Supporting Information

Hydrophobic chromophore cargo in micellar structures : a different strategy to sensitize lanthanide cations

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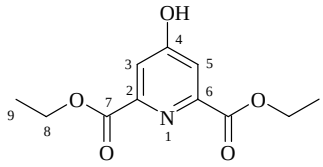
Experimental Section

Synthesis of ligand 4-Dodecyl-2,6-(bis(carboxymethyl)amino)methyl)pyridine (6)

- **Diethyl 4-hydroxy-2,6-pyridinedicarboxylate (1)**



$C_{11}H_{13}NO_5$
239.23 g.mol^{-1}

Concentred sulphuric acid (566µL, 0.011mol, 20 mol %) was added dropwise to a suspension of commercially available chelidamic acid (10.63g, 0.053mol) in ethanol (350mL). The solution was refluxed and stirred during 24 hours. The solvent was evaporated under reduced pressure after return at room temperature. Water and ethyl acetate are added to the oily residue and the organic layer was dried over $MgSO_4$ and concentrated under reduced pressure. The compound **(12)** (10.905g) was obtain by purification on column chromatography (CH_2Cl_2/MeOH; 98:2 to 95:5) as a white solid. Yield: 86%.

NMR^{1}H (DMSO) δ (ppm): 7.57 (s, 2H, H3/5); 4.35 (q, 4H, H8, J_3=7.0Hz); 1.33 (t, 6H, H9, J_3=7.0Hz).

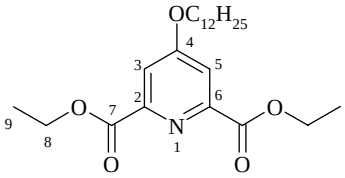
NMR^{13}C (DMSO) δ (ppm): 166.0 (C7); 164.3 (C4); 149.9 (C2/6); 115.2 (C3/5); 61.4 (C8); 14.1 (C9).

IR: ν (cm^{-1}) 2985, 1738, 1722, 1603, 1458, 1332, 1228, 999, 791.

MS (Ionspray®) m/z: 240 $(M+H)^+$, 262.5 $(M+Na)^+$.

T_f: 121-122°C.

- **Diethyl 4-dodecyloxy-2,6-pyridinedicarboxylate (2)**



$C_{23}H_{37}NO_5$
407.56 g.mol^{-1}

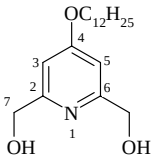
Potassium carbonate (1.49g, 10.78mmol, 5.0 equiv.) was added to a solution of 4-hydroxy-2,6-pyridinedicarboxylatediethyle **(1)** (516mg, 2.16mmol) in acetonitrile (25mL). 1-Bromododecane (1.34mL, 5.54mmol, 1.0 equiv) was added dropwise. The mixture was refluxed with vigorous stirring during 18 hours. Water was added to the cooled reaction until total dissolution of the potassium carbonate. Acetonitrile was evaporated under reduced pressure and the aqueous layer was extract with CH_2Cl_2. Organics layers were dried over $MgSO_4$ and concentrated. The compound **(2)** (2.135g) was obtain after purification on column chromatography (CH_2Cl_2/MeOH; 98:2) as a white solid. Yield: 95%.

NMR^{1}H ($CDCl_3$) δ (ppm): 7.77 (s, 2H, H3/5); 4.47 (q, 4H, H8, J_3=7.3Hz); 4.13 (t, 2H, O-CH_2, J_3=6.5Hz); 1.84 (qt, 2H, CH_2alkyl, J_3=6.5Hz); 1.46 (m, 8H, CH_2alkyl, H9); 1.26 (m, 16H, CH_2alkyl); 0.88 (t, 3H, CH_3alkyl, J_3=6.5Hz).

NMR^{13}C ($CDCl_3$) δ (ppm): 167.2 (C7); 164.9 (C4); 150.2 (C2/6); 114.5 (C3/5); 69.2 (CH_2alkyl); 62.5 (C8); 32.0 (CH_2alkyl); 29.8 ($2CH_2$alkyl); 29.7 (CH_2alkyl); 29.6 (CH_2alkyl);

29.4 (CH_2alkyl); 28.9 (CH_2alkyl); 26.0 (CH_2alkyl); 22.8 (CH_2alkyl); 14.3 (C9); 14.2 (CH_3alkyl).
IR : ν (cm^{-1}) 2917, 2848, 1714, 1598, 1340, 1249, 1108, 1031, 785.
MS (Ionspray®) m/z : 408.5 $(M+H)^+$.
T_f : 47-48°C.

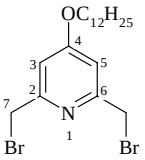
- **4-Dodecyloxy-2,6-dihydroxymethylpyridine (3)**



$C_{19}H_{33}NO_3$
323 g.mol^{-1}

MeOH (15mL) was added over a period of 1h to a boiling mixture of 4-dodecyloxy-2,6-pyridinedicarboxylatediethyle **(2)** (300mg, 0.74mmol) and $NaBH_4$ (140mg, 1.1mmol, 1.5 eq.)) in THF (40mL). The reaction mixture was refluxed for an additional 2 hours, then cooled and slowly diluted with H_2O (30mL). The precipitate was filtered. The compound **(3)** (238mg) is obtained without purification as a white solid. Yield: 92%.
NMR^{1}H (MeOD) δ (ppm): 6.97 (s, 2H, H3/5); 4.62 (s, 4H, H7); 4.11 (t, 2H, O-CH_2, J_3=6.5Hz); 1.82 (qt, 2H, CH_2alkyl, J_3=6.75Hz); 1.48 (m, 2H, CH_2alkyl); 1.30 (s, 18H, CH_2alkyl); 0.90 (s, 3H, CH_3alkyl, J_3=6.75Hz).
NMR^{13}C (MeOD) δ (ppm): 168.9 (C); 163.7 (C); 106.5 (C); 69.4 (CH_2); 65.4 (CH_2); 33.2 (CH_2); 30.90 (CH_2); 30.88 (CH_2); 30.84 (CH_2); 30.82 (CH_2); 30.60 (CH_2); 30.57 (CH_2); 30.2 (CH_2); 27.2 (CH_2); 23.9 (CH_2); 14.6 (CH_3).
IR : ν (cm^{-1}) 3323, 2921, 2847, 1599, 1463, 1354, 1325, 1156, 1035, 866.
T_f : 84°C.

- **4-Dodecyloxy-2,6-dibromomethylpyridine (4)**

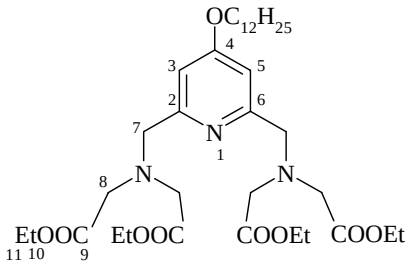


$C_{19}H_{31}Br_2NO$
449.27 g.mol^{-1}

PBr_3 (511µL) in $CHCl_3$ (20mL) was added dropwise to a suspension of 4-dodecyloxy-2,6-dihydroxymethylpyridine **(3)** (220mg) in $CHCl_3$ (20mL) at room temperature. The mixture was refluxed during 16 hours. After cooling at room temperature we added $NaHCO_3$ 1M (100mL) and the solution is stirred during 1 hour until it became clear. The organic layer was dried and concentrated under reduced pressure. The compound **(4)** was obtained without purification by filtration as a white solid. Yield: 100%.
NMR^{1}H ($CDCl_3$) δ (ppm): 6.87 (s, 2H, H3/5); 4.47 (s, 4H, H7); 4.02 (t, 2H, O-CH_2, J_3=6.5Hz); 1.80 (qt, 2H, CH_2alkyl, J_3=6.75Hz); 1.43 (m, 2H, CH_2alkyl); 1.27 (s, 18H, CH_2alkyl); 0.88 (s, 3H, CH_3alkyl, J_3=6.75Hz).
NMR^{13}C ($CDCl_3$) δ (ppm): 166.7 (C4); 158.1 (C2/6); 109.3 (C3/5); 68.4 (CH_2alkyl); 33.7 (C7); 31.9 (CH_2alkyl); 29.6 (CH_2alkyl); 29.6 (CH_2alkyl); 29.5 (CH_2alkyl); 29.5 (CH_2alkyl);

29.3 (CH_2alkyl); 29.3 (CH_2alkyl); 28.8 (CH_2alkyl); 25.9 (CH_2alkyl); 22.7 (CH_2alkyl); 14.1 (CH_3alkyl).
IR : ν (cm^{-1}) 2921, 2850, 1596, 1467, 1341, 1163, 1038, 891, 653.
T_f : 52°C.

