Synthesis and *in vitro* anti-tubercular evaluation of 1,2,3-triazole tethered β-lactam-ferrocene and β-lactam-ferrocenylchalcone chimeric scaffolds

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Supplementary Information:

General

Melting points were determined by open capillary using Veego Precision Digital Melting Point apparatus (MP-D) and are uncorrected. IR spectra were recorded on a Shimadzu D-8001 spectrophotometer. ^{1}H NMR spectra were recorded in deuterochloroform with Jeol 300 (300 MHz) spectrometers using TMS as internal standard. Chemical shift values are expressed as parts per million downfield from TMS and J values are in hertz. Splitting patterns are indicated as s: singlet, d: doublet, t: triplet, m: multiplet, dd: double doublet, ddd: doublet of a doublet of a doublet, and br: broad peak. ^{13}C NMR spectra were recorded on Jeol 300 (75 MHz) spectrometers in deuterochloroform using TMS as internal standard. Mass spectra were recorded on Shimadzu GCMS-QP-2000 mass spectrometer. Column chromatography was performed on a silica gel (60–120 mesh).

Procedure for the preparation of β-lactam ferrocene hybrids (**3a-j**): To a stirred solution of ethynyl-ferrocene **2** (1 mmol) in ethanol-water mixture and 3-azido-2-azetidinones **1** (1 mmol) was added copper sulphate (0.05 mmol) and sodium ascorbate (0.13 mmol). The reaction mixture was allowed to stir at room temperature for 8-12 h and the progress was monitored using tlc. After the completion of reaction, water (20 ml) was added and the reaction mixture was extracted twice with dichloromethane (2x30 ml). The combined organic layers were dried over anhydrous sodium sulphate and concentrated under reduced pressure to yield a crude product which was purified *via* column chromatography using 25:75 (EtOAc: hexane) mixture.

Procedure for the preparation of β-lactam ferrocenylchalcone hybrids (8a-j):

To a stirred solution of *O*-propargylated-ferrocenylchalcone **7** (1 mmol), prepared by the reported protocol involving an initial propargylation of 4-hydroxyacetophenone and subsequent aldol condensation with ferrocene carboxaldehyde,[1,2] and 3-azido-2-azetidinones **1** (1 mmol) in ethanol-water mixture was added copper sulphate (0.05 mmol) and sodium ascorbate (0.13 mmol). The reaction mixture was allowed to stir at room temperature for 12-15 h and the progress was monitored using tlc. After the completion of reaction, water (20 ml) was added and the reaction mixture was extracted twice with dichloromethane (2x30 ml). The combined organic layers were dried over anhydrous sodium sulphate and concentrated under reduced pressure to yield a crude product which was purified *via* column chromatography using 30:70 (EtOAc: hexane) mixture.

***In vitro* anti-tubercular activity**

Bacterial strains and growth conditions: *M. tuberculosis* mc^{2}7000 an unmarked version[3] of mc^{2}6030 was grown at 37°C in Sauton's medium supplemented with 20 µg/ml of pantothenic acid.

Materials and Methods

Drug susceptibility testing. The susceptibility of *M. tuberculosis* mc^{2}7000 to the various compounds was determined as reported previously.[4] In brief, Middlebrook 7H10 solid medium containing oleic-albumin-dextrose-catalase enrichment (OADC) and 20 µg/ml of pantothenic acid was supplemented with increasing concentrations of the chemical analogues. Serial 10-fold dilutions of each actively growing culture were plated and incubated at 37°C for 2-3 weeks. The MIC was defined as the minimum concentration required to inhibit 99% of the growth.

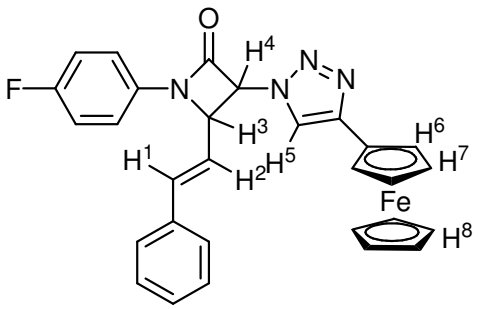
References:

1. G. Nabi, Z.Q. Liu, *Bioorganic & Medicinal Chemistry Letters*, 2011, **21**, 944-946.
2. T. J. Muller, J. Conradie, E. Erasmus, *Polyhedron*, 2012, **33**, 257-266.
3. V.K. Sambandamurthy, S.C. Derrick, T. Hsu, B. Chen, M.H. Larsen, K.V. Jalapathy, M. Chen, J. Kim, S.A. Porcelli, J. Chan, S.L. Morris, W.R. Jacobs, *Vaccine*, 2006, **24**, 6309.

4. L. Kremer, J.D. Douglas, A.R. Baulard, C. Morehouse, M.R. Guy, D. Alland, L.G. Dover, J.H. Lakey, W.R. Jacobs Jr., P.J. Brennan, D.E. Minnikin, G.S. Besra, *J. Biol. Chem.* 2000, **275**, 16857.

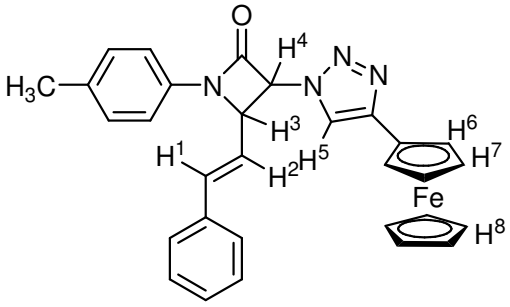
Characterization of compounds:

1-(4-Fluoro-phenyl)-3-(4-ferrocenyl-[1,2,3]triazol-1-yl)-4-styryl-azetidin-2-one (3a):



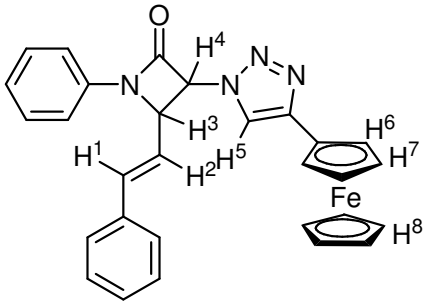
Yield 78%; Yellow Solid; mp 185-186^{0}C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 3.89 (s, 5H, CH^8); 4.26 (brs, 2H, CH^7); 4.65 (brs, 2H, CH^6); 5.23 (dd, *J*=5.7Hz, 7.2Hz, 1H, H^3); 5.90 (dd, *J*=7.2Hz, 15.9Hz, 1H, H^2); 6.25 (d, *J*=5.7Hz, 1H, H^4); 6.77 (d, *J*=15.9Hz, 1H, H^1); 7.17-7.24 (m, 5H, ArH); 7.35 (d, *J*=9.0Hz, 2H, ArH); 7.51 (d, *J*=9.0Hz, 2H, ArH); 7.61 (s, 1H, H^5); ^{13}C NMR ($CDCl_3$, 75MHz): 60.2, 66.5, 66.7, 67.2, 68.7, 69.4, 118.6, 118.8, 119.3, 126.6, 128.8, 129.0, 129.5, 130.5, 134.6, 135.4, 137.0, 147.2, 158.8. MS m/z 518 $(M)^+$

