Supporting Information

Pyrazole Synthesis via a Cascade Sonogashira Coupling/Cyclization from *N*-Propargyl Sulfonylhydrazones

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1 General Information

Chromatography

Thin layer chromatography (TLC) was performed on Huanghai pre-coated glass-backed TLC plates and visualized by UV lamp (254 nm). Column chromatography on silica gel (300-400 mesh) was carried out using technical grade 60-90 ^{o}C petroleum ether (distillated prior to use) and analytical grade EtOAc (without further purification). Concentration under reduced pressure was performed by rotary evaporation. Purified compounds were further addressed under high vacuum (3-5 mmHg). Yields refer to chromatographically purified compounds.

Nuclear magnetic resonance spectra

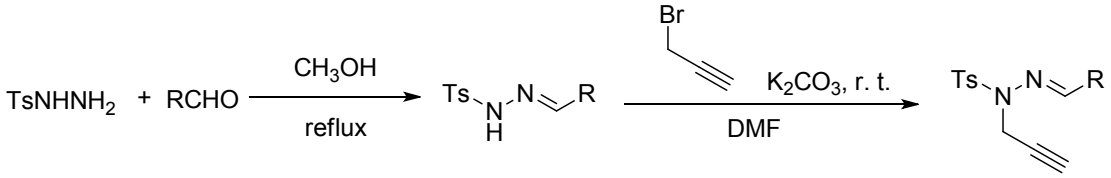
^{1}H and ^{13}C spectra were recorded on Bruker AV 400MHz and Bruker AV 500 MHz spectrometer. Chemical shifts were reported in ppm. ^{1}H NMR spectra were referenced to $CDCl_3$ (7.28 ppm), and ^{13}C-NMR spectra were referenced to $CDCl_3$ (77.0 ppm). All ^{13}C-NMR spectra were measured with complete proton decoupling. Peak multiplicities were designated by the following abbreviations: s, singlet; d, doublet; t, triplet; m, multiplet and *J*, coupling constant in Hz.

Melting point tester

The test of melting point is used in the X-4 digital display micro-melting point tester.

2 General Procedure for the Synthesis of product 3

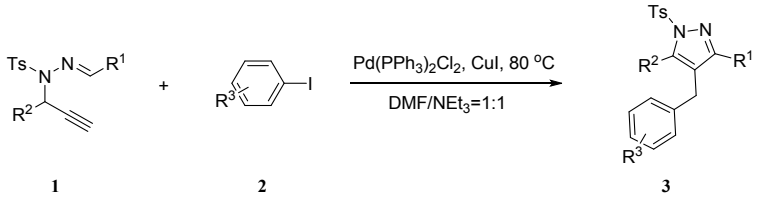
2.1 General procedure for synthesis of *N*-propargylic sulfonylhydrazones **1**



$TsNHNH_2$ (20 mmol) was dissolved in methanol (10 mL), placed in the oil bath pot under 70 ℃, and then adding the corresponding aldehyde (20 mmol), reflux, upon completion (monitored by TLC), the reaction mixture was let stand to afford solid precipitation at room temperature, and filtered off, washed over by petroleum ether (3×10 mL), and finally getting white solid *N*-sulfonic acid hydrazine in 92% yield.

The *N*-sulfonyl hydrazone (10 mmol) and the corresponding acetylene bromide (11 mmol) were dissolved in DMF (20 mL) and K_2CO_3 (11 mmol) was added to the reaction mixture, stirring at room temperature until the reaction was completed (monitored by TLC).Upon completion, H_2O (30 mL×3) was added, extracted by EtOAc (30 mL), and the organic layer was dried over anhydrous Na_2SO_4. The solvent was removed under vacuum, and then the residue was further purified by silica gel column chromatography (petroleum ether and ethyl acetate) to afford *N*-propargyl sulfonyl hydrazine in 87% yield.

2.2 General procedure for synthesis of product **3**

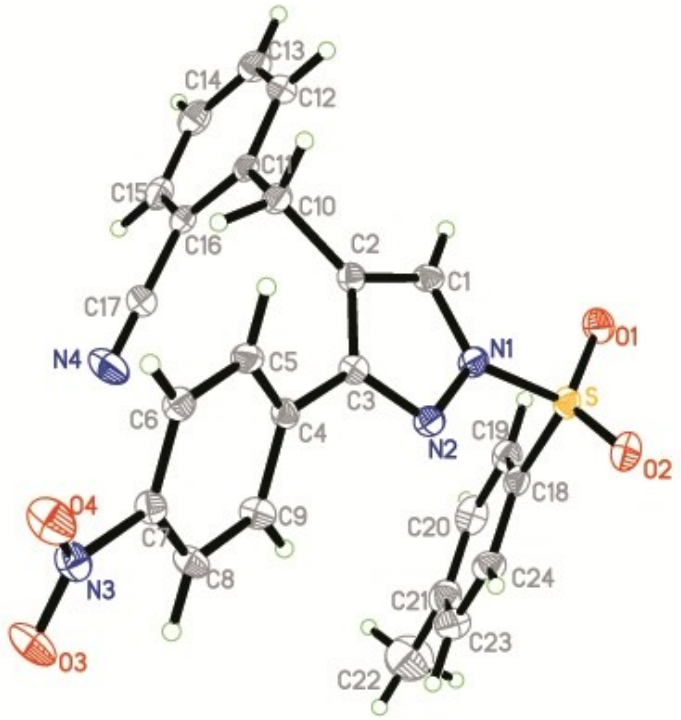


1 **2** **3**

To a 10 mL round bottom flask, the *N*-propargyl sulfonyl hydrazine **1** (0.5 mmol) and the iodobenzonitrile **2** (0.5 mmol) was successfully added, dissolving in the solvent DMF (2 mL), then the catalyst 5 mol% $Pd(PPh_3)_2Cl_2$ along with 5 mol% CuI was gradually added, after 2 minutes, the base Et_3N (2 mL) was poured, the whole mixture was stirred under 80 °C for 3 hours to afford a dark brown solution, upon completion (monitored by TLC), the aqueous phase was extracted with EtOAc (3×10 mL), dried over Na_2SO_4. The solvent was removed under vacuum, and then the residue was further purified by silica gel column chromatography (petroleum ether/ethyl acetate=10/1) to afford the polysubstituted pyrazole **3** (64-93% yields).

3 Crystal Data of Compound 3i

3.1 Single crystal X-ray structure of **3i**.



3.2 Crystal data of **3i**

Table 1 Crystal data and structure refinement for 3i.

Identification code	**3i**
Empirical formula	$C_{24}H_{18}N_4O_4S$
Formula weight	458.48
Temperature/K	203

Crystal system	monoclinic
Space group	Pc
a/Å	7.966(2)
b/Å	9.708(3)
c/Å	13.669(4)
α/°	90
β/°	98.158(5)
γ/°	90
Volume/Å^3	1046.4(5)
Z	2
ρcalcg/cm^3	1.455
μ/mm-1	0.196
F(000)	476.0
Crystal size/mm^3	0.2 × 0.2 × 0.1
Radiation	MoKα (λ = 0.71073)
2Θ range for data collection/°	4.196 to 55.578
Index ranges	-10 ≤ h ≤ 10, -12 ≤ k ≤ 12, -17 ≤ l ≤ 17
Reflections collected	8979
Independent reflections	4646 [Rint = 0.0277, Rsigma = 0.0493]
Data/restraints/parameters	4646/2/299
Goodness-of-fit on F2	1.042
Final R indexes [I>=2σ (I)]	R1 = 0.0423, wR2 = 0.0966
Final R indexes [all data]	R1 = 0.0468, wR2 = 0.0990
Largest diff. peak/hole / e Å^{-3}	0.25/-0.23
Flack parameter	0.03(4)

Table 2 Fractional Atomic Coordinates (×10^4) and Equivalent Isotropic Displacement Parameters (Å^2×10^3) for 3i. Ueq is defined as 1/3 of of the trace of the orthogonalised U_{IJ} tensor.

Atom	x	y	z	U(eq)
S	-2095(1)	-4029.1(8)	-6909.8(6)	31.6(2)
O2	-2311(3)	-4997(2)	-6178.3(18)	41.2(6)
N2	-3657(3)	-2314(3)	-5882.1(19)	29.0(6)
O4	-7858(3)	1417(3)	-2510.3(19)	47.9(7)
N1	-2368(3)	-2484(3)	-6405(2)	30.2(6)
O1	-566(3)	-3915(3)	-7292(2)	41.9(7)
O3	-9837(3)	827(3)	-3638(2)	49.0(7)
N3	-8357(4)	934(3)	-3308(2)	34.1(6)
C3	-3566(4)	-1011(3)	-5627(2)	26.2(6)
C11	-1505(4)	1768(3)	-6879(2)	25.8(6)
C7	-7113(4)	440(3)	-3902(2)	27.3(6)
C1	-1505(4)	-1311(3)	-6504(2)	29.1(7)
C2	-2231(4)	-334(3)	-6002(2)	26.0(6)
C4	-4794(4)	-476(3)	-5029(2)	26.1(6)
C19	-3495(5)	-3960(3)	-8816(3)	37.2(8)
C5	-4307(4)	370(3)	-4235(2)	29.5(7)
C8	-7639(4)	-410(4)	-4683(2)	32.2(7)
C24	-5379(4)	-4387(4)	-7633(3)	36.7(8)
C6	-5466(4)	827(3)	-3661(2)	29.1(7)
C12	73(4)	1936(4)	-7146(3)	32.6(7)
C16	-2882(4)	2185(3)	-7531(2)	29.1(7)
C10	-1740(4)	1147(3)	-5909(2)	30.3(7)
C17	-4530(5)	2063(4)	-7256(3)	36.6(8)
N4	-5816(4)	1964(4)	-7010(3)	59.7(10)
C9	-6466(4)	-871(4)	-5237(2)	31.5(7)
C13	269(5)	2499(3)	-8046(3)	39.0(9)
C18	-3778(4)	-4129(3)	-7854(3)	32.3(7)
C15	-2687(5)	2739(3)	-8441(2)	36.5(8)

C14	-1107(5)	2895(4)	-8687(3)	41.0(9)
C23	-6696(5)	-4481(4)	-8377(3)	46.9(9)
C20	-4842(6)	-4070(4)	-9549(3)	47.1(10)
C21	-6441(6)	-4330(4)	-9345(3)	47.8(9)
C22	-7904(8)	-4462(7)	-10154(4)	85.1(17)

Table 3 Anisotropic Displacement Parameters ($Å^2×10^3$) for 3i. The Anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2a^{*2}U_{11}+2hka^*b^*U_{12}+\ldots]$.

Atom	U_{11}	U_{22}	U_{33}	U_{23}	U_{13}	U_{12}
S	34.4(4)	26.0(4)	35.8(4)	-3.5(4)	10.2(3)	4.3(3)
O2	50.7(16)	31.0(13)	41.2(14)	3.1(11)	3.9(12)	5.4(11)
N2	30.1(14)	29.3(13)	29.6(14)	-3.0(11)	11.6(11)	-0.8(11)
O4	44.3(15)	69.9(18)	31.7(13)	15.4(13)	13.2(11)	3.2(13)
N1	32.4(15)	26.9(14)	34.0(14)	-4.6(11)	13.8(12)	0.1(11)
O1	35.8(14)	38.3(15)	54.1(16)	11.0(12)	14.8(12)	7.3(10)
O3	26.1(13)	80(2)	42.5(15)	-6.0(14)	11.0(11)	7.5(13)
N3	34.3(16)	42.0(16)	28.2(14)	2.5(12)	11.6(12)	6.0(12)
C3	27.1(16)	28.9(16)	22.4(14)	-1.4(12)	3.1(12)	0.0(13)
C11	29.7(15)	19.0(14)	29.5(16)	-3.8(12)	6.8(13)	-1.4(12)
C7	29.0(16)	31.0(16)	23.9(15)	4.4(13)	11.0(12)	3.1(13)
C1	26.4(16)	31.3(17)	30.8(16)	-1.7(14)	8.1(13)	-2.8(13)
C2	26.6(15)	27.3(15)	24.9(15)	0.3(12)	5.9(12)	1.4(12)
C4	25.5(16)	25.7(15)	29.0(15)	2.2(13)	10.2(12)	3.2(12)
C19	43(2)	33.5(19)	37.3(19)	-1.4(14)	14.4(16)	4.0(15)
C5	25.9(16)	29.8(16)	33.7(17)	-2.1(13)	7.7(13)	-2.6(12)
C8	24.3(16)	44(2)	29.4(16)	-3.7(14)	6.7(13)	0.4(13)
C24	39(2)	36.0(18)	36.9(18)	-0.4(15)	13.1(15)	-3.9(15)
C6	33.6(18)	27.8(16)	27.4(15)	-3.3(13)	10.0(13)	-0.2(13)
C12	26.6(17)	33.1(18)	38.2(18)	-0.7(15)	4.7(14)	-0.3(14)

C16	30.4(16)	21.6(15)	34.9(16)	-6.3(13)	3.3(13)	-0.9(12)
C10	32.6(17)	26.0(16)	33.3(17)	-1.7(13)	8.1(13)	-1.1(12)
C17	30.1(18)	33.9(18)	45(2)	0.3(16)	1.5(15)	1.8(14)
N4	29.7(17)	69(3)	82(3)	5(2)	12.9(17)	3.6(16)
C9	30.3(17)	41.1(19)	23.1(16)	-7.2(14)	4.3(13)	-3.3(14)
C13	41(2)	34(2)	46(2)	0.8(16)	22.1(17)	-6.4(15)
C18	37.2(18)	22.5(15)	37.9(18)	-3.7(13)	7.7(14)	3.3(13)
C15	46(2)	26.0(17)	34.9(18)	0.0(14)	-2.6(15)	1.2(15)
C14	57(2)	32.2(19)	36.0(19)	3.3(15)	14.2(17)	-4.7(17)
C23	44(2)	41(2)	56(3)	-1.6(18)	7.8(19)	-6.8(17)
C20	64(3)	41(2)	36(2)	-0.1(16)	6.3(19)	5.4(19)
C21	51(2)	39(2)	50(2)	-2.5(18)	-2.9(19)	-0.6(18)
C22	80(4)	97(4)	69(3)	-1(3)	-21(3)	-8(3)

Table 4 Bond Lengths for 3i.

Atom	Atom	Length/Å	Atom	Atom	Length/Å
S	O2	1.400(3)	C2	C10	1.492(4)
S	N1	1.678(3)	C4	C5	1.372(4)
S	O1	1.396(3)	C4	C9	1.377(4)
S	C18	1.727(4)	C19	C18	1.375(5)
N2	N1	1.342(3)	C19	C20	1.364(5)
N2	C3	1.312(4)	C5	C6	1.368(4)
O4	N3	1.201(4)	C8	C9	1.359(4)
N1	C1	1.347(4)	C24	C18	1.375(5)
O3	N3	1.206(4)	C24	C23	1.357(5)
N3	C7	1.449(4)	C12	C13	1.375(5)
C3	C2	1.407(4)	C16	C17	1.421(5)
C3	C4	1.457(4)	C16	C15	1.384(5)
C11	C12	1.368(4)	C17	N4	1.127(5)

C11	C16	1.373(4)	C13	C14	1.358(5)
C11	C10	1.491(4)	C15	C14	1.357(5)
C7	C8	1.367(5)	C23	C21	1.375(6)
C7	C6	1.360(5)	C20	C21	1.366(6)
C1	C2	1.348(4)	C21	C22	1.494(6)

Table 5 Bond Angles for 3i.

Atom	Atom	Atom	Angle/°	Atom	Atom	Atom	Angle/°
O2	S	N1	105.64(15)	C5	C4	C3	121.4(3)
O2	S	C18	109.57(16)	C5	C4	C9	119.2(3)
N1	S	C18	103.05(15)	C9	C4	C3	119.4(3)
O1	S	O2	121.53(16)	C20	C19	C18	118.3(4)
O1	S	N1	104.70(14)	C6	C5	C4	120.7(3)
O1	S	C18	110.52(16)	C9	C8	C7	118.4(3)
C3	N2	N1	104.0(3)	C23	C24	C18	119.3(3)
N2	N1	S	118.8(2)	C7	C6	C5	118.6(3)
N2	N1	C1	113.0(2)	C11	C12	C13	120.8(3)
C1	N1	S	128.1(2)	C11	C16	C17	119.1(3)
O4	N3	O3	123.6(3)	C11	C16	C15	121.1(3)
O4	N3	C7	118.3(3)	C15	C16	C17	119.7(3)
O3	N3	C7	118.1(3)	C2	C10	C11	112.2(3)
N2	C3	C2	111.7(3)	N4	C17	C16	178.0(4)
N2	C3	C4	118.5(3)	C8	C9	C4	120.9(3)
C2	C3	C4	129.8(3)	C14	C13	C12	120.4(3)
C12	C11	C16	118.1(3)	C19	C18	S	119.5(3)
C12	C11	C10	121.4(3)	C19	C18	C24	121.0(3)
C16	C11	C10	120.5(3)	C24	C18	S	119.5(3)
C8	C7	N3	118.7(3)	C14	C15	C16	119.5(3)
C6	C7	N3	119.1(3)	C15	C14	C13	120.0(3)

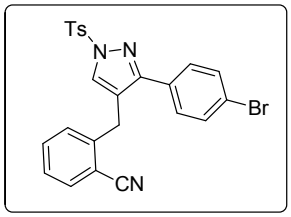
C6	C7	C8	122.3(3)	C24	C23	C21	120.7(4)
N1	C1	C2	106.3(3)	C19	C20	C21	121.6(4)
C3	C2	C10	128.5(3)	C23	C21	C22	119.8(5)
C1	C2	C3	104.9(3)	C20	C21	C23	119.1(4)
C1	C2	C10	126.5(3)	C20	C21	C22	121.1(4)

Table 6 Hydrogen Atom Coordinates (Å×10^4) and Isotropic Displacement Parameters (Å^2×103) for 3i.

