

Synthesis of phosphorus-containing proline analogs and assessment of their antitumor activity

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General. The ^1H and ^{13}C NMR spectra were recorded on a Bruker Avance 600 spectrometer (Bruker, Billerica, MA, USA) with an operating frequency of 600 and 150 MHz, respectively, with respect to the residual proton signals of deuterated solvents ($\text{DMSO-}d_6$, CDCl_3). ^{31}P NMR spectra were recorded on Bruker Avance II-400 spectrometer (working frequency 161.9 MHz) using 85% H_3PO_4 as external standard. Crystalline samples were studied as a suspension in Nujol. The melting points were determined in glass capillaries on a Stuart SMP 10 instrument (Stuart Scientific, Stone, UK). Elemental analysis of the compounds was carried out on a high-temperature 2-reactor C, H, N-analyzer of EuroEA3028-HT-OM (Eurovector SpA, Pavia, Italy). ESI-TOF-MS spectra were recorded on a Bruker AmazonX instrument (Bruker).

General Experimental Procedure for the Synthesis of 3a-i. A mixture of benzene (10 ml), 3-arylidine-1-pyrroline (0.65 mmol), and *H*-phosphonate (0.65 mmol) was stirred at room temperature for 30 minutes. The solvent was removed in vacuum, washed with hexane (10 ml), and the remaining white powder was dried in a vacuum.

(*E*)-2-Diphenylphosphoryl-3-(furan-2-ylmethylene)pyrrolidin-1-ium 2,2,2-trifluoroacetate **3a**: white solid, yield 93%, mp 118–119 °C. ^1H NMR (600 MHz, $\text{DMSO-}d_6$) δ : 8.13–8.02 (m, 2H), 7.93–7.83 (m, 2H), 7.73–7.52 (m, 7H), 6.55–6.44 (m, 1H), 6.31–6.21 (m, 1H), 5.82 (s, 1H), 5.59–5.48 (m, 1H), 3.61–3.52 (m, 1H), 3.49–3.41 (m, 1H), 3.01–2.90 (m, 1H), 2.88–2.76 (m, 1H). ^{13}C NMR (150 MHz, $\text{DMSO-}d_6$) δ : 145.9 (d, $J = 4.2$ Hz), 138.4, 128.1, 126.7 (d, $J = 9.3$ Hz), 126.5 (d, $J = 9.5$ Hz), 125.5, 124.8, 124.3 (d, $J = 11.7$ Hz), 124.0 (d, $J = 11.8$ Hz), 123.5, 107.1, 105.3, 54.8 (d, $J = 66.4$ Hz), 41.5, 24.6. ^{31}P {1H} NMR (161.9 MHz, $\text{DMSO-}d_6$) δ : 28.81 (s, 1s). MS (ESI), m/z : 373 $[\text{M}+\text{Na}]^+$ (calc. for $\text{C}_{21}\text{H}_{21}\text{NO}_2\text{P}^+$, m/z : 350). Found (%): C, 59.80; H, 4.69; N, 2.89; P, 6.78. Calc. for $\text{C}_{23}\text{H}_{21}\text{F}_3\text{NO}_4\text{P}$ (%): C, 59.62; H, 4.57; N, 3.02; P, 6.68.

(*E*)-2-(Di-*p*-tolylphosphoryl)-3-(furan-2-ylmethylene)pyrrolidin-1-ium 2,2,2-trifluoroacetate **3b**: white solid, yield 86%, mp 82–84 °C. ^1H NMR (600 MHz, $\text{DMSO-}d_6$) δ : 7.96–7.88 (m, 2H), 7.77–7.69 (m, 2H), 7.49–7.44 (m, 2H), 7.42–7.37 (m, 2H), 6.56–6.47 (m, 1H), 6.27 (d, 1H, $J = 3.3$ Hz), 5.72 (s, 1H), 5.61–5.54 (m, 1H), 3.55–3.47 (m, 1H), 3.45–3.38 (m, 1H), 2.99–2.89 (m, 1H), 2.84–2.74 (m, 1H), 2.40 (s, 3H), 2.37 (s, 3H). ^{13}C NMR (150 MHz, $\text{DMSO-}d_6$) δ : 153.5 (q, $J = 31.5$ Hz), 146.0 (d, $J = 4.0$ Hz), 138.3 (d, $J = 5.2$ Hz), 126.7 (d, $J = 9.5$ Hz), 126.5 (d, $J = 9.7$ Hz), 124.9 (d, $J = 12.0$ Hz), 124.6 (d, $J = 12.3$ Hz), 123.5, 122.3, 121.6 (d, $J = 15.6$ Hz), 120.8, 112.2 (q, $J = 293.8$ Hz), 109.5, 105.3, 54.9 (d, $J = 68.1$ Hz), 41.5, 24.6, 16.3. ^{31}P {1H} NMR (161.9 MHz, $\text{DMSO-}d_6$) δ : 29.00 (s, 1s). MS (ESI), m/z : 379 $[\text{M}+\text{H}]^+$ (calc. for $\text{C}_{23}\text{H}_{25}\text{NO}_2\text{P}^+$, m/z : 378). Found (%): C, 60.92; H, 5.25; N, 2.98; P, 6.16. Calc. for $\text{C}_{25}\text{H}_{25}\text{F}_3\text{NO}_4\text{P}$ (%): C, 61.10; H, 5.13; N, 2.85; P, 6.30.

(*E*)-2-Dioctylphosphoryl-3-(furan-2-ylmethylene)pyrrolidin-1-ium 2,2,2-trifluoroacetate **3c**: white solid, yield 78%, mp 84–86 °C. ^1H NMR (600 MHz, $\text{DMSO-}d_6$) δ : 7.72 (s, 1H), 6.67–6.63 (m, 1H), 6.58–6.55 (m, 1H), 6.52–6.49 (m, 1H), 4.74 (d, 1H, CH, $^3J = 6.0$ Hz), 3.59–3.52 (m, 1H), 3.46–3.43 (m, 1H), 3.04–2.95 (m, 1H), 2.87–2.78 (m, 1H), 1.99–1.79 (m, 4H), 1.57–1.44 (m, 4H), 1.36–1.17 (m, 20H), 0.81–0.89 (m, 6H). ^{13}C NMR (150 MHz, $\text{DMSO-}d_6$) δ : 158.9 (q, $J = 31.6$ Hz), 151.8 (d, $J = 3.5$ Hz), 143.7, 131.7 (d, $J = 5.7$ Hz), 117.6 (q, $J = 298.9$ Hz), 114.5 (d, $J = 6.2$ Hz), 112.4, 110.8, 59.6 (d, $J = 58.0$ Hz), 46.3, 31.7, 31.6, 30.8, 30.7, 30.6, 29.7, 28.9, 28.8, 27.0 (d, $J = 62.4$ Hz), 25.9 (d, $J = 65.4$ Hz), 22.5, 22.4, 21.3 (d, $J = 35.5$ Hz), 14.4. ^{31}P NMR (161.9 MHz, $\text{DMSO-}d_6$) δ :

48.25 (s, 1s). MS (ESI), m/z : 422 $[M]^+$, 445 $[M+Na]^+$, 457 $[M+K]^+$ (calc. for $C_{25}H_{45}NO_2P^+$, m/z : 422). Found (%): C, 60.55; H, 8.47; N, 2.62; P, 5.78. Calc. for $C_{27}H_{45}F_3NO_4P$ (%): C, 60.55; H, 8.47; N, 2.62; P, 5.78.

(*E*)-3-(Furan-2-ylmethylene)-2-(hydroxy(phenyl)phosphoryl)pyrrolidin-1-ium 2,2,2-trifluoroacetate **3d**: white solid, yield 91%, mp 232–234 °C. 1H NMR (600 MHz, DMSO- d_6) δ : 10.68 (s, 1H), 9.14 (s, 1H), 7.84–7.71 (m, 2H), 7.66–7.57 (m, 2H), 7.54–7.45 (m, 2H), 6.51–6.42 (m, 1H), 6.33 (s, 1H), 4.66 (d, 1H, J = 11.8 Hz), 3.34–3.15 (m, 2H), 2.85–2.73 (m, 1H), 2.60–2.51 (m, 1H). ^{13}C NMR (150 MHz, DMSO- d_6) δ : 146.4 (d, J = 4.2 Hz), 138.14, 128.13, 127.5 (d, J = 9.7 Hz), 125.6 (d, J = 2.7 Hz), 124.54, 123.7 (d, J = 12.7 Hz), 108.91, 107.09, 105.13, 55.3 (d, J = 97.5 Hz), 40.67, 23.93. ^{31}P NMR (161.9 MHz, DMSO- d_6) δ : 25.22 (s, 1s). MS (ESI), m/z : 329 $[M+K]^+$ (calc. for $C_{15}H_{17}NO_3P^+$, m/z : 290). Found (%): C, 50.79; H, 4.41; N, 3.32; P, 7.48. Calc. for $C_{17}H_{17}F_3NO_5P$ (%): C, 50.63; H, 4.25; N, 3.47; P, 7.68.

(*E*)-2-Dioctylphosphoryl-3-(4-methoxybenzylidene)pyrrolidin-1-ium 2,2,2-trifluoroacetate **3e**: white solid, yield 67%, mp 89–90 °C. 1H NMR (600 MHz, DMSO- d_6) δ : 7.32 (s, 1H), 7.30 (d, 2H, J = 8.7 Hz), 6.97 (d, 2H, J = 8.7 Hz), 4.70 (d, 1H, J = 4.6 Hz), 3.77 (s, 3H), 3.61–3.53 (m, 1H), 2.92–2.82 (m, 2H), 2.03–1.80 (m, 4H), 1.62–1.44 (m, 4H), 1.41–1.34 (m, 2H), 1.33–1.11 (m, 19H), 0.86 (t, 3H, J = 6.9 Hz), 0.82 (t, 3H, J = 7.1 Hz). ^{13}C NMR (150 MHz, DMSO- d_6) δ : 159.2, 131.3, 130.3, 129.1, 125.9, 114.6, 60.5 (d, J = 58.6 Hz), 55.6, 46.5, 31.7 (d, J = 12.2 Hz), 30.9, 30.8, 30.7, 29.0, 28.9, 28.8, 27.3 (d, J = 62.5 Hz), 25.7 (d, J = 66.6 Hz), 22.5 (d, J = 12.2 Hz), 21.4, 21.3, 21.2, 14.4, 14.3. ^{31}P NMR (161.9 MHz, DMSO- d_6) δ : 48.43 (s, 1s). MS (ESI), m/z : 463 $[M+H]^+$, 485 $[M+Na]^+$, 497 $[M+K]^+$ (calc. for $C_{28}H_{49}NO_2P^+$, m/z : 462). Found (%): C, 62.77; H, 8.81; N, 2.28; P, 5.26. Calc. for $C_{30}H_{49}F_3NO_4P$ (%): C, 62.59; H, 8.58; N, 2.43; P, 5.38.

(*E*)-2-Dioctylphosphoryl-3-(4-ethylbenzylidene)pyrrolidin-1-ium 2,2,2-trifluoroacetate **3f**: white solid, yield 80%, mp 79–81 °C. 1H NMR (600 MHz, $CDCl_3$) δ : 7.26–7.18 (m, 4H), 6.56 (s, 1H), 4.98 (d, 1H, J = 5.2 Hz), 3.80–3.68 (m, 1H), 3.37–3.28 (m, 1H), 3.09–2.92 (m, 2H), 2.68 (q, 2H, J = 7.6 Hz), 2.09–1.97 (m, 3H), 1.92–1.81 (m, 1H), 1.72–1.54 (m, 4H), 1.37–1.21 (m, 23H), 0.92–0.84 (m, 6H). ^{13}C NMR (150 MHz, $CDCl_3$) δ : 156.9 (q, J = 35.5 Hz), 139.2, 127.8 (d, J = 2.9 Hz), 126.3 (d, J = 4.9 Hz), 123.3, 122.9, 121.9 (d, J = 6.4 Hz), 111.4 (q, J = 292.8 Hz), 54.3 (d, J = 60.1 Hz), 40.9, 26.5, 26.5, 26.4, 25.8, 25.7, 25.6, 24.5, 23.9, 23.8, 23.8, 23.7, 23.7, 23.3, 21.9, 21.4, 20.5, 20.0, 17.3, 17.3, 16.1, 16.1, 16.0, 10.1, 8.8, 8.7. ^{31}P NMR (161.9 MHz, $CDCl_3$) δ : 51.12 (s, 1s). Found (%): C, 65.07; H, 9.12; N, 2.58; P, 5.24. Calc. for $C_{31}H_{51}F_3NO_3P$ (%): C, 64.90; H, 8.96; N, 2.44; P, 5.40.

(*E*)-3-(4-Bromobenzylidene)-2-(dioctylphosphoryl)pyrrolidin-1-ium 2,2,2-trifluoroacetate **3g**: white solid, yield 91%, mp 88–99 °C. 1H NMR (600 MHz, DMSO- d_6) δ : 7.59 (d, 2H, J = 8.5 Hz), 7.32 (d, 2H, J = 8.6 Hz), 6.73 (s, 1H), 4.75 (d, 1H, J = 5.1 Hz), 3.56–3.60 (m, 1H), 3.28–3.32 (m, 1H), 2.81–2.93 (m, 2H), 1.86–2.03 (m, 4H), 1.44–1.58 (m, 4H), 1.34–1.41 (m, 2H), 1.15–1.32 (m, 18H), 0.80–0.89 (m, 6H). ^{13}C NMR (150 MHz, DMSO- d_6) δ : 158.9 (d, J = 31.5 Hz), 135.7, 135.3 (d, J = 5.2 Hz), 132.0, 130.9, 125.1 (d, J = 6.2 Hz), 121.2, 117.6 (q, J = 299.3 Hz), 60.4 (d, J = 57.7 Hz), 46.5, 31.7 (d, J = 10.4 Hz), 30.8, 30.7, 29.2, 28.9, 28.8, 27.2 (d, J = 62.8 Hz), 25.8 (d, J = 65.8 Hz), 22.5 (d, J = 10.2 Hz), 21.4, 21.3, 21.2, 14.4, 14.3. ^{31}P NMR (161.9 MHz, DMSO- d_6) δ : 48.42 (s, 1s). MS (ESI), m/z : 511 $[M+H]^+$, 533 $[M+Na]^+$ (calc. for $C_{27}H_{46}BrNOP^+$, m/z : 510). Found (%): C, 55.89; H, 7.51; Br, 12.65; N, 2.11; P, 5.13. Calc. for $C_{29}H_{46}BrF_3NO_3P$ (%): C, 55.77; H, 7.42; Br, 12.79; N, 2.24; P, 4.96.

