Accepted Manuscript

Submission Date: 2021-03-23
Accepted Date: 2021-04-21
Publication Date: 2021-04-21

Synthesis

Yb(OTf)3-mediated regioselective hydroamination of ynamides with anilines or p-toluenesulfonamide

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DOI: 10.1055/a-1488-4467

Please cite this article as: Zeng X, Gu Q, Dai W et al. Yb(OTf)3-mediated regioselective hydroamination of ynamides with anilines or p-toluenesulfonamide. Synthesis 2021. doi: 10.1055/a-1488-4467

Conflict of Interest: The authors declare that they have no conflict of interest.

This study was supported by National College Students Innovation and Entrepreneurship Training Program, 202010304044Z, the Start-Up Funding for Research of Nantong University, 03081231, the Large Instruments Open Foundation of Nantong University, KFJN2175; KFJN2176

Abstract:
A rare-earth salts Yb(OTf)3-catalyzed regioselective hydroamination of ynamides with anilines or p-toluenesulfonamide has been developed. This protocol provided facile access to a diverse range of amidines with good group functional group tolerance in moderate to high yield.

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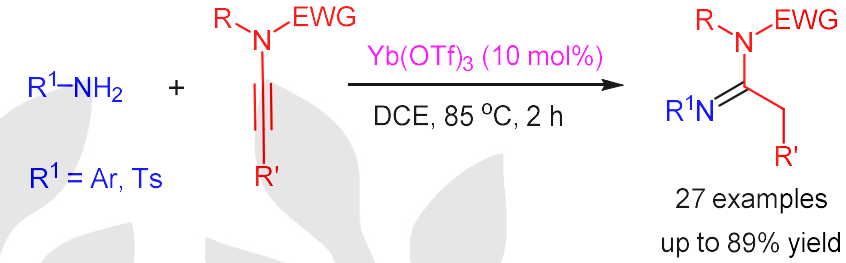
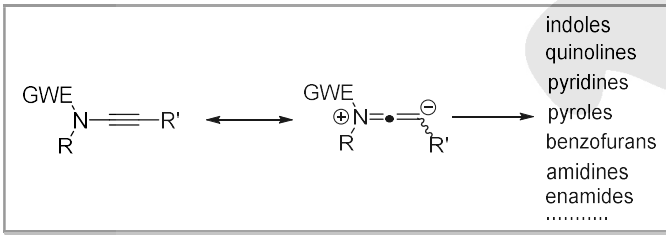


Received:
Accepted:
Published online:
DOI:

Abstract A rare-earth salts $Yb(OTf)_3$-catalyzed regioselective hydroamination of ynamides with anilines or *p*-toluenesulfonamide has been developed. This protocol provided facile access to a diverse range of amidines with good group functional group tolerance in moderate to high yield.

Key words Rare-earth salts, Hydroamination, Ynamides, Amidines, Amide

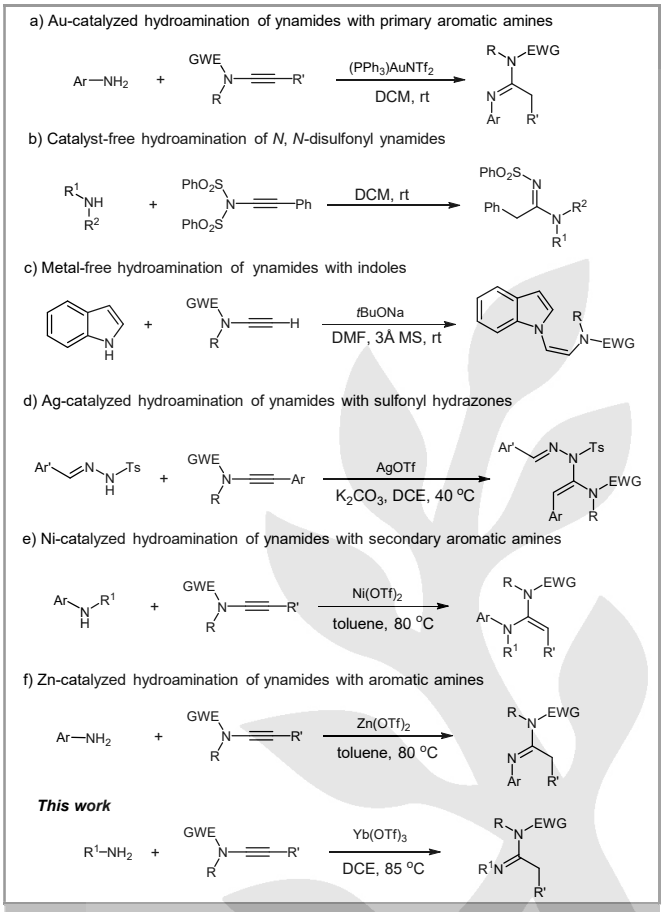
The exploration of synthetic utilities of functionalized alkynes has constantly been the focus of organic chemists.[1] As one of the most popular subclass of functionalized alkynes, ynamides have displayed distinctive reactivity due to the possible delocalization of lone pair by an electron-withdrawing group attached at the nitrogen atom, thus rendering them synthetically attractive synthons in organic synthesis owing to the better balance between increased stability and reactivity.[2] In the past decades, they have widely been applied in transition-metal involved and metal-free transformations to construct various prominent structures such as indoles,[3] quinolones,[4] pyridines,[5] pyroles,[6] benzofurans,[7] amidines[8], enamides[9] and other compounds[10] (Scheme 1).



Scheme 1 Resonance structures of ynamides and their application in organic synthesis

On the other hand, hydroamination of alkynes is a powerful strategy for the synthesis of amidines,[11] which have been characterized as efficient coordinating ligands and versatile functional building blocks.[12] Consequently, considerable efforts have been devoted to accessing these compounds.[13] Among them, direct hydroamination of ynamides with amines is an efficient protocol to generate amidines. For instance, Skrydstrup and coworkers innovatively developed an efficient Au-catalyzed intermolecular hydroamination reaction of ynamides with primary aromatic amines to regioselectively afford numerous *N*-arylimines in 2009 (Scheme 2a),[8c] the strategy was further applied in the intermolecular annulation reaction to synthesize indoles[3e-g] and quinolones[4a, 4b]. Similarly, Cai and coworkers reported the first heterogeneous Au/Ag-catalyzed regiospecific hydroamination of ynamides with anilines.[8h] Catalyst-free hydroamination of *N*, *N*-disulfonyl ynamides with amines was also reported by Cao and coworkers. (Scheme 2b).[8f, 8g] It was worthy to note that the protocol is compatible with both primary aromatic amines and secondary aliphatic amines, affording various *N*-sulfonylamidines in good yields. In 2014, t-BuONa-mediated hydroamination of terminal ynamides to regioselectively afford various (Z)-*N*-(2-aminovinyl)-sulfonamide was developed by Dodd and coworkers (Scheme 2c).[8i] Later, Meng and coworkers disclosed a AgOTf-catalyzed addition of sulfonyl hydrazones with ynamides to synthesize functionalized α-amino alkenyl-substituted hydrazine products in good yields (Scheme 2d).[8d] Recently, Ni-catalyzed hydroamination of ynamides with secondary aromatic amines to generate various substituted ethene-1,1-diamine compounds was reported by Wei and coworkers (Scheme 2e).[8j] The same group also reported $Zn(OTf)_2$-catalyzed hydroamination of ynamides with primary aromatic amines during our preparation of this manuscript. The protocol features facile reaction conditions and broad substrate scope.[8k] Although considerable developments have been achieved in the hydroamination of ynamides, to the best of our knowledge, the amines employed in the process above are mainly aromatic amines, while $TsNH_2$ has never been explored. What's more, the incorporation of rare-earth element to effect synthetically useful hydroamination has gained increasing attention in recent years.[14] As part of our continuous interests in the application of functionalized alkenes and

alkynes,[15] we reported herein $Yb(OTf)_3$-catalyzed hydroamination of ynamides with $ArNH_2$ or $TsNH_2$ for the preparation of amidines.

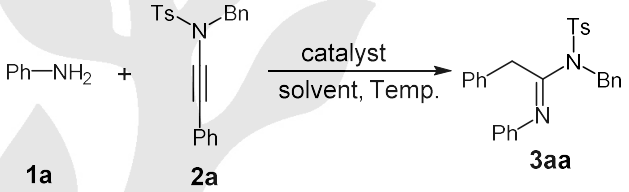


Scheme 2 Hydroamination of ynamides and their application in organic synthesis

We commenced our investigation by choosing **2a** (0.3 mmol) and **1a** (2 equiv.) as model substrates, $BF_3{\cdot}Et_2O$ (10 mol%) as catalyst in 2 mL DCE at 85 °C under air atmosphere. Gratifyingly, the desired product **3aa** could be obtained in 66% yield (Table 1, entry 1). Subsequently, various Lewis acids were screened including $FeCl_3$, $Bi(OTf)_3$, $Zn(OTf)_2$ and $Yb(OTf)_3$, showing that the reaction was compatible with most Lewis acid catalyst to furnish **3aa** in moderate yields, among which $Yb(OTf)_3$ was proved to be superior than other catalyst to afford **3aa** in 89%. However, a trace amount of **3aa** was obtained using $Mg(OTf)_2$ (entries 2-6). The effect of solvent was subsequently investigated. Lower yield was observed when reaction was conducted in toluene or DMF, while no desired products was detected in 1,4-dioxane and CH_3CN. By continuous lowering the amount of $Yb(OTf)_3$ to 5 mol%, the yield of **3aa** was significantly reduced to 71% (entry 11). Next, the substrates proportion of **1a**:**2a** was evaluated. By reducing the ration of **1a**:**2a** to 1.5:1, the yield of **3aa** was reduced to 77%, while further increasing the ration to 3:1 didn't lead to a better yield (entries 12, 13). Furthermore, continuous elevating the reaction temperature to 110 °C or lowering the reaction temperature to 60 °C was detrimental to the reaction, resulting in a lower yield (entries 14, 15). Finally, the optimum conditions were determined as entry 5.

With the optimal reaction conditions established, the generality of the anilines and ynamides was explored (Scheme 3). Firstly, a vast array of *para*-substituted aromatic amines were tested to afford the corresponding products **3aa**-**f** mostly with high yields. The electronic effect had clear impact on the reaction, resulting **3af** with reduced yield compared with **3aa**-**c**. The positional change of *ortho*-, *meta*- and *para*-substituents had little effect on the protocol, affording **3ab**, **3ag** and **3aj** in satisfied yield. Substrates with halide substituents like chlorine, fluorine and iodine underwent the reaction smoothly to produce the corresponding compounds in good yields (**3ad**, **3ah**-**i**). Notably, free hydroxyl group at the *meta*-position of the phenyl ring was also tolerated in the reaction to afford **3al** in 78% yield. Apart from mono-phenyl substituted substrates, di- and tri-phenyl substituted aromatic amines were also suitable substrates (**3am**-**n**).

Table 1 Optimization of conditions.[a]

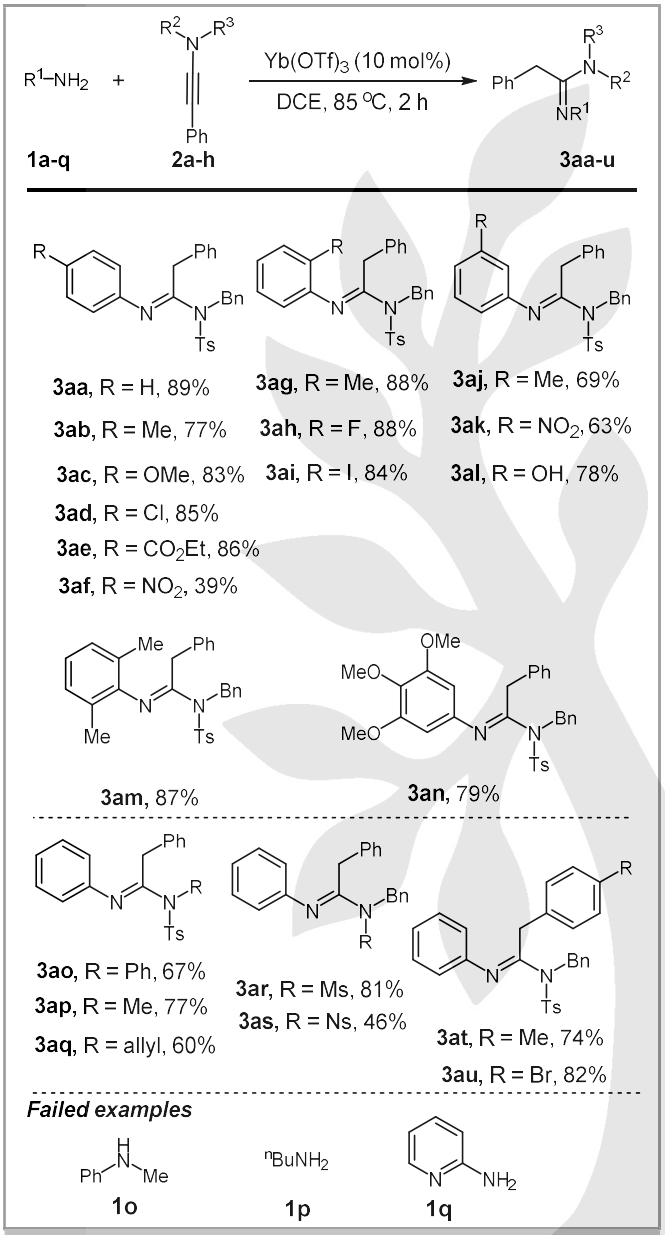


Entry	Catalyst [mol%]	Solvent	Temp. [°C]	Yield[%][b]
1	$BF_3{\cdot}OEt_2$ (10)	DCE	85	66
2	$FeCl_3$ (10)	DCE	85	35
3	$Bi(OTf)_3$ (10)	DCE	85	43
4	$Zn(OTf)_2$ (10)	DCE	85	57
5	$Yb(OTf)_3$ (10)	DCE	85	89
6	$Mg(OTf)_2$ (10)	DCE	85	trace
7	$Yb(OTf)_3$ (10)	toluene	85	45
8	$Yb(OTf)_3$ (10)	DMF	85	35
9	$Yb(OTf)_3$ (10)	1,4-dioxane	85	n.r.
10	$Yb(OTf)_3$ (10)	CH_3CN	85	n.r.
11	$Yb(OTf)_3$ (5)	DCE	85	71
12[c]	$Yb(OTf)_3$ (10)	DCE	85	77
13[d]	$Yb(OTf)_3$ (10)	DCE	85	88
14	$Yb(OTf)_3$ (10)	DCE	110	68
15	$Yb(OTf)_3$ (10)	DCE	60	63

[a] Unless otherwise stated, reactions were carried out on a 0.3 mmol scale of **2a**, **1a** (2 equiv.), catalyst (10 mol%) and solvent (2 mL) at 85 °C for 2 h in a sealed tube under air.
[b] Isolated products.
[c] **1a**:**2a** = 1.5:1.
[d] **1a**:**2a** = 3:1.

Subsequently, the scope of ynamides was examined (Scheme 3). The results demonstrated that substrates with phenyl, methyl and allyl moiety at the nitrogen position were readily transformed into desired products, albeit with lower yield (**3ao**-**q**). Similarly, by switching tosyl group at the nitrogen position to

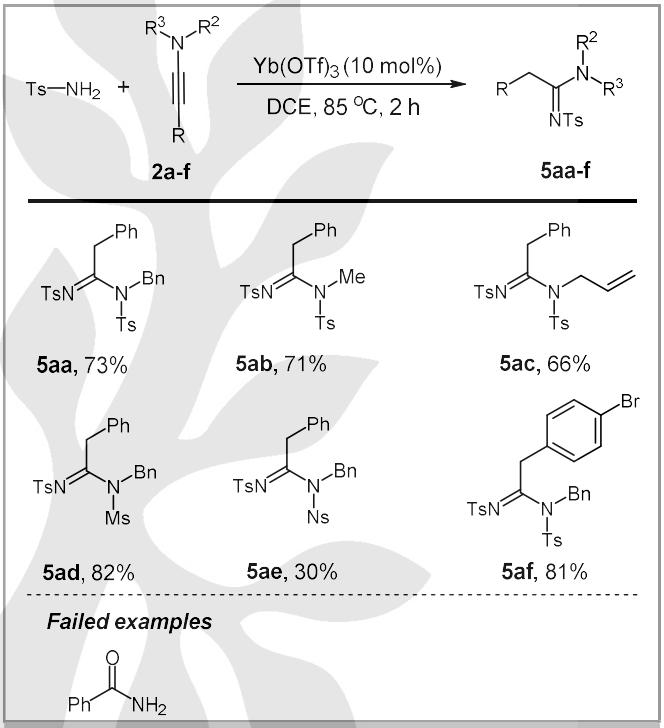
methyl sulfonyl and 4-nitrobenzene sulfonyl, the reaction proceeded smoothly to produce **3ar** and **3as** in 81% and 46% yield. Ynamides bearing methyl and bromo group at the *para*-position of phenyl ring were also subjected to the reaction to furnish **3at**-**u** in good yields. However, no reaction was detected with **1o**-**q** under standard reaction conditions.



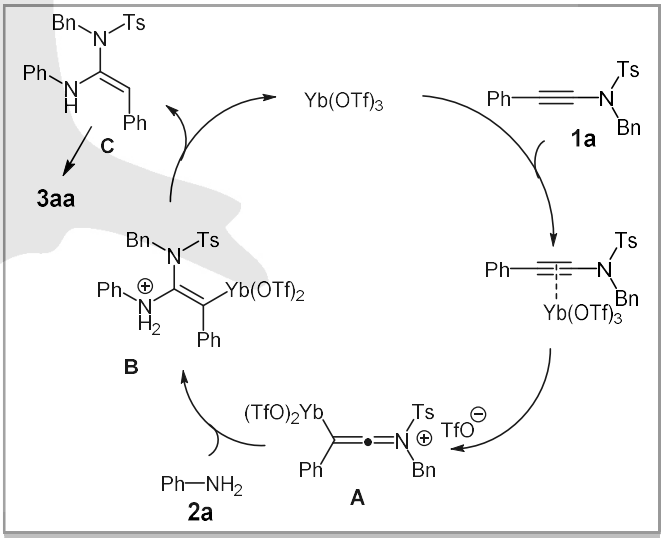
Scheme 3 Substrates scope of anilines and ynamides. Reaction conditions: **2** (0.3 mmol), **1** (2 equiv.), $Yb(OTf)_3$ (10 mol%) and DCE (2 mL) at 85 °C for 2 h in a sealed tube under air; Isolated Yields.

Inspired by the results obtained with aromatic amines, we were next intrigued to apply the present protocol for the hydroamination with $TsNH_2$, resulting **5aa** in 73% yield (Scheme 4). Pleasantly, ynamides with variation at the nitrogen position including methyl, allyl, methyl sulfonyl and 4-nitrobenzene sulfonyl were all tolerated to deliver **5ab**-**d** in moderate to good yield, while **5ae** was obtained in relative lower yield. Ynamide with bromine group at the phenyl ring was also viable substrates for the reaction to afford **5af** in 81% yield. However, the reaction with benzamide was completely shut down under the standard conditions.

Based on the results obtained above and previous reports,[2k, 2m] a plausible mechanism was proposed as shown in Scheme 5. Initially, the highly active ketenimine intermediate **A** was formed by the interaction of $Yb(OTf)_3$ with the triple bond of ynamide **1a**. Nucleophilic addition of aniline **2a** onto the ketenimine **A** would then lead to nitrenium ion intermediate **B**, followed by proton transfer process to afford intermediate **C,** which underwent tautomerization to afford amidine **3aa** and regenerate $Yb(OTf)_3$ to complete the cycle.



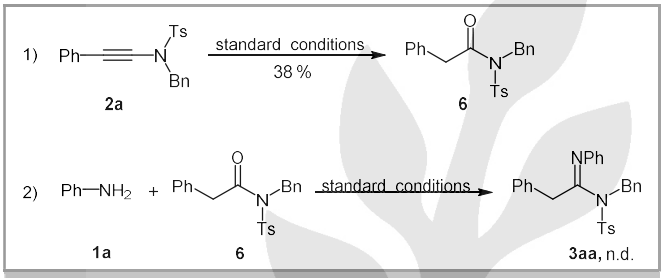
Scheme 4 Substrates scope of $TsNH_2$ and ynamides. Reaction conditions: **2** (0.3 mmol), $TsNH_2$ (2 equiv.), $Yb(OTf)_3$ (10 mol%) and DCE (2 mL) at 85 °C for 2 h in a sealed tube under air; Isolated Yields.



Scheme 5 Plausible mechanism

Although the mechanism proposed above seems to be reasonable based on previous report, control experiments were also

conducted to further verify the mechanism. Firstly, the reaction was conducted with **2a** as substrate under standard reaction conditions in the absence of aniline **1a**, compound **6** was isolated in 38% yield (Scheme 6, equation 1). Compound **6** was then subjected to the reaction with 2 equiv. of aniline **1a** under standard conditions, no desired product was detected in the reaction, and starting material compound **6** remained intact, to further exclude the possibility that **3aa** could be obtained by condensation of **1a** with the hydrolysed product **6** from **2a** (equation 2).



Scheme 6 Control experiments

3. Conclusion

In conclusion, we have developed a Lewis acid $Yb(OTf)_3$-catalyzed hydroamination reaction for the synthesis of a wide range of amidines from ynamides with $ArNH_2$ or $TsNH_2$. The broad functional group tolerance and usage of cheap catalyst has made it a practical method to access these valuable compounds. Further exploration of this methodology is ongoing in our lab.

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General information

All ^1H NMR (400 MHz) and ^{13}C NMR (100 MHz) spectra were recorded in $CDCl_3$. TMS was used as an internal reference and *J* values are given in Hz. HR-MS were obtained on a Bruker micrOTOF-Q II spectrometer. PE is petroleum ether (60–90 °C). All ynamides (**2a-h**)[8] are known compounds. They were prepared according to the reported procedures. Unless otherwise noted, materials obtained from commercial suppliers were used without further purification.

Preparation and characterizations of compounds 3aa-u, 5aa-f

A mixture of amines (**1a-q,** 2 equiv. 0.6 mmol), ynamides (**2a-h**, 0.3 mmol), $Yb(OTf)_3$ (16 mg, 0.03 mmol, 10 mol%) in DCE (2 mL) was stirred at 85 °C for 2 h (monitored by TLC). After it was cooled down to room temperature, the reaction was quenched by the slow addition of a saturated solution of Na_2CO_3. The mixture was poured into water (15 mL) and was extracted with EtOAc (3 x 15 mL). The combined organic layers were washed with brine (2 x 15 mL) and dried over $MgSO_4$. The solvent was removed by vacuum and the residue was purified by column chromatography (10% EtOAc in PE) to give the corresponding products **3aa-u**.

The similar procedure was used for the preparation of products **5aa–f**.

(*E*)-*N*-benzyl-*N*',2-diphenyl-*N*-tosylacetimidamide (**3aa**).[8e]

121.2 mg (89%); White solid; mp 94-96 °C;

^1H NMR (400MHz, $CDCl_3$) δ 7.75–7.73 (m, 2H), 7.35–7.32 (m, 2H), 7.25–7.20 (m, 3H), 7.18–7.07 (m, 5H), 7.03–6.98 (m, 3H), 6.79–6.77 (m, 2H), 6.43–6.41 (m, 2H), 4.65 (s, 2H), 3.87 (s, 2H), 2.46 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 155.6, 148.0, 144.1, 135.8, 135.3, 134.7, 129.5, 129.2, 129.0, 128.8, 128.4, 128.1, 128.0, 127.2, 126.4, 123.5, 119.4, 51.0, 37.7, 21.6.

(*E*)-*N*-benzyl-2-phenyl-*N*'-(*p*-tolyl)-*N*-tosylacetimidamide (**3ab**). 108.1 mg (77%); Yellow oil;

^1H NMR (400MHz, $CDCl_3$) δ 7.74–7.72 (m, 2H), 7.34–7.32 (m, 2H), 7.21–7.09 (m, 6H), 7.05–6.97 (m, 4H), 6.79–6.77 (m, 2H), 6.35–6.33 (m, 2H), 4.64 (s, 2H), 3.88 (s, 2H), 2.45 (s, 3H), 2.27 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 155.7, 145.5, 144.1, 135.8, 135.3, 134.8, 132.9, 129.6, 129.5, 129.2, 128.8, 128.3, 128.1, 128.0, 127.2, 126.4, 119.3, 51.0, 37.6, 21.6, 20.8.

HRMS *m/z* (ESI) calcd. for $C_{29}H_{28}N_2O_2SNa$ $(M + Na)^+$ 491.1764, found 491.1766.

(*E*)-*N*-benzyl-*N*'-(4-methoxyphenyl)-2-phenyl-*N*-tosylacetimidamide (**3ac**).

120.5 mg (83%); Yellow oil;

^1H NMR (400MHz, $CDCl_3$) δ 7.74–7.72 (m, 2H), 7.33–7.31 (m, 2H), 7.20–7.06 (m, 6H), 7.02–7.00 (m, 2H), 6.80–6.75 (m, 4H), 6.39–6.37 (m, 2H), 4.65 (s, 2H), 3.90 (s, 2H), 3.74 (s, 3H), 2.45 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 156.0 (2C), 144.1, 141.3, 135.8, 135.3, 134.8, 129.4, 129.1, 128.8, 128.3, 128.1, 128.0, 127.2, 126.4, 120.5, 114.3, 55.4, 51.0, 37.5, 21.6.

HRMS *m/z* (ESI) calcd. for $C_{29}H_{28}N_2O_3S$ $(M + H)^+$ 485.1893, found 485.1895.

(*E*)-*N*-benzyl-*N*'-(4-chlorophenyl)-2-phenyl-*N*-tosylacetimidamide (**3ad**).

124.4 mg (85%); off-white solid; mp 120–122 °C;

^1H NMR (400MHz, $CDCl_3$) δ 7.72–7.70 (m, 2H), 7.31–7.29 (m, 2H), 7.20–7.13 (m, 6H), 7.11–7.07 (m, 2H), 7.04–7.02 (m, 2H), 6.76–6.74 (m, 2H), 6.33–6.31 (m, 2H), 4.68 (s, 2H), 3.84 (s, 2H), 2.42 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 155.9, 146.5, 144.2, 135.8, 135.3, 134.4, 129.4, 128.9, 128.8, 128.7, 128.5, 128.4, 128.0 (2C), 127.3, 126.5, 120.8, 50.8, 37.4, 21.5.

HRMS *m/z* (ESI) calcd. for $C_{28}H_{25}ClN_2O_2S$ $(M + H)^+$ 489.1398, found 489.1398.

Ethyl (*E*)-4-((1-((*N*-benzyl-4-methylphenyl)sulfonamido)-2-phenylethylidene)amino)benzoate (**3ae**).

