A Synthetic Route to 1,4-Disubstituted Tetrahydro-*β*-carbolines and Tetrahydropyranoindoles via Ring-Opening/Pictet-Spengler Reaction of Aziridines and Epoxides with Indoles/Aldehydes

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Supporting Information

Table of Contents

SL No	Contents	Page No
1	X-ray crystal structures	S1
2	X-ray crystallographic analysis of **5p, 7c**	S2
3	References	S3
4	^{1}H and $^{13}C\{^{1}H\}$ NMR spectra	S5
5	HPLC chromatograms	S35

1. X-ray crystal structures:

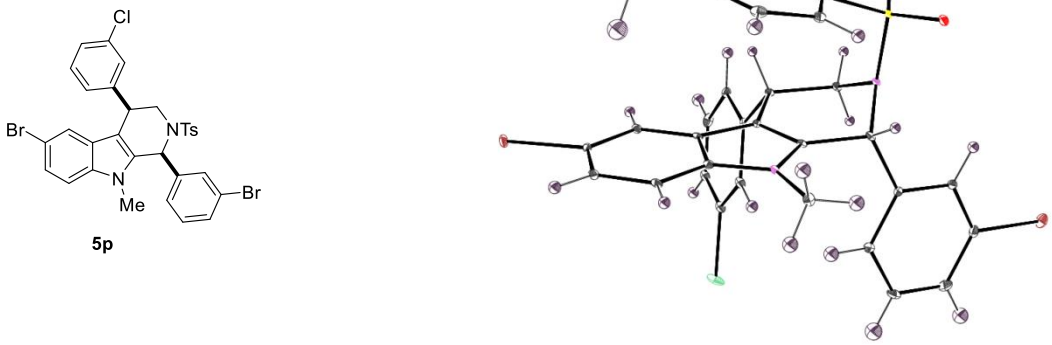

Figure:S1 ORTEP diagram of compound **5p** (50% thermal ellipsoid)

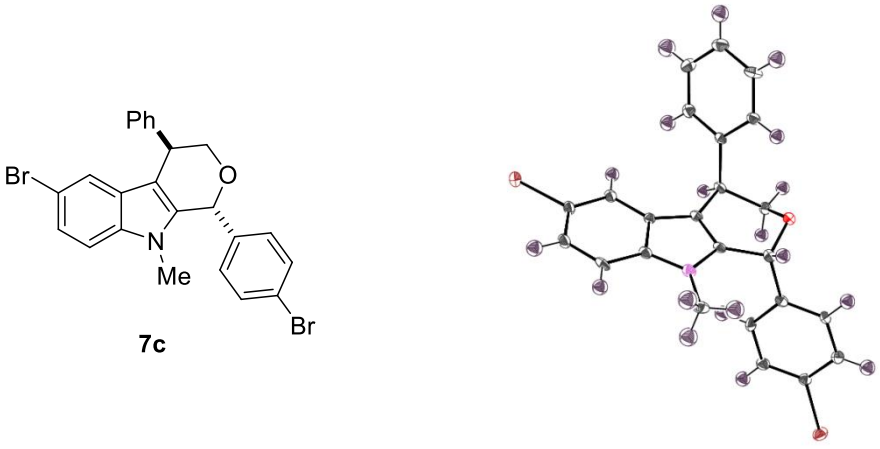

Figure:S2 ORTEP diagram of compound **7c** (50% thermal ellipsoid)

2. X-ray crystallographic analysis of 5p and 7c

The crystals used in the analyses were glued to a glass fiber and mounted on SMART APEX diffractometer. The instrument was equipped with CCD area detector and data were collected using graphite-monochromated Mo Kα radiation (λ= 0.71069 Å) at low temperature (100K). Cell constants were obtained from the least-squares refinement of three-dimensional centroids through the use of CCD recording of narrow ω rotation frames, completing almost all-reciprocal space in the stated θ range. All data were collected with SMART 5.628 and were integrated with the SAINT[1] program. An empirical absorption correction was applied to collect reflections with SADABS[2] using XPREP.[3] The structure was solved using SIR-97[4] and refined using SHELXL-97.[5] The space group of the compounds was determined based on the lack of systematic absence and intensity statistics. Full matrix least squares/difference Fourier cycles were performed which located the remaining non-hydrogen atoms. All non-hydrogen atoms were refined with anisotropic displacement parameters. All the hydrogen atoms are fixed by using geometrical constrains using idealized geometries and have been defined isotropically.

Table S1. X-ray crystallographic data and structure refinement

Compound	**5p**	**7c**
Formula	C_{31} H_{25} Br_2 Cl N2 O_2 S	C_{24} H_{19} Br_2 N O
Formula weight	684.86	497.22
CCDC No.	1854875	1854884
Crystal colour, habit	White, Prism	White, Prism
T / K	100(2)	100(2)
Crystal system	Monoclinic	Monoclinic
Space group	*P-2*$_1$(no. 4)	*P-2*$_1$(no. 4)

a/Å	10.2533(9)	7.571(3)
b/Å	29.303(2	13.464(4)
c/Å	10.6278(10)	20.373(7)
α/°	90	90.00
β/°	116.562(2)	99.227(10)
γ/°	90	90.00
V/Å^3	2856.1(4)	2050.0(12)
Z	4	4
D_c/g cm^{-3}	1.593	1.611
μ/mm^{-1}	3.037	3.969
Reflections measured	28773	16217
Unique reflections	5063	2175
Reflections used $I > 2\sigma(I)$]	7094	3680
$R_1{}^a$, $wR_2{}^b$ [$I > 2\sigma(I)$]	$R_1 = 0.0503^a$	$R_1 = 0.0805^a$
	$wR_2 = 0.0925^b$	$wR_2 = 0.1836^b$
$R_1{}^a$, $wR_2{}^b$ (all data)	R_1=0.0864^a	R_1=0.1459^a
	wR_2=0.1032^b	wR_2= 0.2111^b
GOF on F^2	1.013	1.052

$^aR1 = \Sigma \, || \, F_o \, | - |F_c \, || / \Sigma |F_o|$. $^bwR2 = \{\Sigma[w(|Fo|^2 - |Fc|^2)^2] / \Sigma \, [w(|Fo|^2)^2]\}^{1/2}$

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3. References

1. SAINT+ 6.02ed.; Bruker AXS, Madison, WI, **1999**.

2. Sheldrick, G. M. SADABS, Empirical Absorption Correction Program, University of Göttingen, Göttingen, Germany, 1997.

3. XPREP, 5.1ed. Siemens Industrial Automation Inc., Madison, WI, **1995**.

4. A. Altomare, M. C. Burla, M. Camalli, G. L. Cascarano, C. Giacovazzo, A. Guagliardi, A. G. G. Moliterni, G. Polidori, R. Spagna, *J. Appl. Cryst.* **1999**, *32*, 115.

5. Sheldrick, G. M. SHELXL-97: Program for Crystal Structure Refinement (University of Göttingen, Göttingen, Germany, 1997.

4. ^{1}H and $^{13}C\{^{1}H\}$ NMR spectra

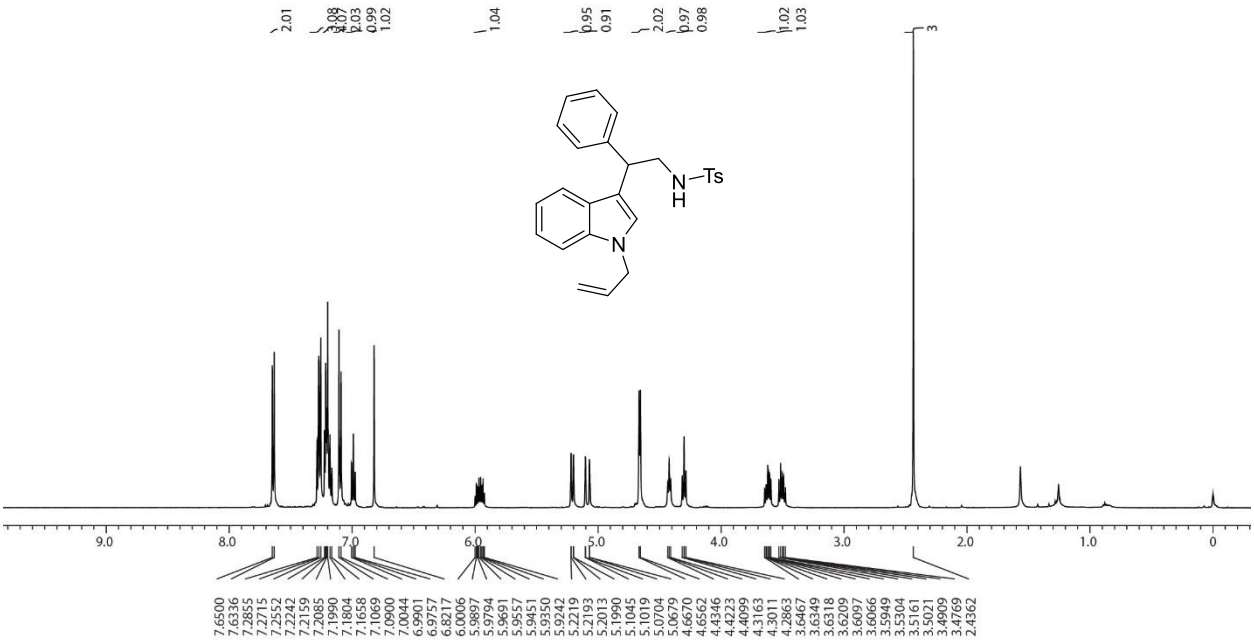

Figure:S3 ^{1}H NMR spectrum of **3a** ($CDCl_3$, 500 MHz)

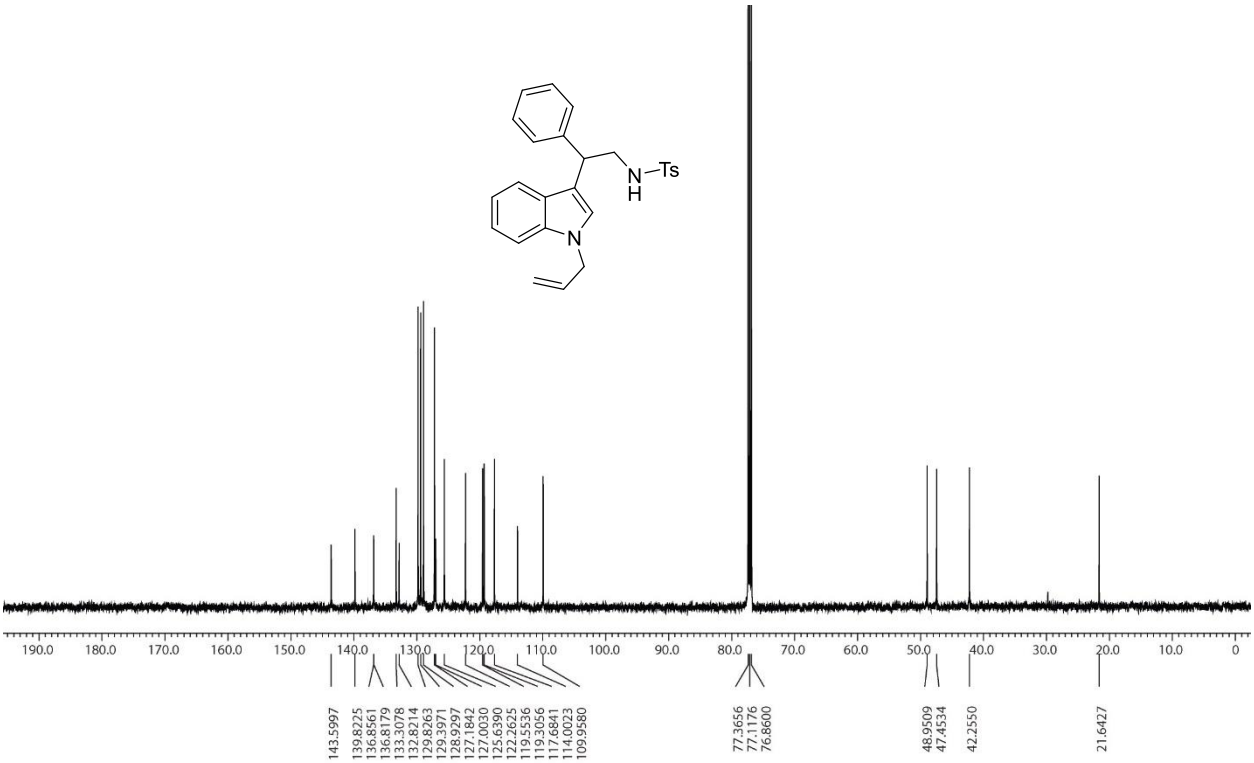

Figure:S4 $^{13}C\{^{1}H\}$ NMR spectrum of **3a** ($CDCl_3$, 125 MHz)

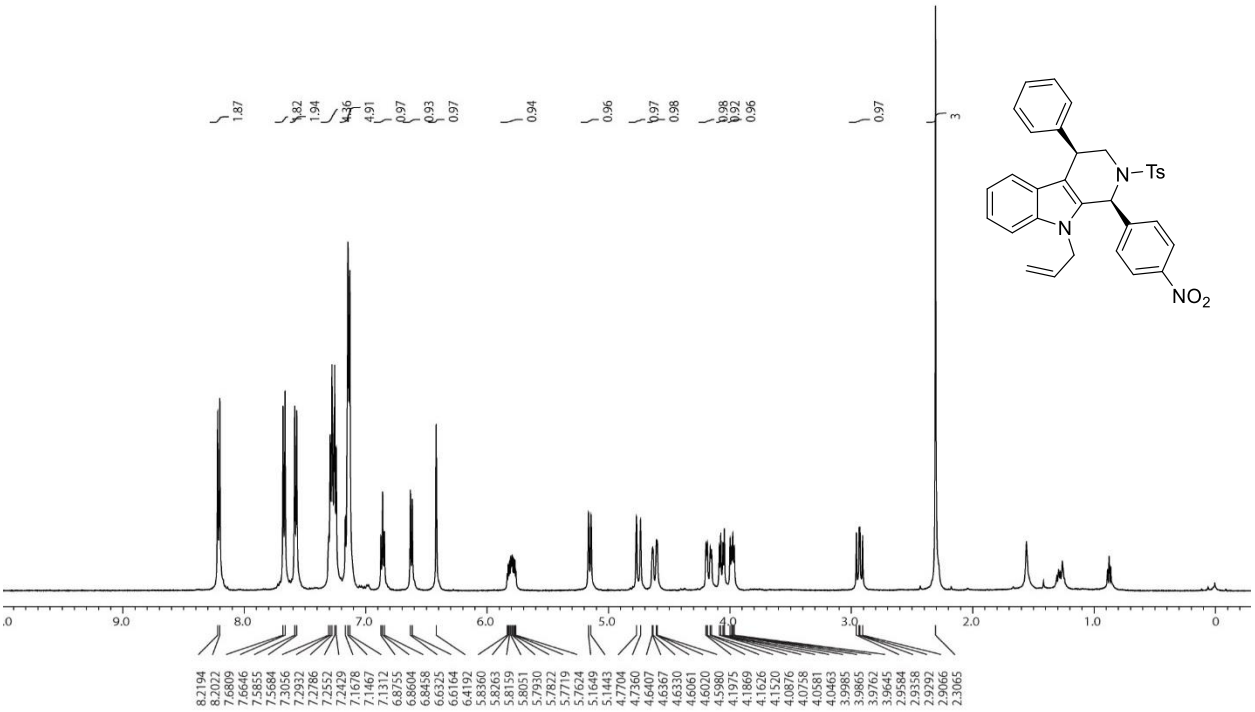

Figure:S5 ^{1}H NMR spectrum of **5a** ($CDCl_3$, 500 MHz)

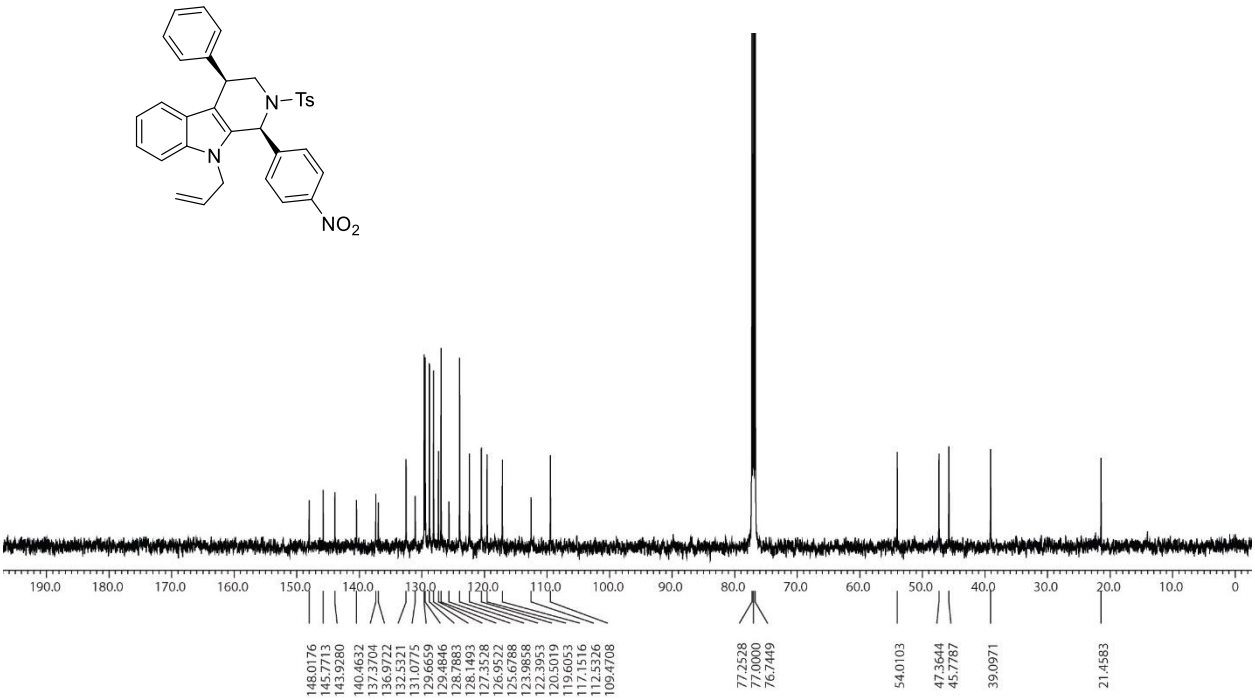

Figure:S6 $^{13}C\{^{1}H\}$ NMR spectrum of **5a** ($CDCl_3$, 125 MHz)

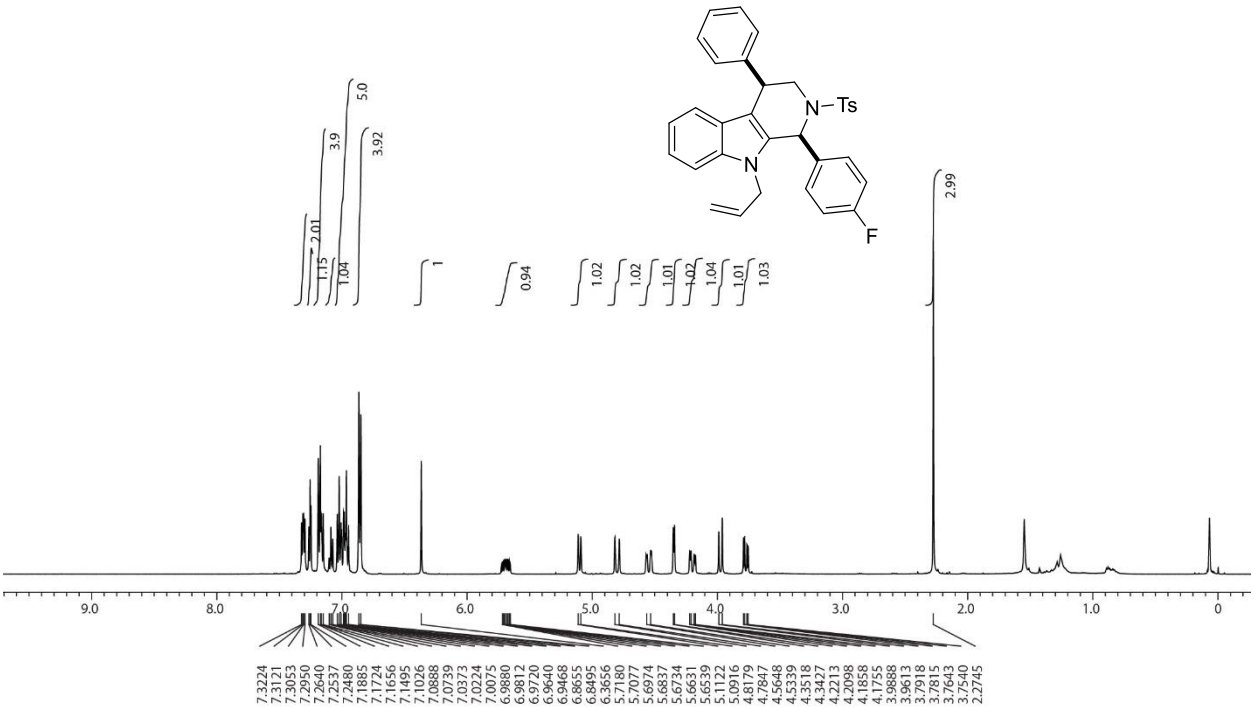

Figure:S7 ^{1}H NMR spectrum of **5b** ($CDCl_3$, 500 MHz)