(*E*)-2-Dioctylphosphoryl-3-(thiophen-2-ylmethylene)pyrrolidin-1-ium 2,2,2-trifluoroacetate **3h**: white solid, yield 77%, mp 92–93 °C. 1H NMR (600 MHz, DMSO- d_6) δ : 9.72 (s, 2H), 7.64 (d, 1H, J = 5.0 Hz), 7.20–7.13 (m, 2H), 7.01 (s, 1H), 4.77 (d, 1H, J = 5.0 Hz), 3.66–3.58 (m, 1H), 3.52–3.46 (m, 1H), 2.97–2.89 (m, 1H), 2.85–2.75 (m, 1H), 2.06–1.79 (m, 4H), 1.59–1.35 (m, 6H), 1.31–1.15 (m, 18H), 0.89–0.82 (m, 6H). ^{13}C NMR (150 MHz, DMSO- d_6) δ : 153.6 (q, J = 31.6 Hz), 134.6, 126.3 (d, J = 5.3 Hz), 123.2, 122.9, 122.3, 114.2, 112.3 (q, J = 301.2 Hz), 54.6 (d, J = 57.7 Hz), 41.1, 26.4, 26.4, 25.5, 25.5, 25.43, 25.4, 24.2, 23.6, 23.6, 23.6, 23.5, 22.2, 21.9 (d, J = 62.2 Hz), 20.6 (d, J = 65.4 Hz), 17.2, 16.1, 16.1, 15.9, 15.9, 9.1. ^{31}P NMR (161.9 MHz, DMSO- d_6) δ : 48.58 (s, 1s). MS (ESI), m/z : 438 $[M]^+$, 461 $[M+Na]^+$ (calc. for $C_{25}H_{45}NOP^+$, m/z : 438). Found (%): C, 58.97; H, 8.45; N, 2.37; P, 5.52; S, 6.05. Calc. for $C_{27}H_{45}F_3NO_3PS$ (%): C, 58.78; H, 8.22; N, 2.54; P, 5.61; S, 5.81.

(*E*)-2-Dioctylphosphoryl-3-(pyridin-3-ylmethylene)pyrrolidin-1-ium 2,2,2-trifluoroacetate **3i**: white solid, yield 62%, mp 53–55 °C. 1H NMR (600 MHz, DMSO- d_6) δ : 8.60 (s, 1H), 8.50 (d, 1H, J = 4.8 Hz), 7.82 (d, 1H, J = 7.9 Hz), 7.49–7.40 (m, 1H), 6.79 (s, 1H), 4.82 (d, 1H, J = 6.1 Hz), 3.65–3.55 (m, 1H), 3.41–3.31 (m, 1H), 3.02–2.95 (m, 1H), 2.92–2.83 (m, 1H), 2.06–1.87 (m, 4H), 1.59–1.45 (m, 4H), 1.36–1.15 (m, 20H), 0.87–0.80 (m, 6H). ^{13}C NMR (150 MHz, DMSO- d_6) δ : 159.1 (q, J = 32.1 Hz), 149.6, 148.4, 136.9 (d, J = 5.0 Hz), 135.9, 132.4,

124.2, 122.8 (d, $J = 6.2$ Hz), 117.5 (q, $J = 298.2$ Hz), 60.2 (d, $J = 57.2$ Hz), 46.4, 31.7, 31.6, 30.8, 30.8, 30.8, 30.7, 29.3, 28.9, 28.9, 28.9, 27.1 (d, $J = 63.1$ Hz), 25.9 (d, $J = 65.5$ Hz), 22.5, 22.5, 21.4, 21.4, 21.2, 21.2, 14.4, 14.3. ^{31}P NMR (161.9 MHz, $\text{DMSO-}d_6$) δ : 48.38 (s, 1s). MS (ESI), m/z : 456 $[\text{M}+\text{Na}]^+$ (calc. for $\text{C}_{26}\text{H}_{46}\text{N}_2\text{OP}^+$, m/z : 433). Found (%): C, 61.70; H, 8.64; N, 4.90; P, 5.89. Calc. for $\text{C}_{28}\text{H}_{46}\text{F}_3\text{N}_2\text{O}_3\text{P}$ (%): C, 61.52; H, 8.48; N, 5.12; P, 5.67.

Cytotoxicity assay.

The toxic effect on cells was determined using the colorimetric method of cell proliferation thiazolyl blue tetrazolium bromide (MTT) (Sigma-Aldrich). For this, 10 μL of MTT reagent in Hank's balanced salt solution (HBSS) (final concentration 0.5 mg/ml) was added to each well. The plates were incubated at 37 °C for 2–3 h in an atmosphere humidified with 5% CO_2 . Absorbance was recorded at 540 nm using an Invitrologic microplate reader (Medical Biological Union, Novosibirsk, Russia). Experiments for all compounds were repeated three times. IC_{50} was calculated using an online tool: microscopy and analysis system – "Quest Graph™ IC_{50} Calculator" AAT Bioquest, Inc 11 May, 2022, <https://www.aatbio.com/tools/ic50-calculator>. 4,6-Diamidino-2-phenylindole (DAPI) and propidium iodide were purchased from Sigma-Aldrich. The M-HeLa clone 11 human, epithelioid cervical carcinoma, strain of HeLa, clone of M-HeLa; human duodenal cancer cell line (HuTu 80) from the Type Culture Collection of the Institute of Cytology (Russian Academy of Sciences, Moscow, Russia) and Chang liver cell line (Human liver cells) from N.F. Gamaleya Research Center of Epidemiology and Microbiology (Moscow, Russia) were used in the experiments. For the experiments we used tumor cell cultures HL-60 – human, peripheral blood, promyelocytic leukemia; RPMI 1788 - human, healthy donor peripheral blood leukocytes from the Type Culture Collection of the Institute of Cytology (Russian Academy of Sciences).

The cells were cultured in a standard Eagle's nutrient medium manufactured at the Chumakov Institute of Poliomyelitis and Virus Encephalitis (PanEco, Moscow, Russia) and supplemented with 10% fetal calf serum (Thermo Fisher Scientific, Waltham, MA, USA) and 1% nonessential amino acids (Thermo Fisher Scientific). The cells were plated into a 96-well plate (Nunc, Roskilde, Denmark) at a concentration of 1×10^5 cells/mL, 150 μL of medium per well, and cultured in a CO_2 incubator at 37 °C. 24 h after seeding the cells into wells, the compound under study was added at a preset dilution, 150 μL to each well. The dilutions of the compounds were prepared immediately in nutrient media; 5% DMSO that does not induce inhibition of cells at this concentration was added for better solubility. The experiments were repeated three times. Intact cells cultured in parallel with experimental cells were used as a control

Copies of ^1H , ^{13}C , ^{31}P NMR spectra

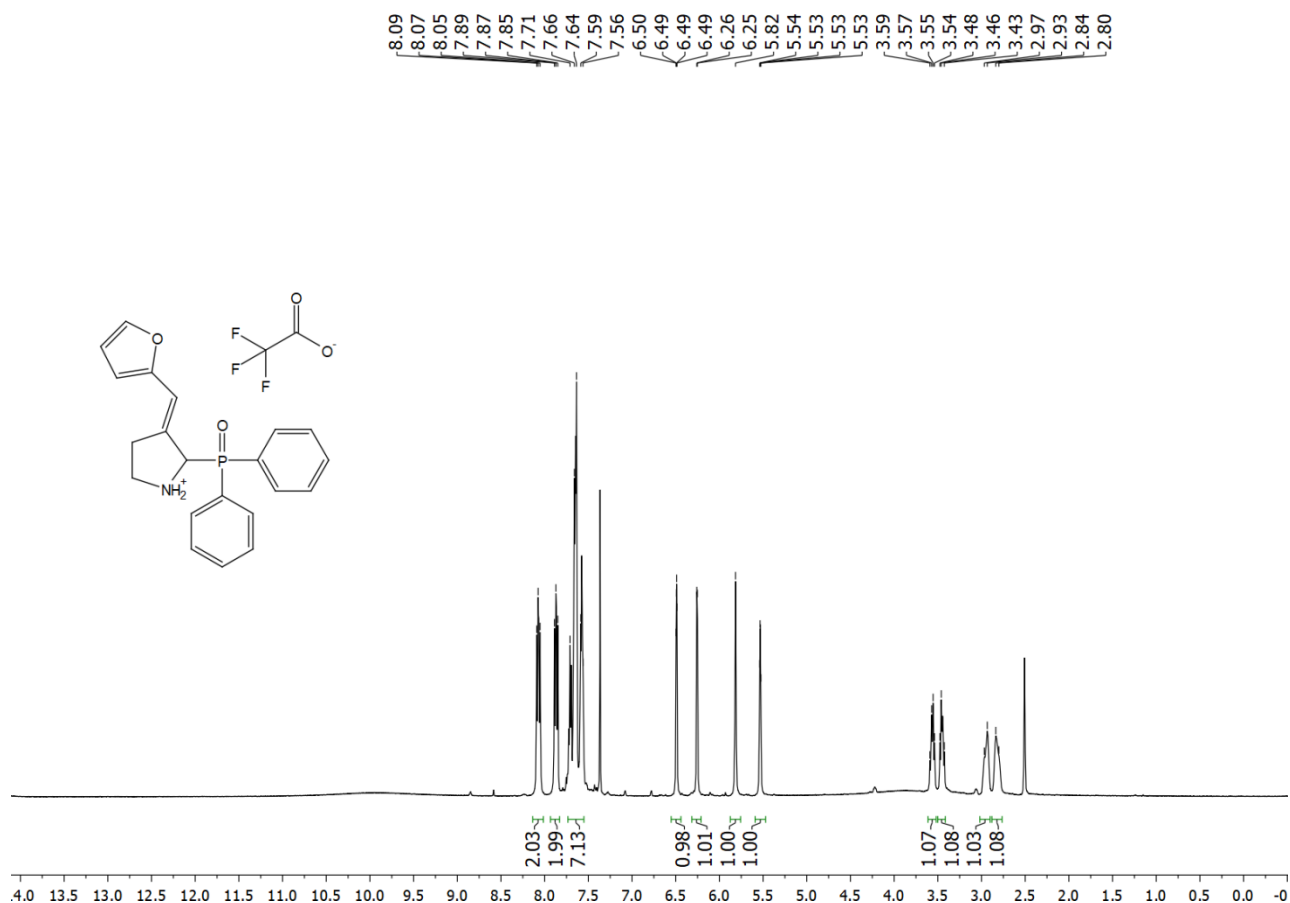


Figure S1. ^1H NMR (DMSO- d_6 , 400 MHz) spectrum of the compound 3a

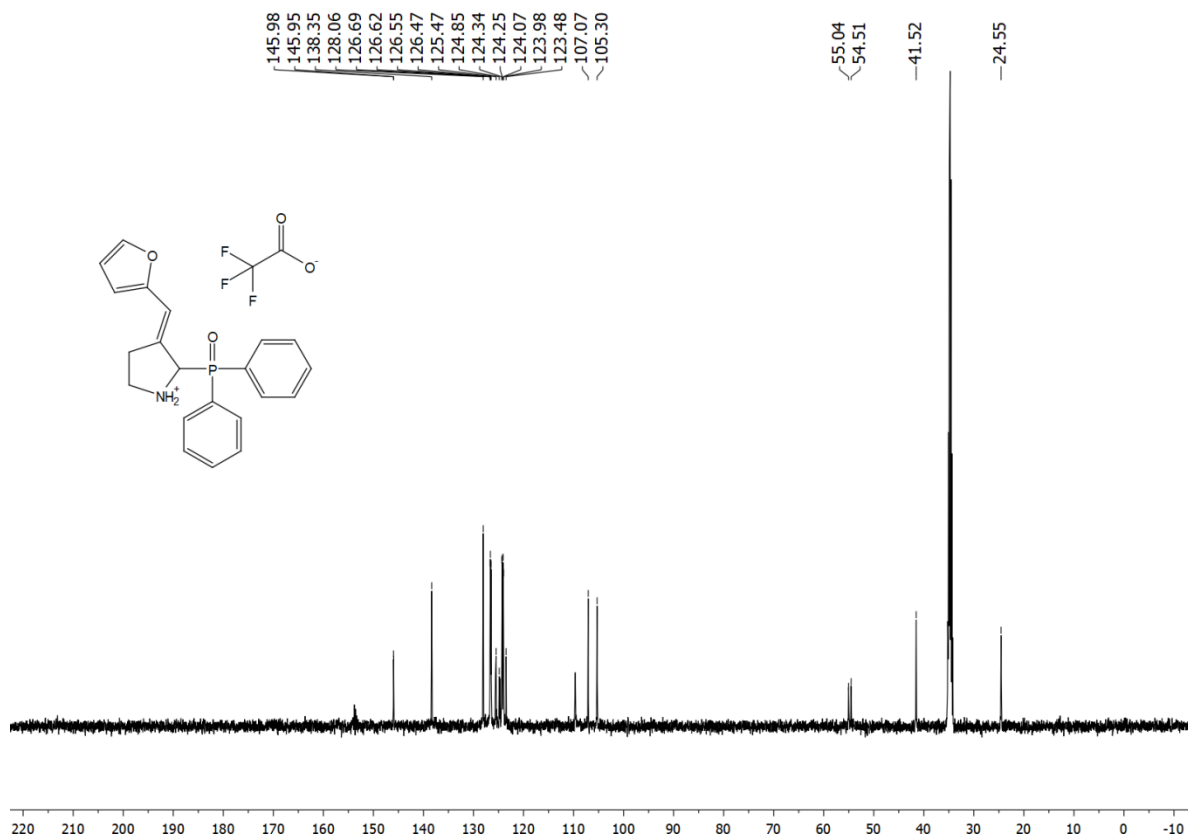


Figure S2. $^{13}\text{C}\{^1\text{H}\}$ NMR (DMSO- d_6 , 150 MHz) spectrum of the compound 3a

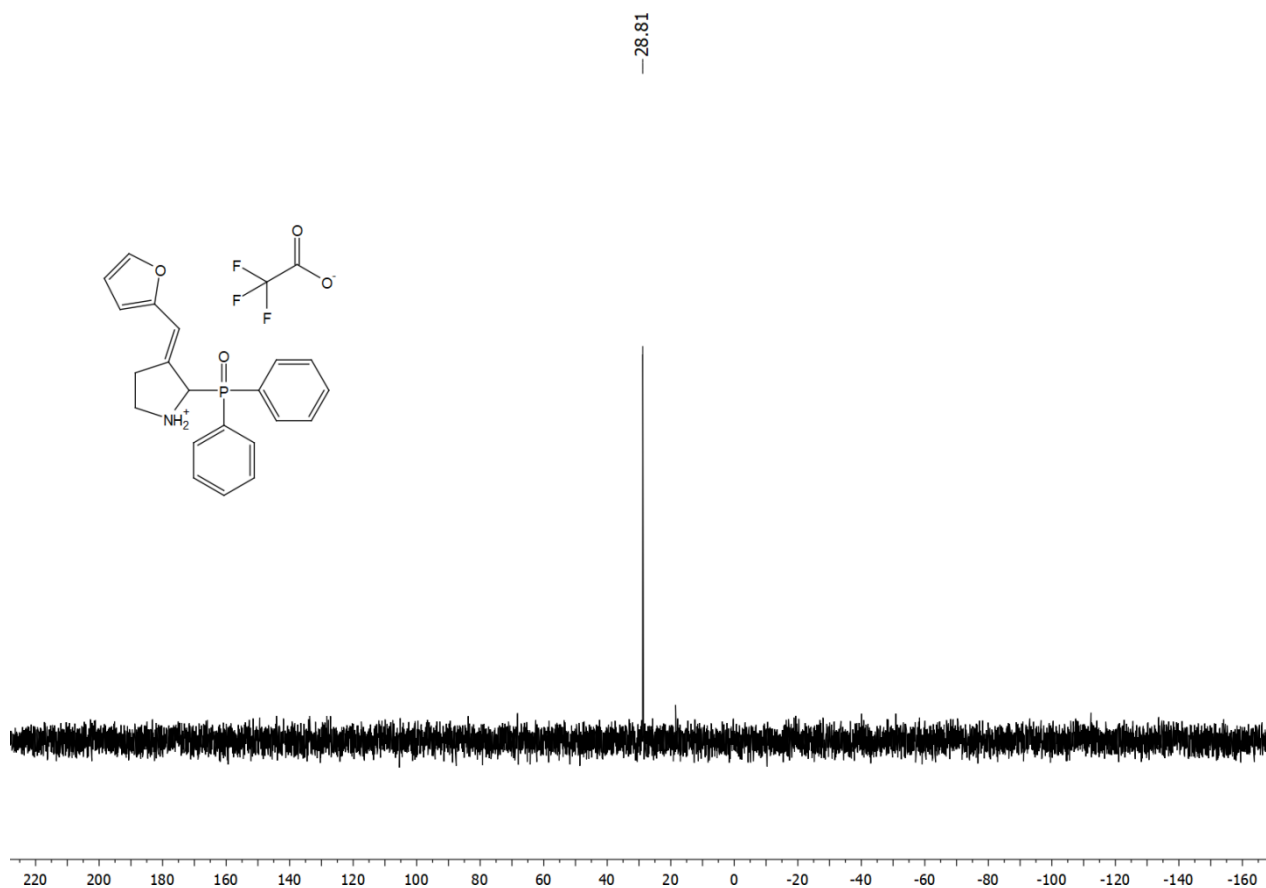


Figure S3. $^{31}\text{P}\{^1\text{H}\}$ NMR (DMSO- d_6 , 161 MHz) spectrum of the compound **3a**