135.7 mg (86%); white solid; mp 110–112 °C;

^1H NMR (400MHz, $CDCl_3$) δ 7.92–7.90 (m, 2H), 7.74–7.72 (m, 2H), 7.33–7.31 (m, 2H), 7.22–7.14 (m, 4H), 7.12–7.08 (m, 2H), 7.06–7.04 (m, 2H), 6.78–6.76 (m, 2H), 6.43–6.41 (m, 2H), 4.70 (s, 2H), 4.31 (q, *J* = 7.1 Hz, 2H), 3.83 (s, 2H), 2.44 (s, 3H), 1.34 (t, *J* = 7.1 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 166.1, 155.2, 152.0, 144.3, 135.7, 135.2, 134.2, 130.6, 129.4, 128.8, 128.4, 128.3, 128.0 (2C), 127.3, 126.6, 125.5, 119.2, 60.6, 50.9, 37.6, 21.5, 14.2.

HRMS *m/z* (ESI) calcd. for $C_{31}H_{30}N_2O_4S$ $(M + H)^+$ 527.1999, found 527.1997.

(*E*)-*N*-benzyl-*N*'-(4-nitrophenyl)-2-phenyl-*N*-tosylacetimidamide (**3af**).

58.4 mg (39%); Yellow solid; mp 146–148 °C;

^1H NMR (400MHz, $CDCl_3$) δ 8.07–8.05 (m, 2H), 7.73–7.71 (m, 2H), 7.36–7.33 (m, 2H), 7.26–7.07 (m, 8H), 6.76–6.74 (m, 2H), 6.44–6.42 (m, 2H), 4.77 (s, 2H), 3.82 (s, 2H), 2.48 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 155.4, 153.8, 144.6, 143.6, 135.8, 135.5, 133.9, 129.6, 128.6 (2C), 128.3 (2C), 128.2, 127.6, 126.9, 124.9, 119.9, 50.9, 37.8, 21.7.

HRMS *m/z* (ESI) calcd. for $C_{28}H_{25}N_3O_4S$ $(M + H)^+$ 500.1639, found 500.1637.

(*E*)-*N*-benzyl-2-phenyl-*N*'-(*o*-tolyl)-*N*-tosylacetimidamide (**3ag**). 123.6 mg (88%); white solid; mp 86-88 °C;

^1H NMR (400MHz, $CDCl_3$) δ 7.78–7.76 (m, 2H), 7.30–7.28 (m, 2H), 7.20–7.11 (m, 6H), 7.07–7.00 (m, 4H), 6.93–6.85 (m, 3H), 6.22 (m, 1H), 4.77 (s, 2H), 3.79 (s, 2H), 2.42 (s, 3H), 1.76 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 155.3, 146.7, 144.1, 136.2, 135.9, 134.6, 130.3, 129.5, 129.2, 128.3, 128.2, 128.1, 128.0, 127.6, 127.2, 126.5, 126.3, 123.6, 118.9, 50.9, 37.7, 21.5, 17.8.

HRMS *m/z* (ESI) calcd. for $C_{29}H_{28}N_2O_2S$ (M + H)$^+$ 469.1944, found 469.1945.

(*E*)-*N*-benzyl-*N*'-(2-fluorophenyl)-2-phenyl-*N*-tosylacetimidamide (**3ah**).

124.6 mg (88%); Colorless oil;

^{1}H NMR (400MHz, $CDCl_3$) δ 7.77-7.75 (m, 2H), 7.31-7.29 (m, 2H), 7.21-7.11 (m, 4H), 7.09-6.94 (m, 7H), 6.78-6.76 (m, 2H), 6.46-6.36 (m, 1H), 4.67 (s, 2H), 3.91 (s, 2H), 2.41 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 158.3, 151.8 (q, $J_{C\text{-}F}$ = 243 Hz), 144.1, 135.7, 135.6, 135.0, 134.3, 129.5, 129.1, 128.7, 128.3, 128.0, 127.9, 127.2, 126.4, 124.6 (q, $J_{C\text{-}F}$ = 7 Hz), 124.3 (q, $J_{C\text{-}F}$ = 3 Hz), 122.3, 115.8 (q, $J_{C\text{-}F}$ = 20 Hz), 51.0, 38.5, 21.5.

HRMS *m/z* (ESI) calcd. for $C_{28}H_{25}FN_2O_2S$ (M + H)$^+$ 473.1694, found 473.1696.

(*E*)-*N*-benzyl-*N*'-(2-iodophenyl)-2-phenyl-*N*-tosylacetimidamide (**3ai**). [8c]

146.2 mg (84%); Yellow oil;

^{1}H NMR (400MHz, $CDCl_3$) δ 7.84–7.82 (m, 2H), 7.75–7.73 (m, 1H), 7.30–7.28 (m, 2H), 7.23–7.12 (m, 9H), 6.89–6.88 (m, 2H), 6.71–6.67 (m, 1H), 6.25–6.23 (m, 1H), 4.83 (s, 2H), 3.80 (s, 2H), 2.43 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 156.6, 149.5, 144.1, 138.9, 136.4, 136.2, 134.6, 129.5, 128.9, 128.8, 128.4 (3C), 128.1, 127.3, 126.6, 124.8, 120.0, 90.1, 50.8, 38.1, 21.6.

(*E*)-*N*-benzyl-2-phenyl-*N*'-(*m*-tolyl)-*N*-tosylacetimidamide (**3aj**).

96.9 mg (69%); White solid; mp 91-93 °C;

^{1}H NMR (400MHz, $CDCl_3$) δ 7.74–7.73 (m, 2H), 7.32–7.30 (m, 2H), 7.19–7.07 (m, 7H), 7.03–7.01 (m, 2H), 6.82–6.78 (m, 3H), 6.27–6.19 (m, 2H), 4.65 (s, 2H), 3.88 (s, 2H), 2.43 (s, 3H), 2.25 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 155.4, 147.9, 144.0, 138.7, 135.8, 135.3, 134.7, 129.4, 129.1, 128.7 (2C), 128.2, 128.0, 127.9, 127.1, 126.3, 124.2, 120.0, 116.4, 50.9, 37.6, 21.5, 21.3.

HRMS *m/z* (ESI) calcd. for $C_{29}H_{28}N_2O_2S$ (M + H)$^+$ 469.1944, found 469.1946.

(*E*)-*N*-benzyl-*N*'-(3-nitrophenyl)-2-phenyl-*N*-tosylacetimidamide (**3ak**).

94.3 mg (63%); Yellow solid; mp 104-106 °C;

^{1}H NMR (400MHz, $CDCl_3$) δ 7.84–7.81 (m, 1H), 7.75–7.73 (m, 2H), 7.37–7.32 (m, 3H), 7.27–7.23 (m, 3H), 7.17–7.12 (m, 6H), 6.74–6.72 (m, 2H), 6.67–6.65 (m, 1H), 4.78 (s, 2H), 3.82 (s, 2H), 2.49 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 156.7, 148.9, 148.6, 144.6, 135.9, 135.5, 134.0, 129.7, 129.6, 128.6 (2C), 128.3 (2C), 128.2, 127.6, 126.9, 125.8, 118.1, 114.7, 50.9, 37.5, 21.7.

HRMS *m/z* (ESI) calcd. for $C_{28}H_{25}N_3O_4S$ (M + H)$^+$ 500.1639, found 500.1637.

(*E*)-*N*-benzyl-*N*'-(3-hydroxyphenyl)-2-phenyl-*N*-tosylacetimidamide (**3al**).

110.0 mg (78%); White solid; mp 100-102 °C;

^{1}H NMR (400MHz, $CDCl_3$) δ 7.72–7.70 (m, 2H), 7.30–7.28 (m, 2H), 7.18–6.98 (m, 9H), 6.78–6.76 (m, 2H), 6.48–6.46 (m, 1H), 5.98–5.97 (m, 2H), 5.67 (brs, 1H), 4.63 (s, 2H), 3.84 (s, 2H), 2.40 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 156.3, 155.6, 149.3, 144.3, 135.6, 135.0, 134.5, 130.0, 129.5, 129.0, 128.6, 128.3, 128.0 (2C), 127.2, 126.4, 111.8, 110.6, 106.6, 50.9, 37.6, 21.5.

HRMS *m/z* (ESI) calcd. for $C_{28}H_{26}N_2O_3S$ (M + H)$^+$ 471.1737, found 471.1737.

(*E*)-*N*-benzyl-*N*'-(2,6-dimethylphenyl)-2-phenyl-*N*-tosylacetimidamide (**3am**).

125.8 mg (87%); off-white solid; mp 95-97 °C;

^{1}H NMR (400MHz, $CDCl_3$) δ 7.81–7.79 (m, 2H), 7.30–7.27 (m, 2H), 7.21–7.12 (m, 6H), 7.07–7.05 (m, 2H), 7.00–6.96 (m, 2H), 6.91–6.89 (m, 2H), 6.87-6.80 (m, 1H), 4.93 (s, 2H), 3.70 (s, 2H), 2.43 (s, 3H), 1.63 (s, 6H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 155.4, 145.5, 144.1, 136.9, 136.8, 134.4, 129.5, 129.2, 128.4, 128.3, 128.2, 128.0, 127.4, 127.2, 126.9, 126.8, 123.2, 50.8, 37.7, 21.6, 18.1.

HRMS *m/z* (ESI) calcd. for $C_{30}H_{30}N_2O_2S$ (M + H)$^+$ 483.2101, found 483.2102.

(*E*)-*N*-benzyl-2-phenyl-*N*-tosyl-*N*'-(3,4,5-trimethoxyphenyl)acetimidamide (**3an**).

129.0 mg (79%); Yellow oil;

^{1}H NMR (400MHz, $CDCl_3$) δ 7.75–7.73 (m, 2H), 7.34–7.32 (m, 2H), 7.21–7.09 (m, 6H), 7.07–7.06 (m, 2H), 6.82–6.80 (m, 2H), 5.53 (s, 2H), 4.71 (s, 2H), 3.89 (s, 2H), 3.76 (s, 3H), 3.66 (s, 6H), 2.44 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 155.7, 153.3, 144.1, 144.0, 135.9, 135.4, 134.8, 133.8, 129.4, 128.9, 128.8, 128.2, 128.1, 127.9, 127.2, 126.4, 96.6, 60.8, 55.8, 51.0, 37.7, 21.5.

HRMS *m/z* (ESI) calcd. for $C_{31}H_{32}N_2O_5S$ (M + H)$^+$ 545.2105, found 545.2103.

(*E*)-*N*,*N*',2-triphenyl-*N*-tosylacetimidamide (**3ao**).

88.4 mg (67%); White solid; mp 88-90 °C;

^{1}H NMR (400MHz, $CDCl_3$) δ 7.78–7.76 (m, 2H), 7.37–7.33 (m, 1H), 7.28–7.25 (m, 6H), 7.20–7.19 (m, 3H), 7.05–6.97 (m, 3H), 6.85–6.84 (m, 2H), 6.73–6.71 (m, 2H), 3.36 (s, 2H), 2.43 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 154.6, 147.9, 143.6, 136.7, 136.6, 134.8, 130.6, 129.8, 129.0, 128.9, 128.8, 128.6, 128.5, 128.4, 126.6, 123.5, 119.9, 35.8, 21.6.

HRMS *m/z* (ESI) calcd. for $C_{27}H_{24}N_2O_2S$ (M + H)$^+$ 441.1631, found 441.1633.

(*E*)-*N*-methyl-*N*',2-diphenyl-*N*-tosylacetimidamide (**3ap**).[8e]

87.3 mg (77%); White solid; mp 106-108 °C;

^{1}H NMR (400MHz, $CDCl_3$) δ 7.65–7.63 (m, 2H), 7.28–7.19 (m, 7H), 7.10–6.99 (m, 3H), 6.63–6.61 (m, 2H), 4.03 (s, 2H), 3.10 (s, 3H), 2.40 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 157.3, 148.0, 143.9, 135.6, 134.9, 129.3, 129.0, 128.6 (2C), 127.8, 126.6, 123.5, 119.7, 37.0, 35.6, 21.5.

(*E*)-*N*-allyl-*N*',2-diphenyl-*N*-tosylacetimidamide (**3aq**).

72.7 mg (60%); Yellow oil;

^{1}H NMR (400MHz, $CDCl_3$) δ 7.74–7.72 (m, 2H), 7.27–7.19 (m, 7H), 7.08–7.00 (m, 3H), 6.61–6.59 (m, 2H), 5.55–5.46 (m, 1H), 5.15–5.03 (m, 2H), 4.19–4.18 (m, 2H), 3.90 (s, 2H), 2.41 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 155.4, 147.9, 143.8, 135.8, 134.8, 132.9, 129.1, 128.9 (2C), 128.4, 128.3, 126.7, 123.5, 119.6, 118.2, 49.7, 37.0, 21.5.

HRMS *m/z* (ESI) calcd. for $C_{24}H_{24}N_2O_2S$ (M + H)$^+$ 405.1631, found 405.1633.

(*E*)-*N*-benzyl-*N*-(methylsulfonyl)-*N*',2-diphenylacetimidamide (**3ar**).[8e]

91.9 mg (81%); White solid; mp 88-90 °C;

^{1}H NMR (400MHz, $CDCl_3$) δ 7.33–7.21 (m, 10H), 7.07–6.99 (m, 3H), 6.74–6.72 (m, 2H), 4.84 (s, 2H), 3.81 (s, 2H), 3.08 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 156.0, 147.9, 136.5, 134.5, 129.1, 128.7, 128.6 (2C), 127.9, 127.6, 126.9, 123.7, 119.7, 50.0, 41.7, 36.3.

(*E*)-*N*-benzyl-*N*-((4-nitrophenyl)sulfonyl)-*N*',2-diphenylacetimidamide (**3as**).

66.9 mg (46%); Yellow solid; mp 124-126 °C.

^{1}H NMR (400MHz, $CDCl_3$) δ 8.31–8.29 (m, 2H), 8.00–7.98 (m, 2H), 7.27–7.16 (m, 8H), 7.06–7.02 (m, 3H), 6.89–6.87 (m, 2H), 6.52–6.50 (m, 2H), 4.76 (s, 2H), 3.78 (s, 2H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 155.1, 150.1, 147.3, 144.7, 135.4, 134.0, 129.7, 129.2, 128.7, 128.6, 128.5, 128.0, 127.7, 126.9, 124.0, 123.7, 119.4, 50.8, 36.8.

HRMS *m/z* (ESI) calcd. for $C_{27}H_{23}N_3O_4S$ (M + H)$^+$ 486.1482, found 486.1485.

(*E*)-*N*-benzyl-*N*'-phenyl-2-(*p*-tolyl)-*N*-tosylacetimidamide (**3at**). 103.9 mg (74%); White solid; mp 94–96 °C;

^{1}H NMR (400MHz, $CDCl_3$) δ 7.75–7.73 (m, 2H), 7.33–7.31 (m, 2H), 7.23–7.18 (m, 3H), 7.16–7.12 (m, 2H), 7.06–6.97 (m, 3H), 6.91–6.89 (m, 2H), 6.69–6.67 (m, 2H), 6.44–6.42 (m, 2H), 4.67 (s, 2H), 3.81 (s, 2H), 2.45 (s, 3H), 2.30 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 155.7, 148.0, 144.0, 136.0, 135.9, 135.4, 131.5, 129.4, 129.0, 128.9 (2C), 128.6, 128.1, 128.0, 127.1, 123.4, 119.5, 50.9, 37.1, 21.6, 21.0.

HRMS *m/z* (ESI) calcd. for $C_{29}H_{28}N_2O_2S$ (M + H)$^+$ 469.1944, found 469.1945.

(*E*)-*N*-benzyl-2-(4-bromophenyl)-*N*'-phenyl-*N*-tosylacetimidamide (**3au**).

130.9 mg (82%); Yellow solid; mp 118–120 °C;

^{1}H NMR (400MHz, $CDCl_3$) δ 7.75–7.73 (m, 2H), 7.37-7.35 (m, 2H), 7.27–7.20 (m, 3H), 7.17–7.13 (m, 4H), 7.05–6.99 (m, 3H), 6.62–6.60 (m, 2H), 6.43–6.42 (m, 2H), 4.59 (s, 2H), 3.86 (s, 2H), 2.46 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 155.6, 147.9, 144.3, 135.2, 134.9, 133.6, 131.3, 131.0, 129.7, 129.2, 129.1, 128.0, 127.8, 127.4, 123.8, 120.4, 119.2, 51.3, 37.6, 21.6.

HRMS *m/z* (ESI) calcd. for $C_{28}H_{25}BrN_2O_2S$ (M + H)$^+$ 533.0893, found 533.0895.

***N*-benzyl-2-phenyl-*N*,*N*'-ditosylacetimidamide** (**5aa**).

116.5 mg (73%); White solid; mp 112–114 °C;

^{1}H NMR (400MHz, $CDCl_3$) δ 7.74–7.72 (m, 2H), 7.33–7.28 (m, 7H), 7.26–7.25 (m, 3H), 7.15–7.13 (m, 2H), 7.04–7.02 (m, 2H), 6.98–6.93 (m, 2H), 4.93 (s, 2H), 4.39 (s, 2H), 2.47 (s, 3H), 2.40 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 165.2, 144.9, 143.3, 138.6, 135.8, 135.1, 132.8, 129.2, 129.1, 129.0, 128.9, 128.7, 127.9, 127.8, 127.3, 127.0, 126.4, 49.9, 39.1, 21.7, 21.6.

HRMS *m/z* (ESI) calcd. for $C_{29}H_{28}N_2O_4S_2$ (M + H)$^+$ 533.1563, found 533.1565.

***N*-methyl-2-phenyl-*N*,*N*'-ditosylacetimidamide** (**5ab**).

97.1 mg (71%); White solid; mp 86–88 °C;

^{1}H NMR (400MHz, $CDCl_3$) δ 7.76–7.74 (m, 2H), 7.34–7.29 (m, 4H), 7.28–7.25 (m, 3H), 7.08–7.02 (m, 4H), 4.52 (s, 2H), 3.22 (s, 3H), 2.45 (s, 3H), 2.37 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 165.4, 144.7, 143.2, 138.7, 134.9, 132.6, 129.1, 129.1, 128.9, 128.2, 128.1, 127.2, 126.8, 39.2, 34.1, 21.5 (2C).

HRMS *m/z* (ESI) calcd. for $C_{23}H_{24}N_2O_4S_2$ (M + H)$^+$ 457.1250, found 457.1252.

***N*-allyl-2-phenyl-*N*,*N*'-ditosylacetimidamide** (**5ac**).

95.4 mg (66%); Yellow solid; mp 76–78 °C;

^{1}H NMR (400MHz, $CDCl_3$) δ 7.76–7.74 (m, 2H), 7.38–7.36 (m, 2H), 7.32–7.30 (m, 2H), 7.27–7.24 (m, 3H), 7.03–7.01 (m, 4H), 5.83–5.72 (m, 1H), 5.27–5.17 (m, 2H), 4.46 (s, 2H), 4.37 (dt, *J* = 4.9, 1.7 Hz, 2H), 2.46 (s, 3H), 2.38 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 164.9, 144.7, 143.2, 138.6, 135.2, 132.8, 132.4, 129.1, 129.0, 128.9, 128.7, 127.8, 127.3, 126.9, 118.2, 48.6, 38.7, 21.6, 21.5.

HRMS *m/z* (ESI) calcd. for $C_{25}H_{26}N_2O_4S_2$ (M + H)$^+$ 483.1407, found 483.1408.

***N*-benzyl-*N*-(methylsulfonyl)-2-phenyl-*N*'-tosylacetimidamide** (**5ad**).

112.2 mg (82%); White solid; mp 96–98 °C;

^{1}H NMR (400MHz, $CDCl_3$) δ 7.84–7.82 (m, 2H), 7.36–7.28 (m, 8H), 7.24–7.22 (m, 2H), 7.17–7.16 (m, 2H), 4.86 (s, 2H), 4.57 (s, 2H), 2.98 (s, 3H), 2.43 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 166.6, 143.5, 138.6, 135.5, 132.6, 129.4, 129.3, 129.1, 128.3, 128.0, 127.6, 126.7, 126.6, 49.6, 42.8, 38.6, 21.6.

HRMS *m/z* (ESI) calcd. for $C_{23}H_{24}N_2O_4S_2$ (M + H)$^+$ 457.1250, found 457.1251.

***N*-benzyl-*N*-((4-nitrophenyl)sulfonyl)-2-phenyl-*N*'-tosylacetimidamide** (**5ae**).

50.7 mg (30%); Yellow solid; mp 118–120 °C;

^{1}H NMR (400MHz, $CDCl_3$) δ 7.94–7.91 (m, 2H), 7.74–7.72 (m, 2H), 7.48–7.45 (m, 2H), 7.40–7.32 (m, 8H), 7.18–7.17 (m, 2H), 7.06–7.04 (m, 2H), 4.97 (s, 2H), 4.39 (s, 2H), 2.53 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 165.2, 150.1, 144.1, 144.0, 138.1, 135.1, 132.1, 129.6, 129.5, 129.3 (2C), 128.3, 127.9, 127.8, 127.1, 126.3, 123.4, 49.7, 39.0, 21.6.

HRMS *m/z* (ESI) calcd. for $C_{28}H_{25}N_3O_6S_2$ (M + H)$^+$ 564.1258, found 564.1259.

***N*-benzyl-2-(4-bromophenyl)-*N*,*N*'-ditosylacetimidamide** (**5af**).

148.2 mg (81%); Yellow solid; mp 104–106 °C;

^{1}H NMR (400MHz, $CDCl_3$) δ 7.68–7.66 (m, 2H), 7.35–7.25 (m, 9H), 7.10–7.06 (m, 4H), 6.83–6.81 (m, 2H), 4.90 (s, 2H), 4.41 (s, 2H), 2.47 (s, 3H), 2.41 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 164.8, 145.1, 143.5, 138.4, 135.4, 135.0, 131.9 (2C), 129.8, 129.3, 129.2, 128.9, 128.4, 127.8, 127.0, 126.7, 121.3, 50.4, 38.5, 21.7, 21.6.

HRMS *m/z* (ESI) calcd. for $C_{29}H_{27}BrN_2O_4S_2$ (M + H)$^+$ 611.0668, found 611.0669.

***N*-benzyl-2-phenyl-*N*-tosylacetamide (6)**[16]

72.0 mg (38%); White solid; mp 123–125 °C

^{1}H NMR (400MHz, $CDCl_3$) δ. 7.64 (d, *J* = 8.4 Hz, 2H), 7.36–7.29 (m, 5H), 7.27–7.22 (m, 5H), 6.99–6.97 (m, 2H), 5.07 (s, 2H), 3.86 (s, 2H), 2.42 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ. 171.2, 144.9, 136.5, 136.4, 133.1, 129.6, 129.2, 128.6, 128.5, 127.9, 127.7, 127.6, 127.1, 49.6, 42.8, 21.6.

Funding Information

This study was supported by National College Students Innovation and Entrepreneurship Training Program (202010304044Z), the Jiangsu's Mass Entrepreneurship and Innovation Program, the Start-Up Funding for Research of Nantong University (03081231), and the Large Instruments Open Foundation of Nantong University (KFJN2175; KFJN2176)

Acknowledgment

We would like to thank the Analysis Center of Nantong University for the Large Instruments Open Foundation.

Supporting Information

YES (this text will be updated with links prior to publication)

Primary Data

NO (this text will be deleted prior to publication)

References

(1) (a) Wu, W.; Jiang, H. *Acc. Chem. Res.* **2014**, *47*, 2483; (b) Minehan, T. G. *Acc. Chem. Res.* **2016**, *49*, 1168. (c) Gabriele, B.; Mancuso, R.; Larock, R. C. *Curr. Org. Chem.* **2014**, *18*, 341. (d) Campeau, D.; León Rayo, D. F.; Mansour, A.; Muratov, K.; Gagosz, F. *Chem. Rev.* **2020**, https://doi.org/10.1021/acs.chemrev.0c00788. (e) Bag, D.; Sawant, S. D. *Chem. Eur. J.* **2021**, *27*, 1165. (f) Suleymanov, A. A.; Severin, K. *Angew. Chem. Int. Ed.* **2021**, *60*, 6879. (g) Hari, D. P.; Caramenti, P.; Waser, J. *Acc. Chem. Res.* **2018**, *51*, 3212.

(2) For selected review in ynamides, see: (a) DeKorver, K. A.; Li, H.; Lohse, A. G.; Hayashi, R.; Lu, Z.; Zhang, Y.; Hsung, R. P. *Chem. Rev.* **2010**, *110*, 5064. (b) Wang, X.-N.; Yeom, H.-S.; Fang, L.-C.; He, S.; Ma, Z.-X.; Kedrowski, B. L.; Hsung, R. P. *Acc. Chem. Res.* **2014**, *47*, 560. (c) Chen, Y.-B.; Qian, P.-C.; Ye, L.-W. *Chem. Soc. Rev.* **2020**, *49*, 8897. (d) Hong, F.-L.; Ye, L.-W. *Acc. Chem. Res.* **2020**, *53*, 2003. (e) Luo, J.; Chen, G.-S.; Chen, S.-J.; Yu, J.-S.; Li, Z.-D.; Liu, Y.-L. *ACS Catal.* **2020**, *10*, 13978. (f) Lynch, C. C.; Sripada, A.; Wolf, C. *Chem. Soc. Rev.* **2020**, *49*, 8543. (g) Mahe, C.; Cariou, K. *Adv. Synth. Catal.* **2020**, *362*, 4820. (h) Hu, Y.-C.; Zhao, Y.; Wan, B.; Chen, Q.-A. *Chem. Soc. Rev.* **2021**, *50*, 2582. (i) Tan, T.-D.; Wang, Z.-S.; Qian, P.-C.; Ye, L.-W. *Small Methods* **2021**, https://doi.org/10.1002/smtd.202000673. (j) Madelaine, C.; Valerio, V.; Maulide, N. *Chem. Asian J.* **2011**, *6*, 2224. (k) Evano, G.; Coste, A.; Jouvin, K. *Angew. Chem. Int. Ed.* **2010**, *49*, 2840. (l) Dodd, R. H.; Cariou, K. *Chem. Eur. J.* **2018**, *24*, 2297. (m) Zhou, B.; Tan, T.-D.; Zhu, X.-Q.; Shang, M.; Ye, L.-W. *ACS Catal.* **2019**, *9*, 6393.

(3) For selected examples, see: (a) Li, L.; Chen, X.-M.; Wang, Z.-S.; Zhou, B.; Liu, X.; Lu, X.; Ye, L.-W. *ACS Catal.* **2017**, *7*, 4004. (b) Frischmuth, A.; Knochel, P. *Angew. Chem. Int. Ed.* **2013**, *52*, 10084. (c) Xu, W.; Chen, Y.; Wang, A.; Liu, Y. *Org. Lett.* **2019**, *21*, 7613. (d) Zhu, C.; Kou, L.; Bao, X. *Chin. J. Chem.* **2020**, *38*, 57. (e) Tian, X.; Song, L.; Rudolph, M.; Rominger, F.; Hashmi, A. S. K. *Org. Lett.* **2019**, *21*, 4327. (f) Shu, C.; Wang, Y.-H.; Zhou, B.; Li, X.-L.; Ping, Y.-F.; Lu, X.; Ye, L.-W. *J. Am. Chem. Soc.* **2015**, *137*, 9567. (g) Jin, H.; Huang, L.; Xie, J.; Rudolph, M.; Rominger, F.; Hashmi, A. S. K. *Angew. Chem. Int. Ed.* **2016**, *55*, 794.