Atom	x	y	z	U(eq)
H1	-571	-1195	-6858	35
H19	-2390	-3772	-8966	45
H5	-3154	642	-4084	35
H8	-8796	-671	-4835	39
H24	-5562	-4499	-6965	44
H6	-5127	1401	-3105	35
H12	1045	1660	-6705	39
H10A	-670	1234	-5447	36
H10B	-2629	1664	-5627	36
H9	-6806	-1475	-5776	38
H13	1373	2612	-8220	47
H15	-3653	3009	-8890	44
H14	-963	3282	-9308	49
H23	-7806	-4653	-8228	56
H20	-4663	-3964	-10217	56
H22A	-7842	-5351	-10486	128
H22B	-7860	-3715	-10633	128
H22C	-8968	-4404	-9874	128

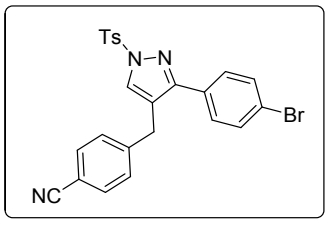
4 ^{1}H NMR, ^{13}C NMR, MP and HRMS Data of the products

2-((3-(4-bromophenyl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3a)**



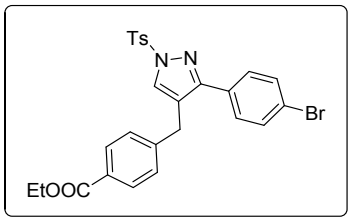
Yellow solid (209 mg, mp: 58-61 ^{o}C); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.43 (s, 3H), 4.13 (s, 2H), 7.14-7.18 (m, 1H), 7.33-7.40 (m, 3H), 7.41-7.45 (m, 2H), 7.48-7.54 (m, 3H), 7.65-7.69 (m, 1H), 7.77 (s, 1H), 7.89-7.93 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 21.7, 29.3, 112.4, 117.5, 119.9, 123.3, 127.5, 128.3, 129.5, 129.6, 130.0, 130.4, 131.3, 131.7, 133.1, 133.2, 133.8, 142.4, 146.0, 154.8. **HRMS** (ESI) m/z Calculated for $C_{24}H_{18}BrN_3O_2S$ $[M+Na]^+$ 514.0201 and 516.0180, found: 514.0205 and 516.0186.

4-((3-(4-bromophenyl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3b)**



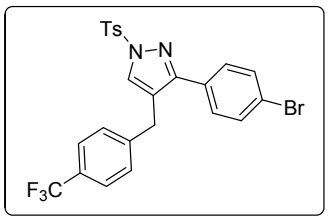
Yellow solid (228 mg, mp: 151-153 ^{o}C); **^{1}H NMR** (500 MHz, $CDCl_3$) δ 2.41 (s, 3H), 3.96 (s, 2H), 7.15-7.23 (m, 2H), 7.31-7.35 (m, 2H), 7.36-7.40 (m, 2H), 7.46-7.50 (m, 2H), 7.54-7.59 (m. 2H), 7.77 (s, 1H), 7.88-7.93 (m, 2H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 21.7, 30.7, 110.7, 118.6, 120.2, 123.3, 128.1, 129.2, 129.5, 130.0, 130.4, 131.3, 131.7, 132.5, 133.8, 144.2, 146.0, 154.7. **HRMS** (ESI) m/z Calculated for $C_{24}H_{18}BrN_3O_2S$ $[M+Na]^+$ 514.0201 and 516.0180, found: 514.0203 and 516.0185.

Ethyl 4-((3-(4-bromophenyl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzoate **(3c)**



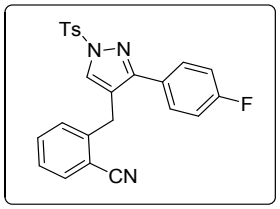
Orange solid (226 mg, mp: 50-53 ^{o}C); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 1.40 (t, 3H, *J* = 7.3 Hz), 2.42 (s, 3H), 3.95 (s, 2H), 4.38 (q, 2H, *J* = 7.2 Hz), 7.18-7.20 (m, 2H), 7.32-7.35 (m, 2H), 7.42-7.45 (m, 2H), 7.47-7.51 (m, 2H), 7.76 (s, 1H), 7.90-7.93 (m, 2H), 7.97-8.00 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 14.2, 21.6, 30.7, 60. 9, 121.1, 123.2, 128.1, 128.4, 129.0, 129.5, 130.0, 130.0, 130.5, 131.4, 131.6, 133.9, 143.9, 145.8, 154.7, 166.2. **HRMS** (ESI) m/z Calculated for $C_{26}H_{23}BrN_2O_4S$ $[M+Na]^+$ 561.0460 and 563.0439, found: 561.0457 and 563.0440.

3-(4-bromophenyl)-1-tosyl-4-(4-(trifluoromethyl)benzyl)-1H-pyrazole **(3d)**



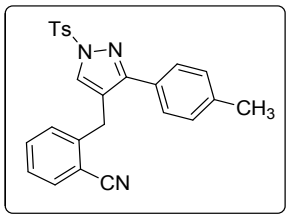
Yellow solid (208 mg, mp: 107-109 ^{o}C); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.44 (s, 3H), 3.98 (s, 2H), 7.25-7.28 (m, 2H), 7.34-7.37 (m, 2H), 7.43-7.47 (m, 2H), 7.50-7.54 (m, 2H), 7.56-7.60 (m, 2H), 7.79 (s, 1H), 7.92-7.97 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 21.7, 30.6, 121.0, 123.3, 124.1 (q, *J* = 276 Hz), 125.5, 125.7, 128.2, 128.9, 129.5 (q, *J* = 32 Hz), 130.1, 130.6, 131.4, 131.8, 134.0, 142.9, 146.0, 154.8. **HRMS** (ESI) m/z Calculated for $C_{24}H_{18}BrF_3N_2O_2S$ $[M+Na]^+$ 557.0122 and 559.0102, found: 557.0120 and 559.0101.

2-((3-(4-fluorophenyl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3e)**



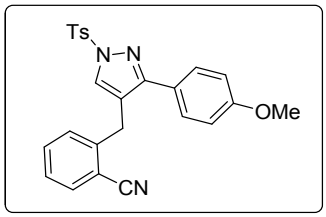
Yellow solid (189 mg, mp: 123-125 ^{o}C); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.43 (s, 3H), 4.13 (s, 2H), 7.04-7.11 (m, 2H), 7.14-7.18 (m, 1H), 7.32-7.39 (m, 3H), 7.47-7.56 (m, 3H), 7.63-7.69 (m, 1H), 7.63-7.69 (m, 1H), 7.78 (s, 1H), 7.89-7.94 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 21.6, 29.2, 112.4, 115.5 (d, J = 22 Hz), 117.5, 119.9, 127.4, 127.5 (d, J = 3.7 Hz), 128.1, 129.5, 129.9, 130.0, 130.0, 131.2, 133.1 (d, J = 8.0 Hz), 133.8, 142.5, 145.8, 155.1, 163.1 (d, J = 249 Hz). **HRMS** (ESI) m/z Calculated for $C_{24}H_{18}FN_3O_2S$ $[M+Na]^+$ 454.1001, found: 454.1003.

2-((3-(p-tolyl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3f)**



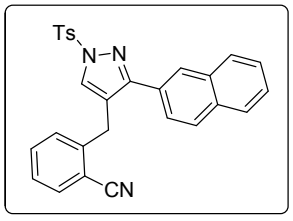
Yellow solid (166 mg, mp: 114-116 ^{o}C); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.37 (s, 3H), 2.42 (s, 3H), 4.15 (s, 2H), 7.14-7.22 (m, 3H), 7.31-7.38 (m, 3H), 7.44-7.52 (m, 3H), 7.64-7.69 (m, 1H), 7.76 (s, 1H), 7.89-7.91 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 21.2, 21.6, 29.3, 112.3, 117.6, 120.0, 127.3, 127.9, 128.0, 128.5, 129.2, 129.5, 129.9, 131.1, 132.9, 133.1, 134.0, 138.9, 142.8, 145.7, 156.1. **HRMS** (ESI) m/z Calculated for $C_{25}H_{21}N_3O_2S$ $[M+Na]^+$ 450.1252, found: 450.1253.

2-((3-(4-methoxyphenyl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3g)**



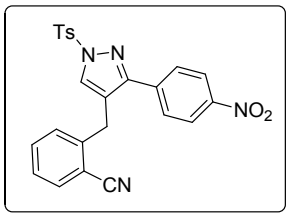
Yellow solid (139 mg, mp: 151-153 ^{o}C); **^{1}H NMR** (500 MHz, $CDCl_3$) δ 2.41 (s, 3H), 3.80 (s, 3H), 4.13 (s, 2H), 6.87-6.91 (m, 2H), 7.12-7.16 (m, 1H), 7.30-7.36 (m, 3H), 7.45-7.51 (m, 3H), 7.64-7.66 (m, 1H), 7.72 (s, 1H), 7.88-7.91 (m, 2H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 21.7, 29.4, 55.3, 112.5, 114.0, 117.7, 120.0, 124.0, 127.4, 128.1, 129.5, 129.6, 130.0, 131.2, 133.1, 133.2, 134.1, 142.9, 145.7, 156.0, 160.2. **HRMS** (ESI) m/z Calculated for $C_{25}H_{21}N_3O_3S$ $[M+Na]^+$ 466.1201, found: 466.1201.

2-((3-(naphthalen-2-yl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3h)**



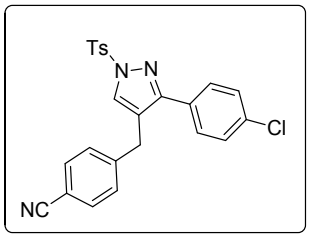
Yellow solid (187 mg, mp: 141-144 ^{o}C); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.42 (s, 3H), 3.83 (s, 2H), 6.77-6.81 (m, 1H), 7.14-7.19 (m, 1H), 7.21-7.26 (m, 1H), 7.31-7.37 (m, 4H), 7.41-7.48 (m, 4H), 7.81-7.88 (m, 2H), 7.91-7.95 (m, 2H), 7.99 (s, 1H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 21.6, 28.9, 112.1, 117.5, 122.3, 124.9, 125.1, 125.9, 126.5, 127.0, 127.8, 128.0, 128.1, 128.6, 129.4, 129.6, 129.9, 130.6, 131.6, 132.6, 132.7, 133.4, 134.0, 142.4, 145.7, 155.9. **HRMS** (ESI) m/z Calculated for $C_{28}H_{21}N_3O_2S$ $[M+Na]^+$ 486.1252, found: 486.1255.

2-((3-(4-nitrophenyl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3i)**



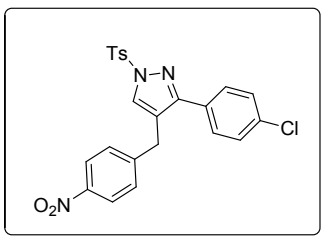
Yellow solid (176 mg, mp: 130-133 ^{o}C); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.45 (s, 3H), 4.12 (s, 2H), 7.16-7.22 (m, 1H), 7.35-7.43 (m, 3H), 7.50-7.57 (m, 1H), 7.66-7.72 (m, 1H), 7.74-7.79 (m, 2H), 7.80-7.84 (s, 1H), 7.91-7.97 (m, 2H), 8.21-8.28 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 21.7, 29.3, 112.5, 117.4, 120.2, 123.8, 127.7, 128.3, 128.9, 129.5, 130.1, 131.6, 133.2, 133.3, 133.5, 137.9, 142.0, 146.3, 147.9, 153.3. **HRMS** (ESI) m/z Calculated for $C_{24}H_{18}BrN_4O_4S$ $[M+Na]^+$ 481.0946, found: 481.0945.

4-((3-(4-chlorophenyl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3j)**



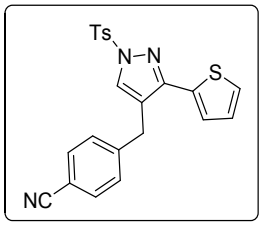
Yellow solid (186 mg, mp: 155-160 ^{o}C); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.44 (s, 3H), 3.98 (s, 2H), 7.21-7.26 (m, 2H), 7.32-7.37 (m, 4H), 7.44-7.49 (m, 2H), 7.56-7.62 (m, 2H), 7.80 (s, 1H), 7.90-7.05 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 21.6, 30.7, 110.7, 118.6, 120.2, 128.1, 128.7, 129.2, 129.2, 129.9, 130.0, 131.3, 132.5, 133.8, 135.0, 144.3, 146.0, 154.7. **HRMS** (ESI) m/z Calculated for $C_{24}H_{18}ClN_3O_2S$ $[M+Na]^+$ 470.0706 and 472.0676, found: 470.0705 and 472.0677.

3-(4-chlorophenyl)-4-(4-nitrobenzyl)-1-tosyl-1H-pyrazole **(3k)**



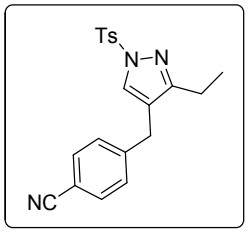
Yellow solid (196 mg, mp: 139-142 °C); **^{1}H NMR** (500 MHz, $CDCl_3$) δ 2.43 (s, 3H), 4.00 (s, 2H), 7.25-7.28 (m, 2H), 7.31-7.36 (m, 4H), 7.43-47 (m, 2H), 7.79 (s, 1H), 7.90-7.94 (m, 2H), 8.12-8.17 (m, 2H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 21.7, 30.6, 120.1, 124.0, 128.2, 128.8, 129.3, 129.3, 129.9, 130.1, 131.3, 133.9, 135.2, 146.0, 146.3, 146.9, 154.7. **HRMS** (ESI) m/z Calculated for $C_{23}H_{18}ClN_3O_4S$ $[M+Na]^+$ 490.0604 and 492.0575, found: 490.0600 and 492.0570.

4-((3-(thiophen-2-yl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3l)**



White solid (134 mg, mp: 182-184 °C); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.44 (s, 3H), 4.05 (s, 2H), 7.02-7.05 (m, 1H), 7.23-7.25 (m, 1H), 7.26-7.30 (m, 2H), 7.33-7.38 (m, 3H), 7.60-7.64 (m, 2H), 7.74 (s, 1H), 7.91-7.96 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 21.7, 30.8, 110.8, 118.6, 119.8, 126.7, 126.8, 127.5, 128.2, 129.3, 130.0, 131.3, 132.5, 133.4, 133.9, 144.0, 145.9, 150.4. **HRMS** (ESI) m/z Calculated for $C_{22}H_{17}N_3O_2S_2$ $[M+Na]^+$ 442.0660, found: 442.0666.

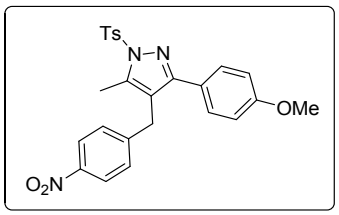
4-((3-ethyl-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3m)**



Yellow solid (151 mg, mp: 161-163 °C); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 1.13 (t, 3H, *J* = 7.6 Hz), 2.44 (s, 3H), 2.48 (q, 2H, *J* = 7.6 Hz), 3.80 (s, 2H), 7.22-7.24 (m, 2H), 7.31-7.36 (m, 2H), 7.58-7.62 (m, 2H), 7.71 (s, 1H), 7.85-7.96 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 12.4, 20.2, 21.7, 29.9, 110.6, 118.7, 120.6, 127.9, 129.2, 129.9, 130.3, 132.5,

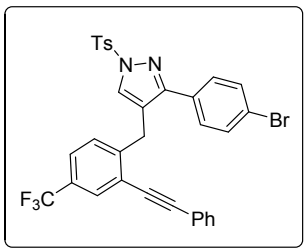
134.4, 144.5, 145.5, 159.3. **HRMS** (ESI) m/z Calculated for $C_{20}H_{19}N_3O_2S$ $[M+Na]^+$ 388.1096, found: 388.1100.

3-(4-methoxyphenyl)-5-methyl-4-(4-nitrobenzyl)-1-tosyl-1H-pyrazole **(3n)**



Orange solid (193 mg, mp: 163-165 °C); **^{1}H NMR** (400 MHz, $CDCl_3$) δ 2.46 (s, 3H), 2.48 (s, 3H), 3.80 (s, 3H), 3.95 (s, 2H), 6.84-6.88 (m, 2H), 7.11-7.17 (m, 2H), 7.33-7.38 (m, 4H), 7.92-7.96 (m, 2H), 8.08-8.13 (m, 2H); **^{13}C NMR** (100 MHz, $CDCl_3$) δ 11.6, 21.7, 29.3, 55.3, 114.0, 117.0, 123.9, 124.1, 127.8, 128.5, 129.4, 130.0, 135.1, 142.0, 145.5, 146.6, 147.0, 155.1, 160.1. **HRMS** (ESI) m/z Calculated for $C_{25}H_{23}N_3O_5S$ $[M+Na]^+$ 500.1256, found: 500.1258.

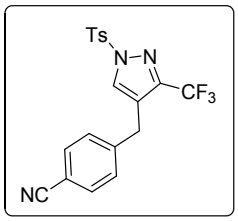
3-(4-bromophenyl)-4-(2-(phenylethynyl)-4-(trifluoromethyl)benzyl)-1-tosyl-1H-pyrazole **(3o)**



Purple solid (254 mg, mp: 161-163 °C); **^{1}H NMR** (500 MHz, $CDCl_3$) δ 2.35 (s, 3H), 4.17 (s, 2H), 7.19-7.28 (m, 7H), 7.31-7.36 (m, 1H), 7.44-7.54 (m, 5H), 7.72 (s, 1H), 7.81-7.88 (m, 3H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 21.6, 29.8, 86.0, 95.6, 120.6, 122.1, 123.3, 123.6 (q, J = 271 Hz), 123.8, 124.7, 125.2, 125.2, 128.0, 128.4, 128.8, 129.4, 129.4, 129.6, 129.7, 129.9, 130.6, 131.6 (q, J = 40 Hz), 134.0, 144.4, 145.7, 154.8. **HRMS** (ESI) m/z Calculated for $C_{32}H_{22}BrF_3N_2O_2S$ $[M+Na]^+$ 657.0435 and 659.0415,

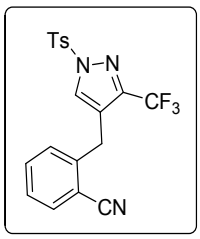
found: 657.0433 and 659.0416.