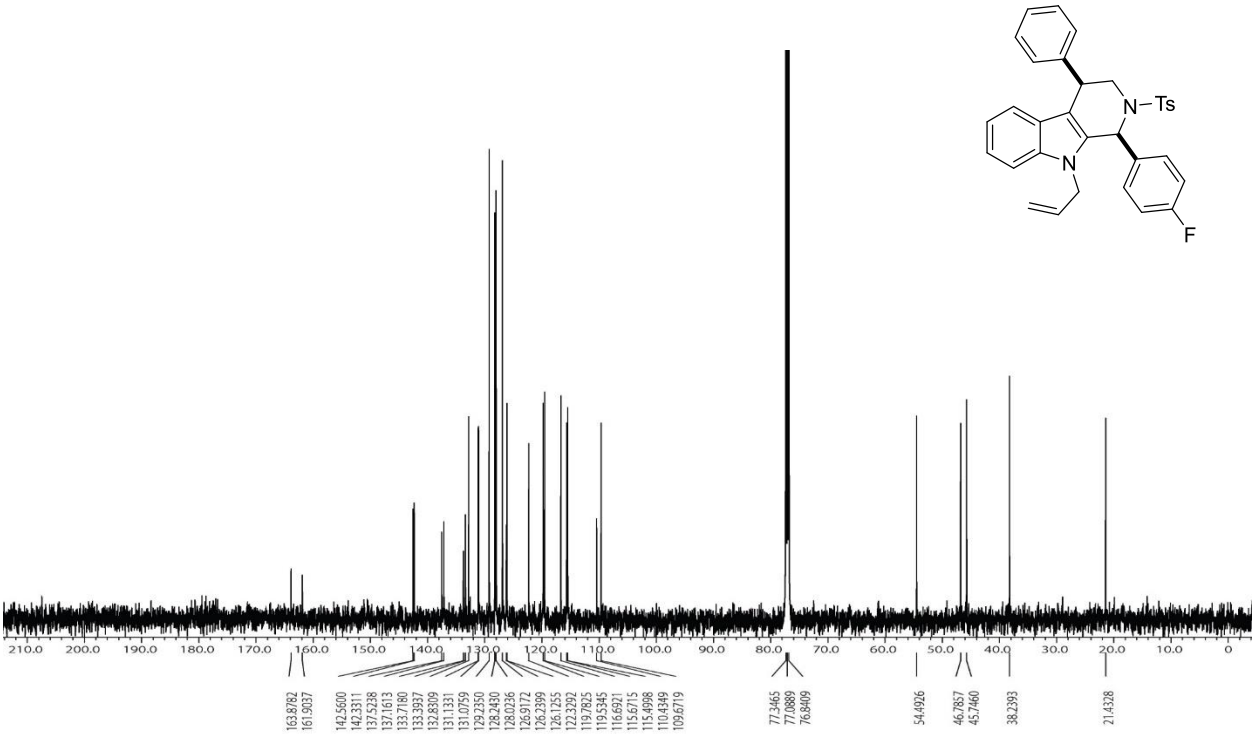

Figure:S8 $^{13}C\{^{1}H\}$ NMR spectrum of **5b** ($CDCl_3$, 125 MHz)

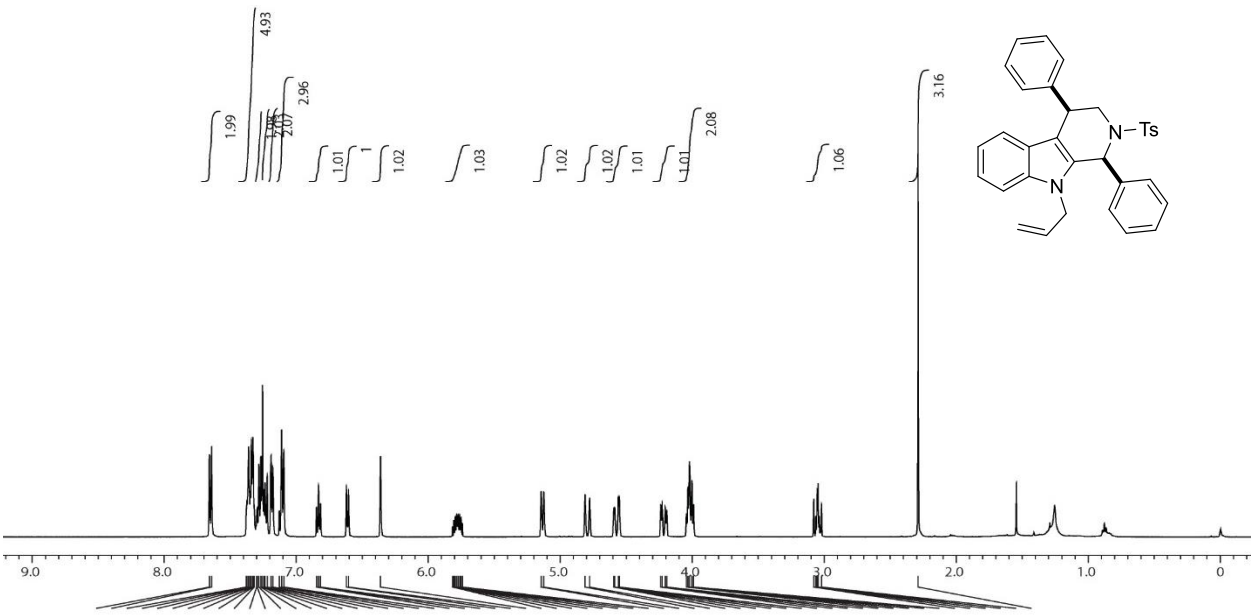

Figure:S9 ^{1}H NMR spectrum of **5c** ($CDCl_3$, 500 MHz)

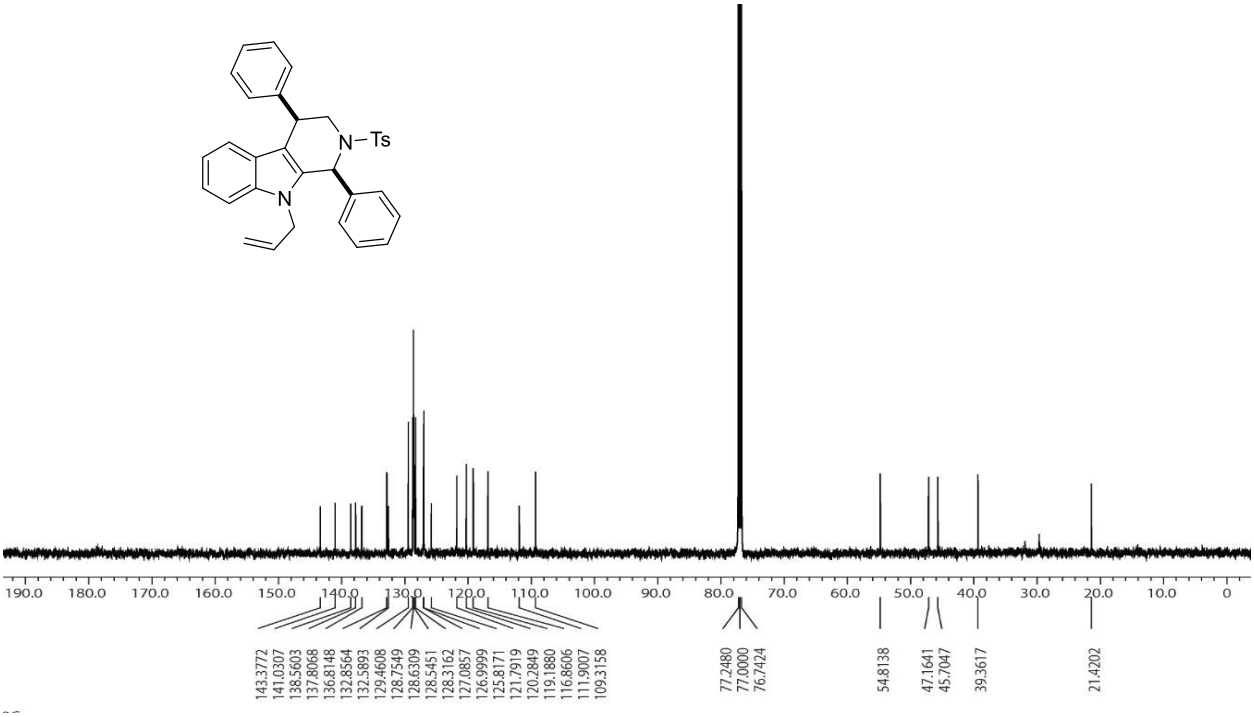

Figure:S10 $^{13}C\{^{1}H\}$ NMR spectrum of **5c** ($CDCl_3$, 125 MHz)

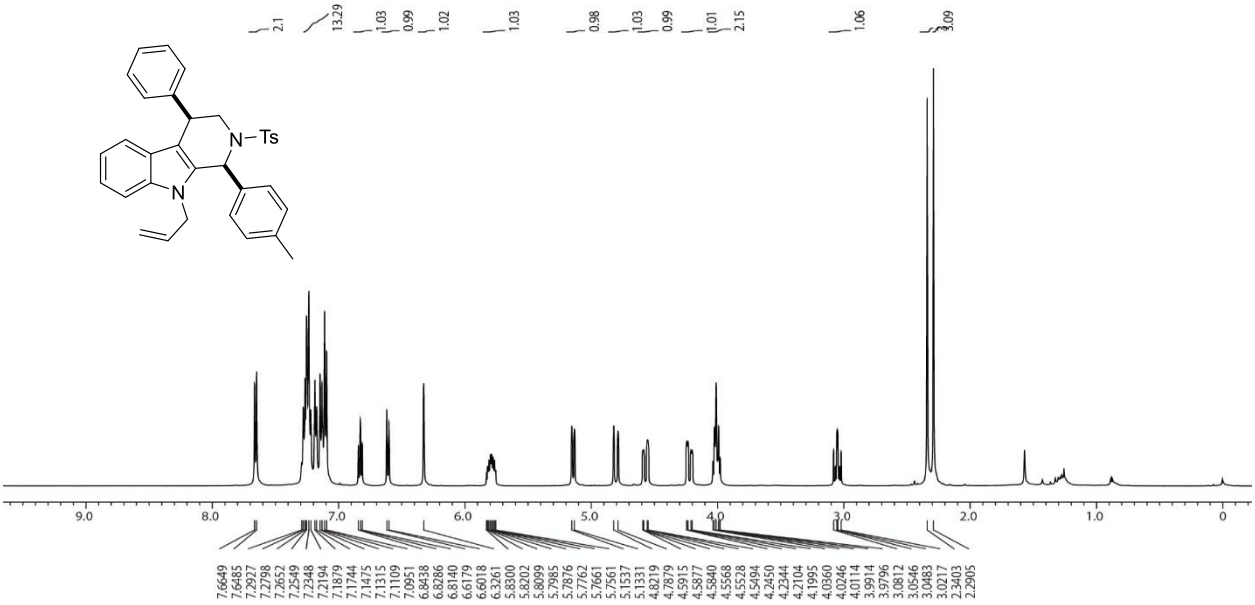

Figure:S11 ^{1}H NMR spectrum of **5d** ($CDCl_3$, 500 MHz)

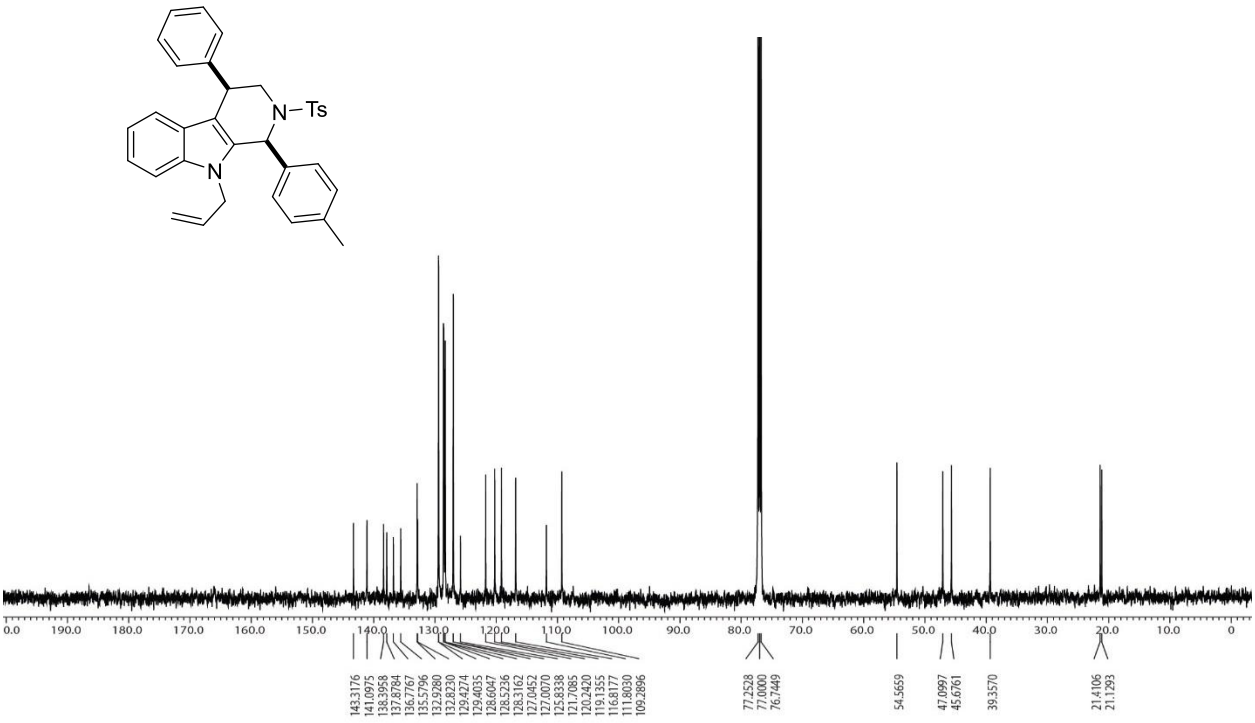

Figure:S12 $^{13}C\{^{1}H\}$ NMR spectrum of **5d** ($CDCl_3$, 125 MHz)

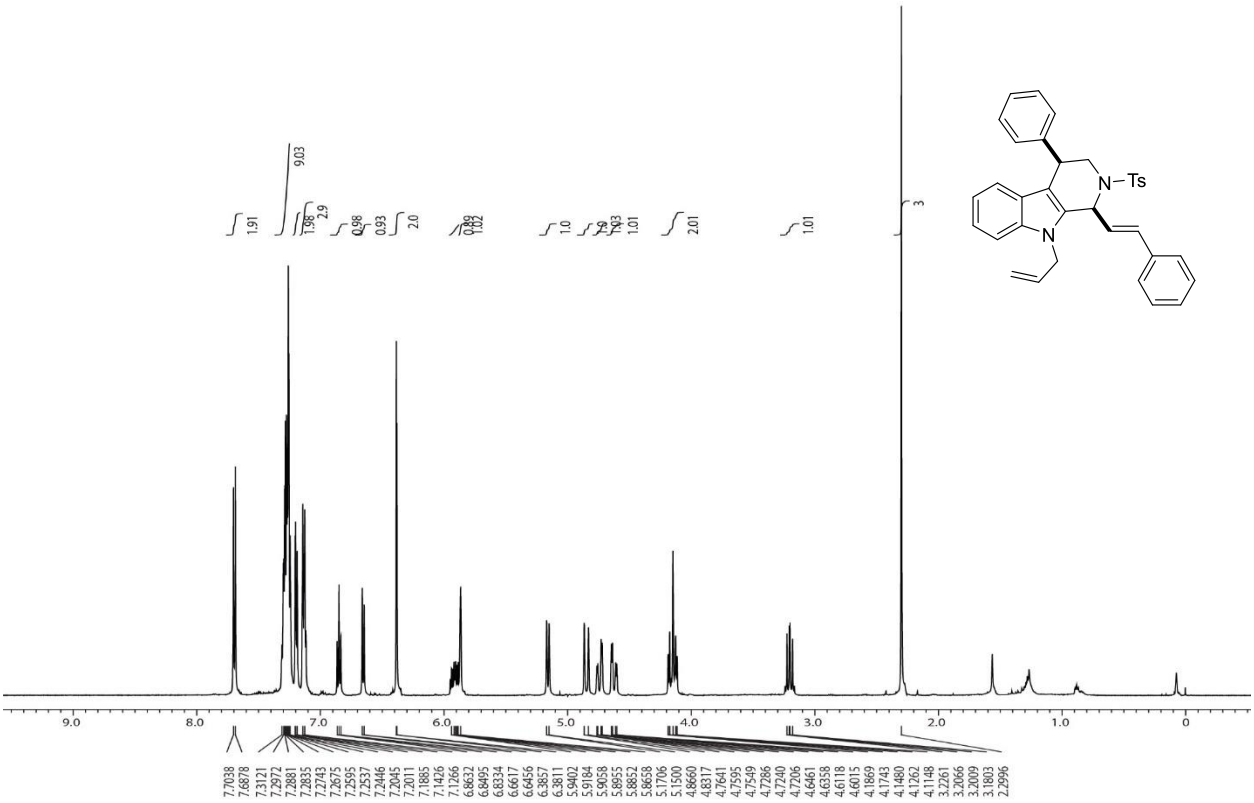

Figure:S13 ^{1}H NMR spectrum of **5e** ($CDCl_3$, 500 MHz)

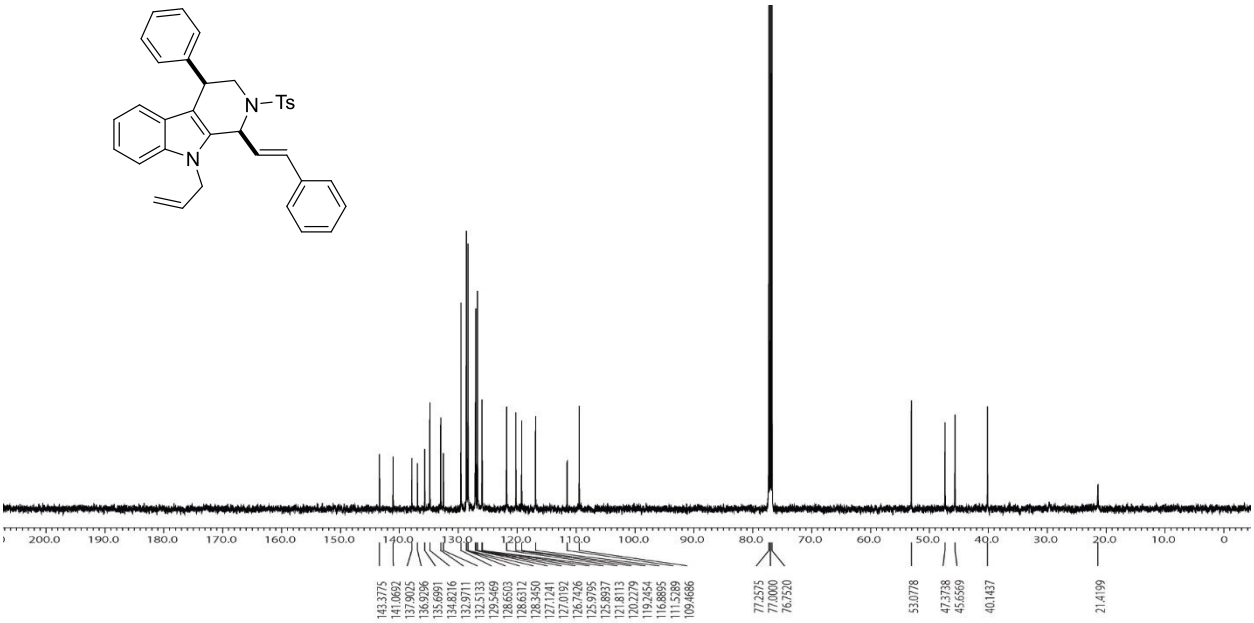

Figure:S14 $^{13}C\{^{1}H\}$ NMR spectrum of **5e** ($CDCl_3$, 125 MHz)

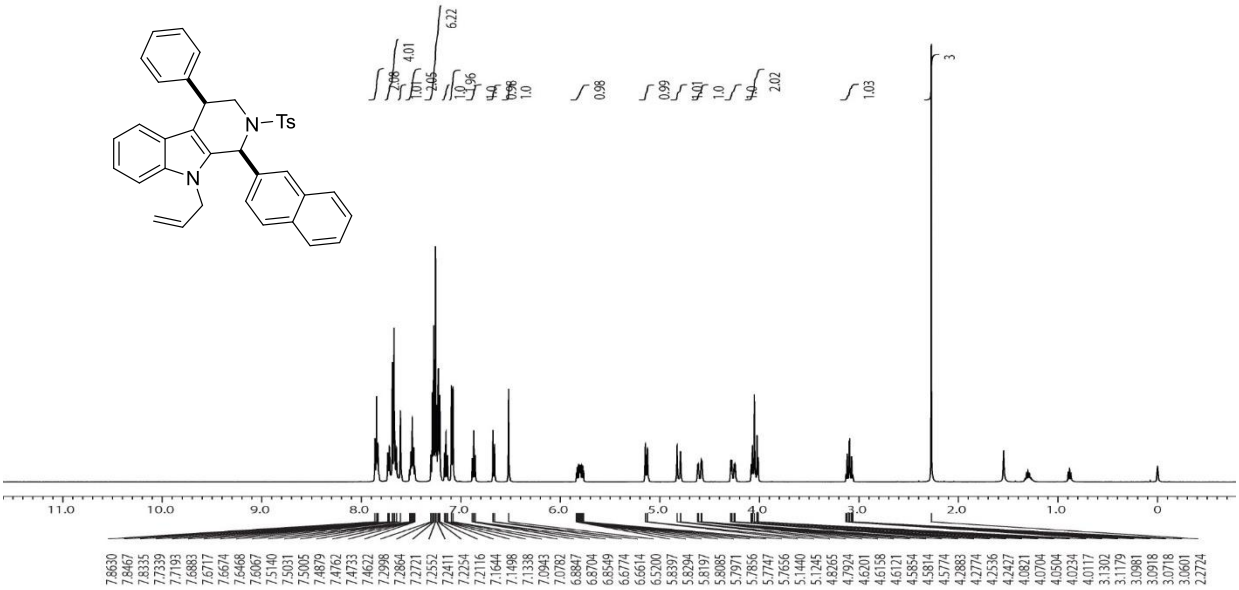

Figure:S15 ^{1}H NMR spectrum of **5f** ($CDCl_3$, 500 MHz)