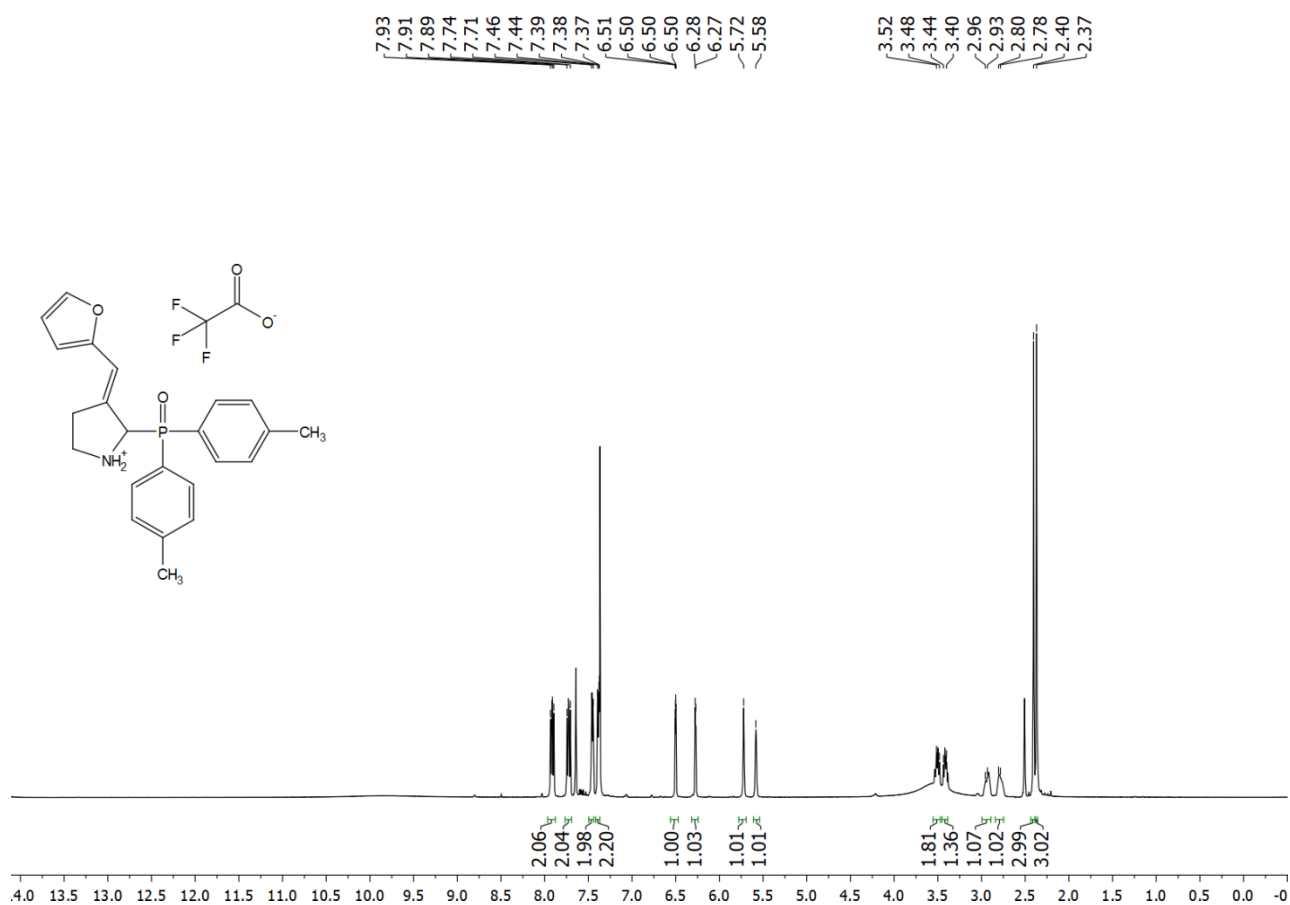


Figure S4. ^1H NMR (DMSO- d_6 , 400 MHz) spectrum of the compound **3b**

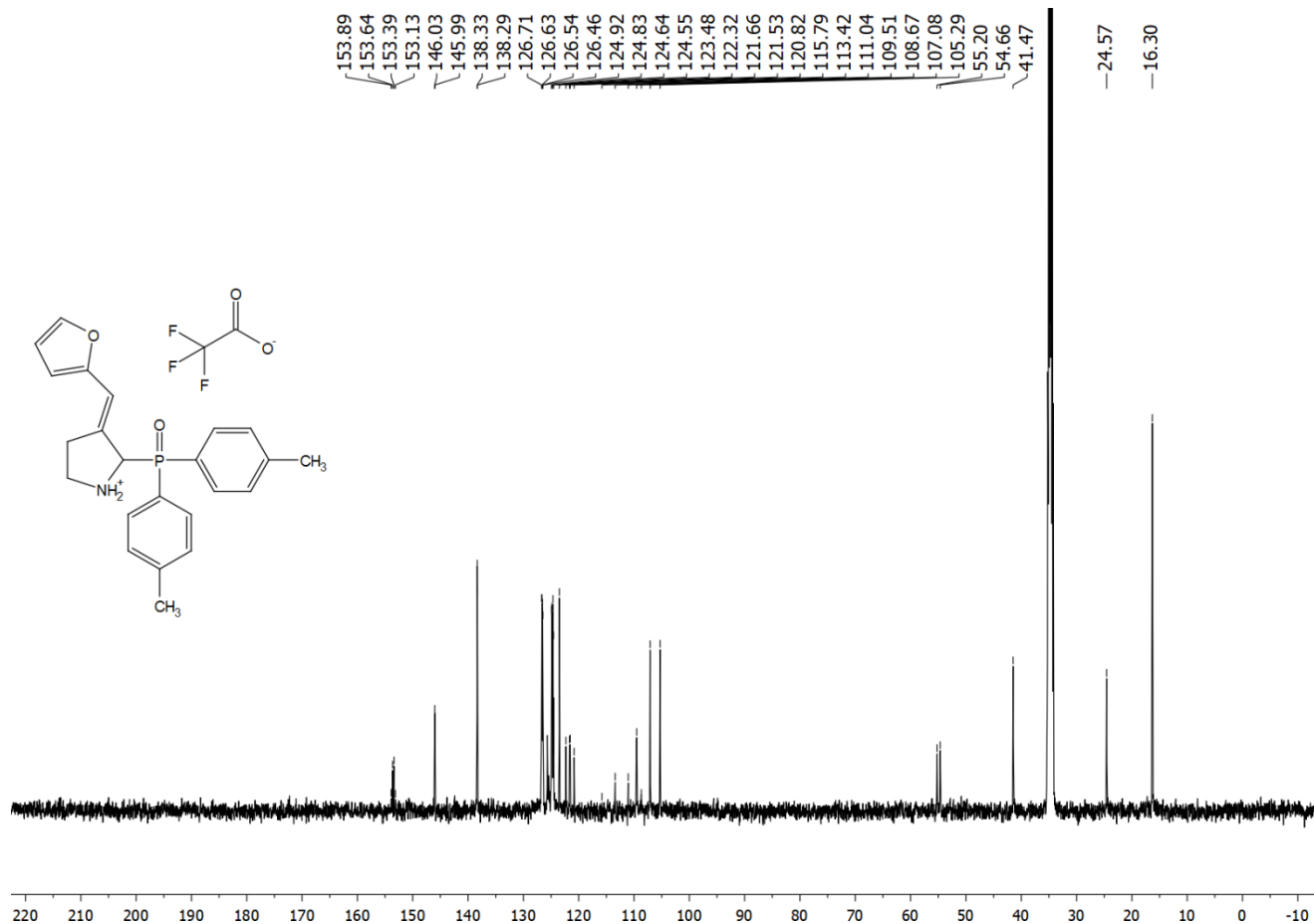


Figure S5. ¹³C{¹H} NMR (DMSO-*d*₆, 150 MHz) spectrum of the compound **3b**

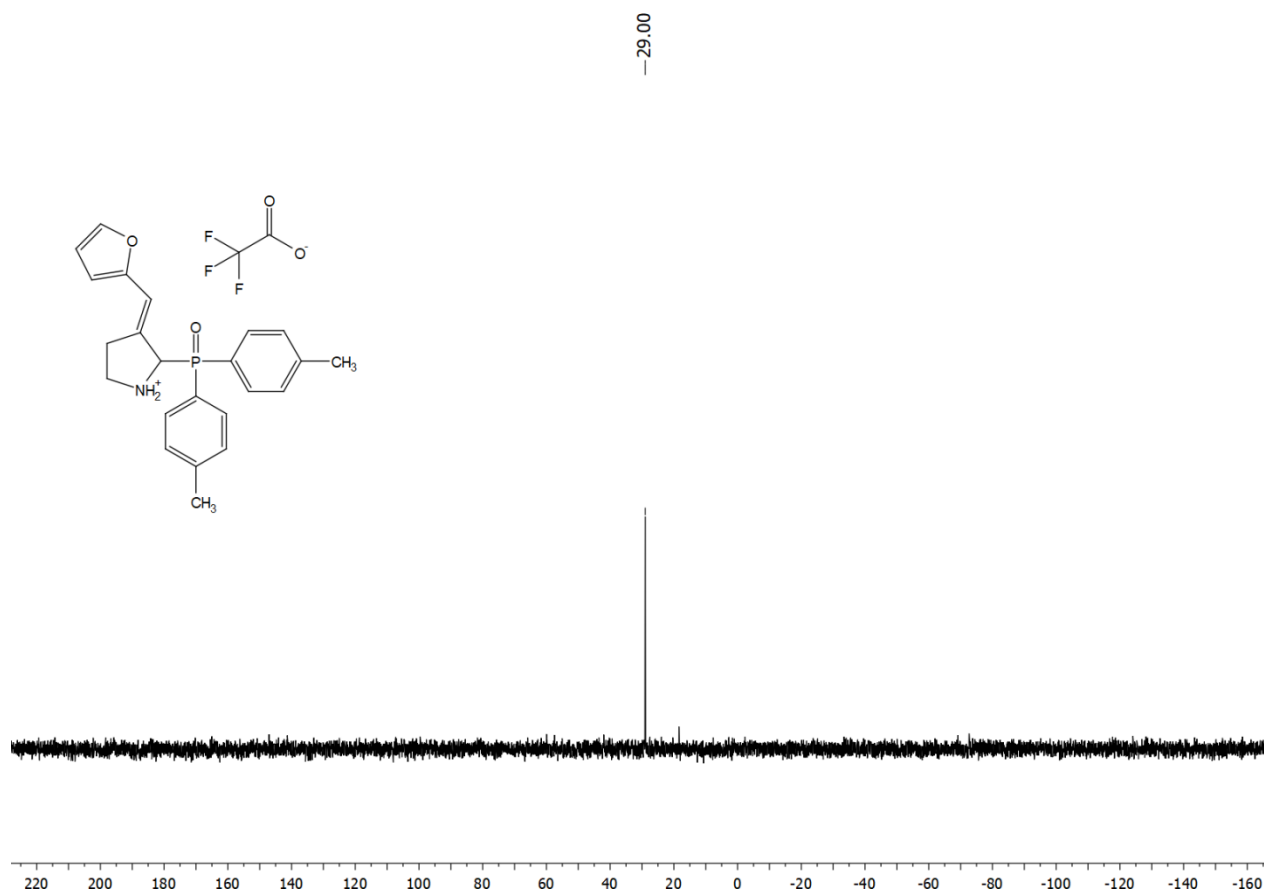


Figure S6. ³¹P{¹H} NMR (DMSO-*d*₆, 161 MHz) spectrum of the compound **3b**

