Supporting Information

Cascade reaction of alkynols and 1-(2-aminophenyl)prop-2-ynols to form a fused 5,5,6-tricyclic system: formation of four bonds in a single reaction

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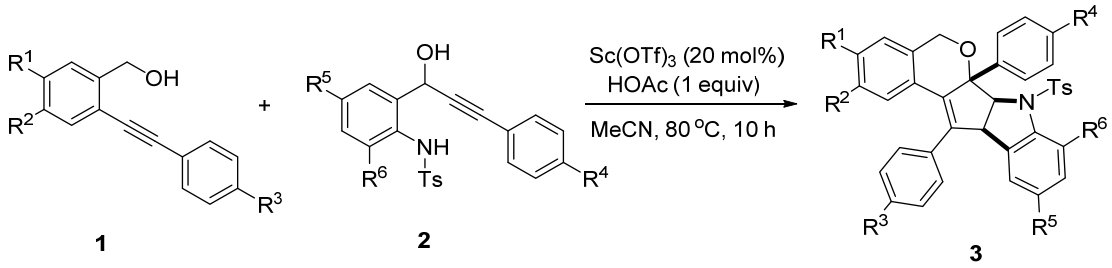
1 General Information.

All manipulations were carried out under a nitrogen or argon atmosphere using standard Schlenk techniques, unless otherwise stated. Solvents were distilled under nitrogen from sodium-benzophenone (THF, toluene, dioxane) or calcium hydride (MeCN, CH_3NO_2, DMF, DCE). Other chemicals were obtained from commercial sources, and were used without further purification. Chemical shifts (δ, ppm) in the ^1H NMR spectra were internally referenced to DMSO-d^6 (δ = 39.52 ppm). Chemical shifts in ^{13}C NMR spectra were internally referenced to $CDCl_3$ (δ = 77.16 ppm).

2 General procedure for the cascade annulation of alkynols with 1-(2-aminophenyl)prop-2-ynols.



To a mixture of internal alkynol **1a** (0.2 mmol) and N-(2-(1-hydroxy-3-phenylprop-2-yn-1-yl)phenyl)-4-methylbenzenesulfonamide **2a** (0.24 mmol) in CH_3CN was added the Scandium trifluoromethanesulfonate (0.04mmol, 20 mol%) and HOAc (0.2 mmol, 1 equiv) under Ar. The reaction mixture was stirred at 80 ^oC for 10 hours and the progress was monitored using TLC detection. After completion of present reaction, the solvent was evaporated under reduced pressure. After that the crude product was passed through flash column chromatography on silica gel to afford the desired products.

3. Crystal data and structure refinement of product 3a, 3f and 4.

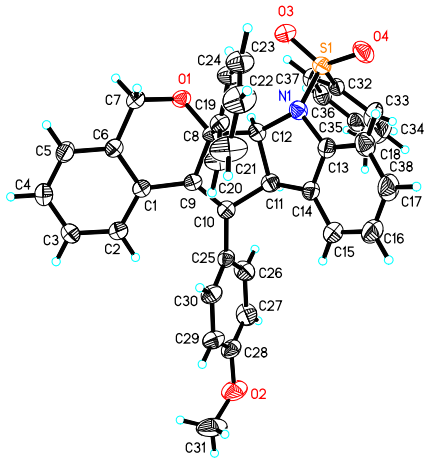


Figure S1. The ORTEP diagram of product **3a**.

Table S1. Crystal data and structure refinement for **3a**.

Identification code	**3a**	
CCDC Number	1552567	
Empirical formula	$C_{38}H_{31}NO_4S$	
Formula weight	597.70	
Temperature	293(2) K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	C 2/c	
Unit cell dimensions	a = 35.535(6) Å	α= 90°.
	b = 8.3152(14) Å	β=126.844(3)°.
	c = 26.015(4) Å	γ = 90°.
Volume	6151.8(18) $Å^3$	
Z	8	
Density (calculated)	1.291 Mg/m^3	
Absorption coefficient	0.148 mm^{-1}	
F(000)	2512	
Crystal size	0.210 x 0.170 x 0.140 mm^3	
Theta range for data collection	1.432 to 25.999°.	
Index ranges	-41<=h<=43, -10<=k<=9, -32<=l<=32	
Reflections collected	18014	

Independent reflections	6046 [R(int) = 0.0458]
Completeness to theta = 25.242°	100.0 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.7456 and 0.6283
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	6046 / 0 / 399
Goodness-of-fit on F^2	1.035
Final R indices [I>2sigma(I)]	R1 = 0.0477, wR2 = 0.1245
R indices (all data)	R1 = 0.0750, wR2 = 0.1392
Extinction coefficient	n/a
Largest diff. peak and hole	0.235 and -0.275 e.Å^{-3}

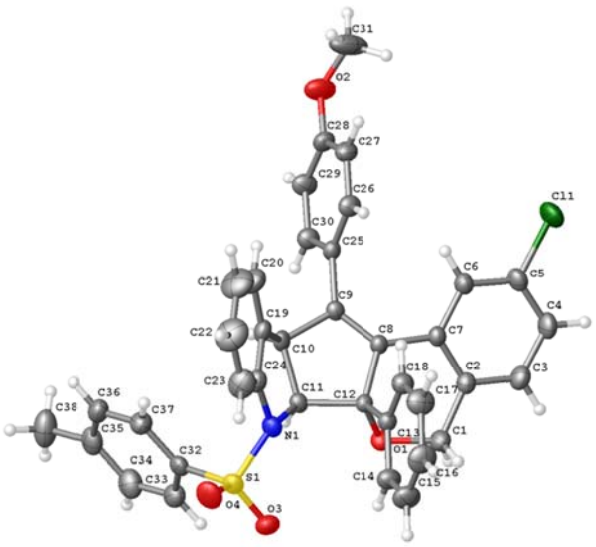


Figure S2. The ORTEP diagram of product **3f**.

Table S2. Crystal data and structure refinement for **3f.**

Identification code	**3f**	
CCDC Number	1552568	
Empirical formula	$C_{38}H_{30}ClNO_4S$	
Formula weight	632.14	
Temperature	296.15 K	
Wavelength	0.71073 Å	
Crystal system	Orthorhombic	
Space group	P b c a	
Unit cell dimensions	a = 11.9530(11) Å	α= 90°.
	b = 16.5209(14) Å	β= 90°.

	c = 31.646(3) Å γ = 90°.
Volume	6249.3(9) $Å^3$
Z	8
Density (calculated)	1.344 Mg/m^3
Absorption coefficient	0.232 mm^{-1}
F(000)	2640
Crystal size	0.33 x 0.3 x 0.28 mm^3
Theta range for data collection	2.135 to 30.605°.
Index ranges	-15<=h<=17, -23<=k<=23, -45<=l<=40
Reflections collected	60012
Independent reflections	9594 [R(int) = 0.0505]
Completeness to theta = 25.242°	100.0 %
Absorption correction	Semi-empirical from equivalents
Max. and min. transmission	0.7461 and 0.6800
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	9594 / 0 / 408
Goodness-of-fit on F^2	1.054
Final R indices [I>2sigma(I)]	R1 = 0.0692, wR2 = 0.1460
R indices (all data)	R1 = 0.1270, wR2 = 0.1787
Extinction coefficient	n/a
Largest diff. peak and hole	0.519 and -0.570 $e.Å^{-3}$

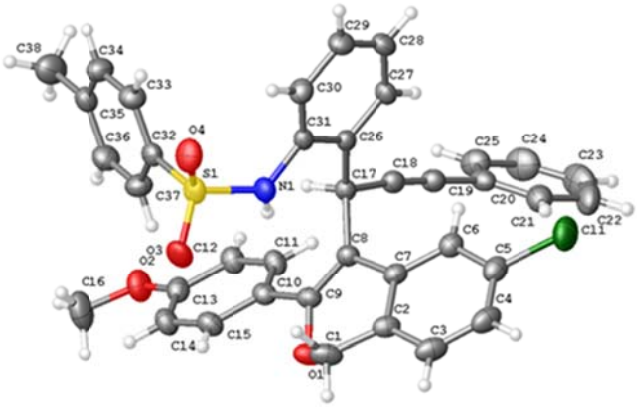


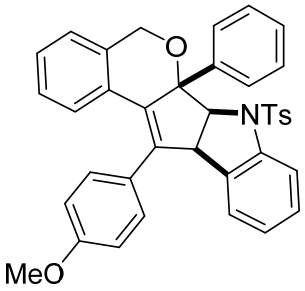
Figure S3. The ORTEP diagram of product **4**.

Table S3. Crystal data and structure refinement for **4**

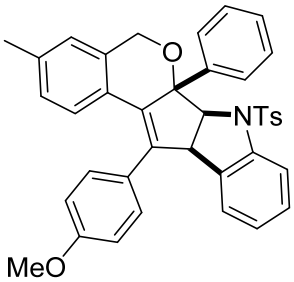
Identification code	**4**

CCDC Number	1552569	
Empirical formula	$C_{38}H_{30}ClNO_4S$	
Formula weight	632.14	
Temperature	296 K	
Wavelength	0.71073 Å	
Crystal system	Triclinic	
Space group	P -1	
Unit cell dimensions	a = 10.0712(10) Å	α=104.565(2)°.
	b = 13.1339(13) Å	β=104.140(2)°.
	c = 13.3013(14) Å	γ=101.177(2)°.
Volume	1589.0(3) $Å^3$	
Z	2	
Density (calculated)	1.321 Mg/m^3	
Absorption coefficient	0.228 mm^{-1}	
F(000)	660	
Crystal size	0.15 x 0.1 x 0.05 mm^3	
Theta range for data collection	1.663 to 28.311°.	
Index ranges	-13<=h<=7, -17<=k<=17, -17<=l<=17	
Reflections collected	13986	
Independent reflections	7882 [R(int) = 0.0267]	
Completeness to theta = 25.242°	100.0 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.7457 and 0.6814	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	7882 / 0 / 408	
Goodness-of-fit on F^2	0.982	
Final R indices [I>2sigma(I)]	R1 = 0.0462, wR2 = 0.1067	
R indices (all data)	R1 = 0.1092, wR2 = 0.1326	
Extinction coefficient	n/a	
Largest diff. peak and hole	0.213 and -0.322 $e.Å^{-3}$	

4. Analytical data for products.

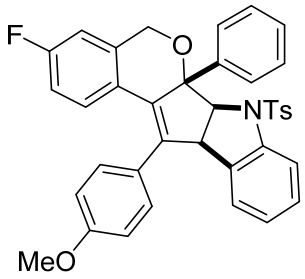


12-(4-Methoxyphenyl)-6a-phenyl-7-tosyl-6a,6b,7,11b-tetrahydro-5H-isochromeno[4',3':4,5]cyclopenta[1,2-b]indole (**3a**). The compound was prepared from (2-((4-methoxyphenyl)ethynyl)phenyl)methanol and N-(2-(1-hydroxy-3-phenylprop-2-yn-1-yl)phenyl)-4-methylbenzenesulfonamide following the general procedure. The product 3a was obtained in 68% yield as a white solid after column chromatography (eluent = petroleum ether/ethyl acetate 10:1 v/v); Mp: 145-148 ^{o}C; ^{1}H NMR (400 MHz, d^{6}-DMSO, 25 ^{o}C): δ 7.47-7.50 (m, 5H), 7.30-7.32 (m, 1H), 7.23-7.26 (m, 3H), 7.06-7.13 (m, 5H), 6.91-6.96 (m, 4H), 6.79-6.85 (m, 2H), 6.46 (d, J = 7.48 Hz, 1H), 5.24 (d, J = 8.80 Hz, 1H), 4.91 (d, J = 16.40 Hz, 1H), 4.62 (d, J = 16.36 Hz, 1H), 4.32 (d, J = 8.80 Hz, 1H), 3.84 (s, 3H), 2.28 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$, 25 ^{o}C): δ 159.5, 143.8, 141.7, 137.5, 137.1, 135.7, 134.9, 133.9, 130.3, 130.0, 129.6, 129.2, 127.9, 127.8, 127.5, 126.9, 126.1, 124.8, 124.3, 123.8, 117.8, 114.5, 92.8, 74.9, 65.3, 55.8, 55.5, 21.7; HRMS (EI, TOF): caled for $C_{38}H_{31}NO_4S^+$ $[M]^+$: 597.1974, found: 597.1973.

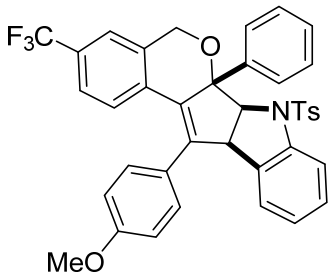


12-(4-Methoxyphenyl)-3-methyl-6a-phenyl-7-tosyl-6a,6b,7,11b-tetrahydro-5H-isochromeno[4',3':4,5]cyclopenta[1,2-b]indole (**3b**). The compound was prepared from (2-((4-methoxyphenyl)ethynyl)-5-methylphenyl)methanol and N-(2-(1-hydroxy-3-phenylprop-2-yn-1-yl)phenyl)-4-methylbenzenesulfonamide following the general procedure. The product 3b was obtained in 56% yield as a white solid after column

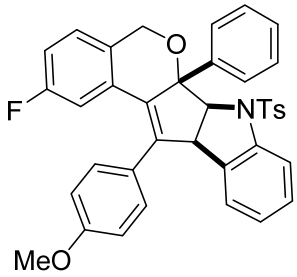
chromatography (eluent = petroleum ether/ethyl acetate 10:1 v/v); Mp: 192-195 ^{o}C; ^{1}H NMR (400 MHz, d^{6}-DMSO, 25 ^{o}C): δ 7.45-7.49 (m, 5H), 7.24 (d, J = 8.16 Hz, 2H), 7.17-7.20 (m, 2H), 7.07-7.12 (m, 4H), 6.90-6.95 (m, 2H), 6.83 (t, J = 7.44 Hz, 1H), 6.78 (d, J =8.08 Hz, 1H), 6.73-6.74 (m, 2H), 6.47 (d, J = 7.48 Hz, 1H), 5.23 (d, J = 8.80 Hz, 1H), 4.86 (d, J = 16.40 Hz, 1H), 4.57 (d, J = 16.24 Hz, 1H), 4.28 (d, J = 8.84 Hz, 1H), 3.83 (s, 3H), 2.28 (s, 3H), 2.10 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$, 25 ^{o}C): δ 159.4, 143.7, 141.7, 137.7, 137.2, 136.4, 135.7, 134.7, 133.9, 132.8, 130.3, 130.1, 129.6, 127.8, 127.4, 127.1, 126.9, 126.4, 125.9, 124.8, 124.7, 123.7, 117.7, 114.4, 92.8, 74.9, 65.2, 55.7, 55.5, 21.6, 21.3; HRMS (EI, TOF): caled for $C_{39}H_{33}NO_4S^+$ $[M]^+$: 611.2130, found: 611.2131.



3-Fluoro-12-(4-methoxyphenyl)-6a-phenyl-7-tosyl-6a,6b,7,11b-tetrahydro-5H-isochromeno[4',3':4,5]cyclopenta[1,2-b]indole (**3c**). The compound was prepared from (5-fluoro-2-((4-methoxyphenyl)ethynyl)phenyl)methanol and N-(2-(1-hydroxy-3-phenylprop-2-yn-1-yl)phenyl)-4-methylbenzenesulfonamide following the general procedure. The product 3c was obtained in 68% yield as a white solid after column chromatography (eluent = petroleum ether/ethyl acetate 10:1 v/v); Mp: 191-193 ^{o}C; ^{1}H NMR (400 MHz, d^{6}-DMSO, 25 ^{o}C): δ 7.47-7.49 (m, 5H), 7.31-7.35 (m, 1H), 7.24-7.26 (m, 3H), 7.09-7.13 (m, 4H), 6.91-6.96 (m, 1H), 6.78-6.85 (m, 5H), 6.45 (d, J =7.52 Hz, 1H), 5.26 (d, J = 8.80 Hz, 1H), 4.93 (d, J = 16.84 Hz, 1H), 4.59 (d, J = 16.72 Hz, 1H), 4.32 (d, J = 8.76 Hz, 1H), 3.84 (s, 3H), 2.28 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$, 25 ^{o}C): δ 162.0 (d, J = 247.2 Hz), 159.6, 143.8, 141.7, 137.3, 137.1 (d, J = 5.1 Hz), 136.8, 135.7, 133.7, 131.9, 130.2, 129.8, 129.7, 128.1 (d, J = 7.9 Hz), 127.9, 127.7, 126.9, 125.4, 124.8, 123.7, 117.8, 114.6, 113.6 (d, J = 21.5 Hz), 110.9 (d, J = 21.8 Hz), 92.9, 74.8, 65.1, 55.8, 55.5, 21.6; ^{19}F NMR (376 MHz, $CDCl_3$, 25 ^{o}C): δ 112.7; HRMS (EI, TOF): caled for $C_{38}H_{30}FNO_4S^+$ $[M]^+$: 615.1880, found: 615.1876.

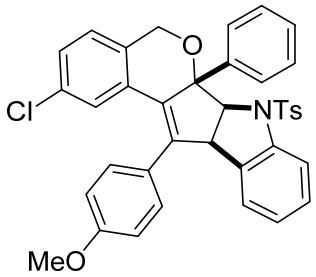


12-(4-Methoxyphenyl)-6a-phenyl-7-tosyl-3-(trifluoromethyl)-6a,6b,7,11b-tetrahydro-5H-isoc hromeno[4',3':4,5]cyclopenta[1,2-b]indole (**3d**). The compound was prepared from (2-((4-methoxyphenyl)ethynyl)-5-(trifluoromethyl)phenyl)methanol and N-(2-(1-hydroxy-3-phenylprop-2-yn-1-yl)phenyl)-4-methylbenzenesulfonamide following the general procedure. The product 3d was obtained in 41% yield as a white solid after column chromatography (eluent = petroleum ether/ethyl acetate 10:1 v/v); Mp: 212-215 ^{o}C; ^{1}H NMR (400 MHz, d^{6}-DMSO, 25 ^{o}C): δ 7.48-7.53 (m, 5H), 7.31-7.37 (m, 4H), 7.21-7.26 (m, 3H), 7.11-7.16 (m, 4H), 6.93-6.97 (m, 1H), 6.81-6.86 (m, 2H), 6.47 (d, J = 7.48 Hz, 1H), 5.30 (d, J = 8.80 Hz, 1H), 5.05 (d, J = 16.92 Hz, 1H), 4.65 (d, J = 16.88 Hz, 1H), 4.38 (d, J = 8.84 Hz, 1H), 3.85 (s, 3H), 2.28 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$, 25 ^{o}C): δ 159.8, 143.9, 141.7, 140.3, 136.7, 135.7, 135.4, 133.3, 132.6, 131.8, 130.1, 129.7, 129.5, 129.3, 128.9, 128.1, 127.8, 126.9, 125.1 (q, J = 273.2 Hz) , 124.9, 122.9, 121.4, 117.8, 114.7, 92.8, 74.8, 65.0, 60.5, 55.9, 55.5, 21.6, 21.2; ^{19}F NMR (376 MHz, $CDCl_3$, 25 ^{o}C): δ 62.9; HRMS (EI, TOF): caled for $C_{39}H_{30}F_3NO_4S^+$ $[M]^+$: 665.1848, found: 665.1843.