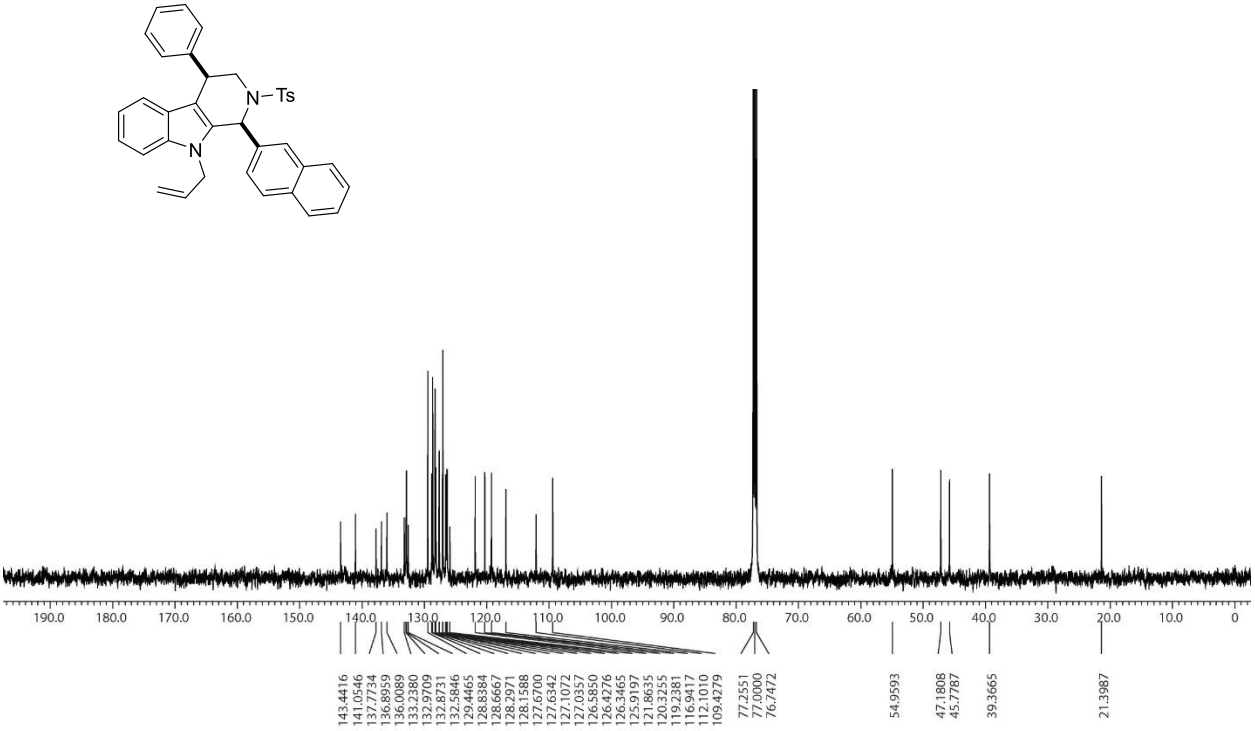

Figure:S16 $^{13}C\{^{1}H\}$ NMR spectrum of **5f** ($CDCl_3$, 125 MHz)

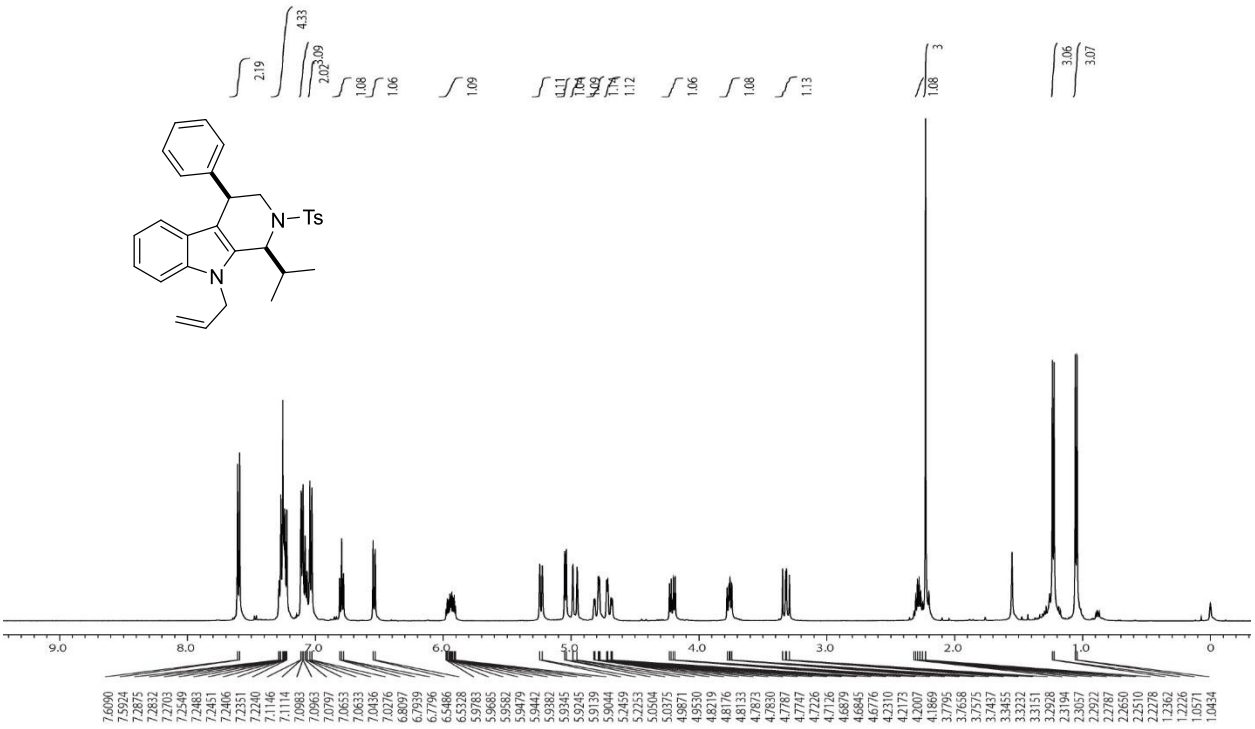

Figure:S17 ^{1}H NMR spectrum of **5g** ($CDCl_3$, 500 MHz)

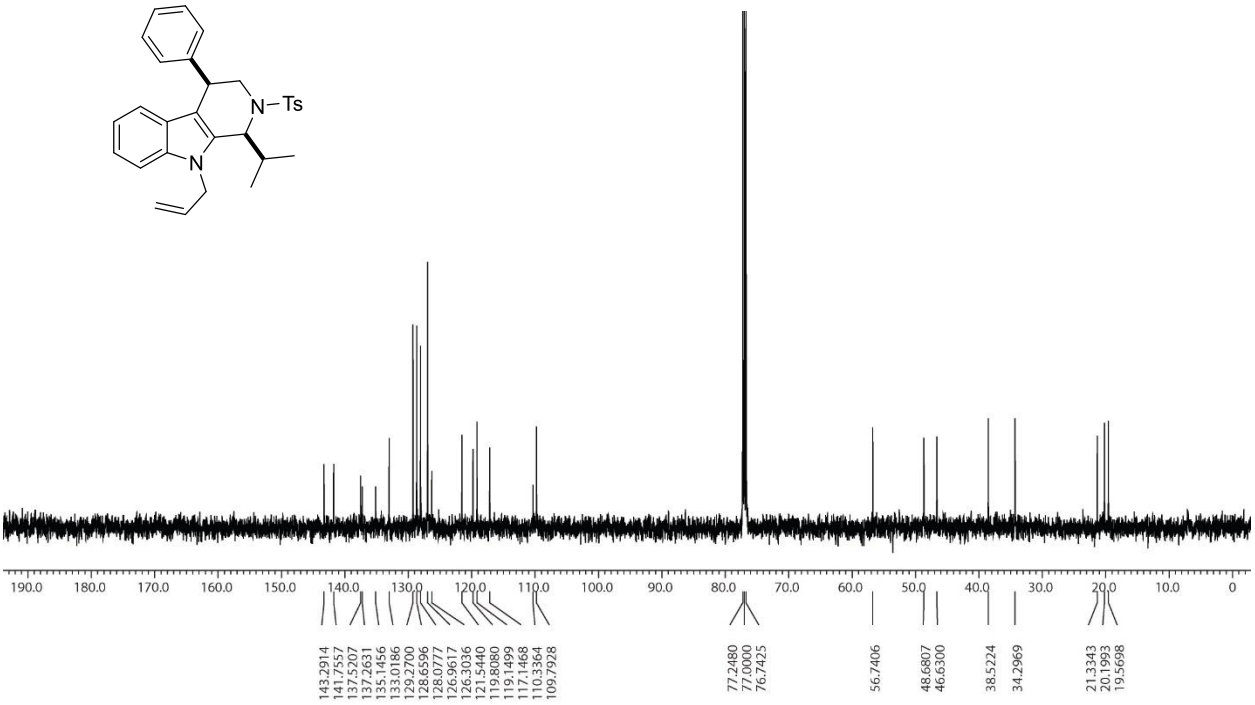

Figure:S18 $^{13}C\{^{1}H\}$ NMR spectrum of **5g** ($CDCl_3$, 125 MHz)

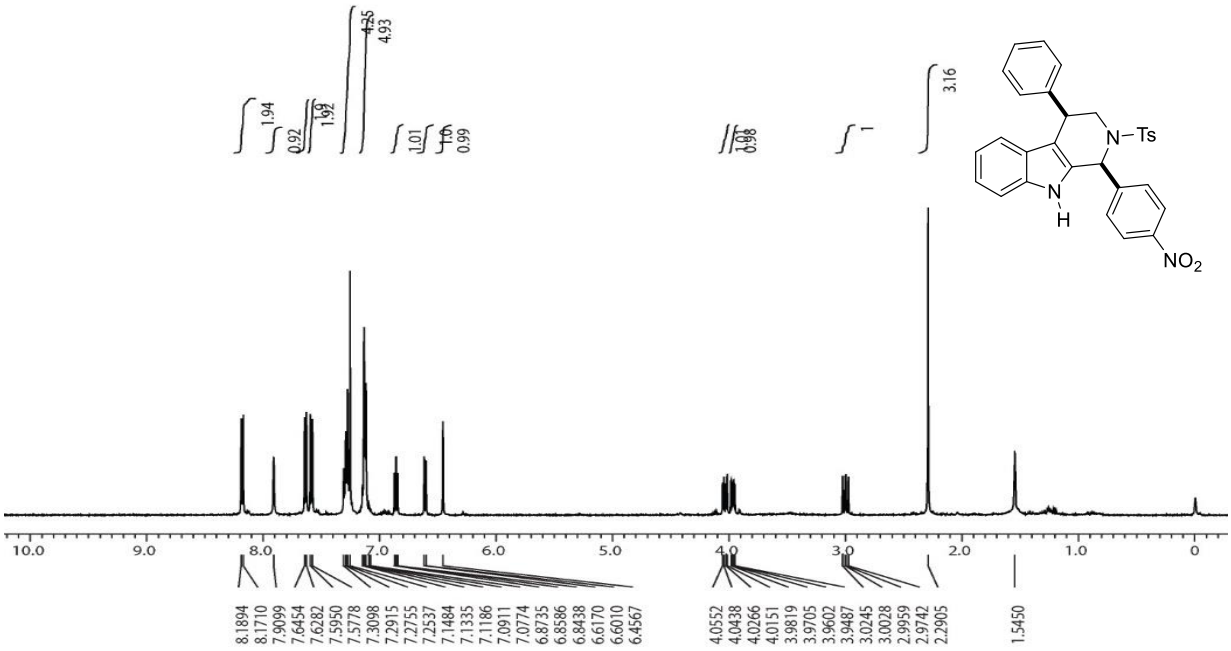

Figure:S19 ^{1}H NMR spectrum of **5h** ($CDCl_3$, 500 MHz)

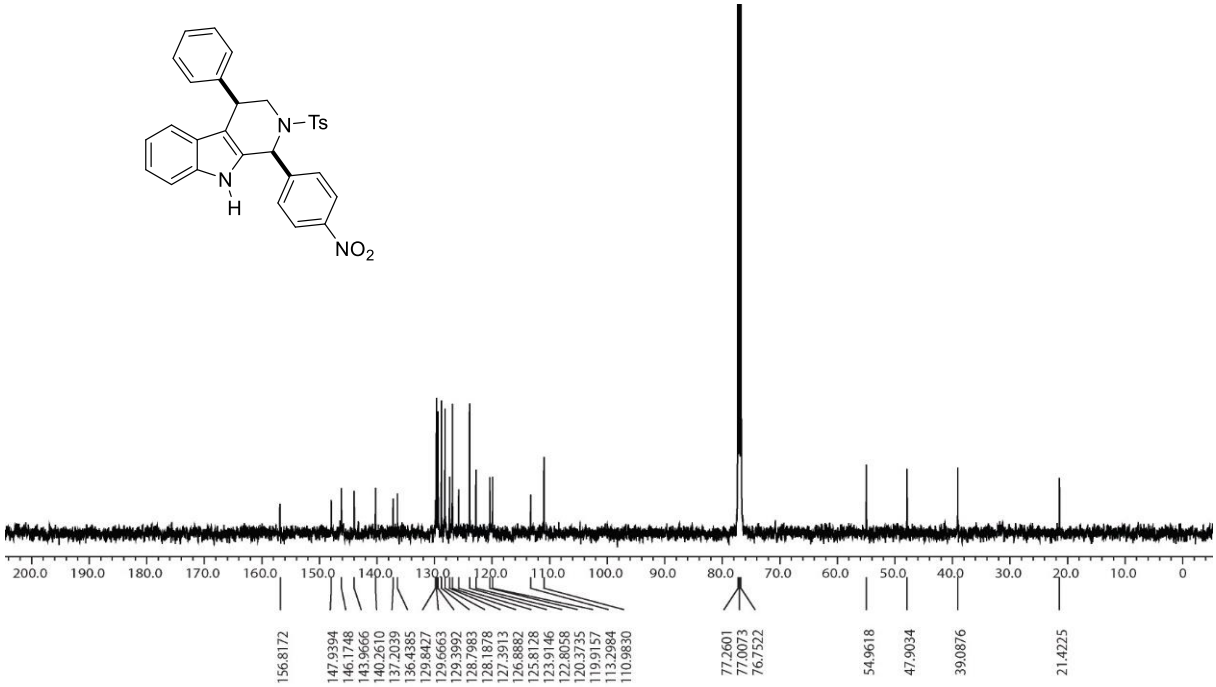

Figure:S20 $^{13}C\{^{1}H\}$ NMR spectrum of **5h** ($CDCl_3$, 125 MHz)

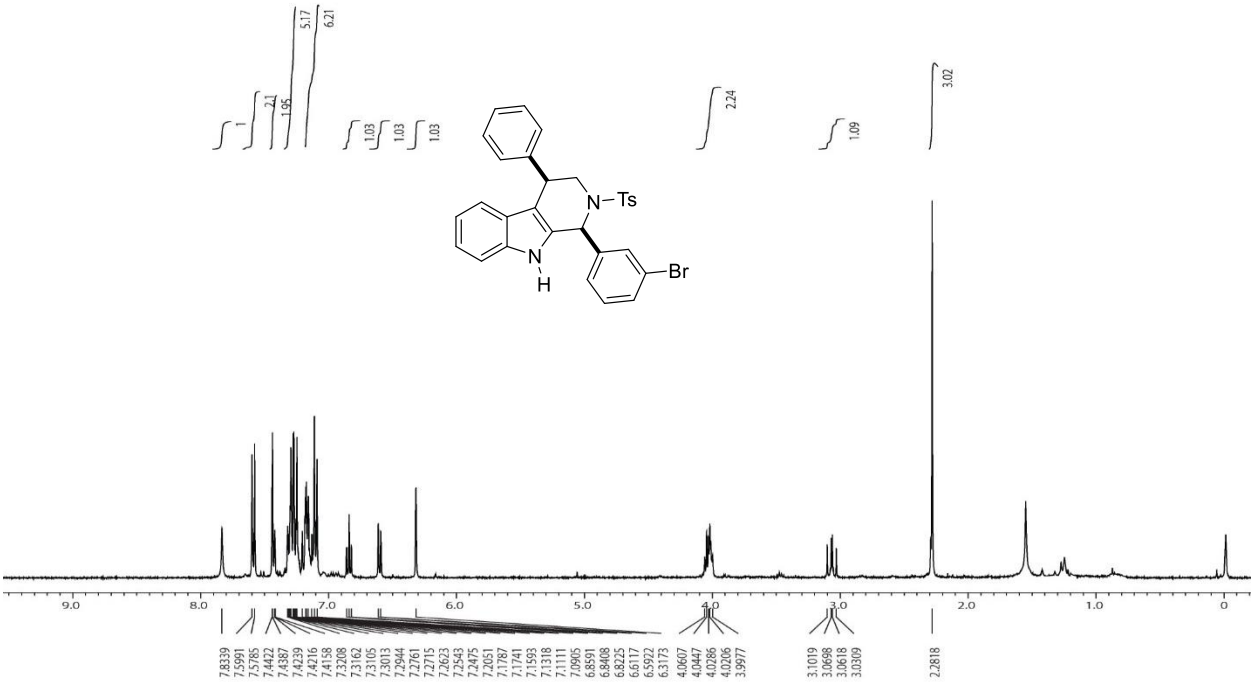

Figure:S21 ^{1}H NMR spectrum of **5i** ($CDCl_3$, 500 MHz)

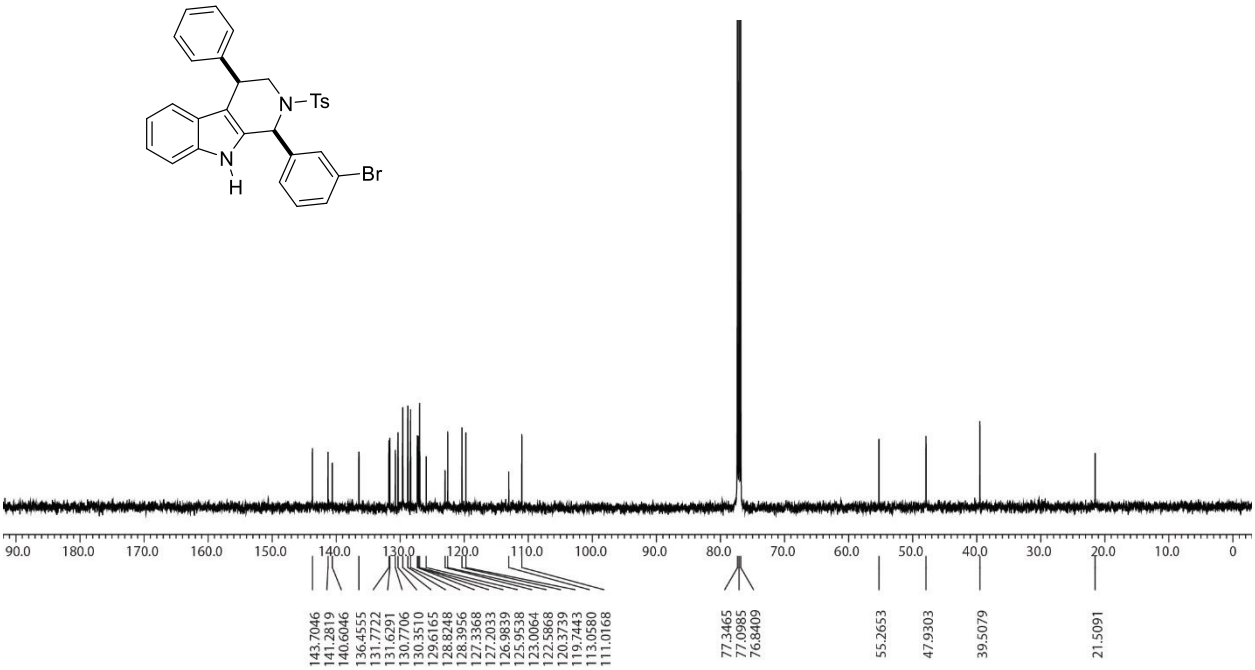

Figure:S22 $^{13}C\{^{1}H\}$ NMR spectrum of **5i** ($CDCl_3$, 125 MHz)

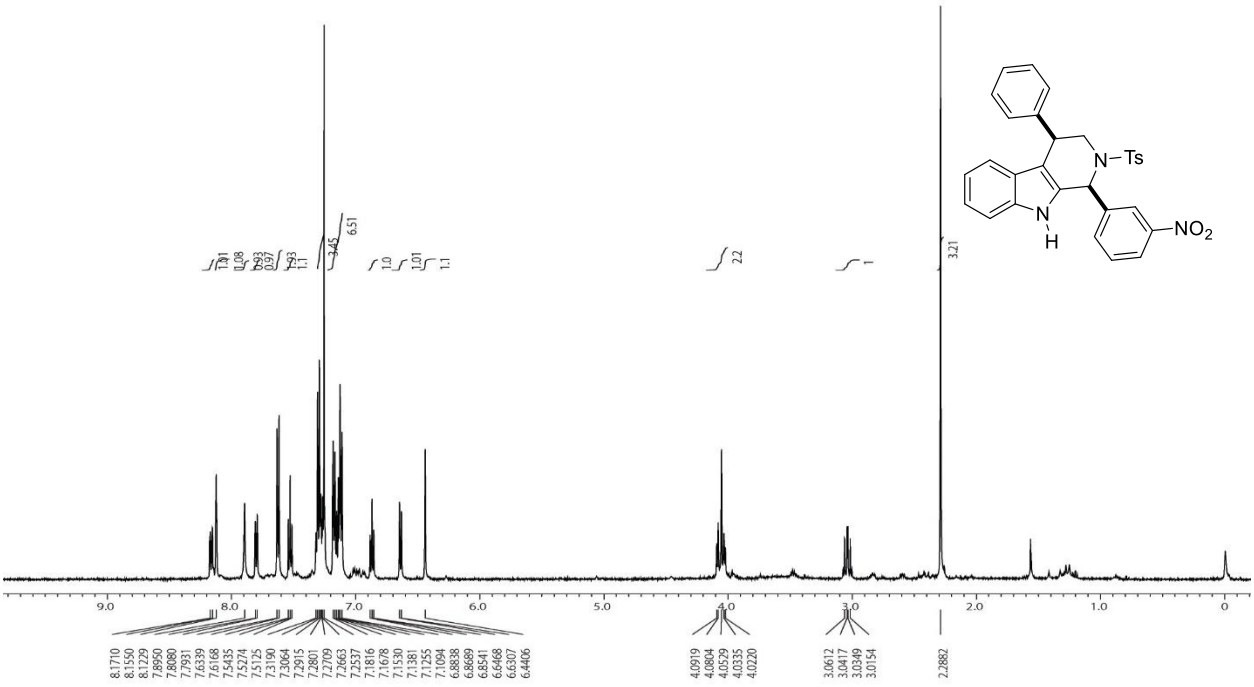

Figure:S23 ^{1}H NMR spectrum of **5j** ($CDCl_3$, 500 MHz)