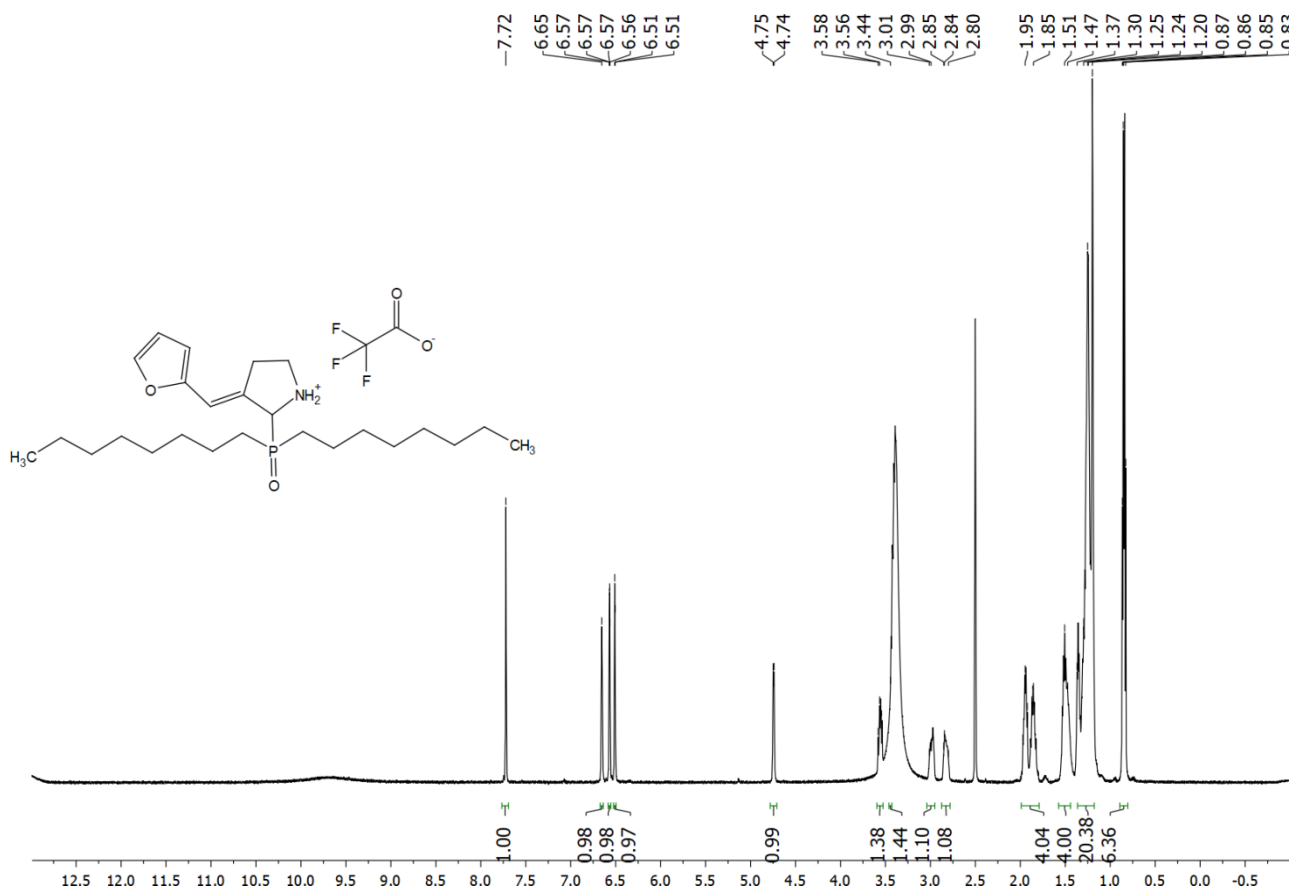


Figure S7. ¹H NMR (DMSO-*d*₆, 400 MHz) spectrum of the compound **3c**

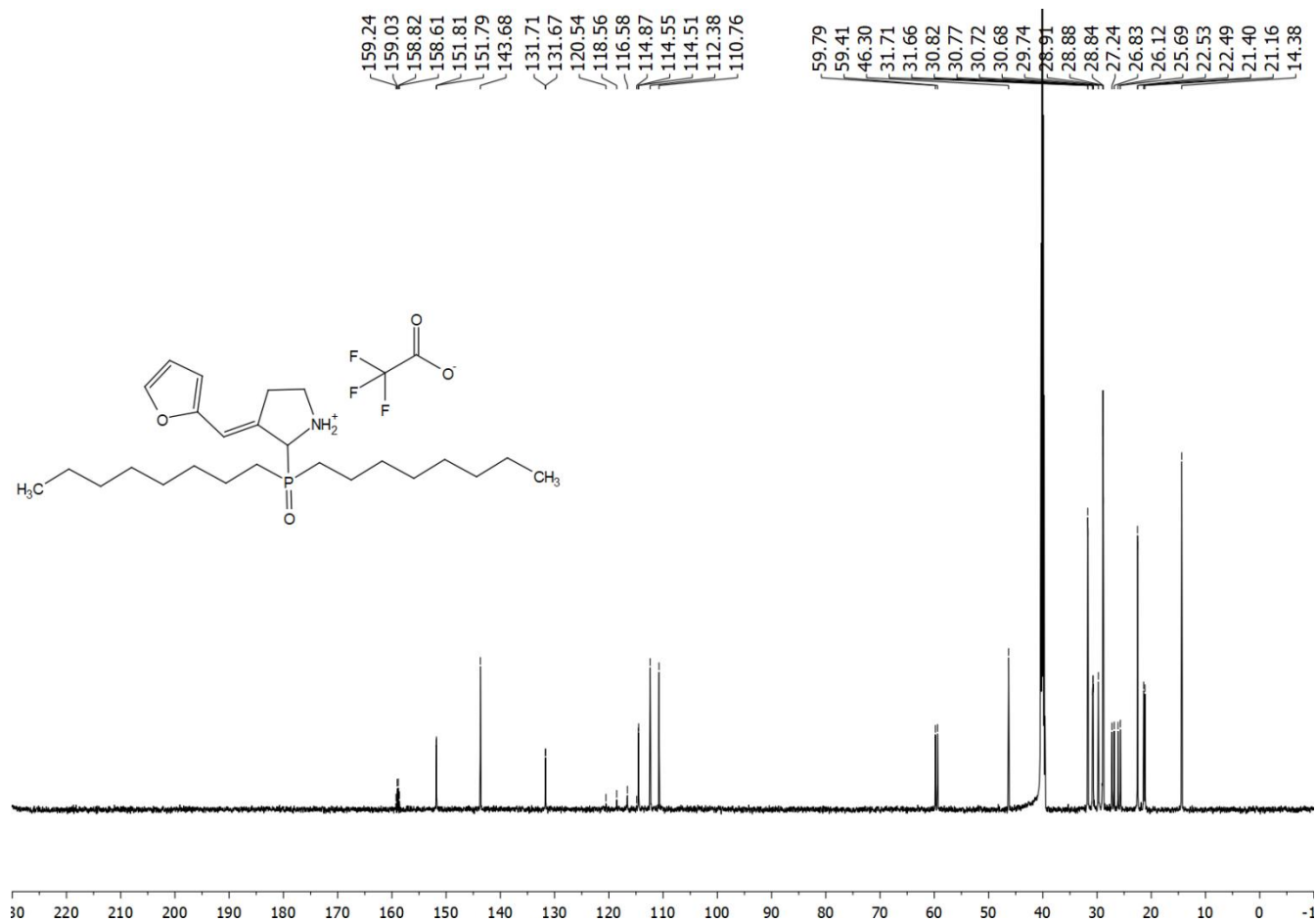


Figure S8. ¹³C{¹H} NMR (DMSO-*d*₆, 150 MHz) spectrum of the compound **3c**

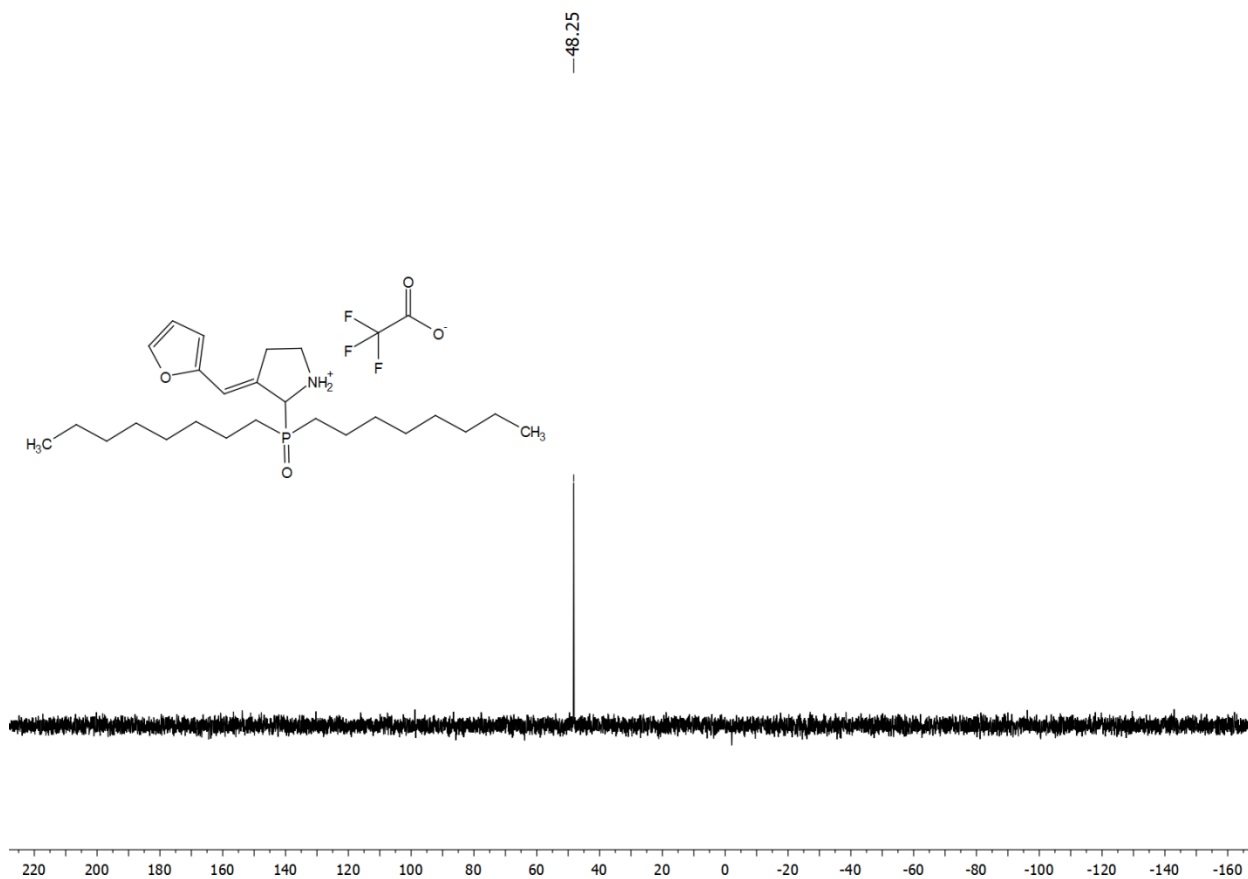


Figure S9. $^{31}\text{P}\{^1\text{H}\}$ NMR (DMSO- d_6 , 161 MHz) spectrum of the compound **3c**