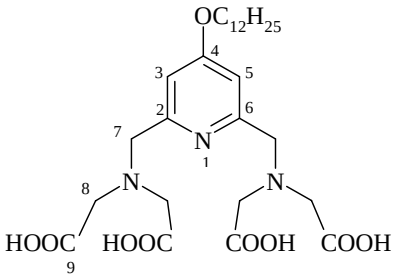
- **4-Dodecyl-2,6-((bis(ethylcarboxymethyl)amino)methyl)pyridine (5)**



$C_{35}H_{59}N_3O_9$
665.88 g.mol^{-1}

A mixture of 4-dodecyloxy-2,6-dibromomethylpyridine (**4**) (305mg, 0.8mmol) , potassium carbonate (375mg, 3.2mmol, 4 eq.) and potassium iodide (225mg, 1.6mmol, 2eq.) was dissolved into acetonitrile (50mL). Iminodiethyl acetate (237µL, 1.6mmol, 2 eq.) is then added. The mixture was refluxed during 12 hours. After cooling to room temperature, the excess of potassium carbonate was dissolved by adding water and acetonitrile is evaporated. The aqueous layer was extracted with methylene chloride and the crude was concentrated under reduced pressure. The compound **(5)** was obtained without purification as a pale yellow solid paste (330mg). Yield: 75%.
NMR^{1}H ($CDCl_3$) δ (ppm): 7.05 (s, 2H, H3/5); 4.17 (q, 8H, H10, J_3=7.2Hz); 4.00(t, 2H, O-CH_2, J_3=6.4Hz); 3.98 (s, 4H, H7); 3.60 (s, 8H, H8); 1.77 (qt, 2H, CH_2alkyl, J_3=6.4Hz); 1.44 (m, 2H, CH_2alkyl); 1.27 (m, 28H, CH_2alkyl, H11); 0.88 (s, 3H, CH_3alkyl, J_3=6.8Hz).
NMR^{13}C ($CDCl_3$) δ (ppm): 175.9 (C9); 171.4 (C4); 160.0 (C2/6); 107.6 (C3/5); 67.9 (OCH_2alkyl); 60.5 (C10); 59.9 (C7); 54.9 (C8); 31.9 (CH_2alkyl); 29.7 (CH_2alkyl); 29.6 (CH_2alkyl); 29.6 (CH_2alkyl); 29.5 (CH_2alkyl); 29.4 (CH_2alkyl); 29.3 (CH_2alkyl); 29.2 (CH_2alkyl); 25.9 (CH_2alkyl); 22.7 (CH_2alkyl); 14.2 (C11); 14.1 (CH_3alkyl).
IR: ν (cm^{-1}) : 3019, 2927, 1739, 1215, 745.
MS (Ionspray®) m/z: 666.5 $(M+H)^+$, 688.5 $(M+Na)^+$.

- **4-Dodecyl-2,6-((bis(carboxymethyl)amino)methyl)pyridine (6)**



$C_{27}H_{43}N_3O_9$
553.66g.mol^{-1}

Esters **(5)** (1.42g, 2.12mmol) was dissolved in THF (25mL) and water (25mL) was added. The mixture was cooled to 0°C. LiOH (12eq., 0.61g, 25.52mmol) was then added and the medium was stirred at room temperature during 5 hours. The organic solvent was evaporated and the aqueous mixture was purified on an anionic exchange resin (DOWEX 1X2-100Cl) (washed with H_20/MeOH; 99/1 and eluted with formic acid 1M) to furnish the ligand **(6)** (573.4mg, 77% yield) as a white solid.

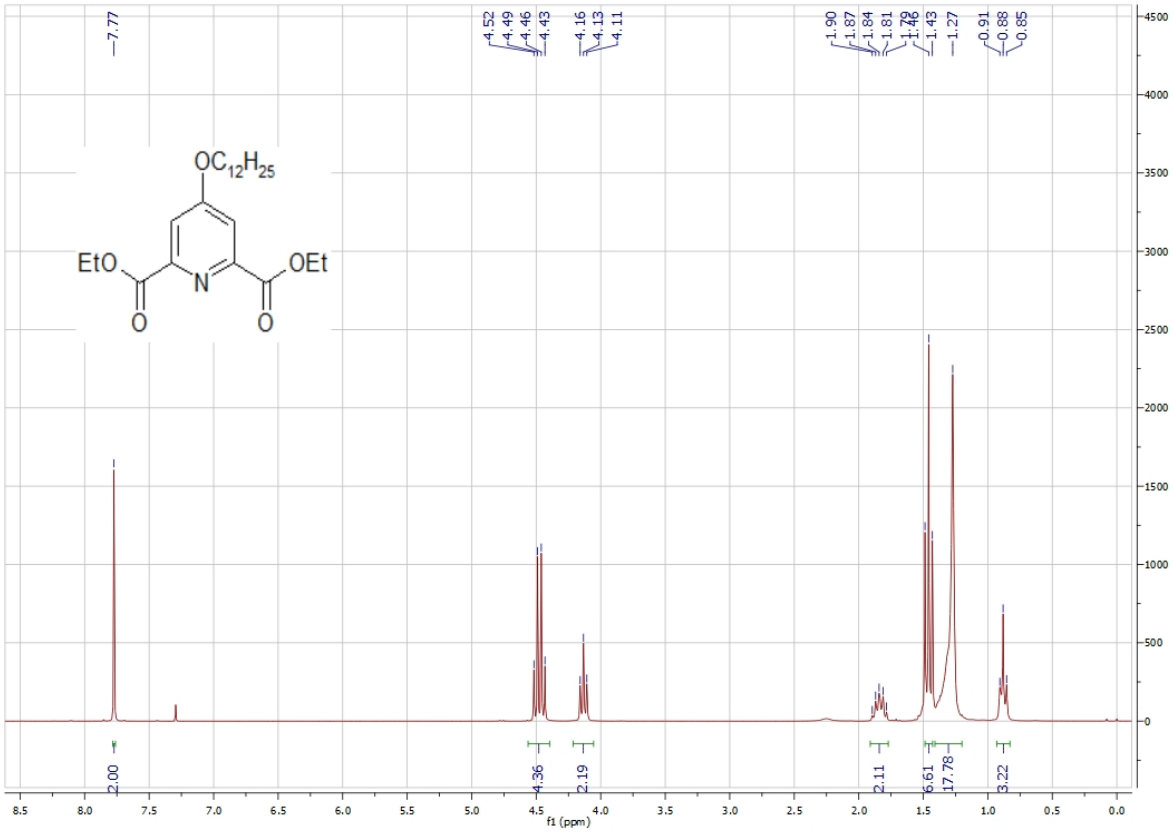
NMR^{1}H (DMSO) δ (ppm): 7.08 (s, 2H, H3/5); 4.06(t, 2H, O-CH_2, J_3=6.4Hz); 3.95 (s, 4H, H7); 3.47 (s, 8H, H8); 1.72 (qt, 2H, CH_2alkyl, J_3=6.4Hz); 1.38 (m, 2H, CH_2alkyl); 1.24 (m, 16H, CH_2alkyl); 0.85 (t, 3H, CH_3alkyl, J_3=6.8Hz).