(4) For selected examples, see: (a) Vanjari, R.; Dutta, S.; Gogoi, M. P.; Gandon, V.; Sahoo, A. K. *Org. Lett.* **2018**, *20*, 8077. (b) Rode, N. D.; Arcadi, A.; Nicola, A. D.; Marinelli, F.; Michelet, V. *Org. Lett.* **2018**, *20*, 5103. (c) Jin, H.; Tian, B.; Song, X.; Xie, J.; Rudolph, M.; Rominger, F.; Hashmi, A. S. K. *Angew. Chem. Int. Ed.* **2016**, *55*, 12688. (d) Oh, K. H.; Kim, J. G.; Park, J. K. *Org. Lett.* **2017**, *19*, 3994. (e) Wezeman, T.; Zhong, S.; Nieger, M.; Bräse, S. *Angew. Chem. Int. Ed.* **2016**, *55*, 3823.

(5) For selected examples, see: (a) Wang, Y.; Song, L.-J.; Zhang, X.; Sun, J. *Angew. Chem. Int. Ed.* **2016**, *55*, 9704. (b) Gati, W.; Rammah, M. M.; Rammah, M. B.; Couty, F.; Evano, G. *J. Am. Chem. Soc.* **2012**, *134*, 9078. (c) Xie, L.-G.; Shaaban, S.; Chen, X.; Maulide, N. *Angew. Chem. Int. Ed.* **2016**, *55*, 12864. (d) Garcia, P.; Evanno, Y.; George, P.; Sevrin, M.; Ricci, G.; Malacria, M.; Aubert, C.; Gandon, V. *Org. Lett.* **2011**, *13*, 2030.

(6) For selected examples, see: (a) Zhu, L.; Yu, Y.; Mao, Z.; Huang, X. *Org. Lett.* **2015**, *17*, 30. (b) Zang, W.; Wei, Y.; Shi, M. *Org. Lett.* **2020**, *22*, 5466. (c) Prabagar, B.; Mallick, R. K.; Prasad, R.; Gandon, V.; Sahoo, A. K. *Angew. Chem. Int. Ed.* **2019**, *58*, 2365. (d) Dutta, S.; Mallick, R. K.; Prasad, R.; Gandon, V.; Sahoo, A. K. *Angew. Chem. Int. Ed.* **2019**, *58*, 2289. (e) Zhou, A.-H.; He, Q.; Shu, C.; Yu, Y.-F.; Liu, S.; Zhao, T.; Zhang, W.; Lu, X.; Ye, L.-W. *Chem. Sci.* **2015**, *6*, 1265.

(7) For selected examples, see: (a) Kong, Y.; Jiang, K.; Cao, J.; Fu, L.; Yu, L.; Lai, G.; Cui, Y.; Hu, Z.; Wang, G. *Org. Lett.* **2013**, *15*, 422. (b) Okitsu, T.; Nakata, K.; Nishigaki, K.; Michioka, N.; Karatani, M.; Wada, A. *J. Org. Chem.* **2014**, *79*, 5914. (c) Oppenheimer, J.; Johnson, W. L.; Tracey, M. R.; Hsung, R. P.; Yao, P.-Y.; Liu, R.; Zhao, K. *Org. Lett.* **2007**, *9*, 2361.

(8) For selected examples, see: (a) Zhang, Y.; DeKorver, K. A.; Lohse, A. G.; Zhang, Y.-S.; Huang, J.; Hsung, R. P. *Org. Lett.* **2009**, *11*, 899. (b) Coste, A.; Couty, F.; Evano, G. *Org. Lett.* **2009**, *11*, 4454. (c) Kramer, S.; Dooleweerdt, K.; Lindhardt, A. T.; Rottländer, M.; Skrydstrup, T. *Org. Lett.* **2009**, *11*, 4208. (d) Cao, Z.; Yan, S.; Zhao, C.; Sun, X.; Tian, L.; Meng, X. *Tetrahedron* **2019**, *75*, 130534. (e) Kim, Y. H.; Yoo, H. J.; Youn, S. W. *Chem. Comm.* **2020**, *56*, 13963. (f) Kong, Y.; Yu, L.; Cui, Y.; Cao, J. *Synthesis* **2014**, *46*, 183. (g) Yu, L.; Deng, Y.; Cao, J. *Synthesis* **2015**, *47*, 783. (h) Liu, D.; Nie, Q.; Zhang, R.; Cai, M. *Adv. Synth. Catal.* **2018**, *360*, 3940. (i) Hentz, A.; Retailleau, P.; Gandon, V.; Cariou, K.; Dodd, R. H. *Angew. Chem. Int. Ed.* **2014**, *53*, 8333. (j) Nie, X.-D.; Han, X.-L.; Sun, J.-T.; Si, C.-M.; Wei, B.-G.; Lin, G.-Q. *J. Org. Chem.* **2021**, *86*, 3433. (k) Chen, Z. Nie, X.-D.; Sun, J.-T.; Yang, A.-M.; Wei, B.-G. *Org. Biomol. Chem.* **2021**, *19*, 2492.

(9) For selected examples, see: (a) Compain, G.; Jouvin, K.; Martin-Mingot, A.; Evano, G.; Marrot, J.; Thibaudeau, S. *Chem. Comm.* **2012**, *48*, 5196. (b) Plamont, R.; Graux, L. V.; Clavier, H. *Eur. J. Org. Chem.* **2018**, *2018*, 1372. (c) Mulder, J. A.; Kurtz, K. C. M.; Hsung, R. P.; Coverdale, H.; Frederick, M. O.; Shen, L.; Zificsak, C. A. *Org. Lett.* **2003**, *5*, 1547. (d) Yang, Y.; Wang, L.; Zhang, F.; Zhu, G. *J. Org. Chem.* **2014**, *79*, 9319. (e) Bai, Y.; Zhang, F.; Shen, J.; Luo, F.; Zhu, G. *Asian J. Org. Chem.* **2015**, *4*, 626. (f) Yang, Y.; Wang, L.; Zhang, J.; Jin, Y.; Zhu, G. *Chem. Commun.* **2014**, *50*, 2347. (g) Ding, R.; Li, Y.; Tao, C.; Cheng, B.; Zhai, H. *Org. Lett.* **2015**, *17*, 3994. (h) Xu, S.; Liu, J.; Hu, D.; Bi, X. *Green Chem.* **2015**, *17*, 184. (i) Liu, Y.-W.; Ma, R.-J.; Wang, Q.-E.; Si, C.-M.; Wei, B.-G. *Tetrahedron* **2020**, *76*, 131649. (j) Dutta, S.; Yang, S.; Vanjari, R.; Mallick, R. K.; Gandon, V.; Sahoo, A. K. *Angew. Chem. Int. Ed.* **2020**, *59*, 10785.

(10) For slected examples, see: (a) Yeh, M.-C. P.; Liang, C.-J.; Chen, H.-F.; Weng, Y.-T. *Adv. Synth. Catal.* **2015**, *357*, 3242. (b) Giri, S. S.; Liu, R.-S. *Adv. Synth. Catal.* **2017**, *359*, 3311. (c) Wang, X.-N.; Winston-McPherson,G. N.; Walton, M. C.; Zhang, Y.; Hsung, R. P.; DeKorver, K. A. *J. Org. Chem.* **2013**, *78*, 6233. (d) Liu, H.; Yang, Y.; Wang, S.; Wu, J.; Wang, X.-N.; Chang, J. *Org. Lett.* **2015**, *17*, 4472. (e) Wang, H.-R.; Huang, E.-H.; Luo, C.; Luo, W.-F.; Xu, Y.; Qian, P.-C.; Zhou, J.-M.; Ye, L.-W. *Chem. Comm.* **2020**, *56*, 4832.

(11) (a) Huang, L.; Arndt, M.; Gooßen, K.; Heydt, H.; Gooßen, L. J. *Chem. Rev.* **2015**, *115*, 2596. (b) Pirnot, M. T.; Wang, Y.-M.; Buchwald, S. L. *Angew. Chem. Int. Ed.* **2016**, *55*, 48. (c) Rabet, P. T. G.; Boyd, S.; Greaney, M. F. *Angew. Chem. Int. Ed.* **2017**, *56*, 4183. (d) Huo, J.; He, G.; Chen, W.; Hu, X.; Deng, Q.; Chen, D. *BMC Chemistry* **2019**, *13*, 89. (e) Severin, R.; Doye, S. *Chem. Soc. Rev.* **2007**, *36*, 1407. (f) Kaper, T.; Fischer, M.; Thye, H.; Geik, D.; Schmidtmann, M.; Beckhaus, R.; Doye, S. *Chem. Eur. J.* **2021**, https://doi.org/10.1002/chem.202100238. (g) Sengupta, M.; Das, S.; Islam, S. M.; Bordoloi, A. *ChemCatChem* **2021**, *13*, 1089. (h) Tashrifi, Z.; Khanaposhtani, M. M.; Biglar, M.; Larijani, B.; Mahdavi, M. *Asian J. Org. Chem.* **2020**, *9*, 969. (i) Patel, M.; Saunthwal, R. K.; Verma, A. K. *Acc. Chem. Res.* **2017**, *50*, 240.

(12) (a) Guo, W.; Zhao, M.; Tan, W.; Zheng, L.; Tao, K.; Fan, X. *Org. Chem. Front.* **2019**, *6*, 2120. (b) Quek, J. Y.; Davis, T. P.; Lowe, A. B. *Chem. Soc. Rev.* **2013**, *42*, 7326. (c) Rauws, T. R. M.; Maes, B. U. W. *Chem. Soc. Rev.* **2012**, *41*, 2463.

(13) (a) Liu, B.; Ning, Y.; Virelli, M.; Zanoni, G.; Anderson, E. A.; Bi, X. *J. Am. Chem. Soc.* **2019**, 141, 1593. (b) Zhang, Z.; Huang, B.; Qiao, G.; Zhu, L.; Xiao, F.; Chen, F.; Fu, B.; Zhang, Z. *Angew. Chem. Int. Ed.* **2017**, *56*, 4320. (c) Kim, J.; Stahl, S. S. *J. Org. Chem.* **2015**, *80*, 2448. (d) Zhou, M.; Li, J.; Tian, C.; Sun, X.; Zhu, X.; Cheng, Y.; An, G.; Li, G. *J. Org. Chem.* **2019**, *84*, 1015.

(14) (a) Dong, S.; Chen, J.; Qiao, K.; Fang, J.; Yang, Y.; Maron, L.; Liu, B. *ACS Catal.* **2021,** *11*, 3790. (b) Motolko, K. S. A.; Emslie, D. J. H.; Jenkins, H. A. *Organometallics* **2017,** *36*, 1601. (c) Hayes, C. E.; Platel, R. H.; Schafer, L. L.; Leznoff, D. B. *Organometallics* **2012,** *31* , 6732. (d) Manna, K.; Kruse, M. L.; Sadow, A. D. *ACS Catal.* **2011,** *1*, 1637.

(15) (a) Gu, Q.; Wang, Q.; Dai, W.; Wang, X.; Ban, Y.; Liu, T.; Zhao, Y.; Zhang, Y.; Ling, Y.; Zeng, X. *Org. Biomol. Chem.* **2021**, *19*, 2512. (b) Zeng, X.; Wang, X.; Zhang, Y.; Zhu, L.; Zhao, Y. *Org. Biomol. Chem.* **2020**, *18*, 3734.

(16) Goulart, T. A. C.; Back, D. F.; Silva, S. M. E.; Zeni, G. *J. Org. Chem.* **2021**, *86*, 980.

Supplementary Information for

Yb(OTf)$_3$-Mediated regioselective hydroamination of ynamides with anilines or *p*-toluenesulfonamide

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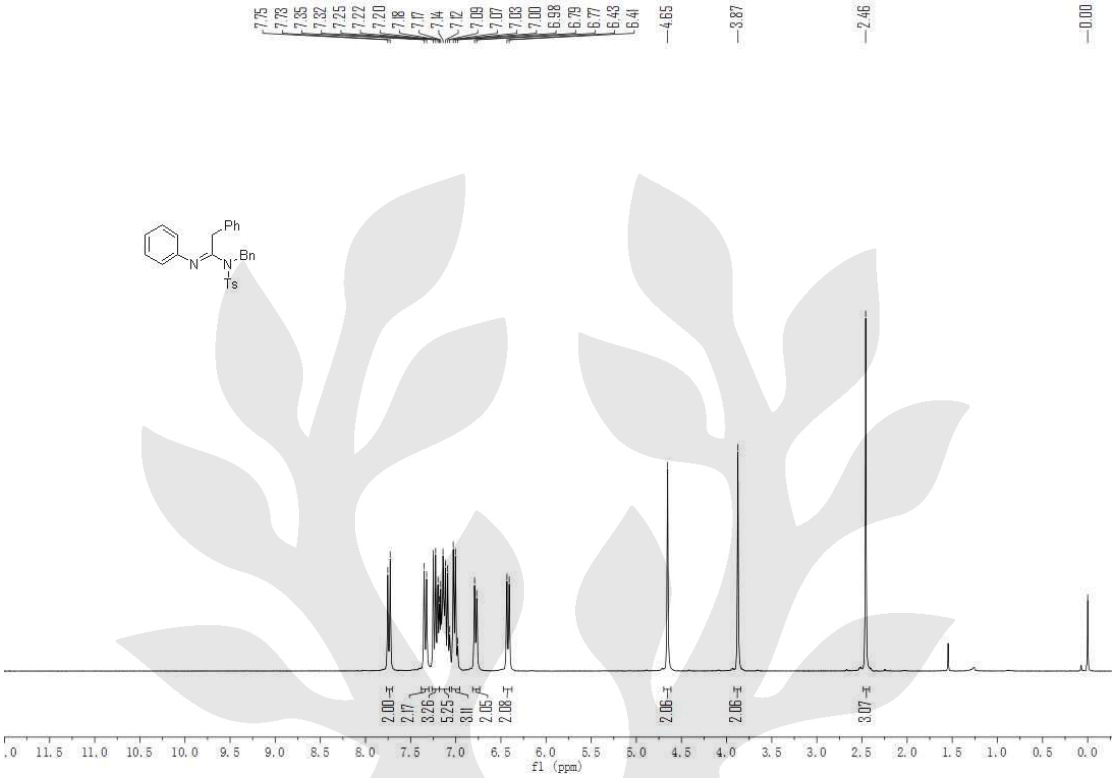
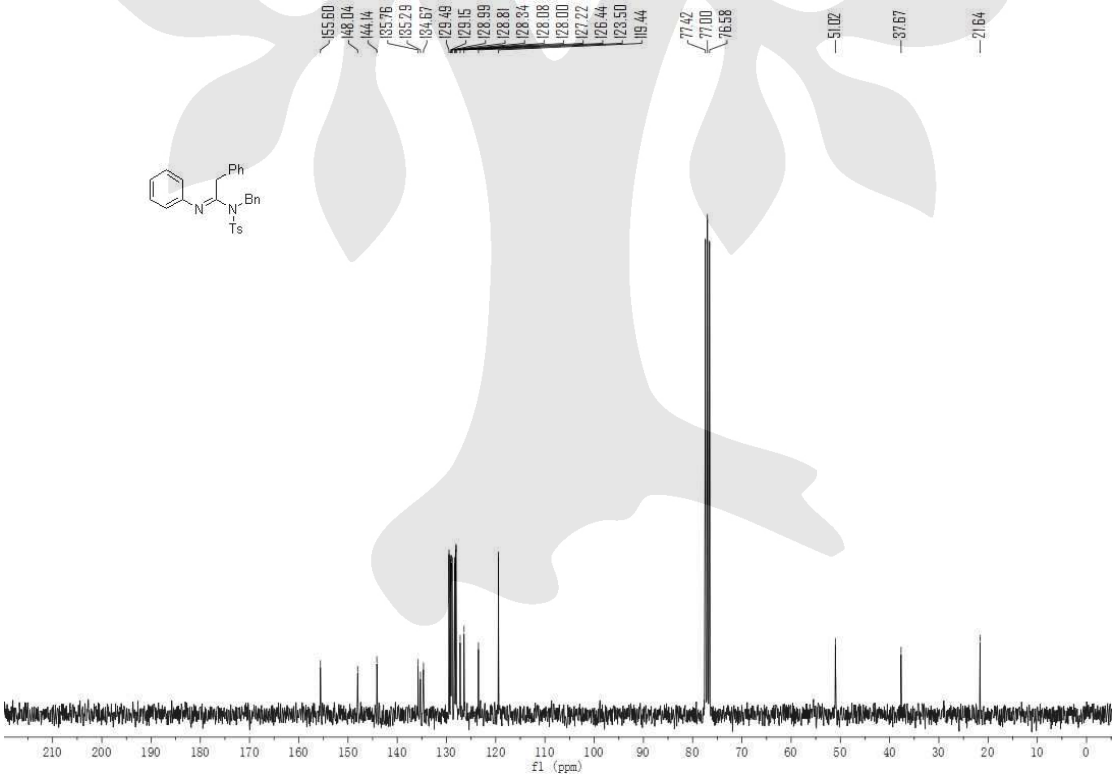
4. ^{1}H NMR and ^{13}C NMR spectra of compounds 3aa-u, 5aa-f

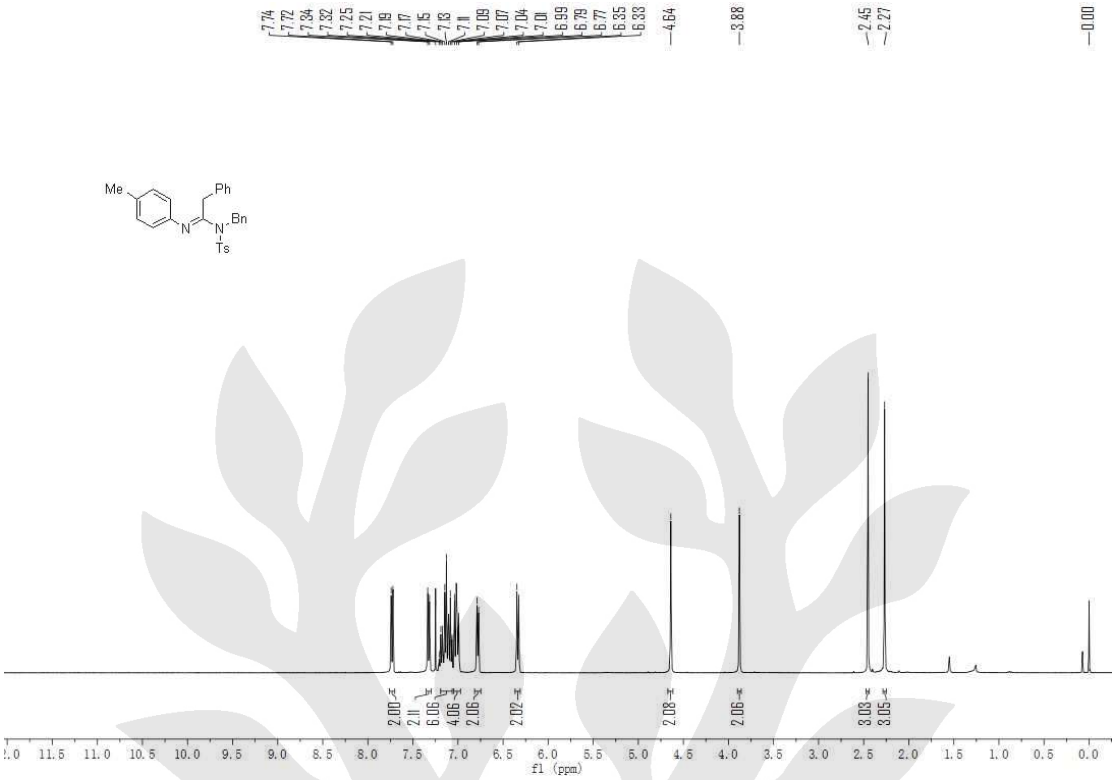
^{1}H NMR spectrum of 3aa



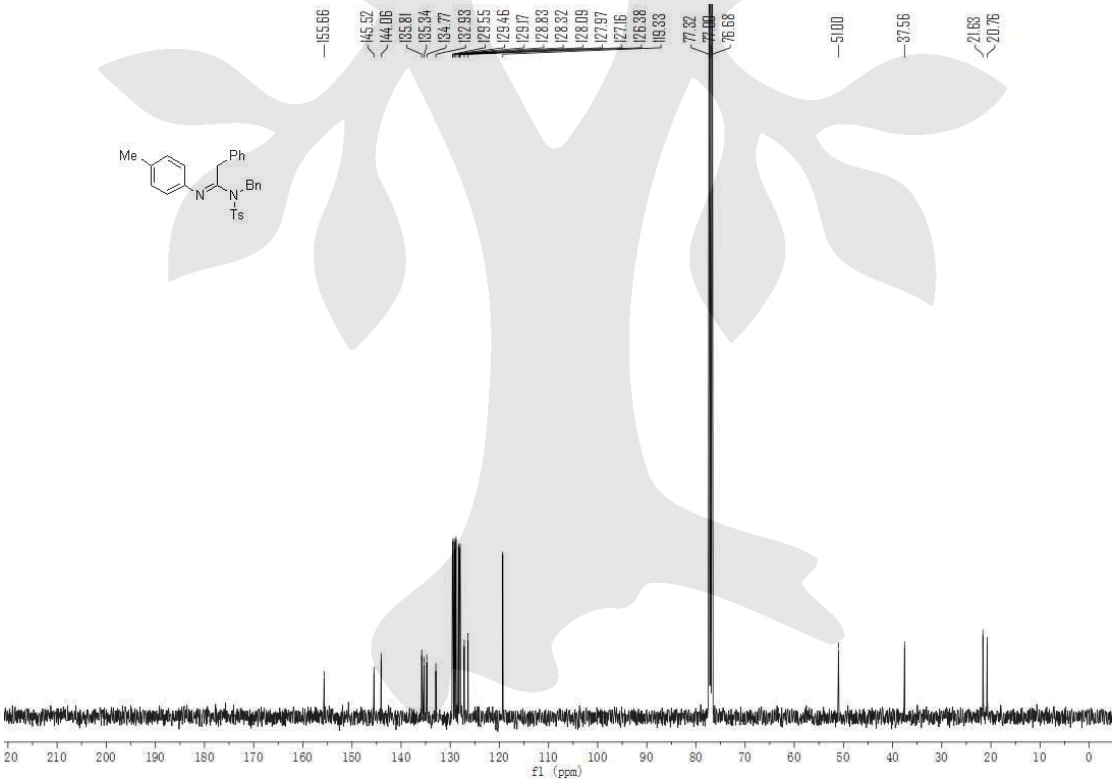
^{13}C NMR spectrum of 3aa



^{1}H NMR spectrum of 3ab



^{13}C NMR spectrum of 3ab



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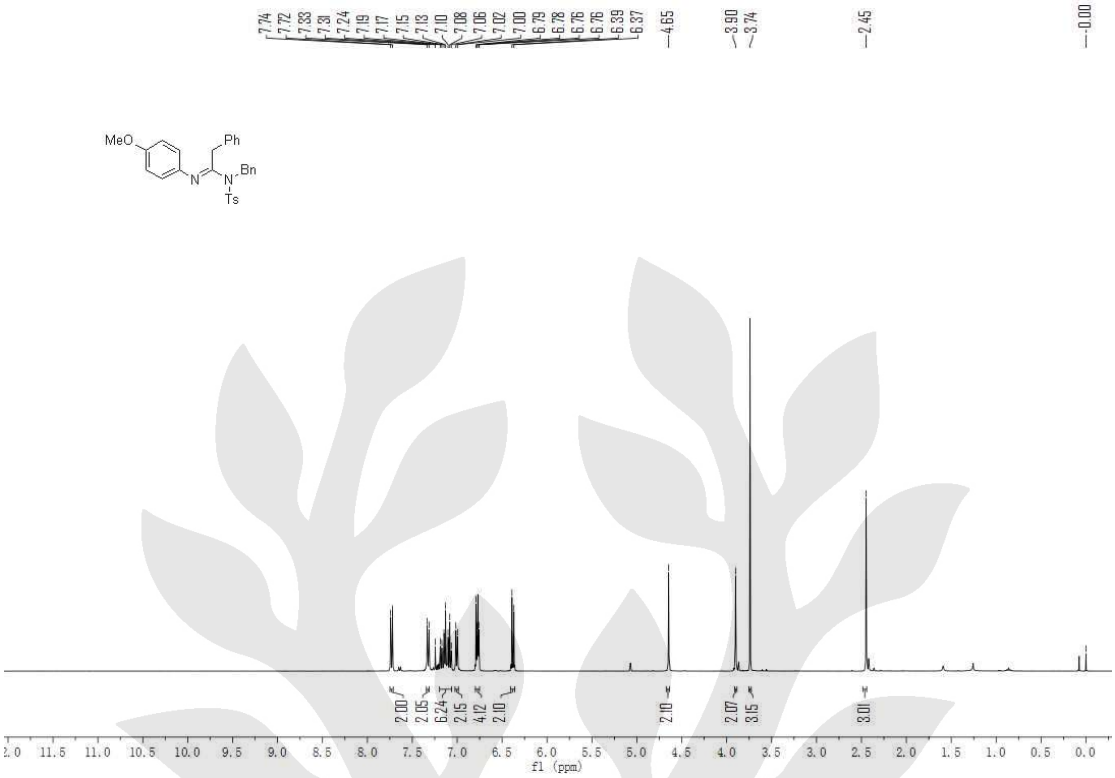

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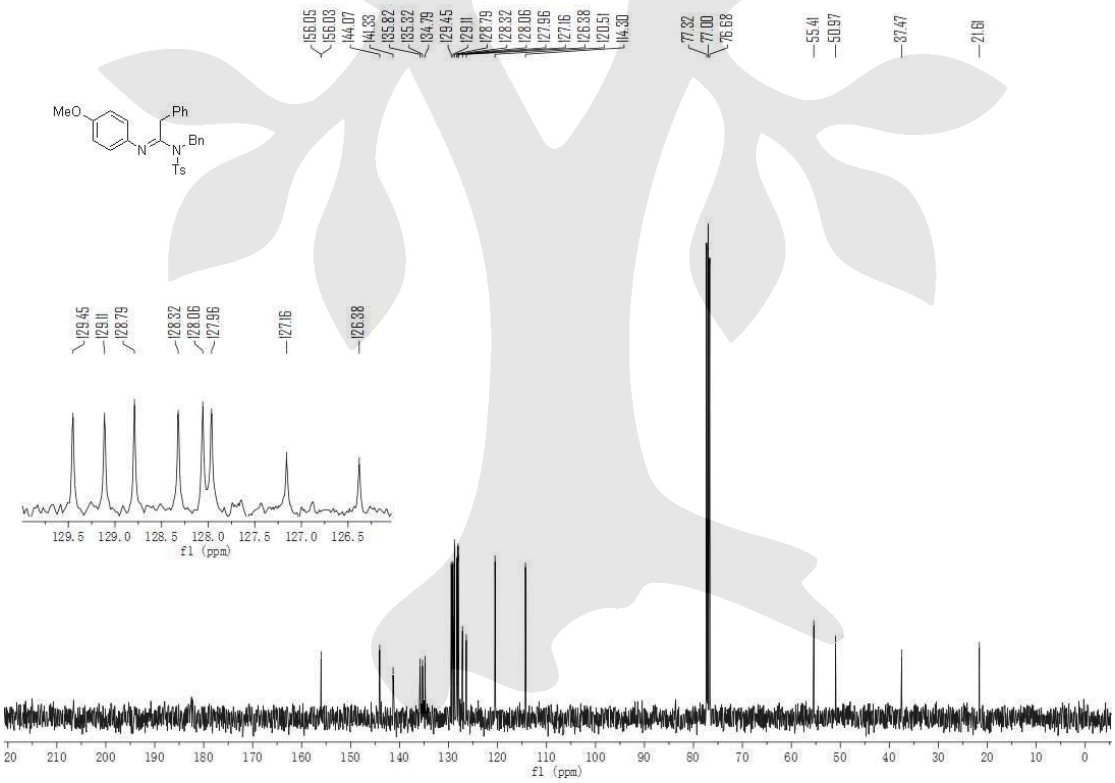