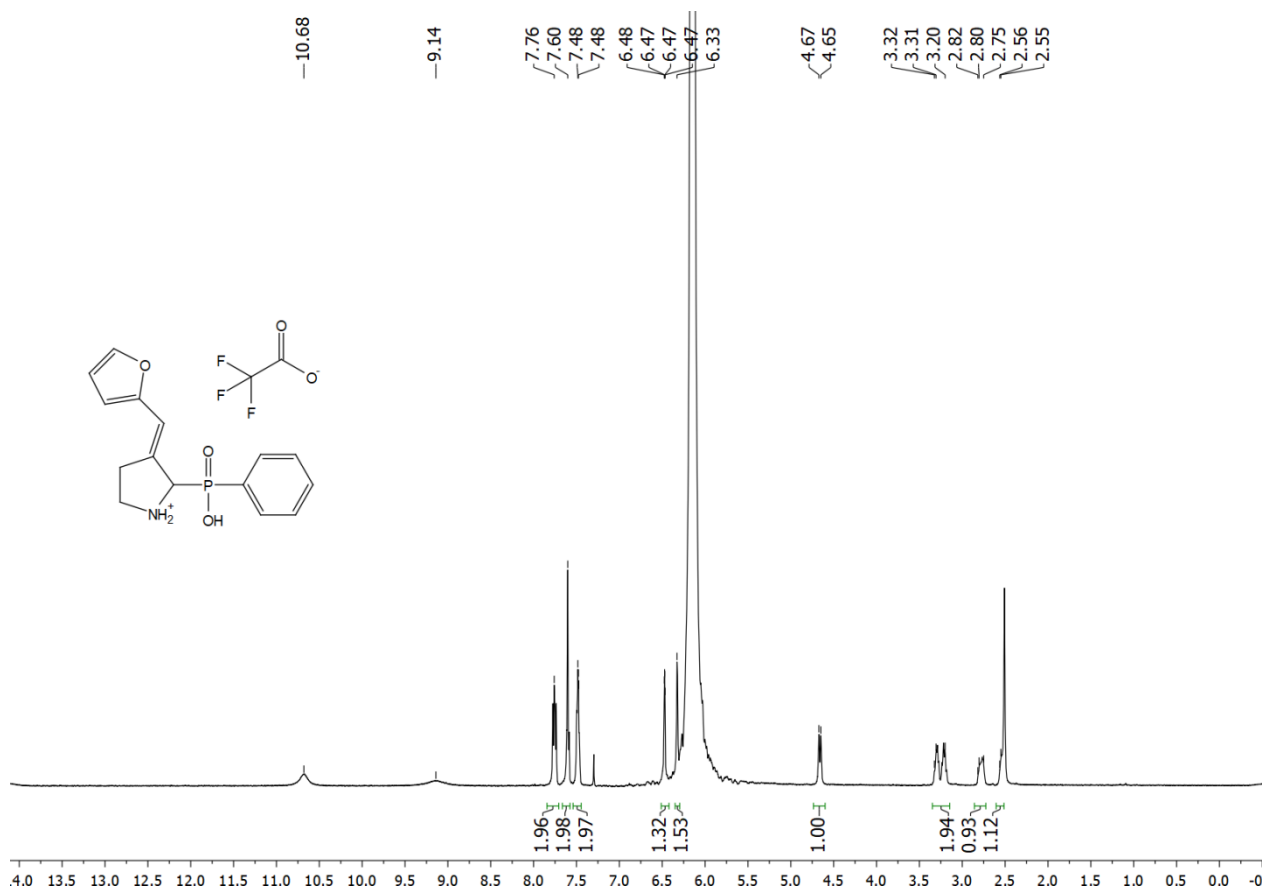


Figure S10. ^1H NMR (DMSO- d_6 , 400 MHz) spectrum of the compound **3d**

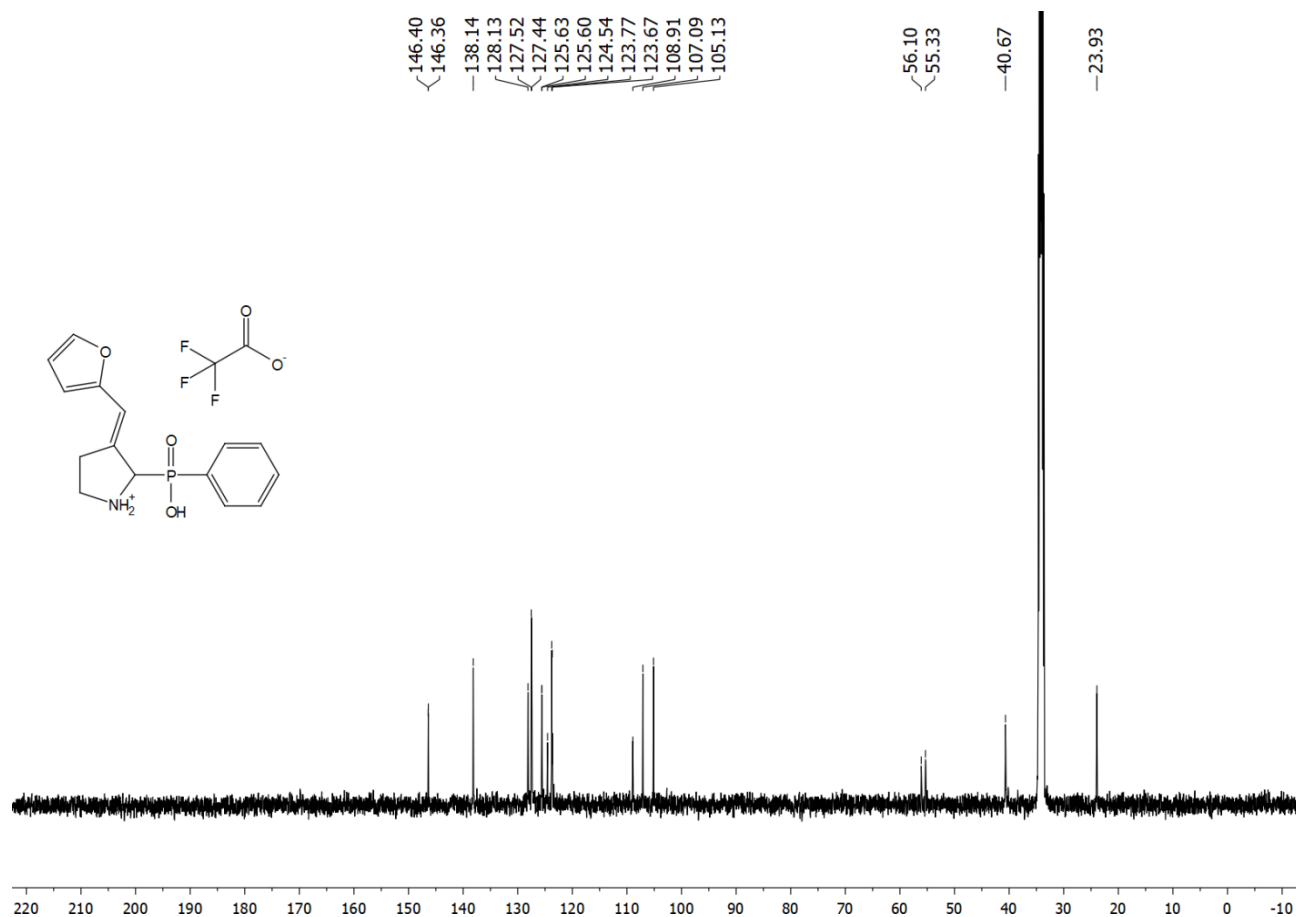


Figure S11. ¹³C{¹H} NMR (DMSO-*d*₆, 150 MHz) spectrum of the compound **3d**

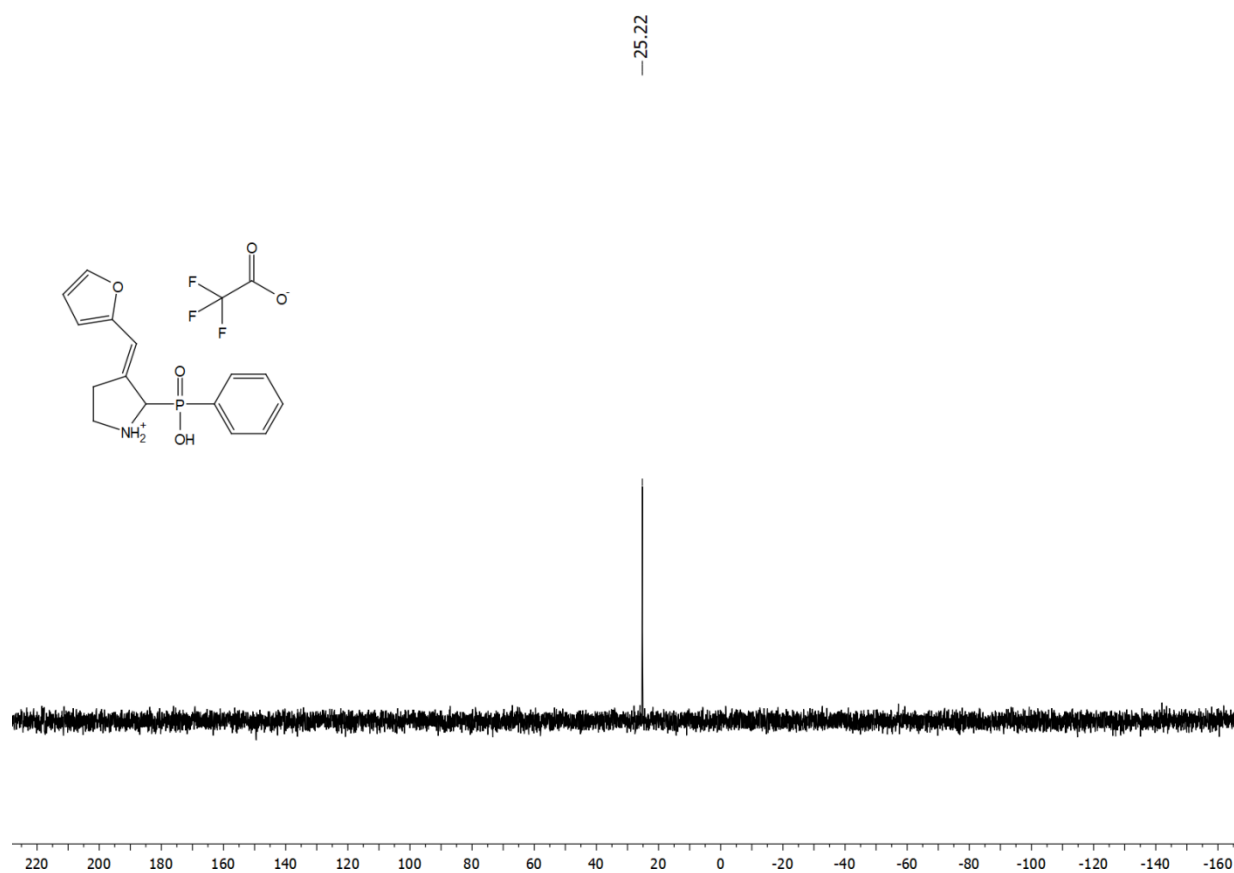


Figure S12. ³¹P{¹H} NMR (DMSO-*d*₆, 161 MHz) spectrum of the compound **3d**

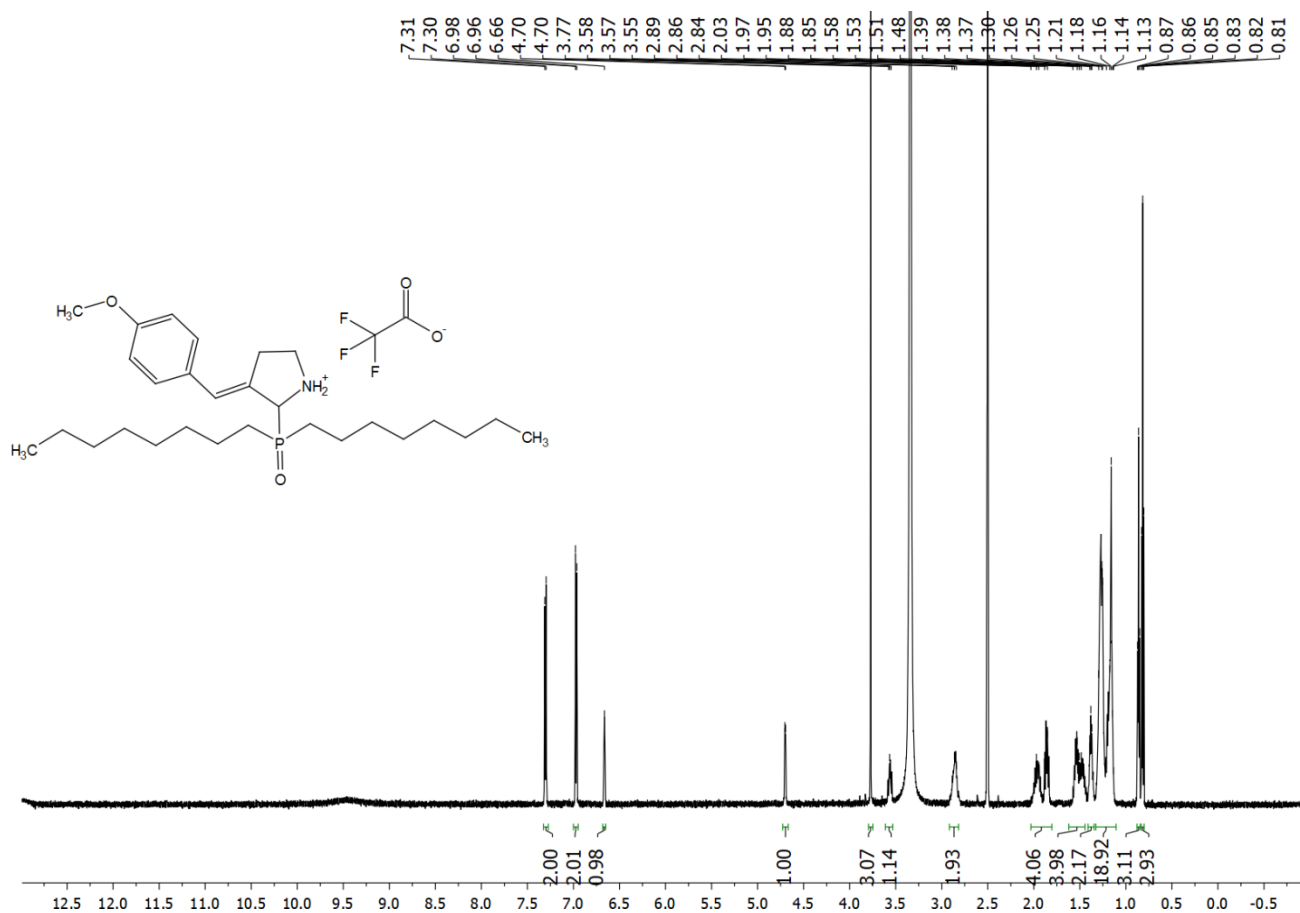


Figure S13. ¹H NMR (DMSO-*d*₆, 400 MHz) spectrum of the compound **3e**

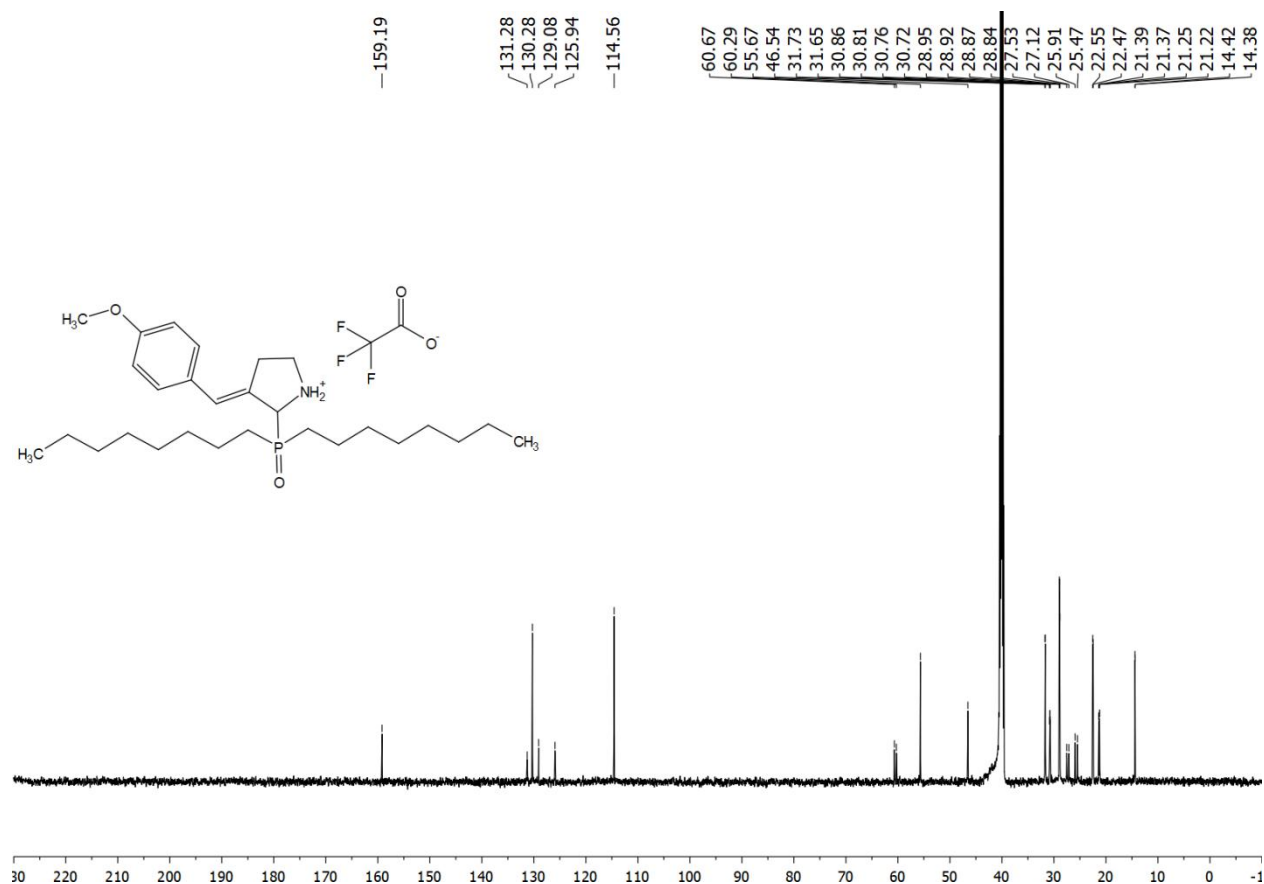


Figure S14. ¹³C{¹H} NMR (DMSO-*d*₆, 150 MHz) spectrum of the compound **3e**

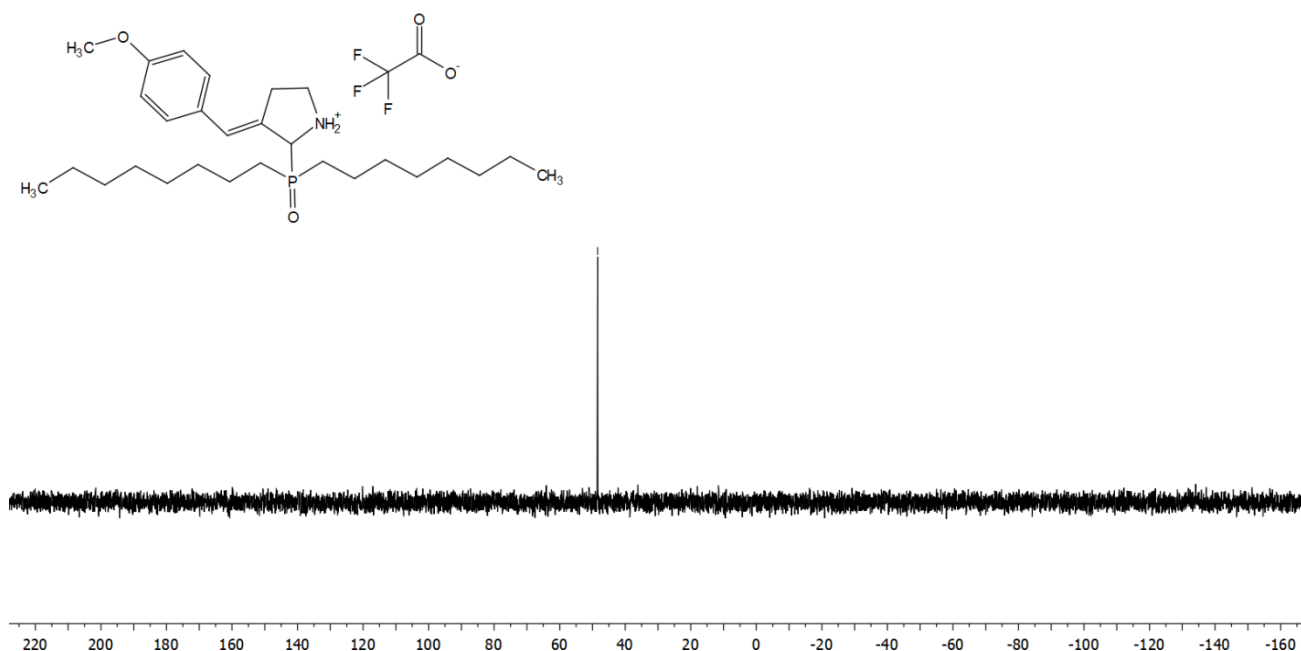


Figure S15. $^{31}\text{P}\{^1\text{H}\}$ NMR (DMSO- d_6 , 161 MHz) spectrum of the compound **3e**