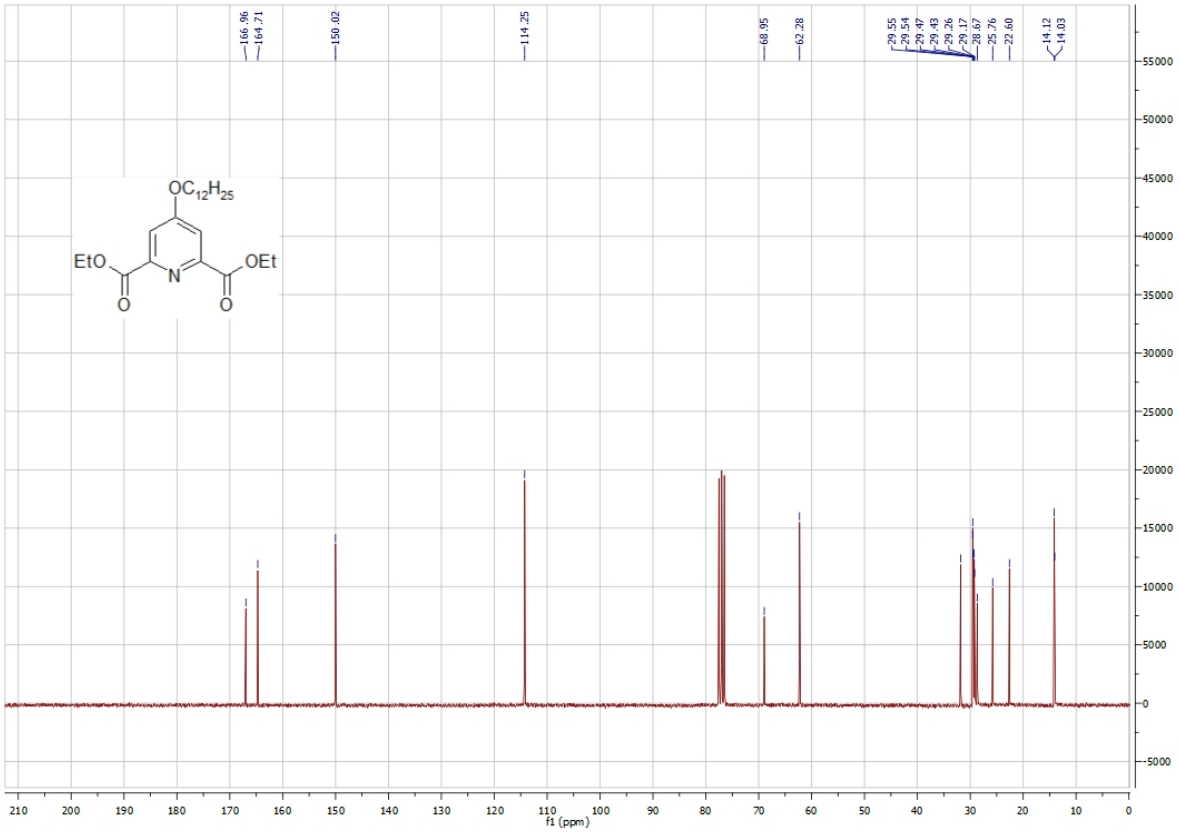
NMR^{13}C (DMSO) δ (ppm): 172.6 (C); 166.3 (C); 160.1 (2C); 107.1 (2C); 67.7 (CH_2); 58.8 (CH_2); 54.9 (CH_2); 31.3 (CH_2); 29.0 (CH_2); 28.9 (3xCH_2); 28.3 (CH_2); 25.4 (CH_2); 22.1 (CH_2); 13.9 (CH_3).

IR: ν (cm^{-1}): 3448, 2996, 2922, 1725, 1610.