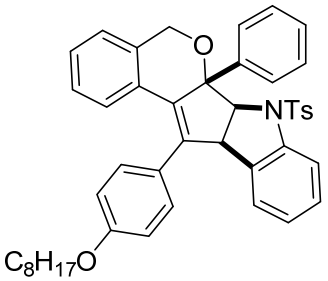


2-Fluoro-12-(4-methoxyphenyl)-6a-phenyl-7-tosyl-6a,6b,7,11b-tetrahydro-5H-isochromeno[4 ',3':4,5]cyclopenta[1,2-b]indole (**3e**). The compound was prepared from (4-fluoro-2-((4-methoxyphenyl)ethynyl)phenyl)methanol and N-(2-(1-hydroxy-3-phenylprop-2-yn-1-yl)phenyl)-4-methylbenzenesulfonamide following the general procedure. The product 3e was obtained in 45% yield as a white solid after column

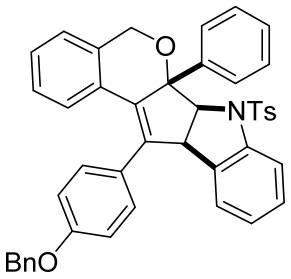
chromatography (eluent = petroleum ether/ethyl acetate 10:1 v/v); Mp: 198-200 ^{o}C; ^{1}H NMR (400 MHz, d^{6}-DMSO, 25 ^{o}C): δ 7.48-7.52 (m, 5H), 7.24-7.26 (m, 3H), 7.10-7.16 (m, 4H), 6.98-7.03 (m, 3H), 6.92-6.96 (m, 2H), 6.79-6.85 (m, 2H), 6.42 (d, J =7.44 Hz, 1H), 5.26 (d, J = 8.80 Hz, 1H), 4.91 (d, J = 16.28 Hz, 1H), 4.57 (d, J = 16.20 Hz, 1H), 4.36 (d, J = 8.88 Hz, 1H), 3.85 (s, 3H), 2.28 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$, 25 ^{o}C): δ 160.8 (d, J = 241.8 Hz), 159.8, 143.8, 141.6, 139.0, 136.9, 135.7, 133.5, 131.9, 130.8, 130.7, 130.5, 130.1, 129.7, 129.2, 128.0, 127.7, 126.9, 125.9 (d, J = 8.3 Hz), 124.9, 123.7, 117.8, 115.1 (d, J = 21.9 Hz), 114.7, 112.4 (d, J = 22.9 Hz), 92.5, 74.7, 64.8, 55.9, 55.5, 21.6; ^{19}F NMR (376 MHz, $CDCl_3$, 25 ^{o}C): δ 115.4; HRMS (EI, TOF): caled for $C_{38}H_{30}NO_4S^+$ $[M]^+$: 615.1880, found: 615.1878.



2-Chloro-12-(4-methoxyphenyl)-6a-phenyl-7-tosyl-6a,6b,7,11b-tetrahydro-5H-isochromeno[4',3':4,5]cyclopenta[1,2-b]indole (**3f**). The compound was prepared from (4-chloro-2-((4-methoxyphenyl)ethynyl)phenyl)methanol and N-(2-(1-hydroxy-3-phenylprop-2-yn-1-yl)phenyl)-4-methylbenzenesulfonamide following the general procedure. The product 3f was obtained in 63% yield as a white solid after column chromatography (eluent = petroleum ether/ethyl acetate 10:1 v/v); Mp: 214-216 ^{o}C; ^{1}H NMR (400 MHz, d^{6}-DMSO, 25 ^{o}C): δ 7.48-7.52 (m, 5H), 7.30 (d, J = 2.12 Hz, 1H), 7.24-7.26 (m, 3H), 7.10-7.16 (m, 5H), 6.92-7.00 (m, 3H), 6.79-6.85 (m, 2H), 6.43 (d, J =7.56 Hz, 1H), 5.26 (d, J = 8.80 Hz, 1H), 4.92 (d, J = 16.72 Hz, 1H), 4.57 (d, J = 16.60 Hz, 1H), 4.36 (d, J = 8.80 Hz, 1H), 3.85 (s, 3H), 2.28 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$, 25 ^{o}C): δ 159.8, 143.9, 141.6, 139.1, 136.8, 135.7, 133.5, 133.2, 131.8, 131.7, 130.8, 130.1, 129.7, 129.2, 128.0, 127.8, 127.7, 126.9, 125.9, 125.7, 124.9, 123.8, 117.8, 114.7, 92.6, 74.7, 64.9, 55.9, 55.5, 21.6; HRMS (EI, TOF): caled for $C_{38}H_{30}ClNO_4S^+$ $[M]^+$: 631.1584, found: 631.1578.

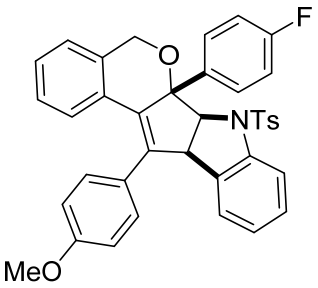


12-(4-(Octyloxy)phenyl)-6a-phenyl-7-tosyl-6a,6b,7,11b-tetrahydro-5H-isochromeno[4',3':4,5] cyclopenta[1,2-b]indole (**3g**). The compound was prepared from (2-((4-(octyloxy)phenyl)ethynyl)phenyl)methanol and N-(2-(1-hydroxy-3-phenylprop-2-yn-1-yl)phenyl)-4-methylbenzenesulfonamide following the general procedure. The product 3g was obtained in 60% yield as a white solid after column chromatography (eluent = petroleum ether/ethyl acetate 10:1 v/v); Mp: 171-173 ^{o}C; ^{1}H NMR (400 MHz, d^{6}-DMSO, 25 ^{o}C): δ 7.45-7.50 (m, 5H), 7.32 (d, J = 7.68 Hz, 1H), 7.23-7.26 (m, 3H), 7.06-7.11 (m, 5H), 6.92-6.94 (m, 4H), 6.78-6.84 (m, 2H), 6.45 (d, J =7.92 Hz, 1H), 5.24 (d, J = 8.80 Hz, 1H), 4.91 (d, J = 16.40 Hz, 1H), 4.61 (d, J = 16.40 Hz, 1H), 4.31 (d, J = 8.72 Hz, 1H), 4.03 (t, J = 6.48 Hz, 2H), 2.28 (s, 3H), 1.72-1.79 (m, 2H), 1.42-1.48 (m, 2H), 1.23-1.32 (m, 8H), 0.85-0.89 (m, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$, 25 ^{o}C): δ 159.2, 143.8, 141.7, 137.6, 137.2, 135.8, 134.8, 133.9, 132.7, 132.6, 130.3, 129.7, 129.6, 129.2, 129.1, 129.0, 127.9, 127.8, 127.7, 127.5, 126.9, 126.2, 126.1, 124.8, 124.3, 123.8, 117.8, 115.0, 92.8, 74.9, 68.3, 65.2, 65.1, 55.8, 31.9, 29.5, 29.4, 29.3, 26.2, 22.8, 21.6, 14.3; HRMS (EI, TOF): caled for $C_{45}H_{45}NO_4S^+$ $[M]^+$: 695.3069, found: 695.3060.

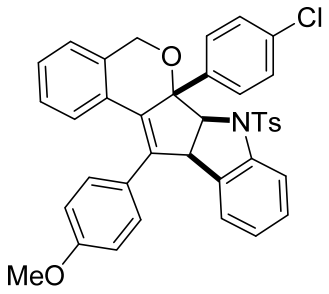


12-(4-(Benzyloxy)phenyl)-6a-phenyl-7-tosyl-6a,6b,7,11b-tetrahydro-5H-isochromeno[4',3':4, 5]cyclopenta[1,2-b]indole (**3h**). The compound was prepared from (2-((4-(benzyloxy)phenyl)ethynyl)phenyl)methanol and N-(2-(1-hydroxy-3-phenylprop-2-yn-1-yl)phenyl)-4-methylbenzenesulfonamide following the

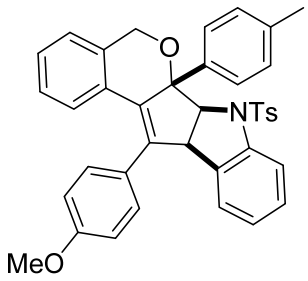
general procedure. The product 3h was obtained in 57% yield as a white solid after column chromatography (eluent = petroleum ether/ethyl acetate 10:1 v/v); Mp: 189-192 ^{o}C; ^{1}H NMR (400 MHz, d^{6}-DMSO, 25 ^{o}C): δ 7.50-7.52 (m, 4H), 7.48 (d, J = 2.32 Hz, 2H), 7.41-7.46 (m, 3H), 7.30-7.38 (m, 4H), 7.24 (d, J = 8.24 Hz, 2H), 7.20 (d, J = 8.64 Hz, 2H), 7.06-7.12 (m, 3H), 6.93-6.96 (m, 3H), 6.79-6.85 (m, 2H), 6.45 (d, J =7.44 Hz, 1H), 5.25 (d, J = 8.80 Hz, 1H), 5.19 (s, 2H), 4.91 (d, J = 16.40 Hz, 1H), 4.62 (d, J = 16.32 Hz, 1H), 4.32 (d, J = 8.72 Hz, 1H), 2.28 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$, 25 ^{o}C): δ 158.7, 143.8, 141.7, 137.4, 137.1, 136.8, 135.7, 134.8, 133.8, 132.8, 130.3, 130.2. 129.6, 129.1, 128.8, 128.3, 127.9, 127.8, 127.7, 127.5, 126.9, 126.1, 124.8, 124.3, 123.8, 117.8, 115.4, 92.7, 74.9, 70.3, 65.2, 55.7, 21.6; HRMS (EI, TOF): caled for $C_{44}H_{35}NO_4S^+$ $[M]^+$: 673.2287, found: 673.2285.



6a-(4-Fluorophenyl)-12-(4-methoxyphenyl)-7-tosyl-6a,6b,7,11b-tetrahydro-5H-isochromeno[4',3':4,5]cyclopenta[1,2-b]indole (**3i**). The compound was prepared from (2-((4-methoxyphenyl)ethynyl)phenyl)methanol and N-(2-(3-(4-fluorophenyl)-1-hydroxyprop-2-yn-1-yl)phenyl)-4-methylbenzenesulfonamide following the general procedure. The product 3i was obtained in 57% yield as a white solid after column chromatography (eluent = petroleum ether/ethyl acetate 10:1 v/v); Mp: 207-210 ^{o}C; ^{1}H NMR (400 MHz, d^{6}-DMSO, 25 ^{o}C): δ 7.48-7.52 (m, 5H), 7.32 (d, J = 7.80 Hz, 1H), 7.24-7.26 (m, 3H), 7.08-7.13 (m, 4H), 6.93-6.99 (m, 4H), 6.83-6.88 (m, 2H), 6.46 (d, J = 7.48 Hz, 1H), 5.25 (d, J = 8.80 Hz, 1H), 4.92 (d, J = 16.44 Hz, 1H), 4.59 (d, J = 16.44 Hz, 1H), 4.33 (d, J = 8.80 Hz, 1H), 3.85 (s, 3H), 2.28 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$, 25 ^{o}C): δ 162.3 (d, J = 244.3 Hz), 159.6, 143.9, 141.6, 137.7, 135.6, 134.7, 133.8, 133.0, 132.9 (d, J = 2.9 Hz), 132.5, 130.2, 129.8, 129.7, 128.9, 128.1, 127.9, 126.9, 126.2 (d, J = 7.7 Hz), 124.9, 124.3, 123.8, 117.8, 114.5, 92.3, 74.8, 65.1, 55.7, 55.5, 21.6; ^{19}F NMR (376 MHz, $CDCl_3$, 25 ^{o}C): δ 115.2; HRMS (EI, TOF): caled for $C_{38}H_{30}FNO_4S^+$ $[M]^+$: 615.1880, found: 615.1882.

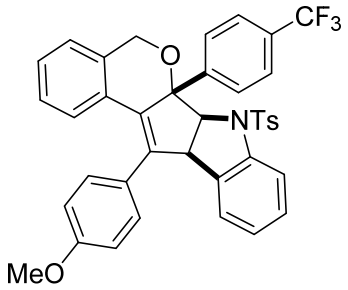


6a-(4-Chlorophenyl)-12-(4-methoxyphenyl)-7-tosyl-6a,6b,7,11b-tetrahydro-5H-isochromeno[4',3':4,5]cyclopenta[1,2-b]indole (**3j**). The compound was prepared from (2-((4-methoxyphenyl)ethynyl)phenyl)methanol and N-(2-(3-(4-chlorophenyl)-1-hydroxyprop-2-yn-1-yl)phenyl)-4-methylbenzenesulfonamide following the general procedure. The product 3j was obtained in 60% yield as a white solid after column chromatography (eluent = petroleum ether/ethyl acetate 10:1 v/v); Mp: 207-209 ^{o}C; ^{1}H NMR (400 MHz, d^{6}-DMSO, 25 ^{o}C): δ 7.47-7.52 (m, 5H), 7.24-7.32 (m, 4H), 7.08-7.13 (m, 4H), 6.93-7.01 (m, 4H), 6.83-6.88 (m, 2H), 6.46 (d, J = 7.44 Hz, 1H), 5.26 (d, J = 8.80 Hz, 1H), 4.93 (d, J = 16.52 Hz, 1H), 4.59 (d, J = 16.40 Hz, 1H), 4.35 (d, J = 8.80 Hz, 1H), 3.85 (s, 3H), 2.28 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$, 25 ^{o}C): δ 159.6, 143.9, 141.5, 137.9, 135.9, 135.6, 134.6, 133.7, 133.4, 132.4, 130.2, 129.7, 128.9, 128.2, 127.9, 126.9, 126.3, 126.2, 124.9, 124.3, 123.8, 117.9, 114.5, 92.4, 74.7, 65.2, 55.7, 55.5, 21.6; HRMS (EI, TOF): caled for $C_{38}H_{30}ClNO_4S^+$ $[M]^+$: 631.1584, found: 631.1585.

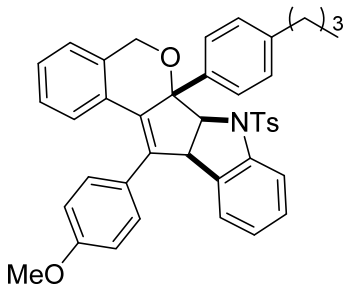


12-(4-Methoxyphenyl)-6a-(p-tolyl)-7-tosyl-6a,6b,7,11b-tetrahydro-5H-isochromeno[4',3':4,5]cyclopenta[1,2-b]indole (**3k**). The compound was prepared from (2-((4-methoxyphenyl)ethynyl)phenyl)methanol and N-(2-(1-hydroxy-3-(p-tolyl)prop-2-yn-1-yl)phenyl)-4-methylbenzenesulfonamide following the general procedure. The product 3k was obtained in 53% yield as a white solid after column chromatography (eluent = petroleum ether/ethyl acetate 10:1 v/v); Mp: 211-213 ^{o}C;

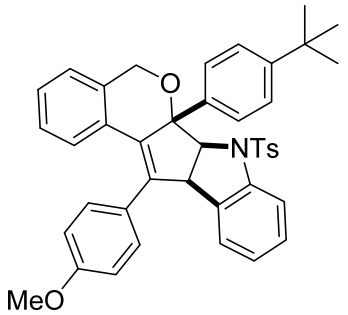
^{1}H NMR (400 MHz, d^{6}-DMSO, 25 ^{o}C): δ 7.45-7.49 (m, 5H), 7.23-7.29 (m, 4H), 7.05-7.12 (m, 4H), 6.90-6.95 (m, 4H), 6.82-6.85 (m, 2H), 6.45 (d, J = 7.76 Hz, 1H), 5.22 (d, J = 8.80 Hz, 1H), 4.88 (d, J = 16.40 Hz, 1H), 4.59 (d, J = 16.44 Hz, 1H), 4.31 (d, J = 9.04 Hz, 1H), 3.84 (s, 3H), 2.28 (s, 3H), 2.16 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$, 25 ^{o}C): δ 159.5, 143.7, 141.7, 137.2, 136.9, 135.8, 134.9, 134.0, 133.9, 132.9, 130.3, 130.1, 129.6, 129.2, 127.8, 127.7, 126.9, 126.1, 126.0, 124.7, 124.3, 123.7, 117.9, 114.5, 92.7, 74.9, 65.2, 55.8, 55.5, 21.6, 21.2; HRMS (EI, TOF): caled for $C_{38}H_{30}NO_4S^+$ $[M]^+$: 611.2130, found: 611.2132.



12-(4-Methoxyphenyl)-7-tosyl-6a-(4-(trifluoromethyl)phenyl)-6a,6b,7,11b-tetrahydro-5H-isochromeno[4',3':4,5]cyclopenta[1,2-b]indole (**3l**). The compound was prepared from (2-((4-methoxyphenyl)ethynyl)phenyl)methanol and N-(2-(1-hydroxy-3-(4-(trifluoromethyl)phenyl)prop-2-yn-1-yl)phenyl)-4-methylbenzenesulfonamide following the general procedure. The product 3l was obtained in 63% yield as a white solid after column chromatography (eluent = petroleum ether/ethyl acetate 10:1 v/v); Mp: 183-185 ^{o}C; ^{1}H NMR (400 MHz, d^{6}-DMSO, 25 ^{o}C): δ 7.49-7.52 (m, 5H), 7.33 (d, J = 8.40 Hz, 2H), 7.25 (d, J = 8.32 Hz, 2H), 7.08-7.14 (m, 4H), 6.94-6.98 (m, 4H), 6.86 (t, J = 7.52 Hz, 1H), 6.78 (d, J = 8.00 Hz, 1H), 6.48 (d, J = 7.56 Hz, 1H), 5.31 (d, J = 8.80 Hz, 1H), 4.97 (d, J = 16.60 Hz, 1H), 4.60 (d, J = 16.36 Hz, 1H), 4.37 (d, J = 8.68 Hz, 1H), 3.85 (s, 3H), 2.28 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$, 25 ^{o}C): δ 159.7, 143.9, 141.6, 141.4, 138.2, 135.5, 134.5, 133.7, 132.1, 130.2, 129.7, 129.6, 128.8, 128.2, 126.9, 126.6 (q, J = 278.4 Hz), 126.4, 126.2, 124.3, 123.8, 117.9, 114.6, 92.4, 74.8, 65.3, 55.7, 55.5, 21.7; ^{19}F NMR (376 MHz, $CDCl_3$, 25 ^{o}C): δ 65.2; HRMS (EI, TOF): caled for $C_{39}H_{30}F_3NO_4S^+$ $[M]^+$: 665.1848, found: 665.1855.