3-(4-ferrocenyl-[1,2,3]triazol-1-yl)-4-styryl-1-p-tolyl-azetidin-2-one (3b):



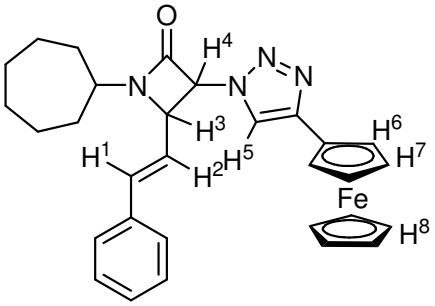
Yield 81%; Yellow Solid; mp 188-189^{0}C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 2.31 (s, 3H, -CH_3); 3.91 (s, 5H, CH^8), 4.30 (brs, 2H, CH^7), 4.67 (brs, 2H, CH^6), 5.25 (dd, *J*=5.7Hz, 7.2Hz, 1H, H^3), 5.91 (dd, *J*=7.2Hz, 15.9Hz, 1H, H^2), 6.27 (d, *J*=5.7Hz, 1H, H^4), 6.78 (d, *J*=15.9Hz, 1H, H^1), 6.98 (d, 2H, *J*=8.1Hz, ArH); 7.11(d, 2H, *J*=8.1Hz, ArH); 7.14-7.30 (m, 5H, ArH), 7.63 (s, 1H, H^5); ^{13}C NMR ($CDCl_3$, 75MHz): 20.9, 60.1, 66.4, 66.8, 67.3, 68.5, 69.6, 118.3, 118.9, 119.6, 126.3, 128.9, 129.3, 129.9, 130.1, 134.7, 135.5, 137.0, 147.8, 158.9. MS m/z 514 $(M)^+$

3-(4-ferrocenyl-[1,2,3]triazol-1-yl)-1-phenyl-4-styryl-azetidin-2-one (3c):



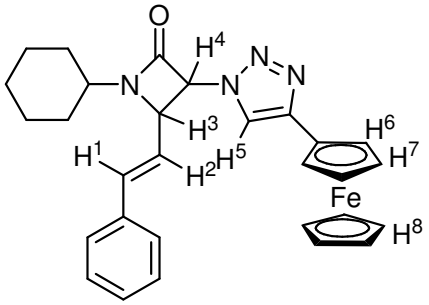
Yield 83%; Yellow Solid; mp 191-192^{0}C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 3.92 (s, 5H, CH^8), 4.33 (brs, 2H, CH^7), 4.69 (brs, 2H, CH^6), 5.23 (dd, *J*=5.7Hz, 7.2Hz, 1H, H^3), 5.99 (dd, *J*=7.2Hz, 15.9Hz, 1H, H^2), 6.25 (d, *J*=5.7Hz, 1H, H^4), 6.77 (d, *J*=15.9Hz, 1H, H^1), 7.10-7.14 (m, 3H, ArH), 7.24-7.31 (m, 7H, ArH); 7.66 (s, 1H, H^5); ^{13}C NMR ($CDCl_3$, 75MHz): 60.0, 66.5, 66.9, 67.1, 68.2, 69.5, 118.4, 118.9, 119.5, 126.4, 128.5, 129.1, 129.4, 130.0, 134.5, 135.6, 137.1, 147.7, 158.8. MS m/z 500 $(M)^+$

1-Cycloheptyl-3-(4-ferrocenyl-[1,2,3]triazol-1-yl)-4-styryl-azetidin-2-one (3d):



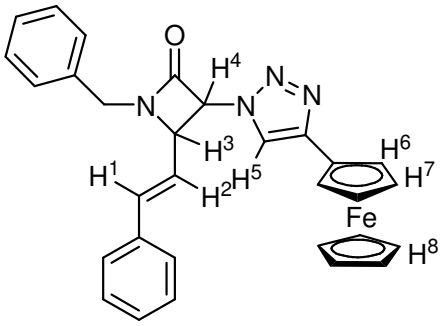
Yield 74%; Yellow Solid; mp 178-179^{0}C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 1.29-1.51 (m, 12H, cycloheptyl); 3.58-3.60 (m, 1H, cycloheptyl H); 3.90 (s, 5H, CH^8), 4.35 (brs, 2H, CH^7), 4.66 (brs, 2H, CH^6), 5.21 (dd, *J*=5.7Hz, 7.2Hz, 1H, H^3); 6.03 (dd, *J*=7.2Hz, 15.9Hz, 1H, H^2), 6.31 (d, *J*=5.7Hz, 1H, H^4), 6.72 (d, *J*=15.9Hz, 1H, H^1), 7.14-7.30 (m, 5H, ArH); 7.60 (s, 1H, H^5); ^{13}C NMR ($CDCl_3$, 75MHz): 24.2, 28.8, 32.3, 49.1, 60.0, 66.5, 66.9, 67.1, 68.2, 69.5, 126.5, 128.7, 129.4, 130.9, 134.6, 135.3, 137.0, 147.8, 159.3. MS m/z 520 $(M)^+$

1-Cyclohexyl-3-(4-ferrocenyl-[1,2,3]triazol-1-yl)-4-styryl-azetidin-2-one (3e):



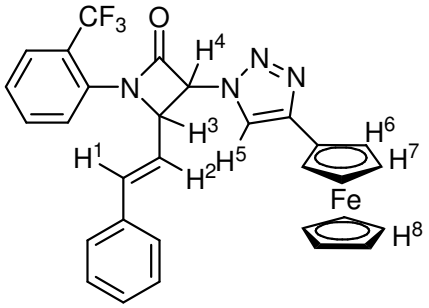
Yield 74%; Yellow Solid; mp 175-176^{0}C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 1.41-2.01 (m, 10H, cyclohexyl); 3.54-3.56 (m, 1H, cyclohexyl H); 3.89 (s, 5H, CH^8), 4.30 (brs, 2H, CH^7), 4.63 (brs, 2H, CH^6), 5.18 (dd, *J*=5.7Hz, 7.2Hz, 1H, H^3); 6.11 (dd, *J*=7.2Hz, 15.9Hz, 1H, H^2), 6.33 (d, *J*=5.7Hz, 1H, H^4), 6.79 (d, *J*=15.9Hz, 1H, H^1), 7.16-7.28 (m, 5H, ArH); 7.67 (s, 1H, H^5); ^{13}C NMR ($CDCl_3$, 75MHz): 22.2, 26.8, 31.3, 47.6, 60.4, 66.2, 66.7, 67.0, 68.3, 69.8, 126.7, 128.8, 129.6, 130.5, 134.0, 135.5, 137.3, 147.9, 159.8. MS m/z 506 $(M)^+$

1-Benzyl-3-(4-ferrocenyl-[1,2,3]triazol-1-yl)-4-styryl-azetidin-2-one (3f):