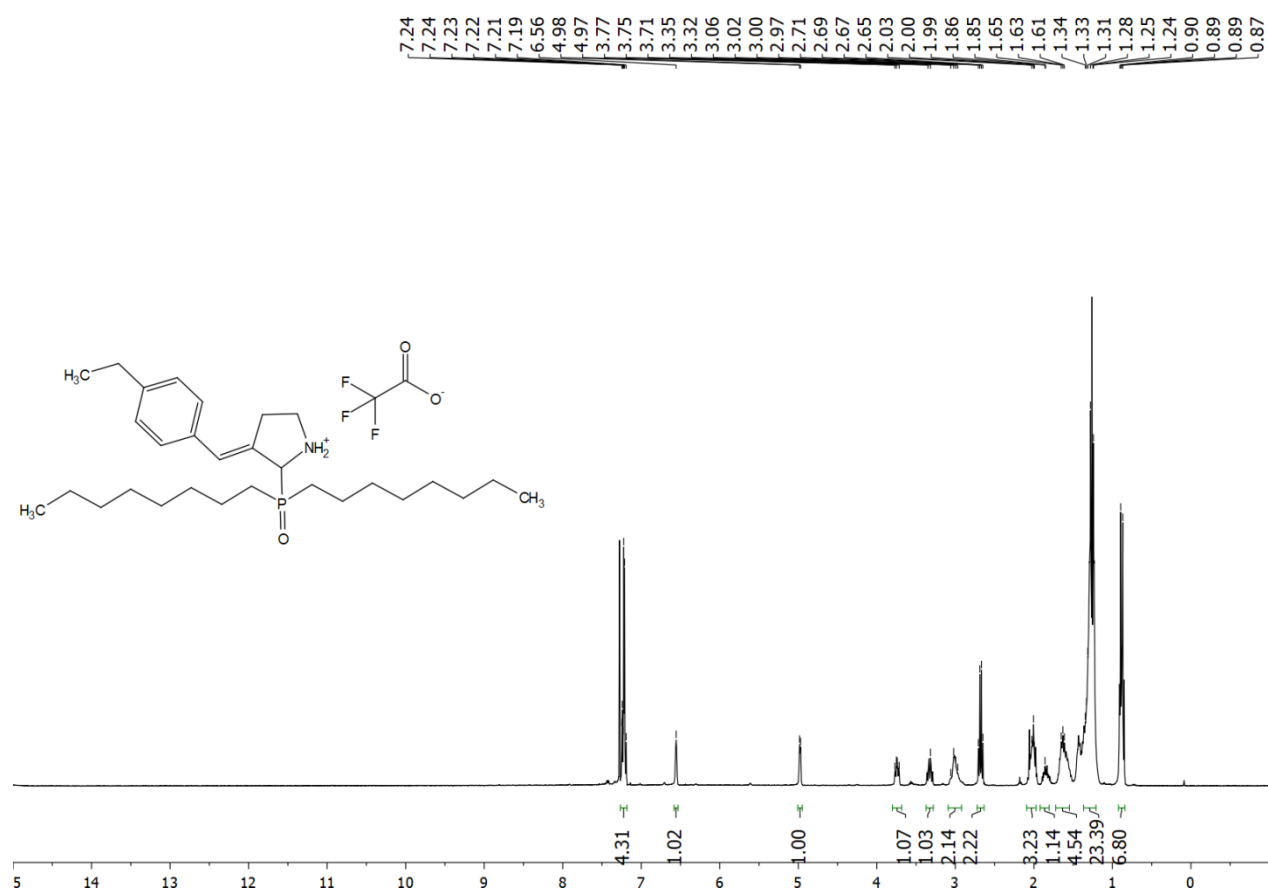


Figure S16. ^1H NMR (CDCl $_3$, 400 MHz) spectrum of the compound **3f**

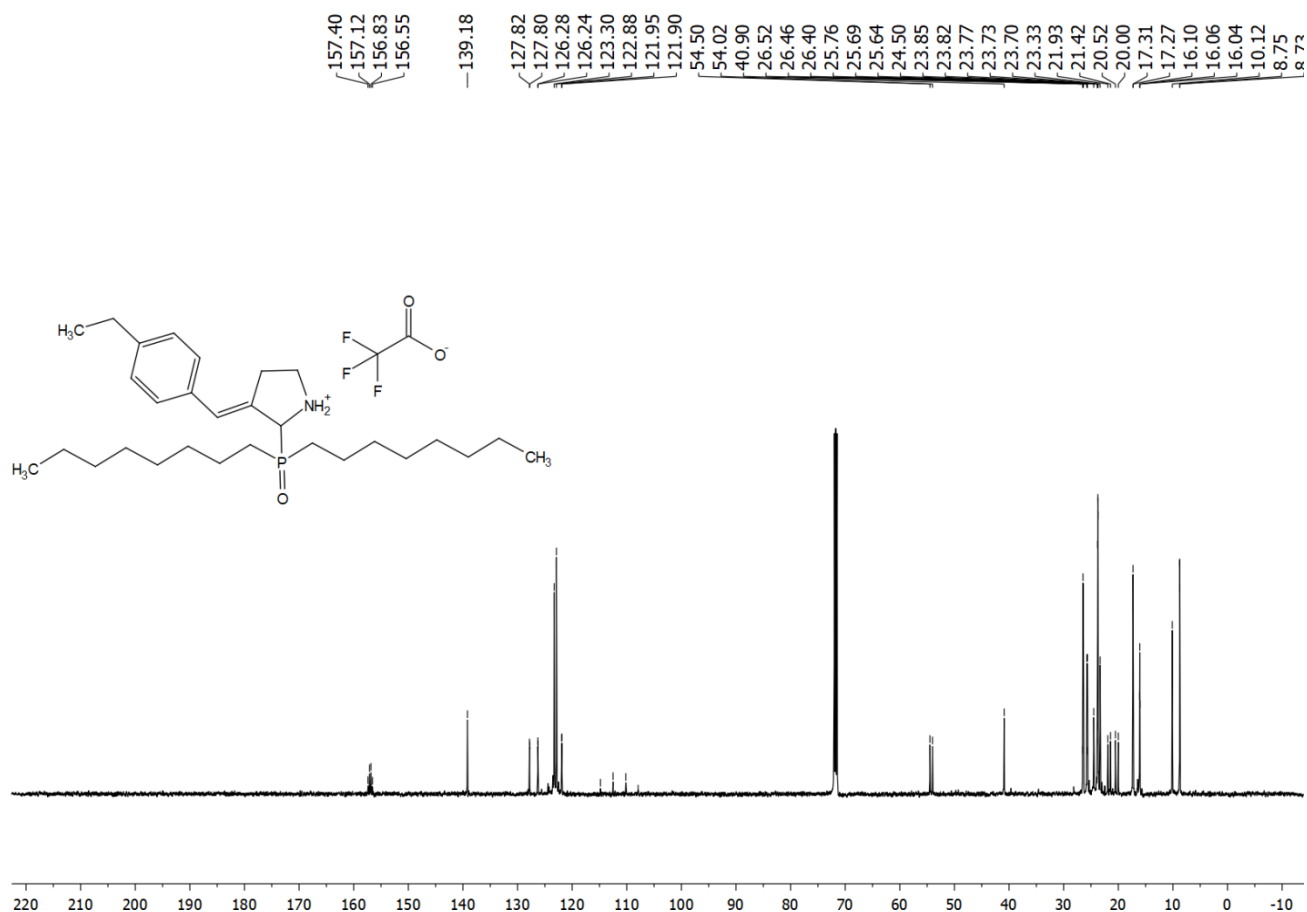


Figure S17. $^{13}\text{C}\{^1\text{H}\}$ NMR (CDCl₃, 150 MHz) spectrum of the compound **3f**

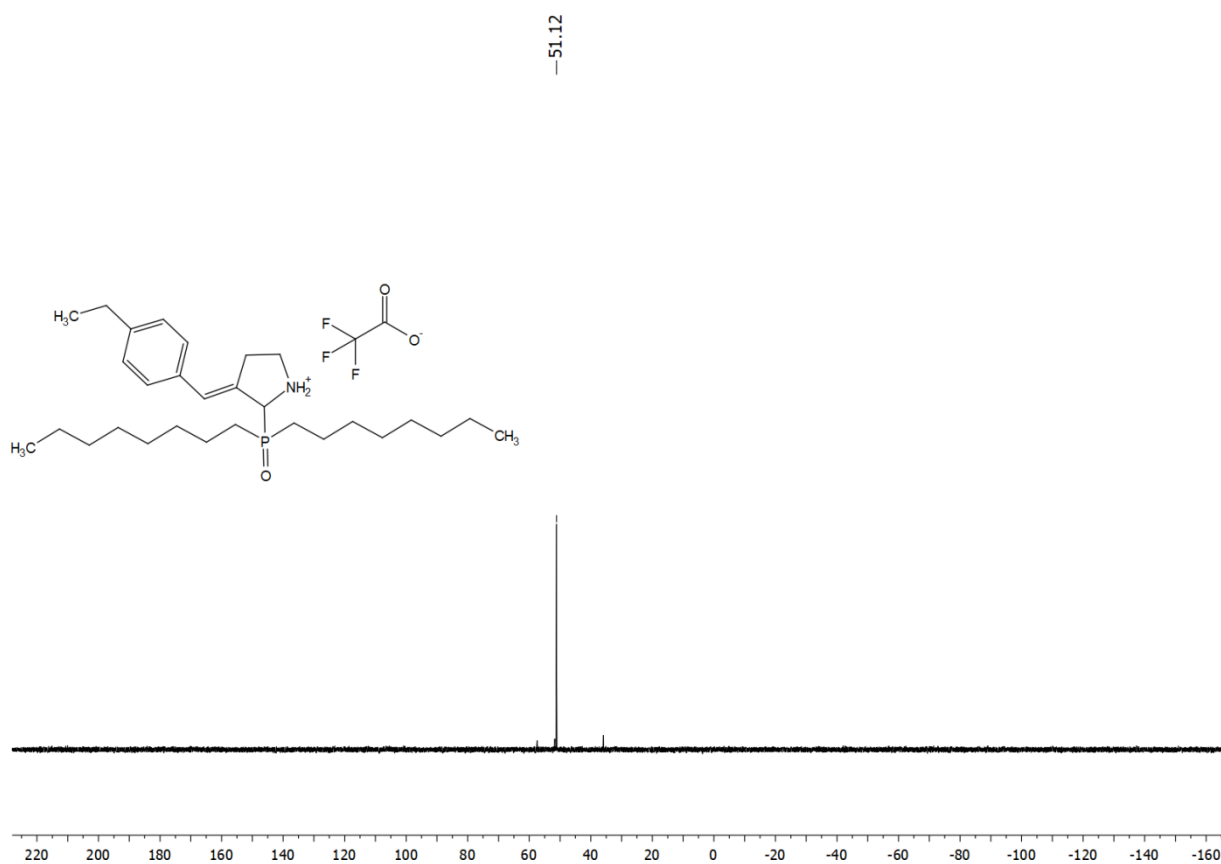


Figure S18. $^{31}\text{P}\{^1\text{H}\}$ NMR (CDCl₃, 161 MHz) spectrum of the compound **3f**

