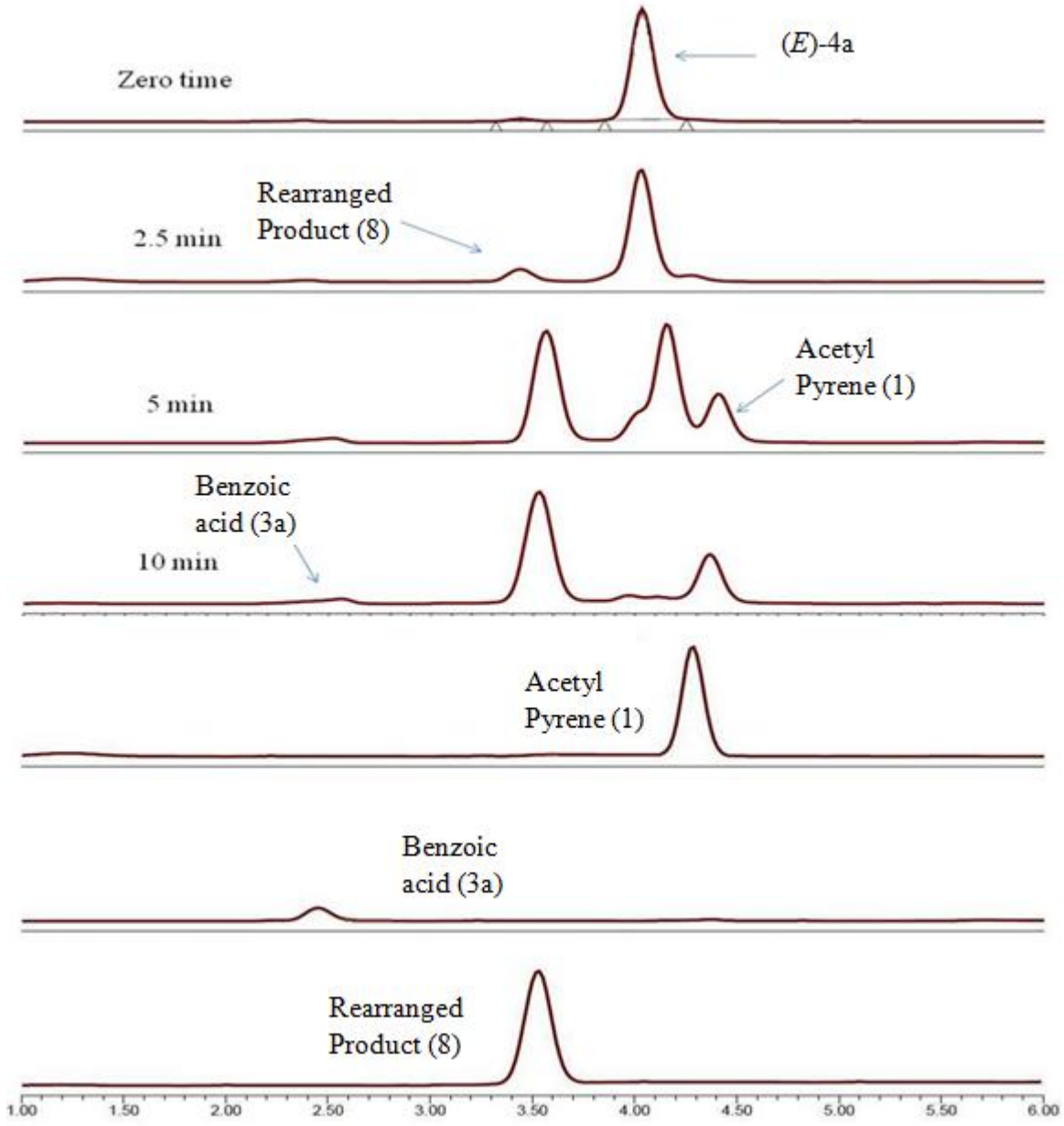


Figure 1s: HPLC chromatogam of compound **4a** after regular interval of time in MeOH/H_2O

DNA Cleavage study:

Table 1s. Single-strand cleavage of supercoiled circular pBR322 DNA (form I) to relaxed circular DNA (form II) on irradiation of pyrene oxime ester 4a at different concentration for 30 min

Entry	Concentration (μM)	% of Form I	% of Form II	Form II/ Form I
1	0	100	–	–
2	5	89.75	10.25	0.11
3	10	72.50	27.50	0.38
4	25	34.75	65.25	1.87
5	50	18.50	81.50	4.40
6	75	10.48	89.52	8.54
7	100	–	97.68	–

Table 2s. Quantum yield of (*E*)–pyrene oxime esters (**4a, 4c, 4g and 4h)** in 10% MeOH/H_2O solvent system

Pyrene oxime ester	Time for 50 % decomposition	Quantum yield (φ)
4a	6	0.32
4c	4	0.48
4g	37	0.052
4h	35	0.055