4-((1-tosyl-3-(trifluoromethyl)-1H-pyrazol-4-yl)methyl)benzonitrile **(3p)**



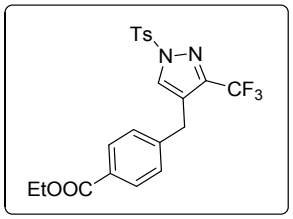
Yellow solid (176 mg, mp: 166-169 ^{o}C); **^{1}H NMR** (500 MHz, $CDCl_3$) δ 2.44 (s, 3H), 3.91 (s, 2H), 7.24-7.26 (m, 2H), 7.33-7.38 (m, 2H), 7.58-7.63 (m, 2H), 7.75 (s, 1H), 7.86-7.7.93 (m, 2H); ^{13}C NMR (125 MHz, $CDCl_3$) δ 21.8, 29.5, 111.1, 118.6, 120.4 (q, J = 272 Hz), 120.5, 128.6, 129.4, 130.3, 131.2, 132.7, 132.8, 143.4, 145.1 (q, J = 37 Hz), 147.0. **HRMS** (ESI) m/z Calculated for $C_{19}H_{14}F_3N_3O_2S$ $[M+Na]^+$ 428.0657, found: 428.0655.

2-((1-tosyl-3-(trifluoromethyl)-1H-pyrazol-4-yl)methyl)benzonitrile **(3q)**



Yellow solid (168 mg, mp: 123-125 ^{o}C); **^{1}H NMR** (500 MHz, $CDCl_3$) δ 2.45 (s, 3H), 4.10 (s, 2H), 7.25-7.29 (m, 1H), 7.35-7.42 (m, 3H), 7.53-7.59 (m, 1H), 7.65-7.70 (m, 1H), 7.82-7.86 (m, 1H), 7.89-7.93 (m, 2H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 21.8, 28.0, 112.5, 117.5, 119.8, 120.4 (q, J = 270 Hz), 127.8, 128.6, 129.9, 130.3, 131.6, 132.8, 133.2, 133.3, 141.6, 145.1 (q, J = 37 Hz), 146.9. **HRMS** (ESI) m/z Calculated for $C_{19}H_{14}F_3N_3O_2S$ $[M+Na]^+$ 428.0657, found: 428.0658.

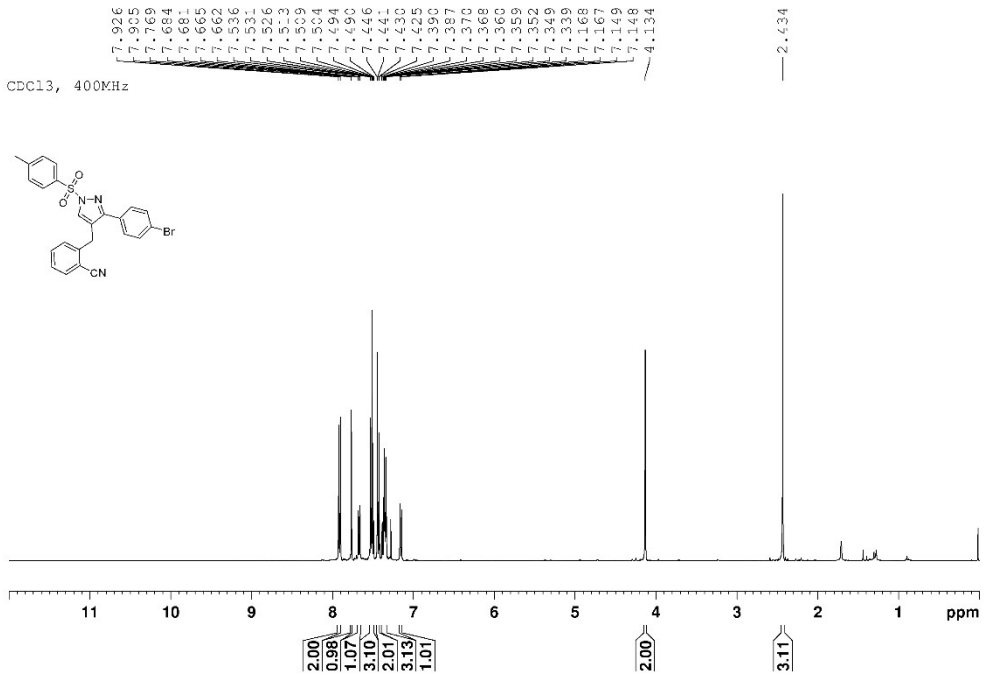
Ethyl 4-((1-tosyl-3-(trifluoromethyl)-1H-pyrazol-4-yl)methyl)benzoate **(3r)**



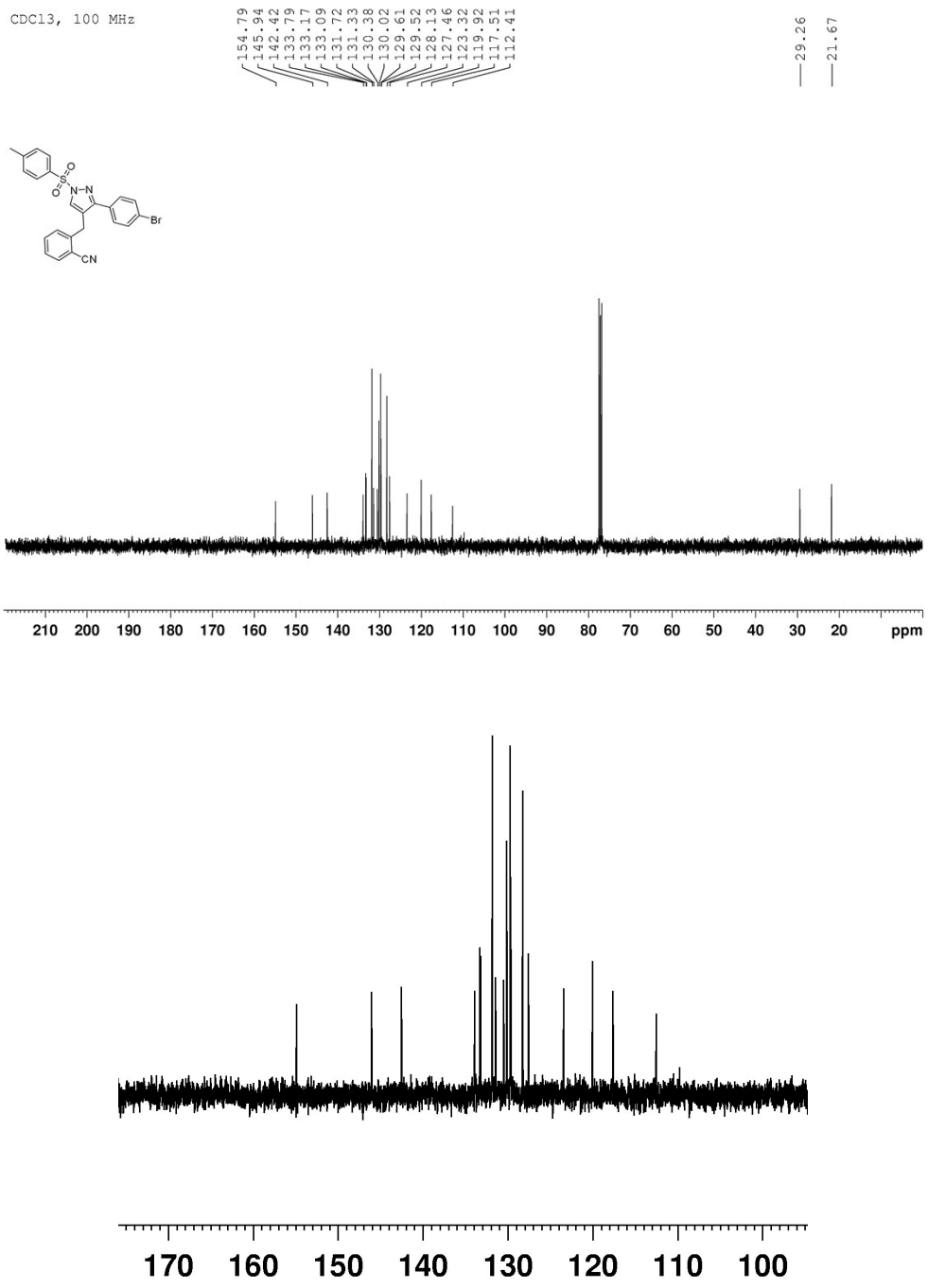
Yellow solid (201 mg, mp: 113-115 ^{o}C); ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.40 (t, 3H, *J* = 7.2 Hz), 2.45 (s, 3H), 3.90 (s, 2H), 4.38 (q, 2H, *J* = 7.2 Hz), 7.21-7.26 (m, 2H), 7.33-7.39 (m, 2H), 7.69 (s, 1H), 7.87-7.92 (m, 2H), 7.98-8.03 (m, 2H); **^{13}C NMR** (125 MHz, $CDCl_3$) δ 14.3, 21.8, 29.4, 61.0, 120.5 (q, *J* = 263 Hz), 121.6, 128.6, 128.6, 129.4, 130.1, 130.3, 131.2, 132.9, 142.9, 145.1 (q, *J* = 38 Hz), 146.8, 166.3. **HRMS** (ESI) m/z Calculated for $C_{21}H_{19}F_3N_2O_4S$ $[M+Na]^+$ 475.0915, found: 475.0910.

5 ^{1}H NMR and ^{13}C NMR Spectra of the products

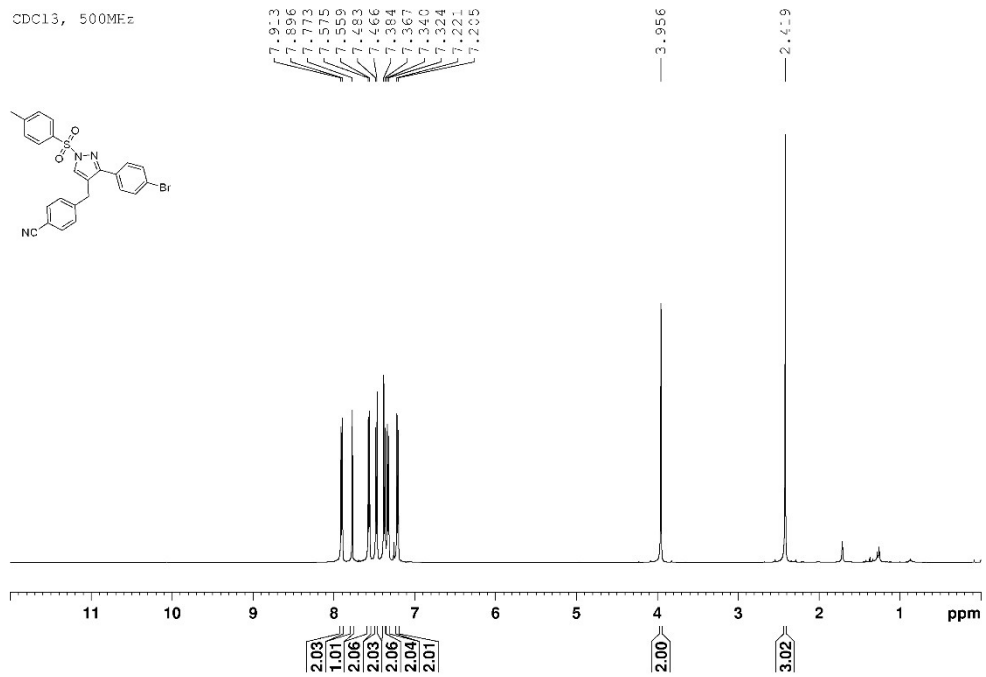
2-((3-(4-bromophenyl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile) **(3a)**



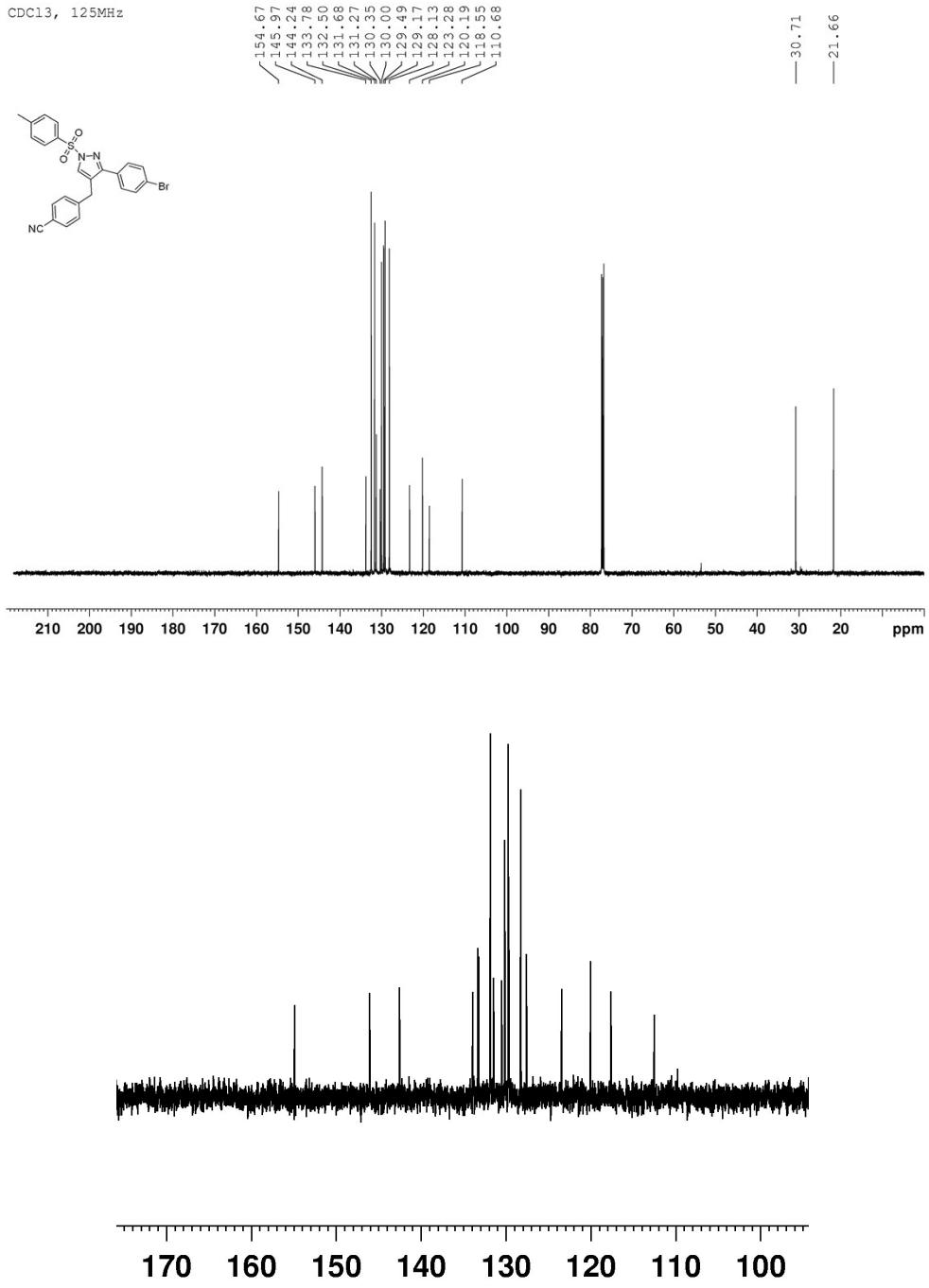
2-((3-(4-bromophenyl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile) **(3a)**



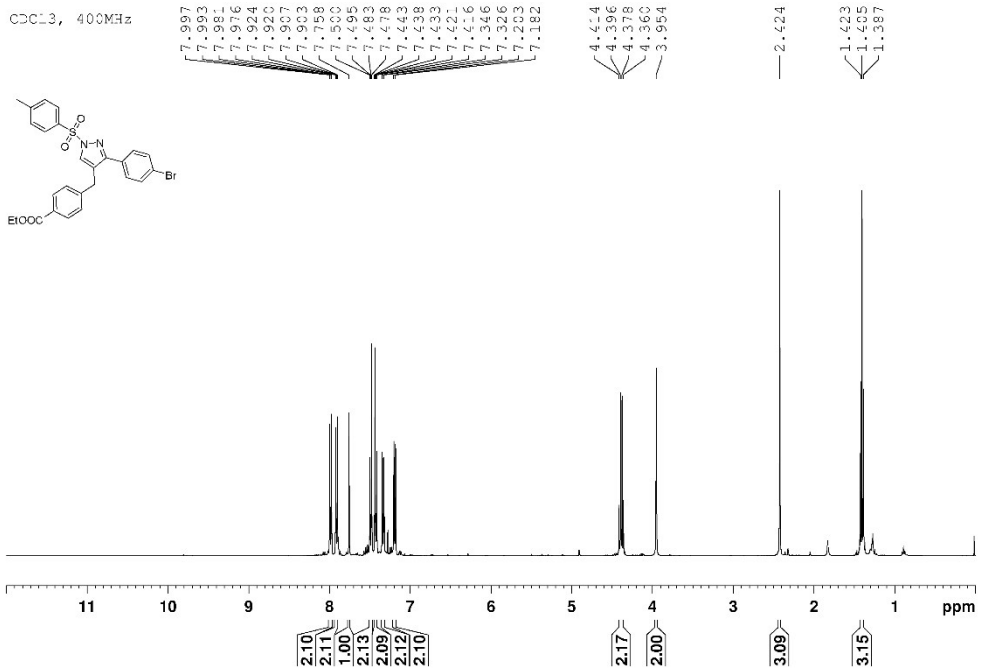
4-((3-(4-bromophenyl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3b)**