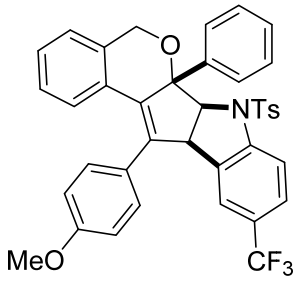


6a-(4-Ethylphenyl)-12-(4-methoxyphenyl)-7-tosyl-6a,6b,7,11b-tetrahydro-5H-isochromeno[4',3':4,5]cyclopenta[1,2-b]indole (**3m**). The compound was prepared from (2-((4-methoxyphenyl)ethynyl)phenyl)methanol and N-(2-(3-(4-butylphenyl)-1-hydroxyprop-2-yn-1-yl)phenyl)-4-methylbenzenesulfonamide following the general procedure. The product 3m was obtained in 58% yield as a white solid after column chromatography (eluent = petroleum ether/ethyl acetate 10:1 v/v); Mp: 193-195 ^{o}C; ^{1}H NMR (400 MHz, d^{6}-DMSO, 25 ^{o}C): δ 7.46-7.49 (m, 5H), 7.30 (d, J = 7.88 Hz, 1H), 7.22-7.24 (m, 3H), 7.05-7.13 (m, 4H), 6.84-6.94 (m, 4H), 6.83 (t, J = 7.32 Hz, 1H), 6.77 (d, J = 7.88 Hz, 1H), 6.46 (d, J = 7.40 Hz, 1H), 5.22 (d, J = 8.68 Hz, 1H), 4.88 (d, J = 16.36 Hz, 1H), 4.61 (d, J = 16.24 Hz, 1H), 4.37 (d, J = 8.72 Hz, 1H), 3.84 (s, 3H), 2.41-2.45 (m, 2H), 2.27 (s, 3H), 1.39-1.45 (m, 2H), 1.16-1.19 (m, 2H), 0.84 (t, J = 7.24 Hz, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$, 25 ^{o}C): δ 159.5, 143.7, 142.0, 141.7, 137.1, 135.8, 134.9, 134.1, 132.8, 130.3, 130.2, 129.6, 129.2, 127.7, 126.9, 126.1, 124.8, 124.3, 123.6, 117.9, 114.5, 92.6, 74.9, 65.2, 55.6, 55.5, 35.3, 33.6, 22.2, 21.6, 14.1; HRMS (EI, TOF): caled for $C_{42}H_{39}NO_4S^+$ $[M]^+$: 653.2600, found: 653.2599.

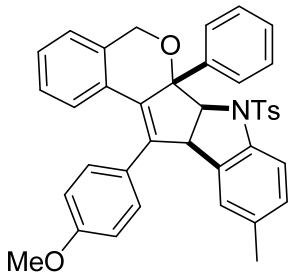


6a-(4-(*tert*-Butyl)phenyl)-12-(4-methoxyphenyl)-7-tosyl-6a,6b,7,11b-tetrahydro-5H-isochromeno[4',3':4,5]cyclopenta[1,2-b]indole (**3n**). The compound was prepared from (2-((4-methoxyphenyl)ethynyl)phenyl)methanol and N-(2-(3-(4-(tert-butyl)phenyl)-1-hydroxyprop-2-yn-1-yl)phenyl)-4-methylbenzenesulfonamid

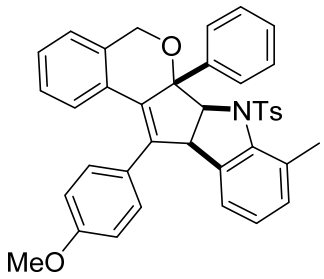
e following the general procedure. The product 3n was obtained in 53% yield as a white solid after column chromatography (eluent = petroleum ether/ethyl acetate 10:1 v/v); Mp: 206-208 ^{o}C; ^{1}H NMR (400 MHz, d^{6}-DMSO, 25 ^{o}C): δ 7.45-7.48 (m, 5H), 7.31 (d, J = 7.88 Hz, 1H), 7.22-7.24 (m, 3H), 7.06-7.13 (m, 4H), 6.93-6.96 (m, 2H), 6.87-6.91 (m, 2H), 6.81-6.85 (m, 1H), 6.70 (d, J = 7.24 Hz, 1H), 6.46 (d, J = 7.48 Hz, 1H), 5.19 (d, J = 8.56 Hz, 1H), 4.88 (d, J = 16.40 Hz, 1H), 4.63 (d, J = 16.24 Hz, 1H), 4.20 (d, J = 8.60 Hz, 1H), 3.85 (s, 3H), 2.28 (s, 3H), 1.16 (s, 9H); ^{13}C NMR (100.6 MHz, $CDCl_3$, 25 ^{o}C): δ 159.5, 150.2, 143.7, 141.8, 137.0, 135.9, 135.0, 134.3, 133.8, 132.6, 130.3, 129.6, 129.2, 127.7, 127.6, 126.1, 126.0, 124.8, 124.4, 123.5, 118.0, 114.5, 92.4, 75.0, 65.2, 55.5, 34.5, 31.4, 21.6; HRMS (EI, TOF): caled for $C_{42}H_{39}NO_4S^+$ $[M]^+$: 653.2600, found: 653.2595.



12-(4-Methoxyphenyl)-6a-phenyl-7-tosyl-10-(trifluoromethyl)-6a,6b,7,11b-tetrahydro-5H-isochromeno[4',3':4,5]cyclopenta[1,2-b]indole (**3o**). The compound was prepared from (2-((4-methoxyphenyl)ethynyl)phenyl)methanol and N-(2-(1-hydroxy-3-phenylprop-2-yn-1-yl)-4-(trifluoromethyl)phenyl)-4-methylbenzenesulfonamide following the general procedure. The product 3o was obtained in 50% yield as a white solid after column chromatography (eluent = petroleum ether/ethyl acetate 10:1 v/v); Mp: 189-192 ^{o}C; ^{1}H NMR (400 MHz, d^{6}-DMSO, 25 ^{o}C): δ 7.52-7.55 (m, 5H), 7.23-7.35 (m, 6H), 7.08-7.15 (m, 5H), 6.93-6.94 (m, 3H), 6.66 (d, J = 7.92 Hz, 1H), 5.35 (d, J = 8.80 Hz, 1H), 4.93 (d, J = 16.44 Hz, 1H), 4.64 (d, J = 16.36 Hz, 1H), 4.46 (d, J = 8.76 Hz, 1H), 3.85 (s, 3H), 2.28 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$, 25 ^{o}C): δ 159.7, 144.2, 142.2, 137.6, 136.8, 136.3, 135.5, 134.9, 133.3, 130.3, 129.9, 129.6, 128.1, 127.9, 127.5 (q, J = 287.2 Hz), 126.9, 126.3, 124.4, 124.1, 121.7, 114.7, 114.5, 92.8, 75.1, 65.3, 55.6, 55.5, 21.7; ^{19}F NMR (376 MHz, $CDCl_3$, 25 ^{o}C): δ 62.4; HRMS (EI, TOF): caled for $C_{39}H_{30}F_3NO_4S^+$ $[M]^+$: 665.1848, found: 665.1847.

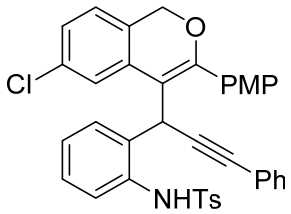


12-(4-Methoxyphenyl)-10-methyl-6a-phenyl-7-tosyl-6a,6b,7,11b-tetrahydro-5H-isochromeno [4',3':4,5]cyclopenta[1,2-b]indole (**3p**). The compound was prepared from (2-((4-methoxyphenyl)ethynyl)phenyl)methanol and N-(2-(1-hydroxy-3-phenylprop-2-yn-1-yl)-4-methylphenyl)-4-methylbenzenesulfonamide following the general procedure. The product 3p was obtained in 67% yield as a white solid after column chromatography (eluent = petroleum ether/ethyl acetate 10:1 v/v); Mp: 196-198 ^{o}C; ^{1}H NMR (400 MHz, d^{6}-DMSO, 25 ^{o}C): δ 7.46-7.48 (m, 5H), 7.24-7.29 (m, 4H), 7.09-7.12 (m, 4H), 7.05-7.07 (m, 2H), 6.91-6.94 (m, 2H), 6.75 (d, J = 8.88 Hz, 1H), 6.69 (d, J = 8.20 Hz, 1H), 6.29 (s, 1H), 5.21 (d, J = 8.72 Hz, 1H), 4.90 (d, J = 16.48 Hz, 1H), 4.60 (d, J = 16.48 Hz, 1H), 4.24 (d, J = 8.84 Hz, 1H), 3.85 (s, 3H), 2.28 (s, 3H), 2.05 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$, 25 ^{o}C): δ 159.5, 143.6, 139.3, 137.6, 137.1, 135.7, 134.9, 134.5, 133.9, 132.7, 130.3, 129.6, 129.2, 128.6, 127.7, 127.4, 127.0, 126.1, 126.0, 124.3, 124.2, 117.5, 114.4, 92.7, 75.0, 65.2, 55.7, 55.5, 21.6, 21.3; HRMS (EI, TOF): caled for $C_{39}H_{33}NO_4S^+$ $[M]^+$: 611.2130, found: 611.2125.



12-(4-Methoxyphenyl)-8-methyl-6a-phenyl-7-tosyl-6a,6b,7,11b-tetrahydro-5H-isochromeno[4',3':4,5]cyclopenta[1,2-b]indole (**3q**). The compound was prepared from (2-((4-methoxyphenyl)ethynyl)phenyl)methanol and N-(2-(1-hydroxy-3-phenylprop-2-yn-1-yl)-6-methylphenyl)-4-methylbenzenesulfonamide

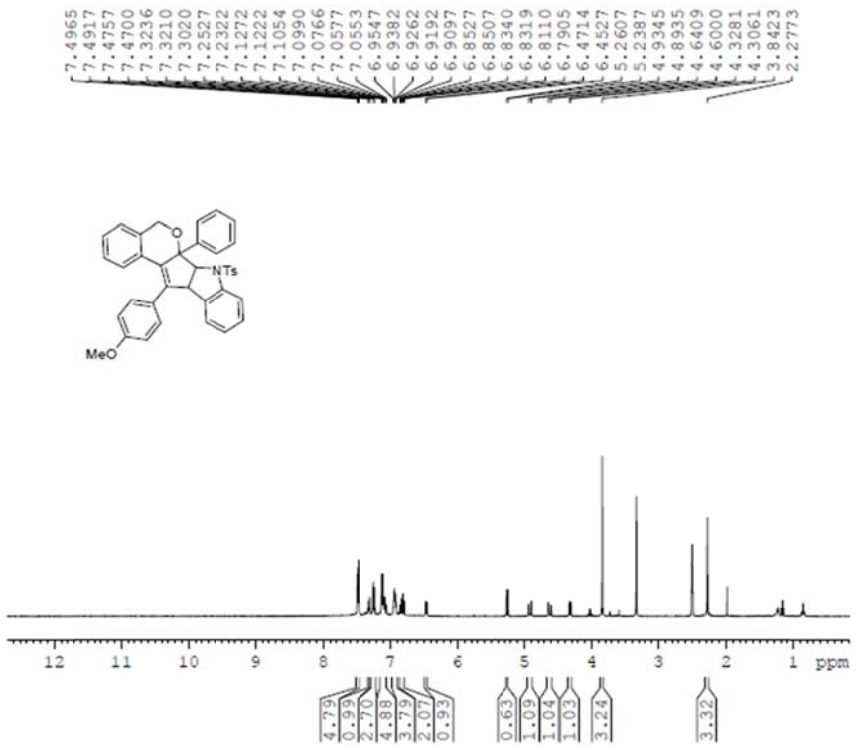
following the general procedure. The product 3q was obtained in 40% yield as a white solid after column chromatography (eluent = petroleum ether/ethyl acetate 10:1 v/v); Mp: 215-217 ^{o}C; ^{1}H NMR (400 MHz, d^{6}-DMSO, 25 ^{o}C): δ 7.25-7.33 (m, 8H), 7.18-7.20 (m, 1H), 7.07-7.13 (m, 4H), 7.04 (t, J = 7.48 Hz, 1H), 6.87-6.90 (m, 4H), 6.80 (d, J = 7.36 Hz, 1H), 6.39 (d, J = 7.48 Hz, 1H), 5.08 (d, J = 7.64 Hz, 1H), 4.86 (d, J = 16.60 Hz, 1H), 4.52 (d, J = 16.28 Hz, 1H), 3.83 (s, 3H), 3.56 (d, J = 7.68 Hz, 1H), 2.33 (s, 3H), 1.68 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$, 25 ^{o}C): δ 159.5, 143.9, 140.9, 138.3, 137.8, 137.2, 134.7, 134.5, 133.5, 132.8, 130.3, 130.1, 129.4, 129.1, 127.9, 127.7, 127.4, 126.2, 126.1, 126.0, 124.2, 120.8, 114.4, 91.7, 75.5, 65.0, 55.5, 55.3, 21.7, 19.3; HRMS (EI, TOF): caled for $C_{39}H_{33}NO_4S^+$ $[M]^+$: 611.2130, found: 611.2132.



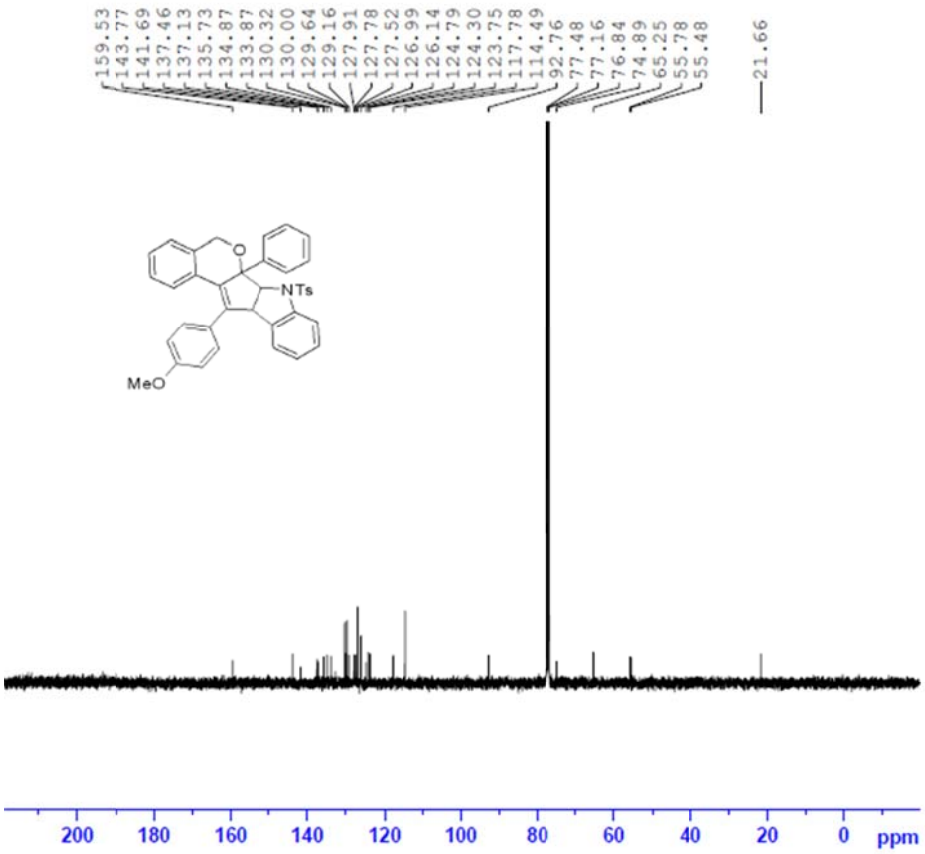
N-(2-(1-(6-chloro-3-(4-methoxyphenyl)-1H-isochromen-4-yl)-3-phenylprop-2-yn-1-yl)phenyl)-4-methylbenzenesulfonamide (**4**). ^{1}H NMR (400 MHz, $CDCl_3$, 25 ^{o}C): δ 7.75-7.78 (m, 3H), 7.50 (d, J = 1.92 Hz, 1H), 7.43-7.47 (m, 3H), 7.29-7.31 (m, 3H), 7.10-7.13 (m, 1H), 7.04-7.08 (m, 2H), 7.01-7.04 (m, 1H), 6.98 (d, J = 8.24 Hz, 2H), 6.86-6.95 (m, 5H), 5.14 (d, J = 12.52 Hz, 1H), 4.96 (d, J = 12.44 Hz, 1H), 4.74 (s, 1H), 3.86 (s, 3H), 2.23 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$, 25 ^{o}C): δ 161.6, 155.4, 143.5, 136.1, 135.1, 133.5, 132.3, 132.1, 131.7, 129.6, 129.4, 128.9, 128.7, 128.5, 128.4, 127.7, 126.7, 126.4, 125.3, 125.1, 125.0, 123.7, 122.7, 122.6, 114.1, 109.4, 87.9, 87.1, 69.0, 55.6, 34.9, 21.5; HRMS (EI, TOF): caled for $C_{38}H_{30}ClNO_4S^+$ $[M]^+$: 631.1584, found: 631.1574.

5. Copies of the ^{1}H NMR, ^{13}C NMR and ^{19}F NMR spectra of products.

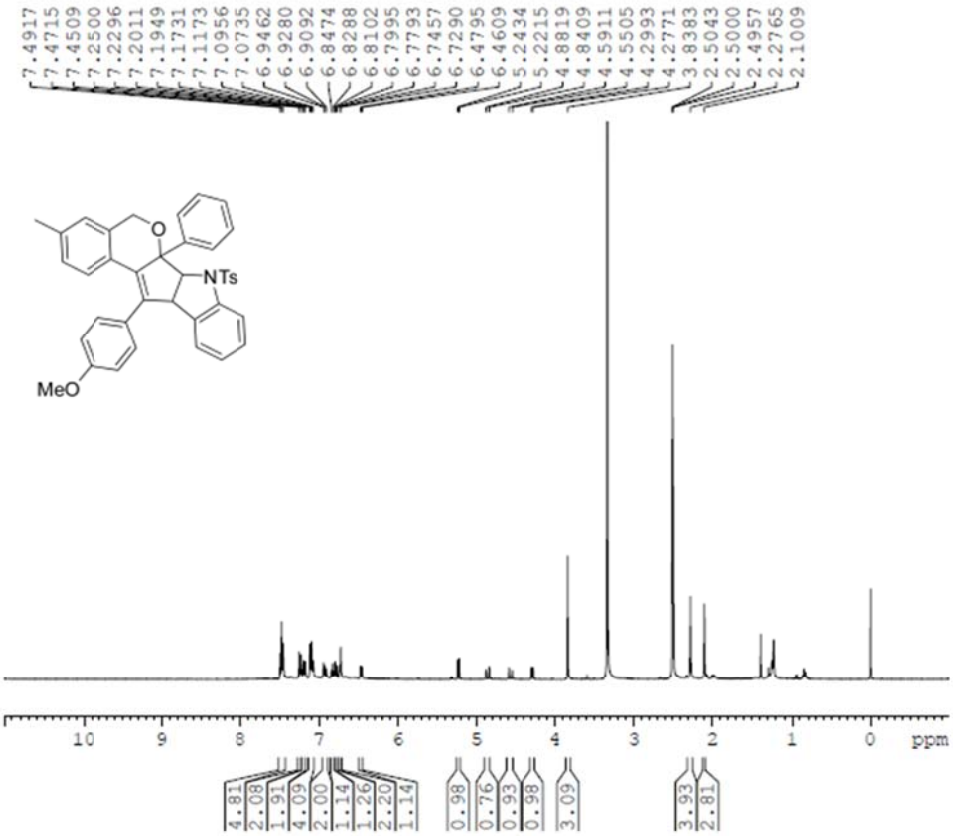
^{1}H NMR of product **3a**.