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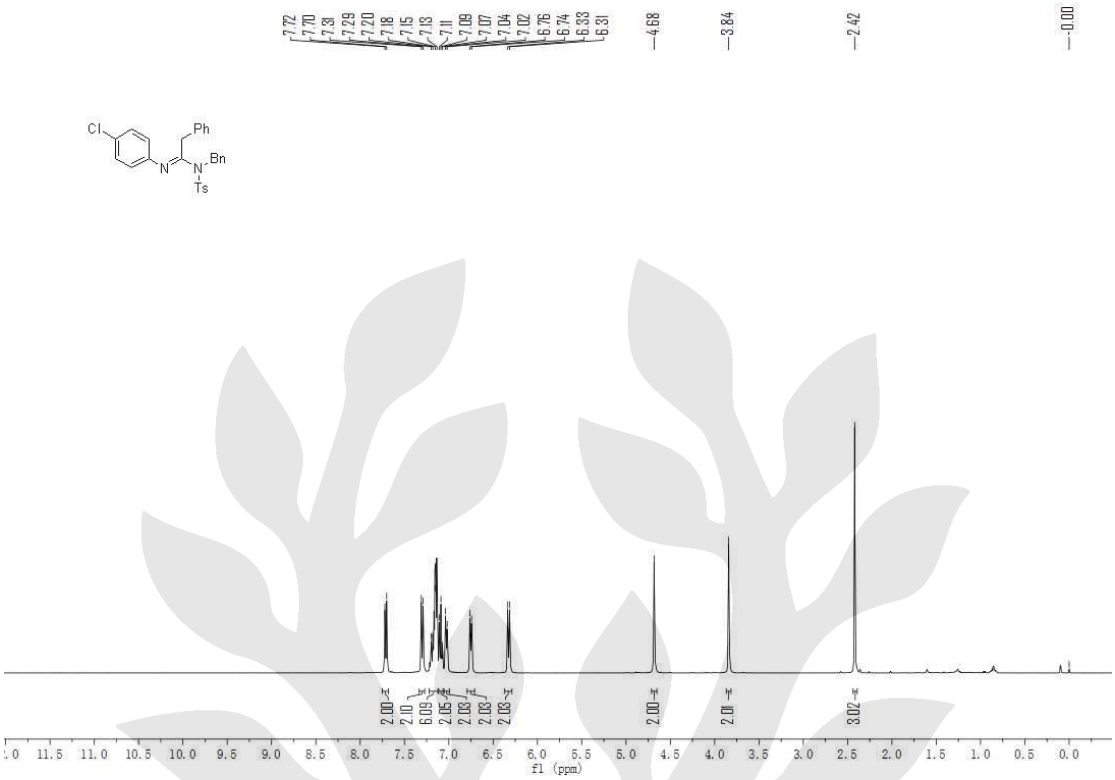
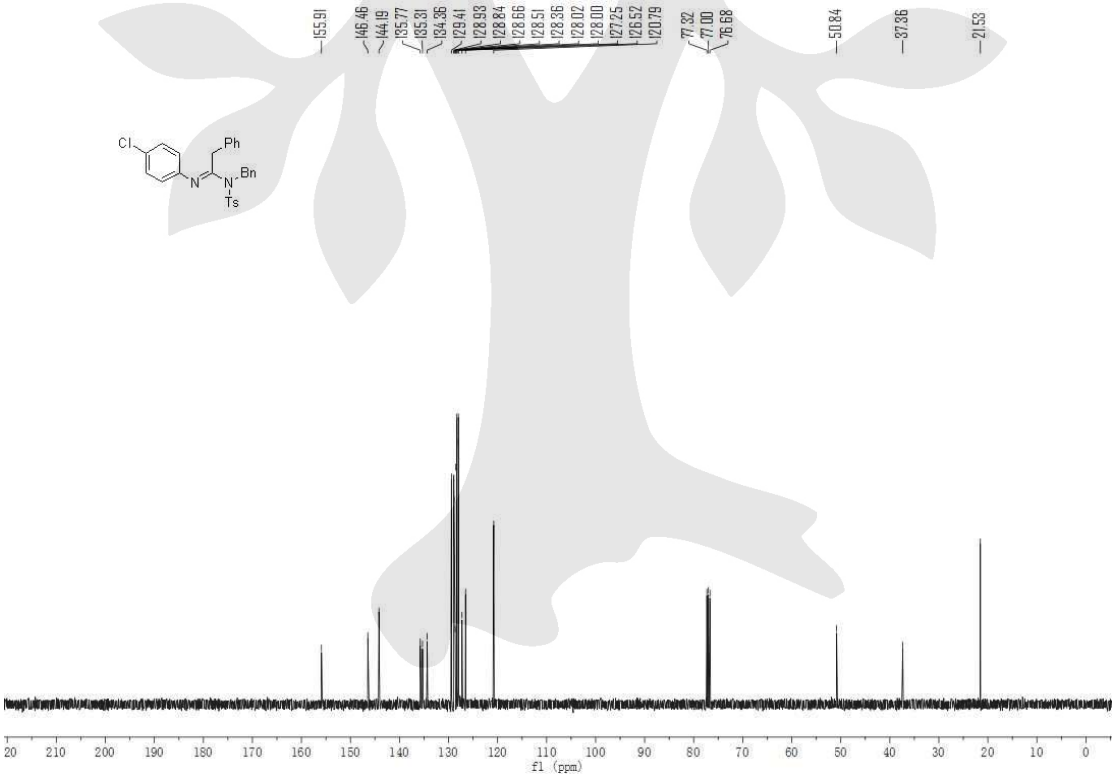
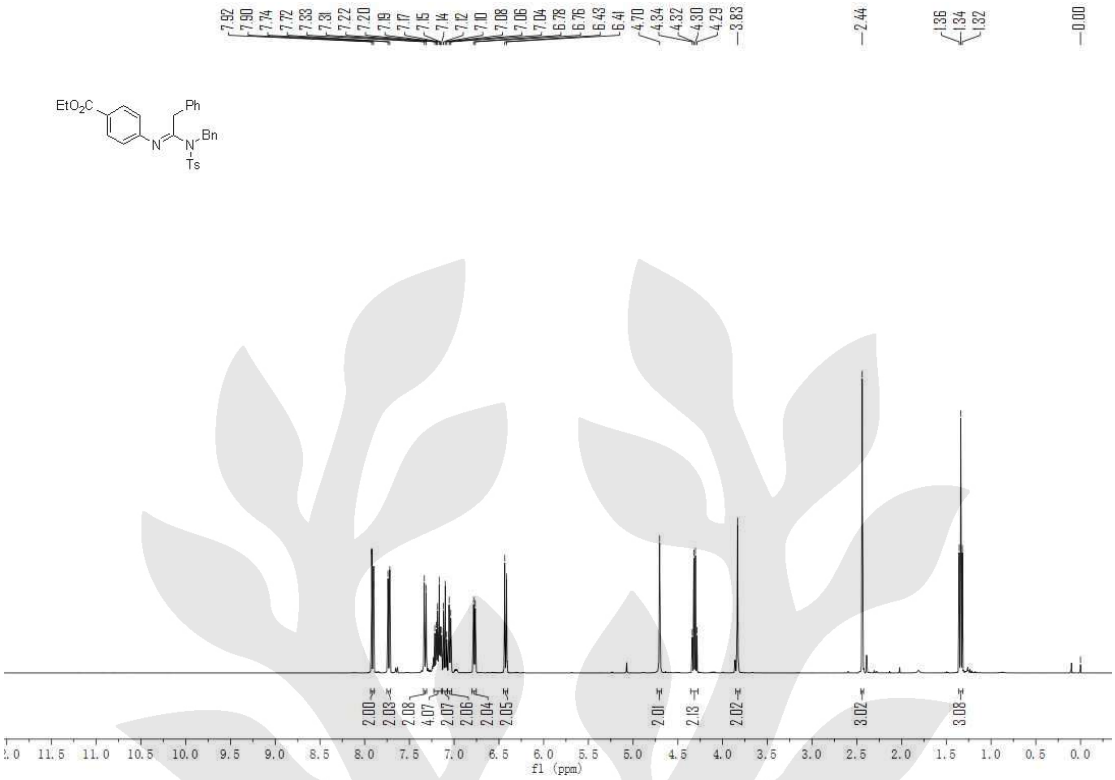


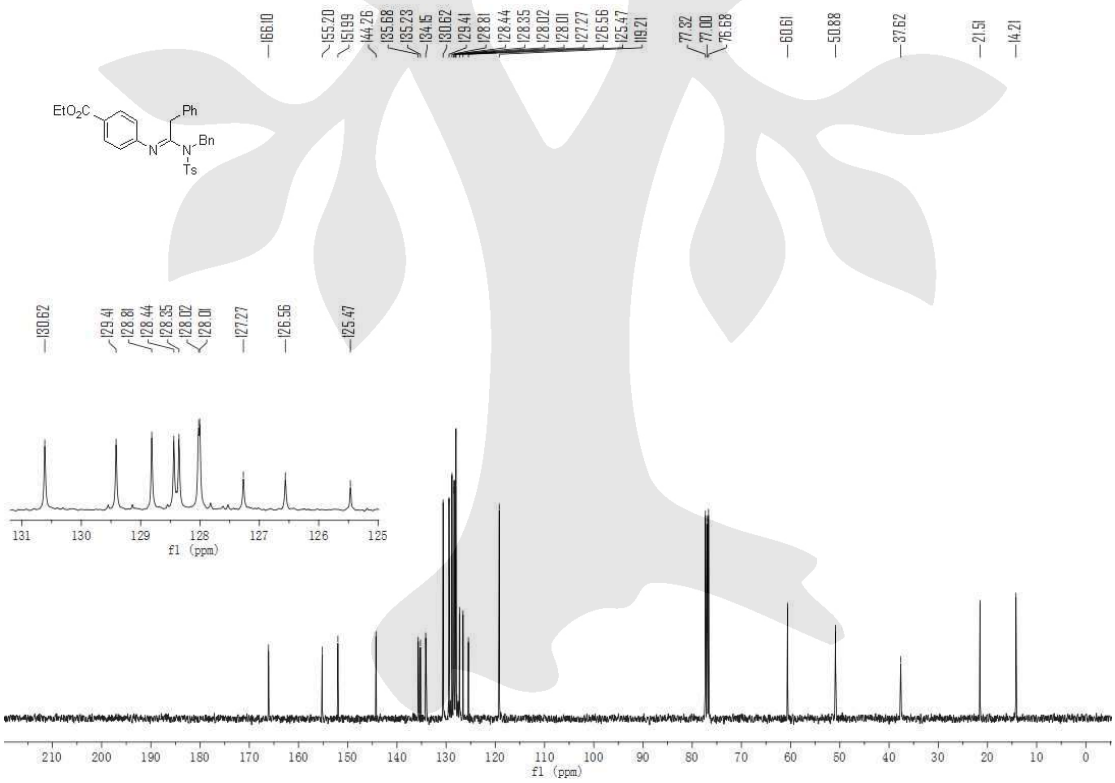
^{13}C NMR spectrum of 3ad



^{1}H NMR spectrum of 3ae



^{13}C NMR spectrum of 3ae



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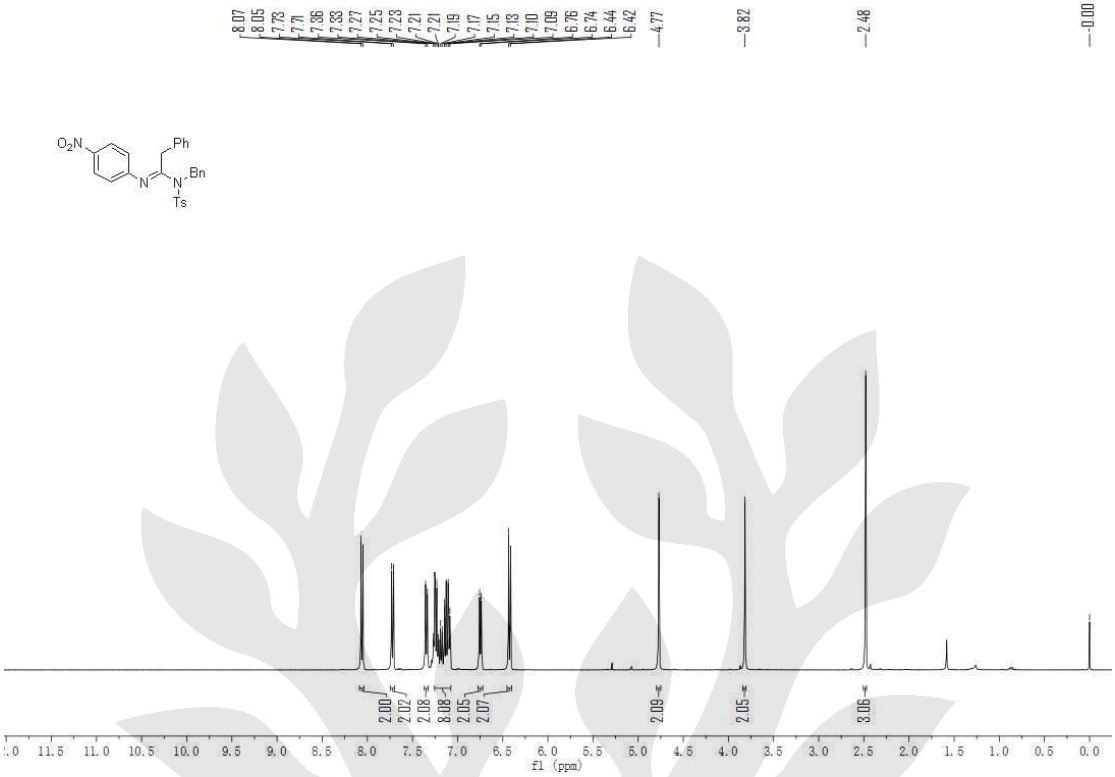
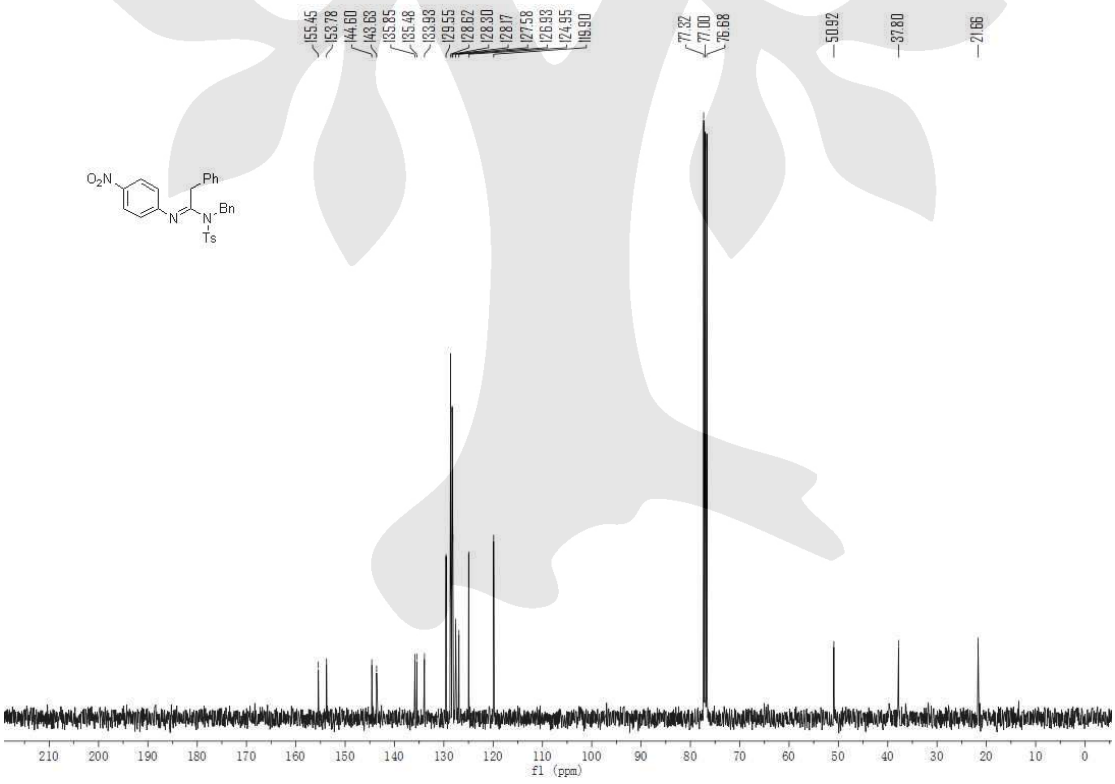


^{13}C NMR spectrum of 3af



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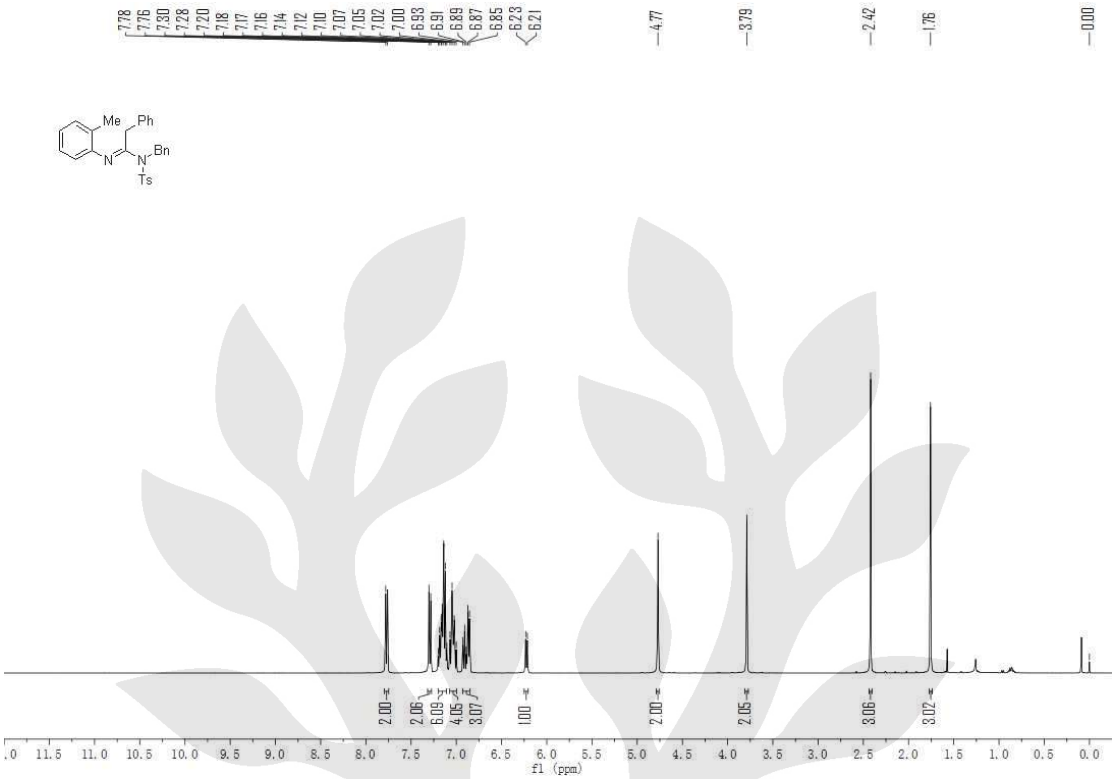
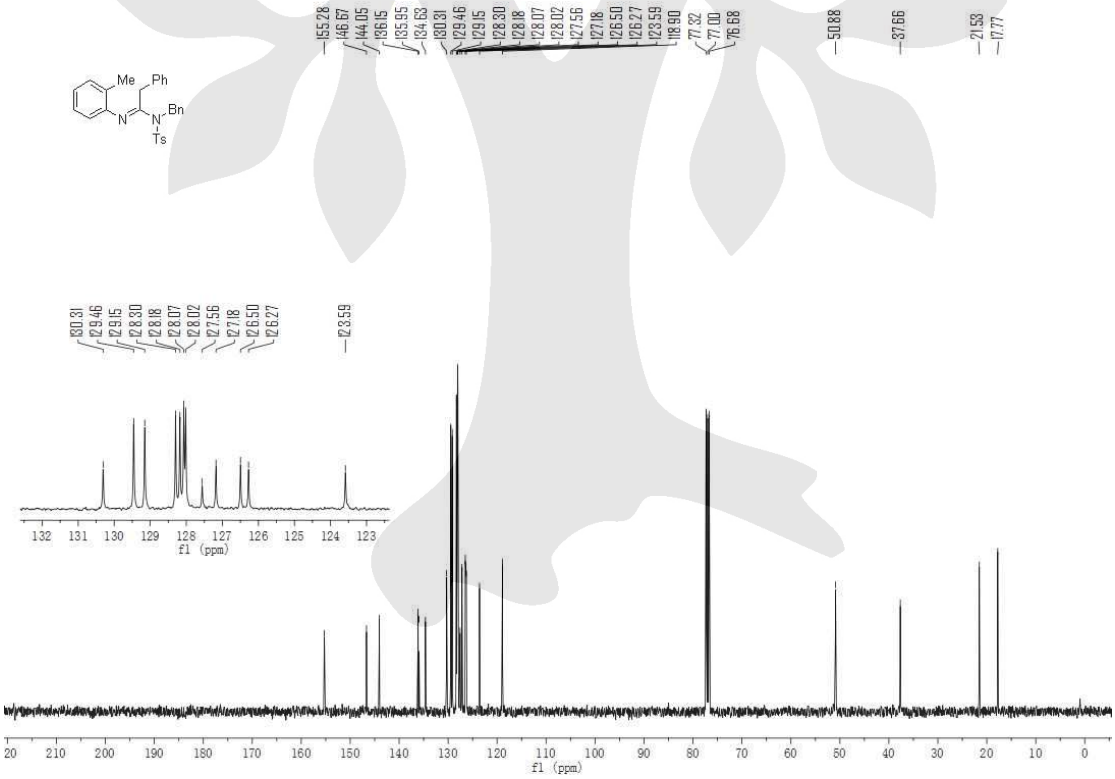
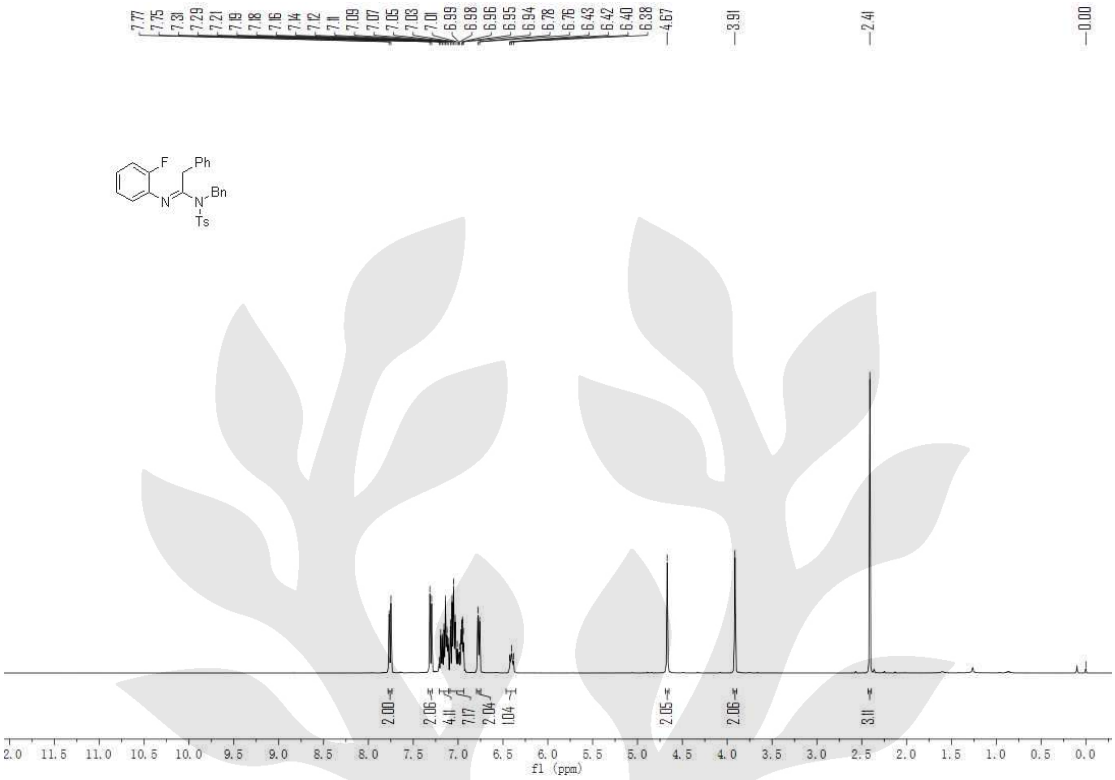