T_f : 129-130°C

^{1}H and ^{13}C NMR Spectra

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14.03
OC12H25
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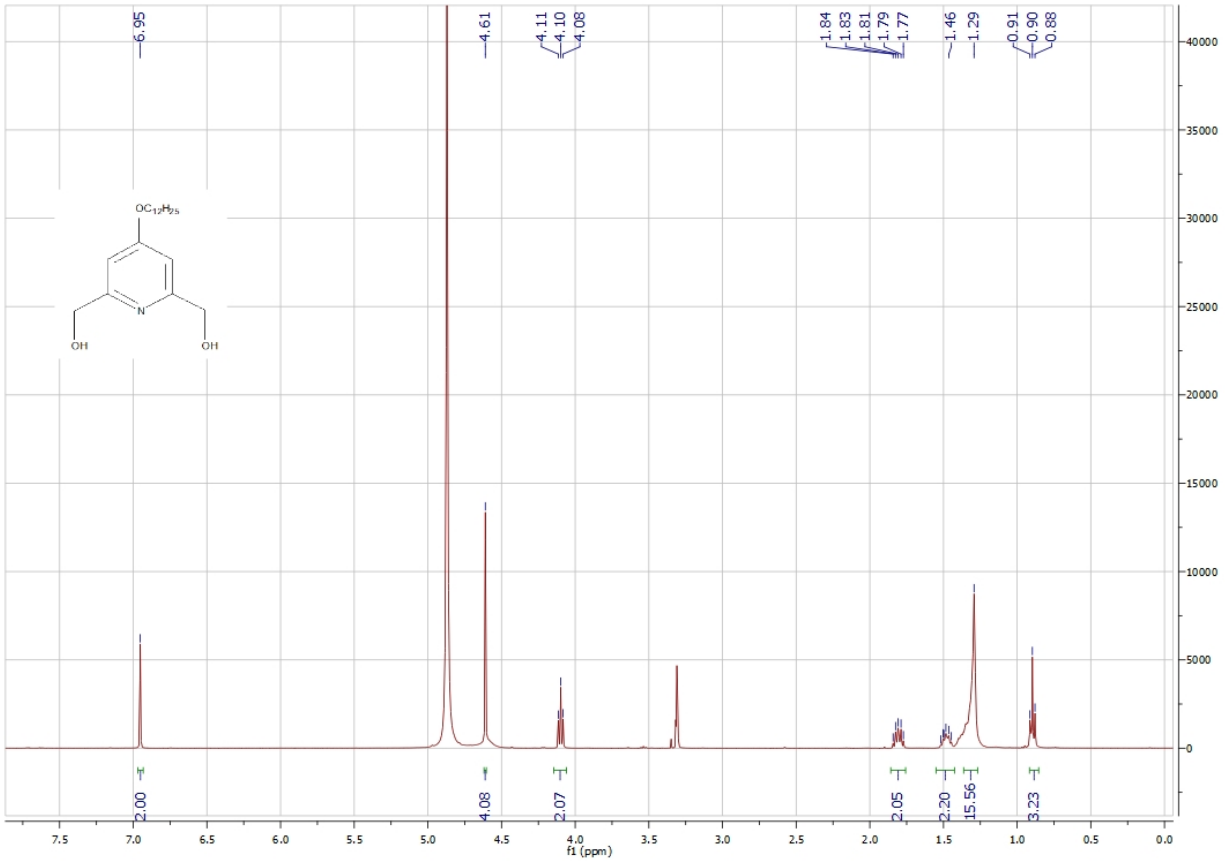
OEt
N
O
O
f1 (ppm)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0.90
0.88
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OH
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2.05
2.20
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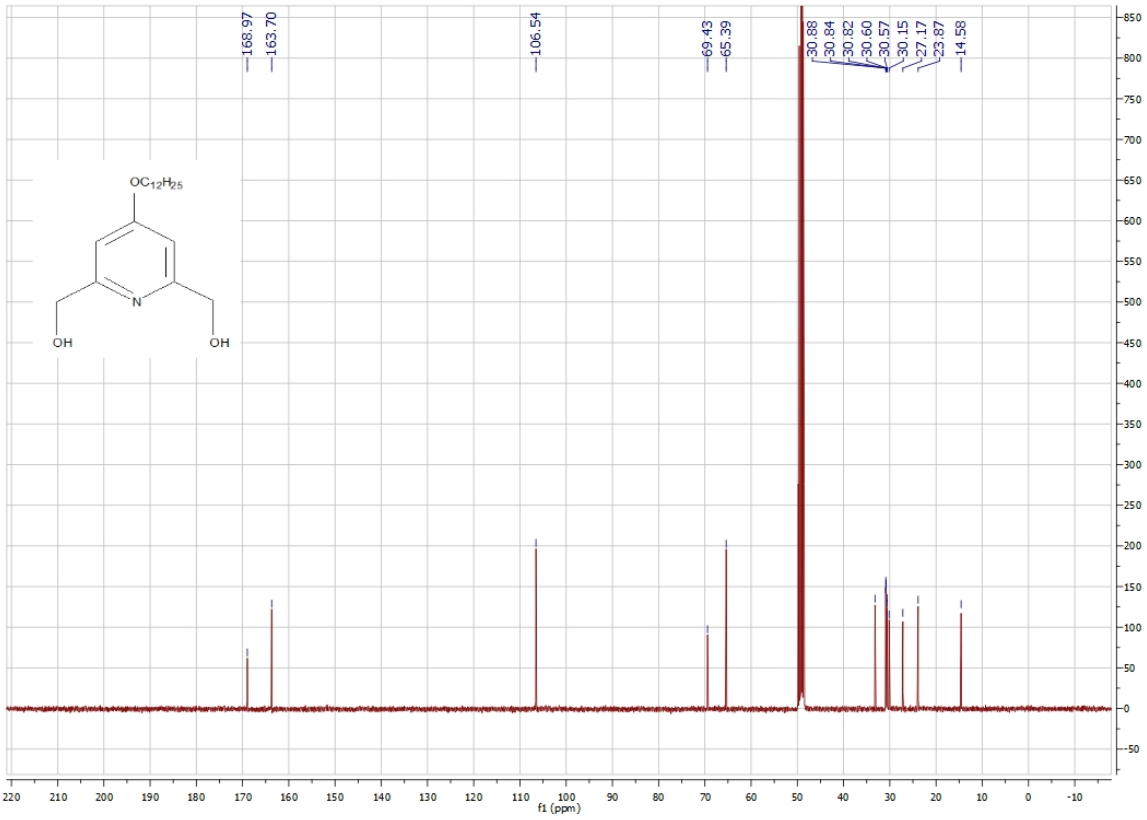
3.23
f1 (ppm)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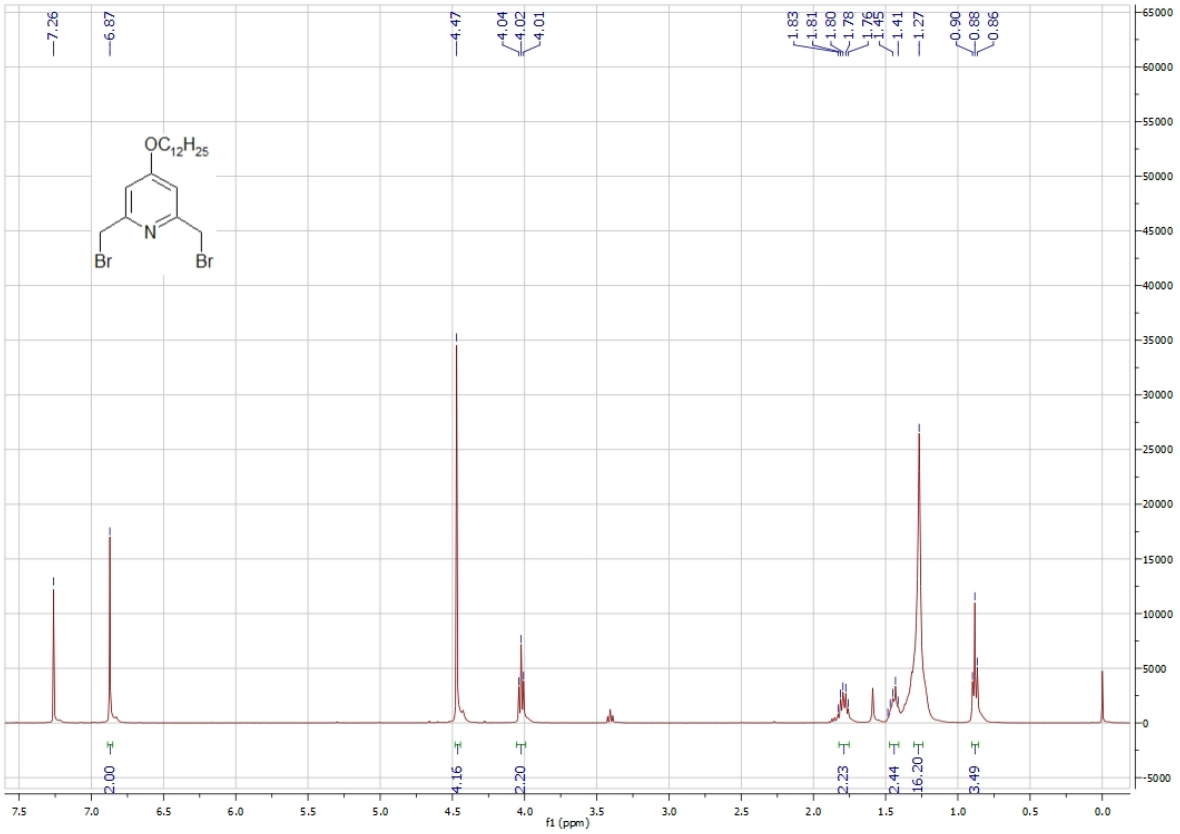
OH
OH
f1 (ppm)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1.27
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0.88
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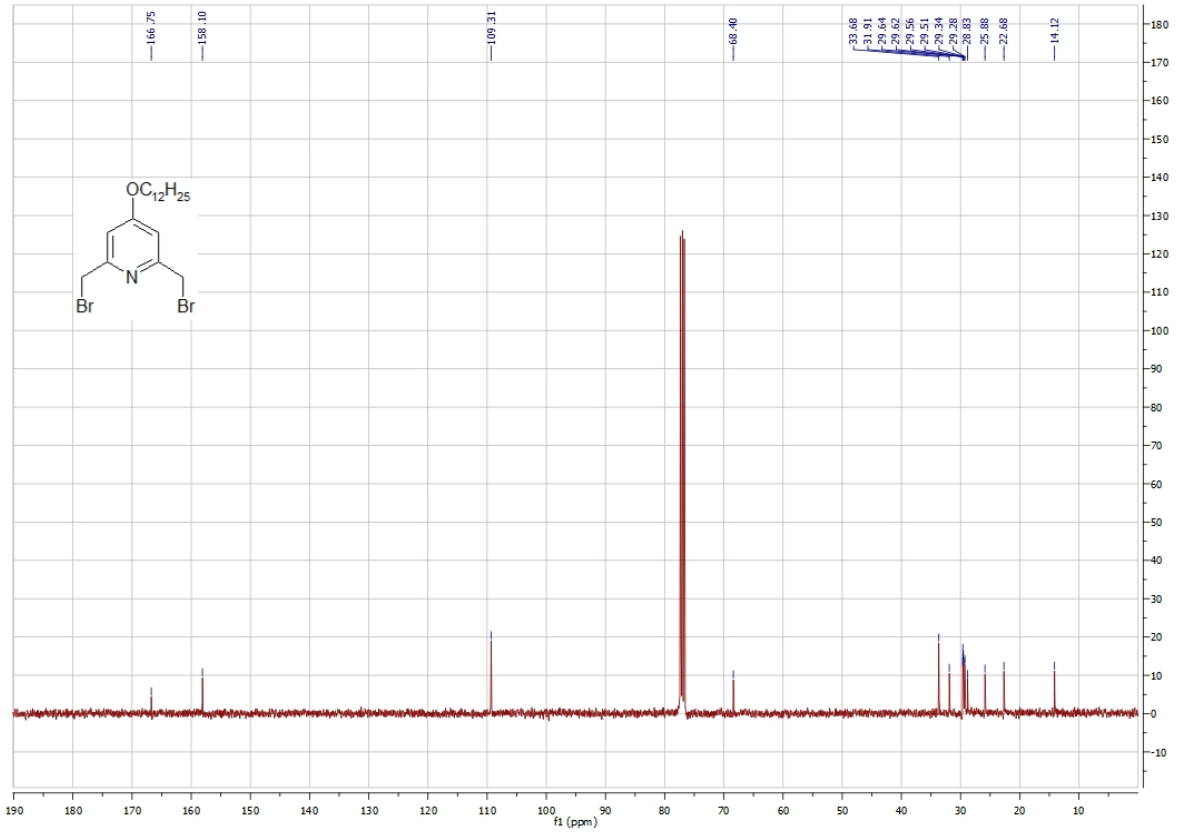