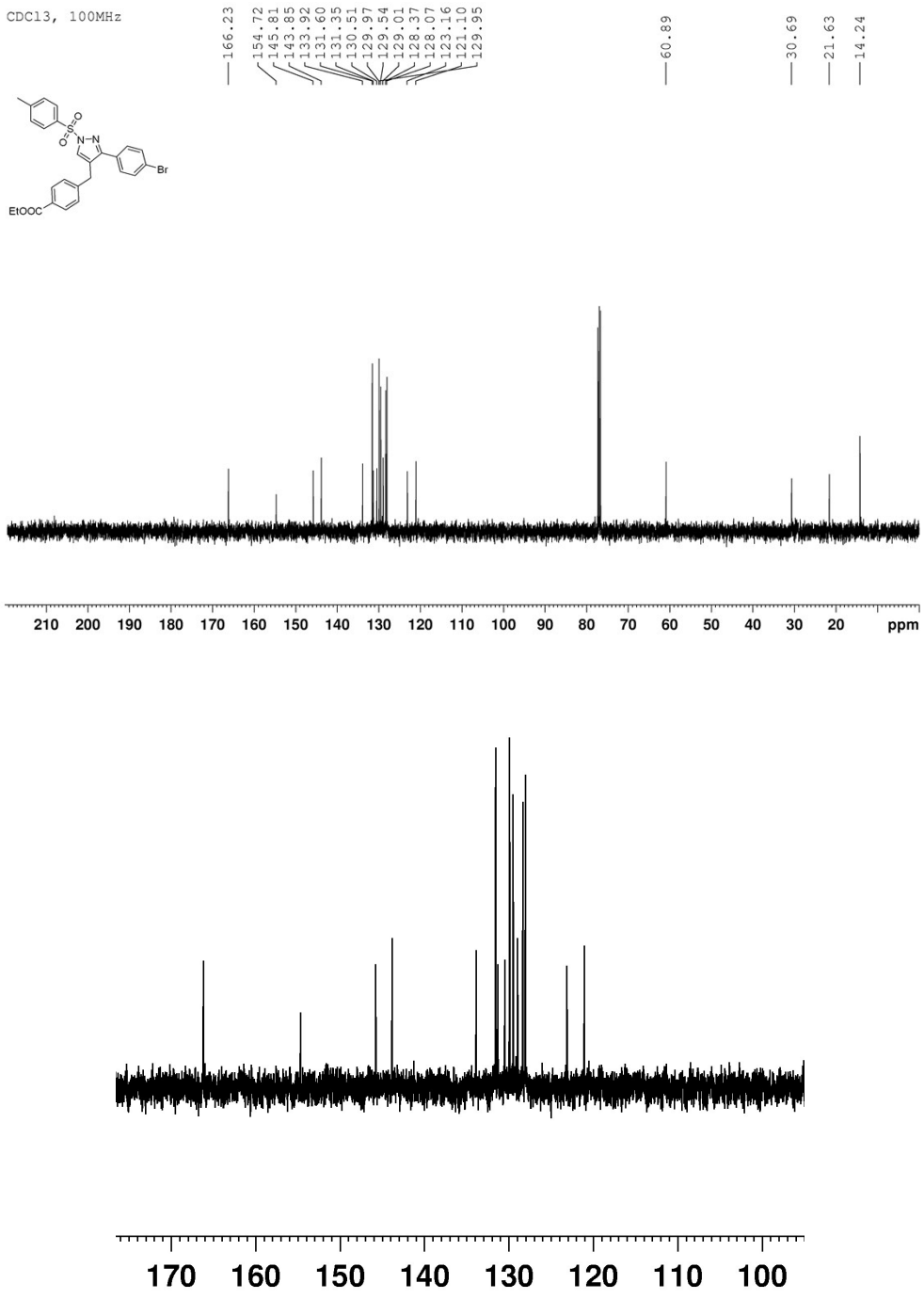
4-((3-(4-bromophenyl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3b)**



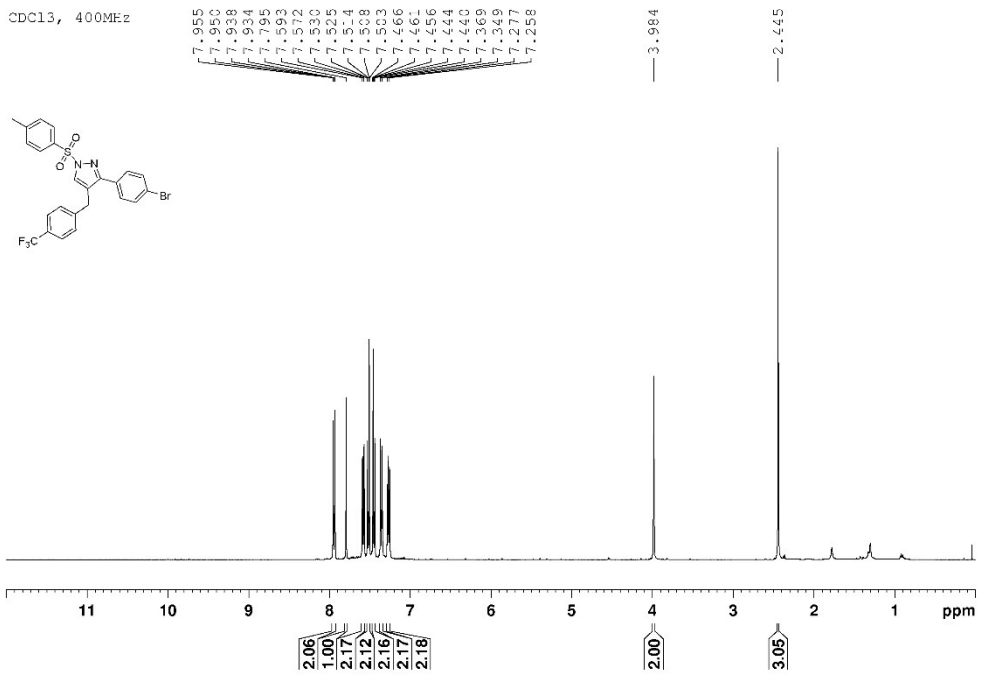
Ethyl 4-((3-(4-bromophenyl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzoate **(3c)**



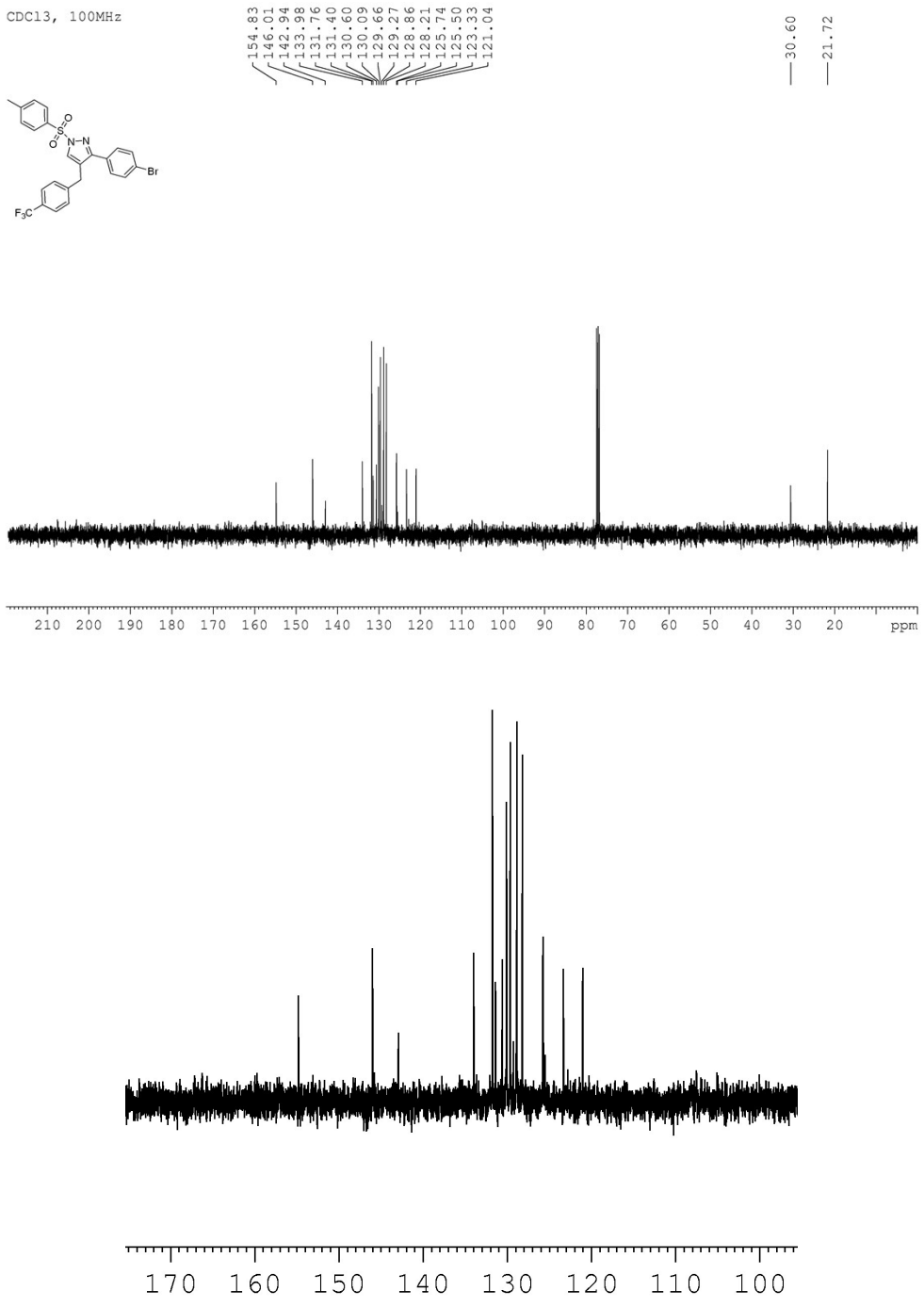
Ethyl 4-((3-(4-bromophenyl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzoate **(3c)**



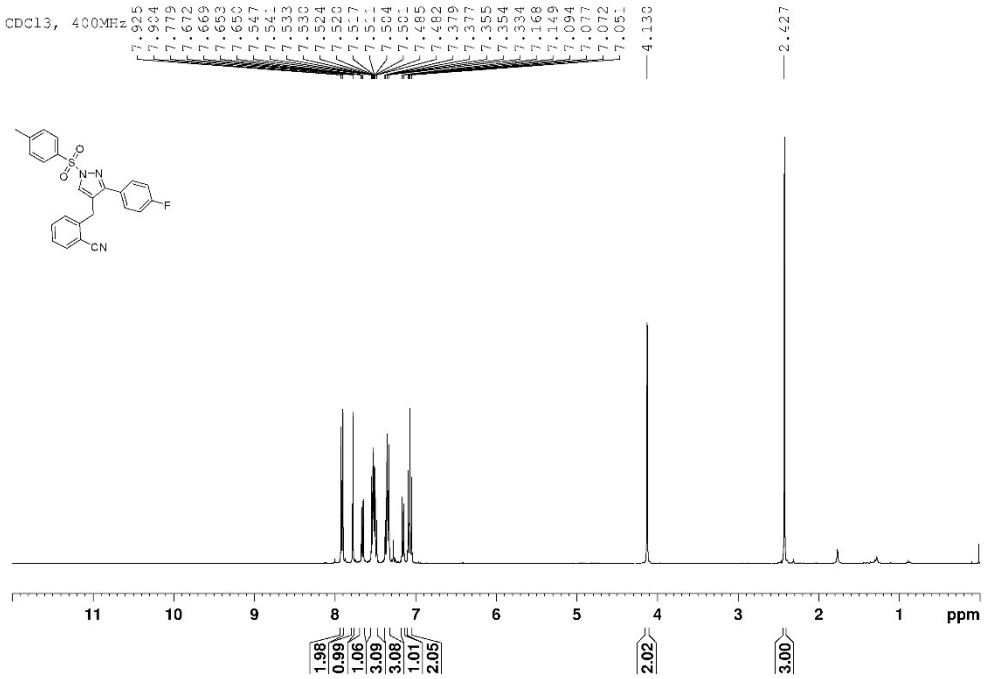
3-(4-bromophenyl)-1-tosyl-4-(4-(trifluoromethyl)benzyl)-1H-pyrazole **(3d)**



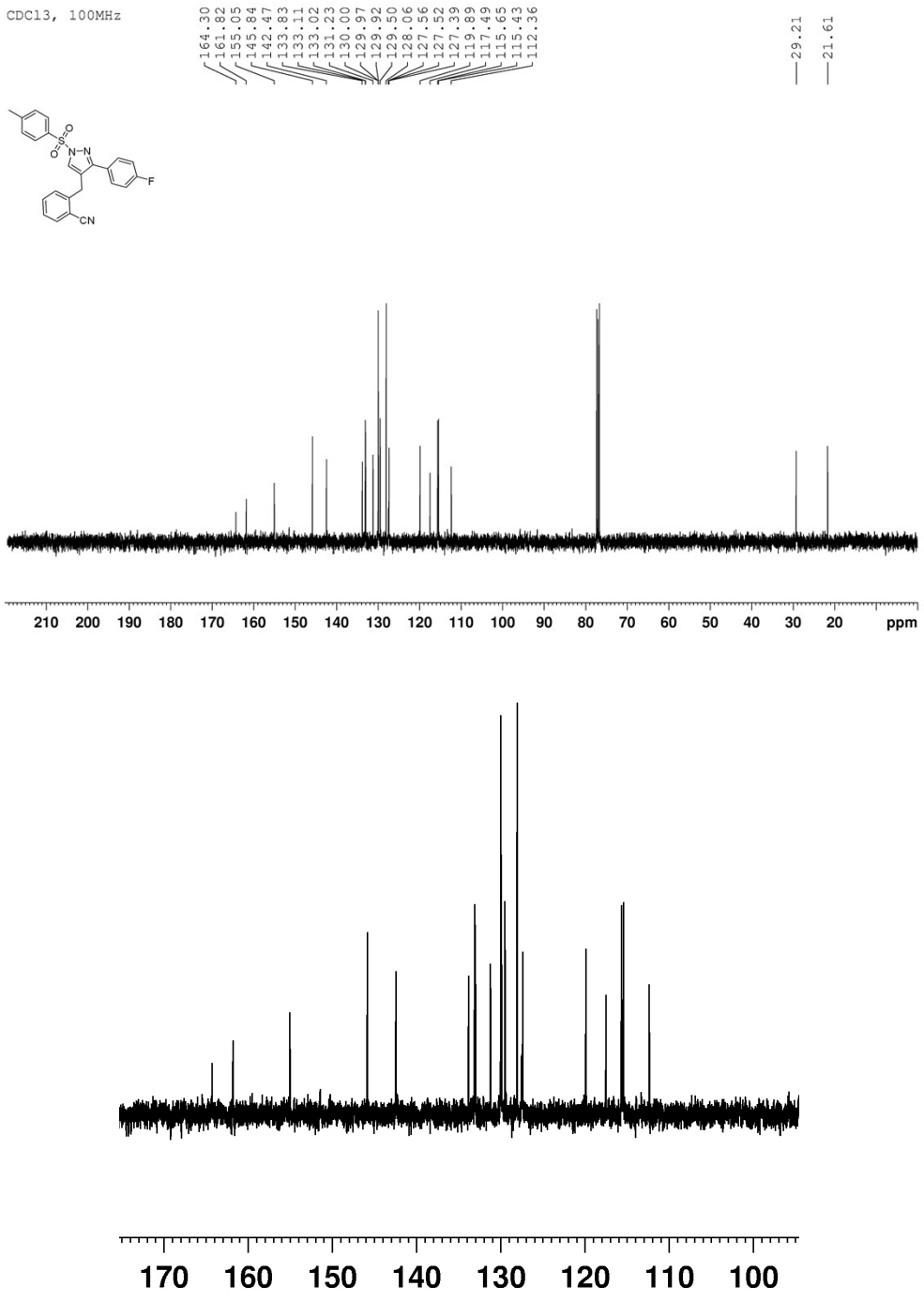
3-(4-bromophenyl)-1-tosyl-4-(4-(trifluoromethyl)benzyl)-1H-pyrazole **(3d)**



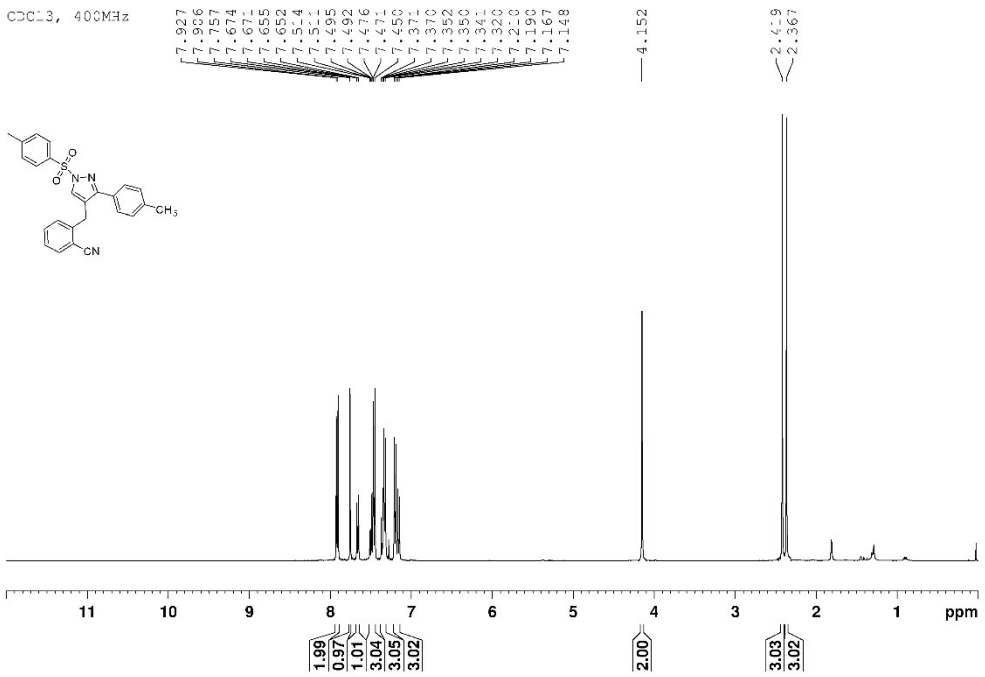
2-((3-(4-fluorophenyl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3e)**