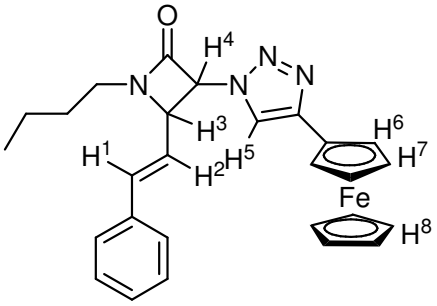
Yield 76%; Yellow Solid; mp 182-183^{0}C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 3.90 (s, 5H, CH^8), 4.36 (brs, 2H, CH^7), 4.46 (s, 2H, CH_2), 4.63 (brs, 2H, CH^6), 5.28 (dd, *J*=5.7Hz, 7.2Hz, 1H, H^3), 6.04 (dd, *J*=7.2Hz, 15.9Hz, 1H, H^2), 6.29 (d, *J*=5.7Hz, 1H, H^4), 6.78 (d, *J*=15.9Hz, 1H, H^1), 7.06-7.14 (m, 6H, ArH), 7.21-7.30 (m, 4H, ArH); 7.71 (s, 1H, H^5); ^{13}C NMR ($CDCl_3$, 75MHz): 53.1, 60.4, 66.6, 66.8, 67.4, 68.1, 69.6, 118.8, 118.9, 119.4, 126.6, 128.8, 129.0, 129.7, 130.3, 134.6, 135.8, 137.0, 147.8, 158.3. MS m/z 514 $(M)^+$

3-(4-ferrocenyl-[1,2,3]triazol-1-yl)-4-styryl-1-(2-trifluoromethyl-phenyl)-azetidin-2-one (3g):



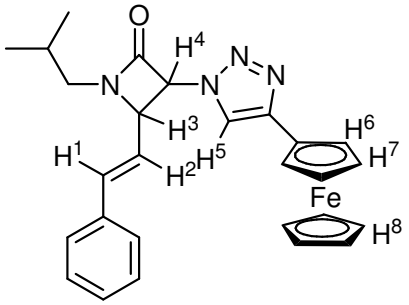
Yield 72 %; Yellow Solid; mp 181-182^{0}C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 3.92 (s, 5H, CH^8), 4.33 (brs, 2H, CH^7), 4.69 (brs, 2H, CH^6), 5.23 (dd, *J*=5.7Hz, 7.2Hz, 1H, H^3), 5.99 (dd, *J*=7.2Hz, 15.9Hz, 1H, H^2), 6.25 (d, *J*=5.7Hz, 1H, H^4), 6.77 (d, *J*=15.9Hz, 1H, H^1), 7.10-7.14 (m, 3H, ArH), 7.24-7.31 (m, 7H, ArH); 7.66 (s, 1H, H^5); ^{13}C NMR ($CDCl_3$, 75MHz): 60.2, 66.7, 66.8, 67.3, 68.2, 69.4, 118.6, 118.8, 119.6, 126.5, 128.6, 129.3, 129.6, 130.1,130.4, 134.4, 135.7, 137.2, 147.9, 158.7. MS m/z 568 $(M)^+$

1-Butyl-3-(4-ferrocenyl-[1,2,3]triazol-1-yl)-4-styryl-azetidin-2-one (3h):



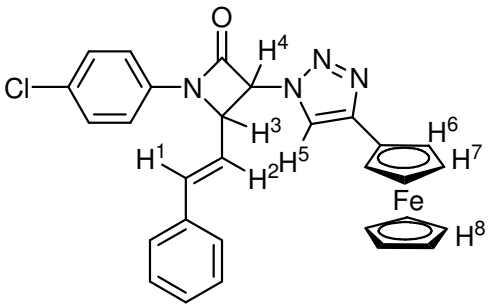
Yield 77%; Yellow Solid; mp 173-174^{0}C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 0.96-0.99 (t, 3H, -CH_3); 1.33-1.63 (m, 4H, -CH_2-CH_2-); 3.20-3.22 (q, 2H, -CH_2); 3.87 (s, 5H, CH^8), 4.33 (brs, 2H, CH^7), 4.67 (brs, 2H, CH^6), 5.26 (dd, *J*=5.7Hz, 7.2Hz, 1H, H^3); 6.14 (dd, *J*=7.2Hz, 15.9Hz, 1H, H^2), 6.38 (d, *J*=5.7Hz, 1H, H^4), 6.77 (d, *J*=15.9Hz, 1H, H^1), 7.14-7.30 (m, 5H, ArH); 7.71 (s, 1H, H^5); ^{13}C NMR ($CDCl_3$, 75MHz): 13.7, 20.5, 31.8, 47.3, 60.6, 66.4, 66.8, 67.2, 68.4, 69.9, 123.3, 126.8, 128.8, 130.6, 134.9, 135.7, 137.4, 148.0, 161.0. MS m/z 480 $(M)^+$

1-Isobutyl-3-(4-ferrocenyl-[1,2,3]triazol-1-yl)-4-styryl-azetidin-2-one (3i):



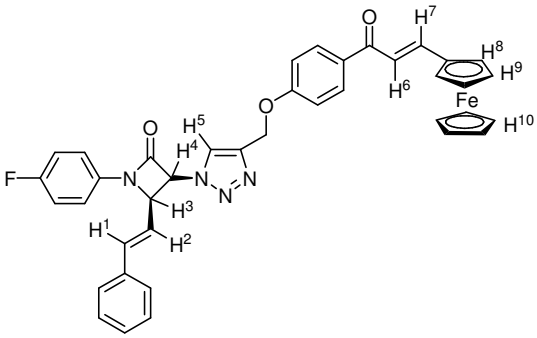
Yield 73%; Yellow Solid; mp 176-177^{0}C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 1.01 (d, J= 6H, -$(CH_3)_2$); 2.46-2.48 (m, 1H, CH); 3.16(s, 2H, CH_2); 3.91 (s, 5H, CH^8), 4.36 (brs, 2H, CH^7), 4.71 (brs, 2H, CH^6), 5.29 (dd, *J*=5.7Hz, 7.2Hz, 1H, H^3); 6.19 (dd, *J*=7.2Hz, 15.9Hz, 1H, H^2), 6.42 (d, *J*=5.7Hz, 1H, H^4), 6.80 (d, *J*=15.9Hz, 1H, H^1), 7.19-7.32 (m, 5H, ArH); 7.68 (s, 1H, H^5); ^{13}C NMR ($CDCl_3$, 75MHz): 19.7, 27.8, 56.7, 60.5, 66.7, 66.9, 67.5, 68.8, 70.3, 123.8, 126.9, 128.4, 130.7, 134.4, 135.3, 137.8, 148.9, 161.4. MS m/z 480 $(M)^+$

1-(4-Chloro-phenyl)-3-(4-ferrocenyl-[1,2,3]triazol-1-yl)-4-styryl-azetidin-2-one (3j):