^{13}C NMR spectrum of 3ag



^{1}H NMR spectrum of 3ah



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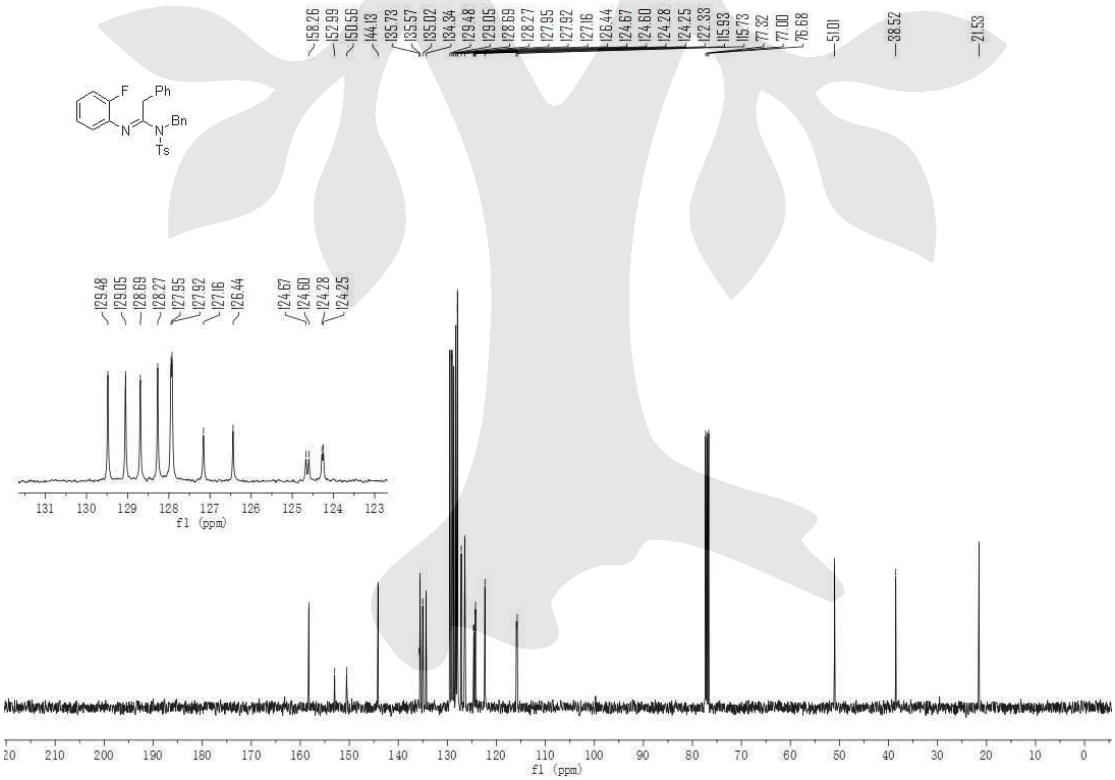
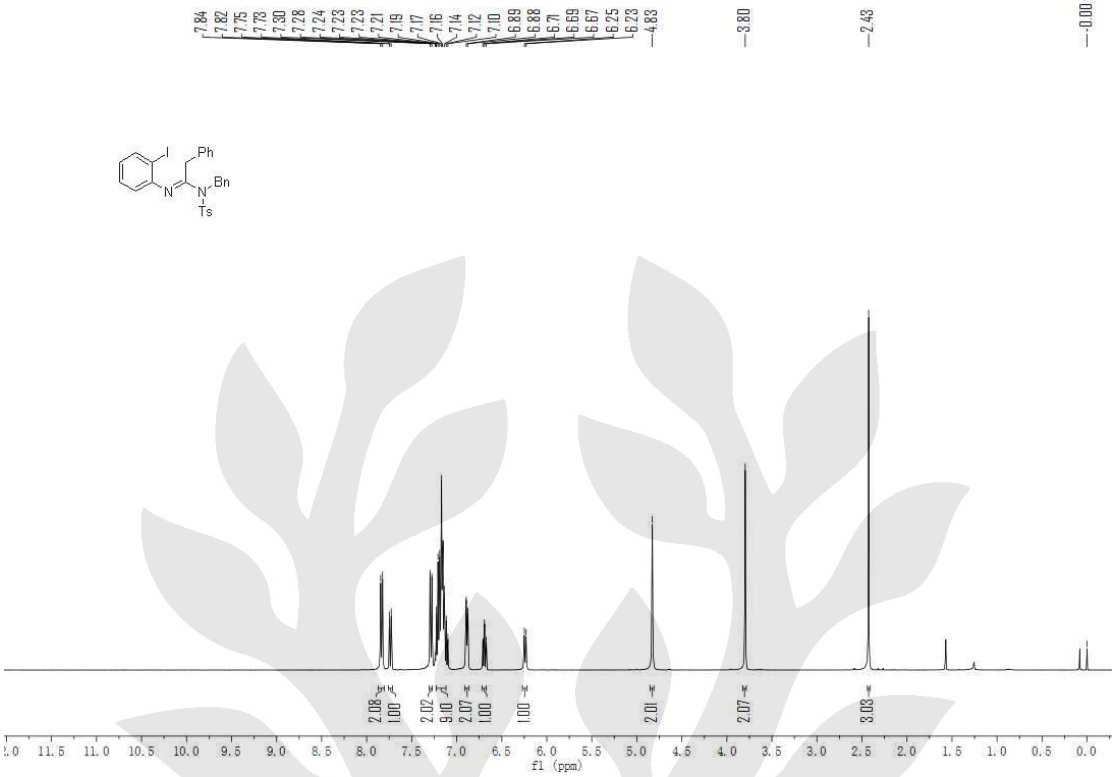
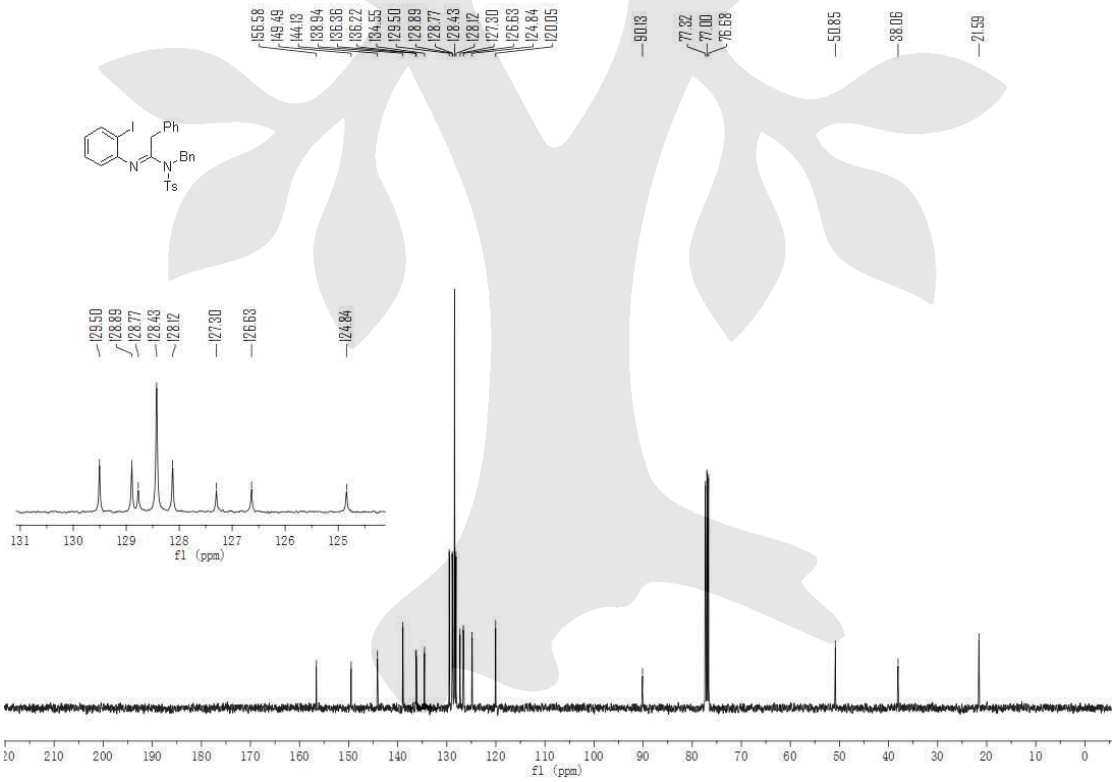


^{1}H NMR spectrum of 3ai



^{13}C NMR spectrum of 3ai



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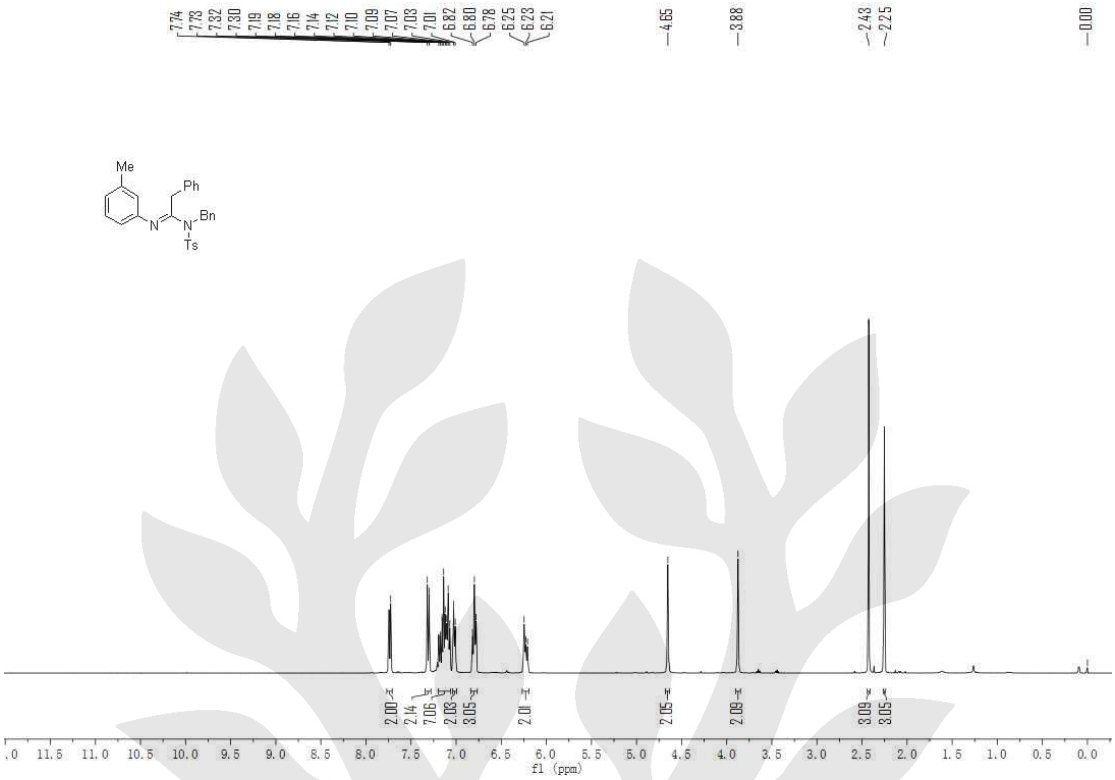

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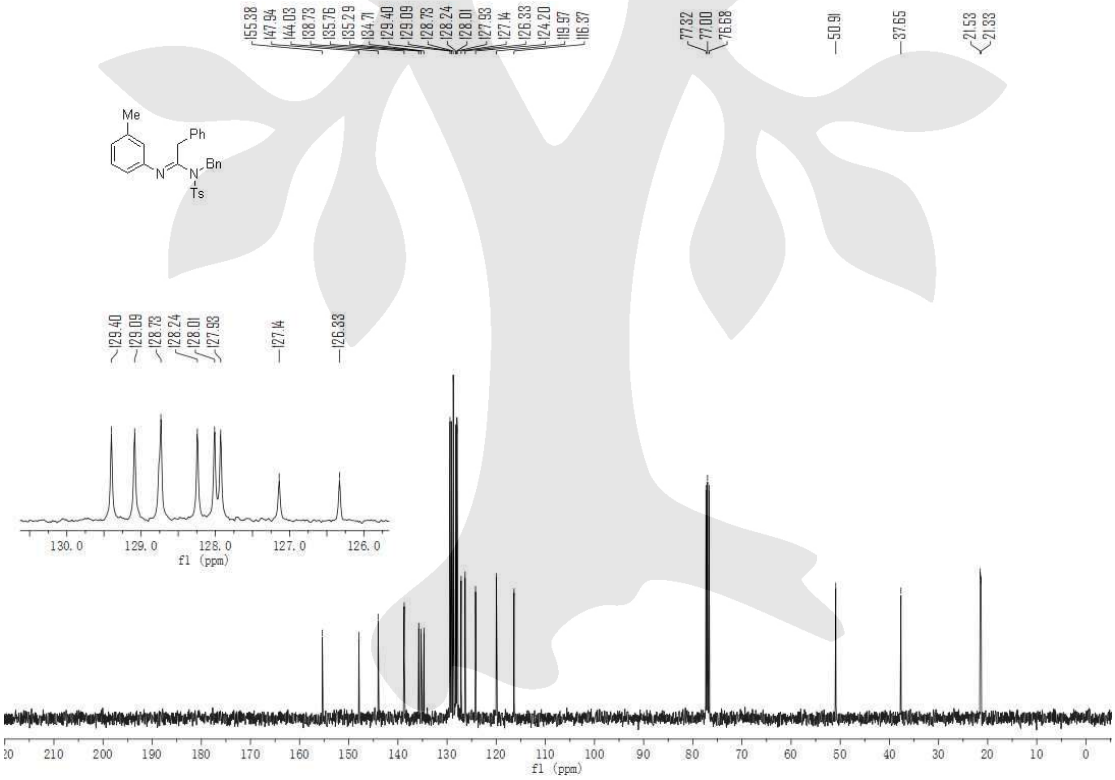

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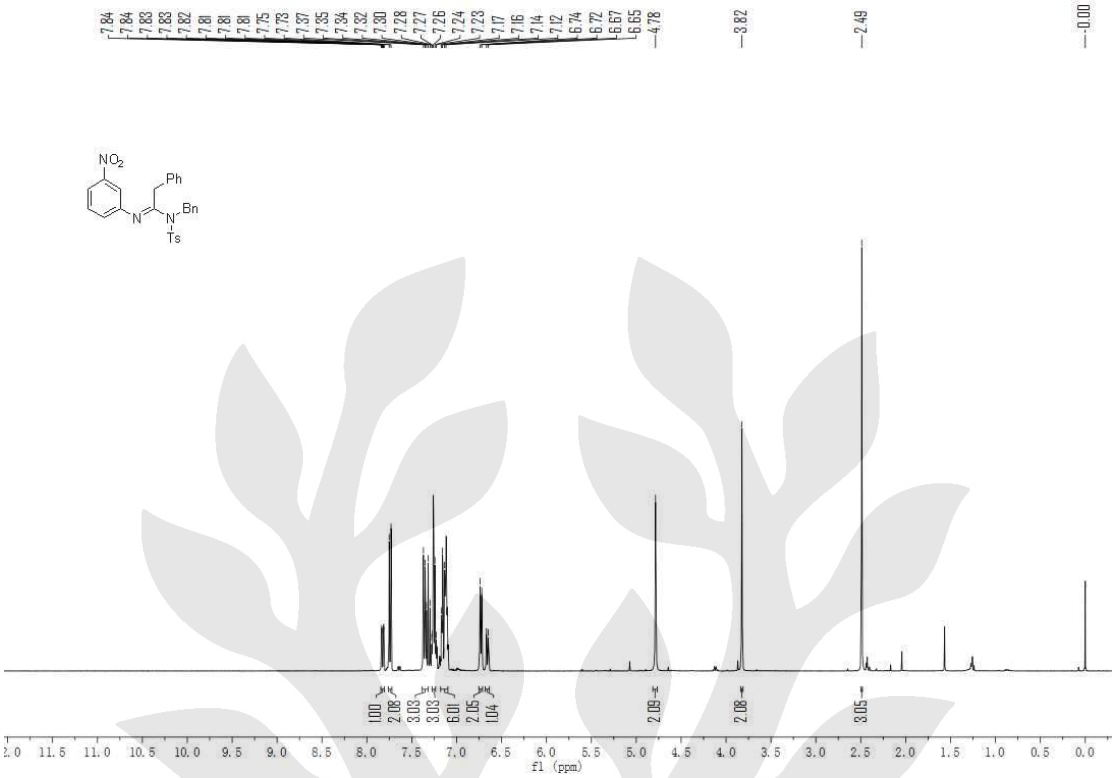
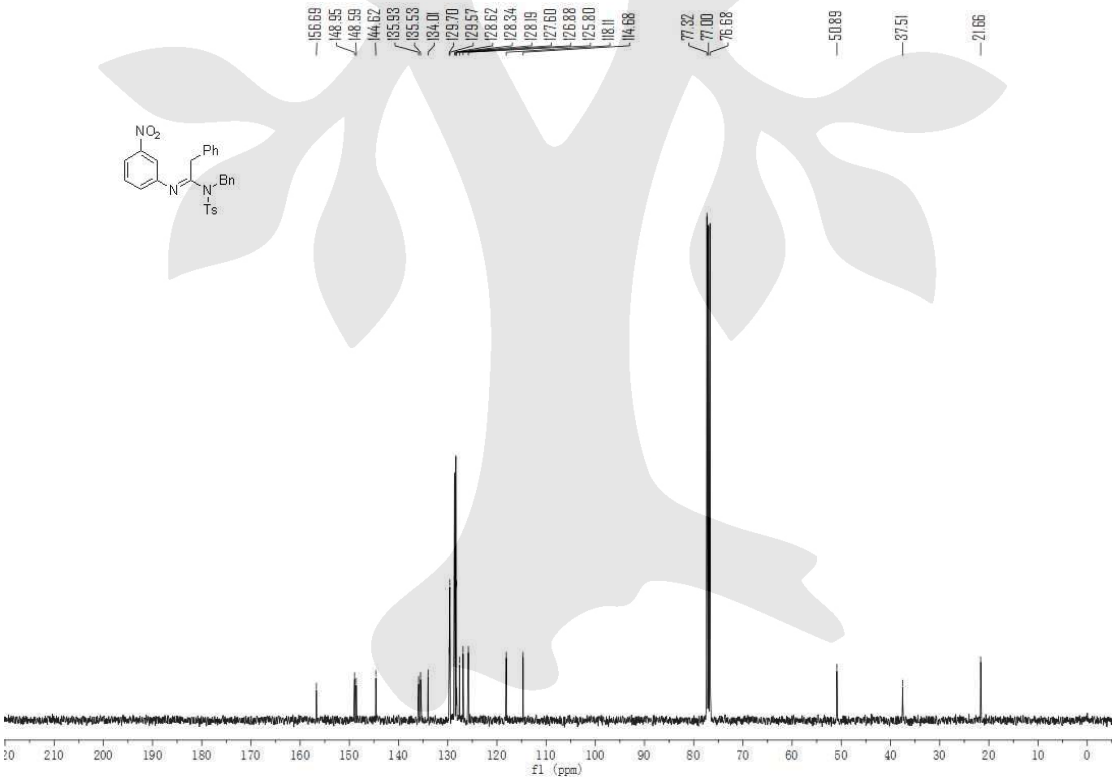
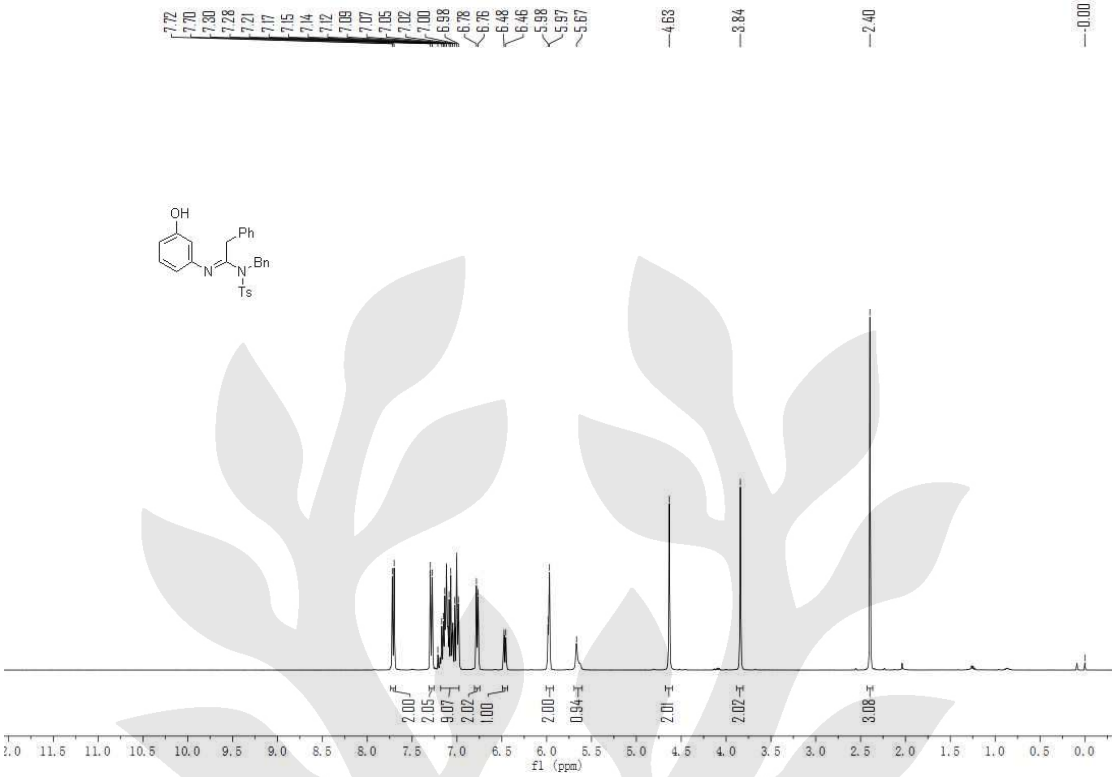


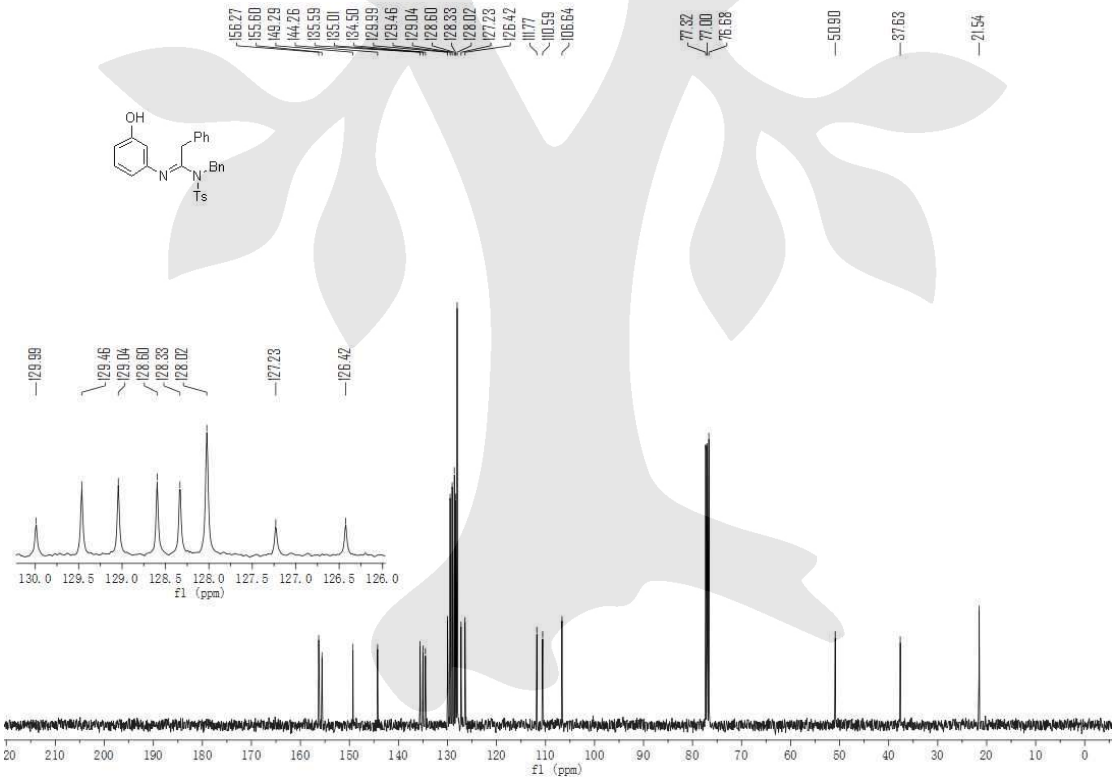
^{13}C NMR spectrum of 3ak



^{1}H NMR spectrum of 3al



^{13}C NMR spectrum of 3al



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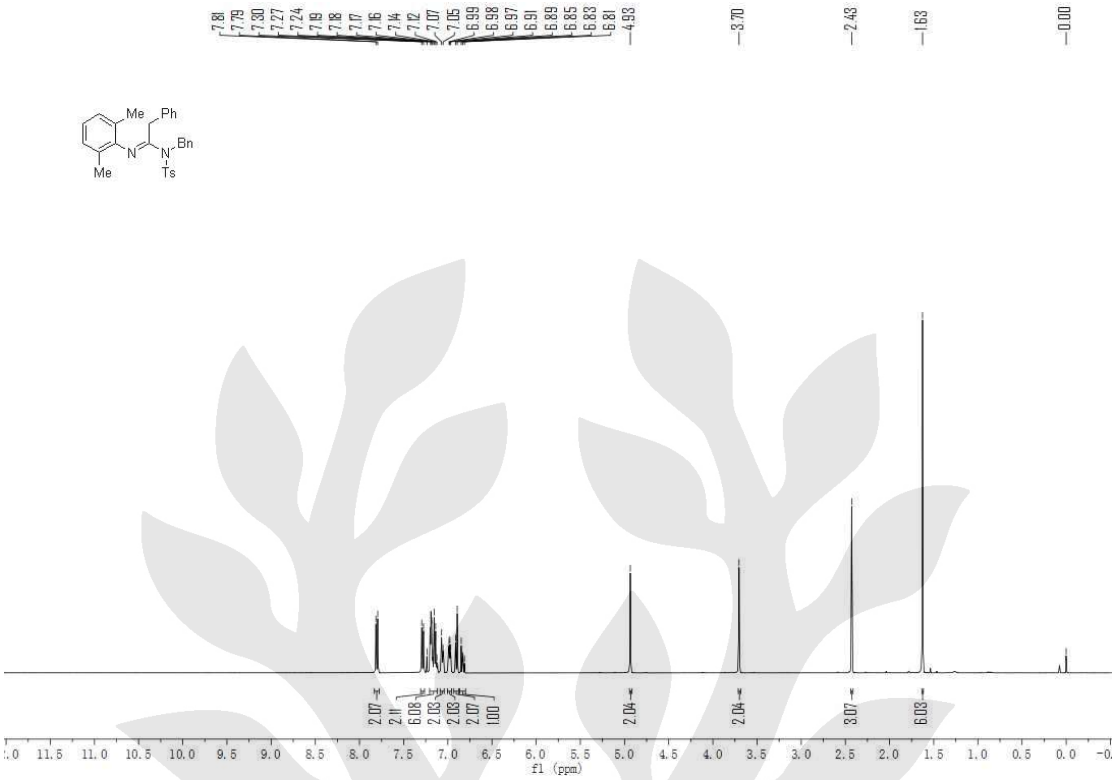