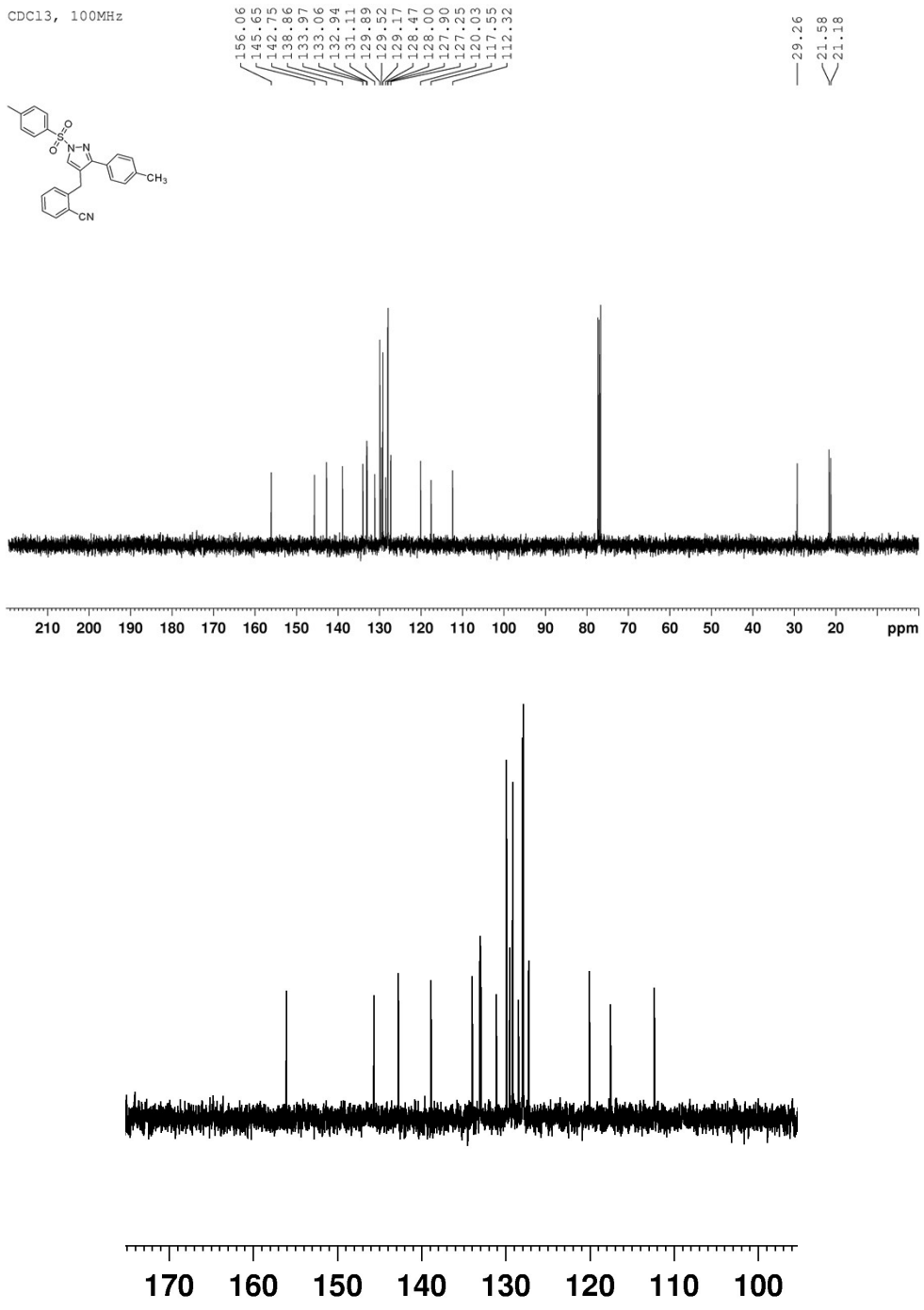
2-((3-(4-fluorophenyl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3e)**



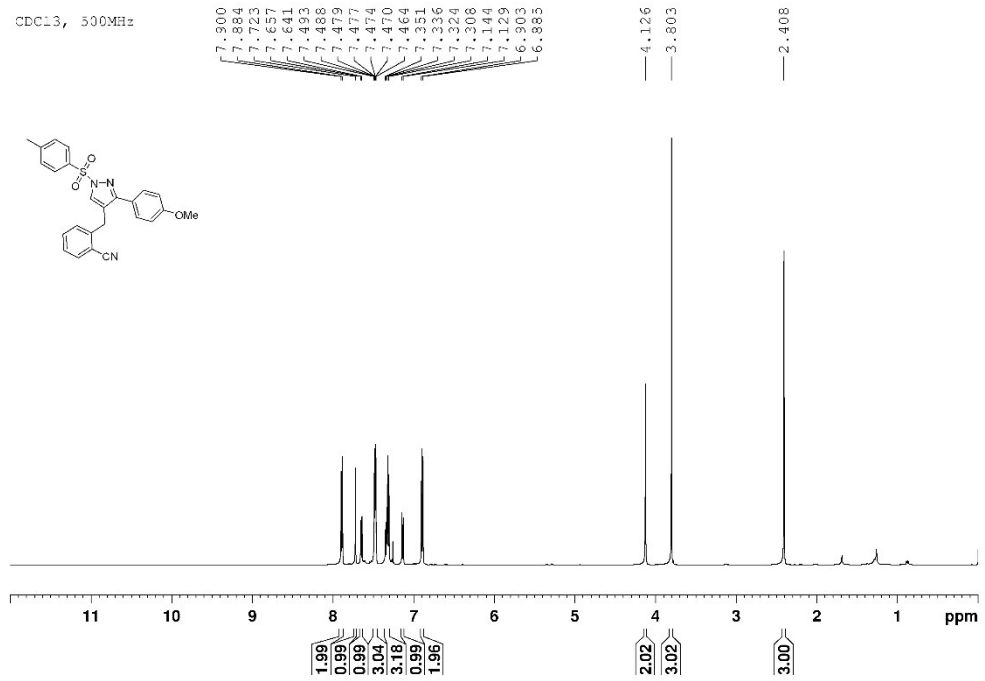
2-((3-(p-tolyl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3f)**



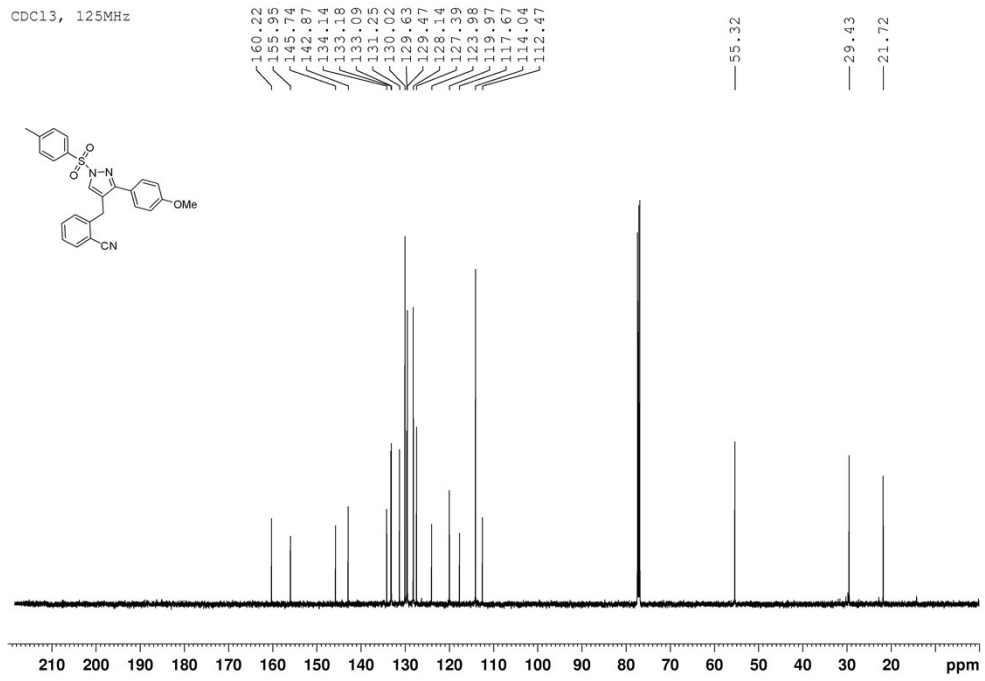
2-((3-(p-tolyl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3f)**

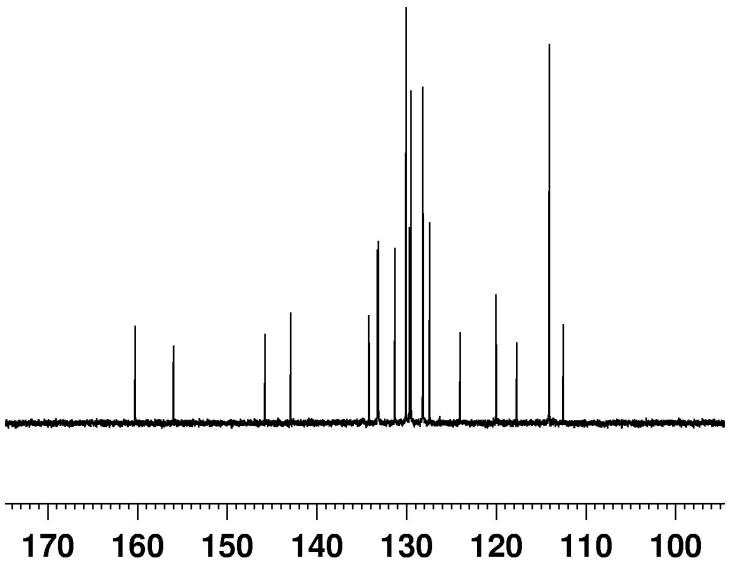


2-((3-(4-methoxyphenyl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3g)**

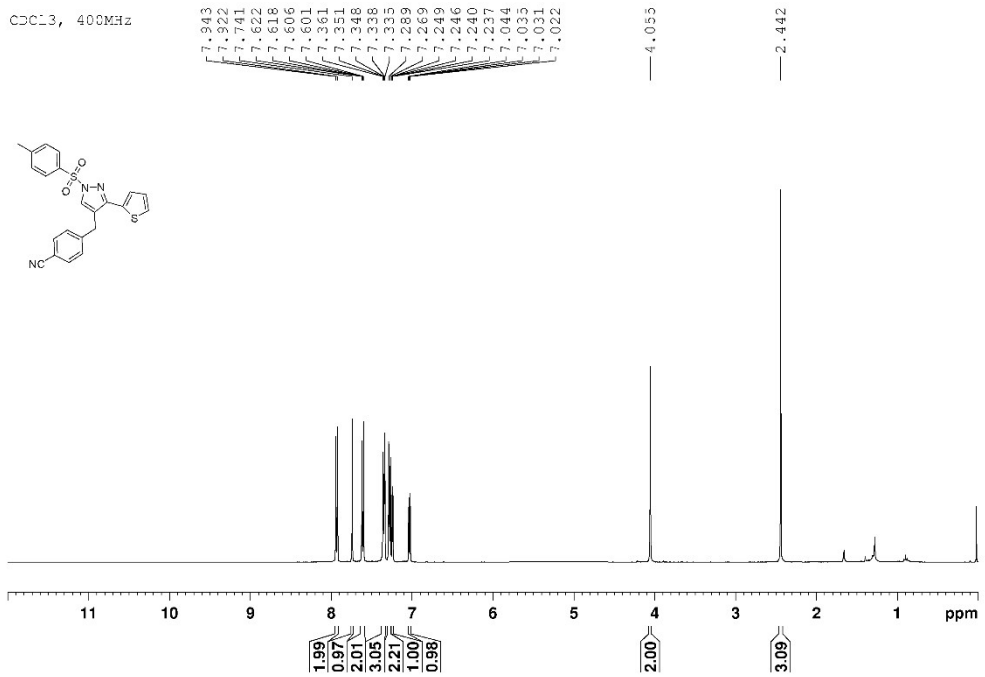


2-((3-(4-methoxyphenyl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3g)**

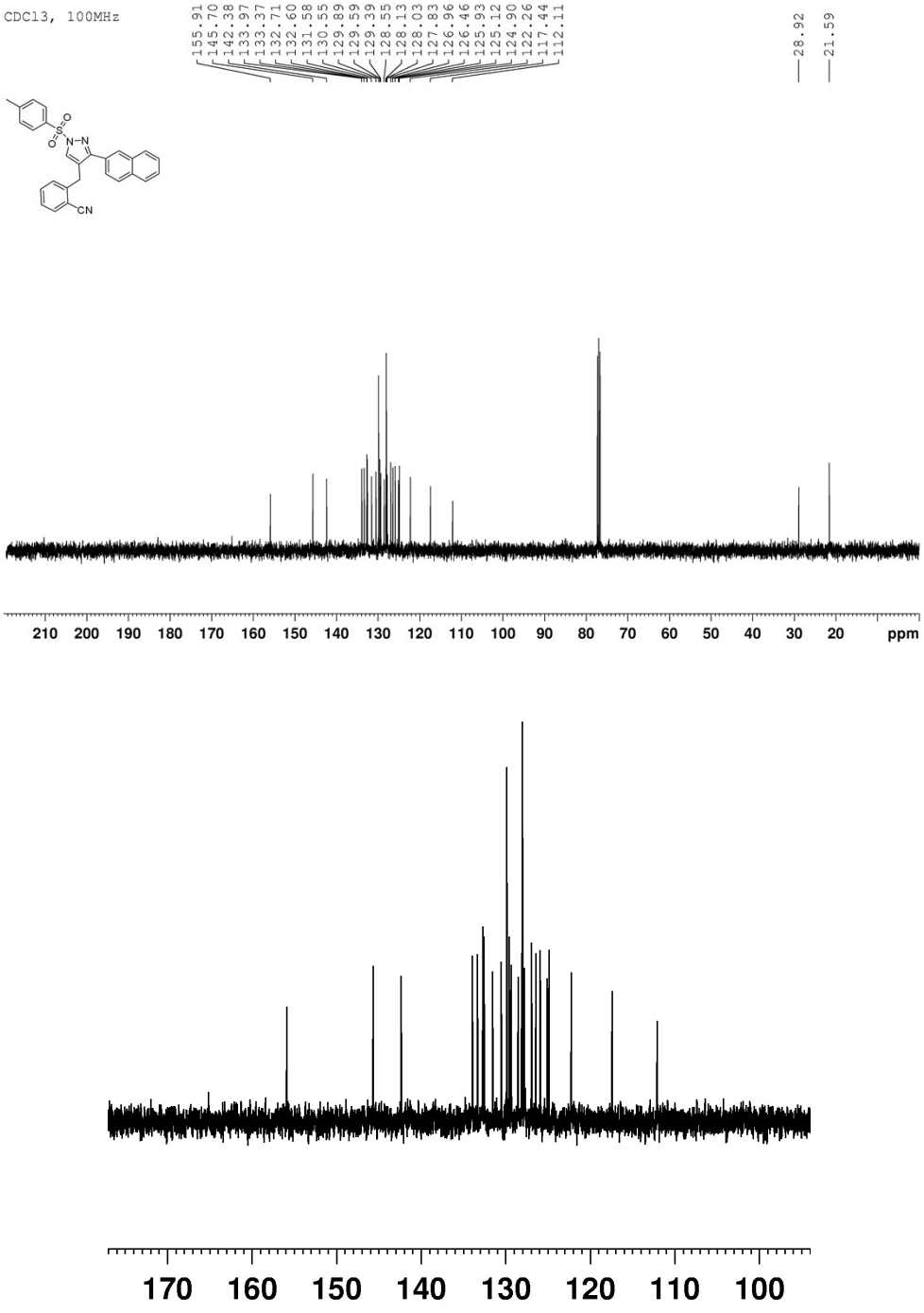




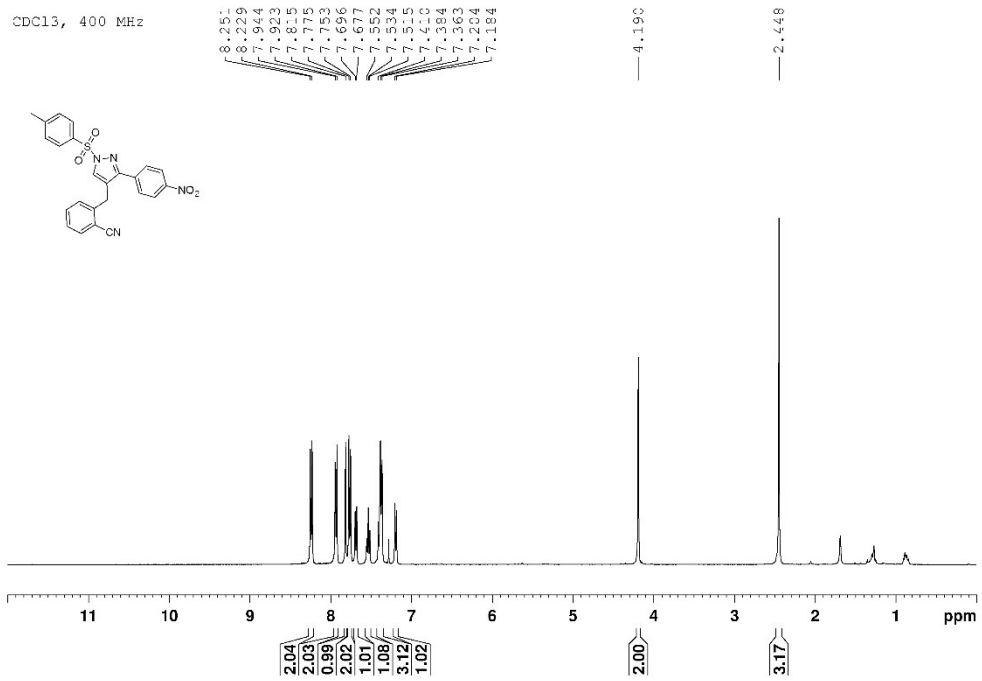
2-((3-(naphthalen-2-yl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3h)**