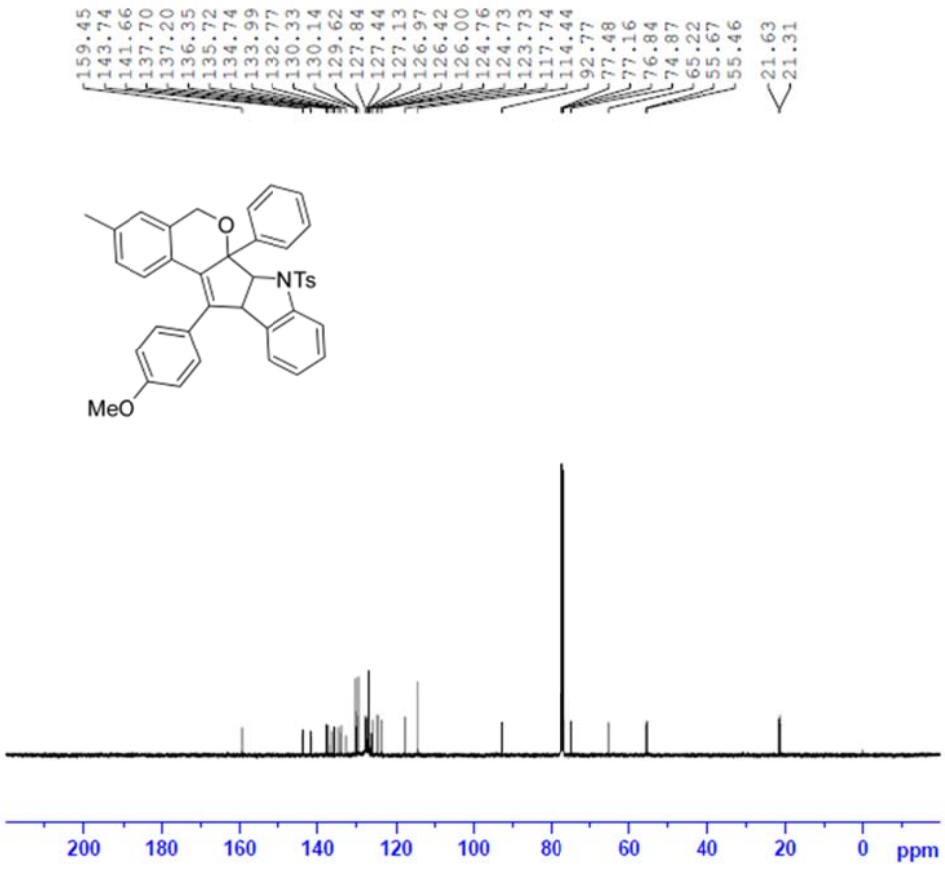
^{13}C NMR of product **3a**.



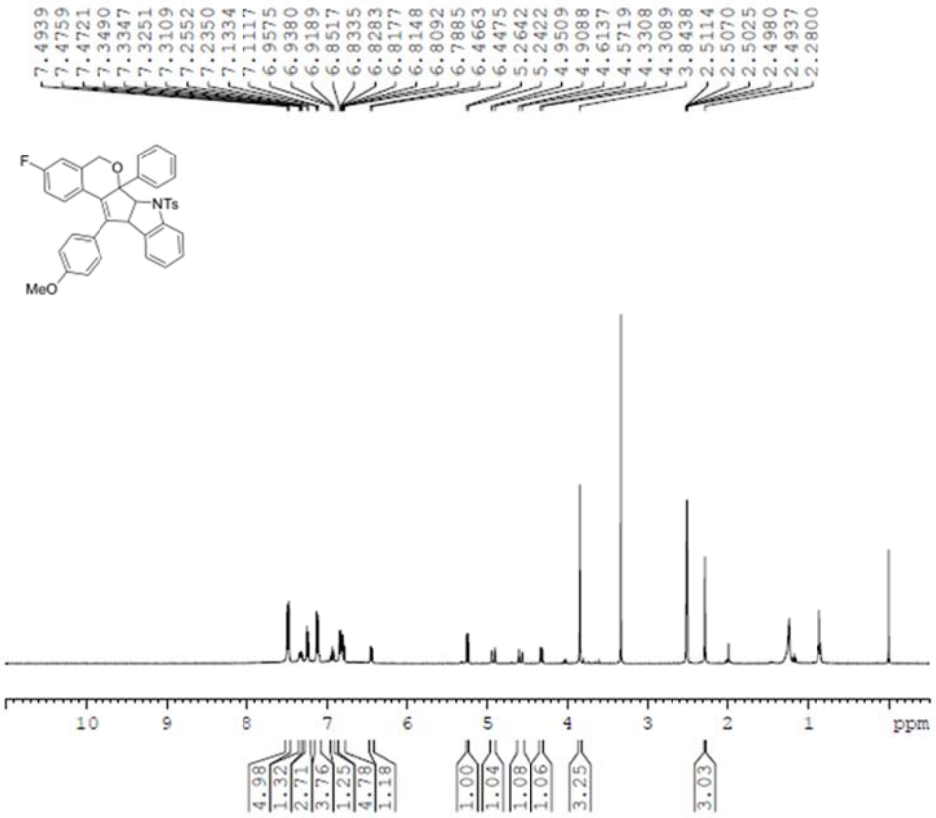
^{1}H NMR of product **3b**.



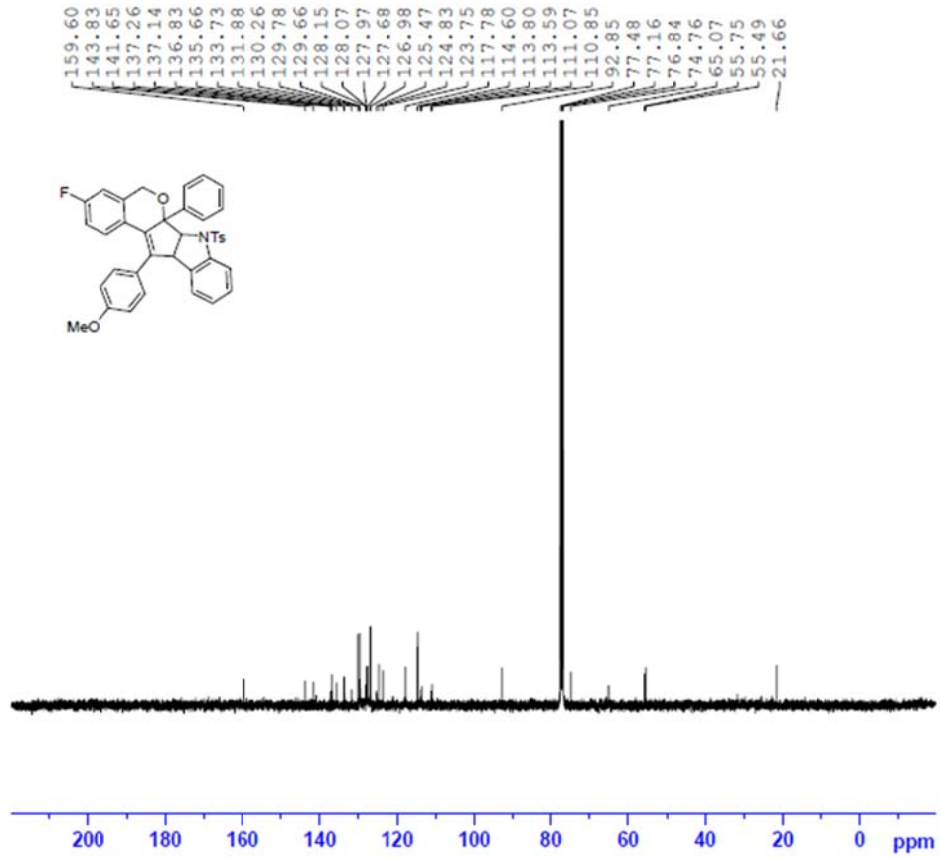
^{13}C NMR of product **3b**.