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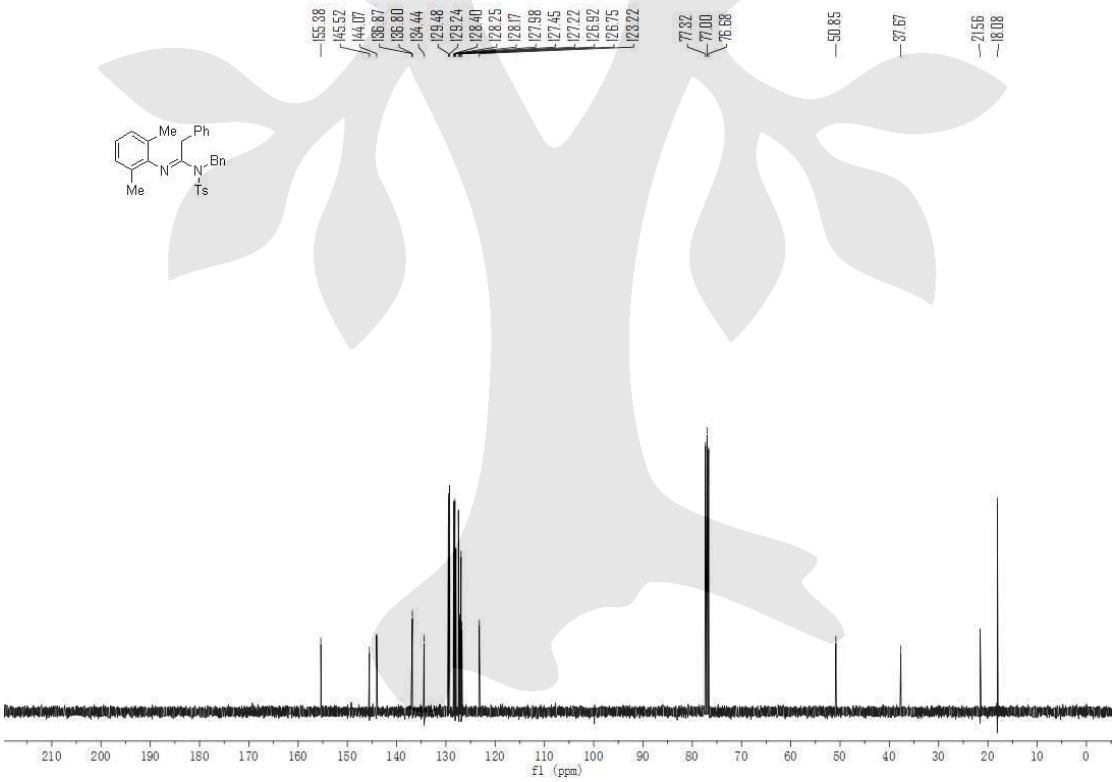
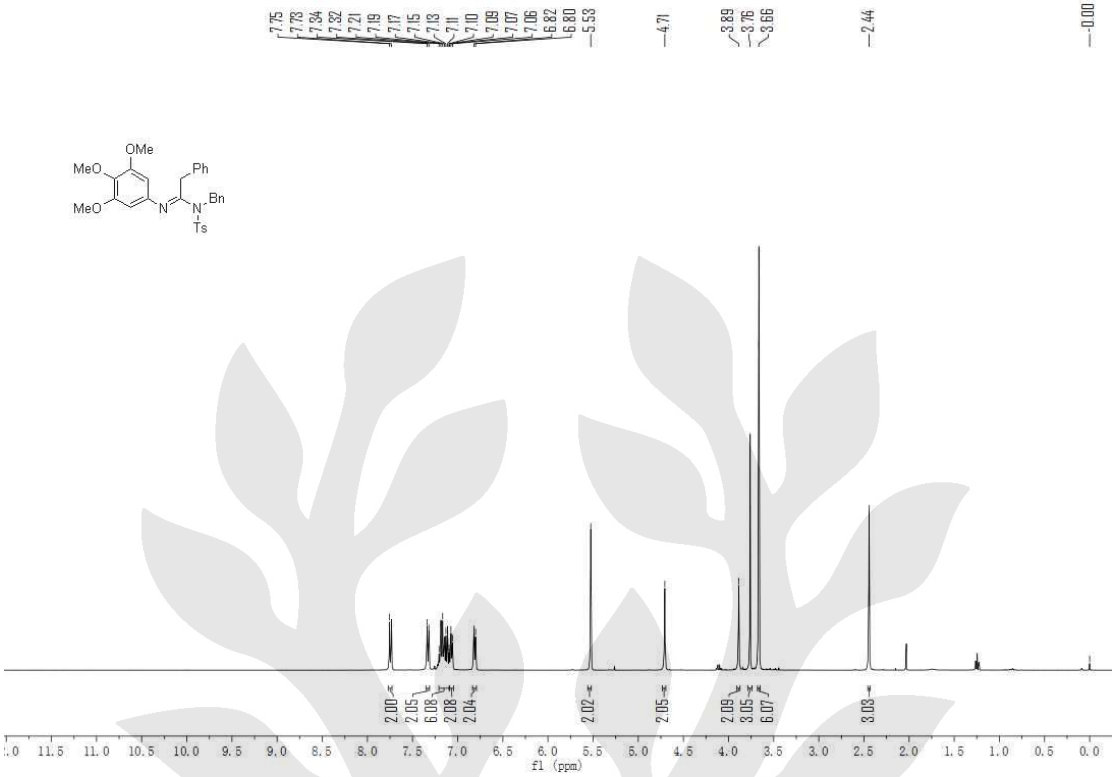
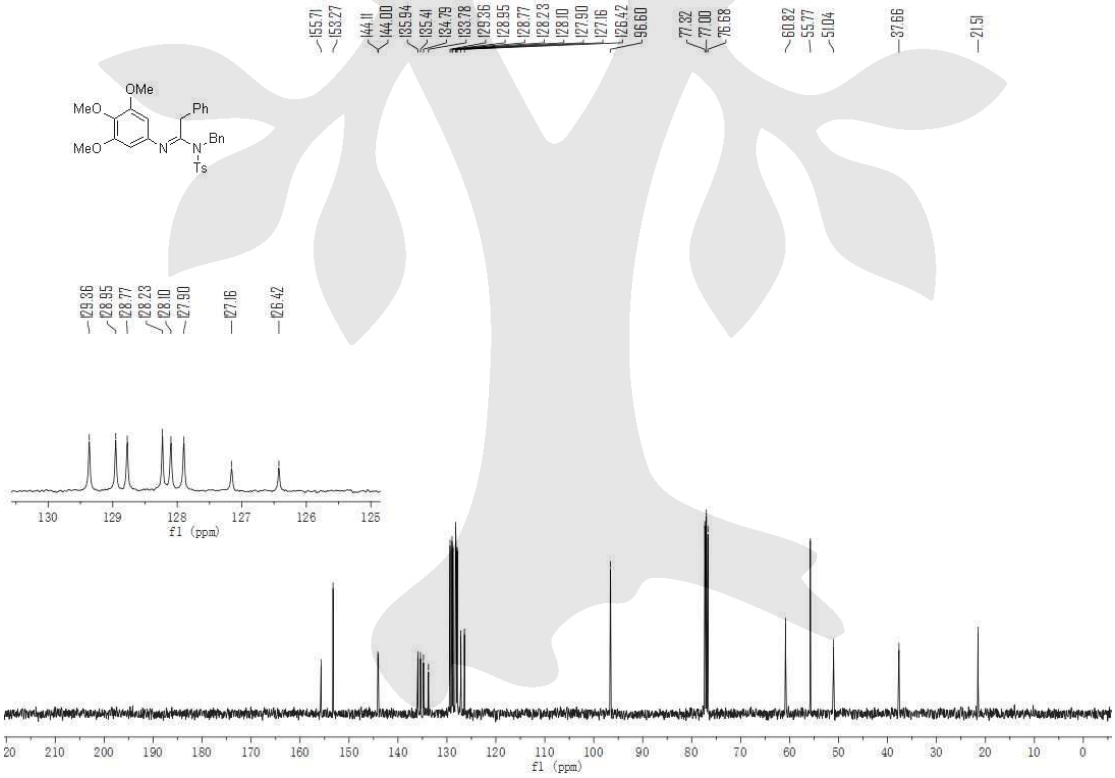


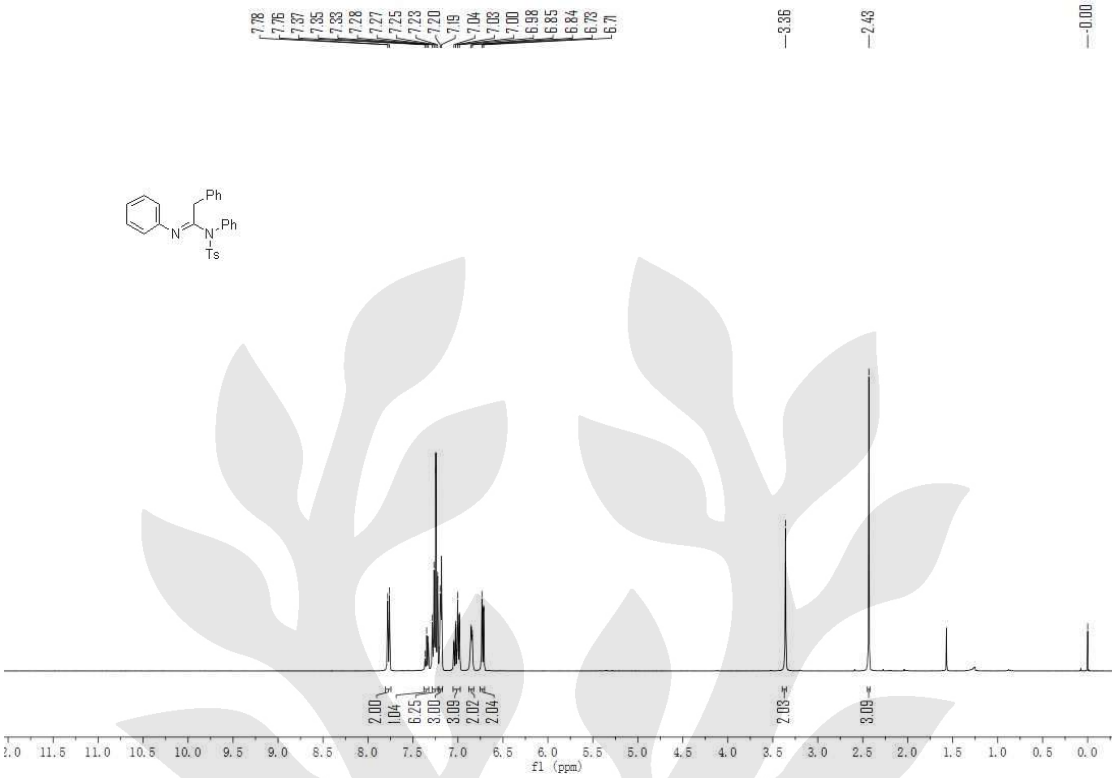
^{1}H NMR spectrum of 3an



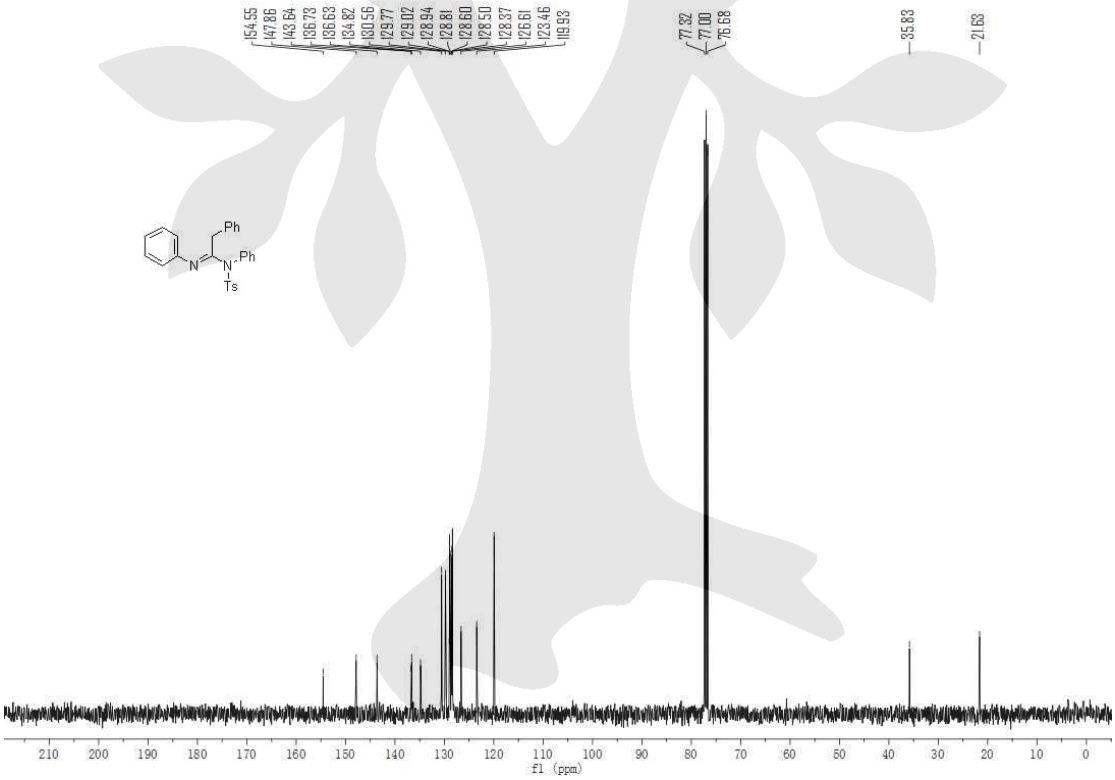
^{13}C NMR spectrum of 3an



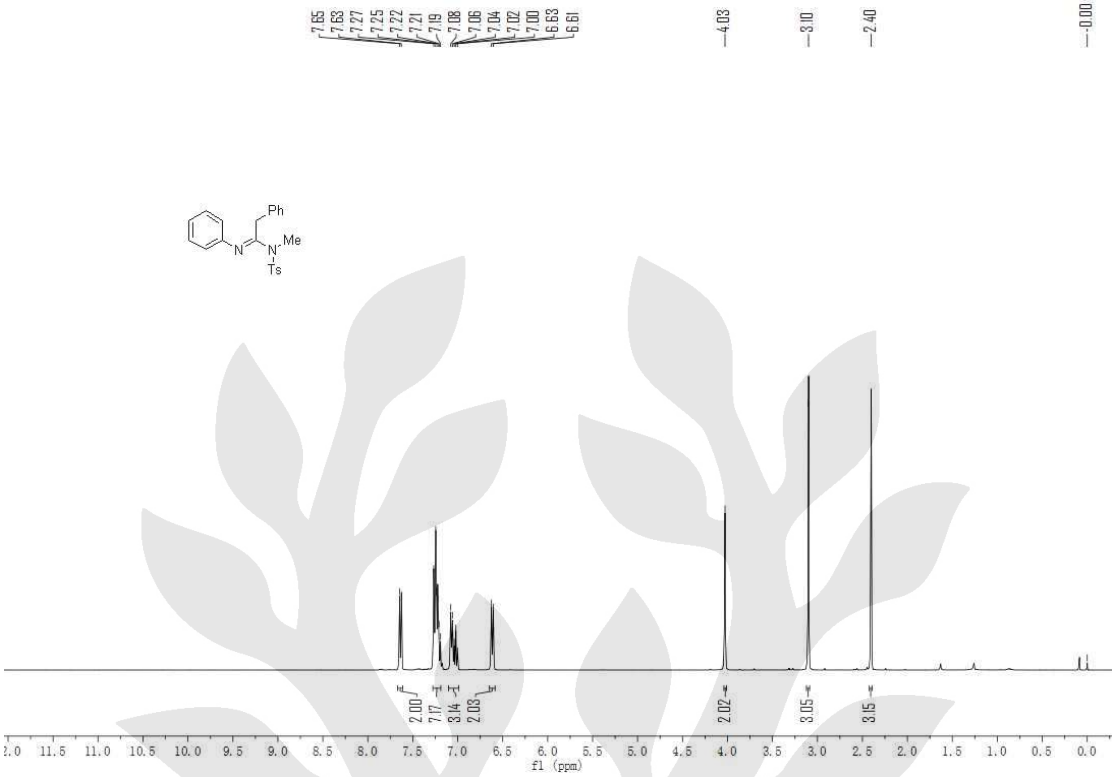
^{1}H NMR spectrum of 3ao



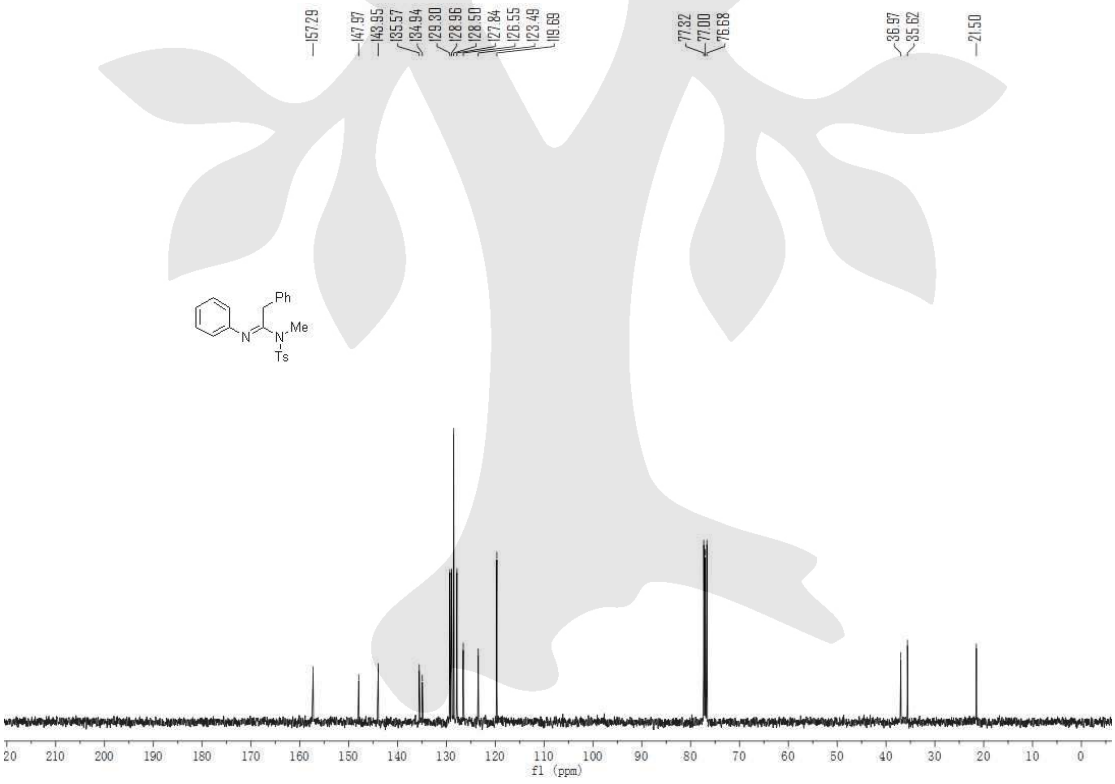
^{13}C NMR spectrum of 3ao



^{1}H NMR spectrum of 3ap



^{13}C NMR spectrum of 3ap



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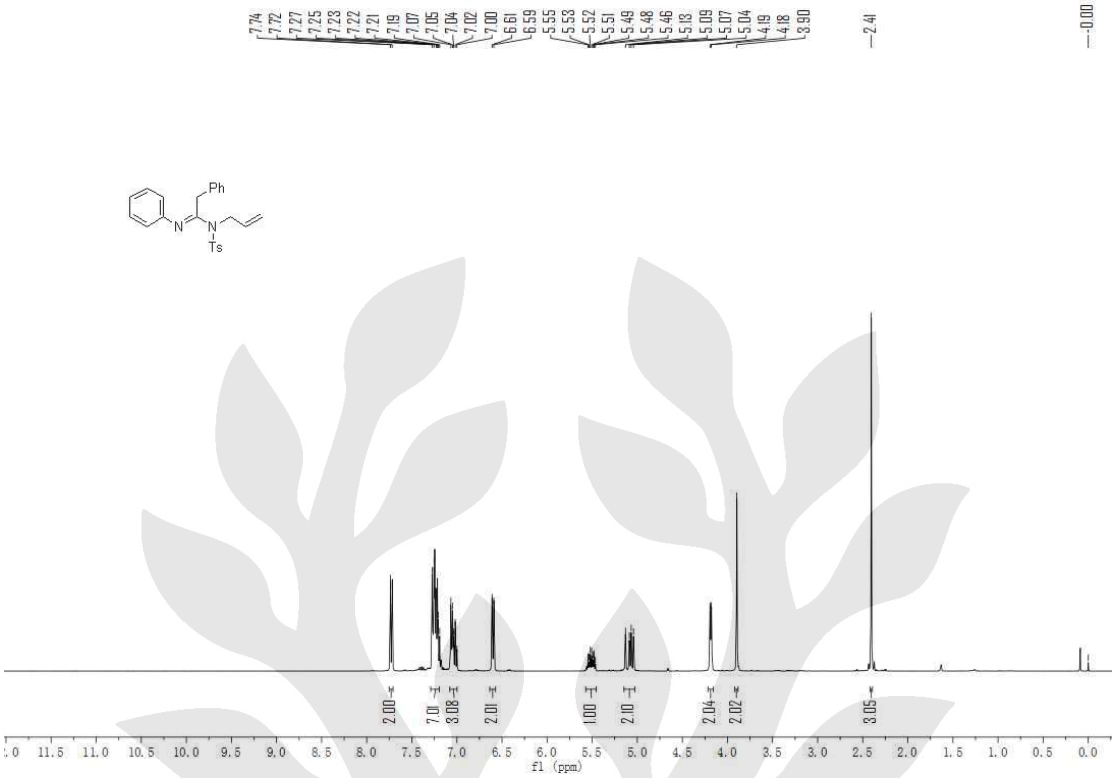

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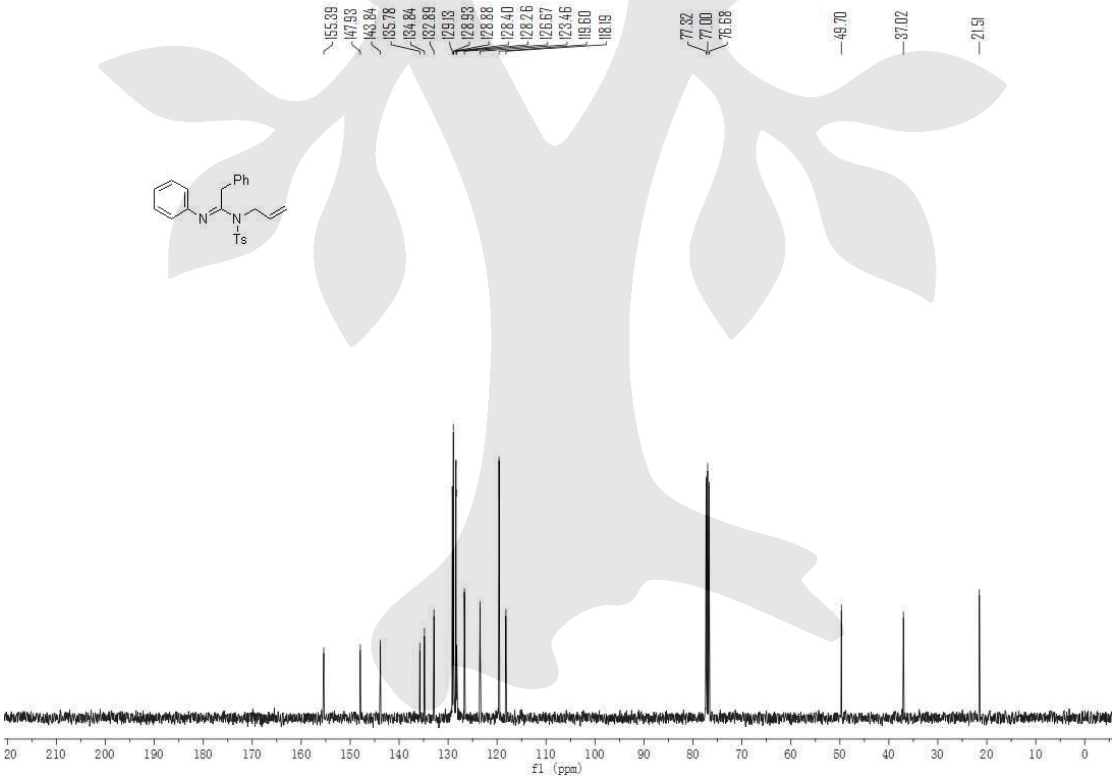

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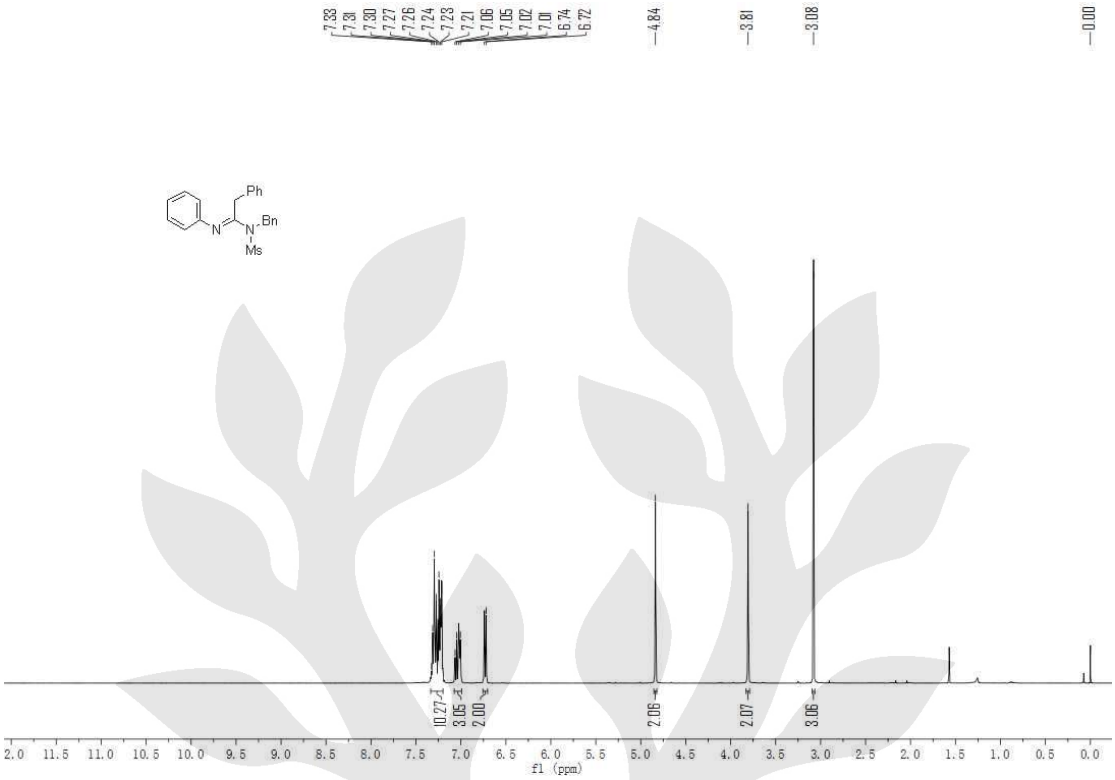
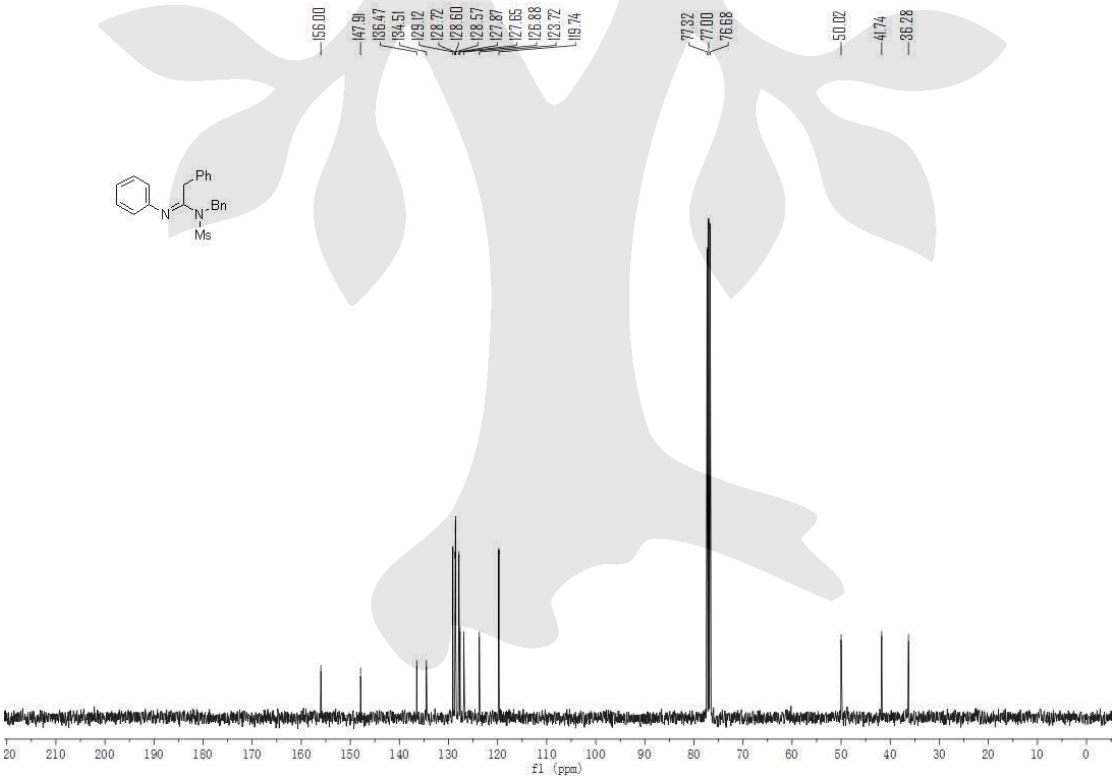