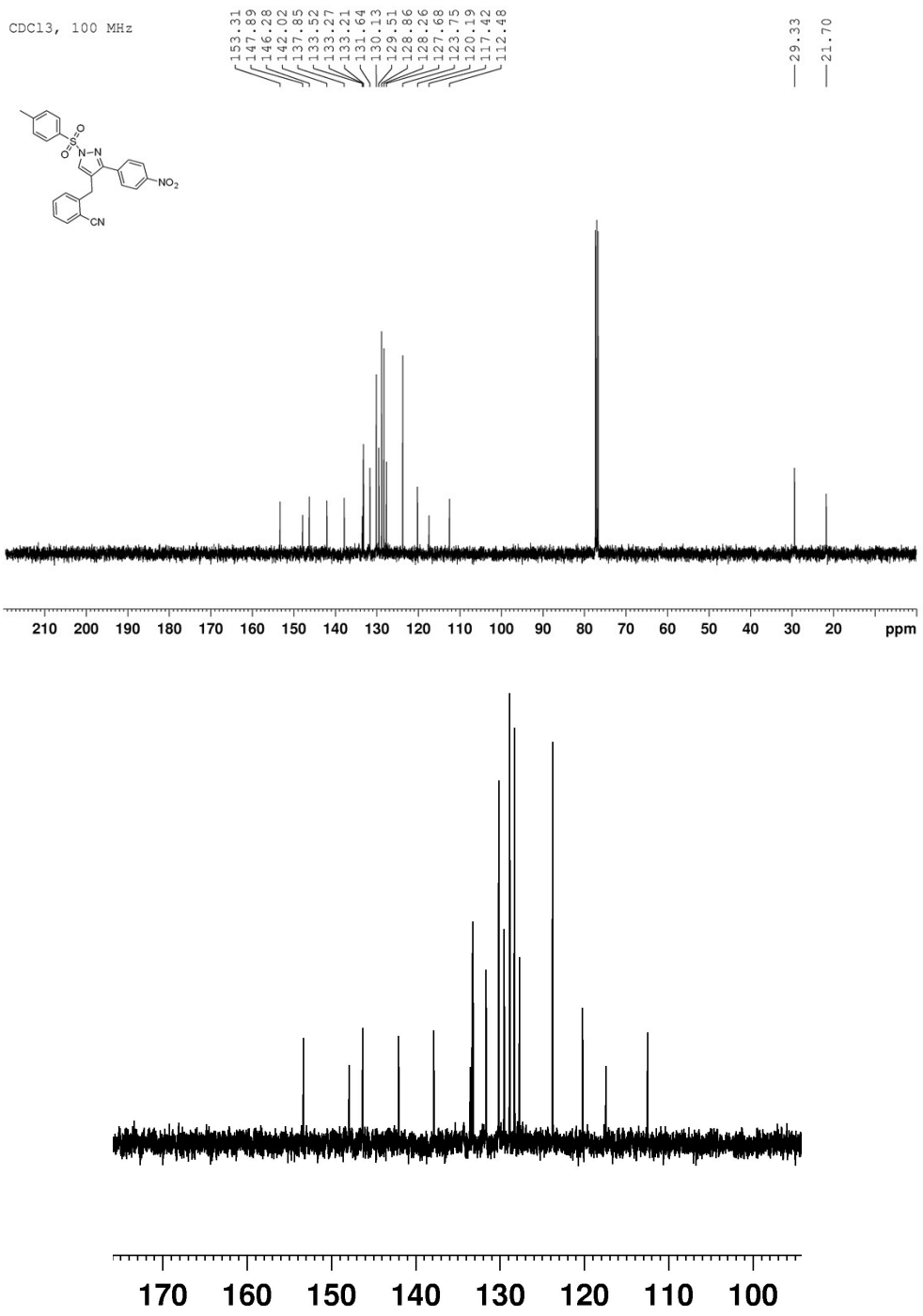
2-((3-(naphthalen-2-yl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3h)**



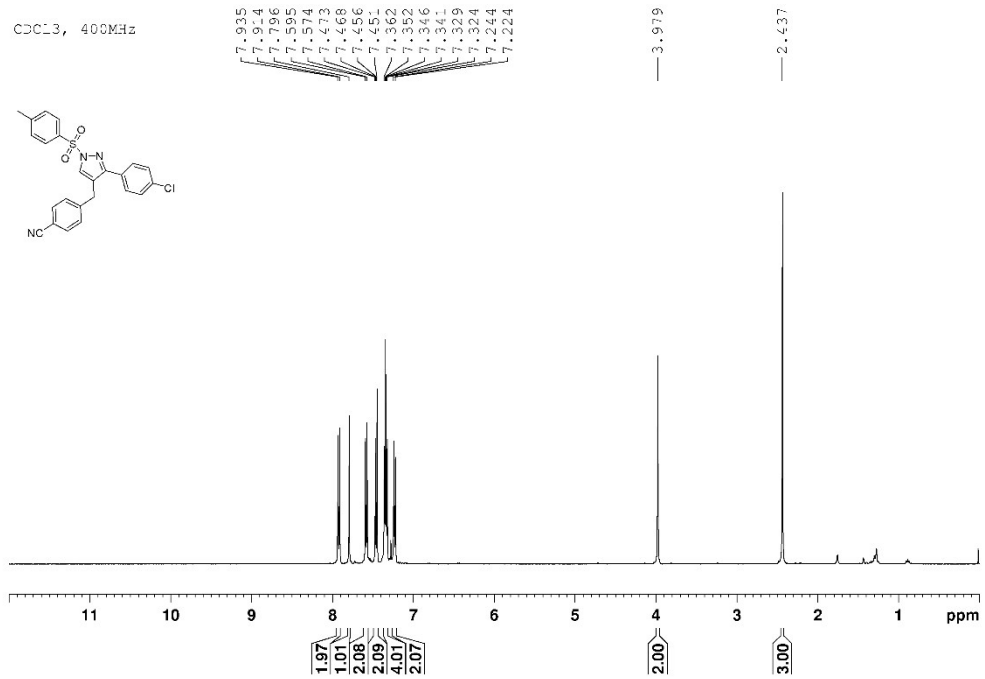
2-((3-(4-nitrophenyl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3i)**



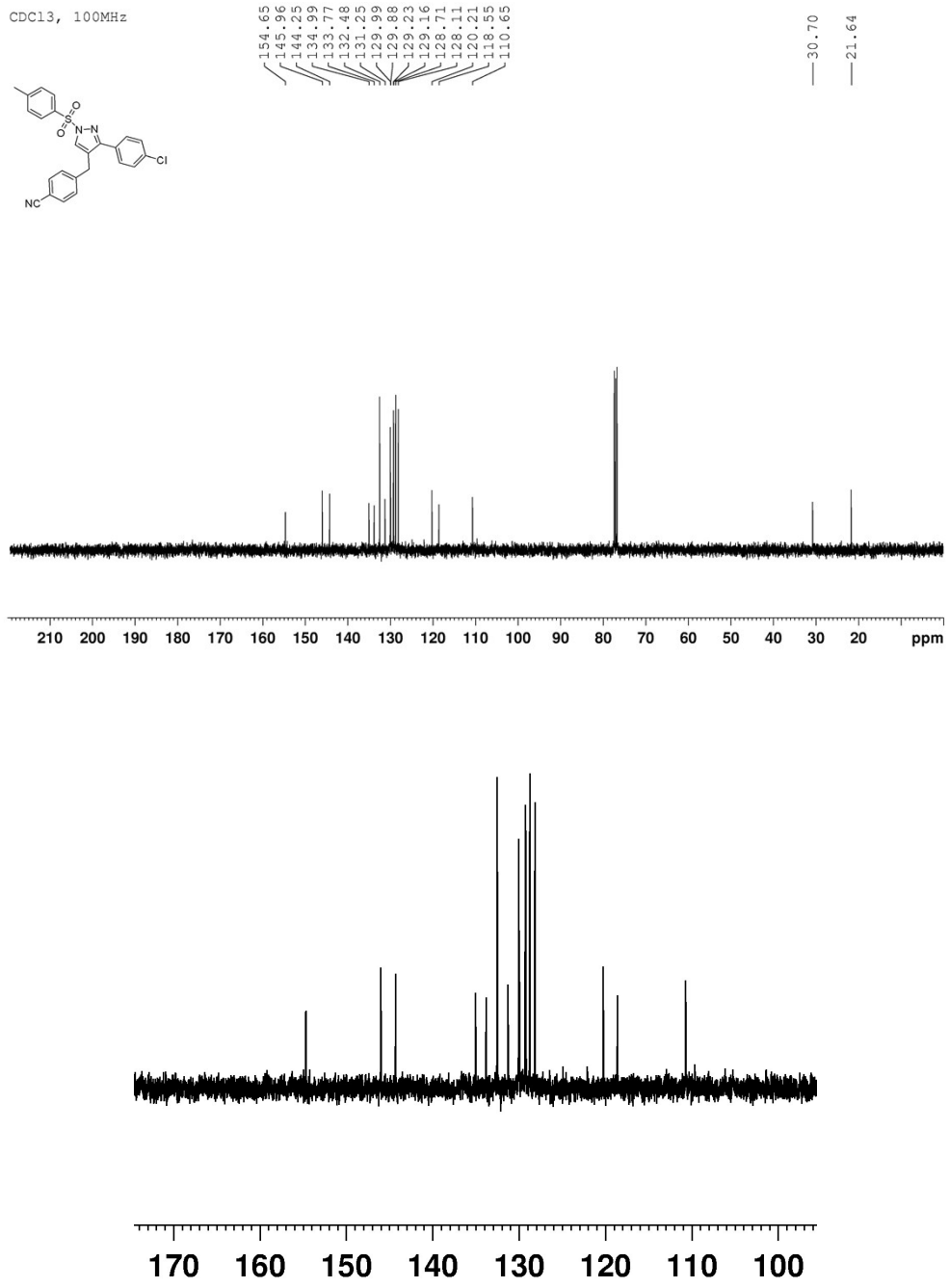
2-((3-(4-nitrophenyl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3i)**



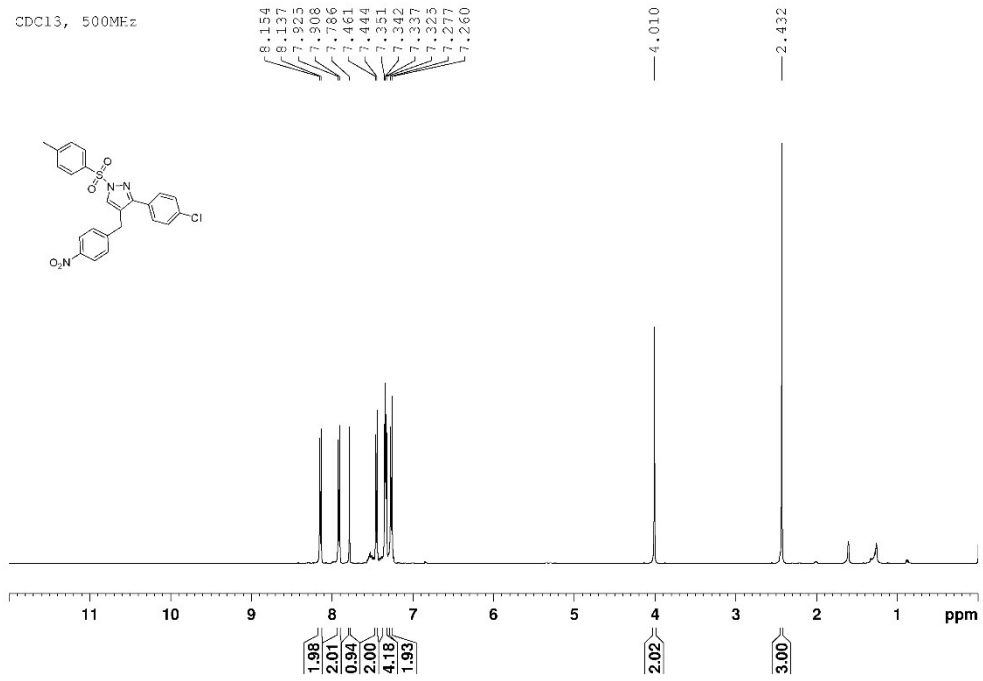
4-((3-(4-chlorophenyl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3j)**



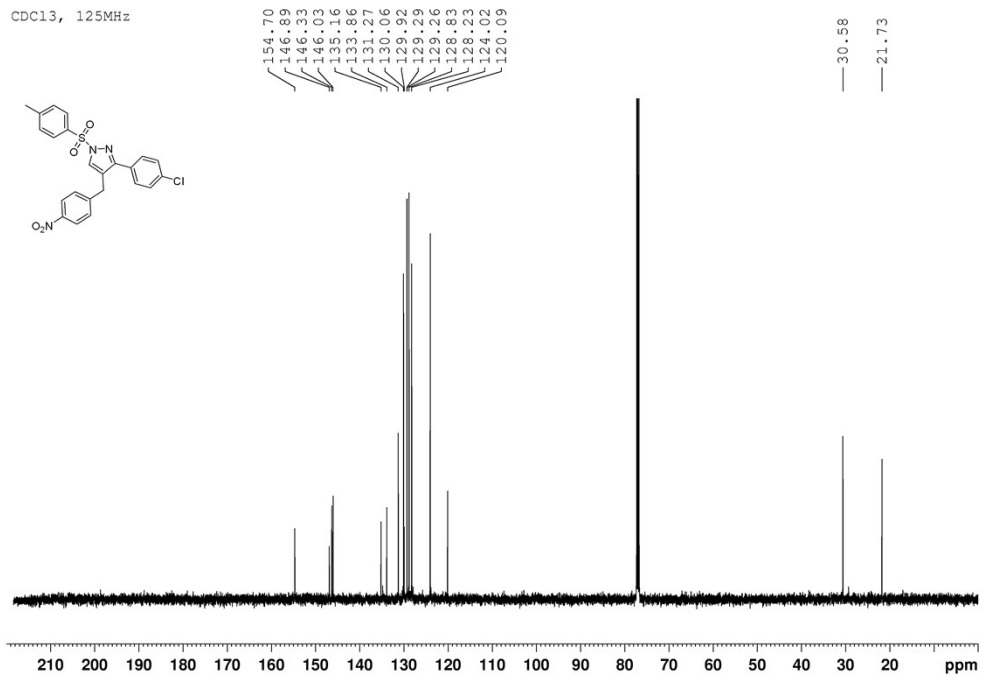
4-((3-(4-chlorophenyl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3j)**

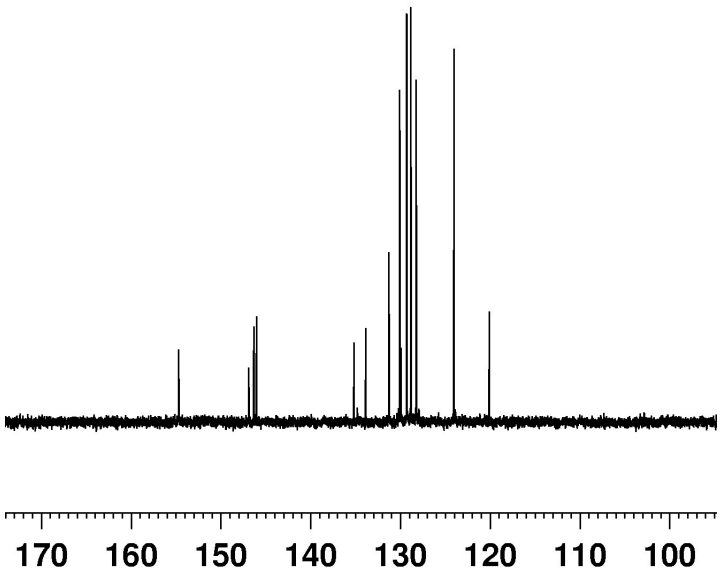


3-(4-chlorophenyl)-4-(4-nitrobenzyl)-1-tosyl-1H-pyrazole **(3k)**



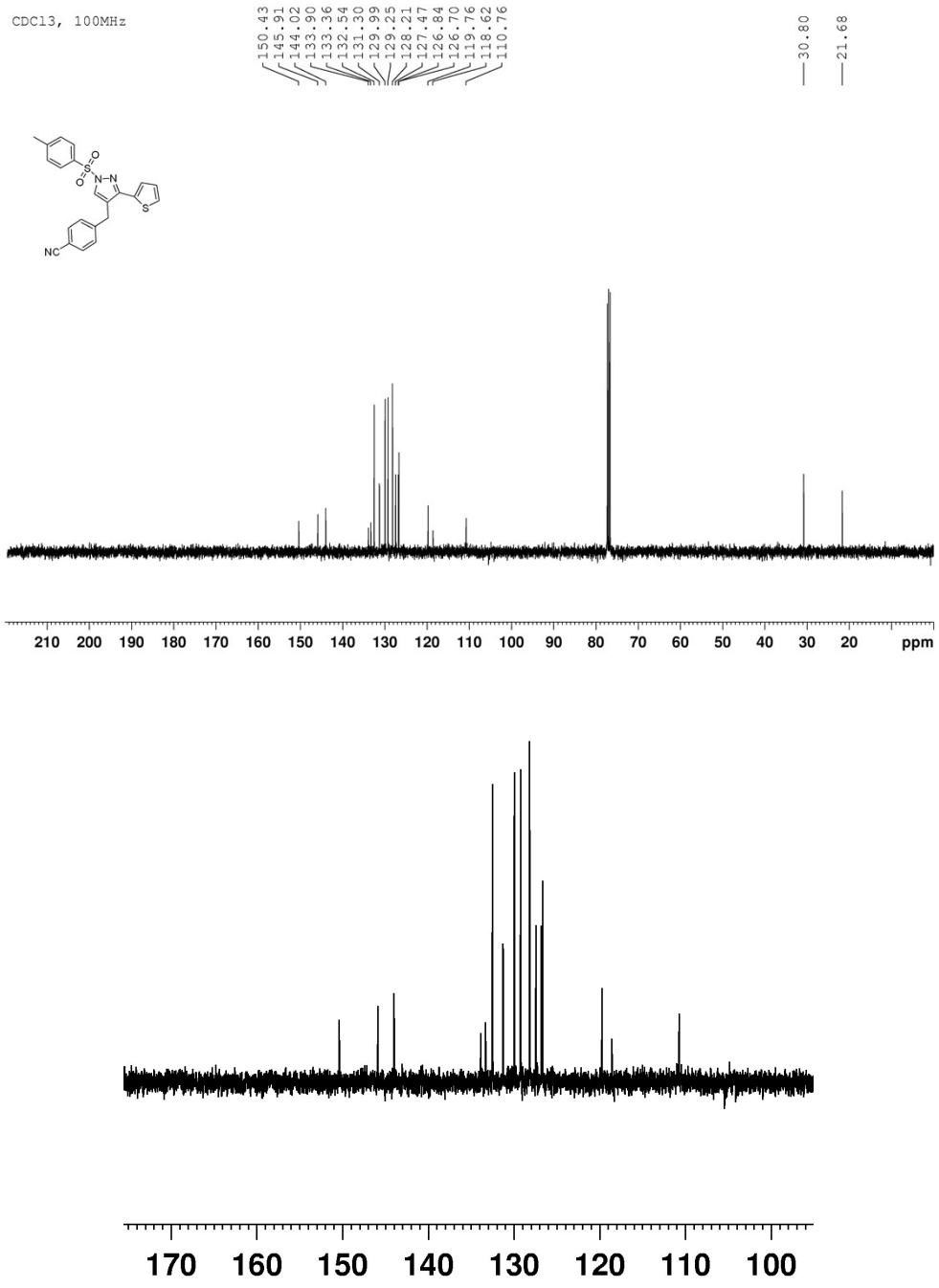
3-(4-chlorophenyl)-4-(4-nitrobenzyl)-1-tosyl-1H-pyrazole **(3k)**