f1 (ppm)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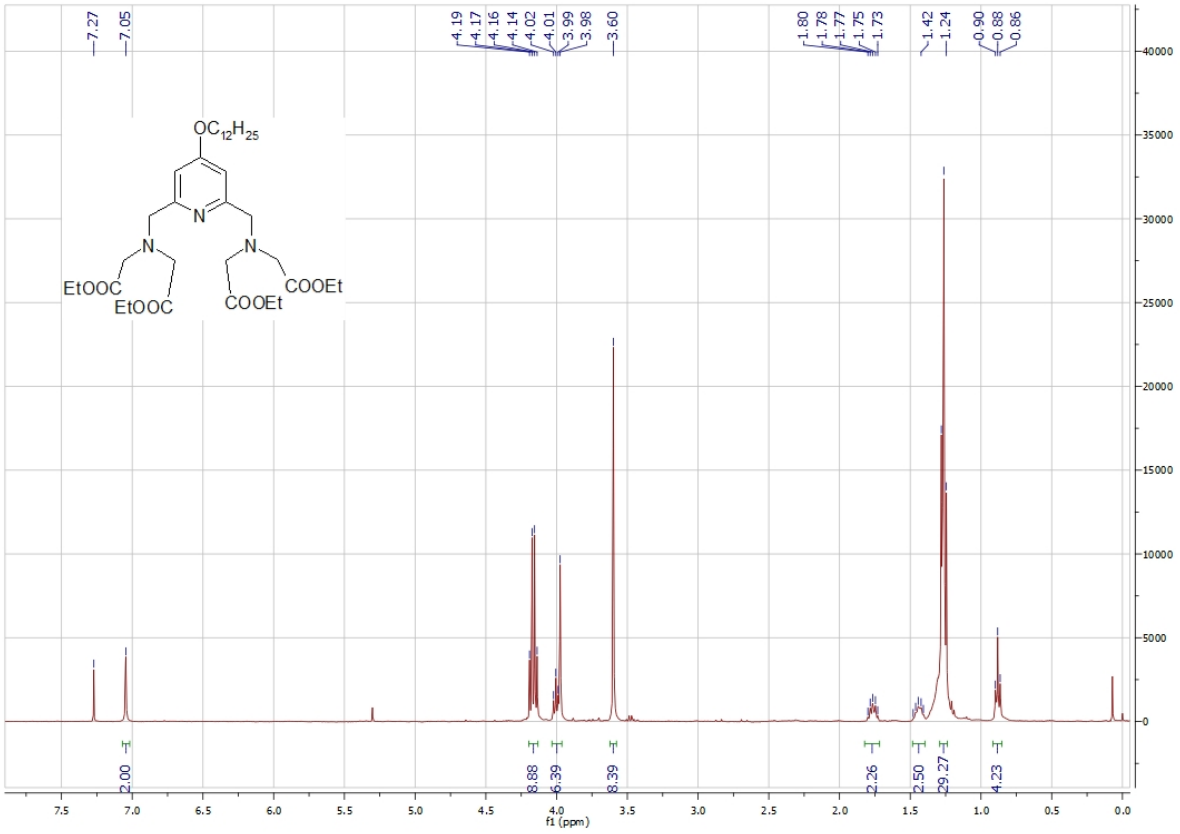
N
Br
Br
f1 (ppm)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1.77
1.75
1.73
1.42
1.24
0.90
0.88
0.86
OC12H25
N
N
N
EtOOC
EtOOC
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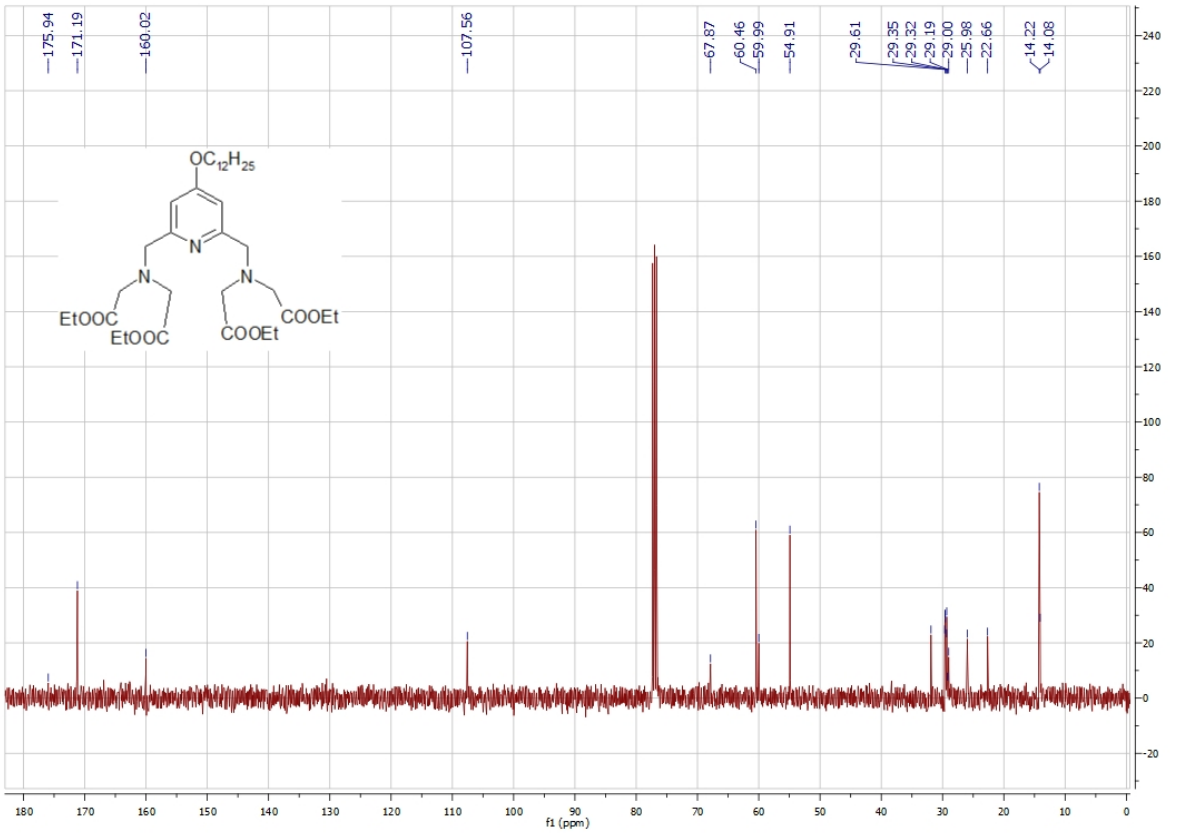
29.27
4.23
f1 (ppm)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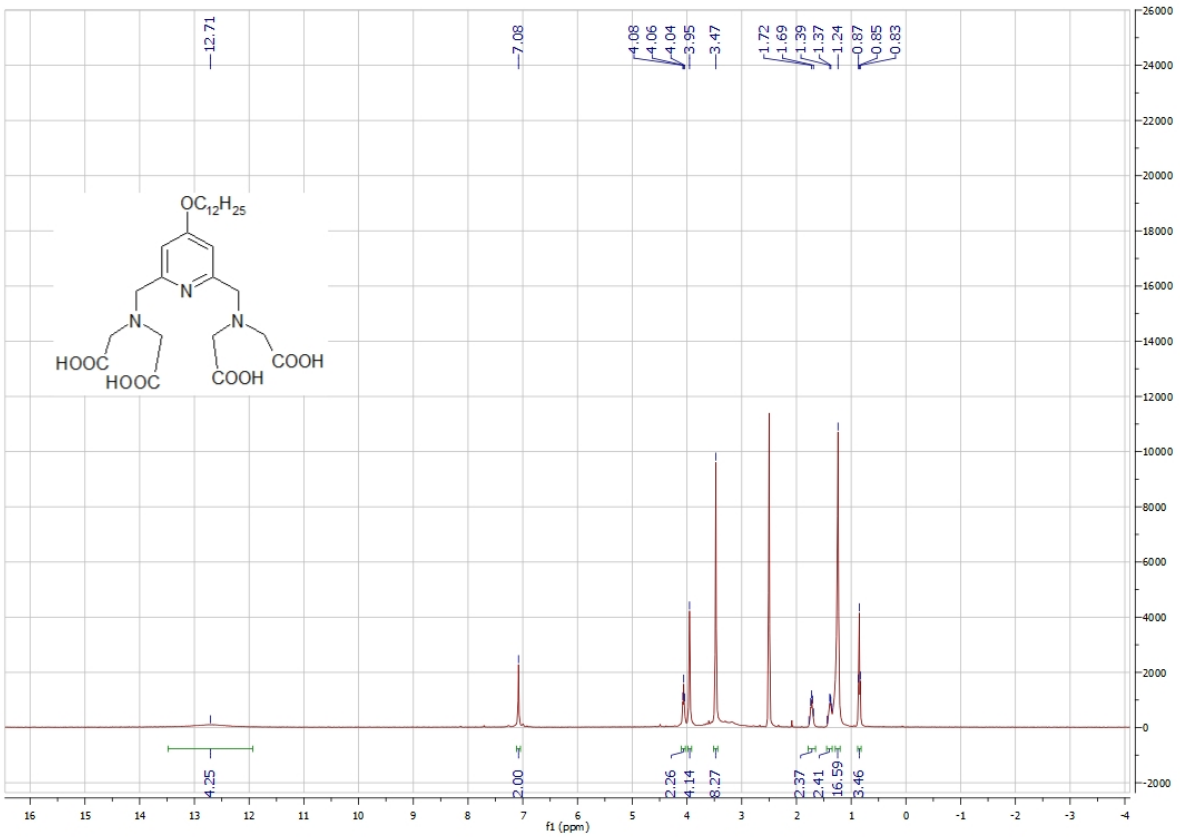
COOEt
f1 (ppm)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0.87
0.85
0.83
OC12H25
HOOC
HOOC
COOH
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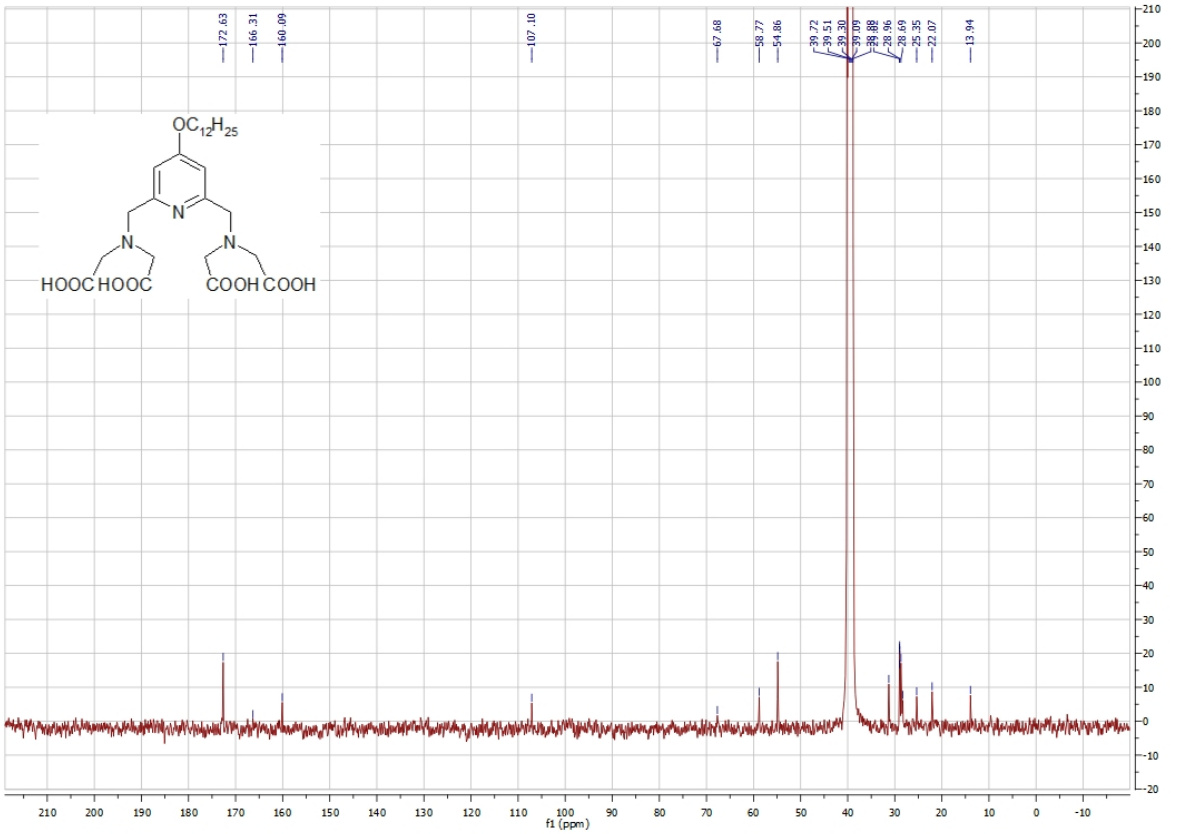
f1 (ppm)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39.30
39.09
28.96
28.69
25.35
22.07
13.94
OC12H25
HOOC HOOC
COOH COOH
f1 (ppm)