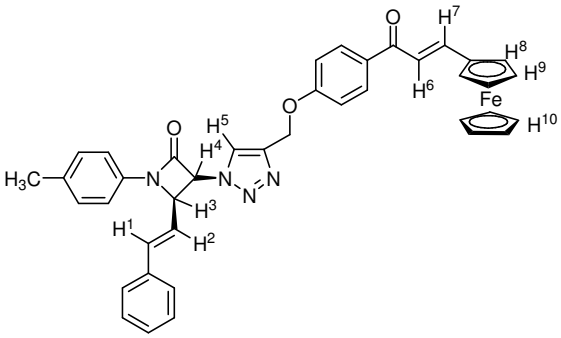
Yield 82%; Yellow Solid; mp 187-188^{0}C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 3.88 (s, 5H, CH^8); 4.23 (brs, 2H, CH^7); 4.66 (brs, 2H, CH^6); 5.20 (dd, *J*=5.7Hz, 7.2Hz, 1H, H^3); 5.92 (dd, *J*=7.2Hz, 15.9Hz, 1H, H^2); 6.27 (d, *J*=5.7Hz, 1H, H^4); 6.76 (d, *J*=15.9Hz, 1H, H^1); 7.04 (d, 2H, *J*= 8.1Hz, ArH); 7.14-7.32 (m, 7H, ArH); 7.63 (s, 1H, H^5); ^{13}C NMR ($CDCl_3$, 75MHz): 60.1, 66.3, 66.8, 67.1, 68.9, 69.5, 118.3, 118.9, 119.1, 126.3, 128.2, 129.1, 129.5, 130.2,134.3, 135.5, 137.1, 147.3, 158.2. MS m/z 535 $(M)^+$, 537 $(M+2)^+$

1-(4-Fluoro-phenyl)-4-styryl-3-{4-[4-(3-ferrocenyl-acryloyl)-phenoxymethyl]-[1,2,3]triazol-1-yl}-azetidin-2-one (8a):



Yield 75%; Dark red; mp 188-189^{0}C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 4.17 (s, 5H, CH^{10}), 4.50 (t, J=1.8Hz, 2H, CH^9), 4.61 (t, J=1.8Hz, 2H, CH^8), 5.20 (dd, J=5.7Hz, 7.2Hz, 1H, H^3); 5.25 (s, 2H, -OCH_2); 5.85 (dd, J= 7.5Hz, 15.9Hz, 1H, H^2), 6.25 (d, J= 5.5Hz, 1H, H^4), 6.77 (d, J=15.9Hz, 1H, H^1), 6.91 (d, J=8.7Hz, 2H, ArH), 7.12 (d, J=15Hz, 1H, H^6), 7.14-7.27 (m, 5H, ArH), 7.35 (d, J=8.7Hz, 2H, ArH), 7.46 (d, J=8.7Hz, 2H, ArH), 7.72 (d, J=15.0Hz, 1H, H^7), 7.80 (s, 1H, triazole-H^5), 7.94 (d, J=8.7Hz, 2H, ArH); ^{13}C NMR ($CDCl_3$, 75MHz): 60.2, 62.4, 67.7, 69.3, 69.7, 71.6, 79.5, 114.6, 118.5, 118.8, 119.6, 123.8, 126.2, 128.4, 129.5, 129.7, 129.9, 130.5, 132.2, 134.7, 135.9, 138.1, 144.5, 146.7, 158.8, 161.4, 188.3. MS m/z 678 $(M)^+$

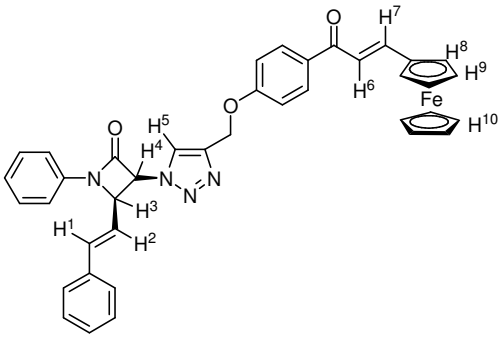
4-Styryl-1-p-tolyl-3-{4-[4-(3-ferrocenyl-acryloyl)-phenoxymethyl]-[1,2,3]triazol-1-yl}-azetidin-2-one (8b):



Yield 71%; Dark red; mp 182-183^{0}C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 2.35 (s, 3H, -CH_3); 4.18 (s, 5H, CH^{10}), 4.52 (t, J=1.8Hz, 2H, CH^9), 4.60 (t, J=1.8Hz, 2H, CH^8), 5.22 (dd, J=5.7Hz, 7.2Hz, 1H, H^3); 5.26 (s, 2H, -OCH_2); 5.83 (dd, J= 7.5Hz, 15.9Hz, 1H, H^2), 6.26 (d, J= 5.5Hz, 1H, H^4), 6.78 (d, J=15.9Hz, 1H, H^1), 6.96-6.98 (m, 4H, ArH), 7.11 (d, J=8.1Hz, 2H, ArH), 7.14 (d, J=15Hz, 1H, H^6), 7.17-7.30 (m, 5H, ArH), 7.74 (d, J=15.0Hz, 1H, H^7), 7.82 (s, 1H, triazole-H^5), 7.90 (d, J=8.7Hz, 2H, ArH); ^{13}C NMR ($CDCl_3$, 75MHz): 21.1, 60.6, 61.9, 67.4,

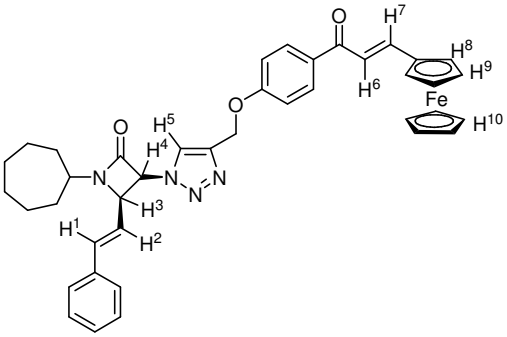
69.5, 70.0, 71.7, 79.1, 114.4, 118.5, 118.7, 119.2, 123.8, 127.0, 128.8, 129.4, 129.6, 129.9, 130.4, 132.5, 134.9, 135.4, 138.7, 144.1, 146.5, 158.8, 161.4, 188.7. MS m/z 675 $(M)^+$

1-Phenyl-4-styryl-3-{4-[4-(3-ferrocenyl-acryloyl)-phenoxymethyl]-[1,2,3]triazol-1-yl}-azetidin-2-one (8c):



Yield 75%; Dark red; mp 185-186^{0}C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 4.16 (s, 5H, CH^{10}), 4.51 (t, J=1.8Hz, 2H, CH^9), 4.62 (t, J=1.8Hz, 2H, CH^8), 5.20-5.25 (m, 3H, -OCH_2+ H^3); 5.82 (dd, J= 7.5Hz, 15.9Hz, 1H, H^2), 6.25 (d, J= 5.5Hz, 1H, H^4), 6.77 (d, J=15.9Hz, 1H, H^1), 6.96 (d, J=8.4Hz, 2H, ArH), 7.10-7.34 (m, 11H, ArH); 7.75 (d, J=15.0Hz, 1H, H^7), 7.80 (s, 1H, triazole-H^5), 7.93 (d, J=8.4Hz, 2H, ArH); ^{13}C NMR ($CDCl_3$, 75MHz): 60.6, 61.8, 67.8, 69.2, 69.7, 71.5, 79.3, 114.6, 118.6, 118.9, 119.3, 123.7, 126.8, 129.0, 129.1, 129.7, 129.8, 130.6, 132.7, 134.7, 135.4, 138.5, 144.3, 146.0, 158.6, 161.5, 188.4. MS m/z 660 $(M)^+$