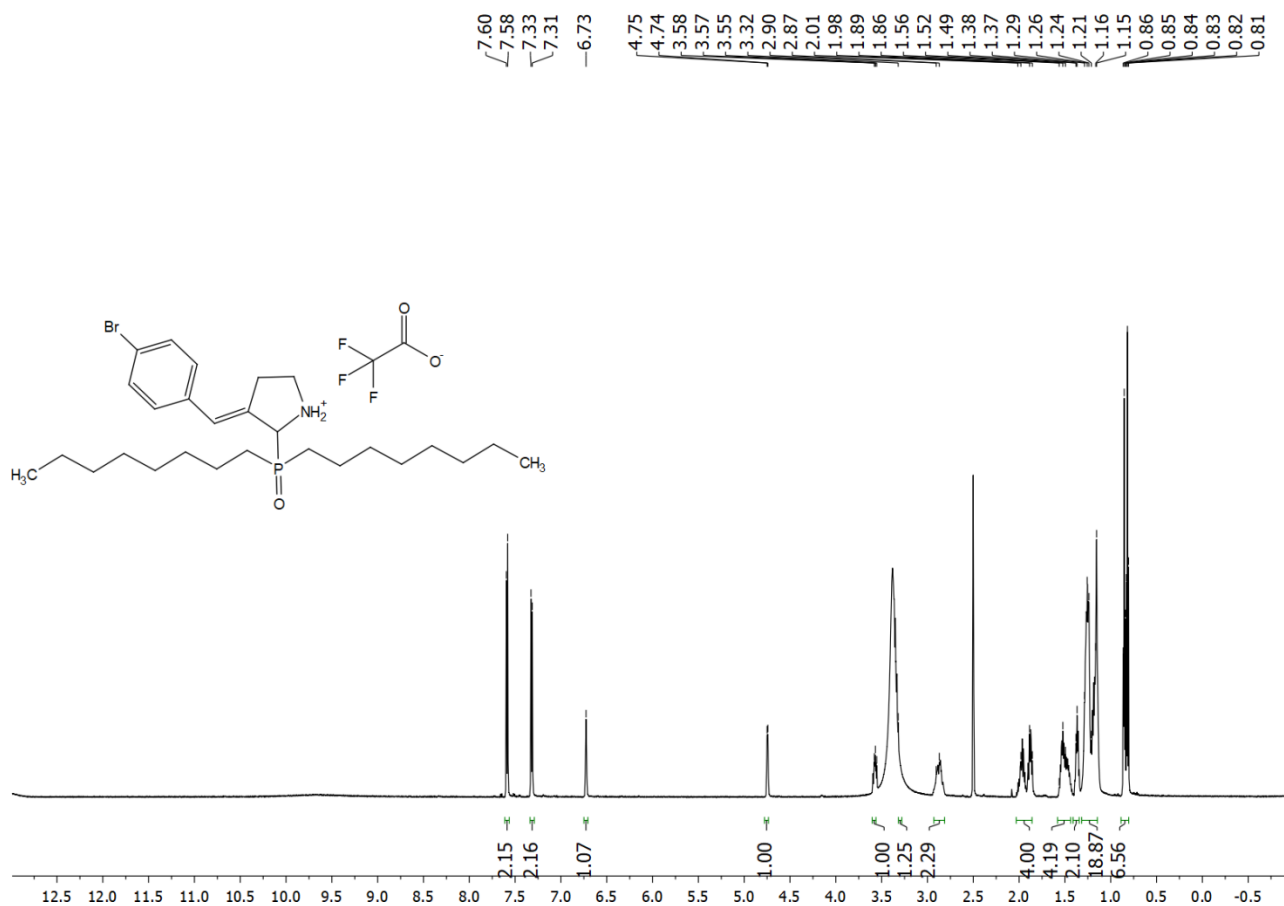


Figure S19. ¹H NMR (DMSO-*d*₆, 400 MHz) spectrum of the compound **3g**

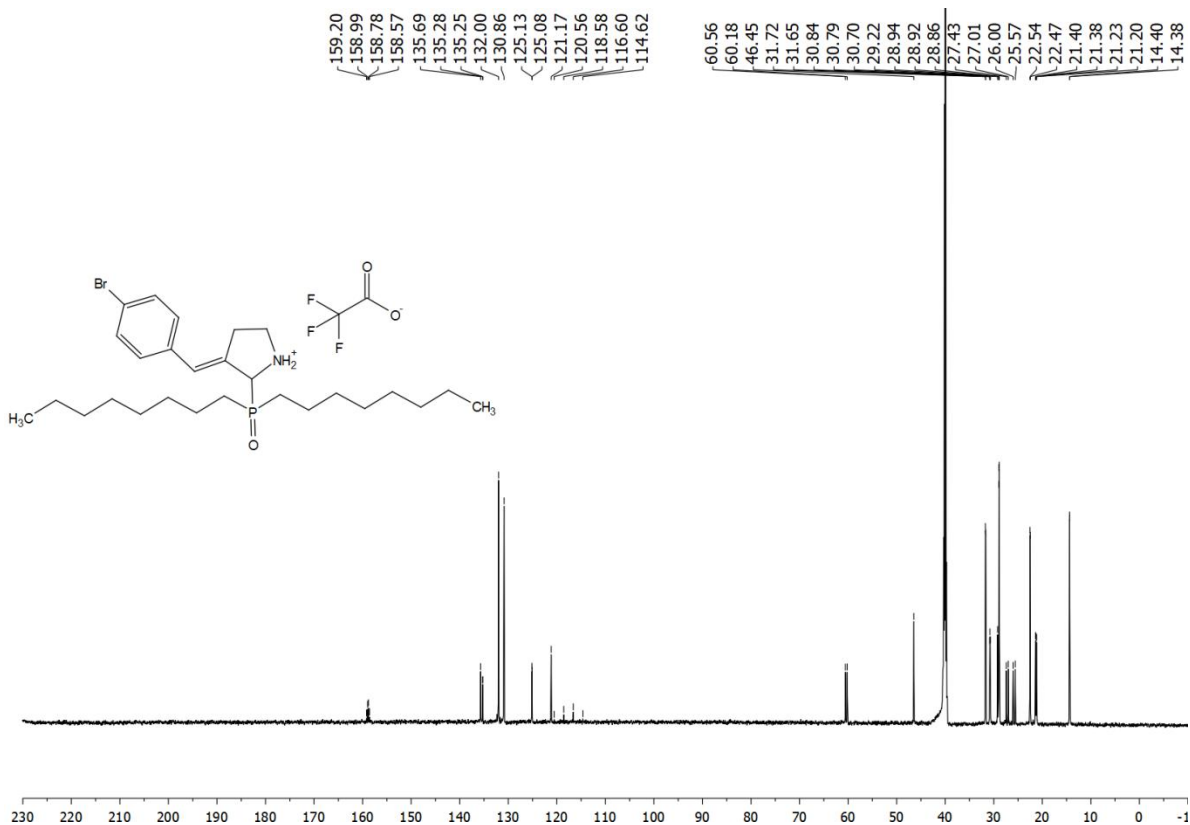


Figure S20. ¹³C{¹H} NMR (DMSO-*d*₆, 150 MHz) spectrum of the compound **3g**

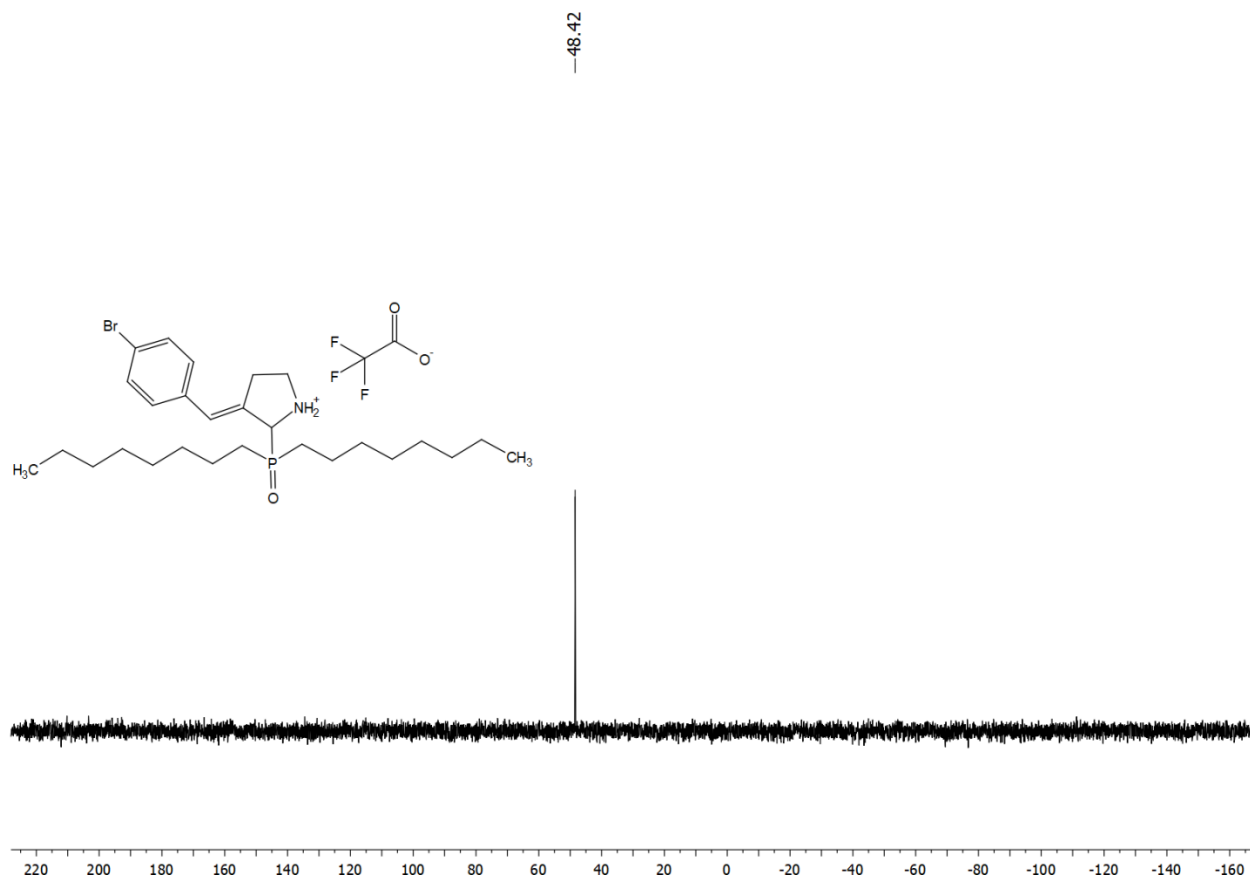


Figure S21. $^{31}\text{P}\{^1\text{H}\}$ NMR (DMSO- d_6 , 161 MHz) spectrum of the compound **3g**

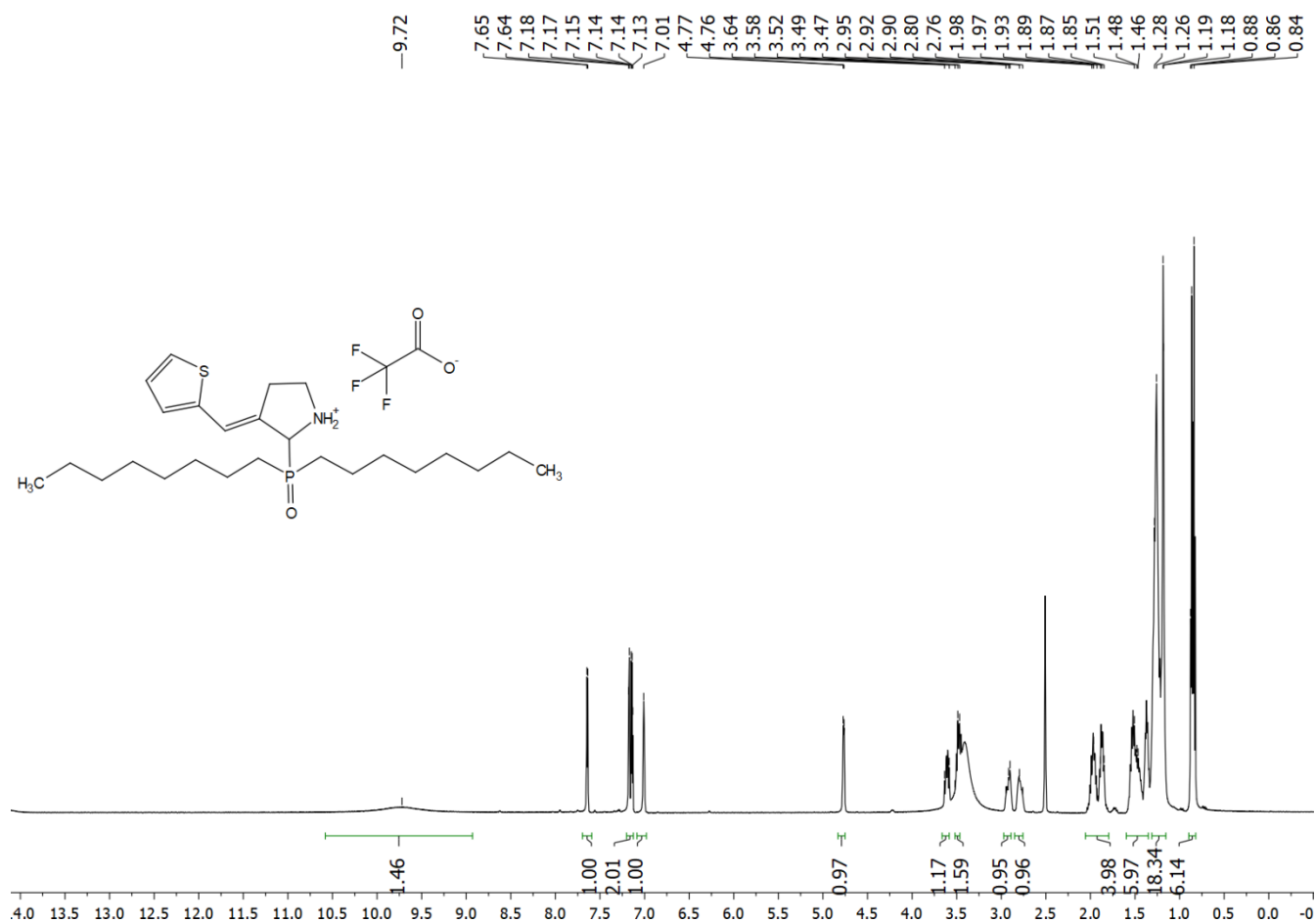


Figure S22. ^1H NMR (DMSO- d_6 , 400 MHz) spectrum of the compound **3h**

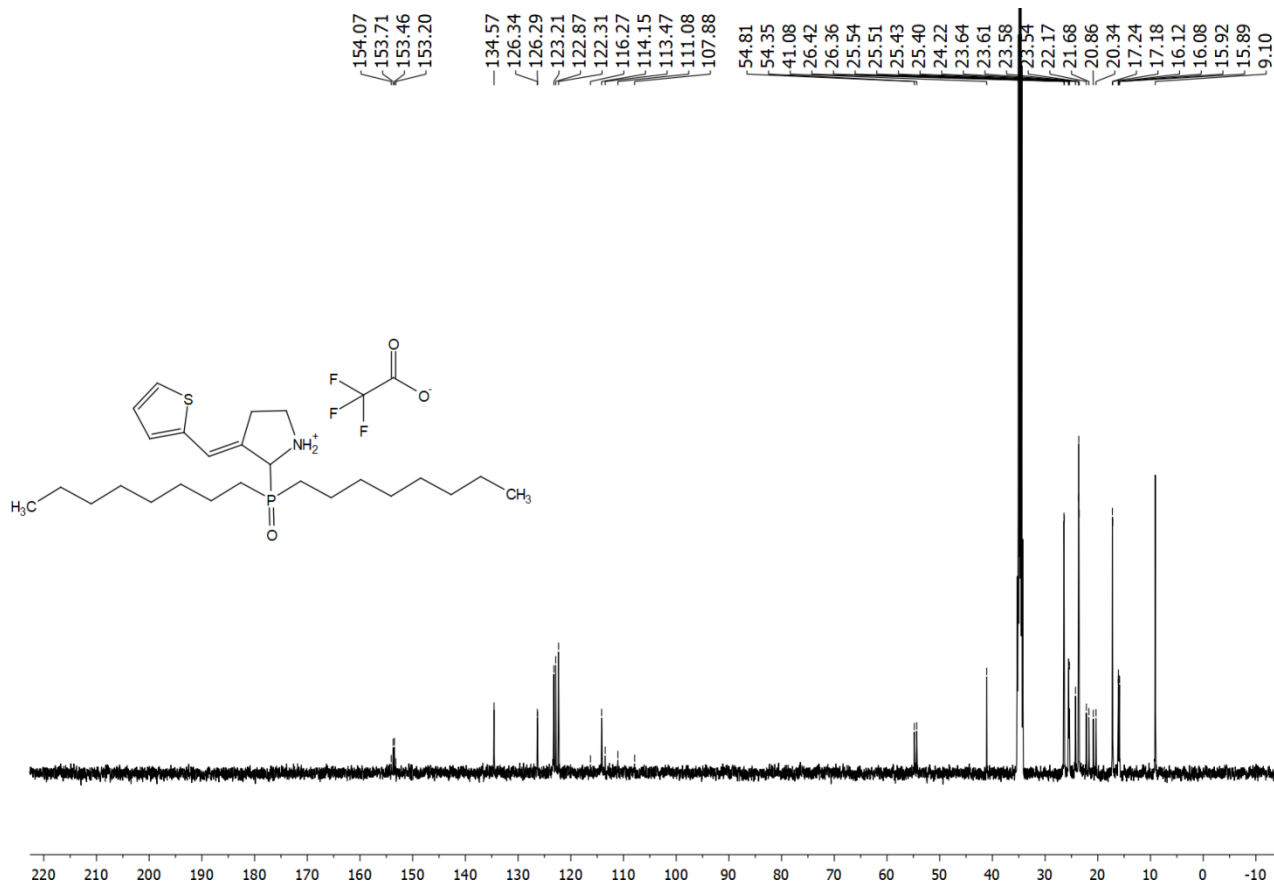


Figure S23. $^{13}\text{C}\{^1\text{H}\}$ NMR (DMSO- d_6 , 150 MHz) spectrum of the compound **3h**