Photophysical measurements

Absorbance UV spectra were performed on an Uvikon spectrophotometer. Emission and excitation spectra were measured using modified Jobin-Yvon Horiba Fluorolog-322 spectrofluorimeter equipped with a Hamamatsu R928 detector. Spectra were recorded in a quartz triangular luminescence cell. Settings for time-delayed fluorescence were: time delay after flash of 0.1 ms, sample window of 2 ms, time per flash of 61 ms and 10 flash counts. The emission spectra were recorded using a 385 nm cut-off filter, after an excitation at 345 nm. The excitation spectra were recorded with a 495 nm cut-off filter, monitoring the emission at 614 nm.

Europium luminescence lifetimes

The Eu^{3+} luminescence lifetime measurements were performed by excitation of solutions in 1 mm quartz cells (NSG Precision Cells, Inc.) using a Nd:YAG Continuum Powerlite 8010 laser (266nm, fourth harmonic) as the excitation source. Emission was collected at a right angle to the excitation beam, and wavelengths were selected by means of a Spectral Products CM 110 1/8 meter monochromator (with two independent gratings). The signal was monitored by a Hamamatsu R928 photomultiplier to a 500 MHz bandpass digital oscilloscope (Tektronix TDS 620B). Signals from > 2000 flashes were collected and averaged. Quality of luminescence lifetime data was confirmed by at least two independent measurements. Experimental luminescence decay curves were imported into Origin 7.0 scientific data analysis software, and analyzed using the Advanced Fitting Tool module. The decay curves were best fit with a double exponential fitting mode, based on a reduced chi-square criteria. The lifetimes corresponding unambiguously to Eu^{3+} are reported table S1.