^{13}C NMR spectrum of 3ar



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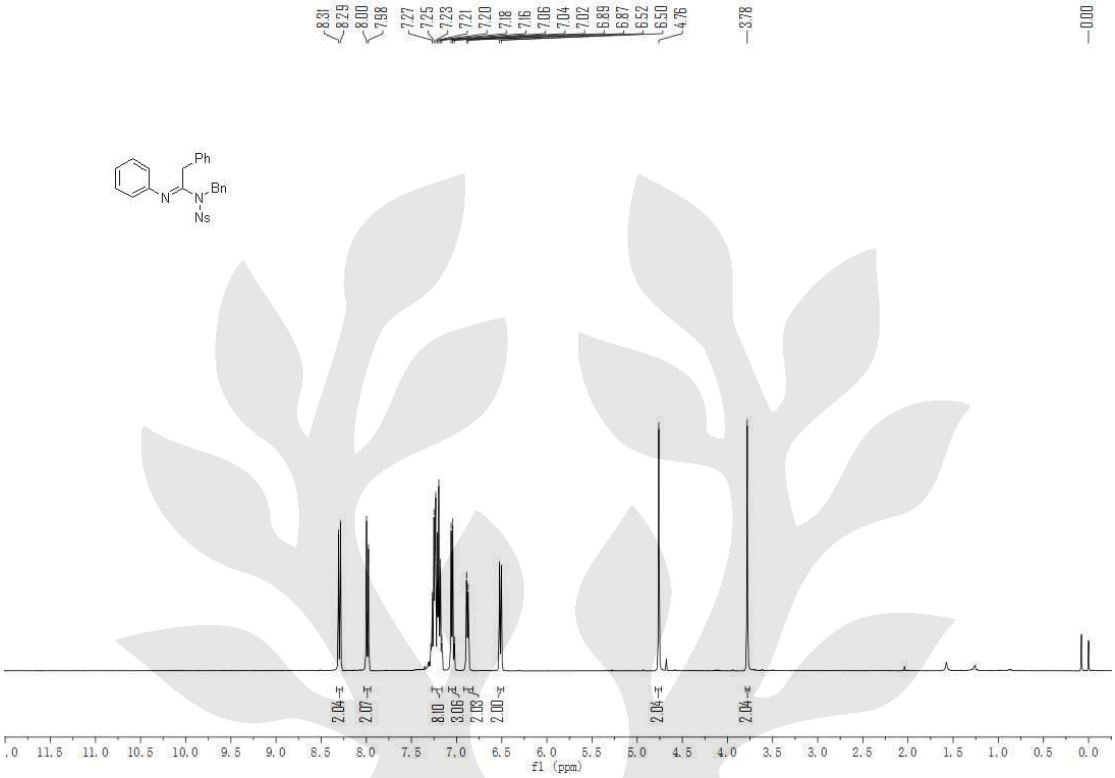
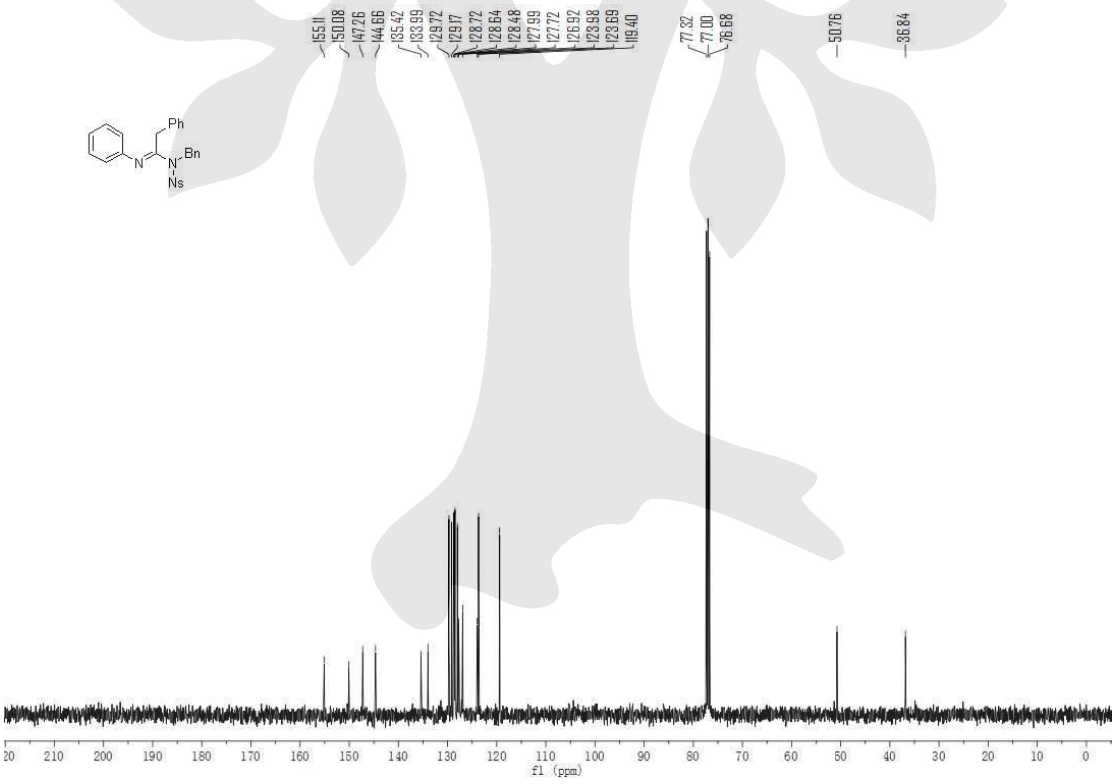
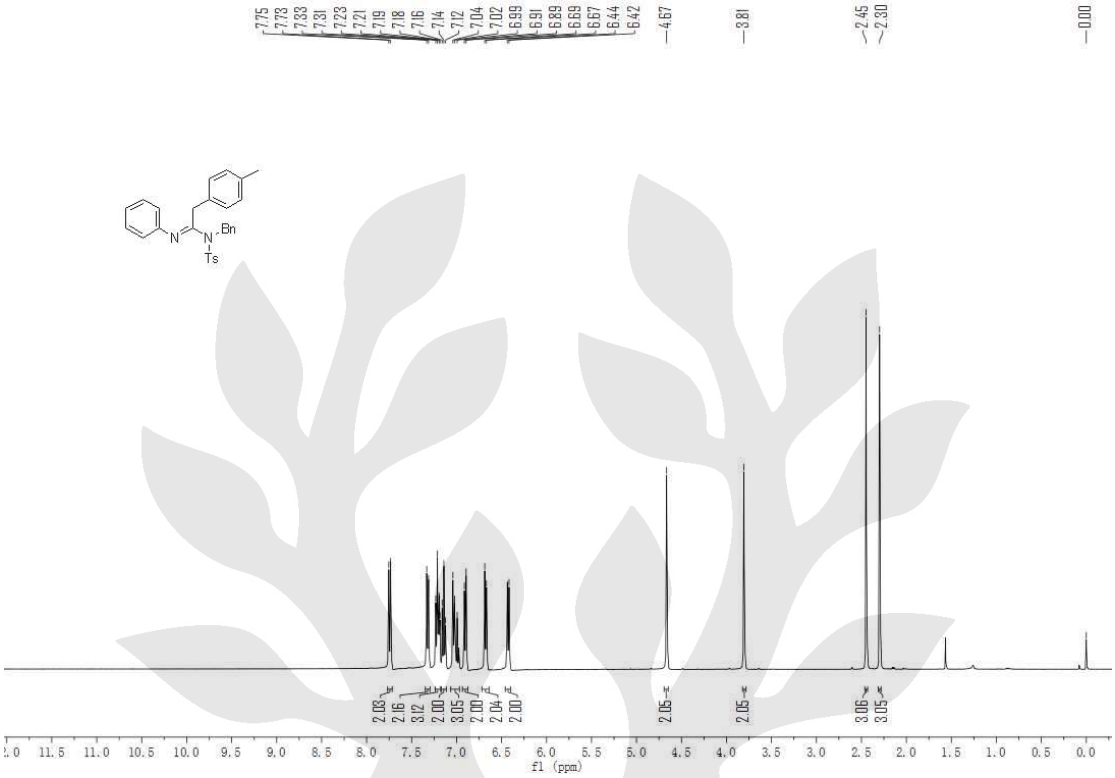