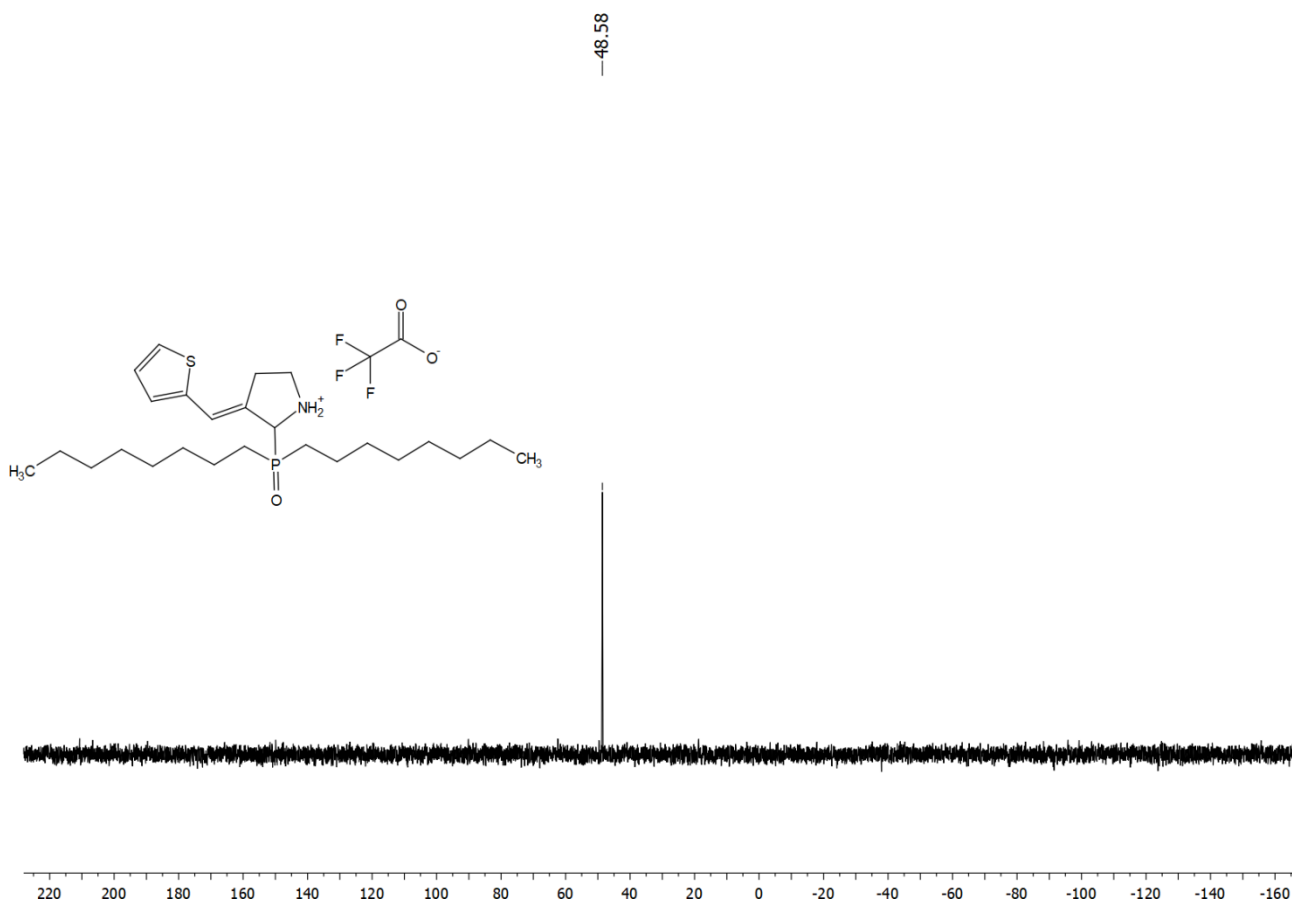


Figure S24. $^{31}\text{P}\{^1\text{H}\}$ NMR (DMSO- d_6 , 161 MHz) spectrum of the compound **3h**

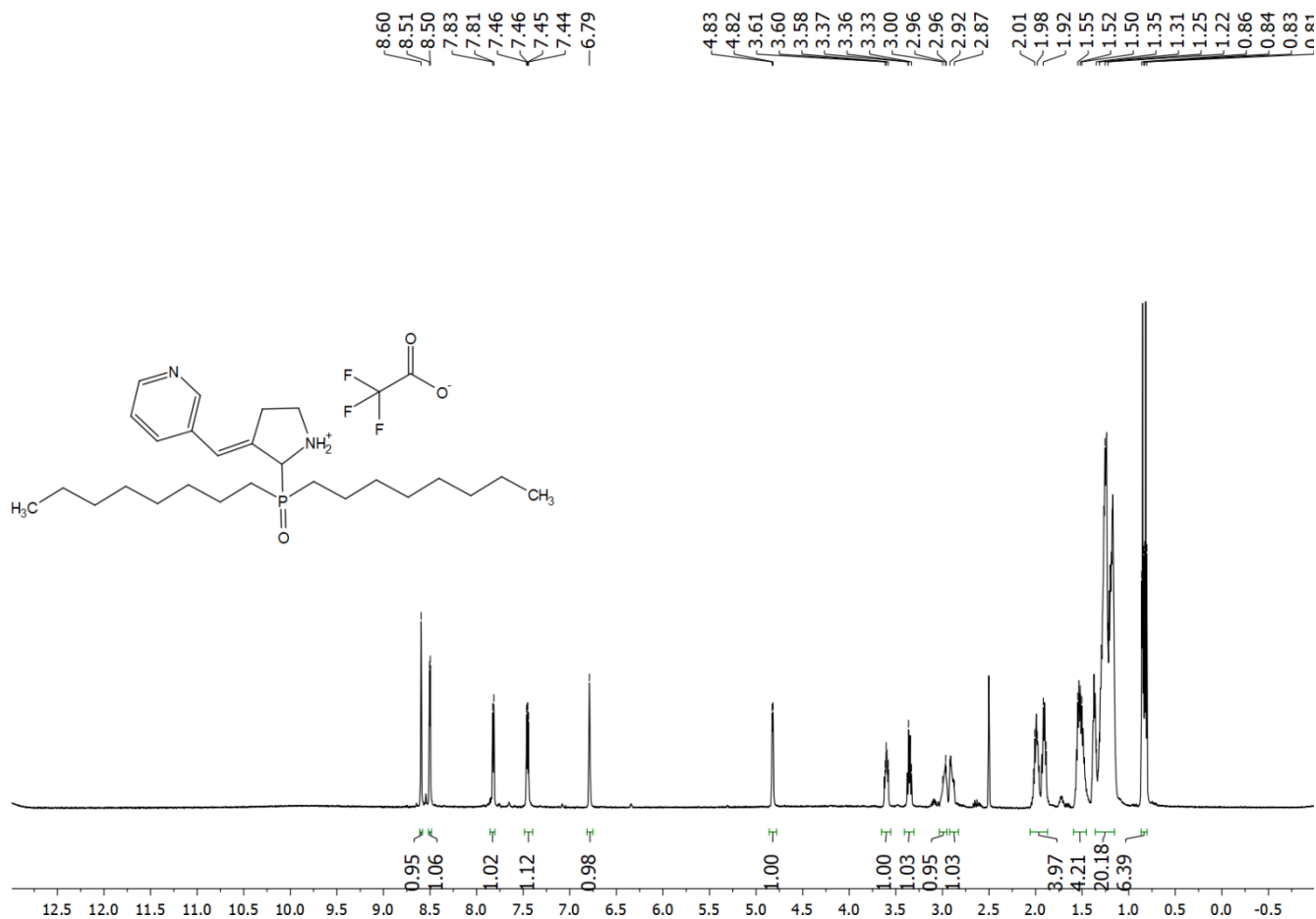


Figure S25. ¹H NMR (DMSO-*d*₆, 400 MHz) spectrum of the compound **3i**

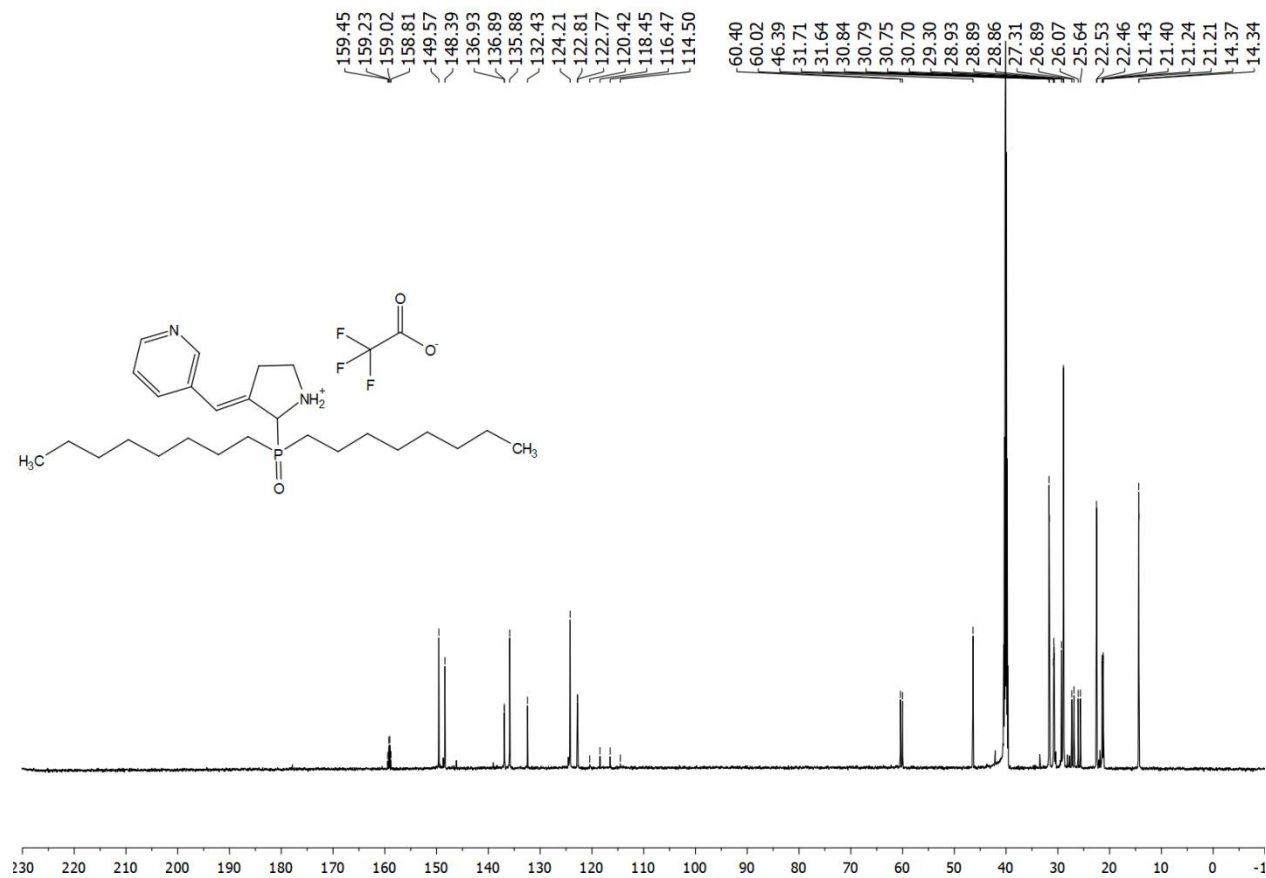


Figure S26. ¹³C{¹H} NMR (DMSO-*d*₆, 150 MHz) spectrum of the compound **3i**

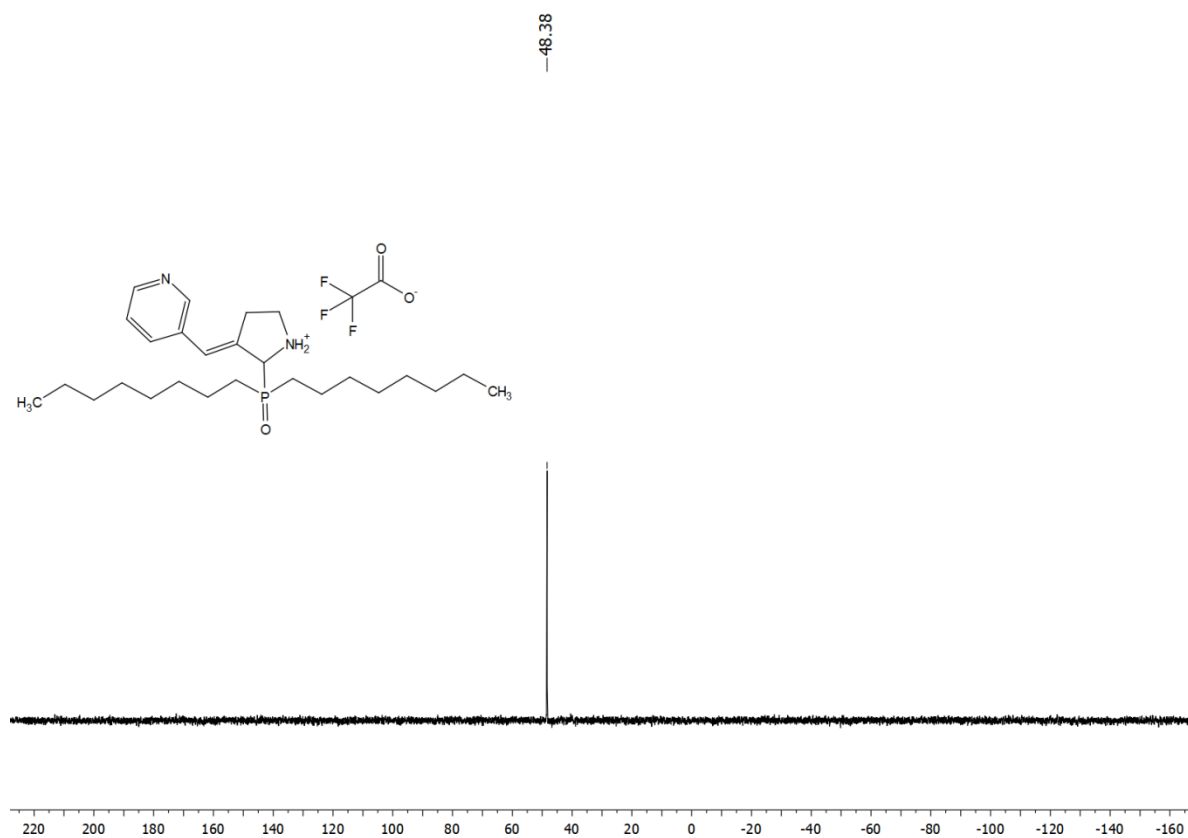


Figure S27. $^{31}\text{P}\{^1\text{H}\}$ NMR (DMSO- d_6 , 161 MHz) spectrum of the compound **3i**