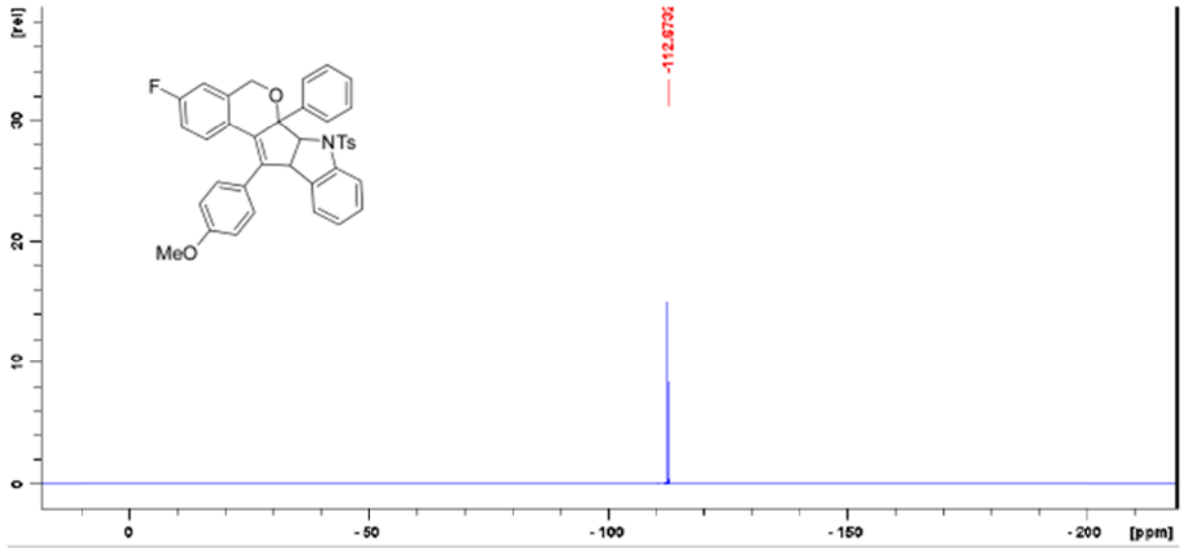
^{1}H NMR of product **3c**



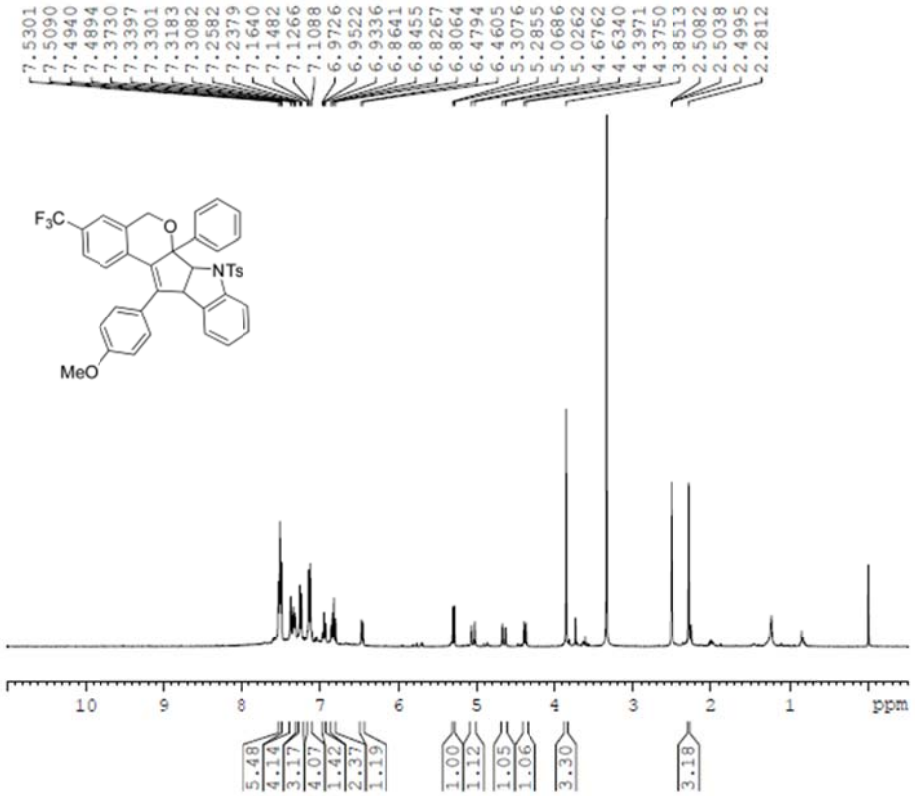
^{13}C NMR of product **3c**



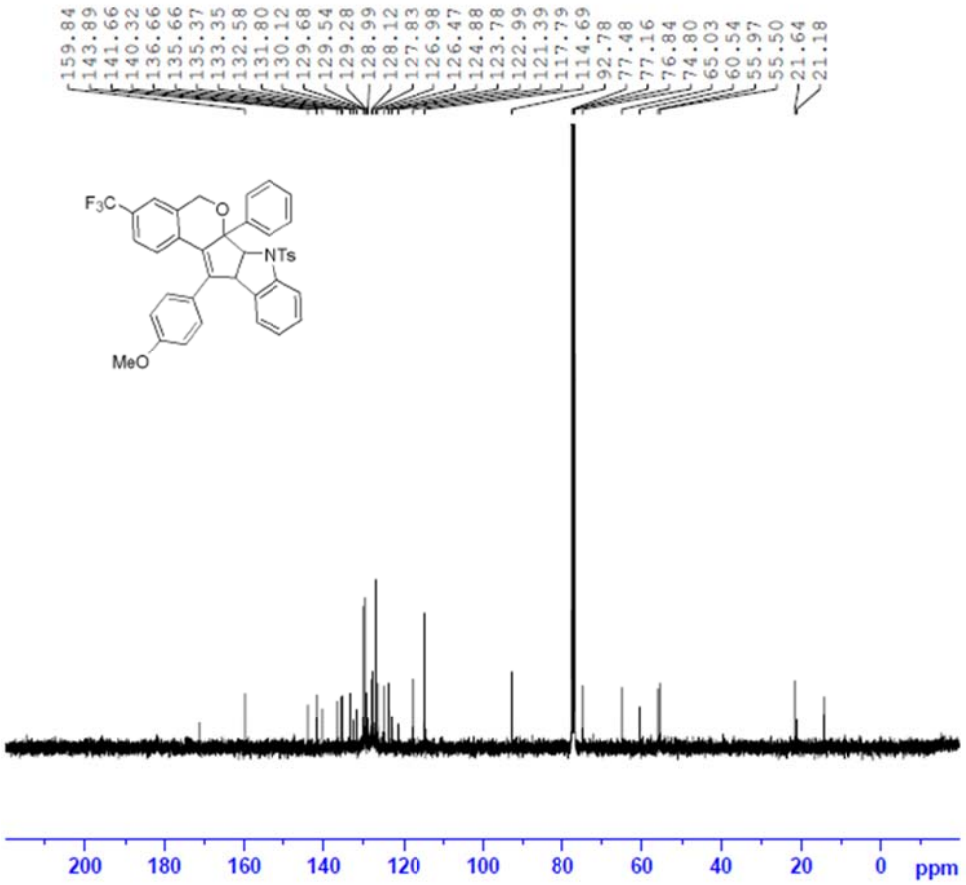
^{19}F NMR of product **3c**



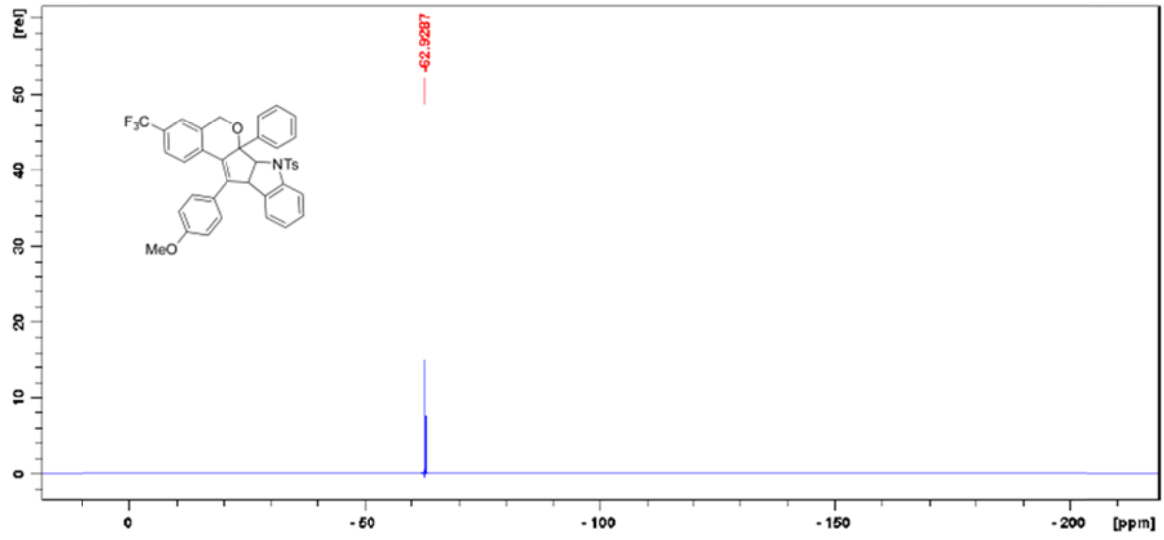
^{1}H NMR of product **3d**



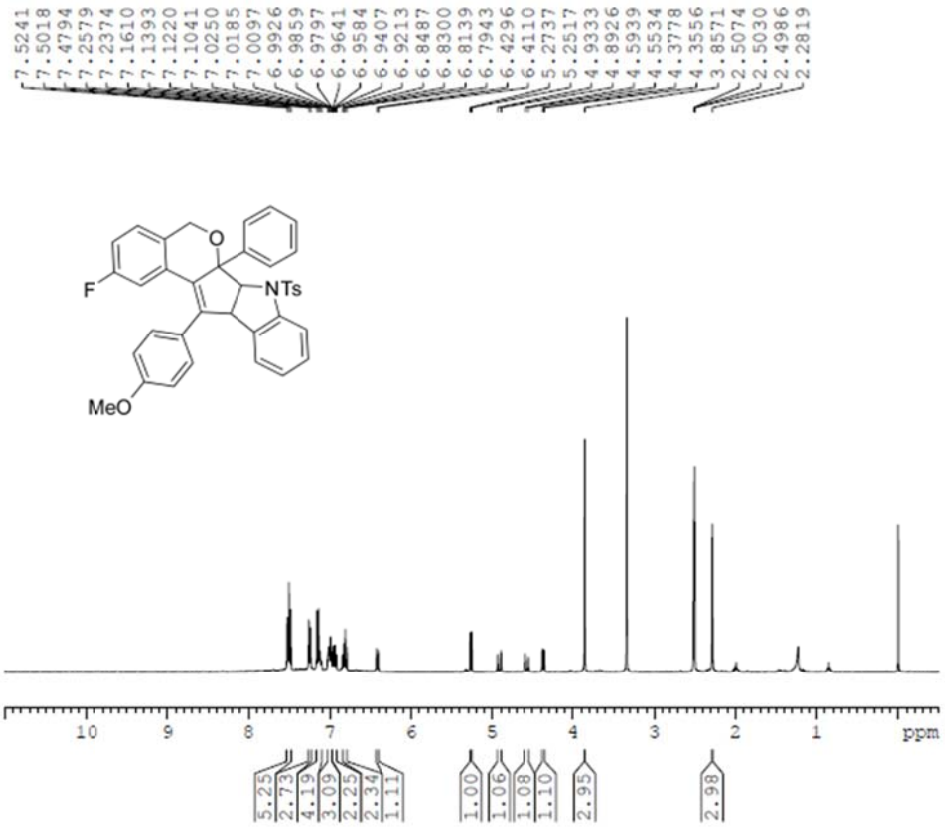
^{13}C NMR of product **3d**



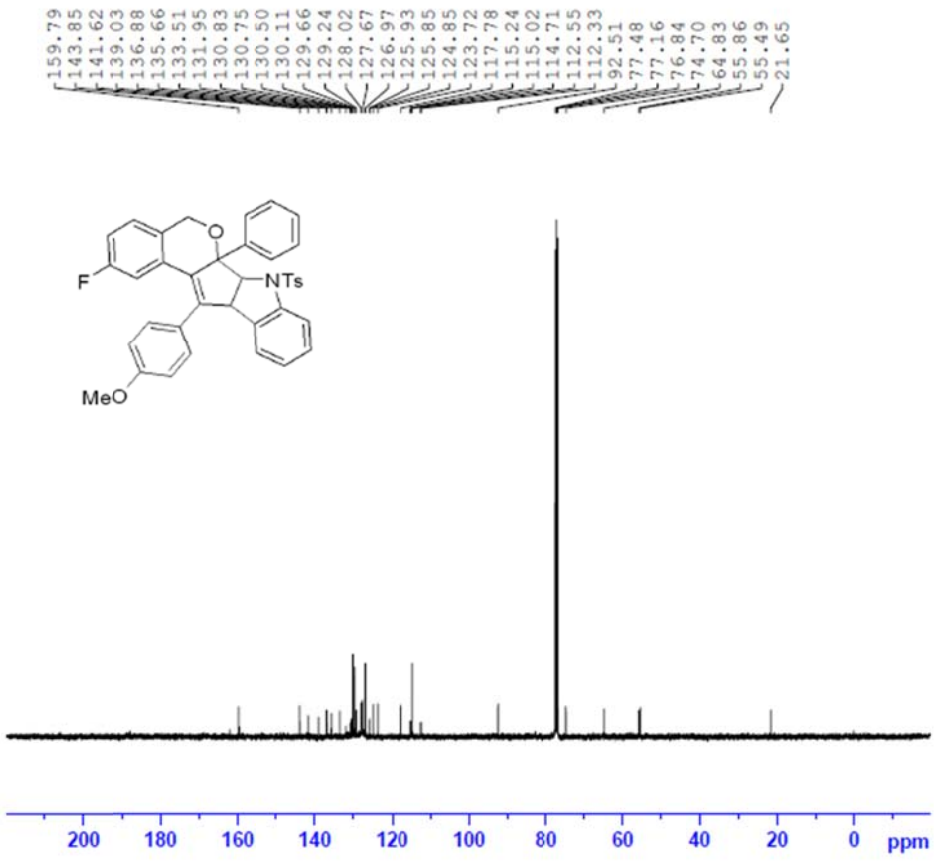
^{19}F NMR of product **3d**



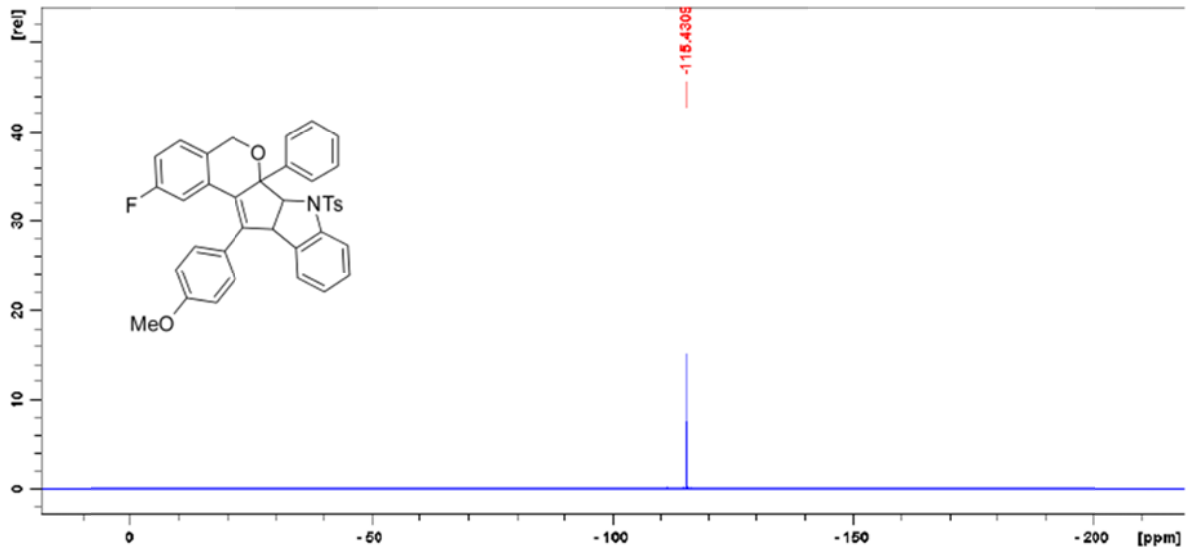
^{1}H NMR of product **3e**



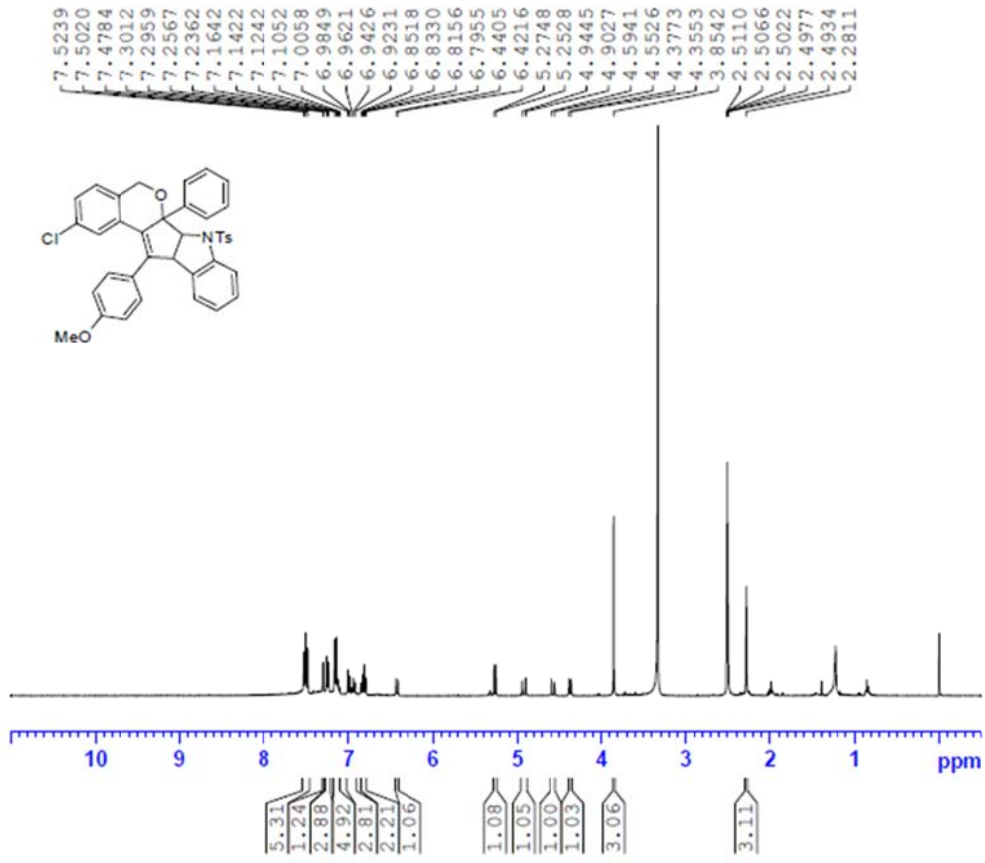
^{13}C NMR of product **3e**



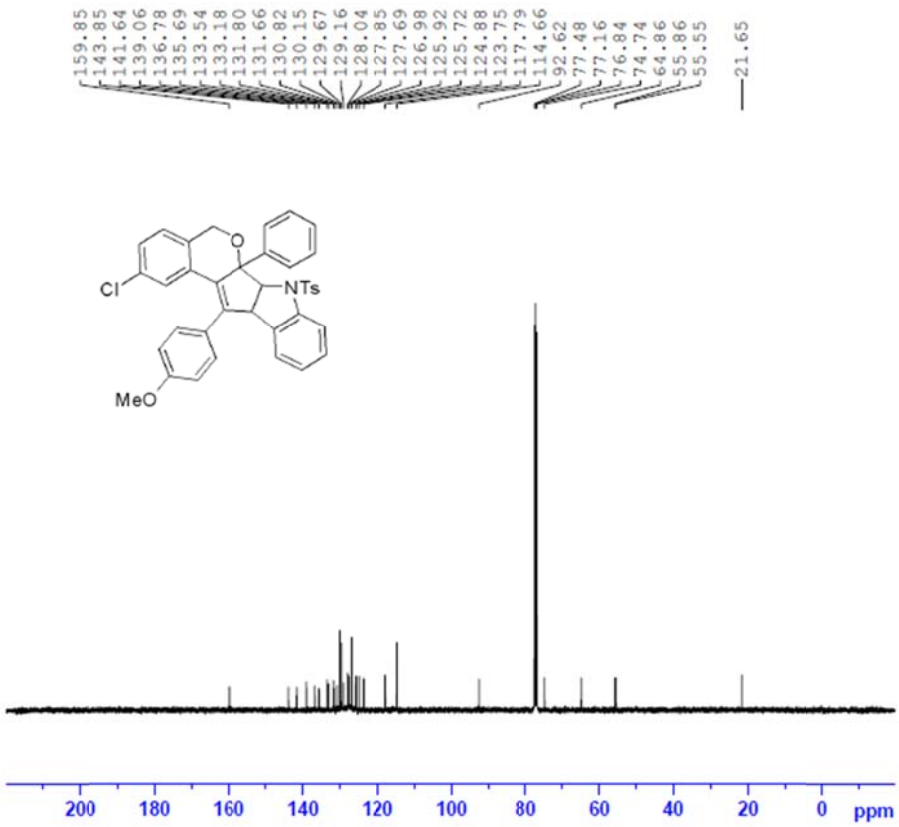
^{19}F NMR of product **3e**



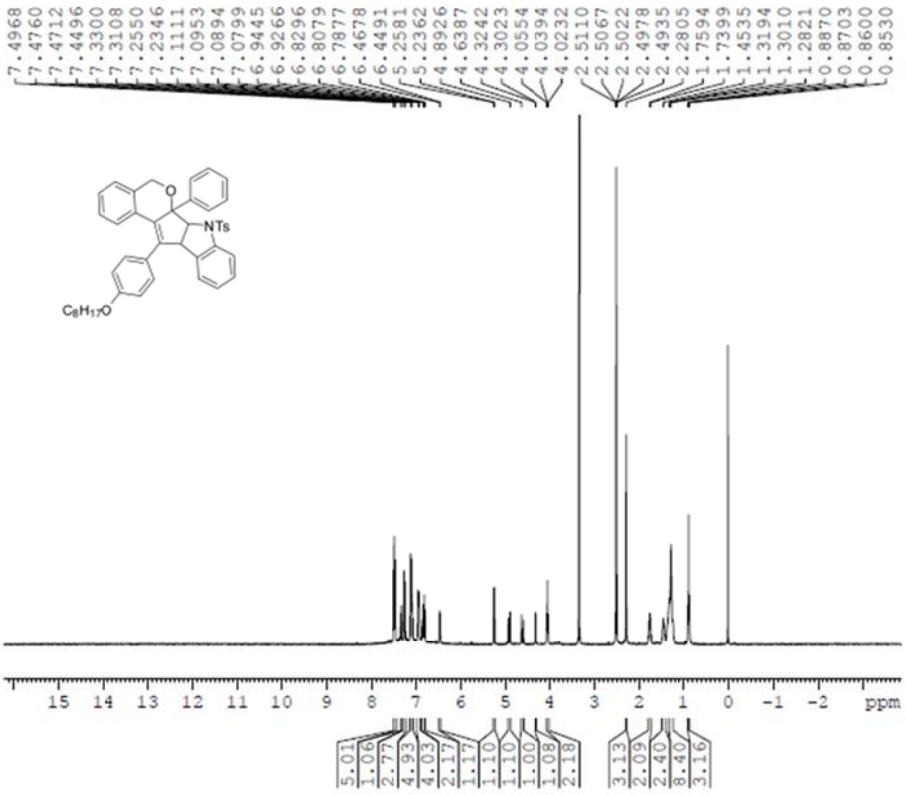
^{1}H NMR of product **3f**



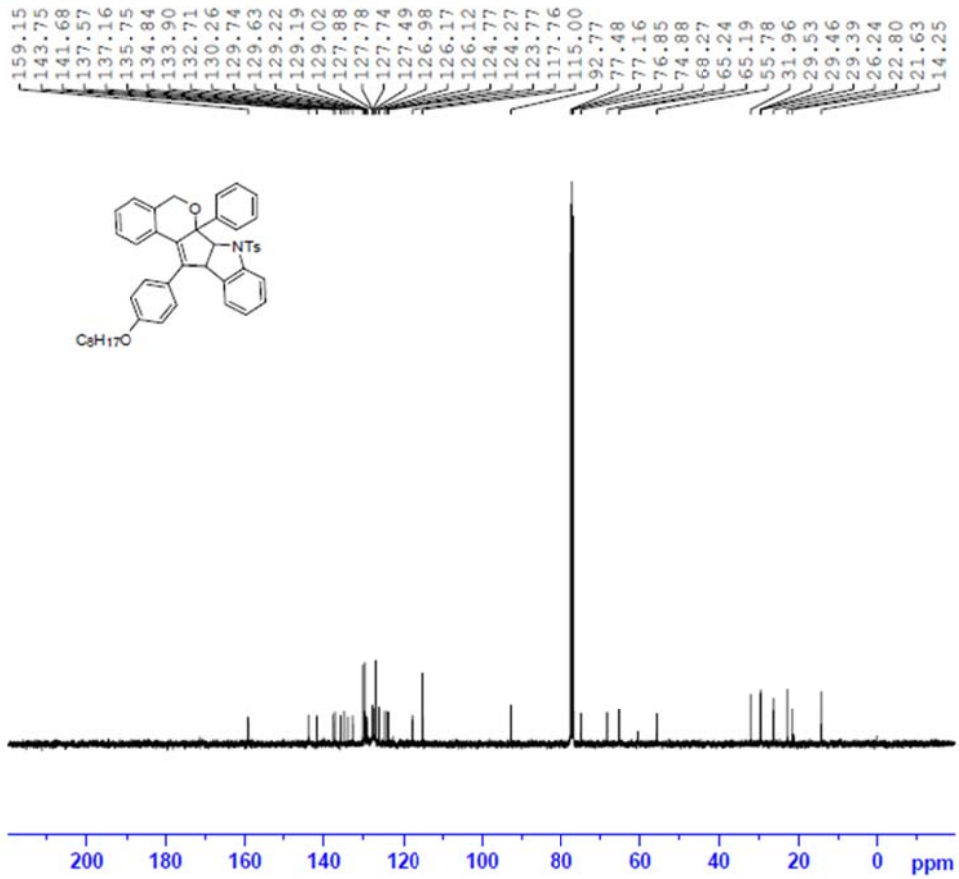