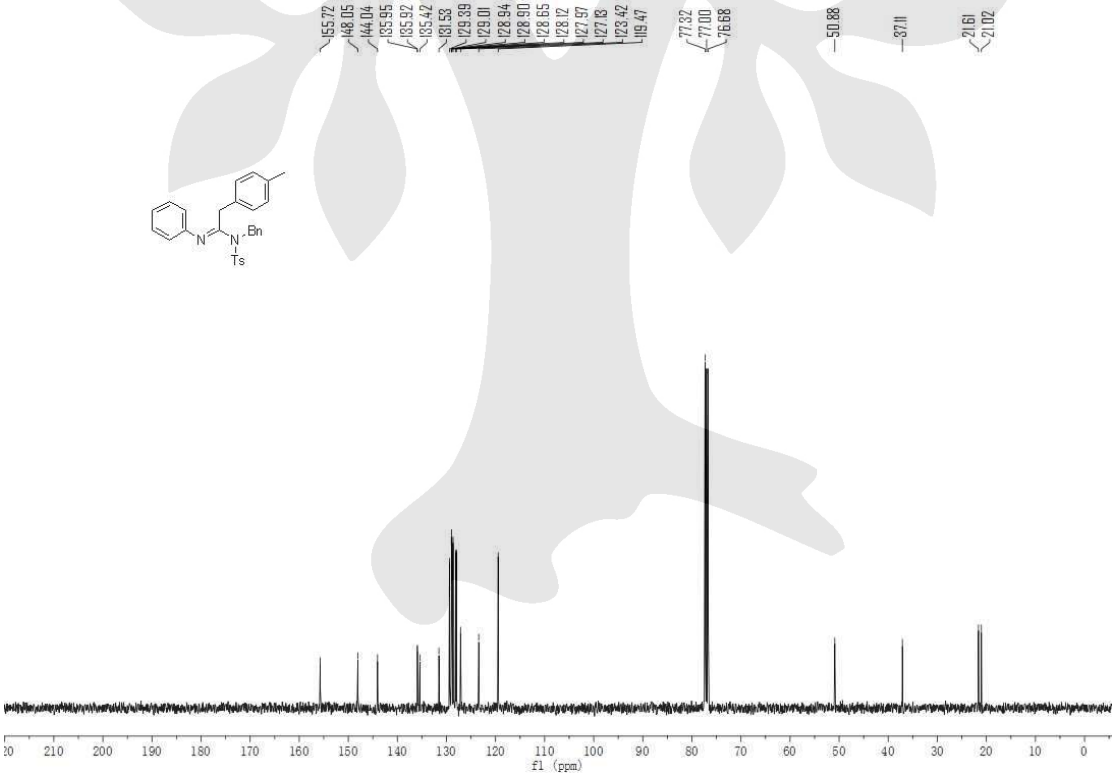
^{13}C NMR spectrum of 3as



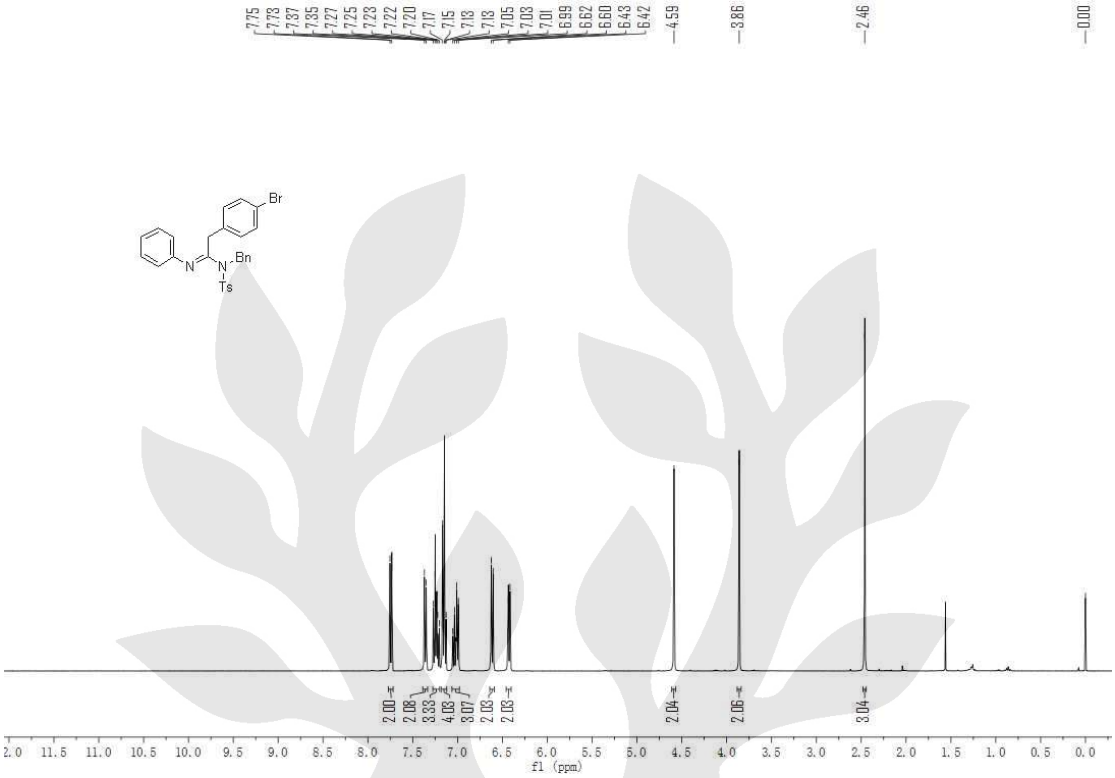
^{1}H NMR spectrum of 3at



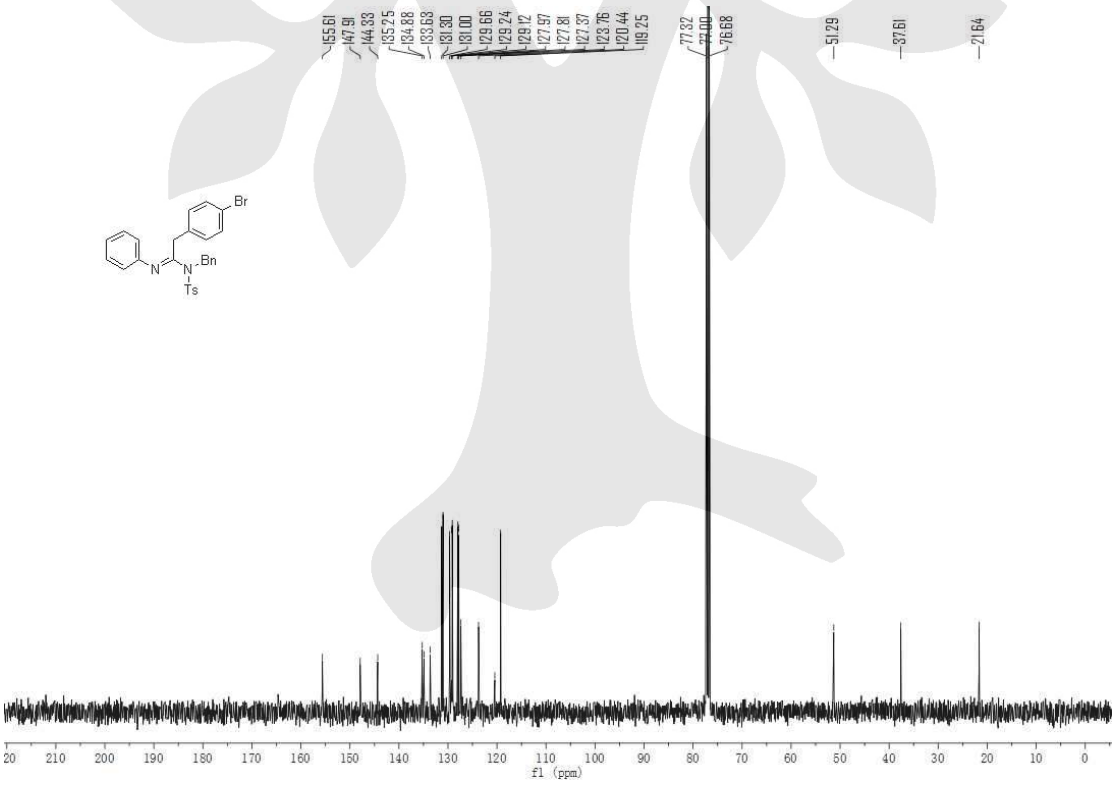
^{13}C NMR spectrum of 3at



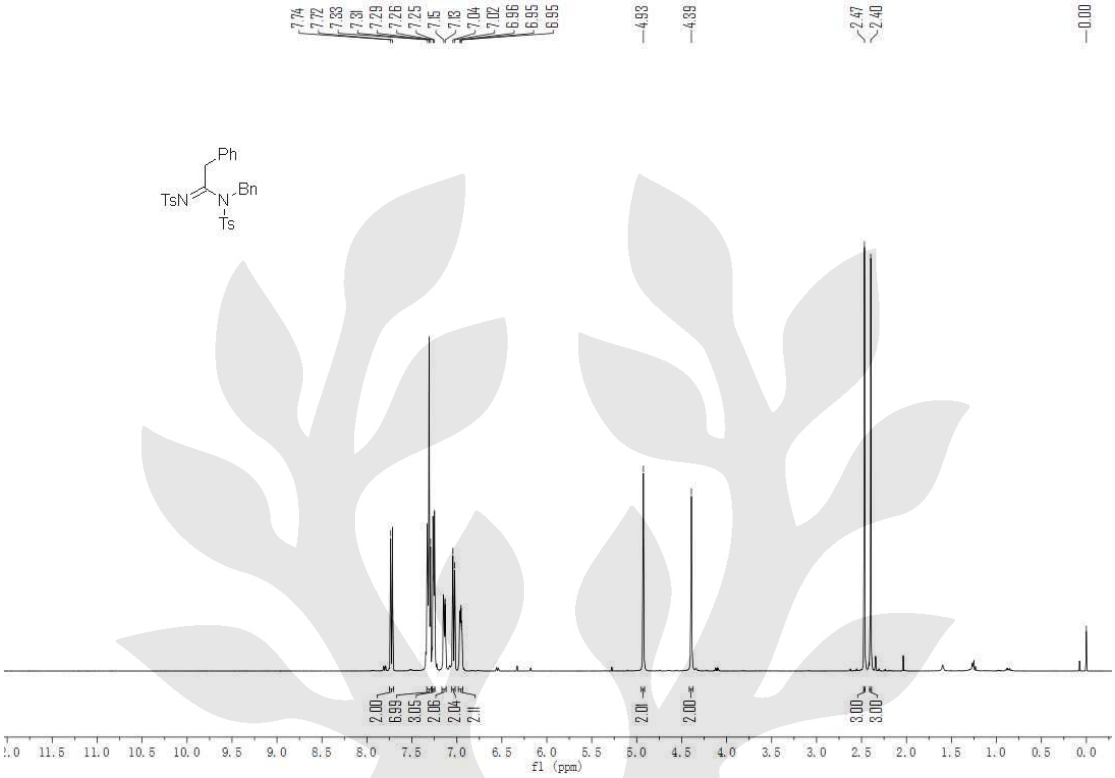
^{1}H NMR spectrum of 3au



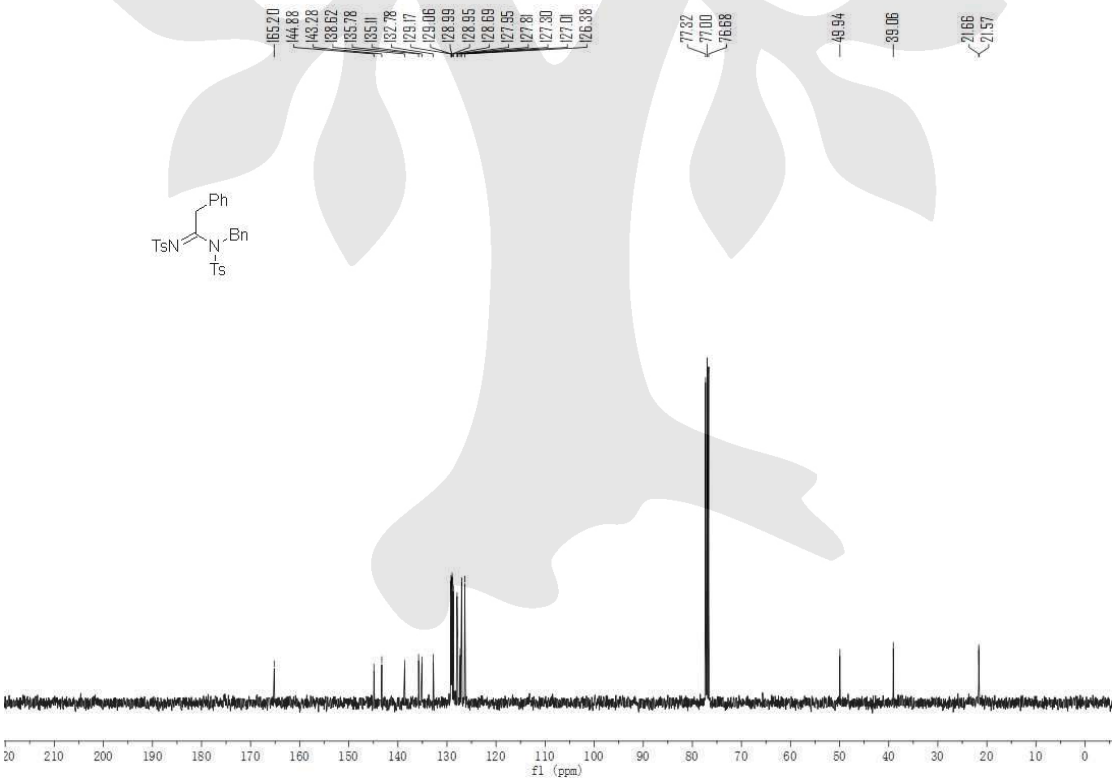
^{13}C NMR spectrum of 3au



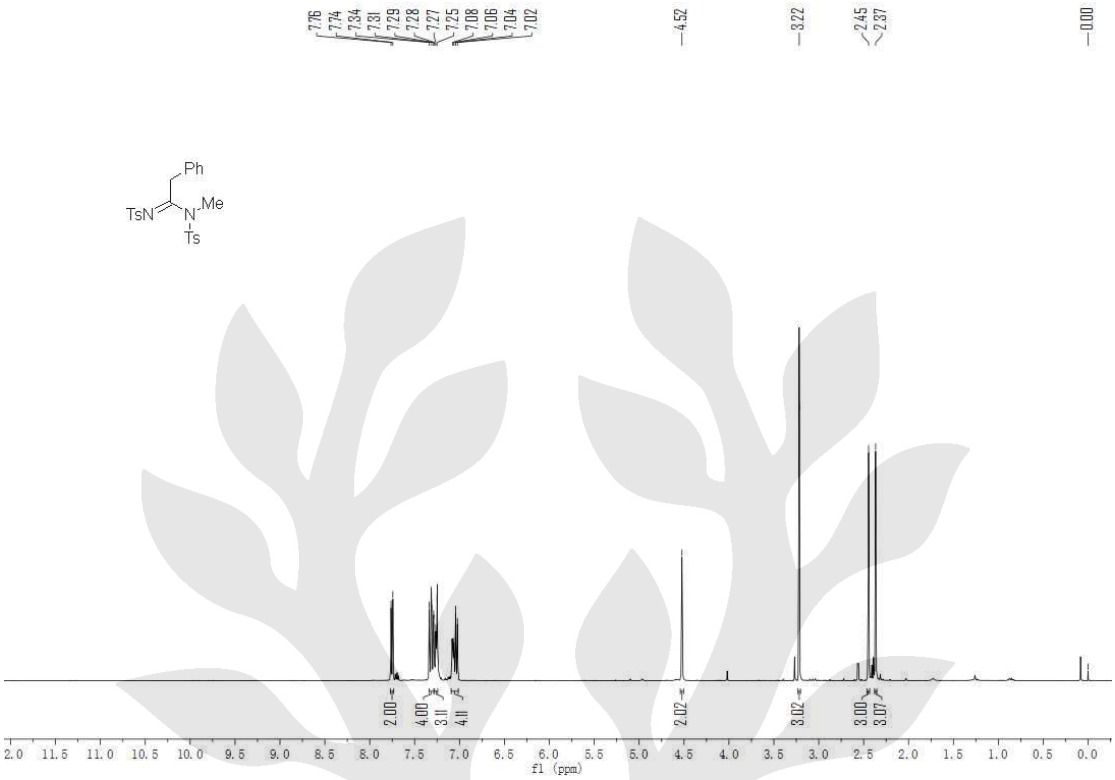
^{1}H NMR spectrum of 5aa



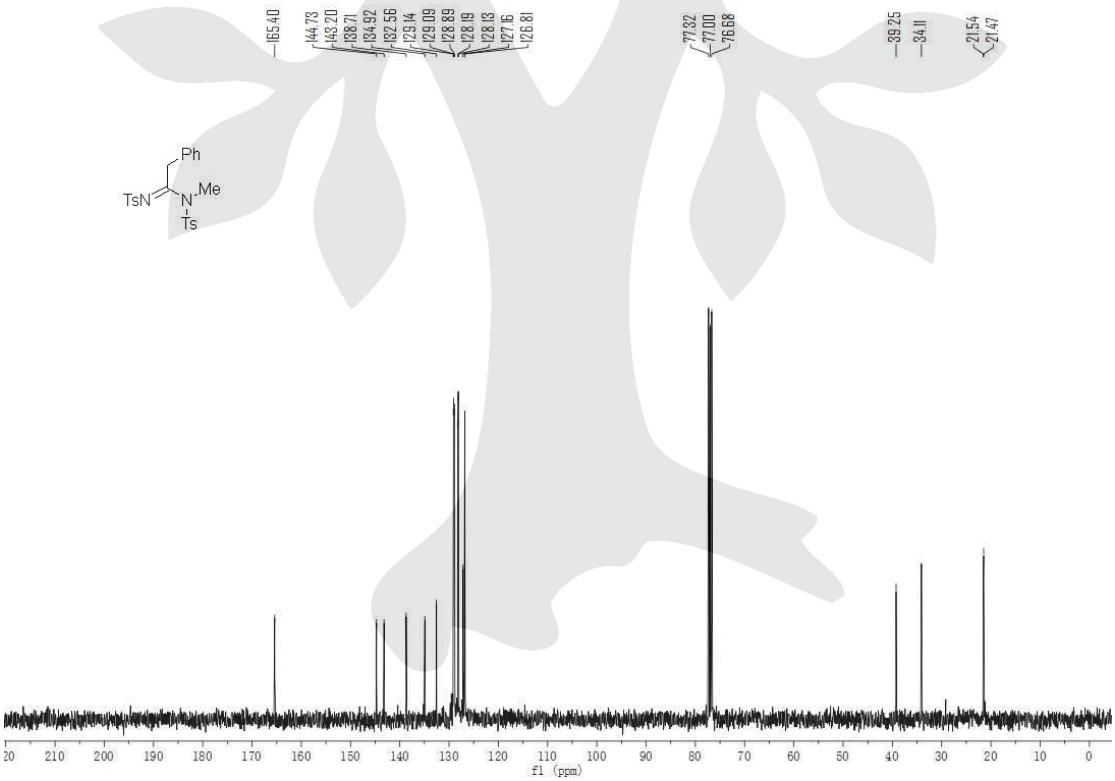
^{13}C NMR spectrum of 5aa



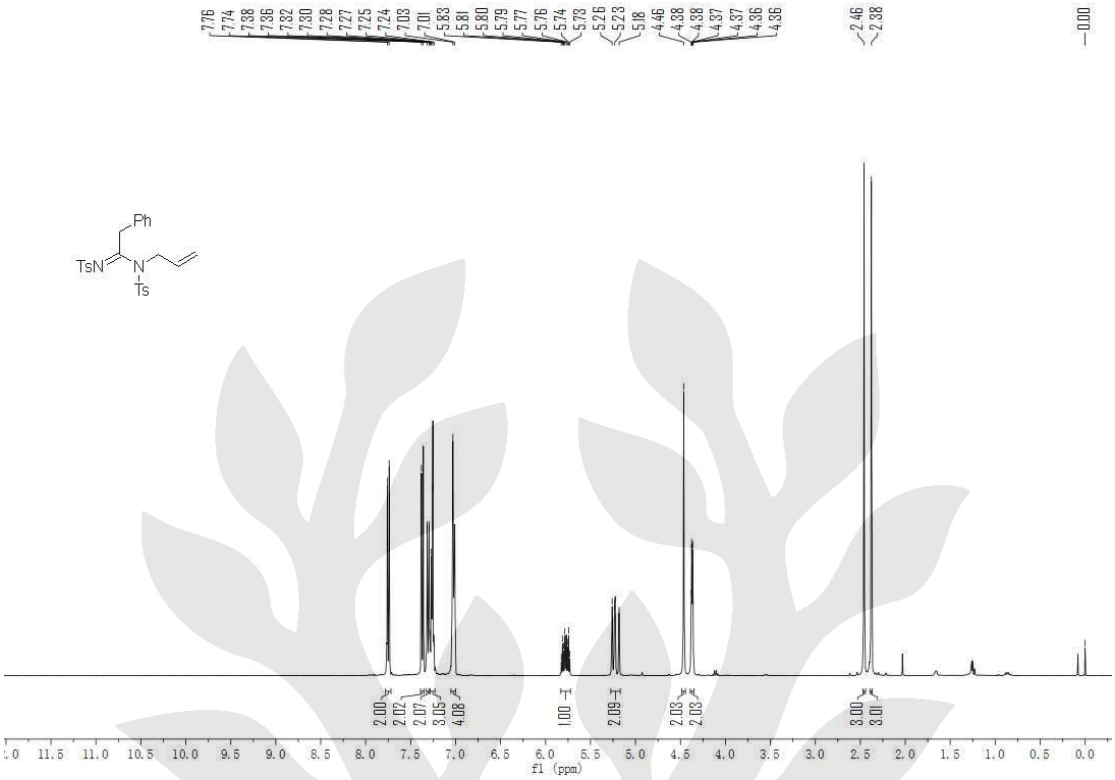
^{1}H NMR spectrum of 5ab



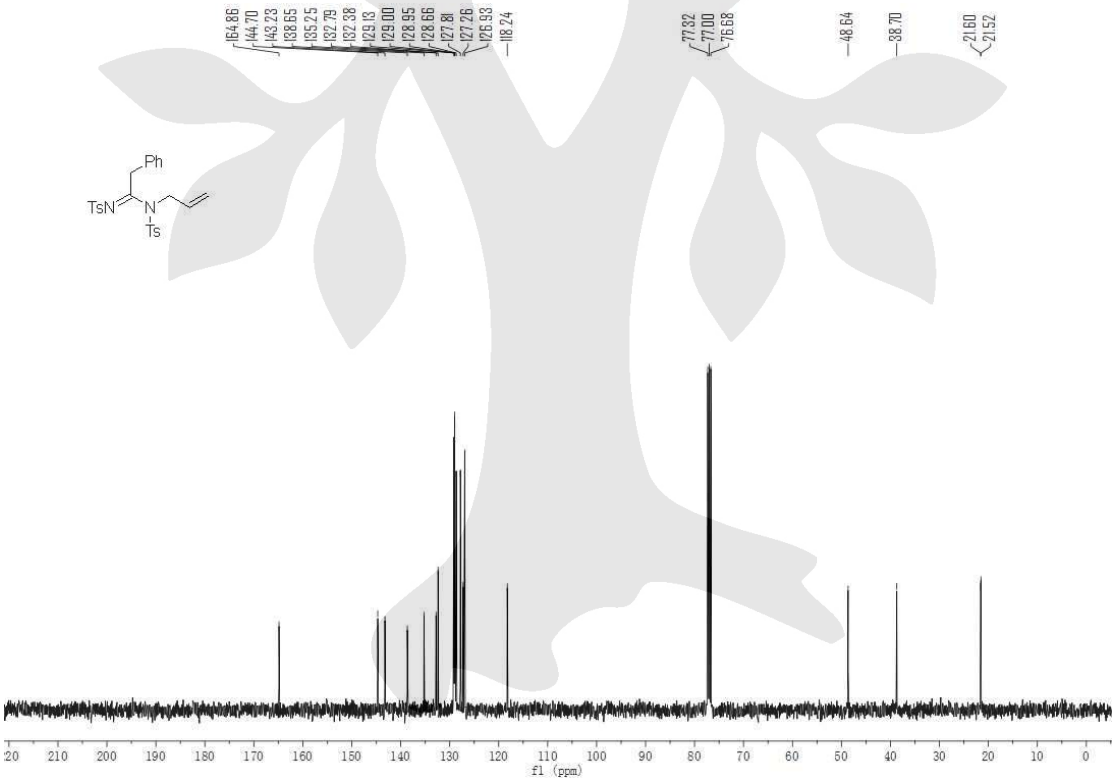
^{13}C NMR spectrum of 5ab



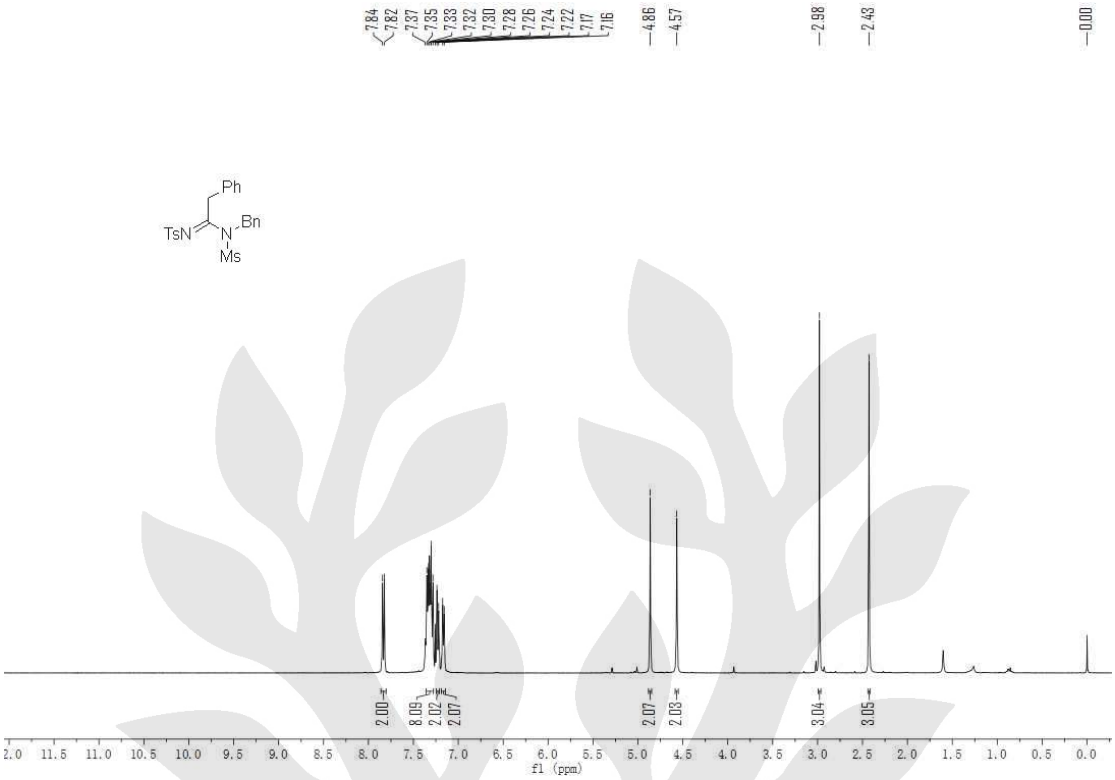
^{1}H NMR spectrum of 5ac



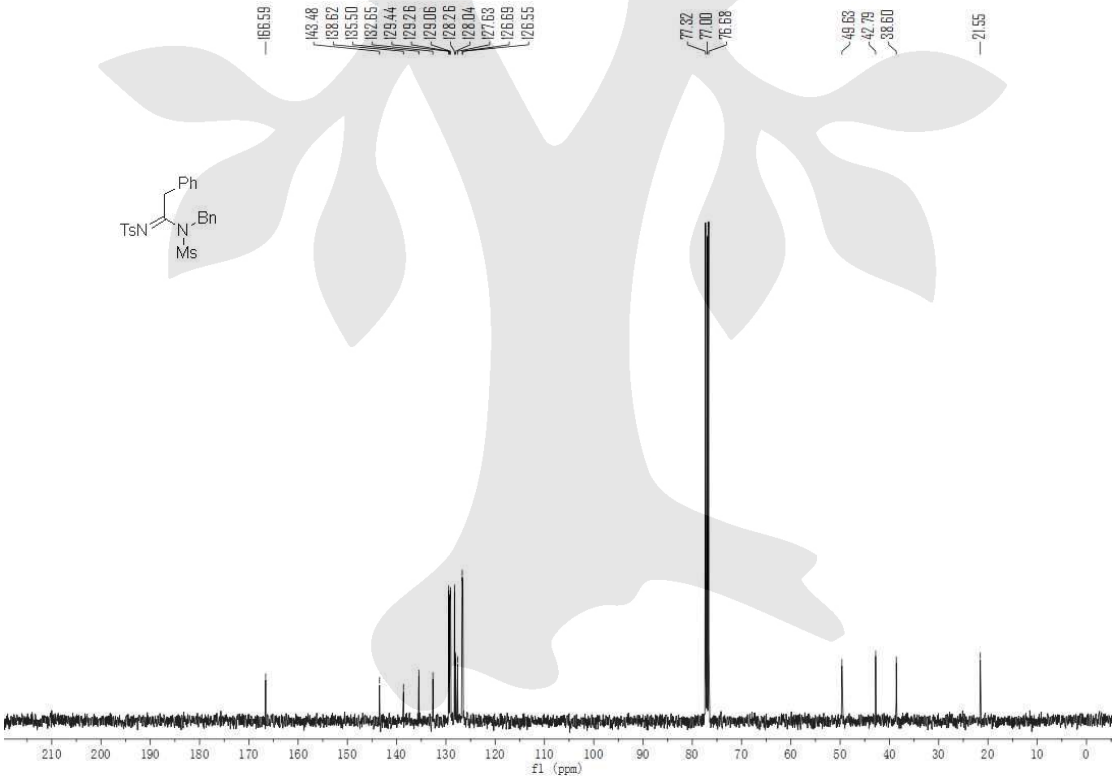
^{13}C NMR spectrum of 5ac



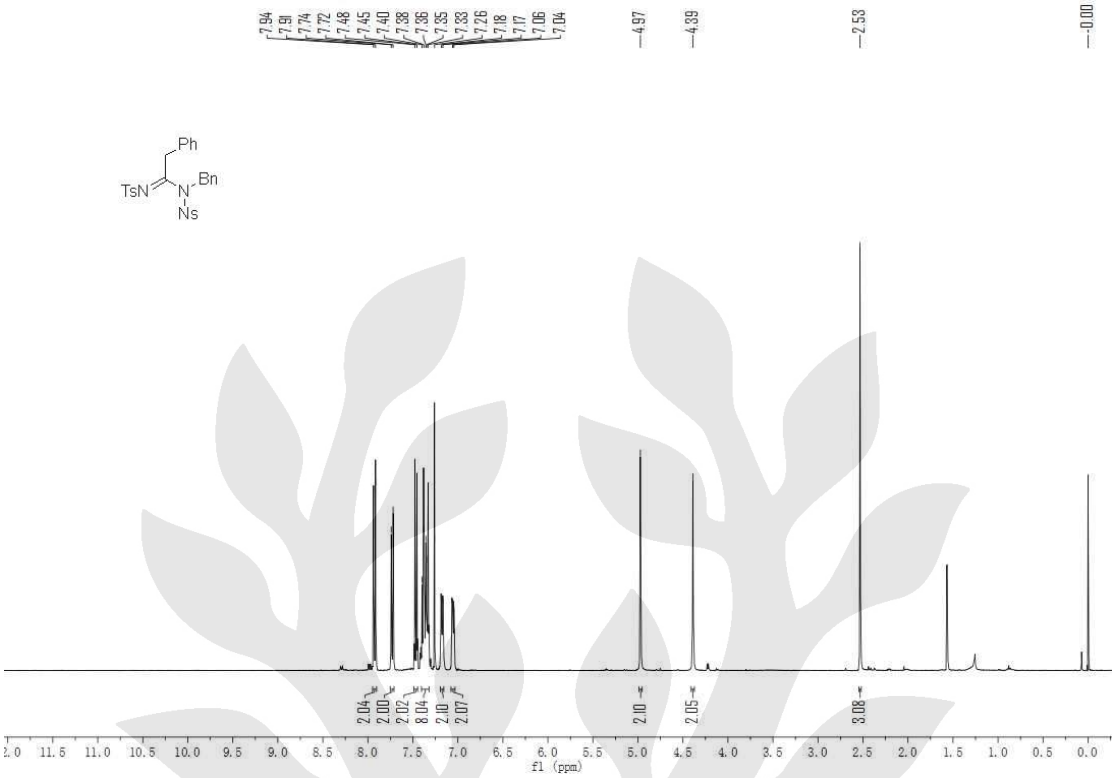
^{1}H NMR spectrum of 5ad



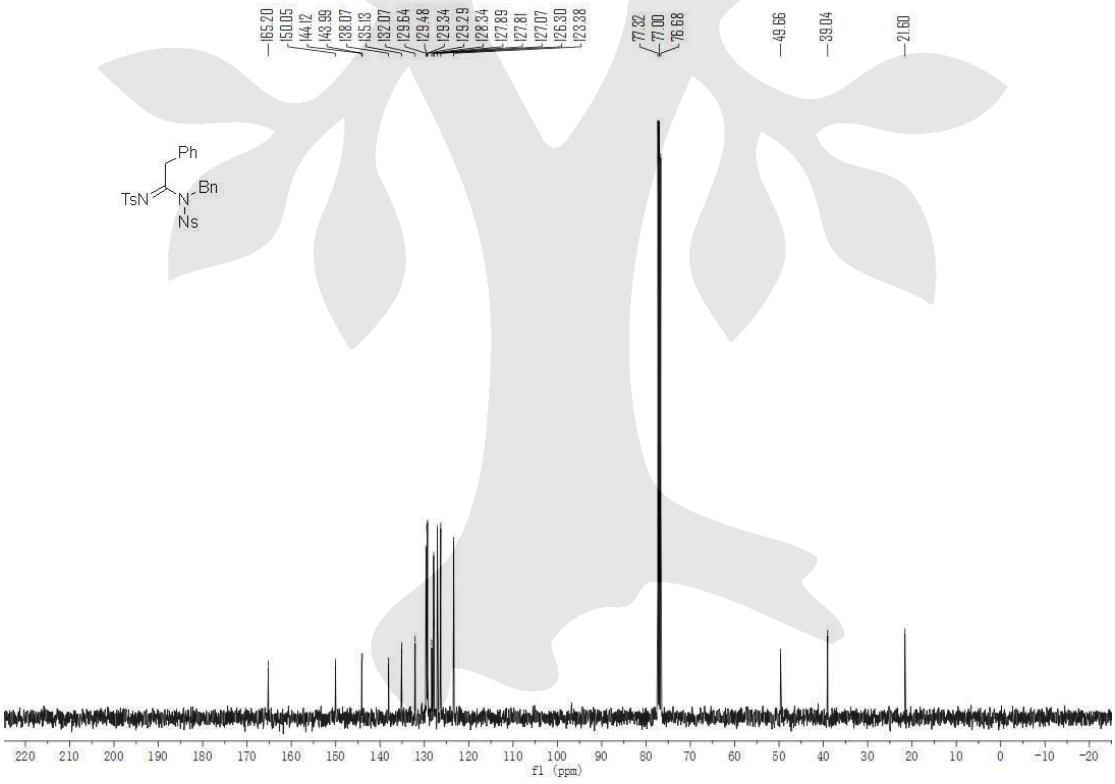
^{13}C NMR spectrum of 5ad



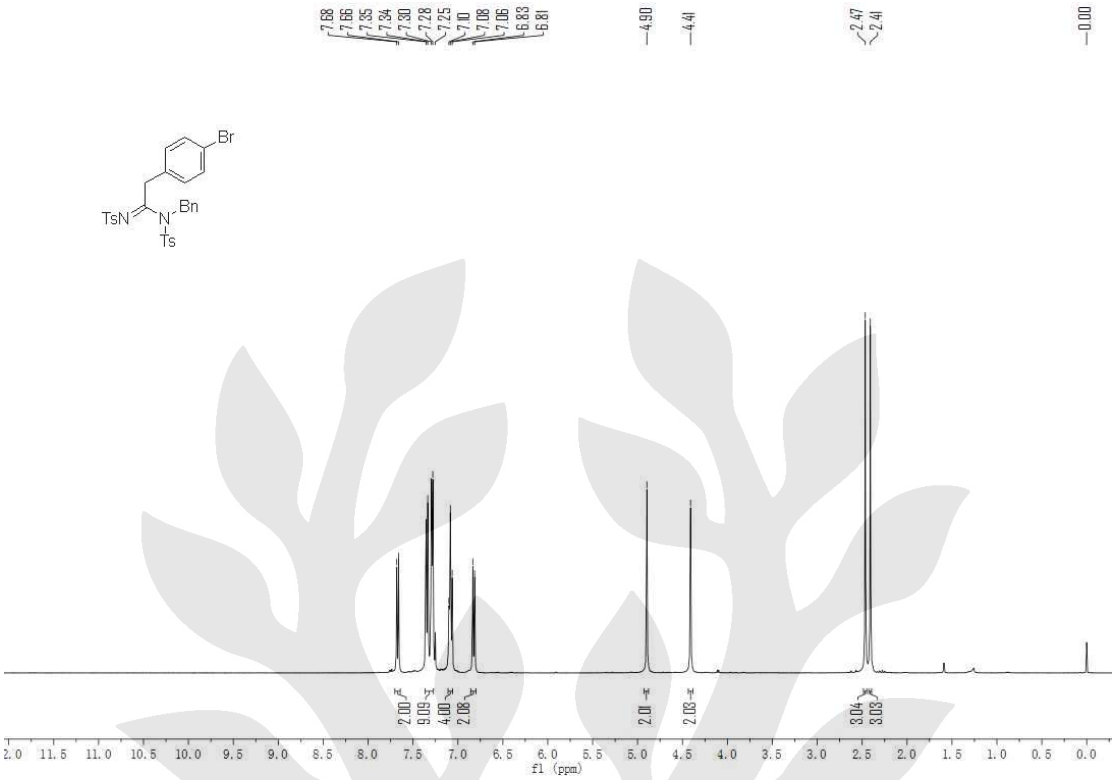
^{1}H NMR spectrum of 5ae



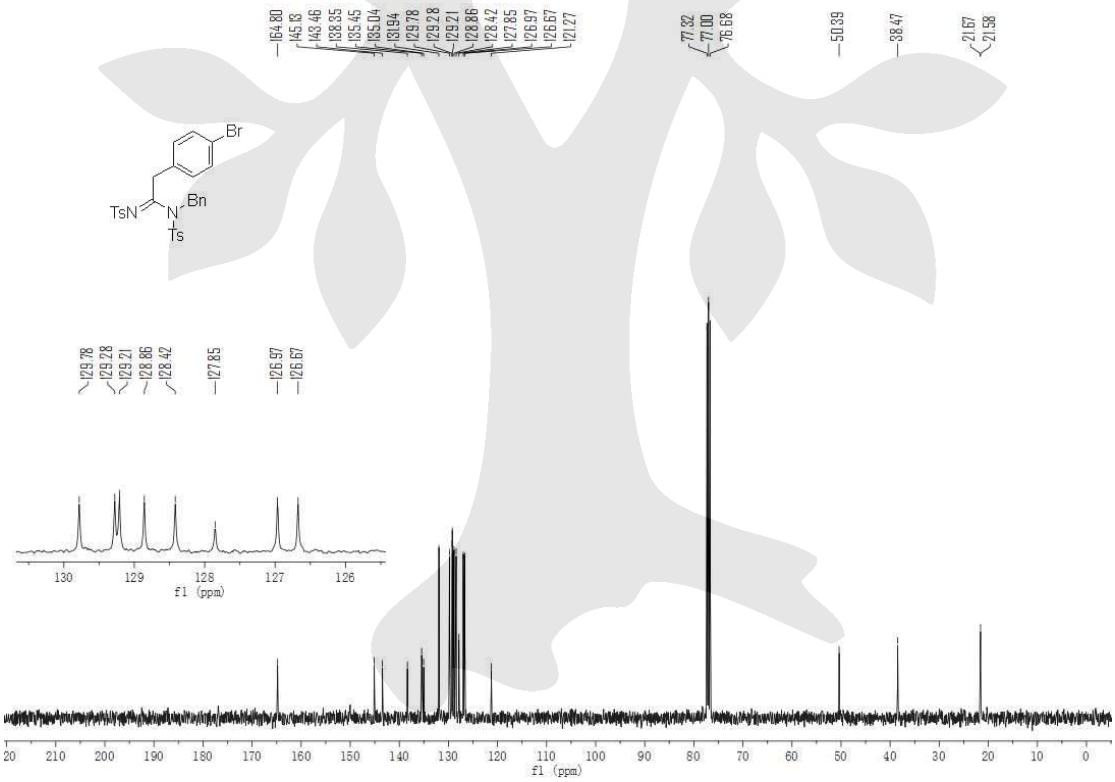
^{13}C NMR spectrum of 5ae



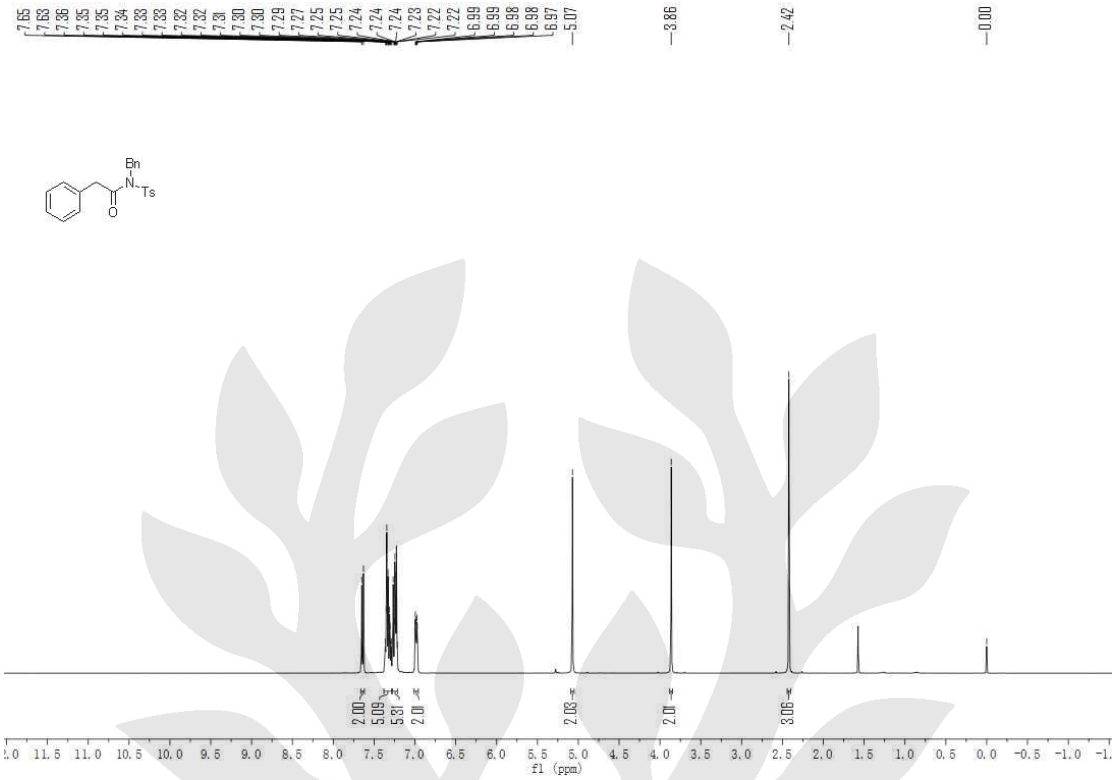
^{1}H NMR spectrum of 5af



^{13}C NMR spectrum of 5af



^{1}H NMR spectrum of 6



^{13}C NMR spectrum of 6