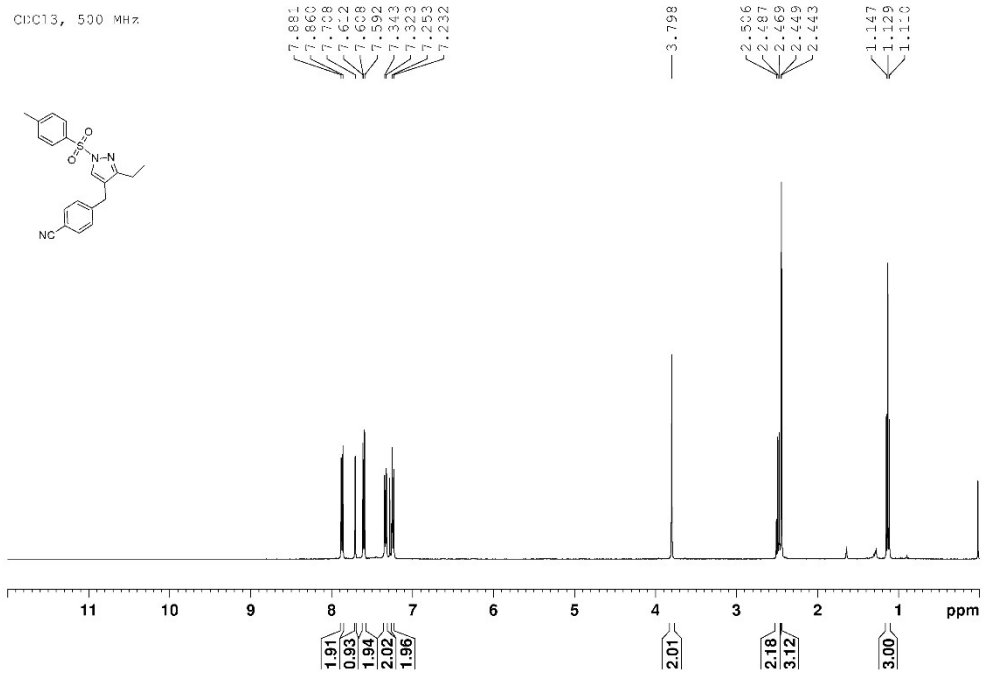


4-((3-(thiophen-2-yl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3l)**

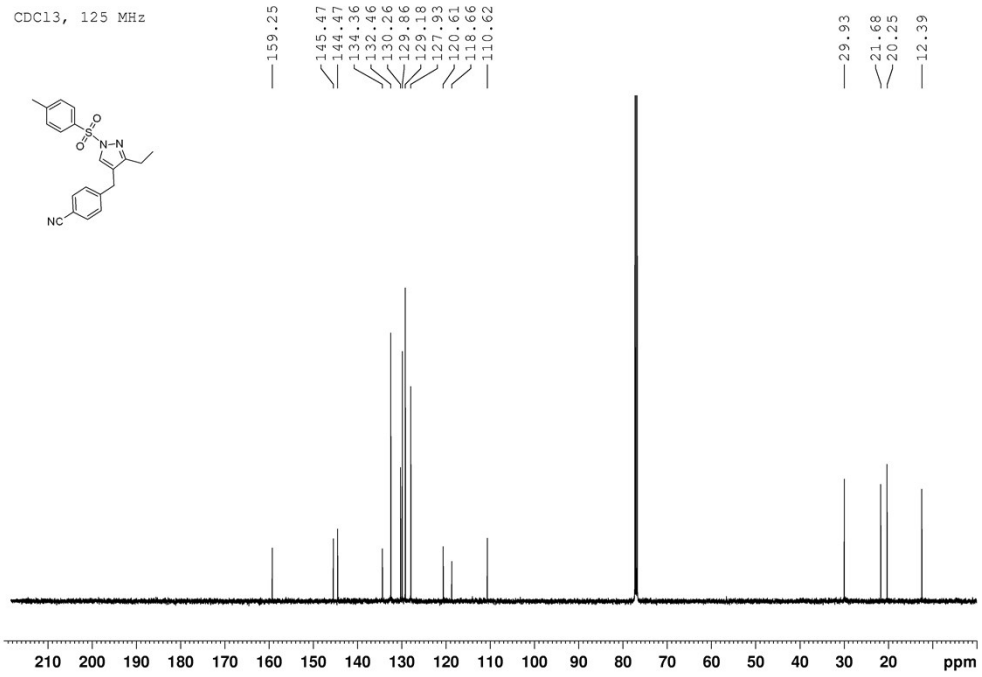
4-((3-(thiophen-2-yl)-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3l)**

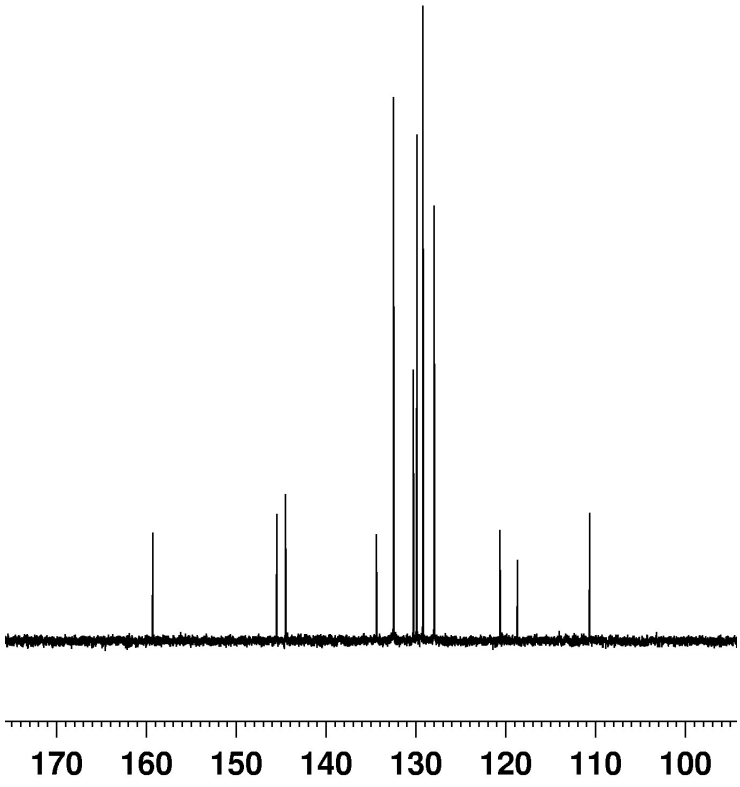


4-((3-ethyl-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3m)**

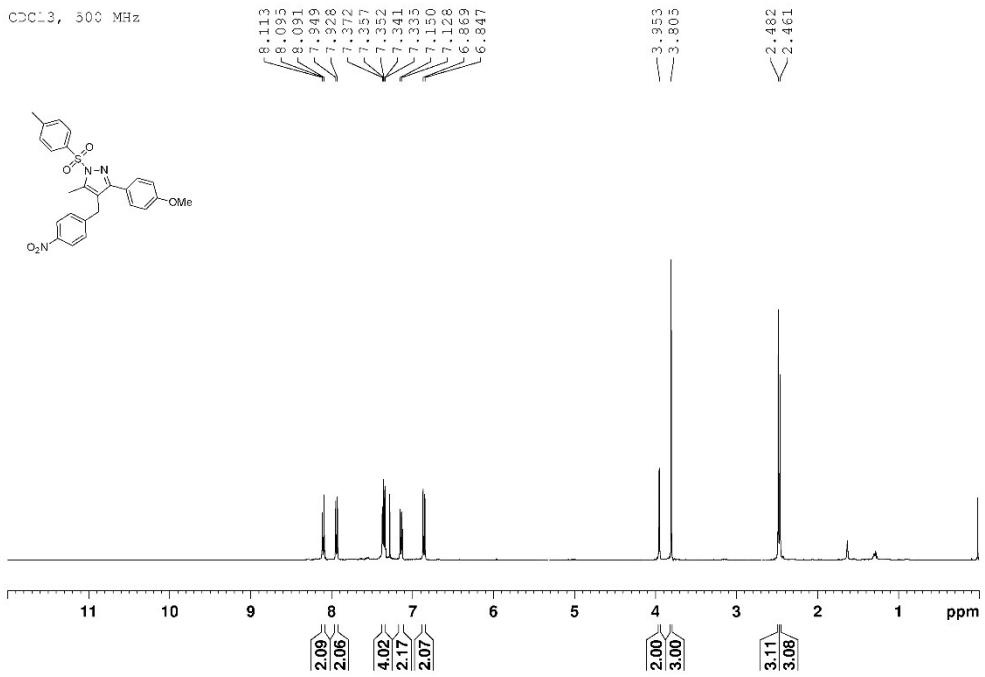


4-((3-ethyl-1-tosyl-1H-pyrazol-4-yl)methyl)benzonitrile **(3m)**

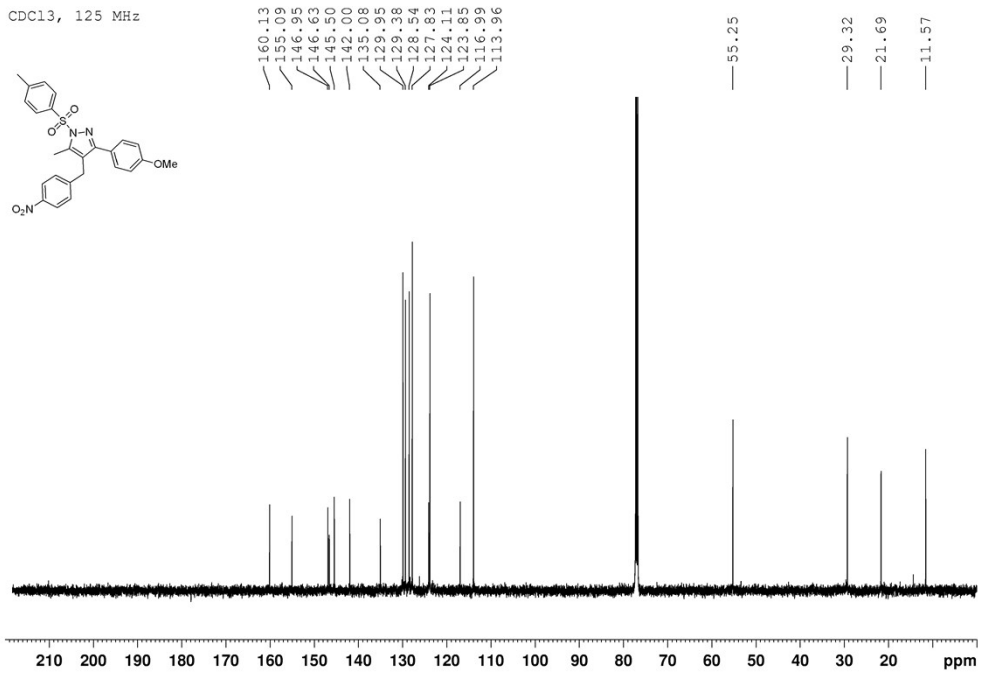


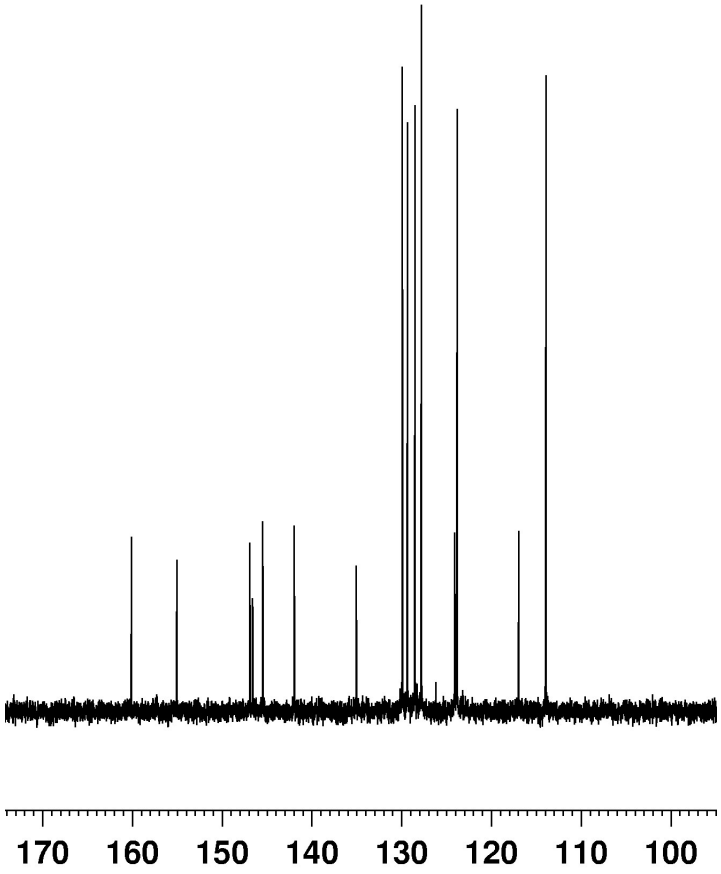


3-(4-methoxyphenyl)-5-methyl-4-(4-nitrobenzyl)-1-tosyl-1H-pyrazole **(3n)**

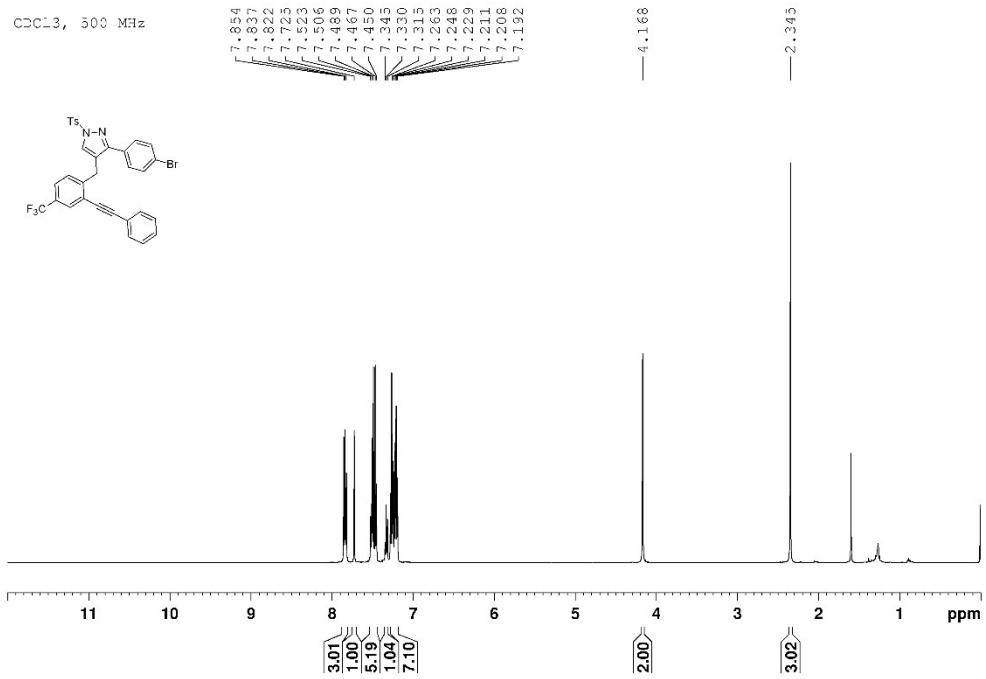


3-(4-methoxyphenyl)-5-methyl-4-(4-nitrobenzyl)-1-tosyl-1H-pyrazole **(3n)**

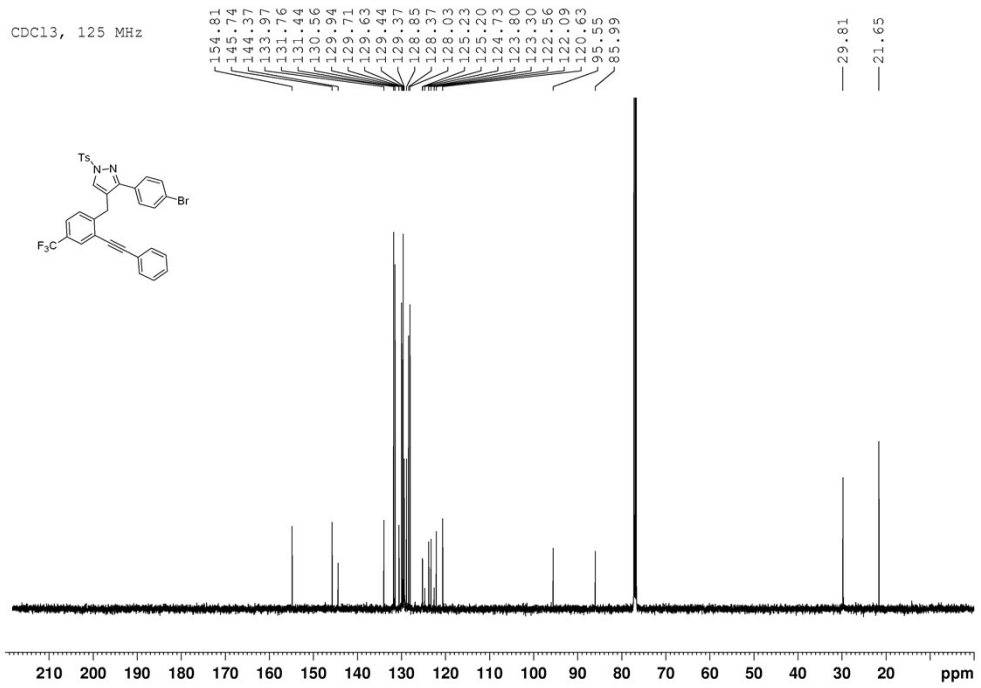


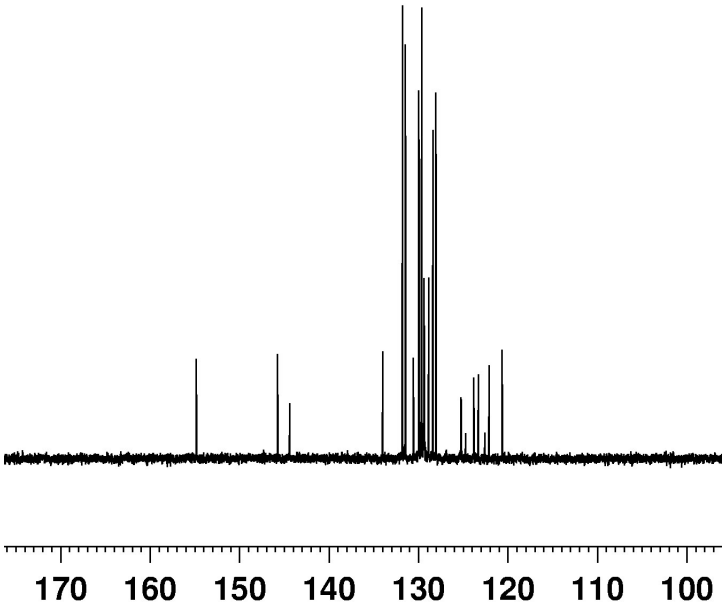


3-(4-bromophenyl)-4-(2-(phenylethynyl)-4-(trifluoromethyl)benzyl)-1-tosyl-1H-pyrazole **(3o)**