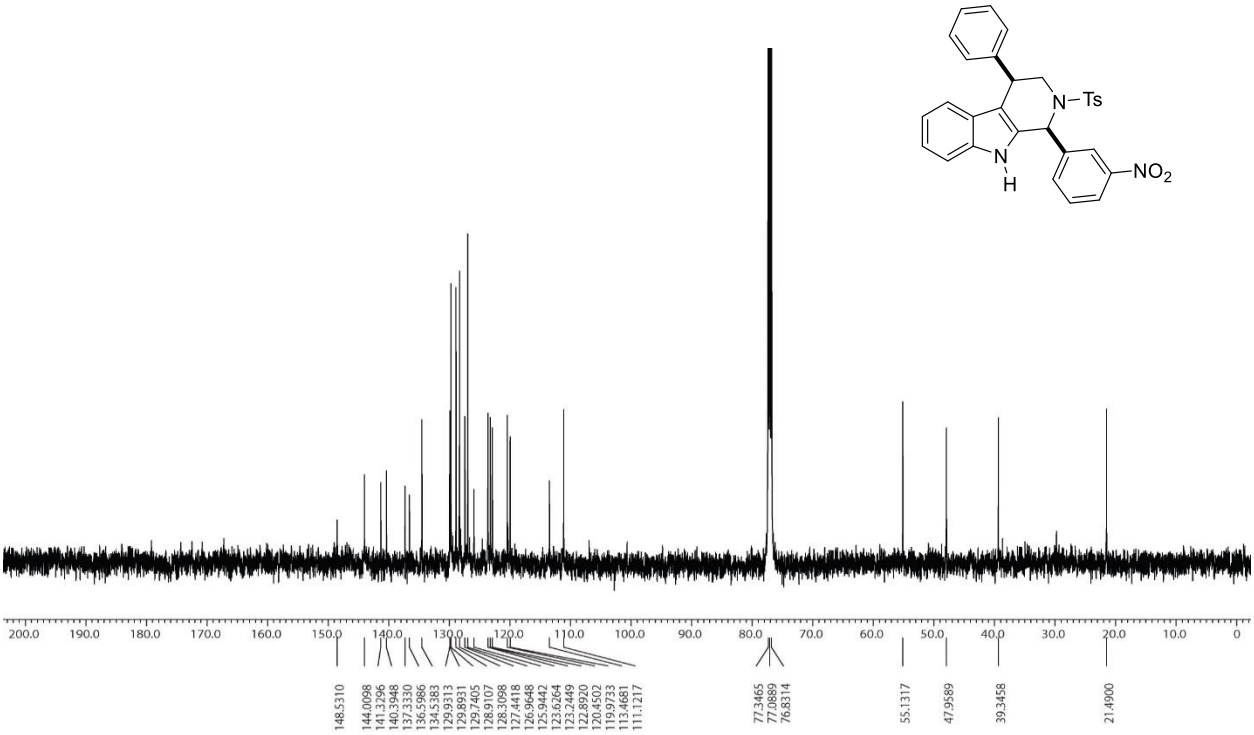

Figure:S24 $^{13}C\{^{1}H\}$ NMR spectrum of **5j** ($CDCl_3$, 125 MHz)

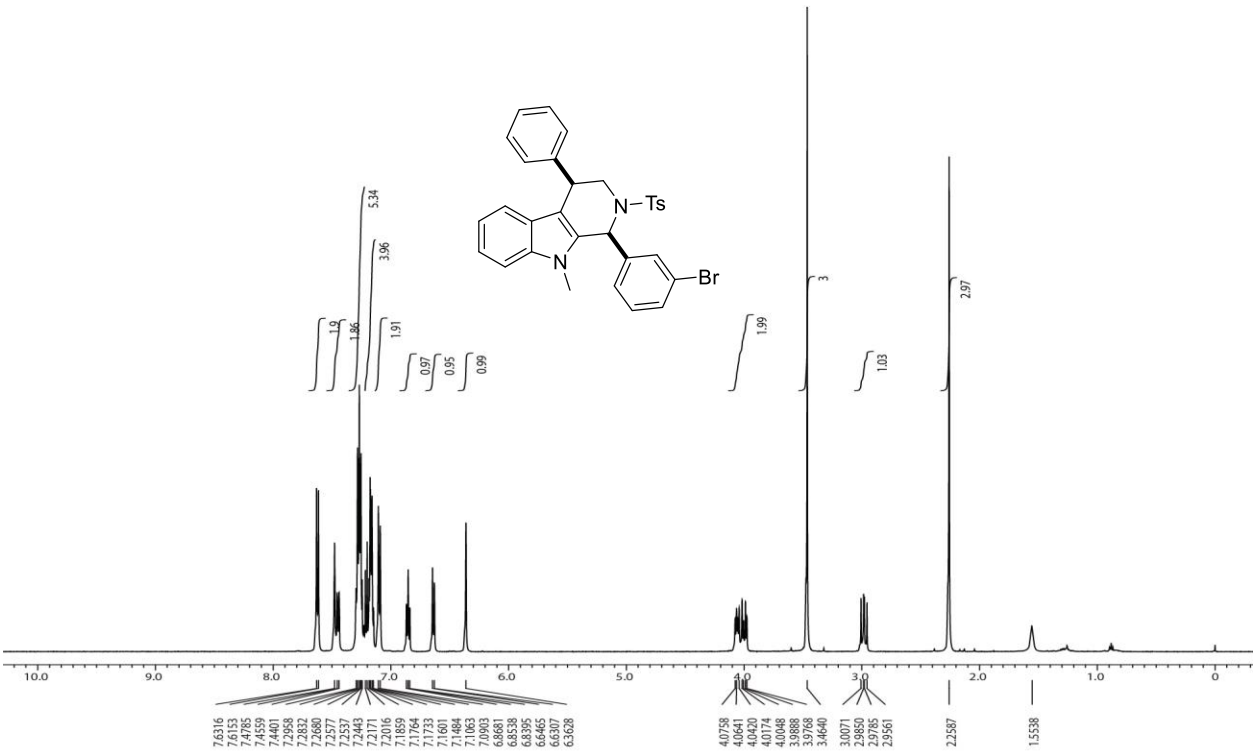

Figure:S25 ^{1}H NMR spectrum of **5k** ($CDCl_3$, 500 MHz)

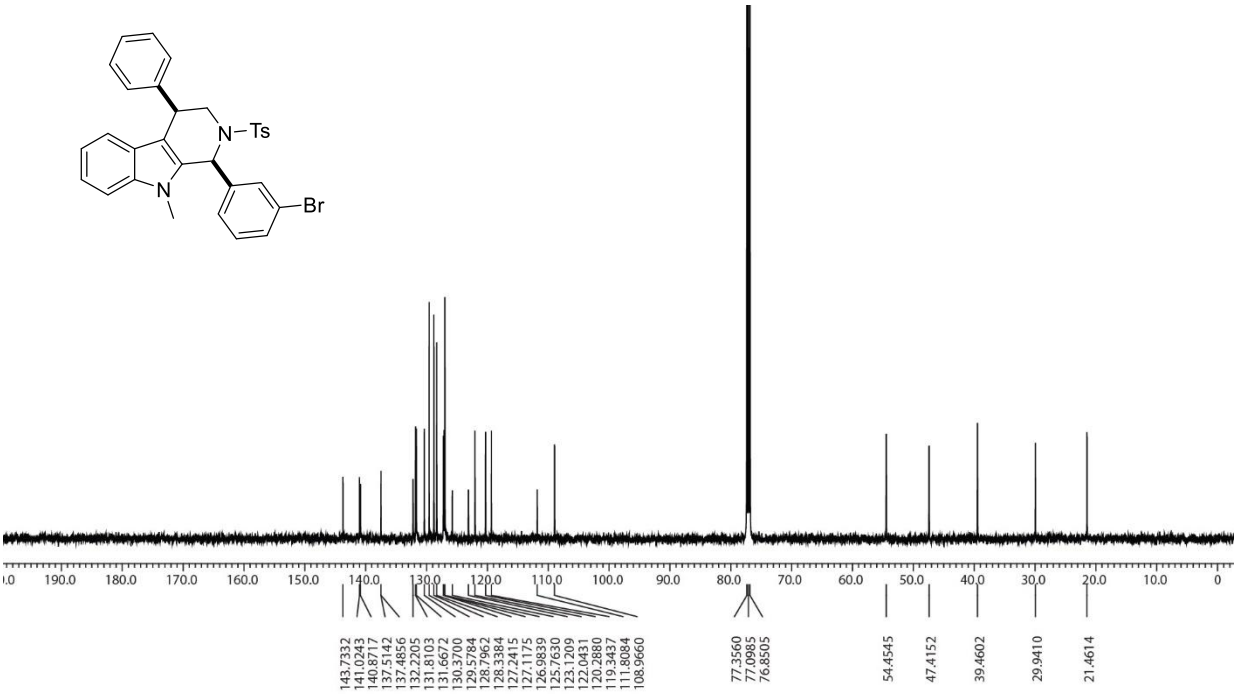

Figure:S26 $^{13}C\{^{1}H\}$ NMR spectrum of **5k** ($CDCl_3$, 125 MHz)

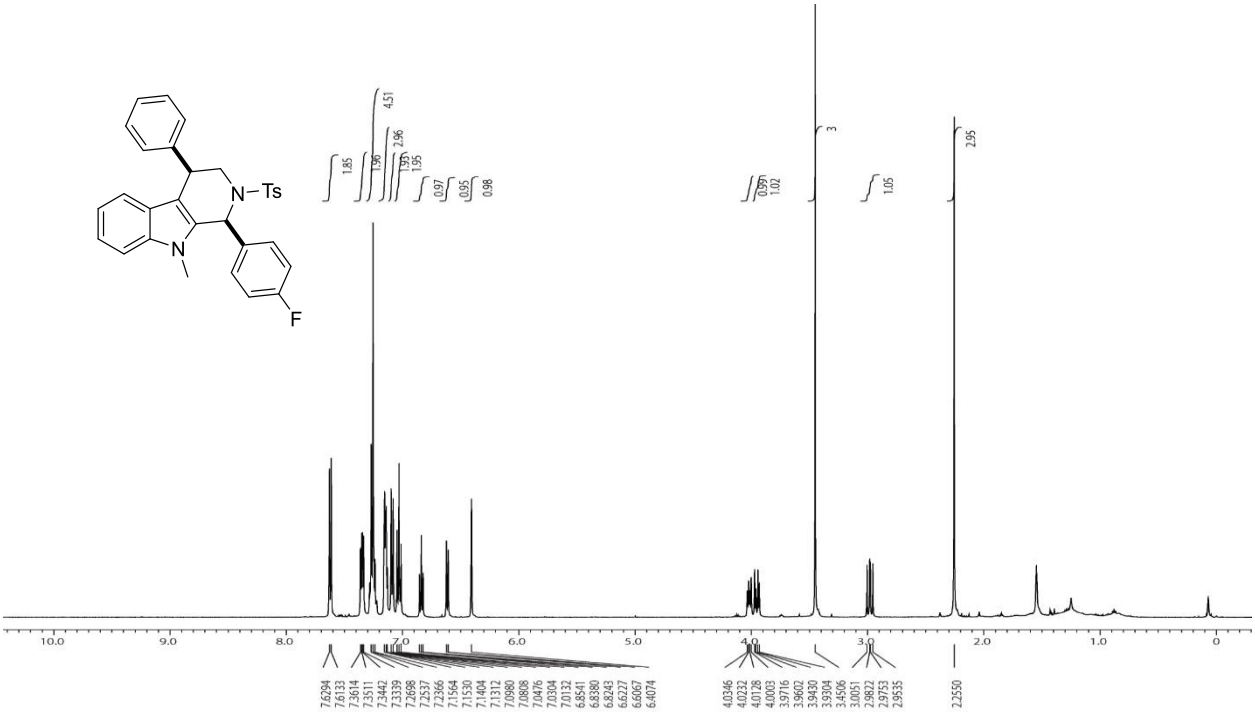

Figure:S27 ^{1}H NMR spectrum of **5l** ($CDCl_3$, 500 MHz)

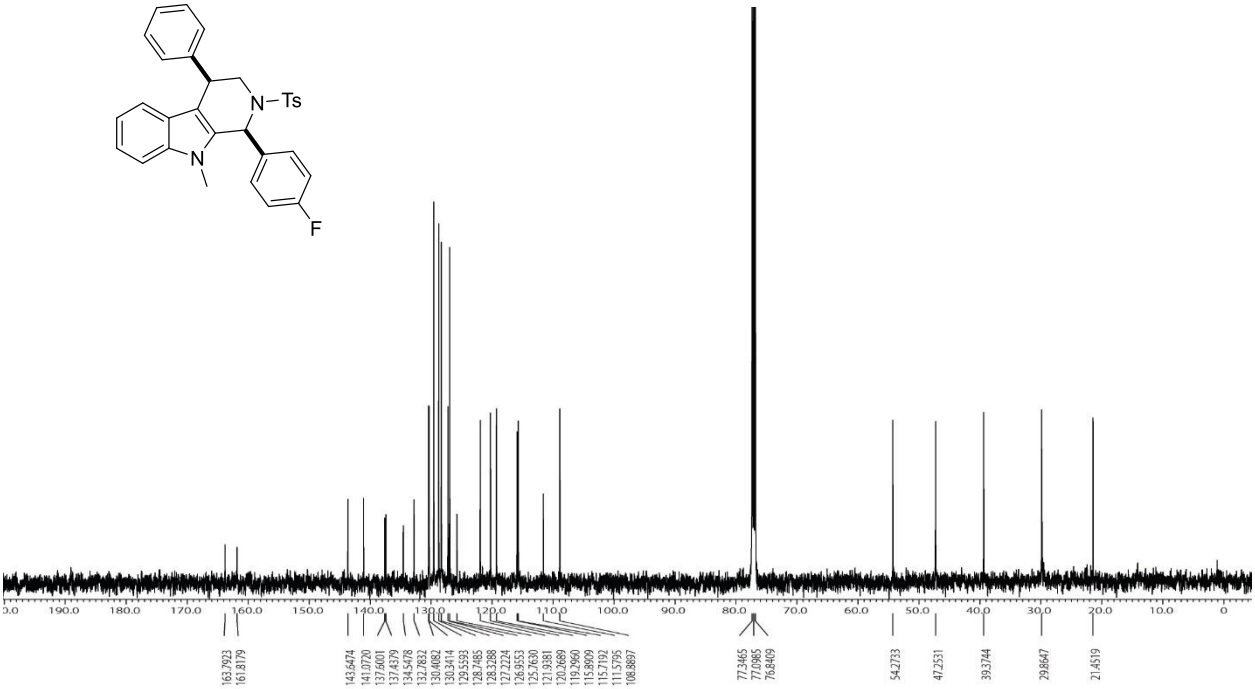

Figure:S28 $^{13}C\{^{1}H\}$ NMR spectrum of **5l** ($CDCl_3$, 125 MHz)

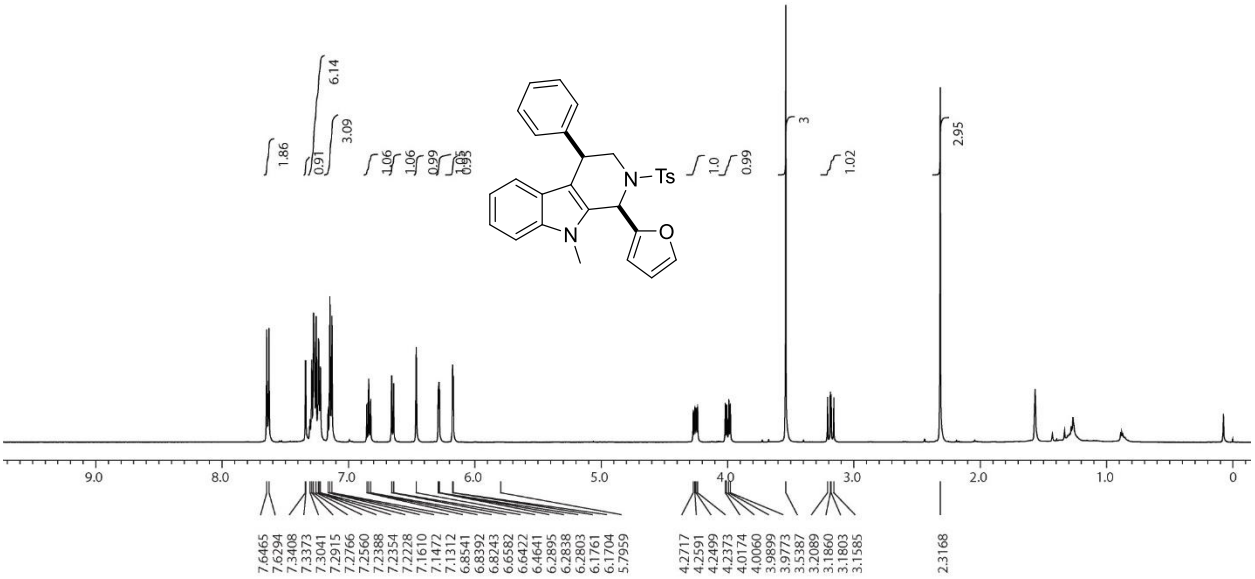

Figure:S29 ^{1}H NMR spectrum of **5m** ($CDCl_3$, 500 MHz)

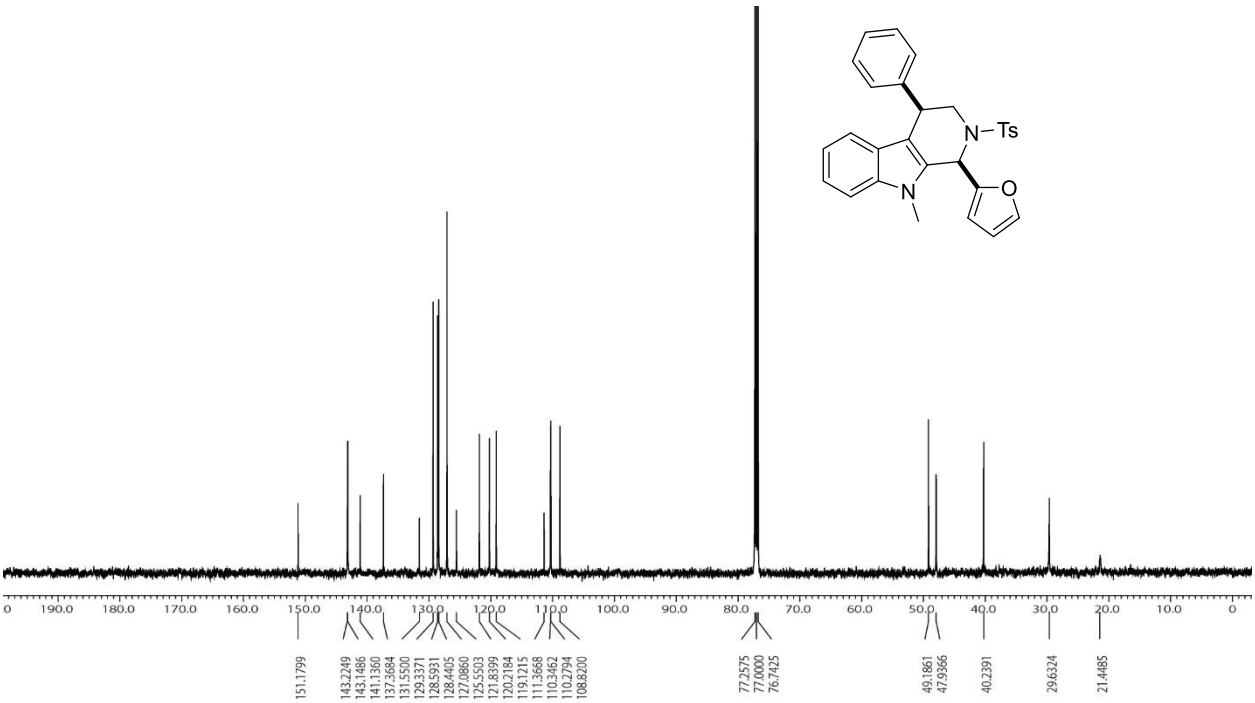

Figure:S30 $^{13}C\{^{1}H\}$ NMR spectrum of **5m** ($CDCl_3$, 125 MHz)

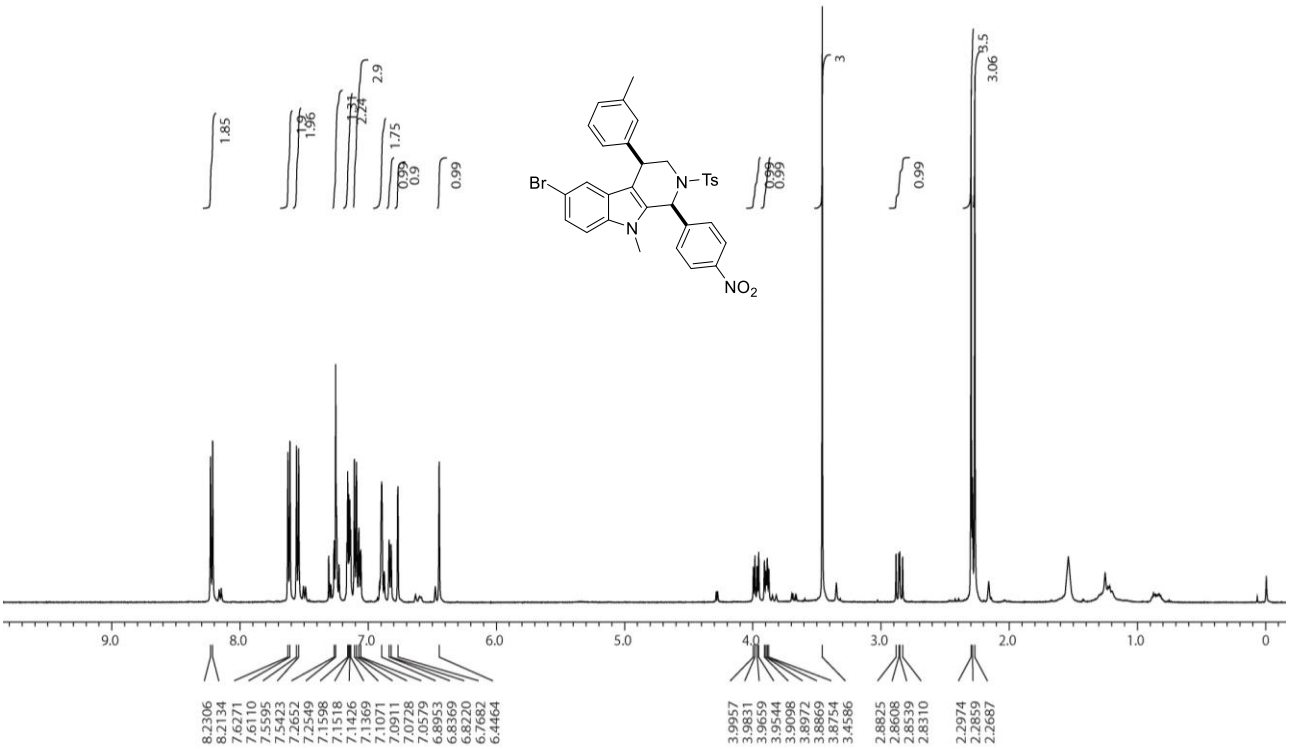

Figure:S31 ^{1}H NMR spectrum of **5n** ($CDCl_3$, 500 MHz)