Quantum yield

Steady-state luminescence quantum yields were collected with a modified JY Horiba Fluorolog-322 Spectrofluorimeter, fitted with an integration sphere developed by Frédéric Gumy and Prof. Jean-Claude G. Bünzli (Laboratory of Lanthanide Supramolecular Chemistry, École Polytechnique Féderale de Lausanne (EPFL), BCH 1402, CH- 1015 Lausanne, Switzerland) as an accessory to the Fluorolog-322 spectrometer (Patent pending), using a quartz tube sample holder.[1] Spectra were corrected for variations in lamp output, the non-linear response of the detector, and the use of neutral density filters, where applicable. The calculated values were determined by integrating the emission profiles, averaged from four separate trials, and substitution into the ratio of emitted photons over absorbed photons.

Relaxometric measurements

Longitudinal relaxation rates have been recorded on a Stelar SMARtracer Fast Field Cycling NMR relaxometer (0.0110 MHz) and a Bruker WP80 NMR electromagnet adapted to variable field measurements and controlled by the SMARtracer PC-NMR console. The temperature was controlled by a VTC91 temperature control unit and maintained by a gas flow. The temperature was determined according to previous calibration with a Pt resistance temperature probe.

Figure S1 : *Variation of the water ^{1}H longitudinal relaxation rate versus the total GdL concentration at 6.95 MHz and 25°C.*

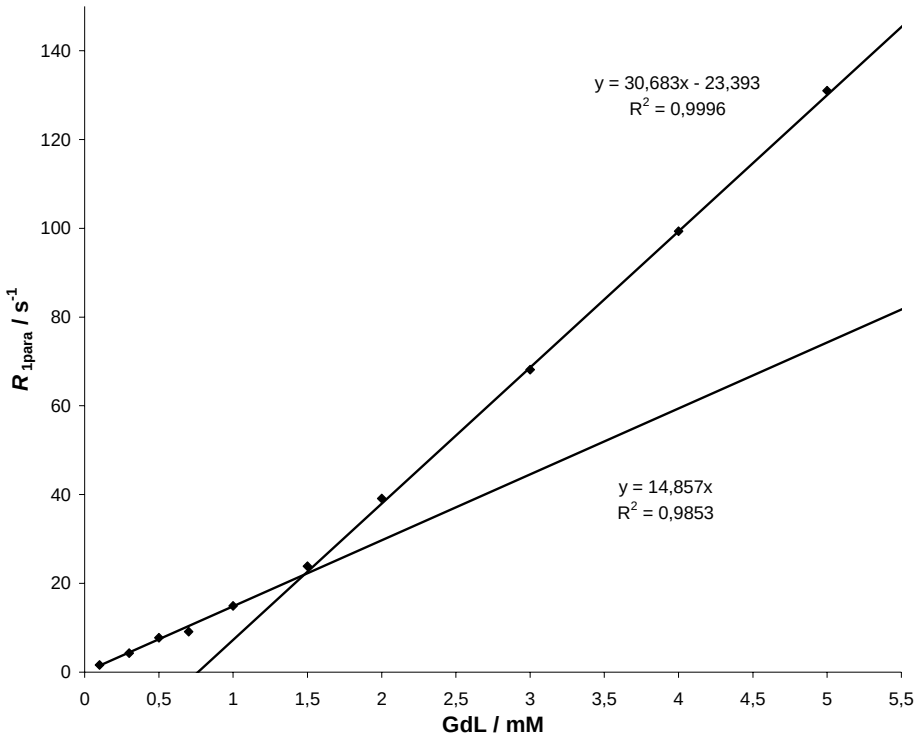


Figure S2 : *Variation of the water ^{1}H longitudinal relaxation rate of GdEuL-Nap versus the total GdEuL concentration at 40 MHz and 25°C ([Nap] = 0.093 [GdEuL]).*

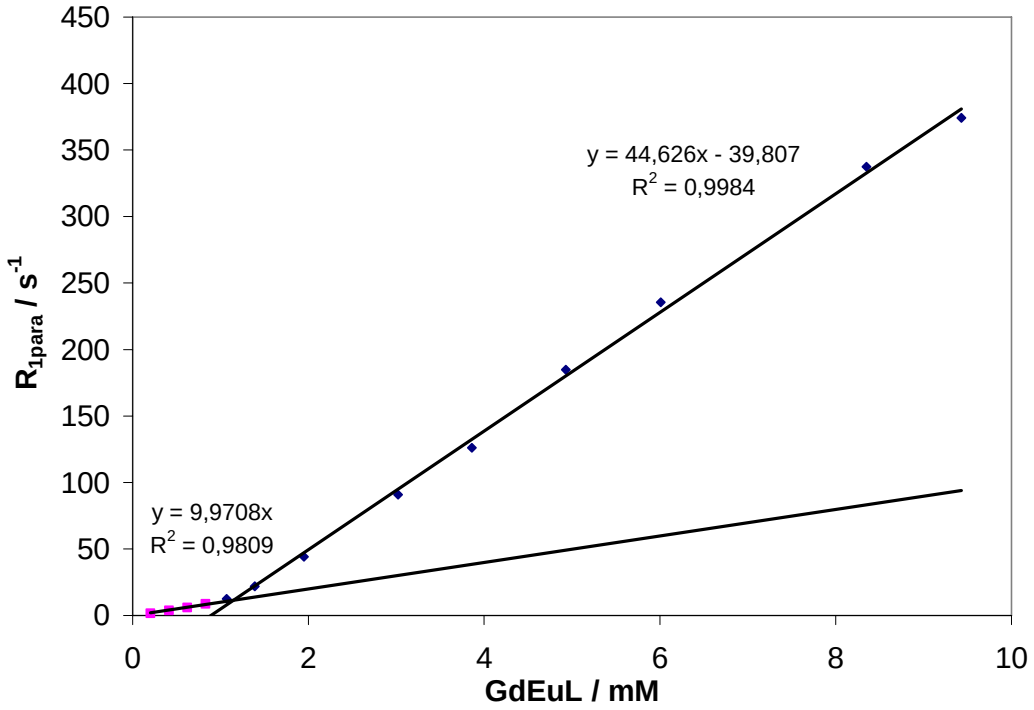


Figure S3 : *UV spectra of GdEuL, GdEuL in the presence of 2,3-naphthalimide and of pure 2,3-naphthalimide in water.*