^{13}C NMR of product **3f**



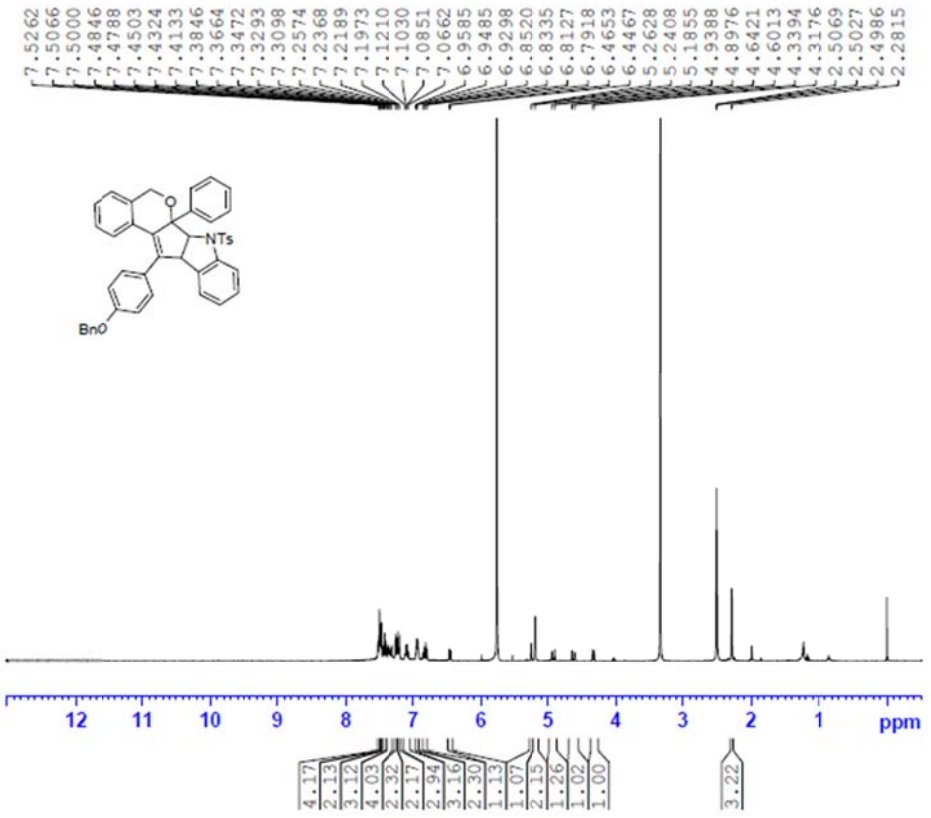
^{1}H NMR of product **3g**



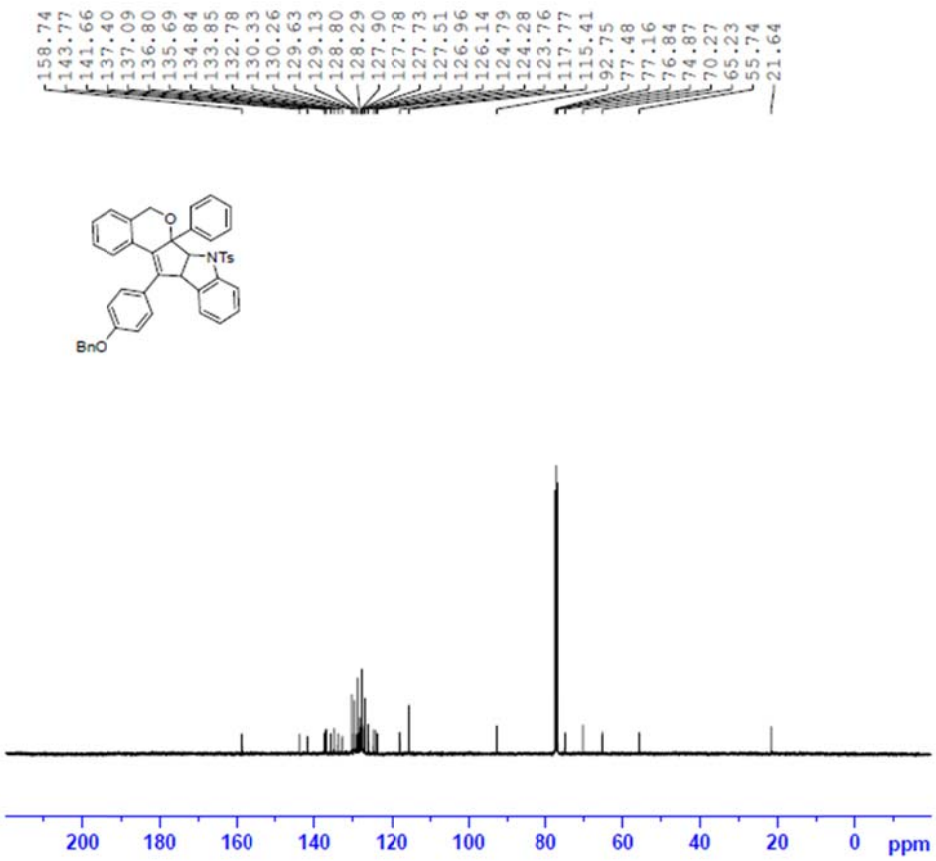
^{13}C NMR of product **3g**



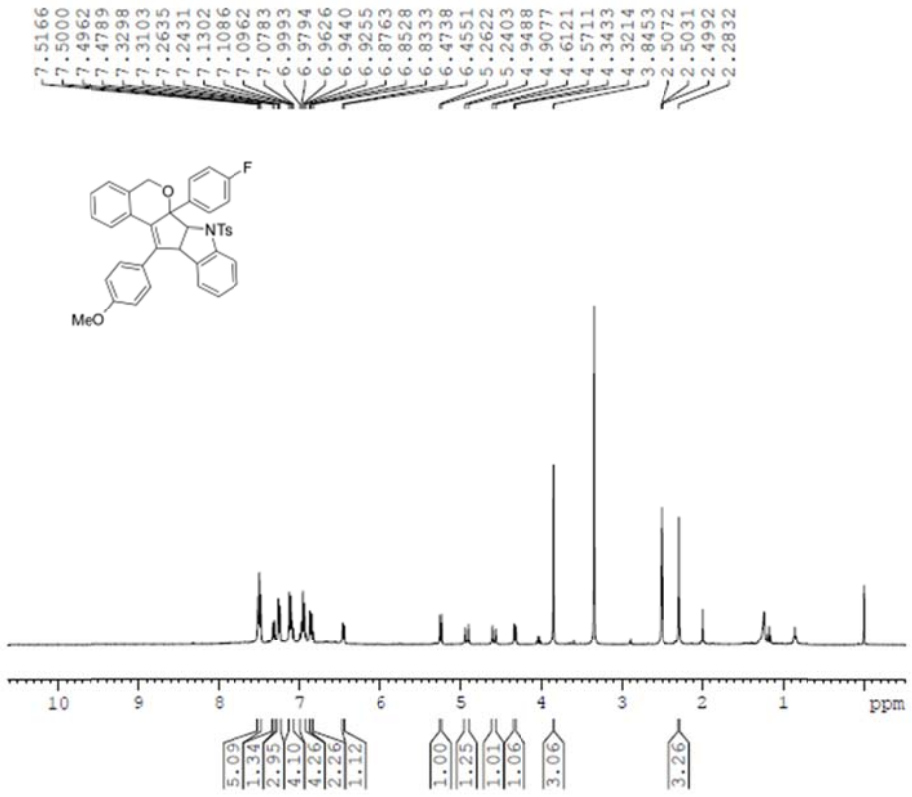
^{1}H NMR of product **3h**



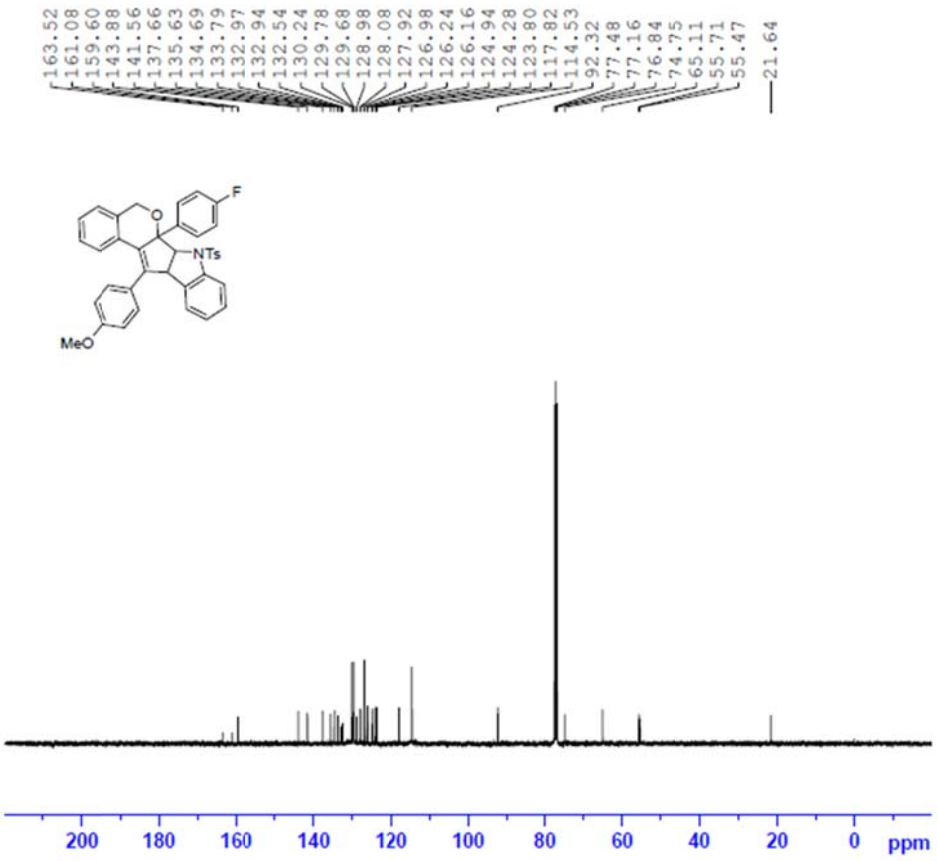
^{13}C NMR of product **3h**



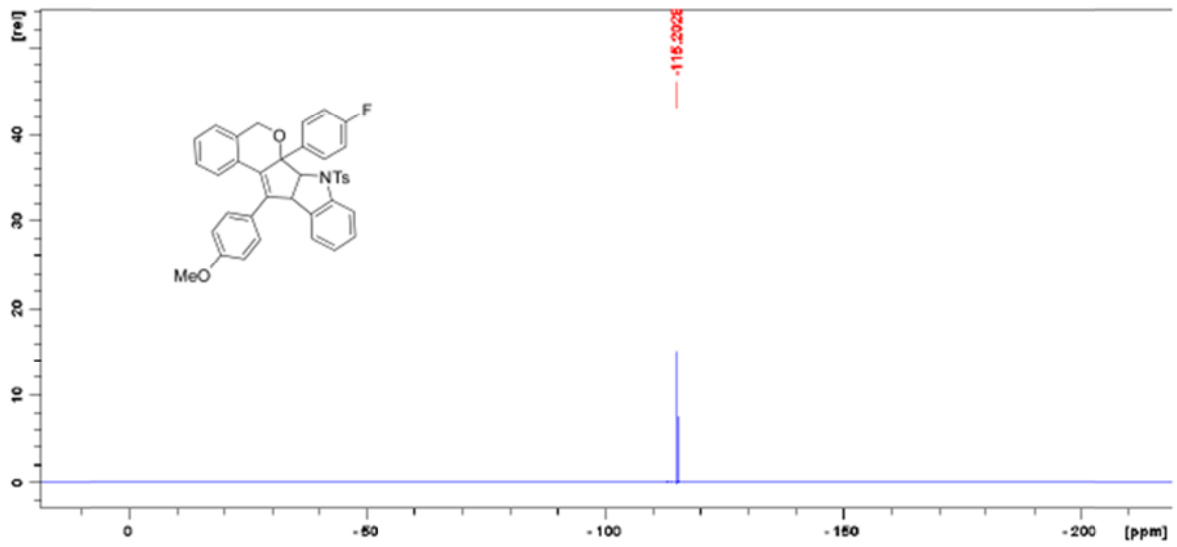
^{1}H NMR of product **3i**



^{13}C NMR of product **3i**



^{19}f NMR of product **3i**



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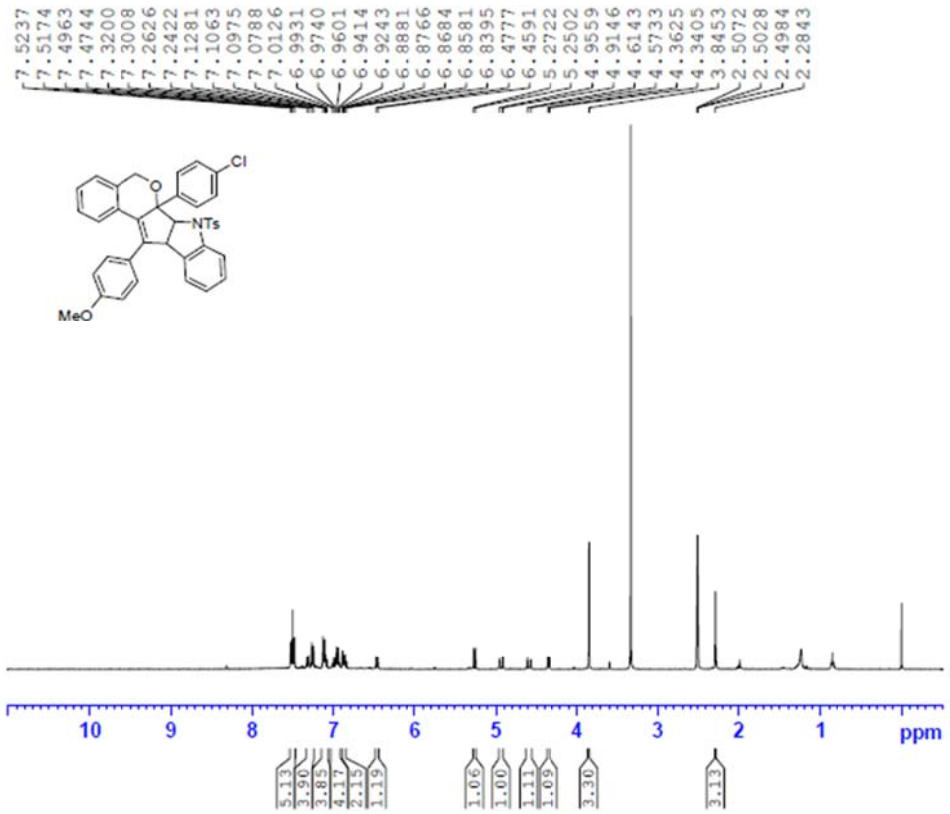

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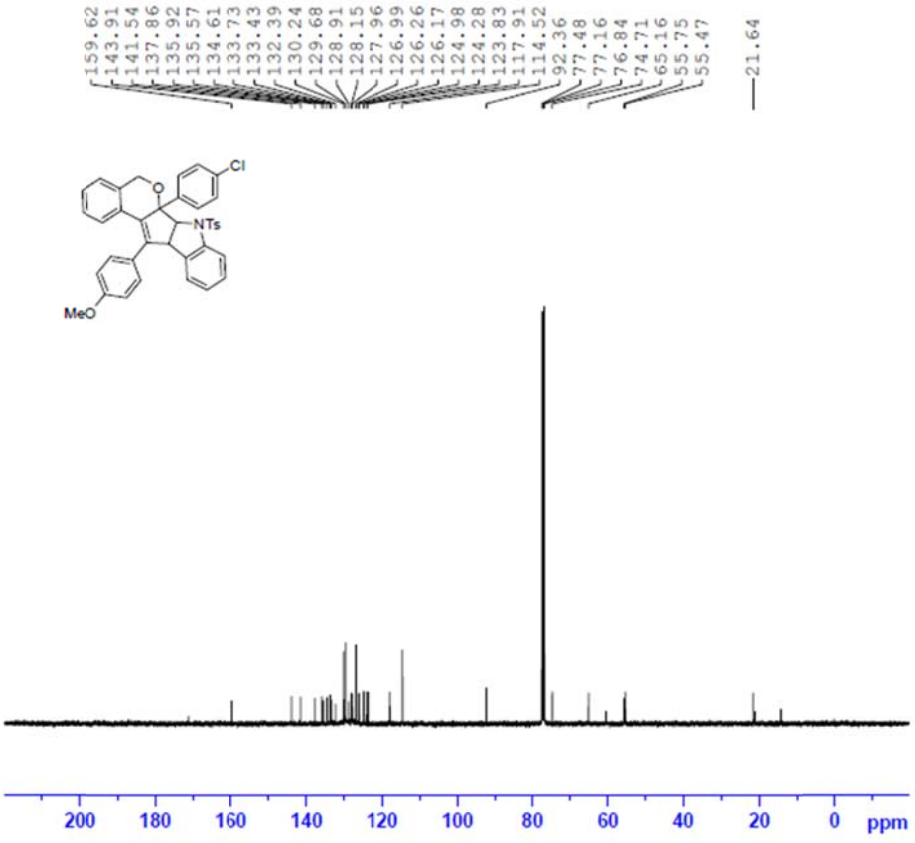
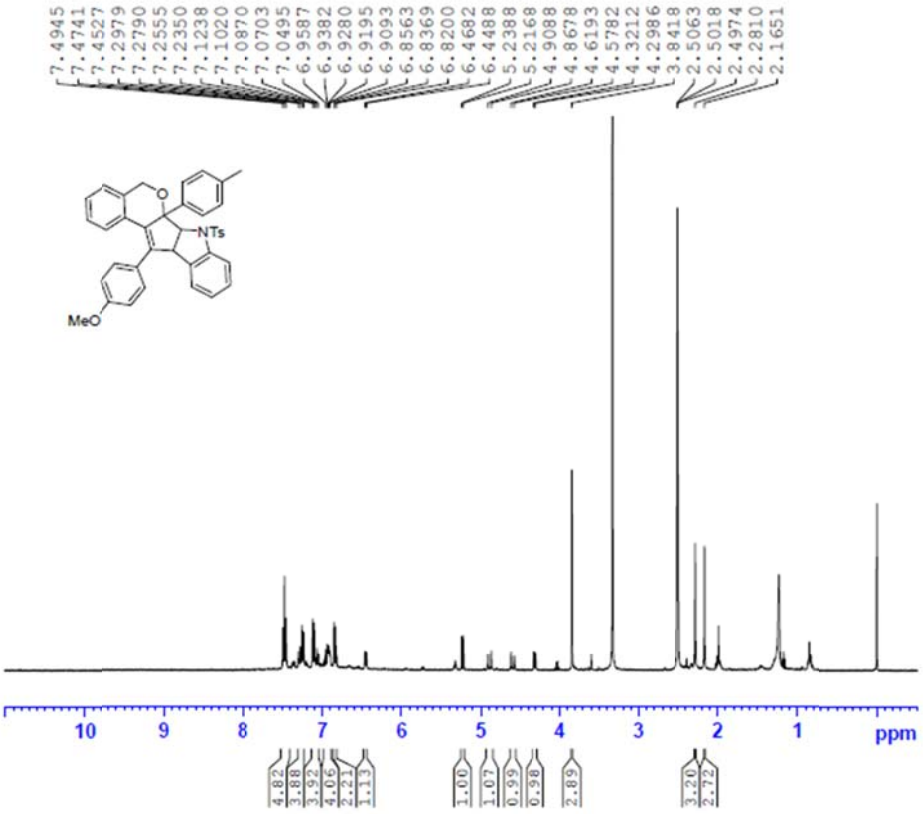
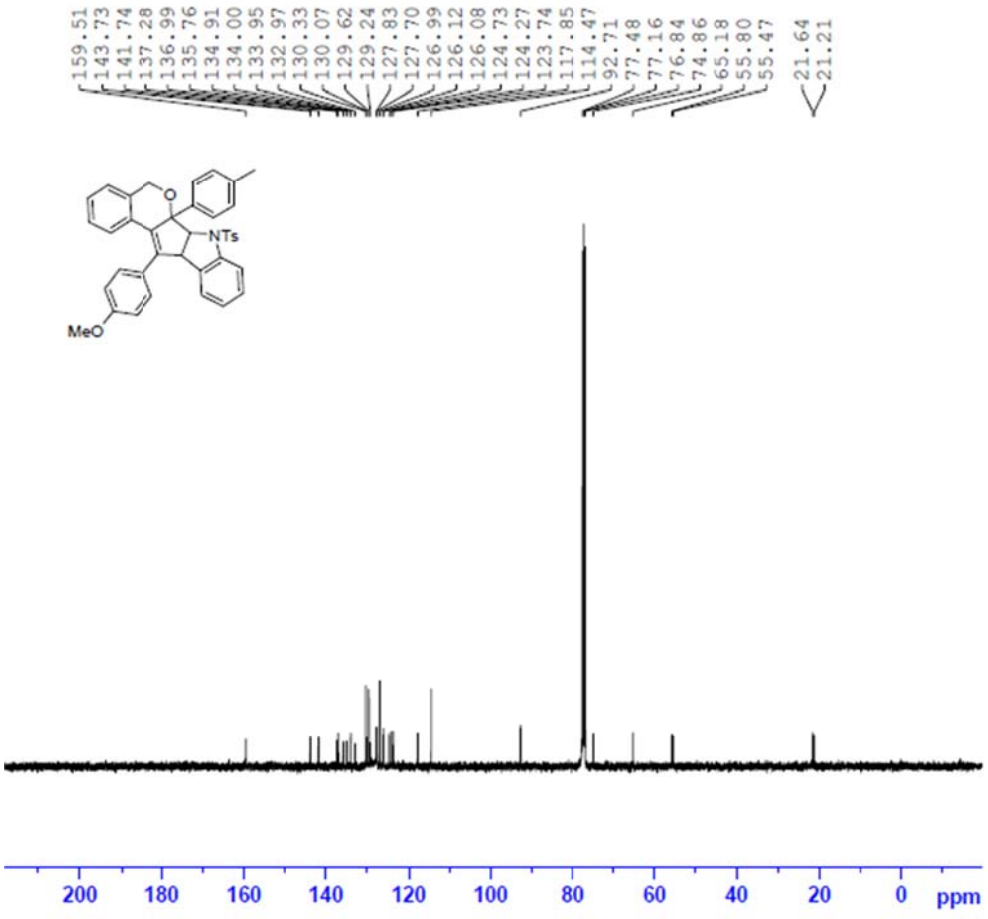