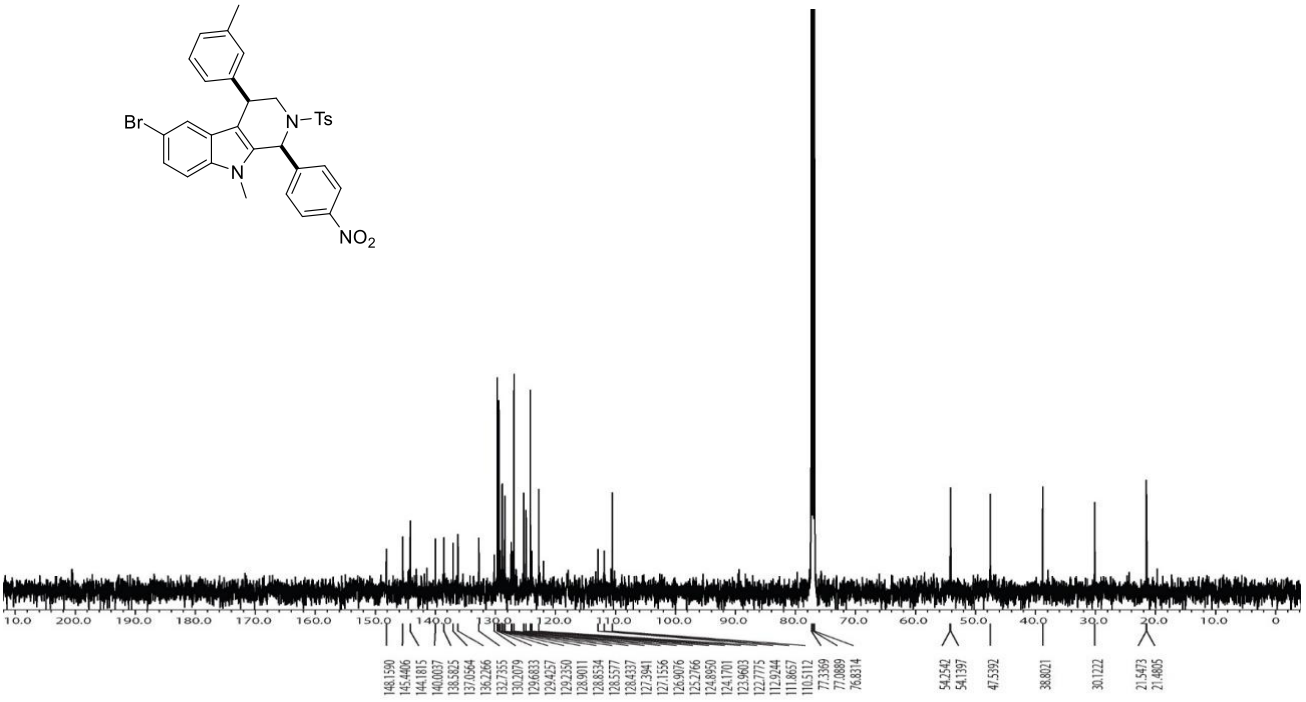

Figure:S32 $^{13}C\{^{1}H\}$ NMR spectrum of **5n** ($CDCl_3$, 125 MHz)

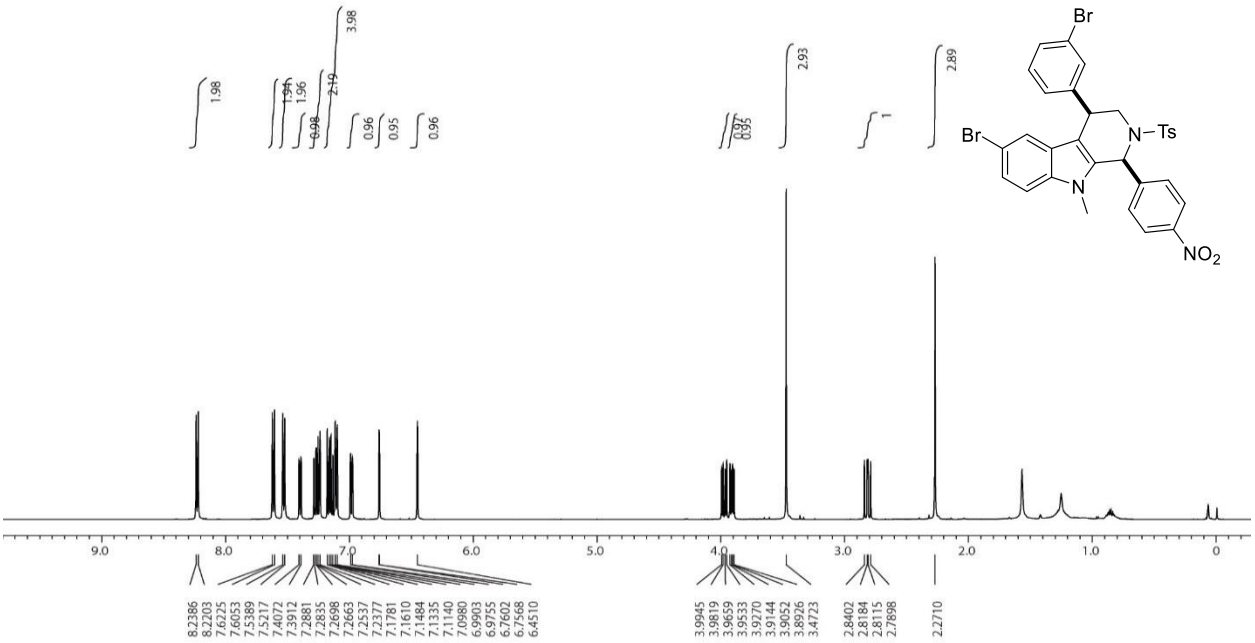

Figure:S33 ^{1}H NMR spectrum of **5o** ($CDCl_3$, 500 MHz)

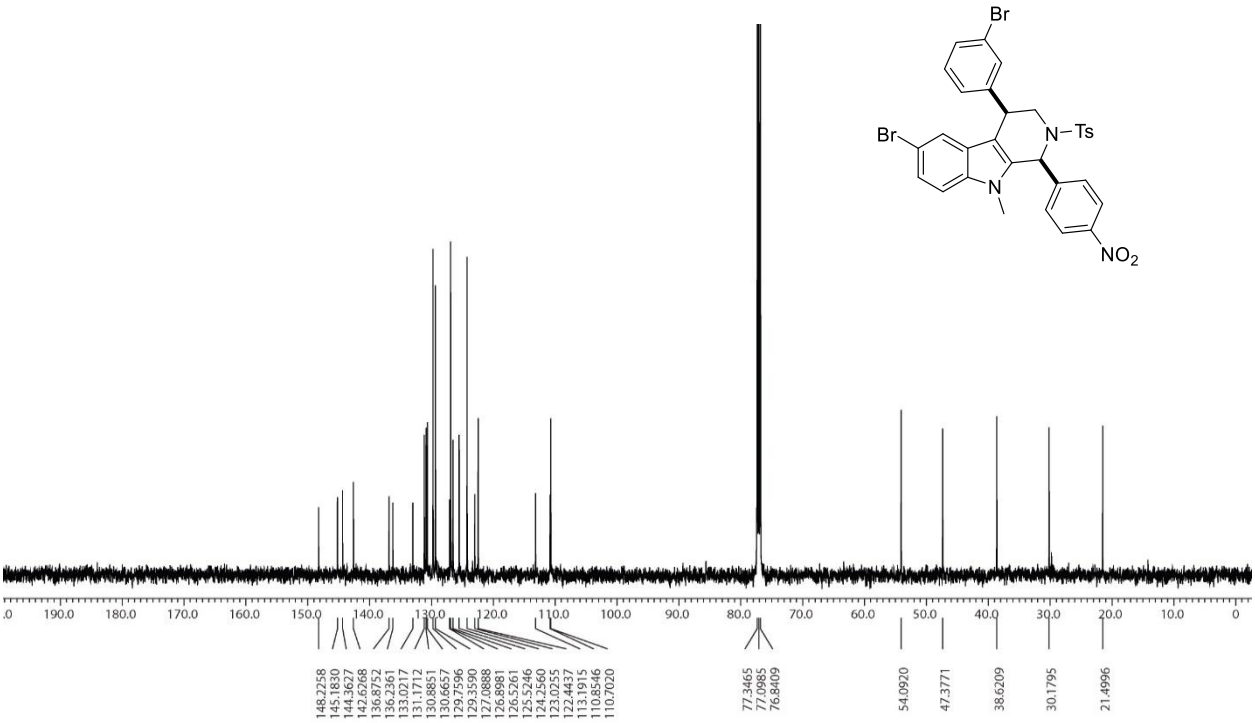

Figure:S34 $^{13}C\{^{1}H\}$ NMR spectrum of **5o** ($CDCl_3$, 125 MHz)

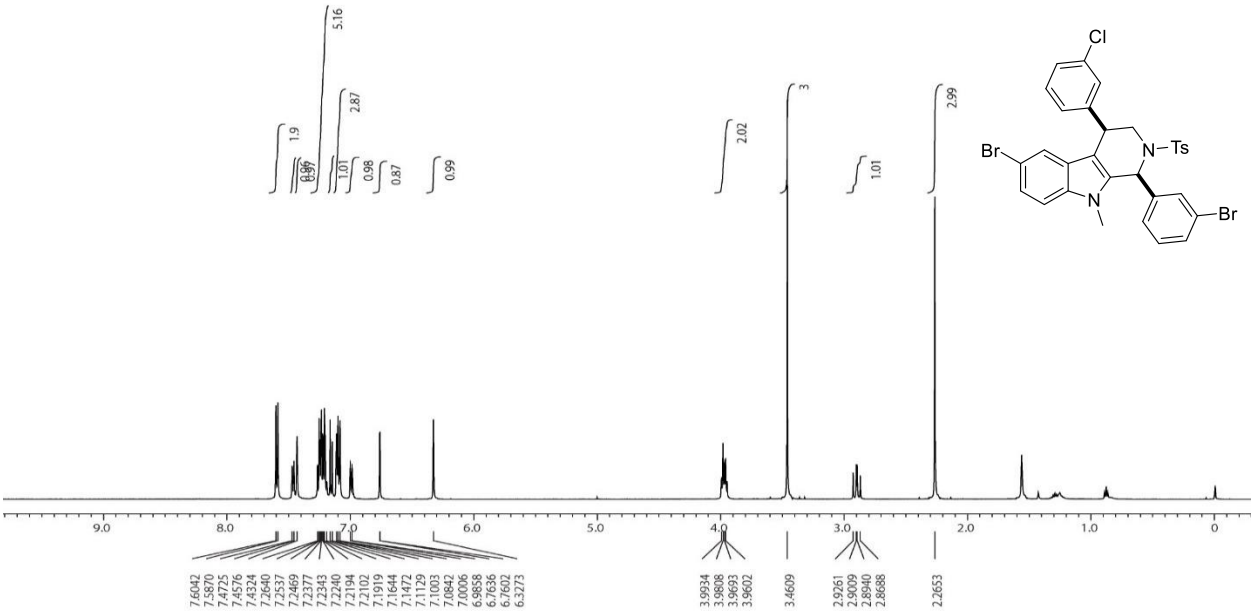

Figure:S35 ^{1}H NMR spectrum of **5p** ($CDCl_3$, 500 MHz)

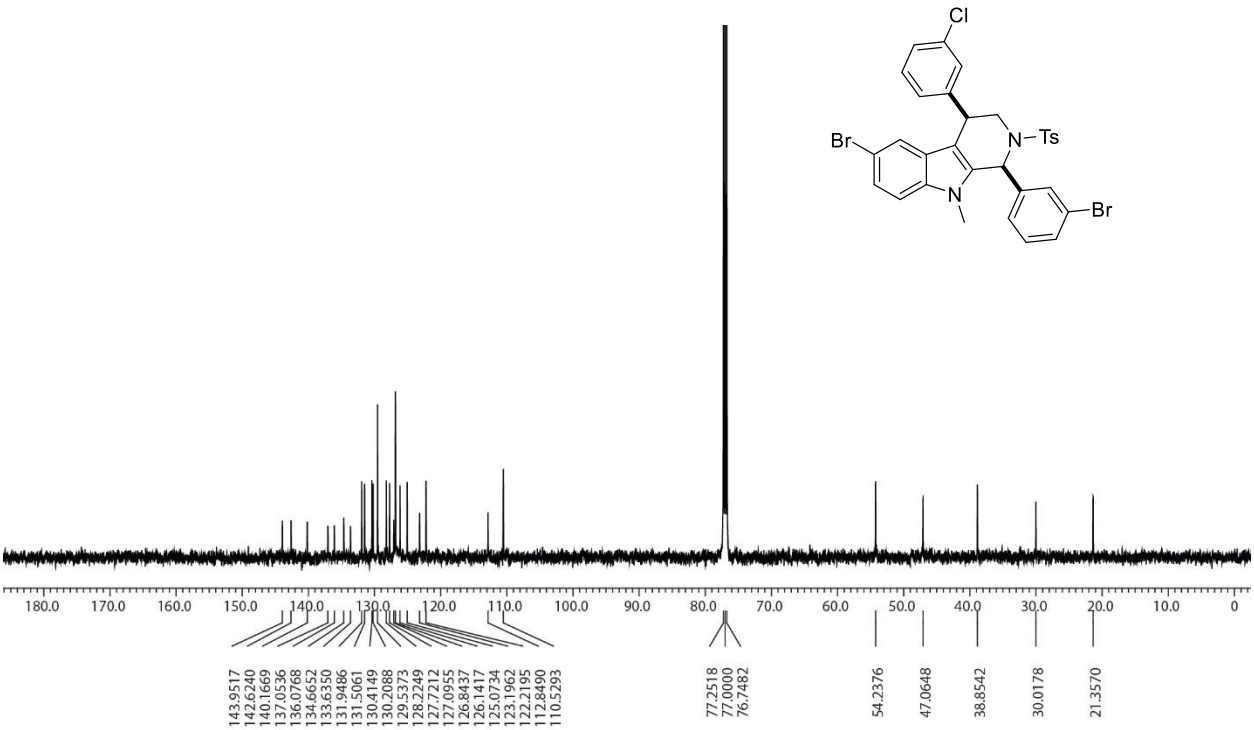

Figure:S36 $^{13}C\{^{1}H\}$ NMR spectrum of **5p** ($CDCl_3$, 125 MHz)

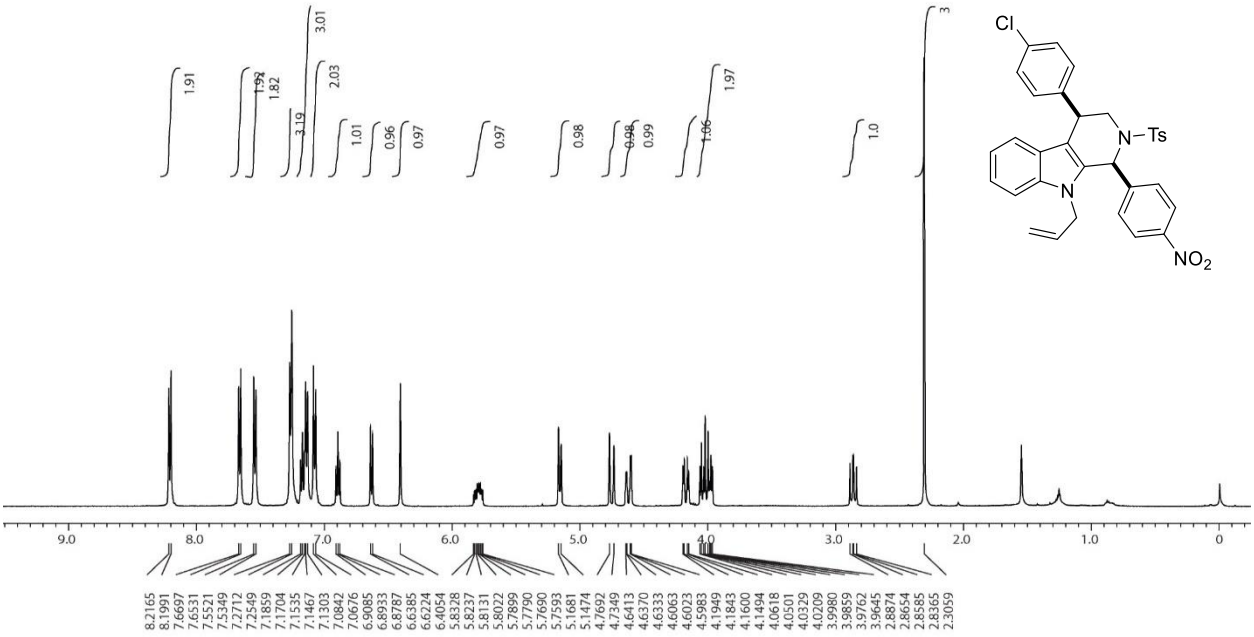

Figure:S37 ^{1}H NMR spectrum of **5q** ($CDCl_3$, 500 MHz)

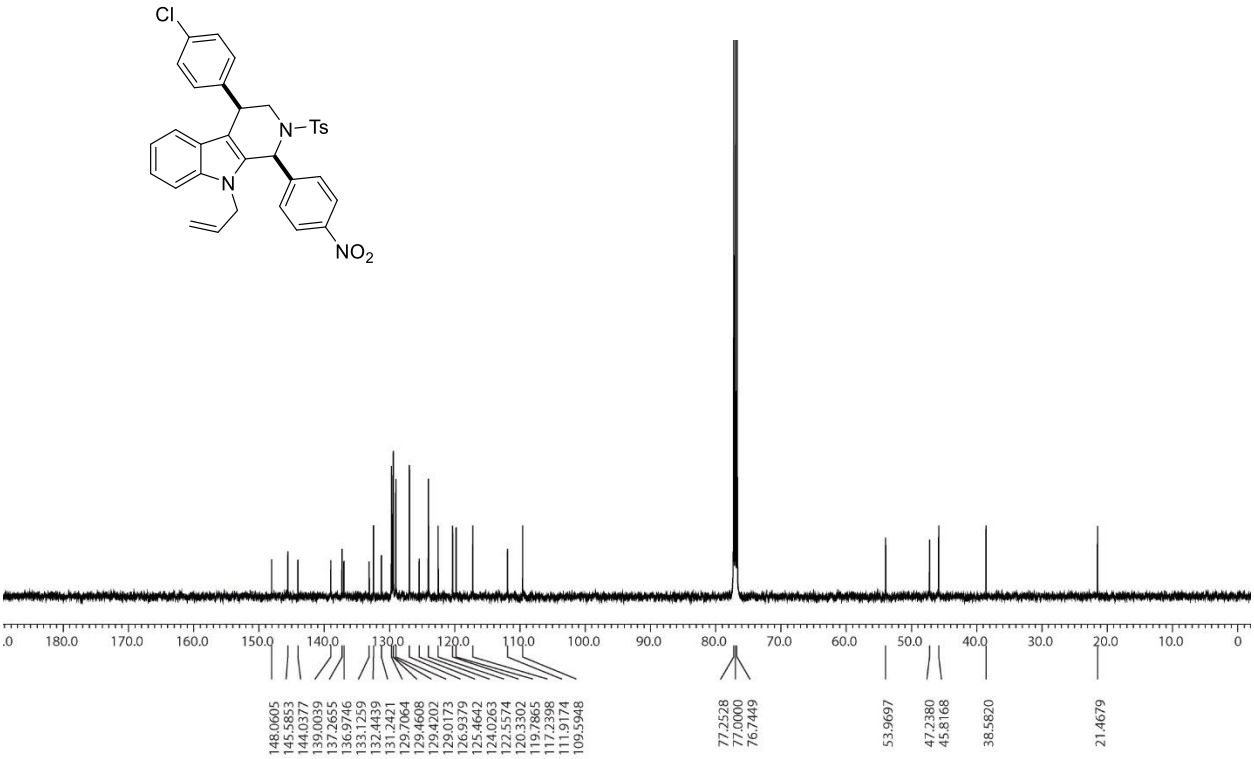

Figure:S38 $^{13}C\{^{1}H\}$ NMR spectrum of **5q** ($CDCl_3$, 125 MHz)

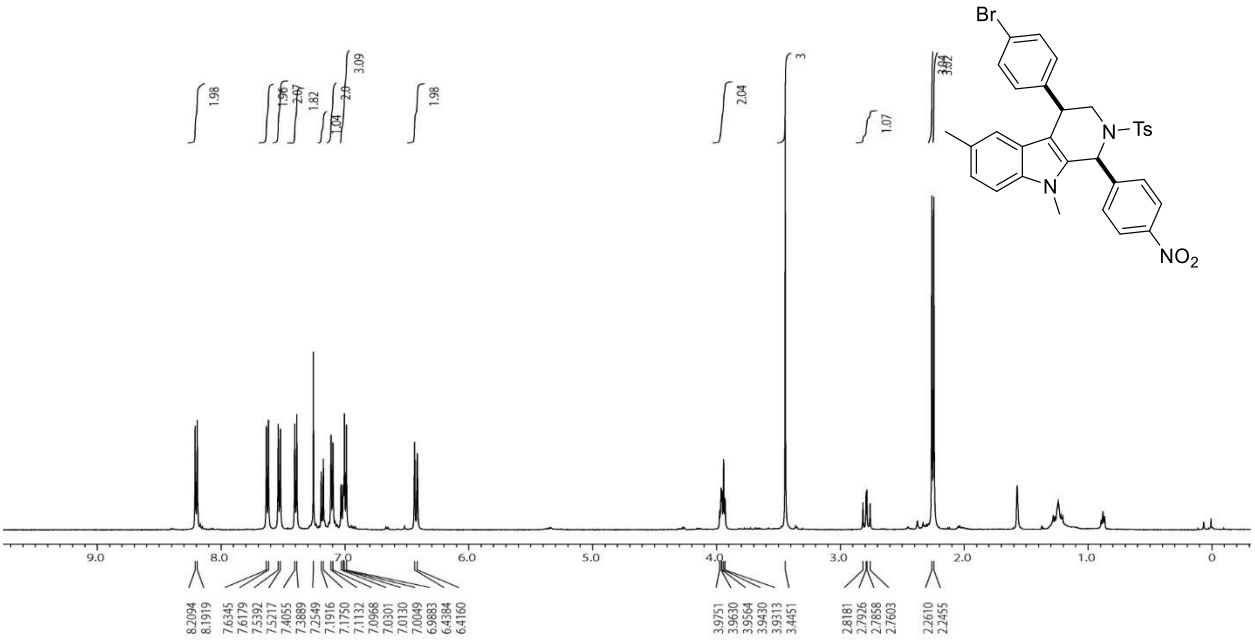

Figure:S39 ^{1}H NMR spectrum of **5r** ($CDCl_3$, 500 MHz)