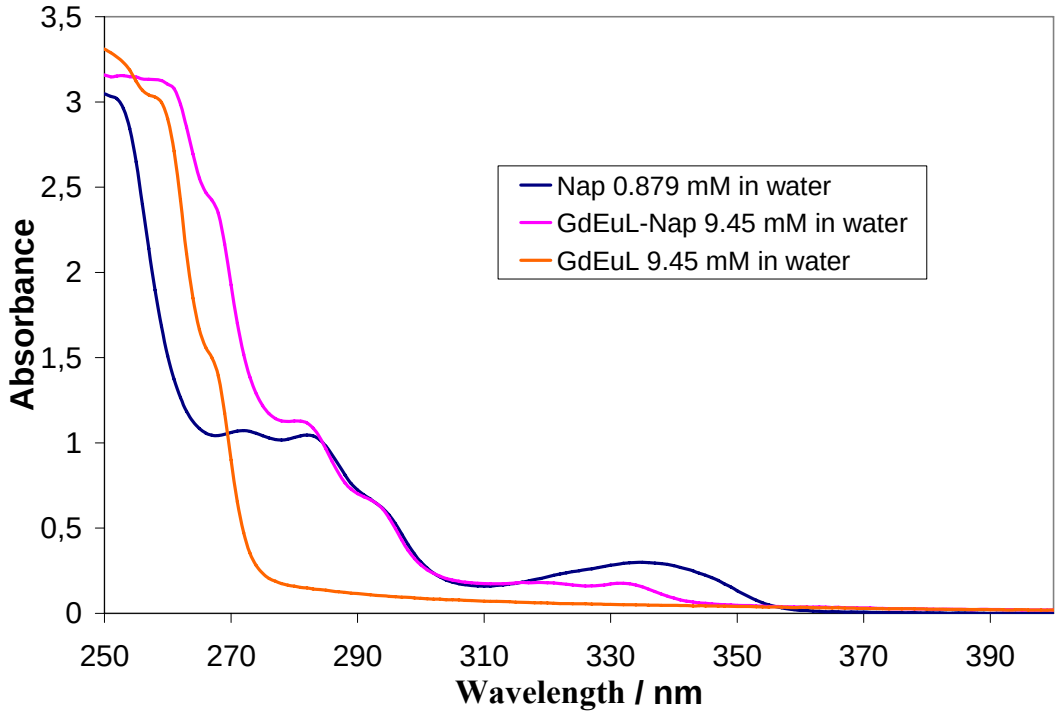
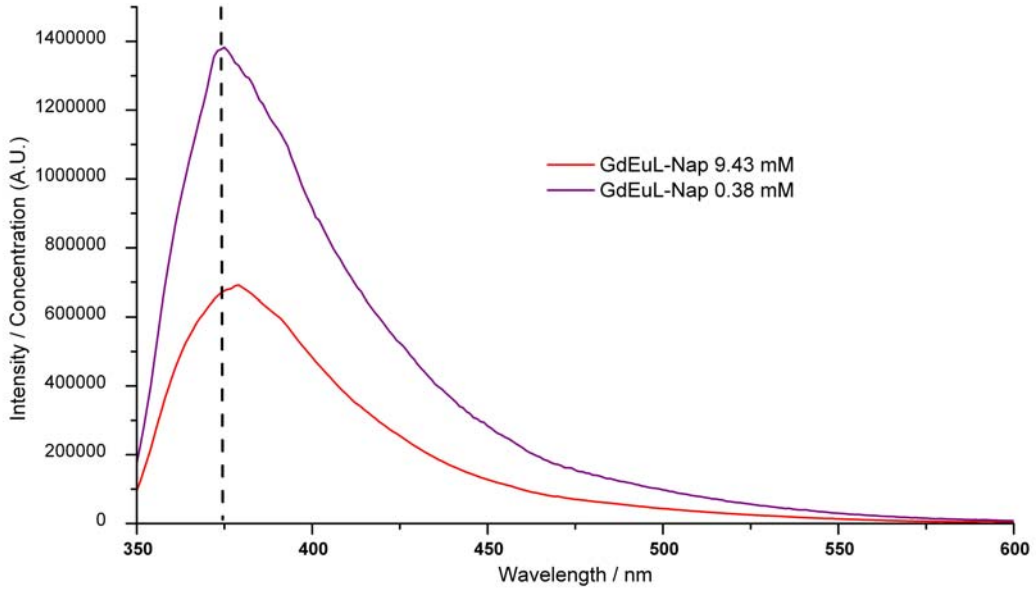


Figure S4 : *a) Fluorescence emission spectra recorded with a 351 nm cut-off filter and after an excitation at 330 nm. Integration time of 0.5 ms. b) Fluorescence excitation spectra recorded looking at the 614 nm emission band. Integration time of 0.5 ms.*

a



b

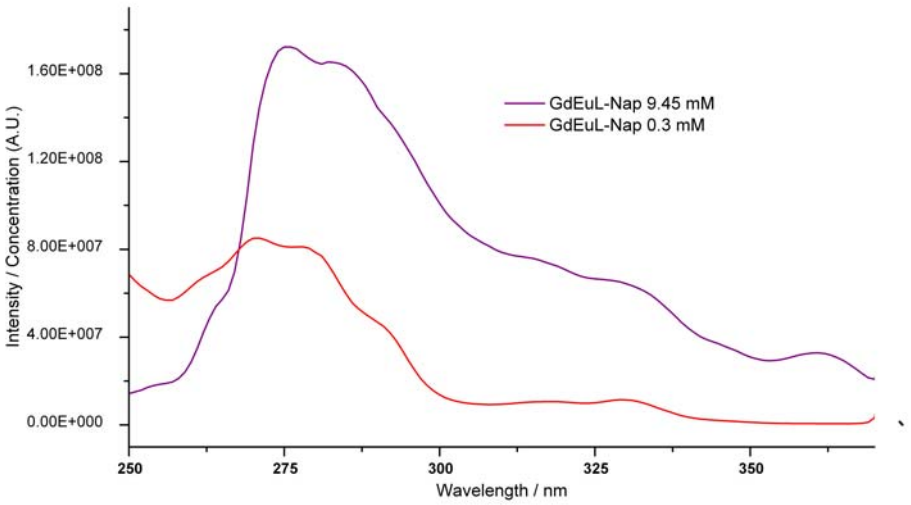


Figure S5 : *Emission spectra of GdEuL complex 4.73 mM at pH 7 in 50% fetal calf serum solution and in the presence of β-cyclodextrin (CD). A 450 nm cut-off filter was used to record those spectra with an excitation at 330 nm, an integration time of 0.5 ms and slit widths for the excitation and the emission of 2 nm.*

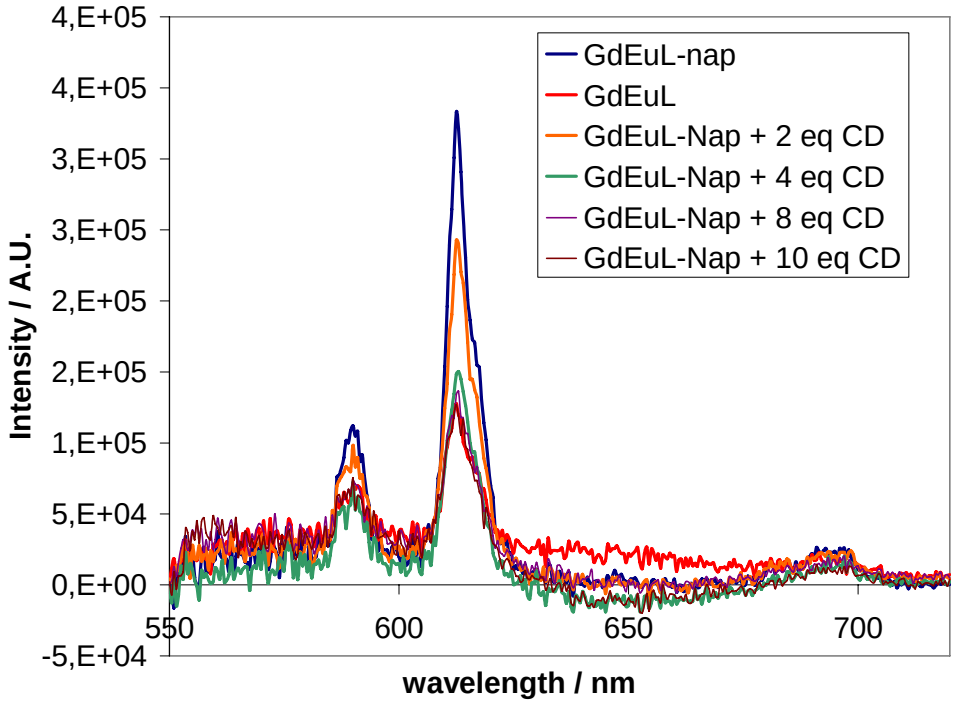


Table S1 : *Concentration dependence of luminescence lifetimes of the EuL complex. Q values were calculated using the empirical formula described in the reference*[1]

[EuL] (mM)	τ_{D2O} (ms)	τ_{H2O}(ms)	q
30	1.336(1)	0.401(3)	1.7
15	1.404(2)	0.4043(7)	1.8
7.5	1.487(2)	0.3979(2)	1.8
3.75	1.639(2)	0.3738(6)	2.1
1.875	1.743(3)	0.3900(4)	2.0
0.937	1.984(5)	0.3922(5)	2.0
0.467	2.10(1)	0.387(1)	2.1

[1] A. Beeby, I. M. Clarkson, R. S. Dickins, S. Faulkner, D. Parker, L. Royle, A. S. d. Sousa, J. A. G. Williams, M. J. Woods, *J. Chem. Soc., Perkin Trans.*, **1999**, 493.