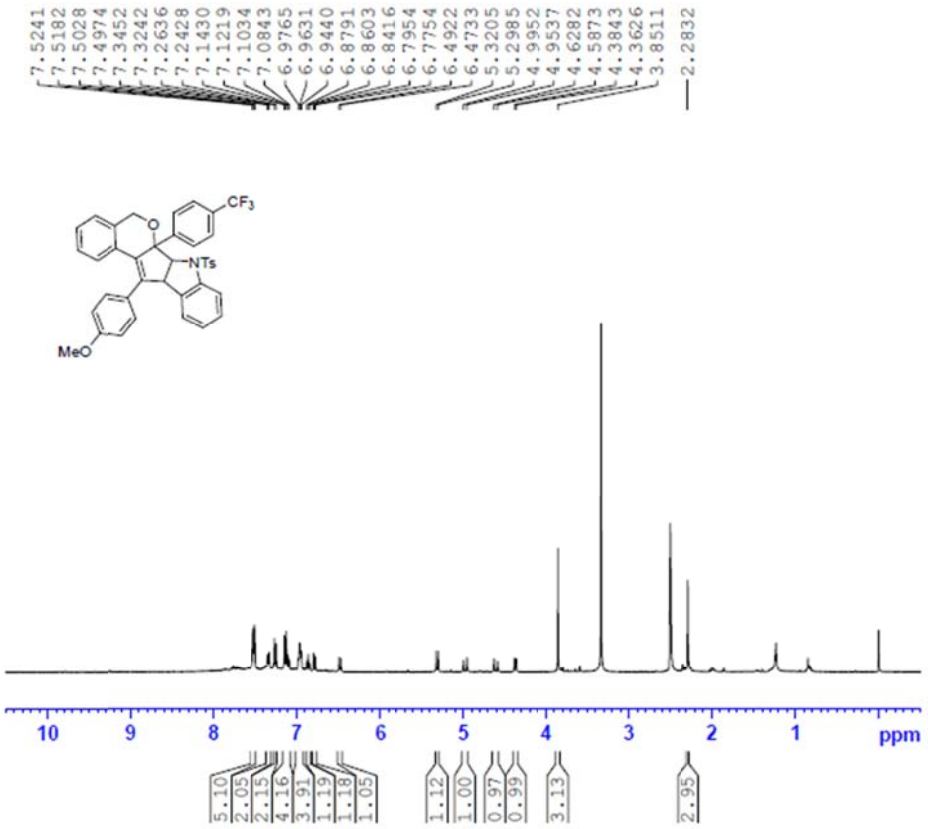
^{1}H NMR of product **3k**



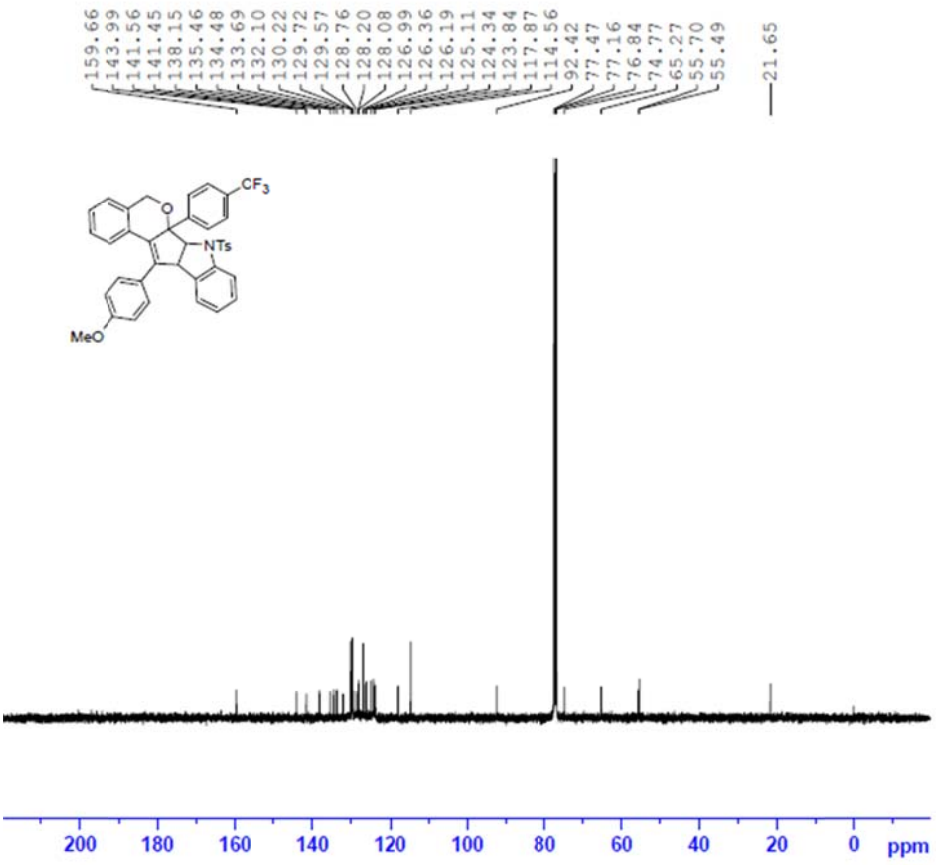
^{13}C NMR of product **3k**



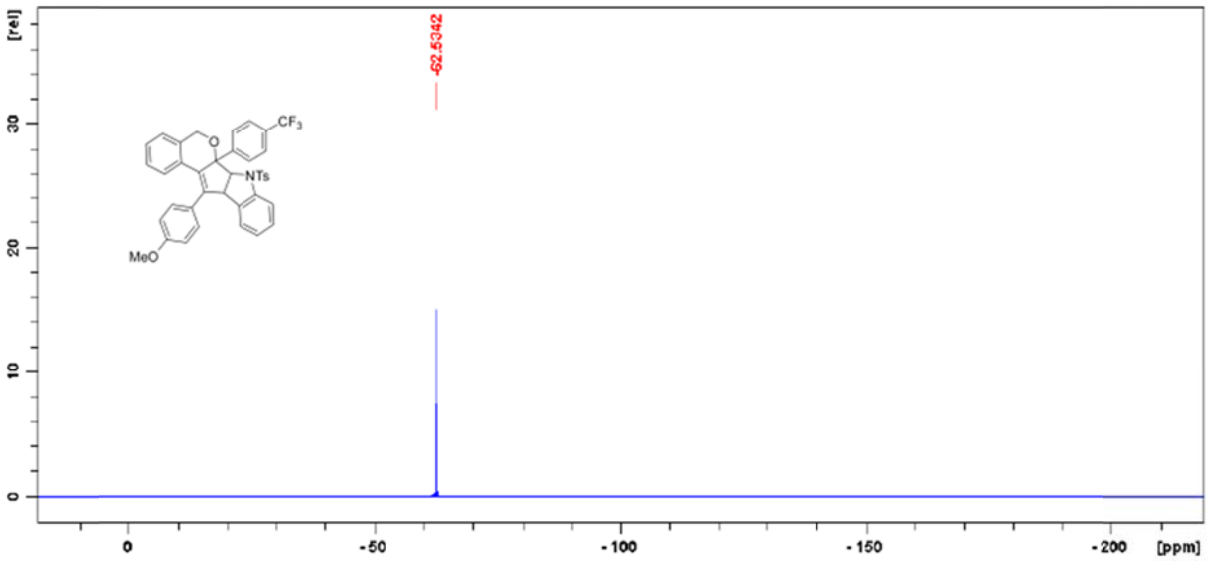
^{1}H NMR of product **3l**



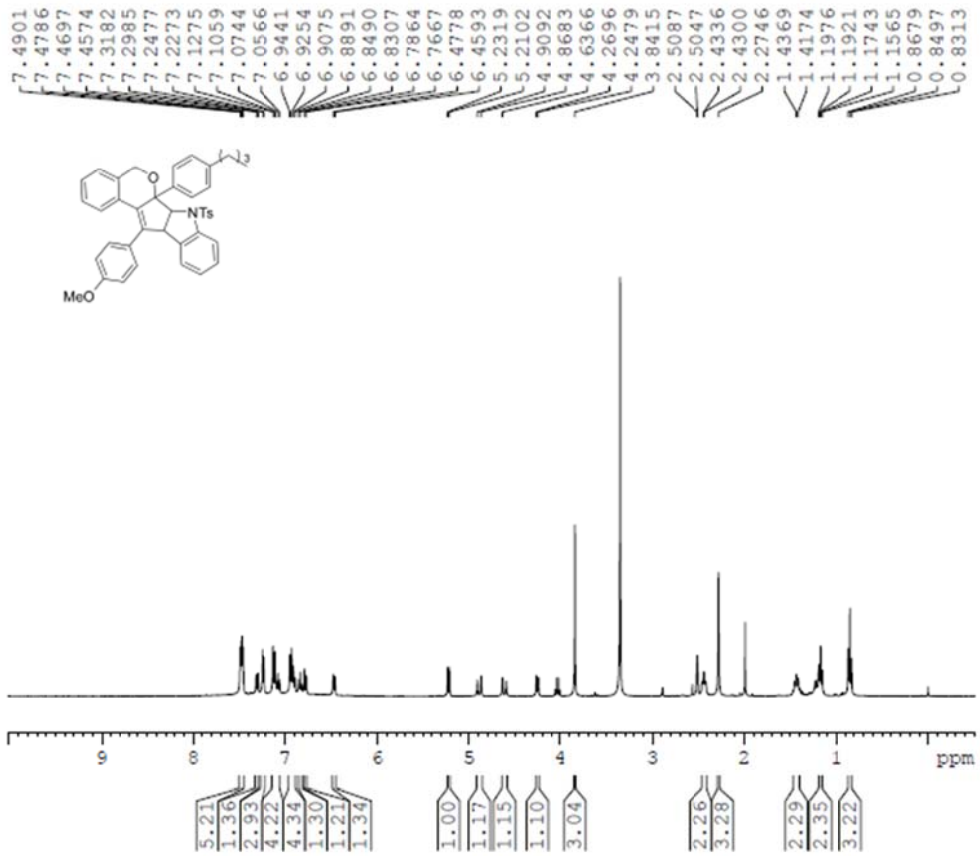
^{13}C NMR of product **3l**



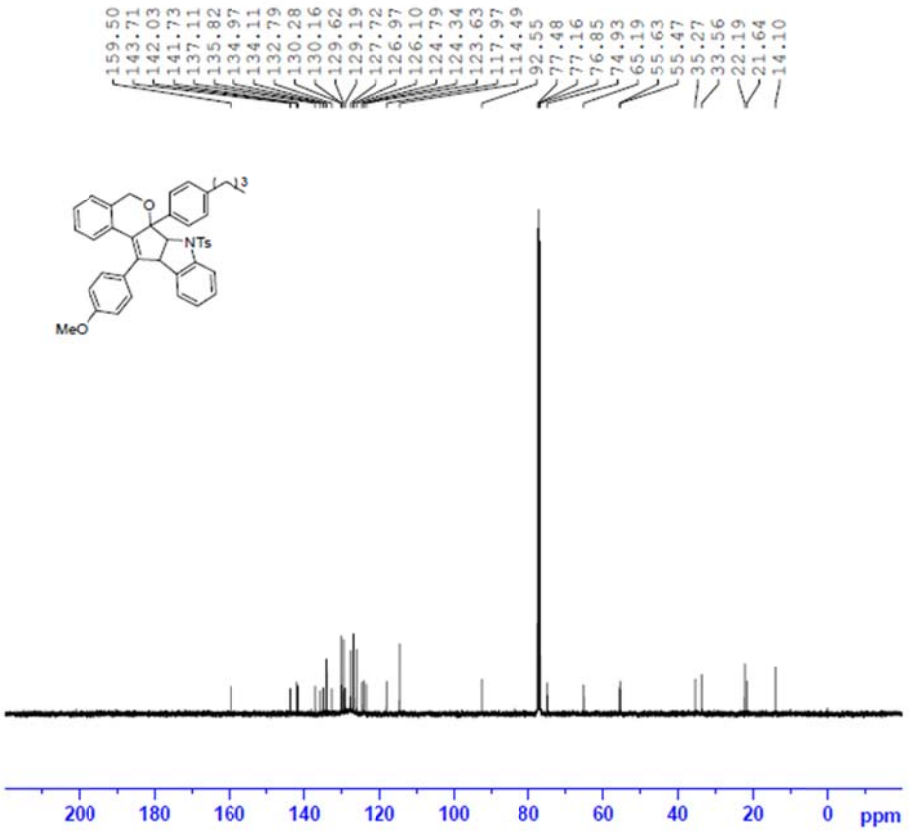
^{19}F NMR of product **3l**



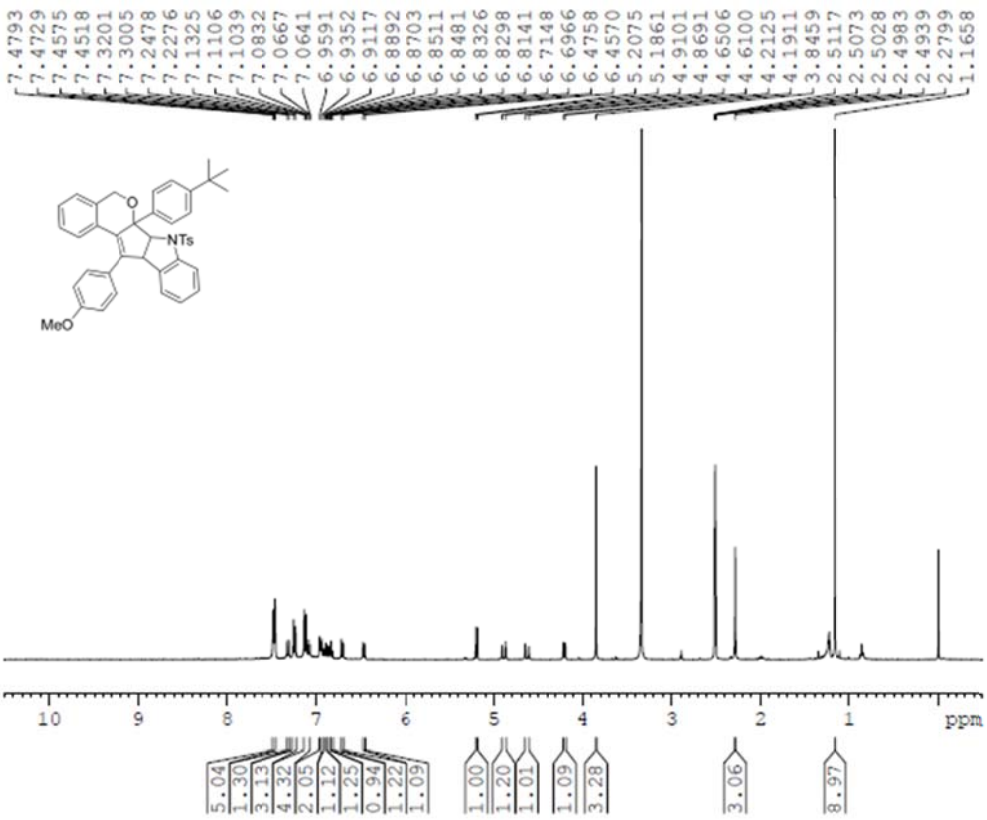
^{1}H NMR of product **3m**



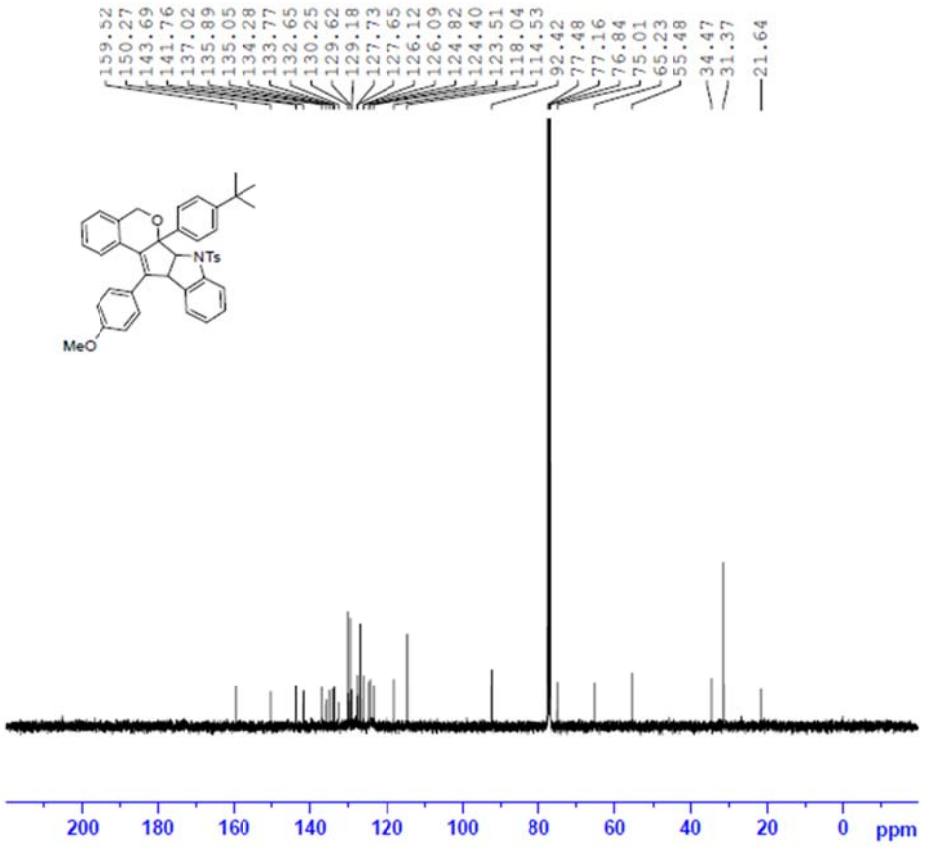
^{13}C NMR of product **3m**



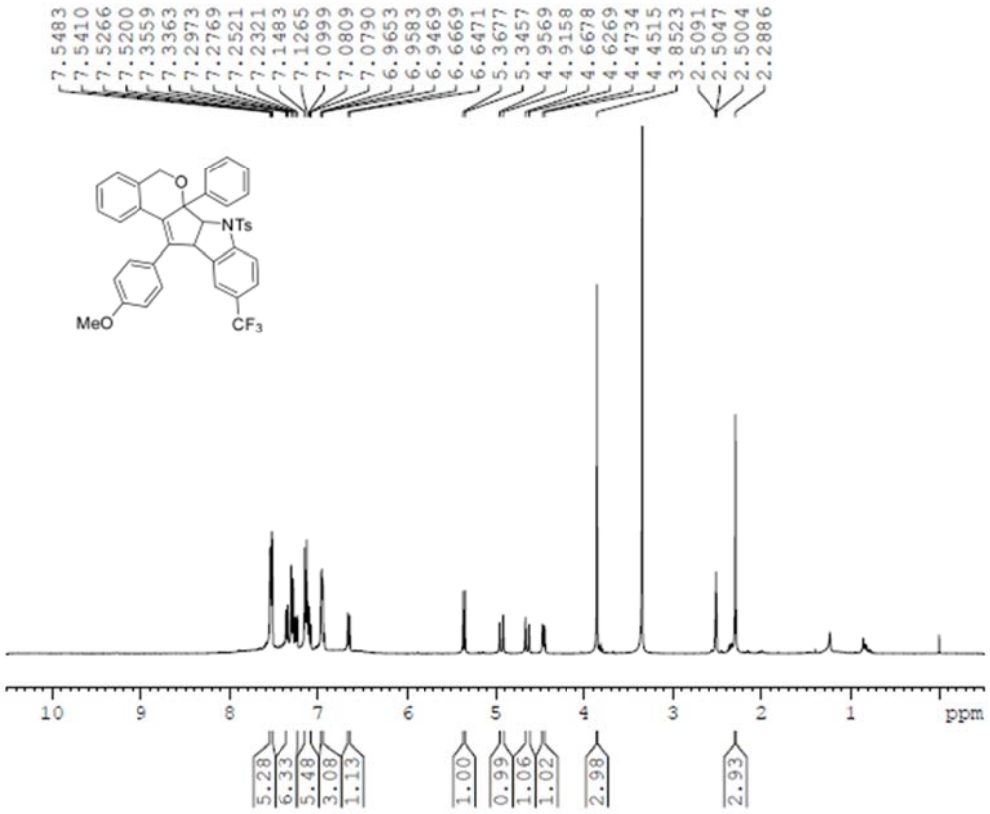
^{1}H NMR of product **3n**