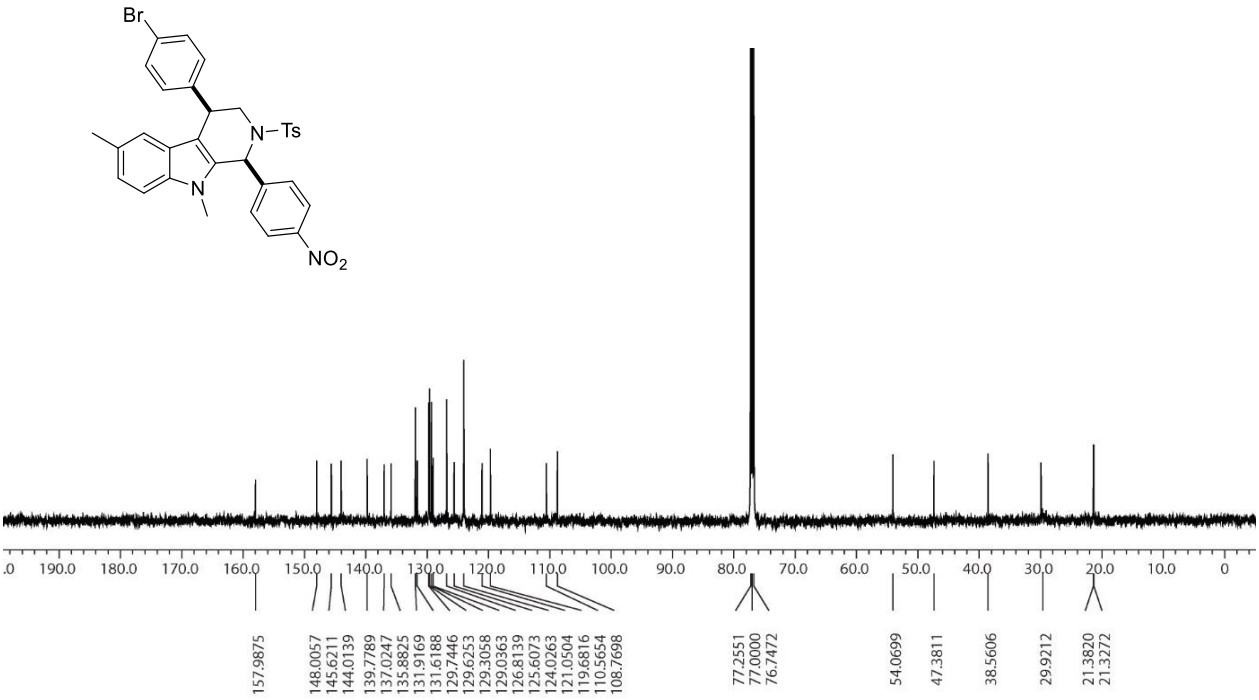

Figure:S40 $^{13}C\{^{1}H\}$ NMR spectrum of **5r** ($CDCl_3$, 125 MHz)

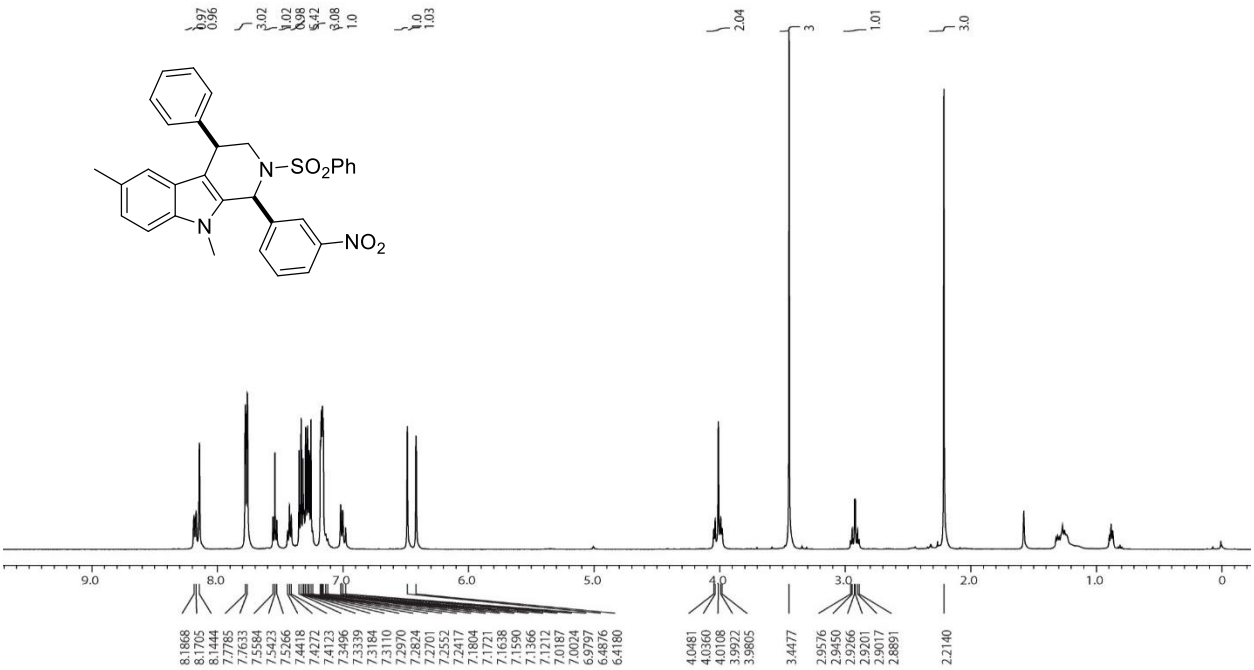

Figure:S41 ^{1}H NMR spectrum of **5s** ($CDCl_3$, 500 MHz)

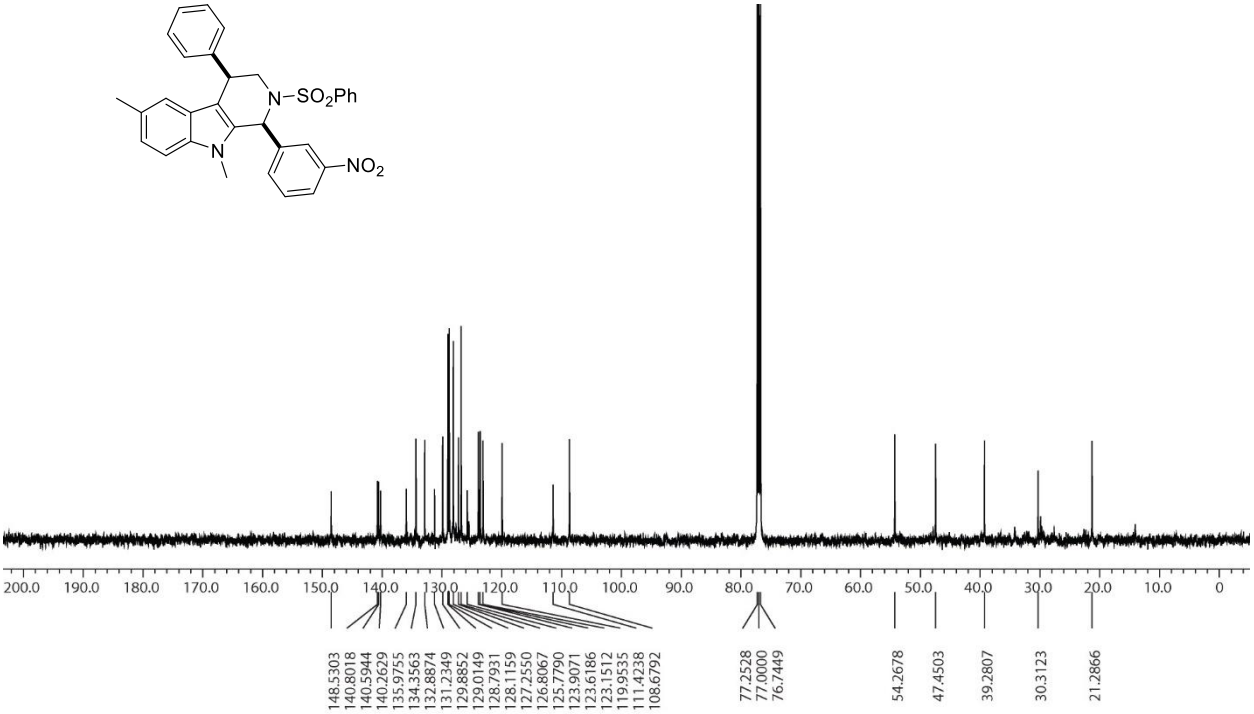

Figure:S42 $^{13}C\{^{1}H\}$ NMR spectrum of **5s** ($CDCl_3$, 125 MHz)

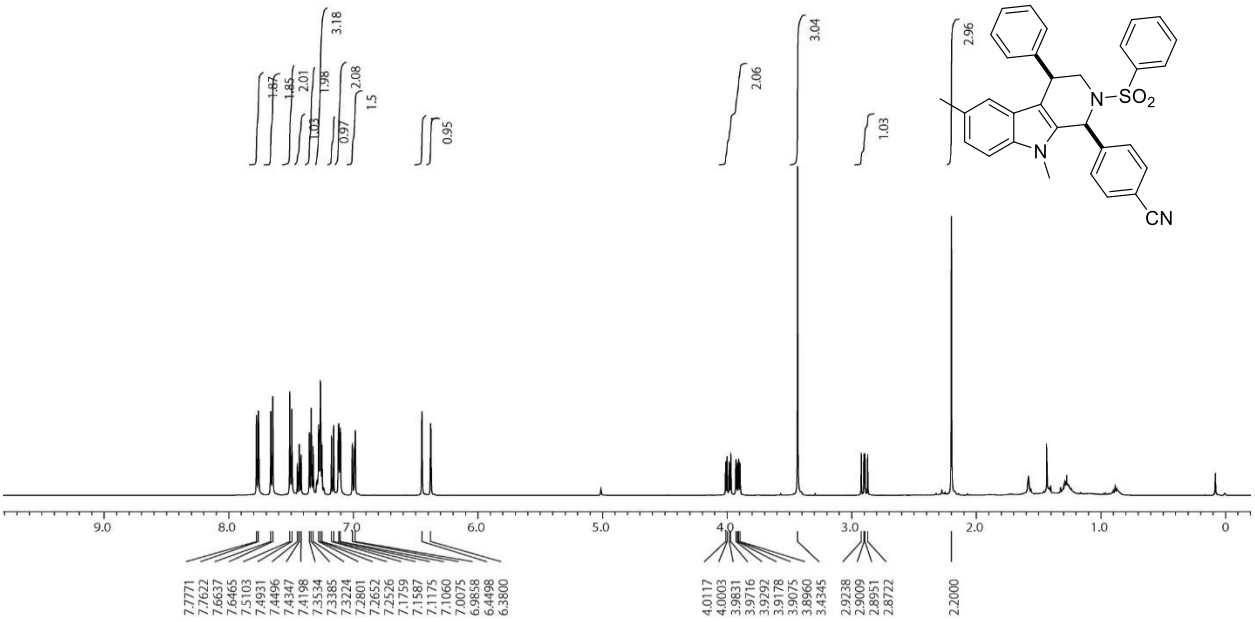

Figure:S43 ^{1}H NMR spectrum of **5t** ($CDCl_3$, 500 MHz)

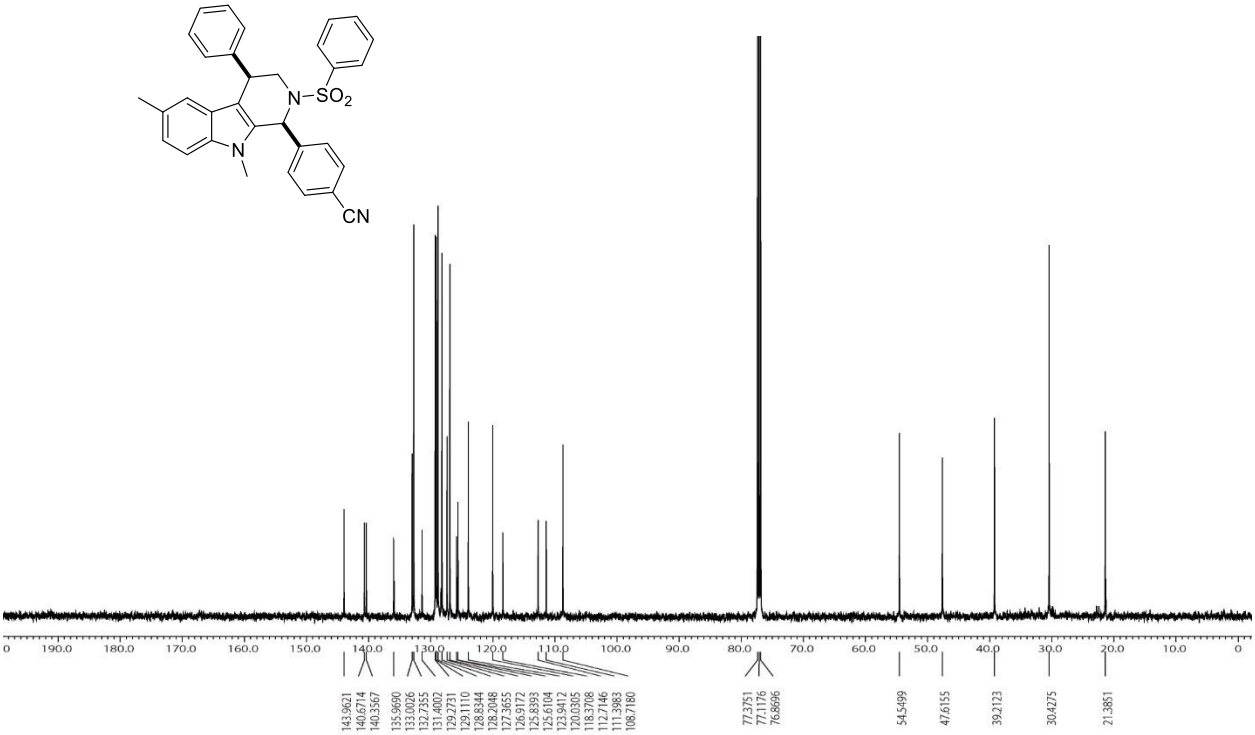

Figure:S44 $^{13}C\{^{1}H\}$ NMR spectrum of **5t** ($CDCl_3$, 125 MHz)

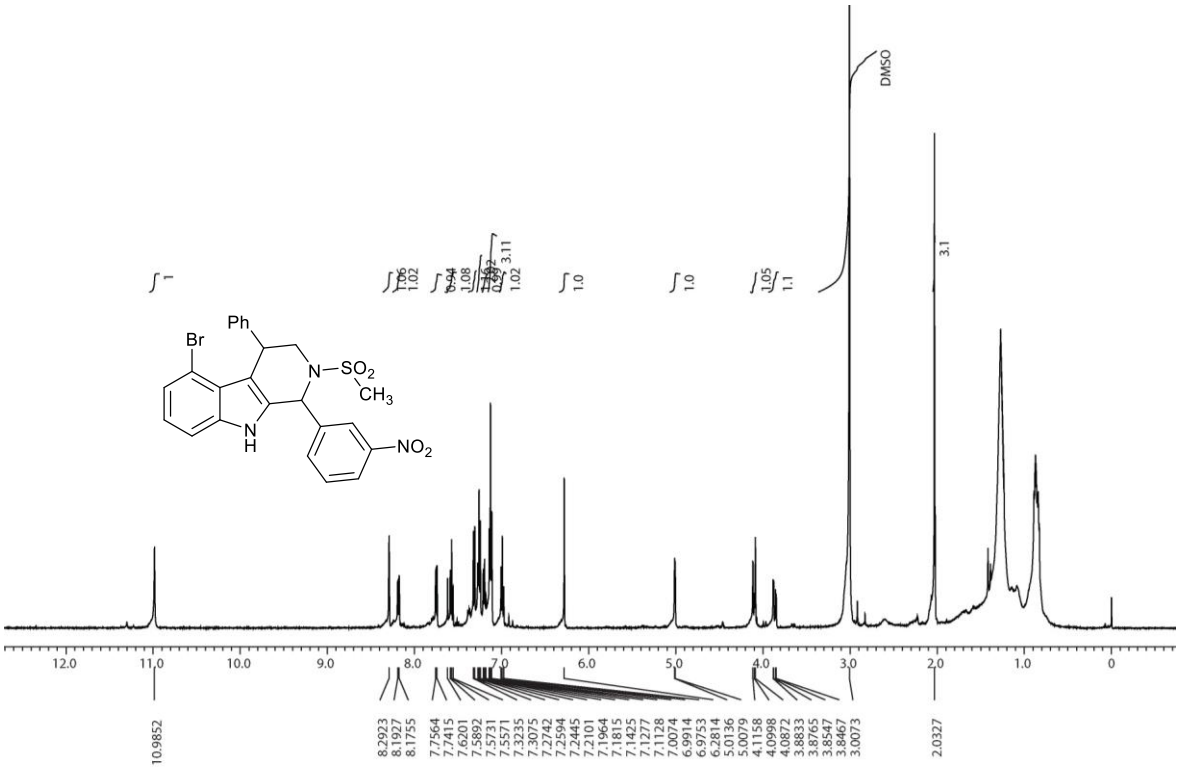

Figure:S45 ^{1}H NMR spectrum of **5u** ($CDCl_3$ + few drops of DMSO, 400 MHz)

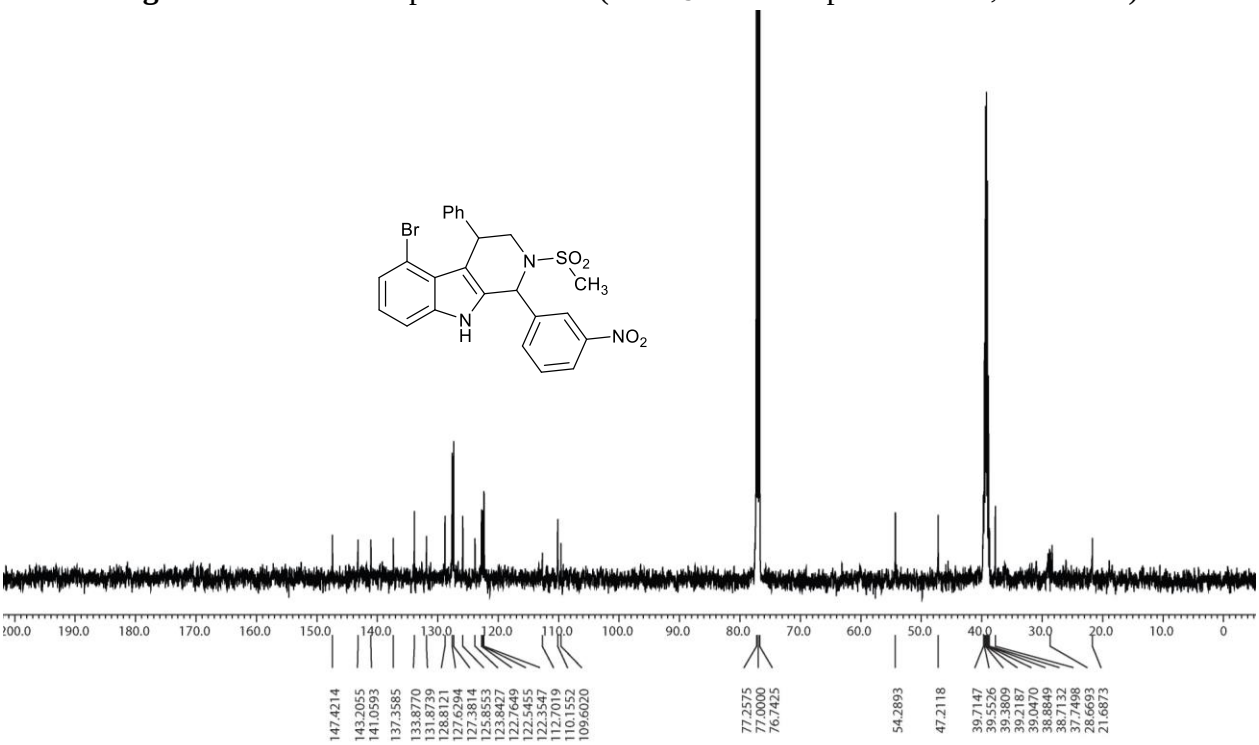

Figure:S46 $^{13}C\{^{1}H\}$ NMR spectrum of **5u** ($CDCl_3$, 100 MHz)

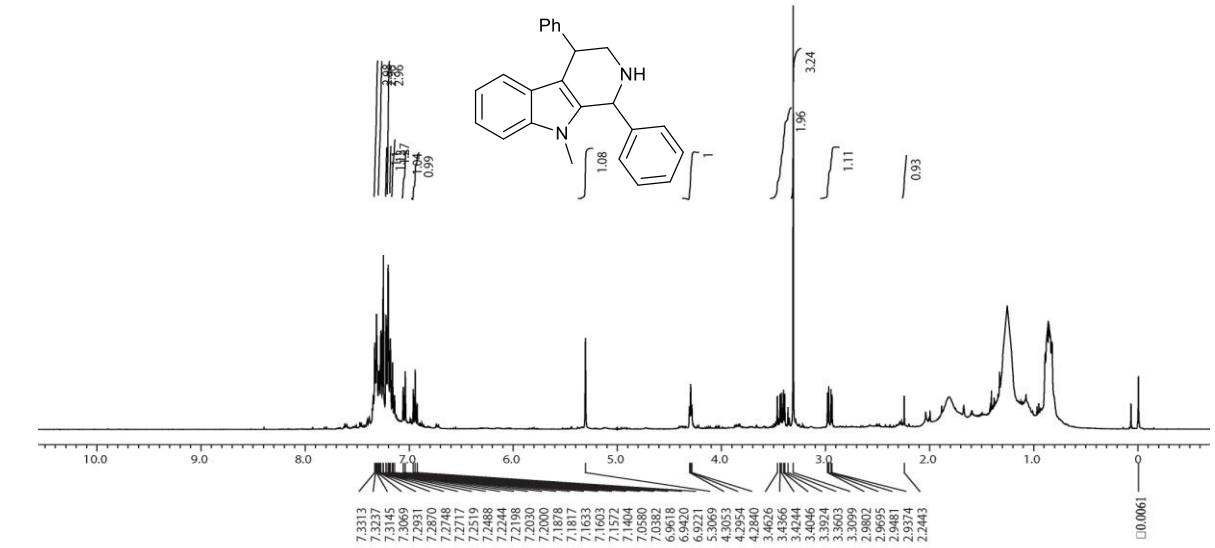

Figure:S47 ^{1}H NMR spectrum of **5v** ($CDCl_3$, 400 MHz)