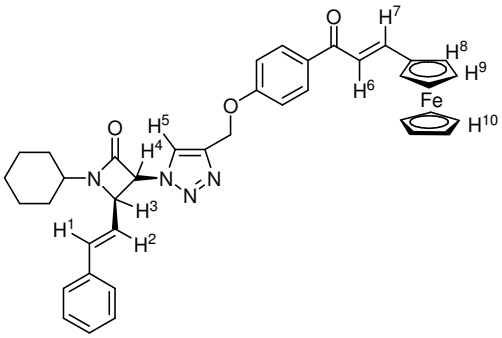
1-Cycloheptyl-4-styryl-3-{4-[4-(3-ferrocenyl-acryloyl)-phenoxymethyl]-[1,2,3]triazol-1-yl}-azetidin-2-one (8d):



Yield 75%; Dark red; mp 178-179^{0}C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 1.29-1.51 (m, 12H, cycloheptyl); 3.58-3.60 (m, 1H, cycloheptyl H); 4.19 (s, 5H, CH^{10}), 4.55 (t, J=1.8Hz, 2H, CH^9), 4.63 (t, J=1.8Hz, 2H, CH^8), 5.21-5.26 (m, 3H, -OCH_2+ H^3); 5.80 (dd, J= 7.5Hz, 15.9Hz, 1H, H^2), 6.26 (d, J= 5.5Hz, 1H, H^4), 6.80 (d, J=15.9Hz, 1H, H^1), 6.97 (d, J=8.4Hz, 2H, ArH), 7.10 (d, J=15.0Hz, 1H, H^6), 7.15-7.28 (m, 5H, ArH); 7.78 (d, J=15.0Hz, 1H, H^7), 7.82 (s, 1H, triazole-H^5), 7.91 (d, J=8.4Hz, 2H, ArH); ^{13}C NMR ($CDCl_3$, 75MHz): 23.9,

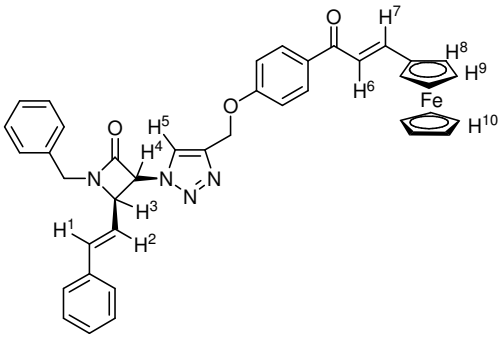
28.7, 32.8, 48.9, 60.5, 61.8, 67.7, 69.4, 69.6, 71.2, 79.3, 114.4, 118.6, 118.9, 119.4, 129.7, 129.9, 130.5, 132.0, 134.8, 135.4, 138.5,144.3, 146.6, 158.7, 161.5, 188.9. MS m/z 681 $(M)^+$

1-Cyclohexyl-4-styryl-3-{4-[4-(3-ferrocenyl-acryloyl)-phenoxymethyl]-[1,2,3]triazol-1-yl}-azetidin-2-one (8e):



Yield 81%; Dark red; mp 181-182^{0}C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 1.41-2.01 (m, 10H, cyclohexyl); 3.54-3.56 (m, 1H, cyclohexyl H); 4.18 (s, 5H, CH^{10}), 4.52 (t, J=1.8Hz, 2H, CH^9), 4.60 (t, J=1.8Hz, 2H, CH^8), 5.17 (dd, J=5.7Hz, 7.2Hz, 1H, H^3); 5.25 (s, 2H, -OCH_2); 5.81 (dd, J= 7.5Hz, 15.9Hz, 1H, H^2), 6.24 (d, J= 5.5Hz, 1H, H^4), 6.71 (d, J=15.9Hz, 1H, H^1), 6.88 (d, J=8.7Hz, 2H, ArH), 7.11 (d, J=15Hz, 1H, H^6), 7.13-7.27 (m, 5H, ArH), 7.74 (d, J=15.0Hz, 1H, H^7), 7.81 (s, 1H, triazole-H^5), 7.91 (d, J=8.7Hz, 2H, ArH); ^{13}C NMR ($CDCl_3$, 75MHz): 22.0, 27.1, 31.3, 47.2, 60.5, 61.7, 67.3, 69.2, 69.9, 71.5, 79.6, 114.3, 118.7, 118.8, 119.7, 129.6, 129.8, 130.6, 132.2, 134.8, 135.2, 138.3, 144.4, 146.1, 158.6, 161.7, 188.0. MS m/z 667 $(M)^+$

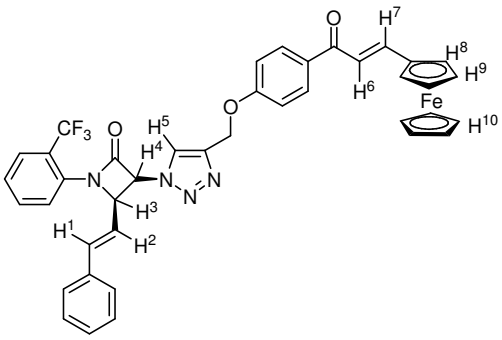
1-Benzyl-4-styryl-3-{4-[4-(3-ferrocenyl-acryloyl)-phenoxymethyl]-[1,2,3]triazol-1-yl}-azetidin-2-one (8f):



Yield 75%; Dark red; mp 185-186^{0}C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 4.16 (s, 5H, CH^{10}), 4.46 (s, 2H, CH_2); 4.50 (t, J=1.8Hz, 2H, CH^9), 4.63 (t, J=1.8Hz, 2H, CH^8), 5.22-5.27 (m, 3H, -OCH_2+ H^3); 5.80 (dd, J= 7.5Hz, 15.9Hz, 1H, H^2), 6.23 (d, J= 5.5Hz, 1H, H^4), 6.81 (d, J=15.9Hz, 1H, H^1), 6.96 (d, J=8.4Hz, 2H, ArH), 7.06-7.31(m, 11H, ArH); 7.70 (d, J=15.0Hz, 1H, H^7), 7.82 (s, 1H, triazole-H^5), 7.91 (d, J=8.4Hz, 2H, ArH); ^{13}C NMR ($CDCl_3$, 75MHz):