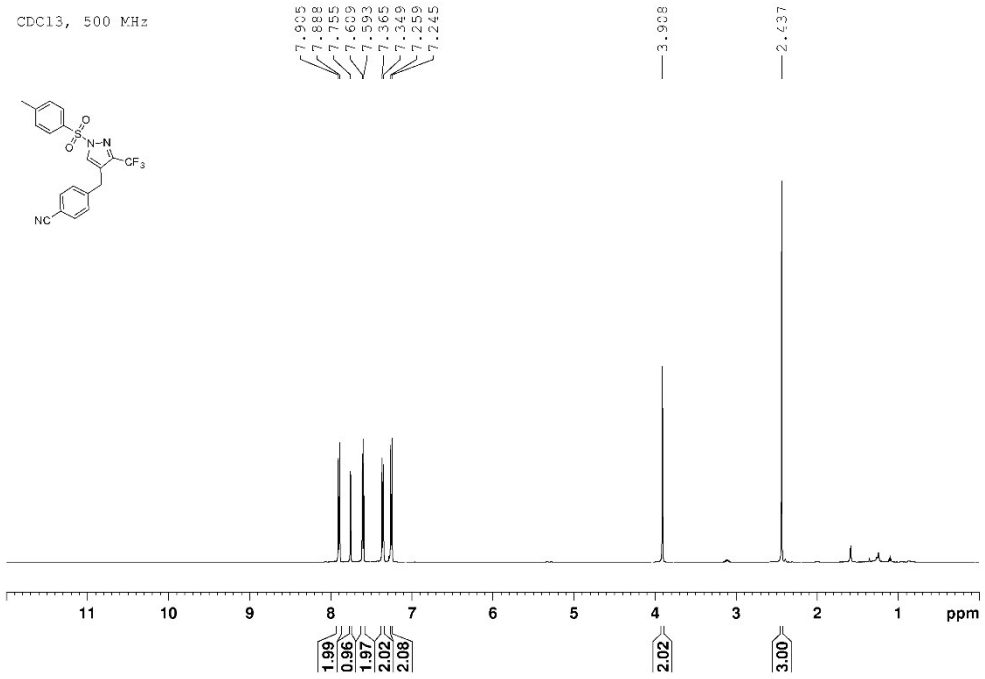


3-(4-bromophenyl)-4-(2-(phenylethynyl)-4-(trifluoromethyl)benzyl)-1-tosyl-1H-pyrazole **(3o)**

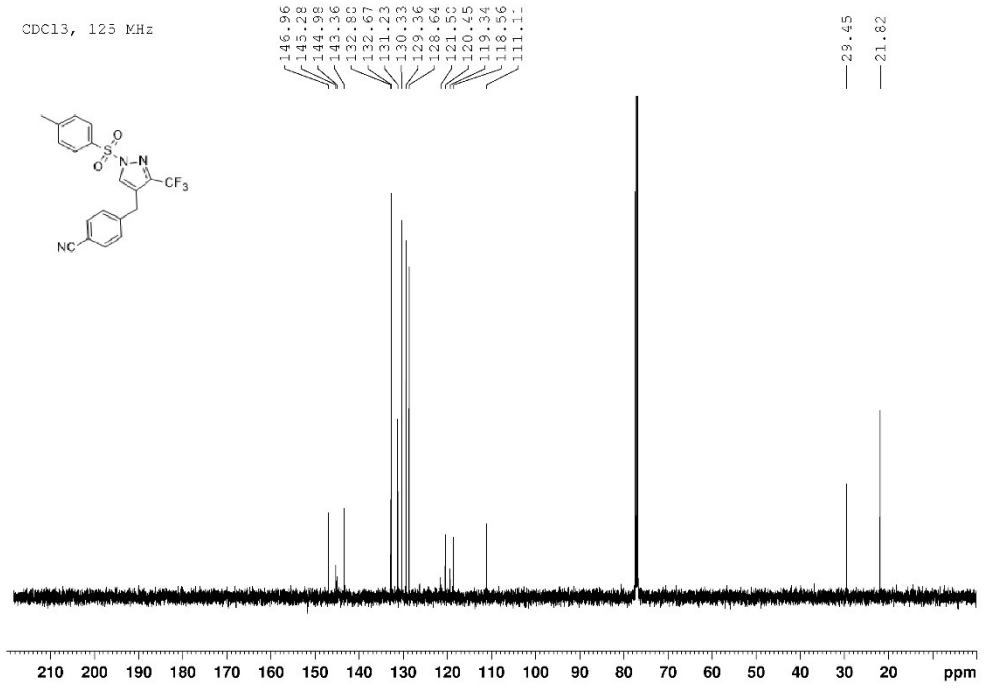


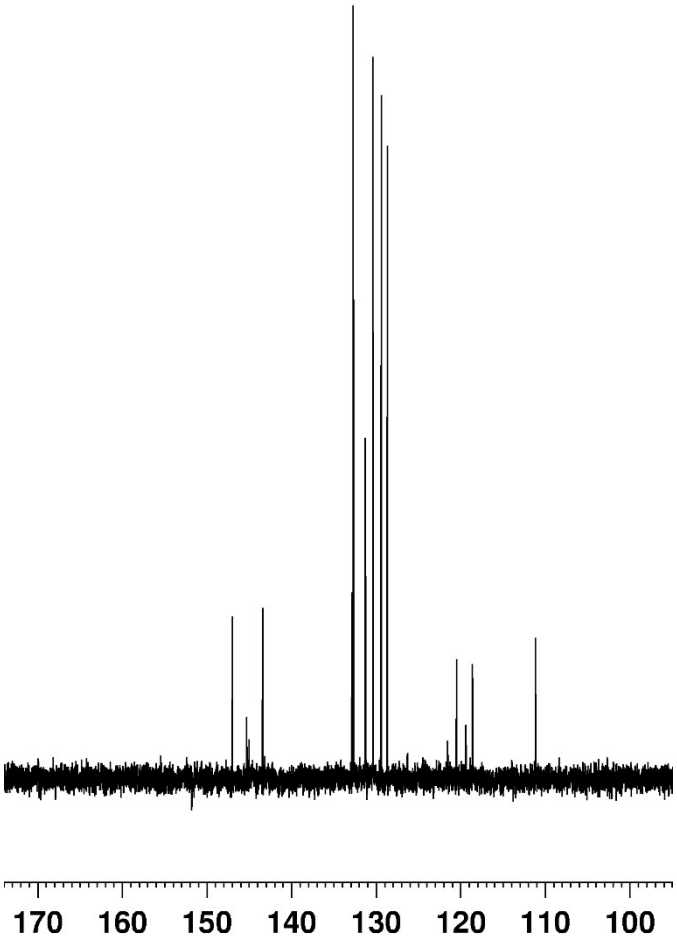


4-((1-tosyl-3-(trifluoromethyl)-1H-pyrazol-4-yl)methyl)benzonitrile **(3p)**

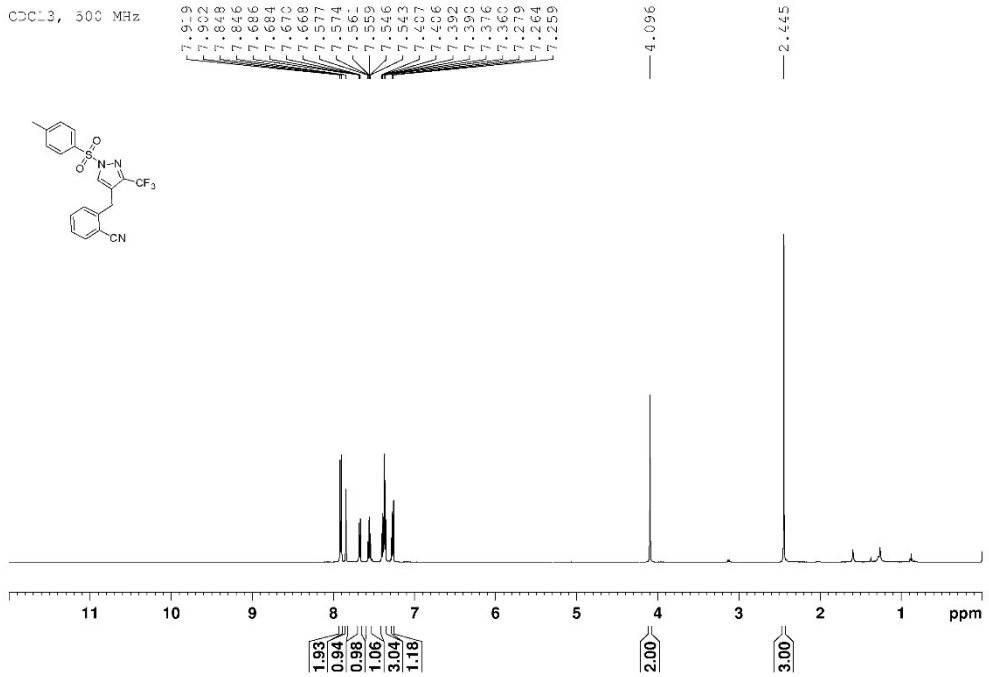


4-((1-tosyl-3-(trifluoromethyl)-1H-pyrazol-4-yl)methyl)benzonitrile **(3p)**

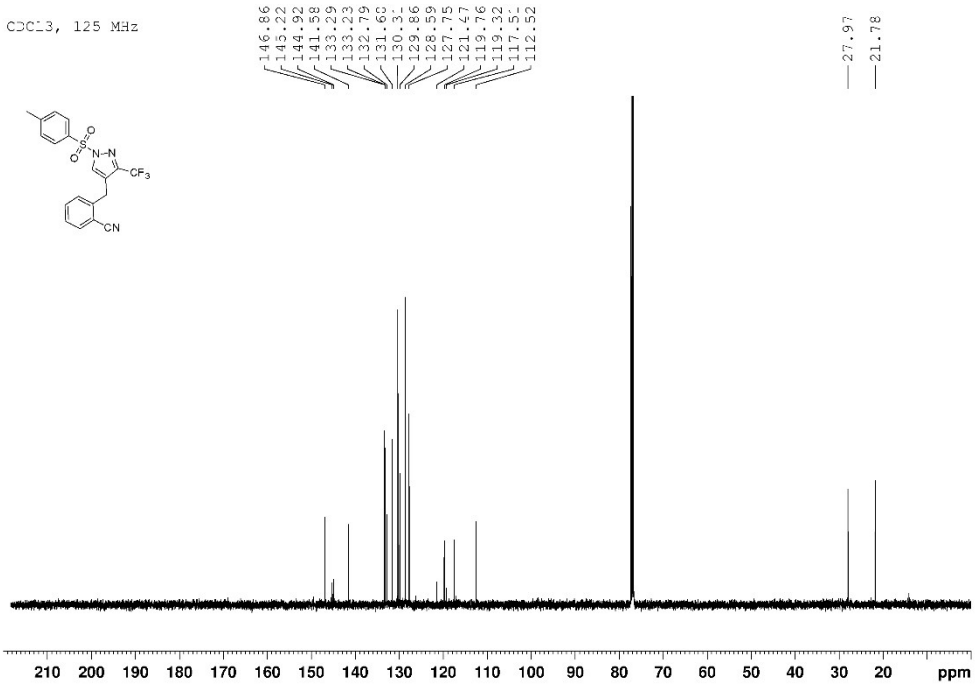


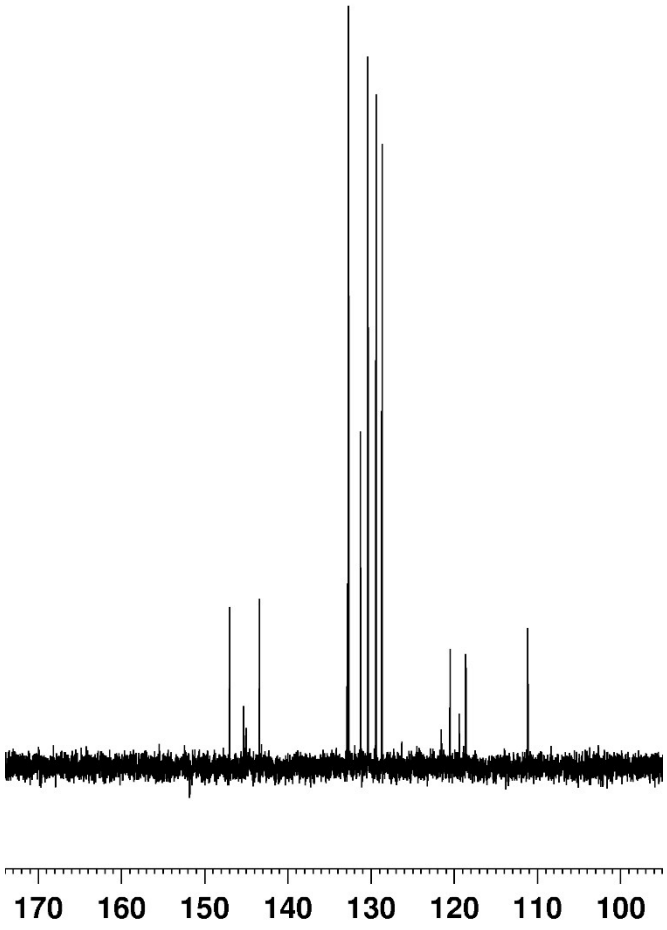


2-((1-tosyl-3-(trifluoromethyl)-1H-pyrazol-4-yl)methyl)benzonitrile **(3q)**

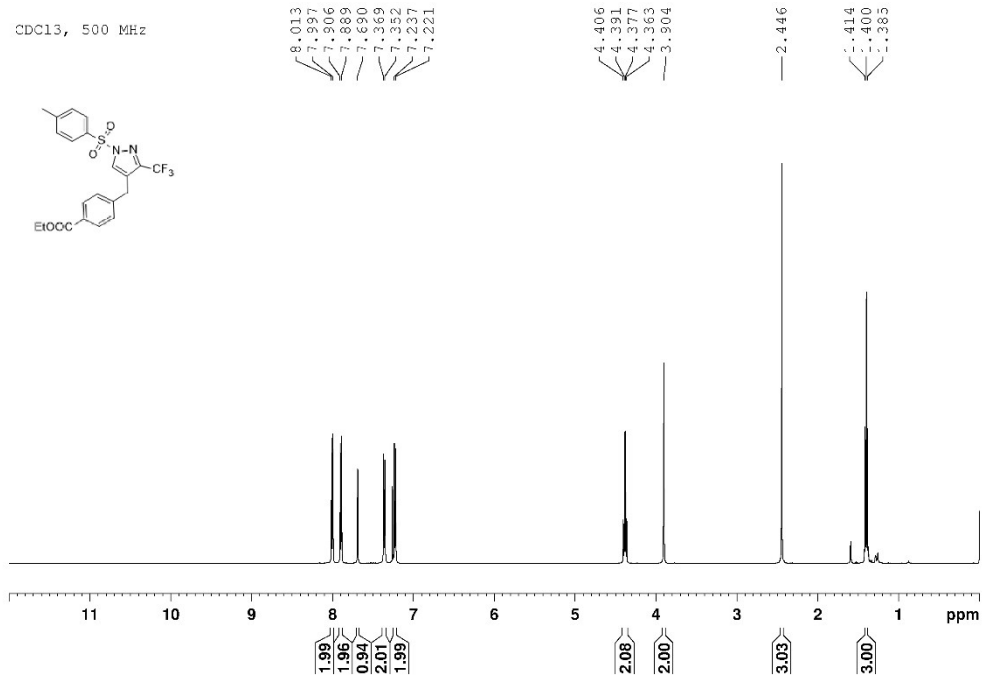


2-((1-tosyl-3-(trifluoromethyl)-1H-pyrazol-4-yl)methyl)benzonitrile **(3q)**





Ethyl 4-((1-tosyl-3-(trifluoromethyl)-1H-pyrazol-4-yl)methyl)benzoate **(3r)**



Ethyl 4-((1-tosyl-3-(trifluoromethyl)-1H-pyrazol-4-yl)methyl)benzoate **(3r)**