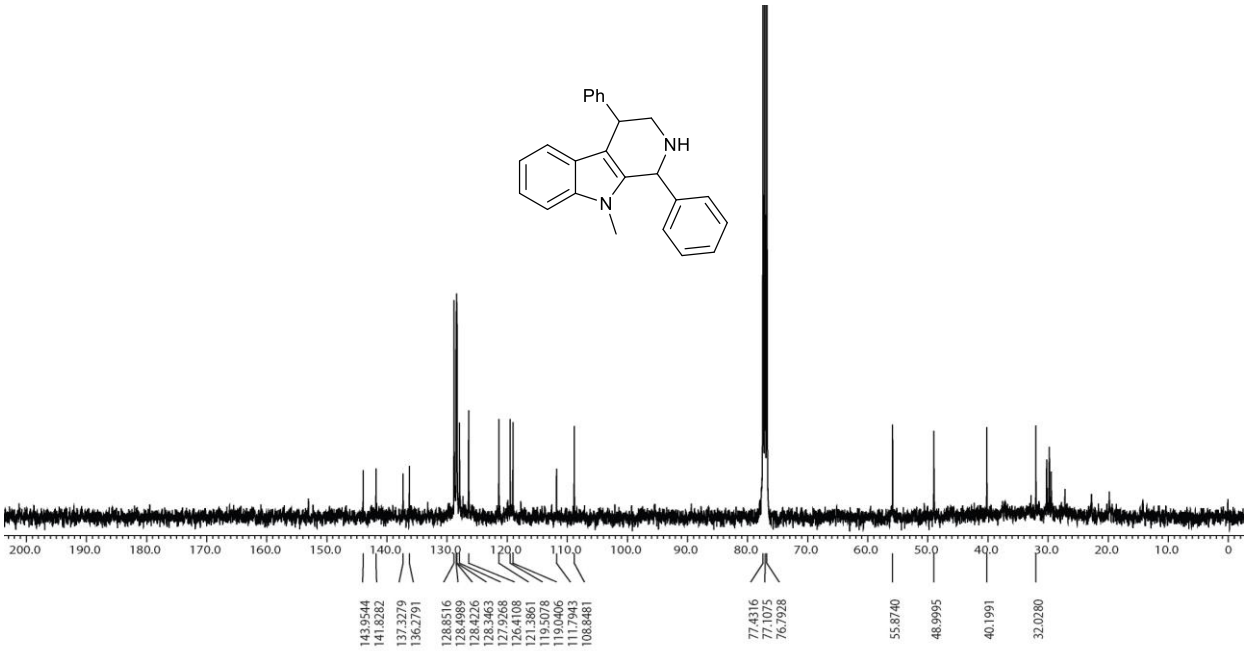

Figure:S48 $^{13}C\{^{1}H\}$ NMR spectrum of **5v** ($CDCl_3$, 100 MHz)

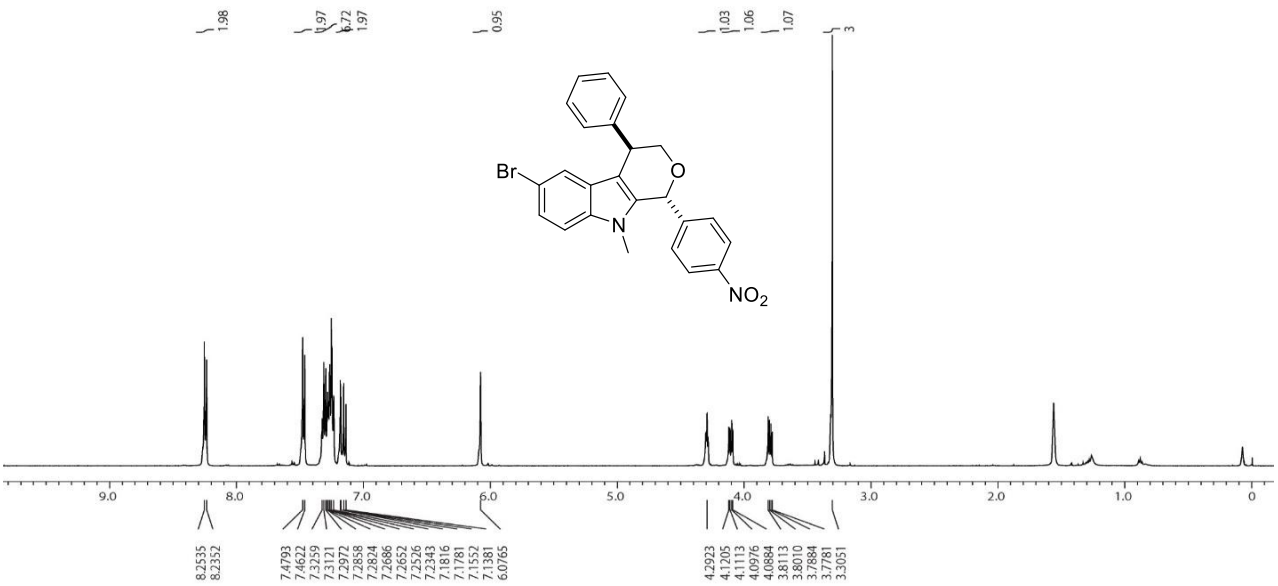

Figure:S49 ^{1}H NMR spectrum of **7a** ($CDCl_3$, 500 MHz)

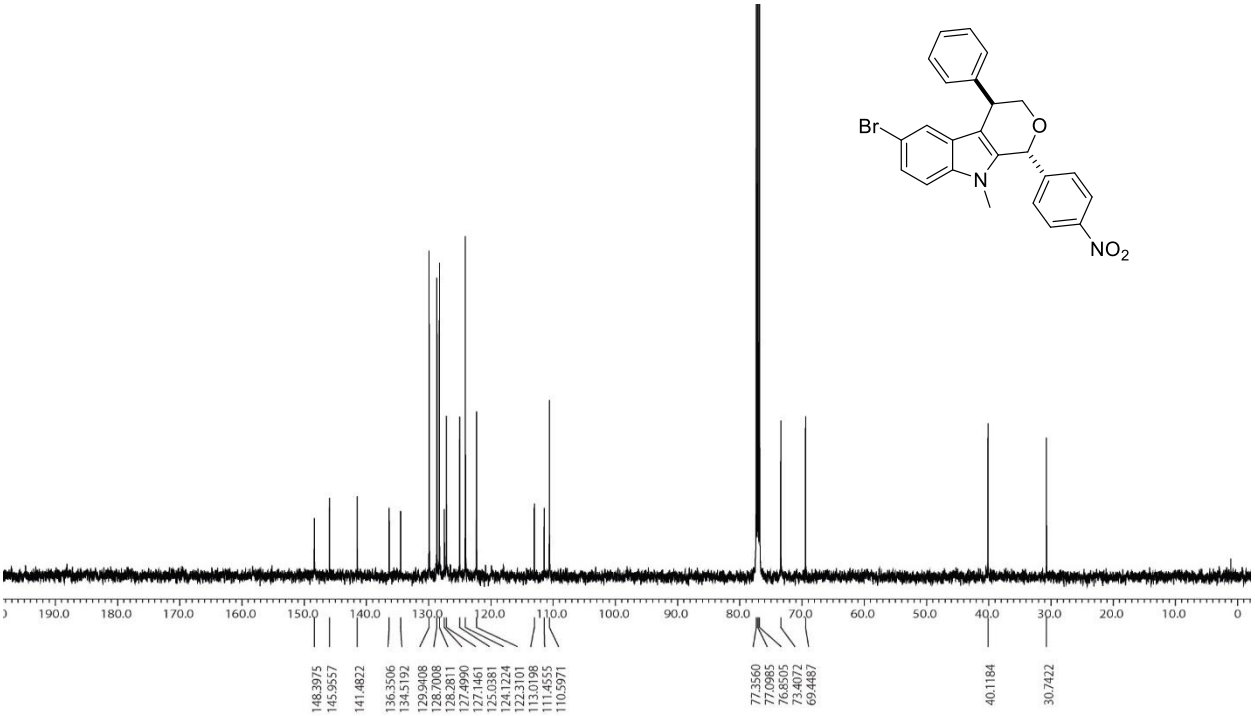

Figure:S50 $^{13}C\{^{1}H\}$ NMR spectrum of **7a** ($CDCl_3$, 125 MHz)

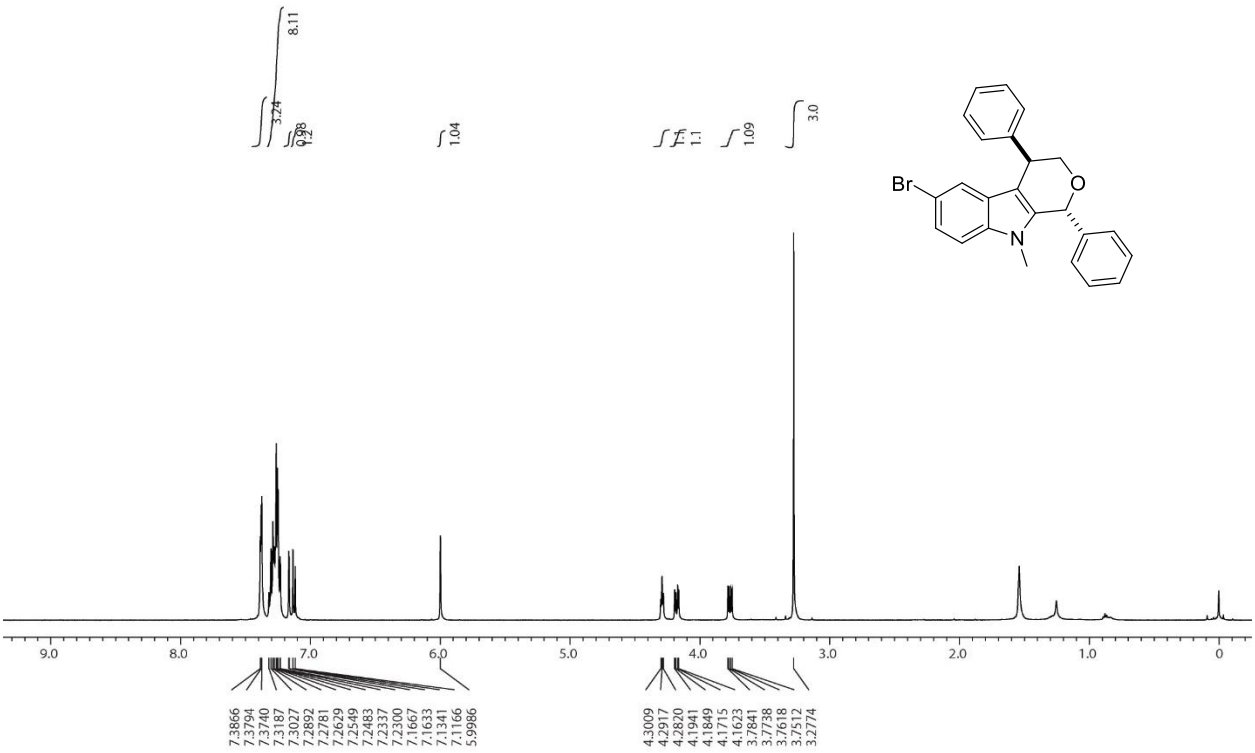

Figure:S51 ^{1}H NMR spectrum of **7b** ($CDCl_3$, 500 MHz)

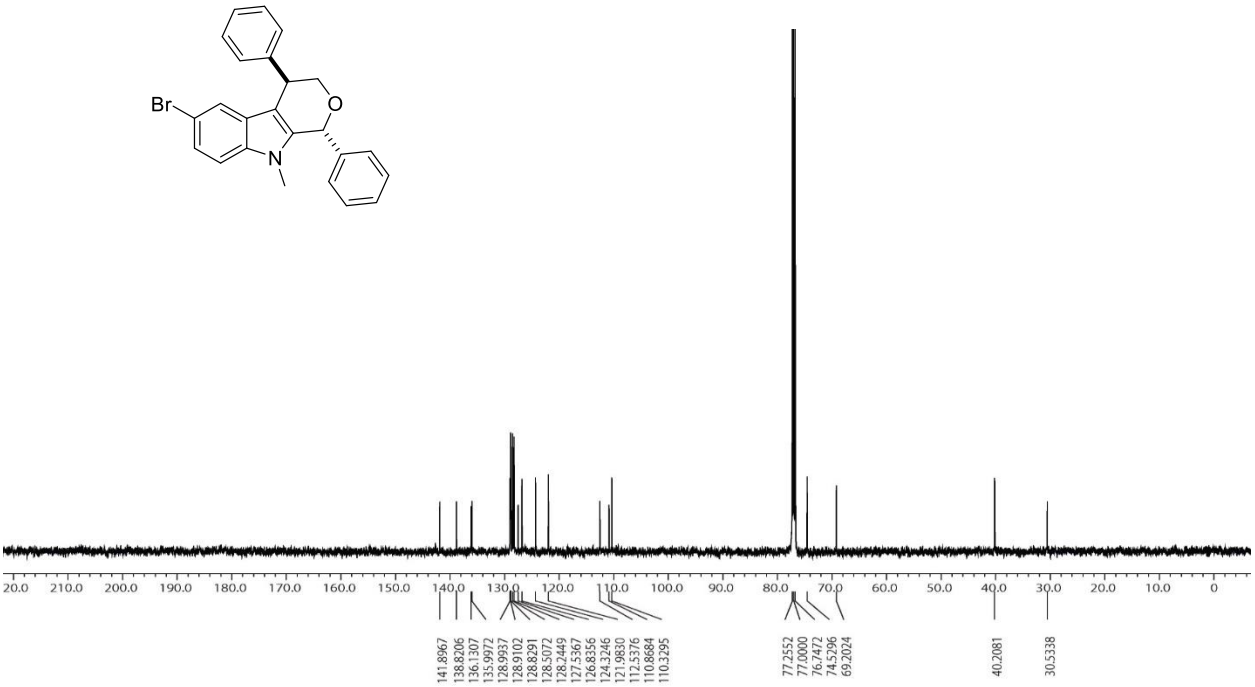

Figure:S52 $^{13}C\{^{1}H\}$ NMR spectrum of **7b** ($CDCl_3$, 125 MHz)

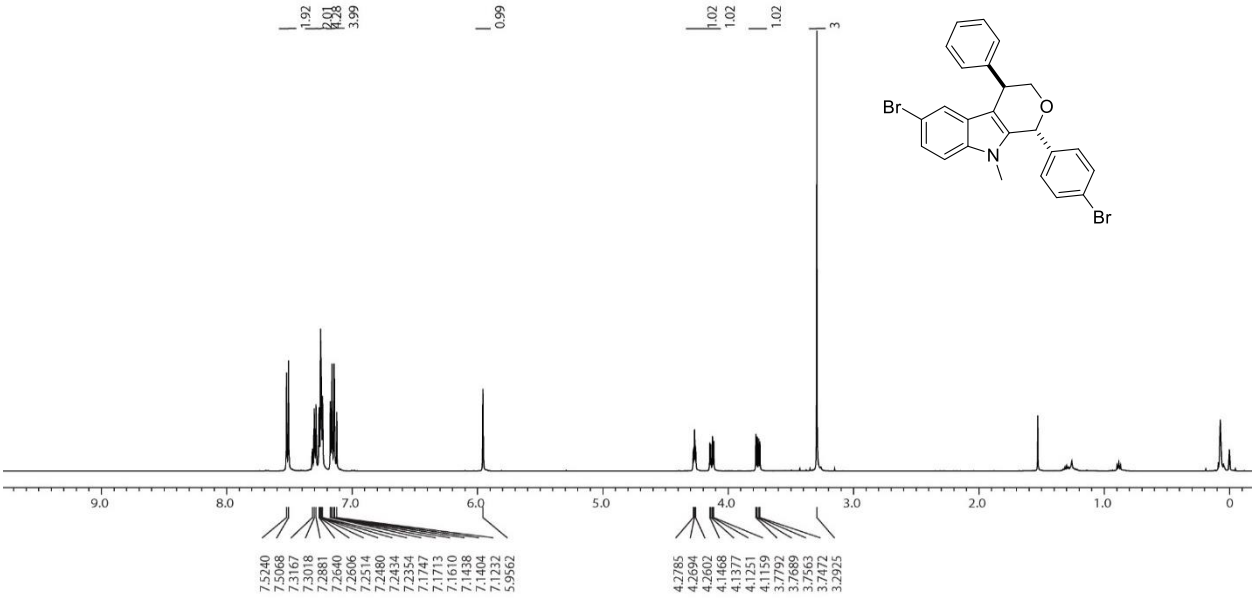

Figure:S53 ^{1}H NMR spectrum of **7c** ($CDCl_3$, 500 MHz)

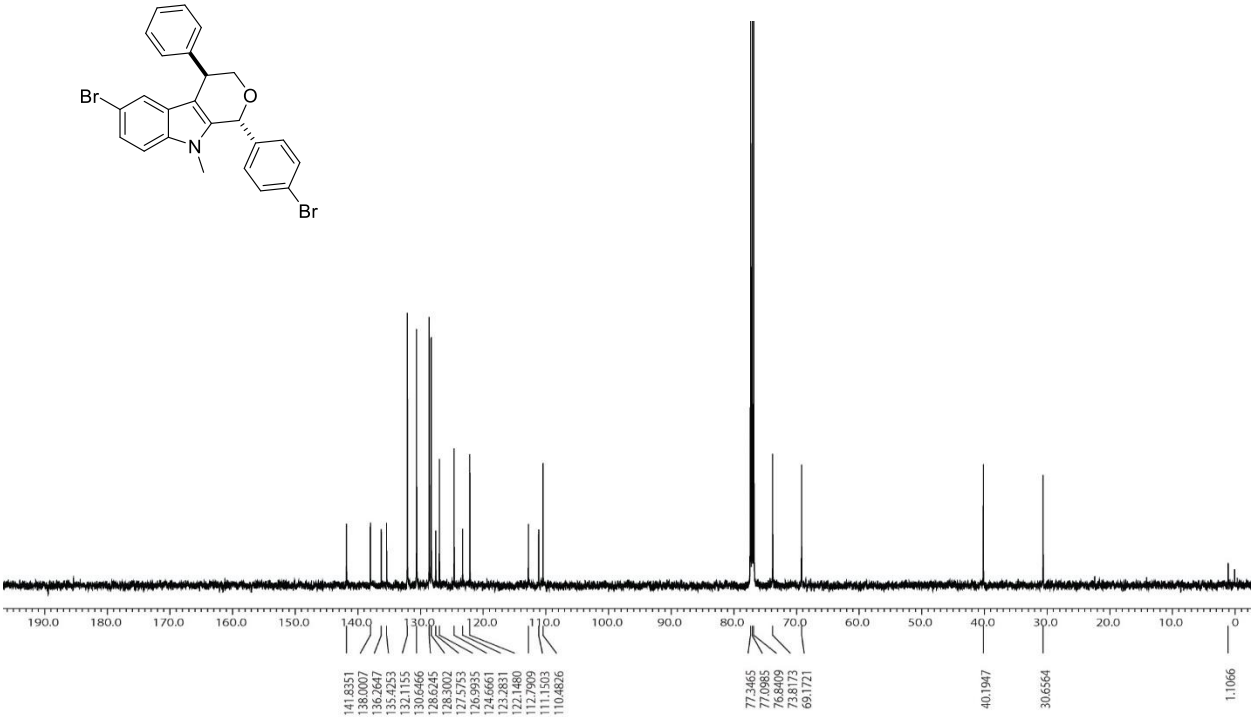

Figure:S54 $^{13}C\{^{1}H\}$ NMR spectrum of **7c** ($CDCl_3$, 125 MHz)

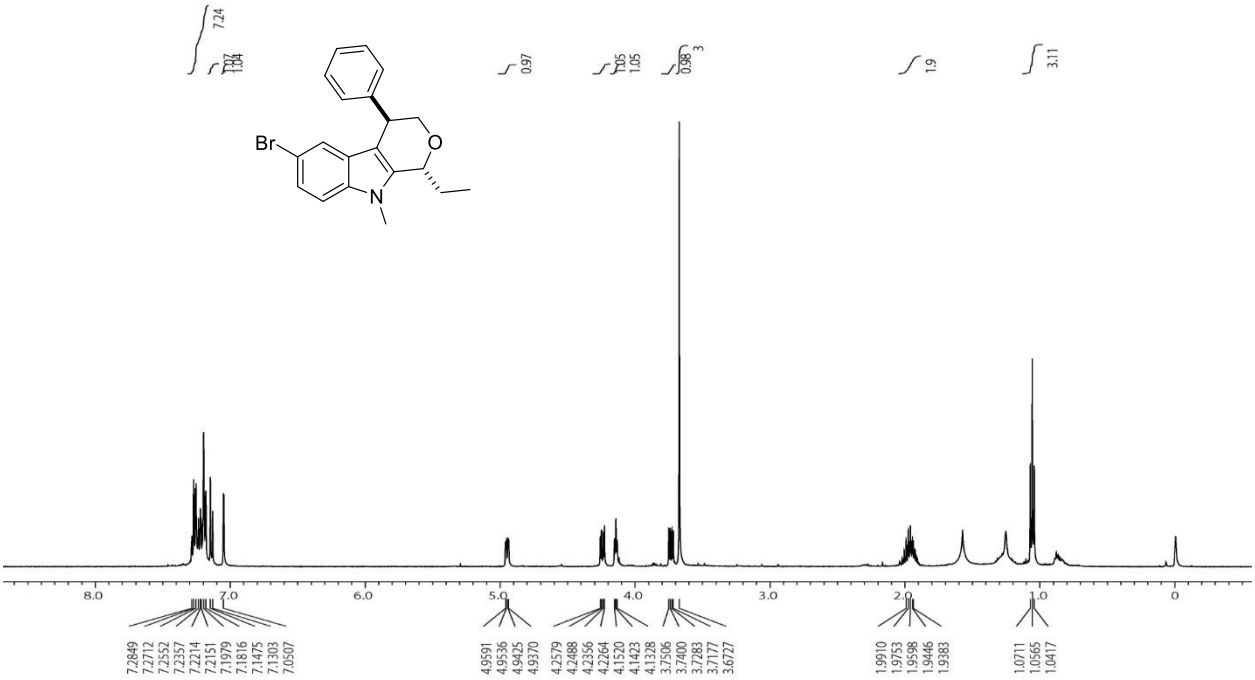

Figure:S55 ^{1}H NMR spectrum of **7d** ($CDCl_3$, 500 MHz)