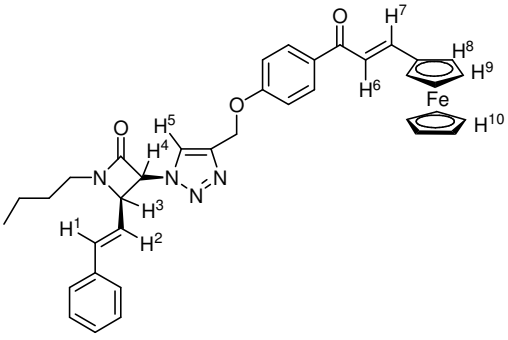
52.7, 60.3, 62.4, 67.3, 69.2, 69.8, 71.7, 79.8, 114.4, 118.6, 118.7, 119.3, 123.7, 126.8, 128.7, 129.3, 129.5, 129.8, 130.6, 132.2, 134.7, 135.6, 138.2, 144.3, 146.6, 158.6, 161.4, 188.3. MS m/z 674 $(M)^+$

4-Styryl-3-{4-[4-(3-ferrocenyl-acryloyl)-phenoxymethyl]-[1,2,3]triazol-1-yl}-1-(2-trifluoromethyl-phenyl)-azetidin-2-one (8g):



Yield 73%; Dark red; mp 189-190^{0}C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 4.15 (s, 5H, CH^{10}), 4.48 (t, J=1.8Hz, 2H, CH^9), 4.62 (t, J=1.8Hz, 2H, CH^8), 5.24 (dd, J=5.7Hz, 7.2Hz, 1H, H^3); 5.26 (s, 2H, -OCH_2); 5.82 (dd, J= 7.5Hz, 15.9Hz, 1H, H^2), 6.23 (d, J= 5.5Hz, 1H, H^4), 6.75 (d, J=15.9Hz, 1H, H^1), 6.91 (d, J=8.7Hz, 2H, ArH), 7.03-7.22 (m, 5H, ArH), 7.31-7.50 (m, 4H, ArH), 7.72 (d, J=15.0Hz, 1H, H^7), 7.80 (s, 1H, triazole-H^5), 7.96 (d, J=8.7Hz, 2H, ArH) ^{13}C NMR ($CDCl_3$, 75MHz): 60.7, 61.5, 67.8, 69.2, 69.7, 71.5, 79.6, 114.5, 118.3, 118.7, 119.5, 123.3,124.9, 126.6, 128.5, 128.8, 129.7, 129.9, 130.4, 130.8, 132.1, 132.4, 134.7, 135.5, 137.2, 144.6, 146.2, 158.4, 161.9, 188.2. MS m/z 728 $(M)^+$

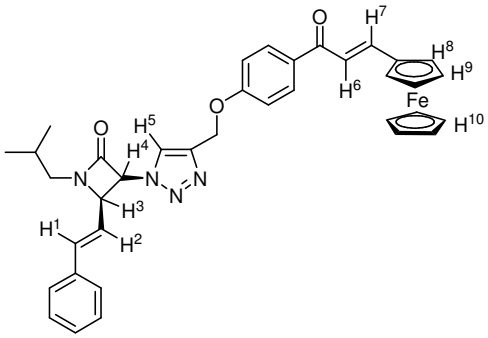
1-Butyl-4-styryl-3-{4-[4-(3-ferrocenyl-acryloyl)-phenoxymethyl]-[1,2,3]triazol-1-yl}-azetidin-2-one (8h):



Yield 76%; Yellow Solid; mp 179-180^{0}C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 0.96-0.99 (t, 3H, -CH_3); 1.31-1.60 (m, 4H, -CH_2-CH_2-); 3.20-3.22 (q, 2H, -CH_2); 4.22 (s, 5H, CH^{10}), 4.51 (t, J=1.8Hz, 2H, CH^9), 4.58 (t, J=1.8Hz, 2H, CH^8), 5.15 (dd, J=5.7Hz, 7.2Hz, 1H, H^3); 5.21 (s, 2H, -OCH_2); 5.80 (dd, J= 7.5Hz, 15.9Hz, 1H, H^2), 6.23 (d, J= 5.5Hz, 1H, H^4), 6.71 (d,

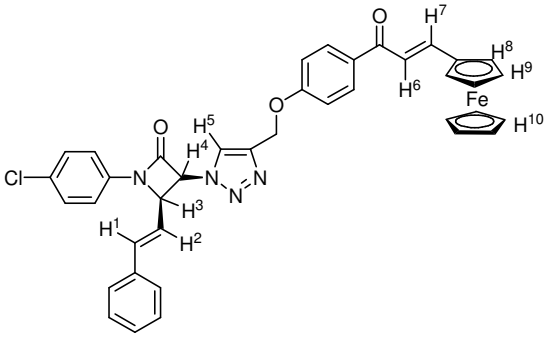
J=15.9Hz, 1H, H^1), 6.92 (d, *J*=8.7Hz, 2H, ArH), 7.11 (d, *J*=15Hz, 1H, H^6), 7.14-7.28 (m, 5H, ArH), 7.71 (d, *J*=15.0Hz, 1H, H^7), 7.82 (s, 1H, triazole-H^5), 7.88 (d, *J*=8.7Hz, 2H, ArH); ^{13}C NMR ($CDCl_3$, 75MHz): 12.9, 21.1, 31.2, 46.8, 60.3, 61.9, 67.5, 69.0, 69.8, 71.3, 79.4, 114.4, 118.7, 118.8, 119.4, 123.5, 129.6, 129.8, 130.6, 132.0, 134.7, 135.4, 144.1, 146.0, 158.5, 161.5, 188.0. MS m/z 641 $(M)^+$

1-Isobutyl-4-styryl-3-{4-[4-(3-ferrocenyl-acryloyl)-phenoxymethyl]-[1,2,3]triazol-1-yl}-azetidin-2-one (8i):



Yield 76%; Yellow Solid; mp 177-178^{0}C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 1.00 (d, J= 6H, -$(CH_3)_2$); 2.46-2.48 (m, 1H, CH); 3.19(s, 2H, CH_2); 4.21 (s, 5H, CH^{10}), 4.50 (t, *J*=1.8Hz, 2H, CH^9), 4.55 (t, *J*=1.8Hz, 2H, CH^8), 5.16 (dd, *J*=5.7Hz, 7.2Hz, 1H, H^3); 5.22 (s, 2H, -OCH_2); 5.83 (dd, *J*= 7.5Hz, 15.9Hz, 1H, H^2), 6.25 (d, *J*= 5.5Hz, 1H, H^4), 6.70 (d, *J*=15.9Hz, 1H, H^1), 6.89 (d, *J*=8.7Hz, 2H, ArH), 7.10 (d, *J*=15Hz, 1H, H^6), 7.12-7.26 (m, 5H, ArH), 7.69 (d, *J*=15.0Hz, 1H, H^7), 7.80 (s, 1H, triazole-H^5), 7.87 (d, *J*=8.7Hz, 2H, ArH); ^{13}C NMR ($CDCl_3$, 75MHz): 20.4, 28.3, 59.7, 60.3, 62.0, 67.4, 68.8, 69.9, 71.6, 79.4, 114.6, 118.7, 118.9, 119.5, 123.6, 129.8, 129.9, 130.7, 132.3, 134.9, 135.6, 144.5, 146.4, 158.6, 161.7, 188.6. MS m/z 641 $(M)^+$