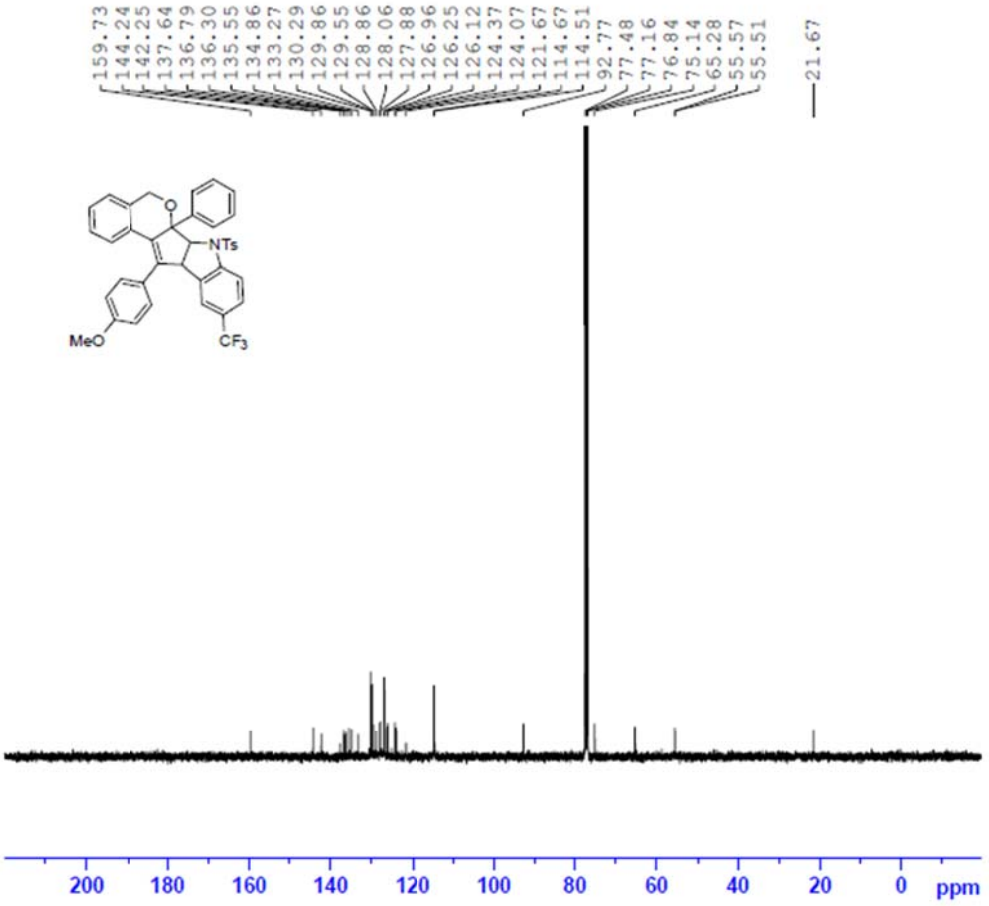
^{13}C NMR of product **3n**



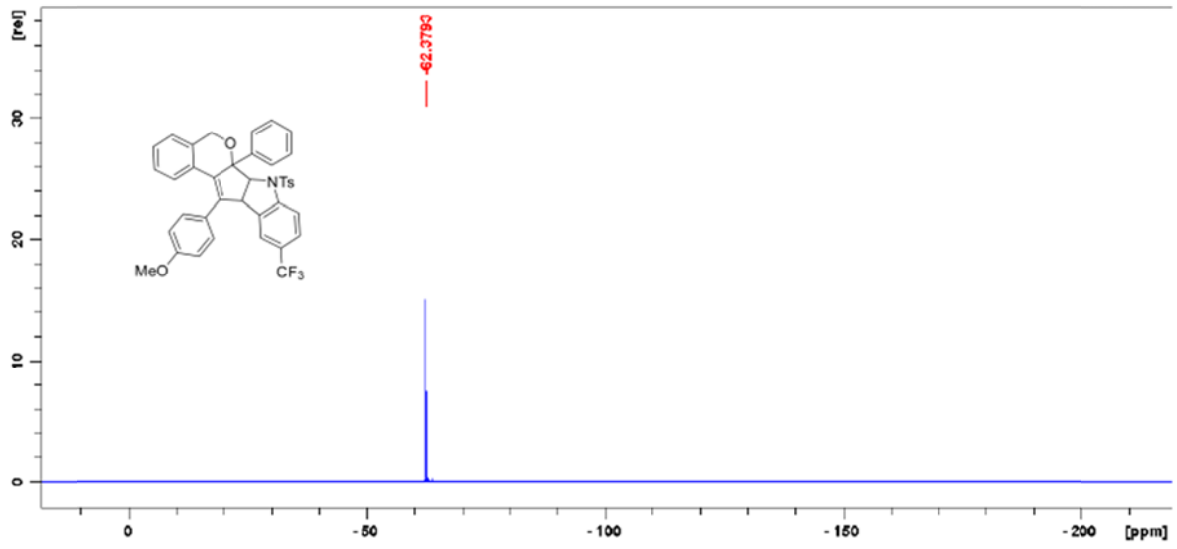
^{1}H NMR of product **3o**



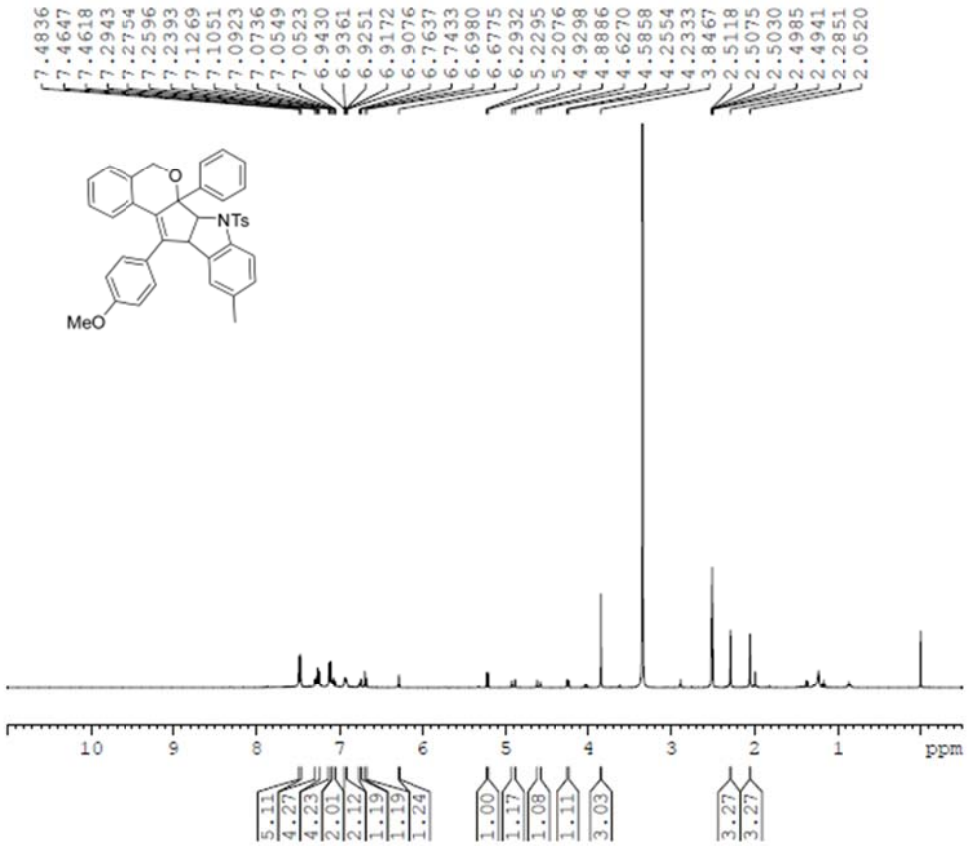
^{13}C NMR of product **3o**



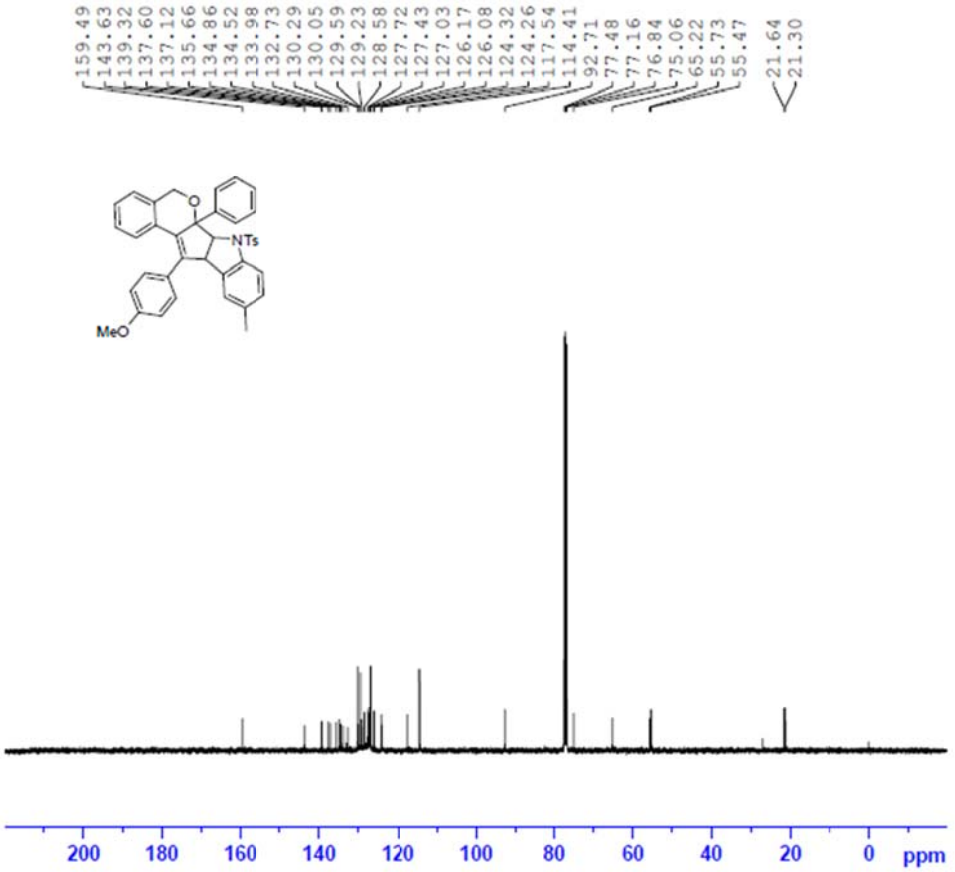
^{19}F NMR of product **3o**



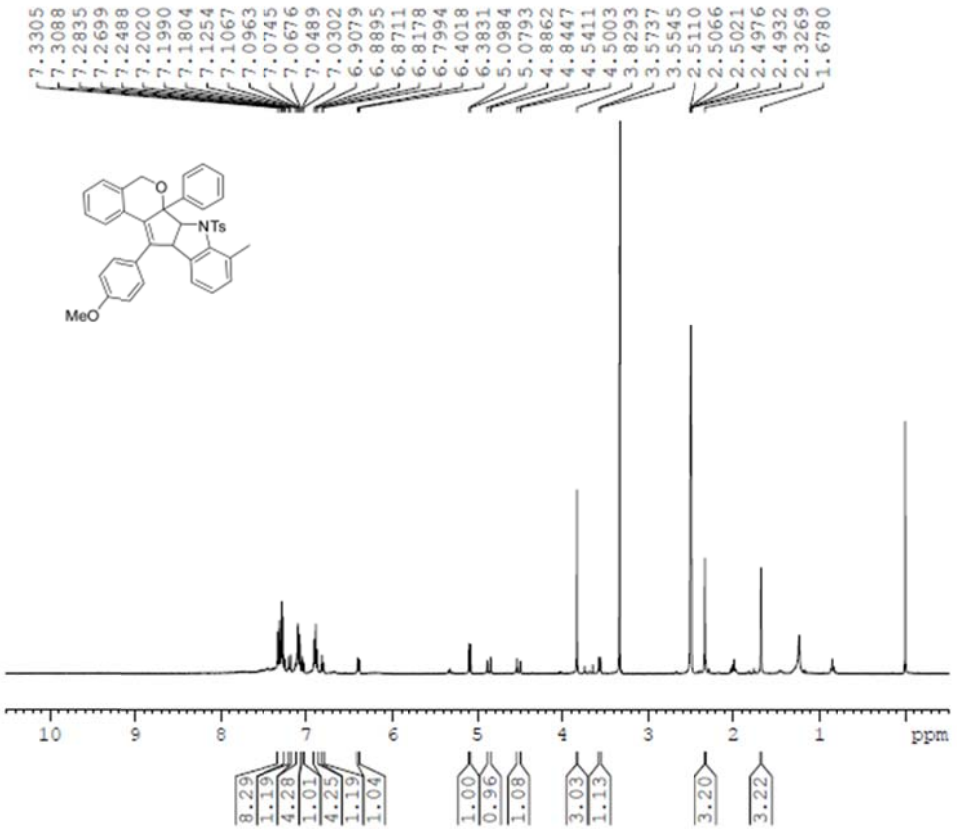
^{1}H NMR of product **3p**



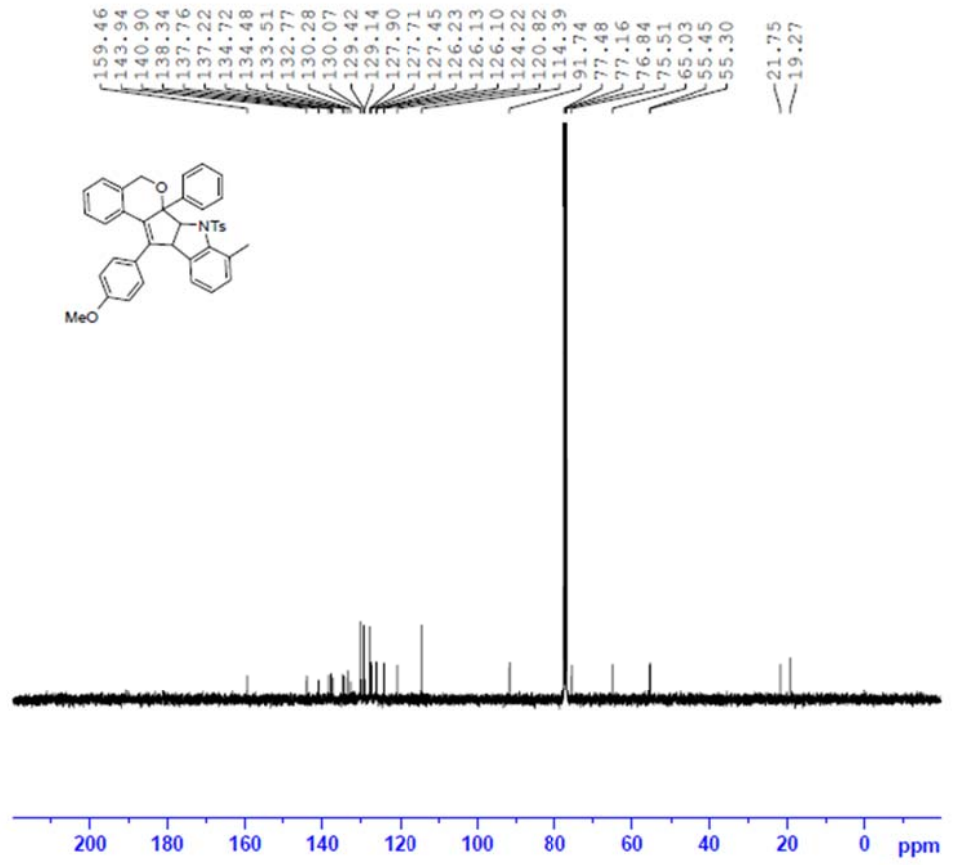
^{13}C NMR of product **3p**



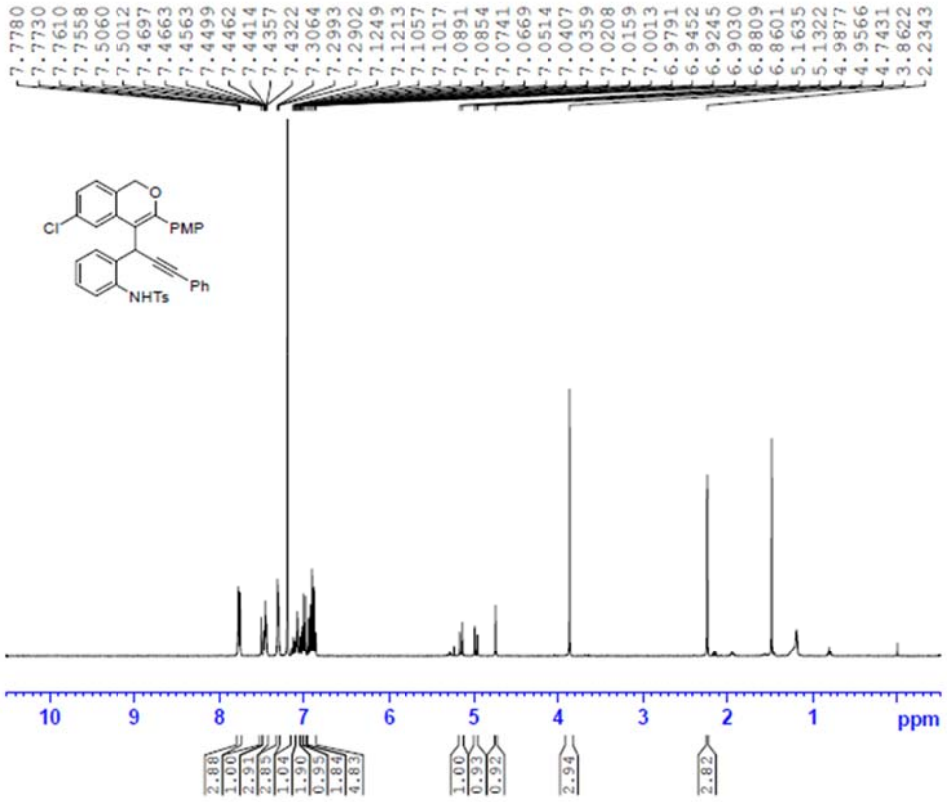
^{1}H NMR of product **3q**



^{13}C NMR of product **3q**



^{1}H NMR of intermediate **4**



^{13}C NMR of intermediate **4**