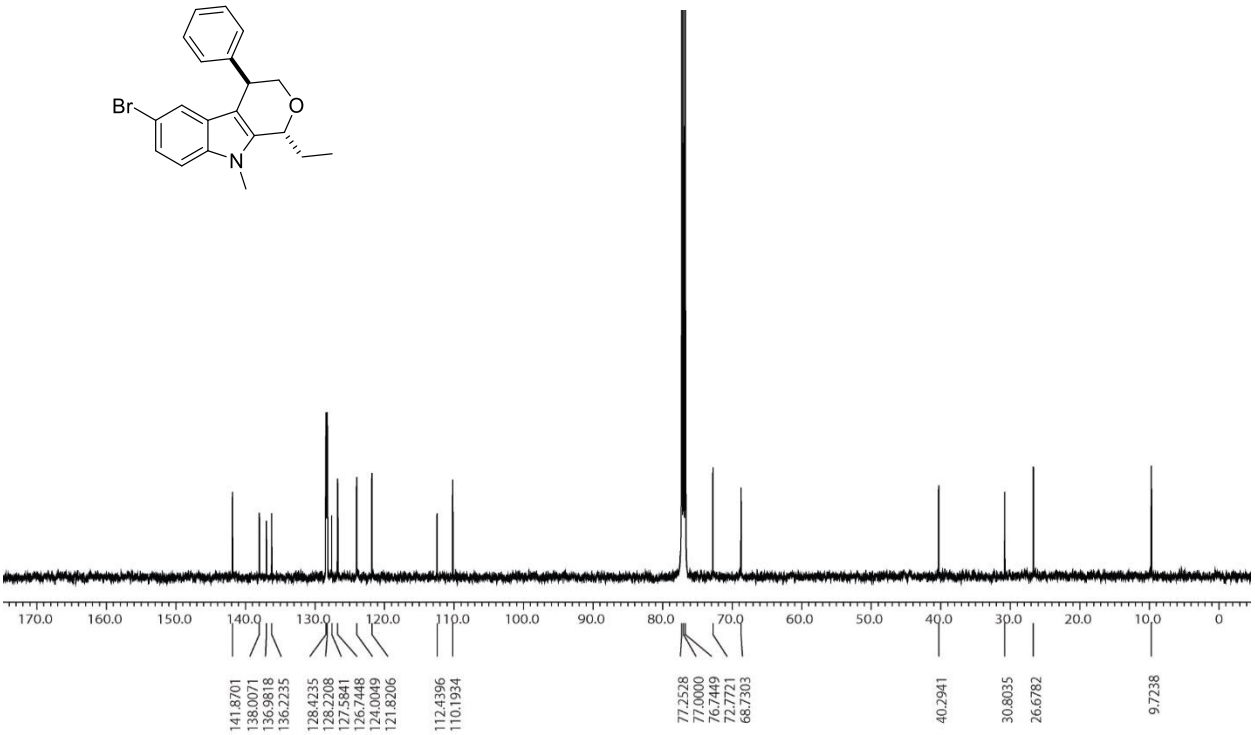

Figure:S56 $^{13}C\{^{1}H\}$ NMR spectrum of **7d** ($CDCl_3$, 125 MHz)

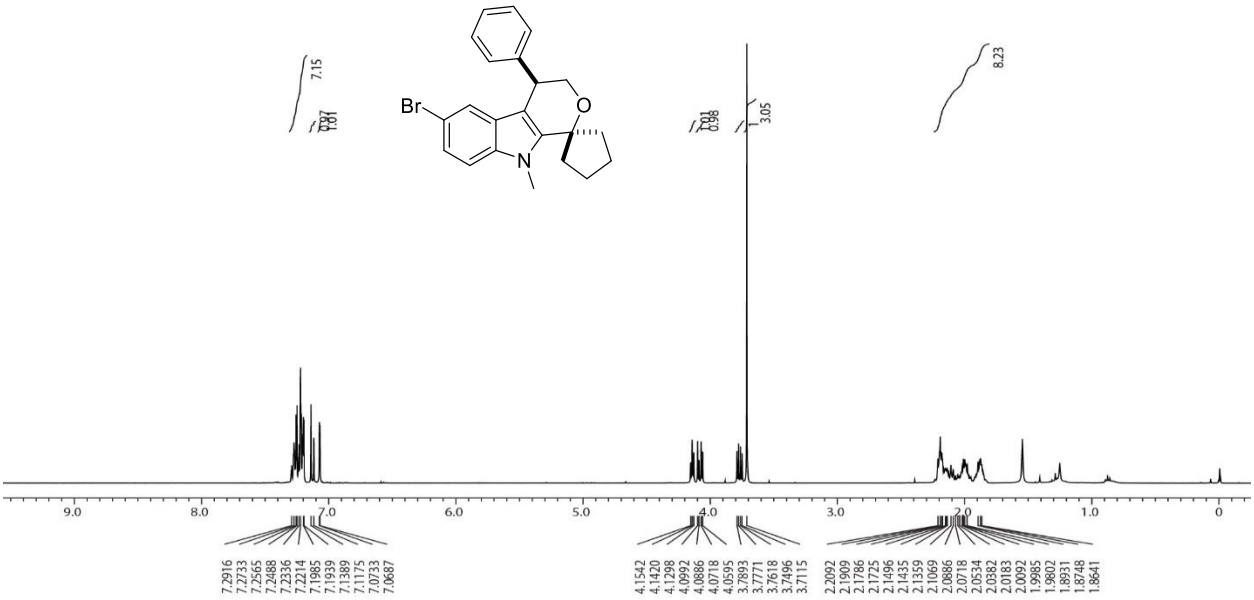

Figure:S57 ^{1}H NMR spectrum of **7e** ($CDCl_3$, 500 MHz)

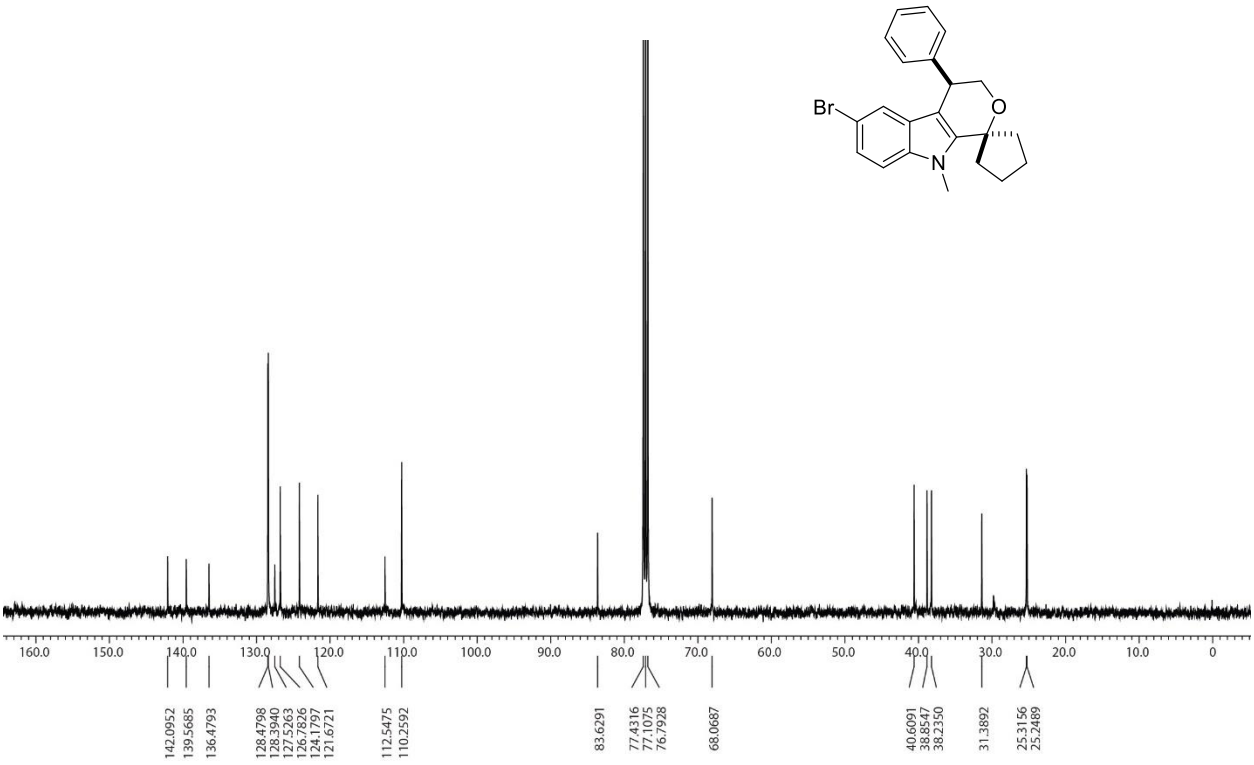

Figure:S58 $^{13}C\{^{1}H\}$ NMR spectrum of **7e** ($CDCl_3$, 125 MHz)

5. Selected HPLC chromatogram for *ee* determination:

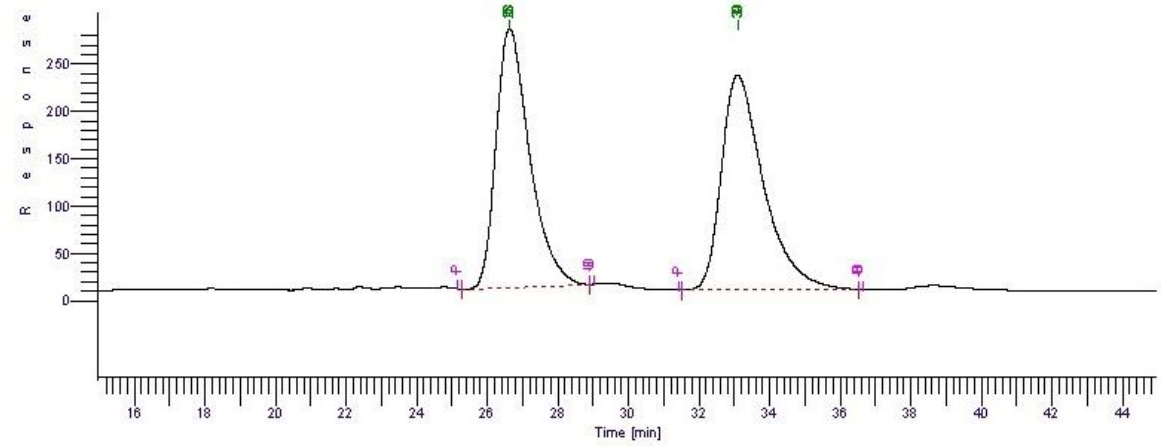

Figure:S59 HPLC chromatogram of racemic compound **5a** (AD-H column; 90:10 Hexane−Isopropanol; 1.0 mL min^{-1})

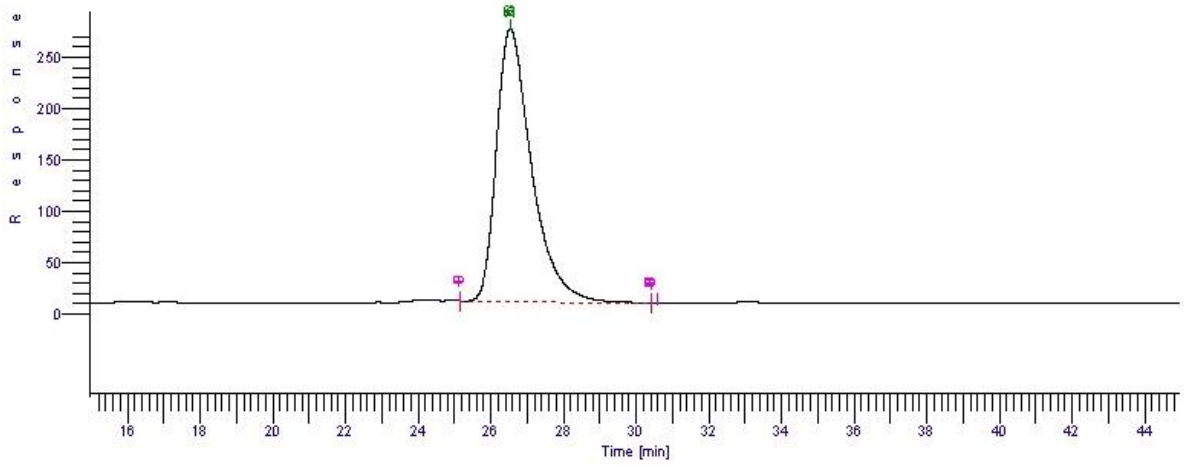

Figure:S60 HPLC chromatogram of chiral compound **5a** (>99% *ee*; AD-H column; 90:10 Hexane−Isopropanol; 1.0 mL min^{-1})

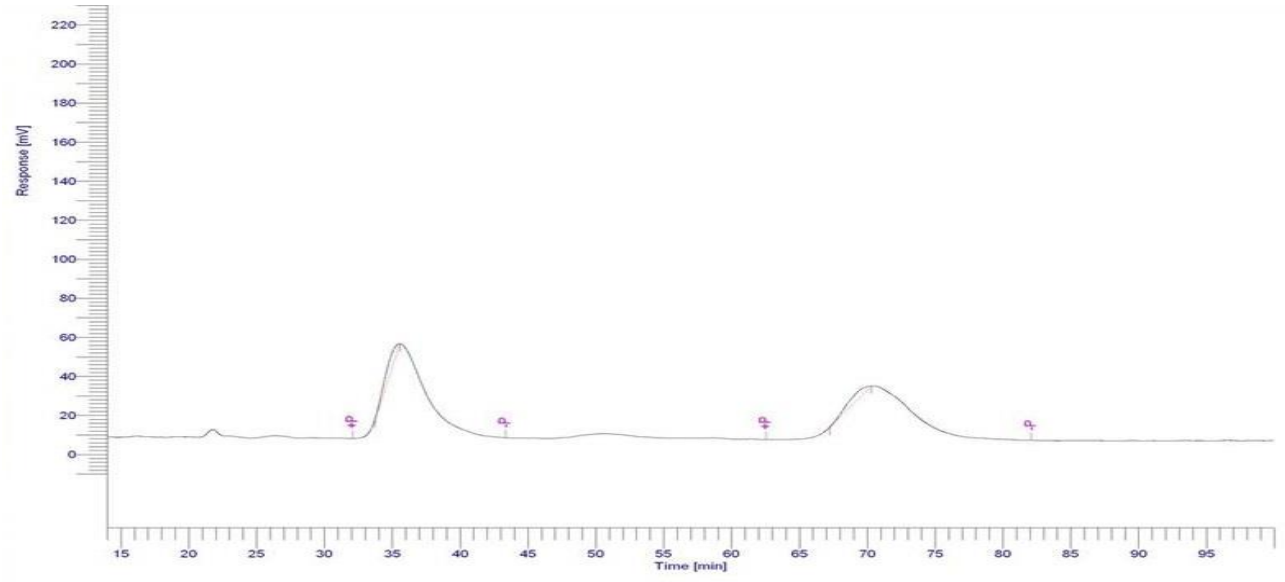

Figure:S61 HPLC chromatogram of racemic compound **5k** (OD-H column; 95:5 Hexane−Isopropanol; 1.0 mL min^{-1})

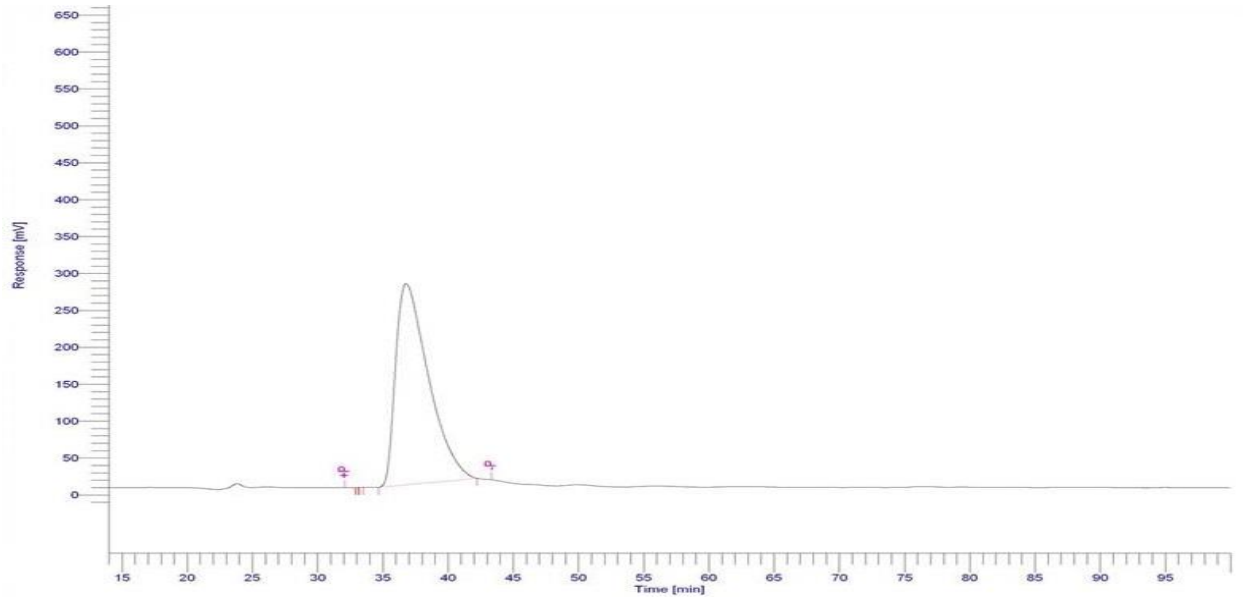

Figure:S562 HPLC chromatogram of chiral compound **5k** (OD-H column; 95:5 Hexane−Isopropanol; 1.0 mL min^{-1})

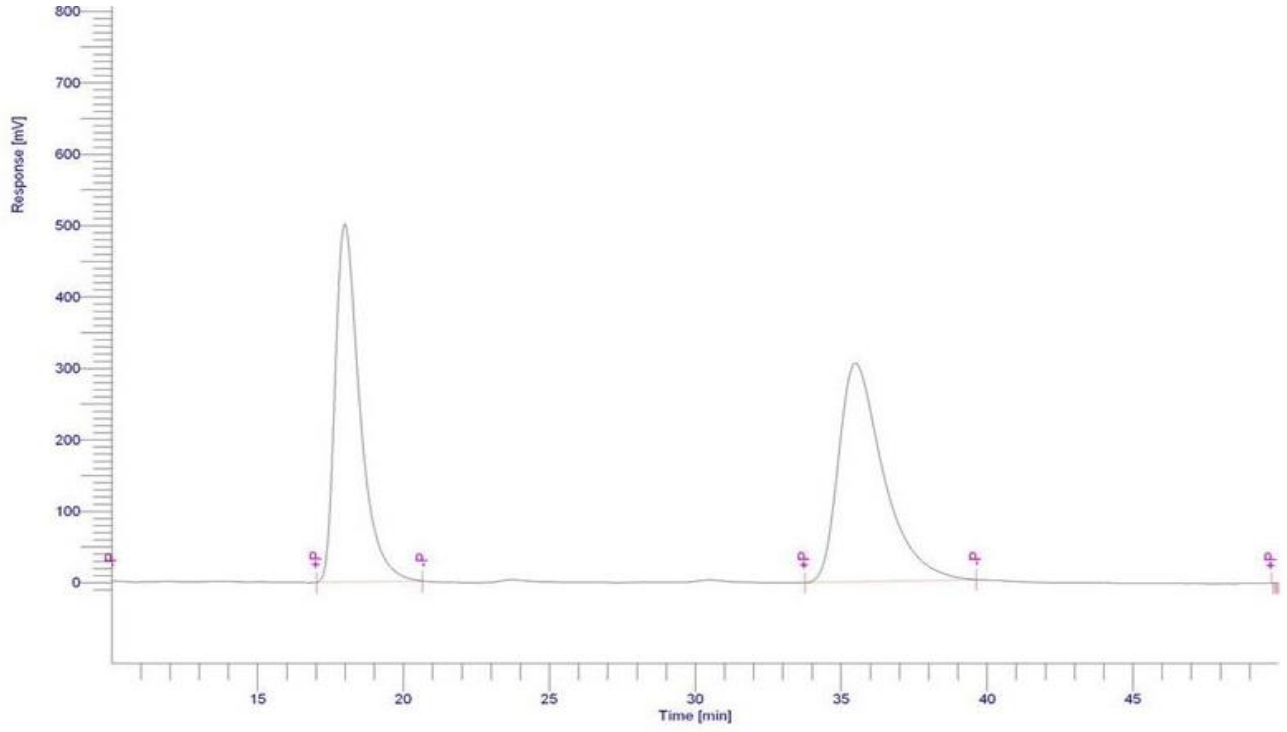

Figure:S63 HPLC chromatogram of racemic compound **5m** (AD-H column; 90:10 Hexane−Isopropanol; 1.0 mL min^{-1})

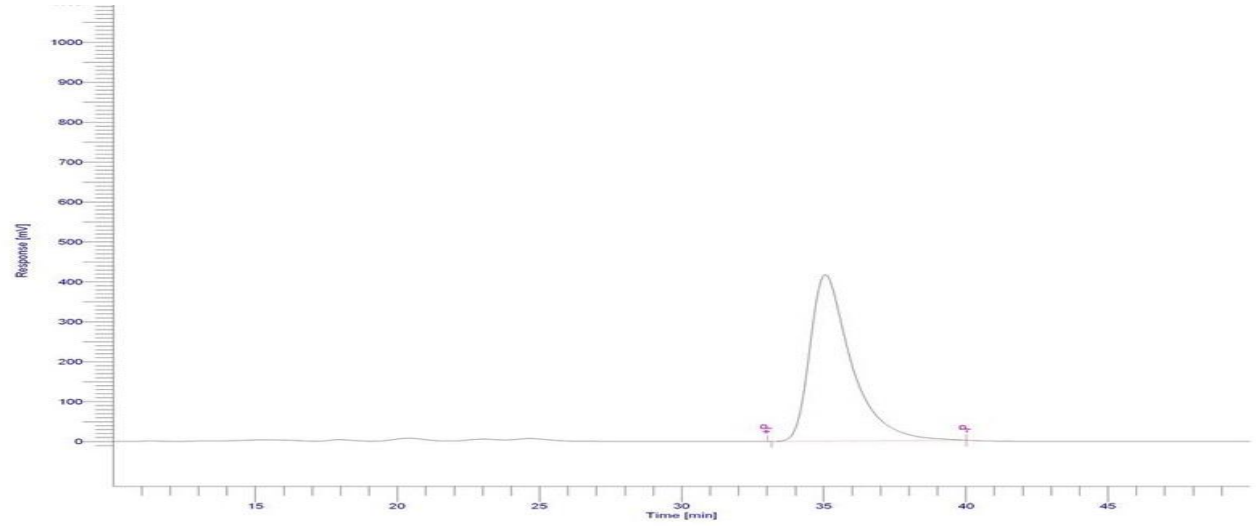

Figure:S64 HPLC chromatogram of chiral compound **5m** (AD-H column; 90:10 Hexane−Isopropanol; 1.0 mL min^{-1})