1-(4-Chloro-phenyl)-4-styryl-3-{4-[4-(3-ferrocenyl-acryloyl)-phenoxymethyl]-[1,2,3]triazol-1-yl}-azetidin-2-one (8j):

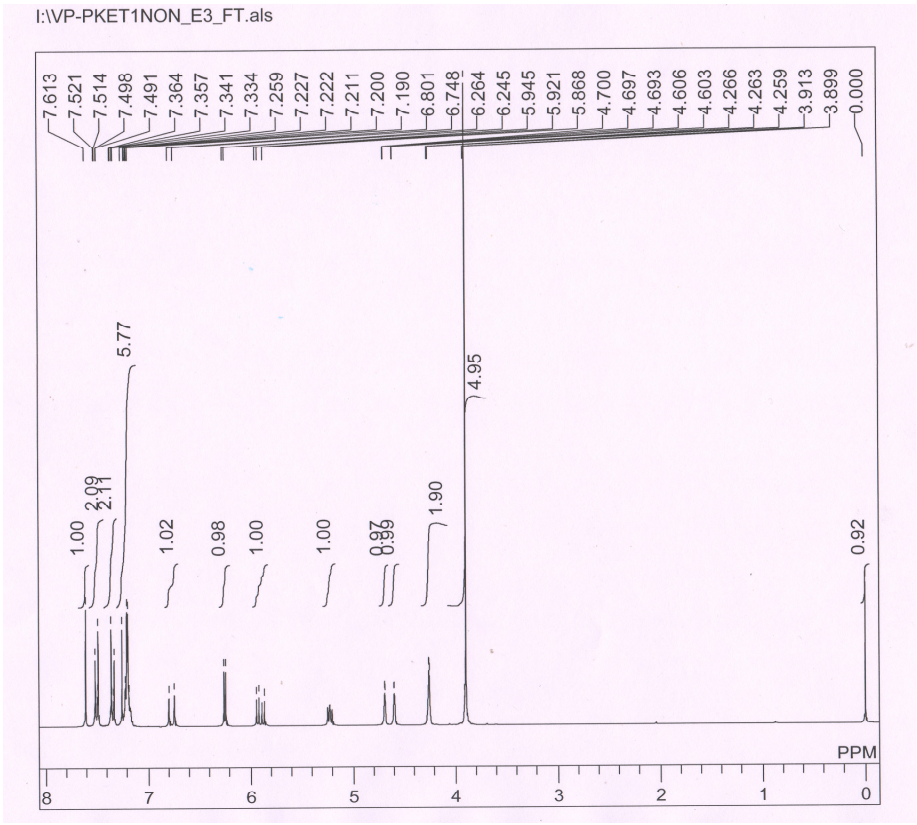


Yield 75%; Dark red; mp 185-186^{0}C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 4.18 (s, 5H, CH^{10}), 4.48 (t, *J*=1.8Hz, 2H, CH^9), 4.59 (t, *J*=1.8Hz, 2H, CH^8), 5.19-5.25 (m, 3H, -OCH_2+ H^3); 5.83 (dd, *J*= 7.5Hz, 15.9Hz, 1H, H^2), 6.23 (d, *J*= 5.5Hz, 1H, H^4), 6.74 (d, *J*=15.9Hz, 1H, H^1), 6.93 (d,

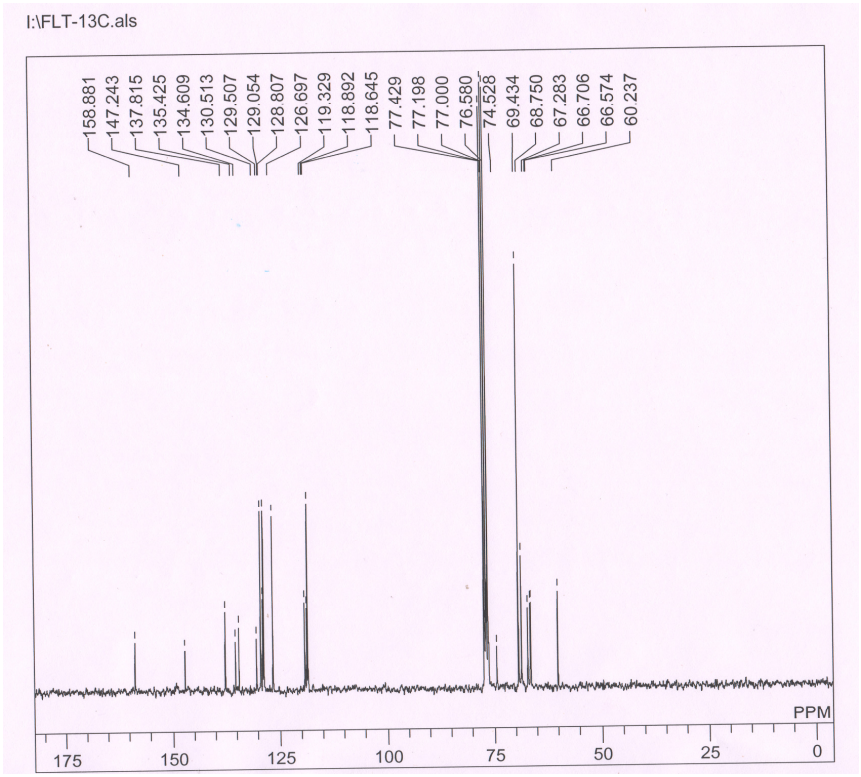
J=8.7Hz, 2H, ArH), 7.10 (d, *J*=15Hz, 1H, H^6), 7.12-7.25 (m, 5H, ArH), 7.33 (d, *J*=8.7Hz, 2H, ArH), 7.47 (d, *J*=8.7Hz, 2H, ArH), 7.73 (d, *J*=15.0Hz, 1H, H^7), 7.82 (s, 1H, triazole-H^5), 7.91 (d, *J*=9.0Hz, 2H, ArH); ^{13}C NMR ($CDCl_3$, 75MHz): 60.4, 62.0, 67.5, 69.1, 69.9, 71.4, 79.4, 114.5, 118.7, 118.8, 119.4, 123.6, 126.9, 128.9, 129.2, 129.6, 129.7, 130.7, 132.0, 134.8, 135.5, 138.3, 144.2, 146.1, 158.5, 161.6, 188.1. MS m/z 694 $(M)^+$, 696 $(M+2)^+$

^{1}H and ^{13}C NMR spectra of representative compounds:

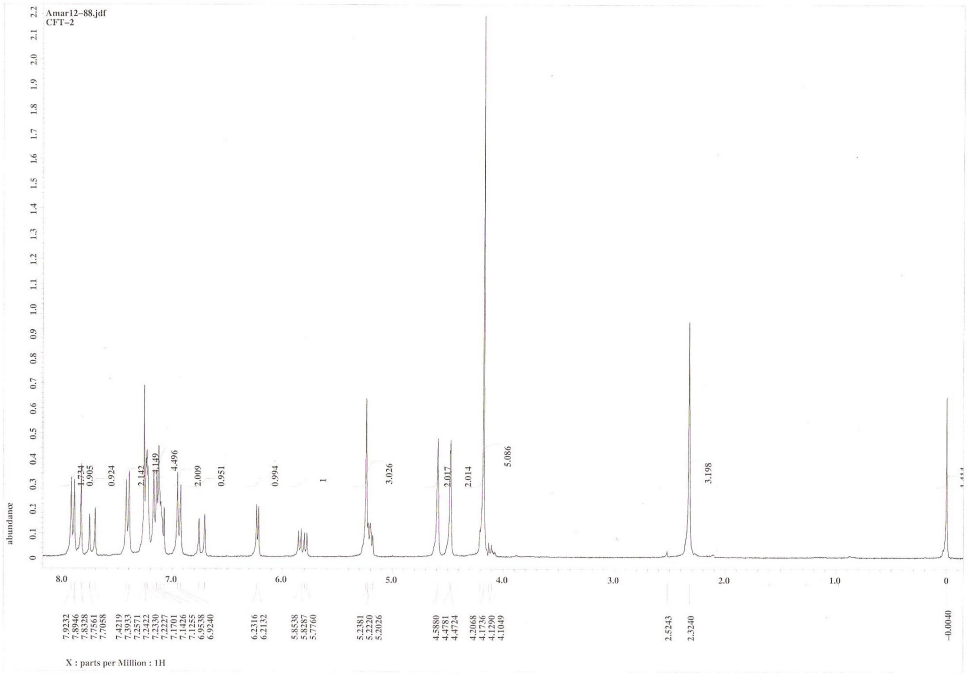
^{1}H NMR spectrum of **3j**:



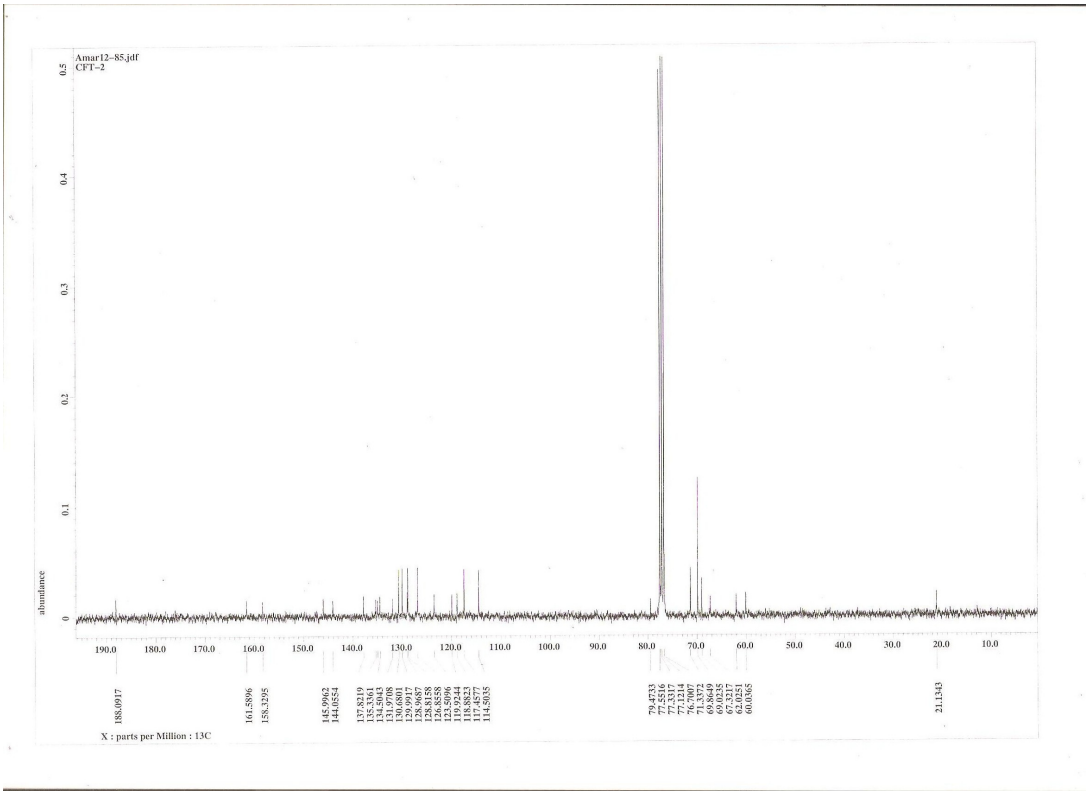
^{13}C NMR spectrum of **3j**:



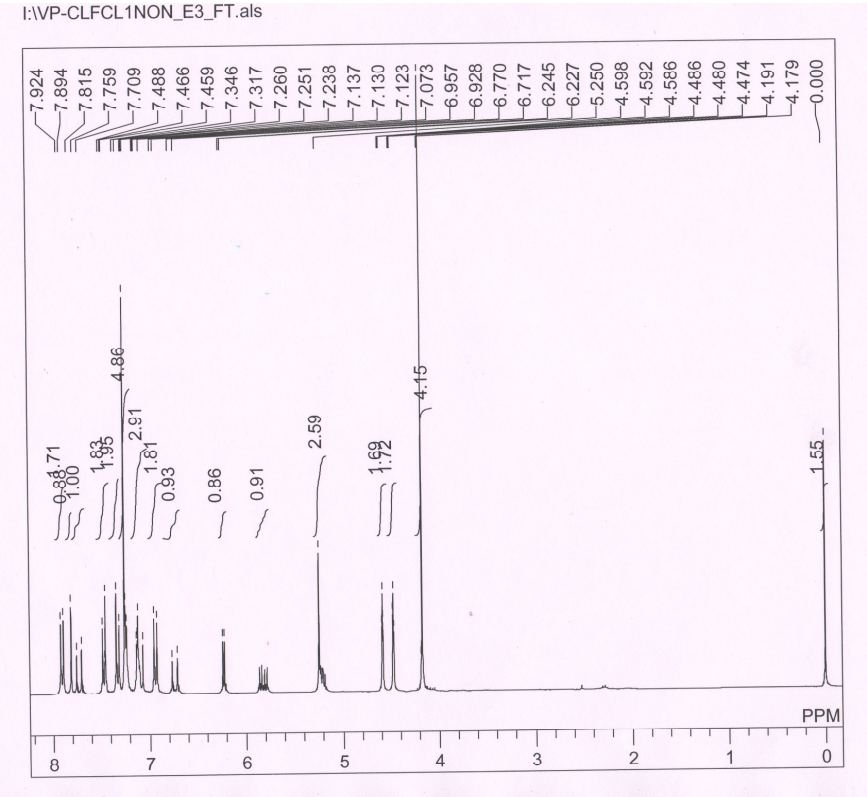
^{1}H NMR spectrum of **8b**:



^{13}C NMR spectrum of **8b**:



^{1}H NMR of spectrum of **8j**:



^{13}C NMR spectrum of **8j**: