JOC The Journal of Organic Chemistry

Article

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Preparation of *trans*-2-Substituted-4-halopiperidines and *cis*-2-Substituted-4-halotetrahydropyrans via $AlCl_3$-Catalyzed Prins Reaction

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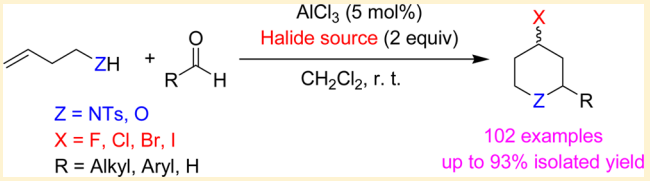
Supporting Information

ABSTRACT: A general and practical method for the preparation of *trans*-2-substituted-4-halopiperidines and *cis*-2-substituted-4-halotetrahydropyrans is reported. Using 5 mol % of $AlCl_3$ as the catalyst and 2 equiv of trimethylsilyl halides as the halide sources, aza-Prins cyclization of *N*-tosyl homoallylamine or Prins cyclization of homoallylic alcohol with carbonyl compounds could be readily realized, giving the corresponding *trans*-2-substituted-4-halopiperidines or *cis*-2-substituted-4-halotetrahydropyrans in high yields and satisfactory diastereoselectivity.



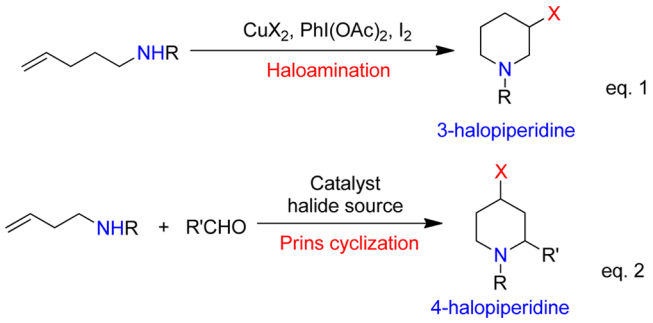
INTRODUCTION

Six-membered ring heterocycles such as piperidines and tetrahydropyrans are important structural motifs in a variety of biologically interesting compounds and can be used as useful building blocks for the synthesis of complex natural products.[1] In addition, these structures also constitute the important part of the privileged structures in drug research and discovery.[2] To this end, different methods have been developed for the constructions of piperidines and tetrahydropyrans. Of the variety of methods developed, Prins-type cyclization of homoallylic amines/alcohols with carbonyl compounds would be one of the most attractive strategies for the formation of these heterocycles. Since the first publication of H_2SO_4-mediated addition of formaldehyde to alkenes by Prins,[3] considerable work has been carried out to expand the application scope of this transformation:[4] different Brønsted and Lewis acids such as TfOH,[5] *p*-TSA,[6] TFA,[7] HF,[8] BF_3,[9] FeX_3,[10] $Sc(OTf)_3$,[11] Ga(III),[12] In(III),[13] I_2,[14] Au(I),[15] and TMSOTf[16] have been successfully applied in Prins-type cyclization reactions. Further, Prins reactions have also been used as key steps for the syntheses of an increasing number of natural products.[17] It is our purpose to develop a mild and convenient method for the construction of substituted piperidine and tetrahydropyran structures. In this paper, we wish to report $AlCl_3$-catalyzed Prins reactions as a continuation of our program on the construction of nitrogen- and oxygen-containing heterocycles.[18]

RESULTS AND DISCUSSION

Recently, we have shown that 3-halopiperidines could be obtained via intramolecular haloamination of unfunctionalized olefins. The reactions were carried out using Cu(II), iodine, or hypervalent iodine as the reaction promoters, and the corresponding haloamination products could be obtained in good isolated yields at ambient temperature in the absence of anhydrous conditions (Scheme 1, eq 1).[18] As 4-halopiperidines could be used as important building blocks in the synthesis of different natural products and biologically active compounds,[19] developing a concise and general strategy for the construction of such heterocycles would also be highly desirable (Scheme 1, eq 2). On the basis of our understanding of Lewis acid catalyzed intramolecular cyclizaton reactions, the aza-Prins reaction between *N*-tosyl homoallylamine (**1**) and 4-methylbenzaldehyde (**2**) was proposed, and the preliminary results are summarized in Table 1.

Scheme 1. Schematic Presentation of Halopiperidines

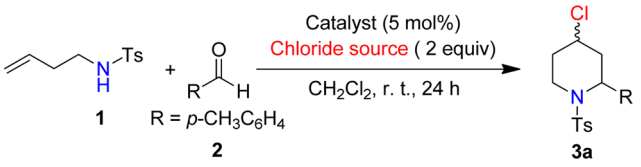


The results in Table 1 indicated that $AlCl_3$-catalyzed aza-Prins cyclization of **1** and **2** proceeded readily when TMSCl was used as the chloride source. In the presence of 5 mol % of $AlCl_3$ and 2 equiv of TMSCl, 2-(4-methylphenyl)-4-chloro-

Received: April 5, 2016
Published: May 23, 2016

DOI: 10.1021/acs.joc.6b00725
J. Org. Chem. 2016, 81, 5144−5161

Table 1. Optimization of the Reaction Conditions[a]



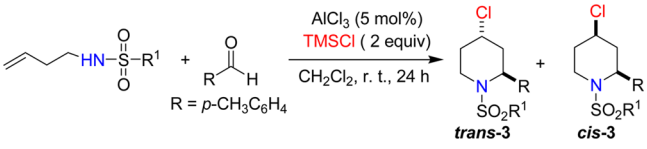
entry	catalyst	chloride source	isolated yield (%)
1	$AlCl_3$	TMSCl	83
2	$AlCl_3$	TBSCl	14
3	$AlCl_3$	$(nBu)_4NCl$	<5
4	$AlCl_3$	LiCl	22
5	$AlCl_3$	$ZnCl_2$	17
6	CuCl	TMSCl	70
7	CuBr	TMSCl	63
8	CuF_2	TMSCl	43
9	$Zn(OTf)_2$	TMSCl	55
10		TMSCl	<5

[a]Reaction conditions: the reactions were conducted in 0.5 mmol scale in 2 mL of CH_2Cl_2 at room temperature.

piperidine **3a** was obtained in 83% isolated yield (entry 1). Other Lewis acids such as CuI, CuF_2, $CuCl_2{\cdot}2H_2O$, $Cu(OAc)_2$, $CuSO_4$, or $MgBr_2$ were not efficient enough to promote the reaction, possibly due to the relatively weak Lewis acidity of these catalysts.[20] Also, low yields were observed when TBSCl, $(nBu)_4NCl$, LiCl, or $ZnCl_2$ were used as the chloride sources (entries 2−5). No product was detected in the absence of $AlCl_3$ (entry 10), indicating the important role played by the catalyst.

Substrates bearing different sulfonyl groups were also tested to study the electronic effect of the sulfonamides on the course of the reaction. As shown in Table 2, substituents on the

Table 2. Scope of the Sulfonamides[a]



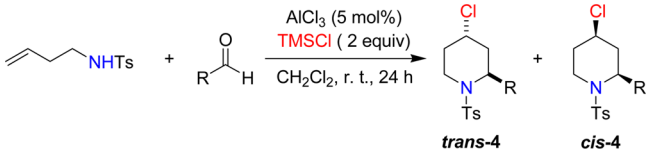
entry	R^1	isolated yield (%)	*trans*:*cis*[b]
1	*p*-MePh	83 (**3a**)	98:2
2	*p*-MeOPh	88 (**3b**)	91:9
3	Ph	78 (**3c**)	95:5
4	*p*-O_2NPh	51 (**3d**)	95:5
5	CH_3	66 (**3e**)	86:14

[a]Reaction conditions: the reactions were conducted in 0.5 mmol scale in 2 mL of CH_2Cl_2 at room temperature. [b]Diastereoisomeric ratios were determined by ^{1}H NMR.

aromatic ring had a significant impact on the outcomes of the reactions. Arenesulfonyl groups bearing electron-donating groups on benzene rings generally gave high isolated yields (entries 1 and 2 vs entry 3), and the arenesulfonyl group with an electron-withdrawing group on the benzene ring was unfavorable for the reaction (entry 4). This was possibly because of the slow formation of the reaction intermediate sulfoniminium due to the low reactivity of the *p*-nitrobenzenesulfonamide. The substrate with a small methanesulfonyl group on the nitrogen atom gave a moderate isolated yield with a slight drop of the diastereoselectivity (entry 5).

Encouraged by these preliminary results, different aldehydes were subjected to this aza-Prins reaction to test the scope of the protocol. As shown in Table 3, aromatic, heteroaromatic,

Table 3. Scope of Aldehydes in $AlCl_3$-Catalyzed Aza-Prins Cyclization Reaction[a]



entry	R	isolated yield (%)	*trans*:*cis*[b]
1	2-MePh	74 (**4a**)	89:11
2	3-MePh	77 (**4b**)	87:13
3	4-MeOPh	87 (**4c**)	96:4
4	3-MeOPh	85 (**4d**)	95:5
5	2-MeOPh	92 (**4e**)	87:13
6	Ph	80 (**4f**)	96:4
7	4-*i*PrPh	84 (**4g**)	95:5
8	4-FPh	75 (**4h**)	96:4
9	2-FPh	70 (**4i**)	90:10
10	4-ClPh	80 (**4j**)	91:9
11	3-ClPh	78 (**4k**)	89:11
12	4-BrPh	78 (**4l**)	90:10
13	4-*t*BuPh	84 (**4m**)	96:4
14	4-CNPh	63 (**4n**)	96:4
15	4-CO_2MePh	60 (**4o**)	99:1
16	4-NO_2Ph	51 (**4p**)	99:1
17	2-furanyl	84 (**4q**)	96:4
18	H	90 (**4r**)	
19	C_2H_5	86 (**4s**)	89:11
20	*n*-C_3H_7	81 (**4t**)	86:14
21	*i*-C_3H_7	92 (**4u**)	98:2
22	*i*-C_4H_9	90 (**4v**)	89:11
23	*n*-C_5H_{11}	93 (**4w**)	97:3
24	*n*-C_6H_{13}	91 (**4x**)	92:8
25	$PhCH_2$	83 (**4y**)	91:9
26	PhCH=CH	67 (**4z**)	93:7
27	2-pyridinyl	no reaction	

[a]Reaction conditions: the reactions were conducted in 0.5 mmol scale in 2 mL of CH_2Cl_2 at room temperature. [b]Diastereoisomeric ratios were determined by ^{1}H NMR.

aliphatic, and α,β-unsaturated aldehydes underwent aza-Prins cyclization with *N*-tosyl homoallylamine, giving the corresponding 4-chloropiperidines in good isolated yields with high diastereoselectivity.

As shown in Table 3, *trans*-2-substituted 4-chloropiperidines were obtained with moderate to good isolated yields and satisfactory diastereoselectivity. The electronic properties of the aromatic aldehydes showed some effect on the course of the reactions. In general, aromatic aldehydes bearing electron-donating groups on the benzene rings gave relatively higher yields than aromatic aldehydes bearing electron-withdrawing groups on the benzene rings (compounds **4a**−**4g** vs **4h**−**4p**), and a wide range of functional groups such as Me, MeO, *t*Bu, −X, $-CO_2Me$, −CN, and $-NO_2$ were tolerated during the reactions. Furthermore, the heteroatom-containing furfural could also undergo cyclization under the optimal conditions (**4q**). The *trans* stereochemistry was ascertained by single-crystal X-ray diffraction experiment on compound **4j**. As shown in Figure 1, **4j** bore a typical chair conformation with the *p*-

DOI: 10.1021/acs.joc.6b00725
J. Org. Chem. 2016, 81, 5144−5161

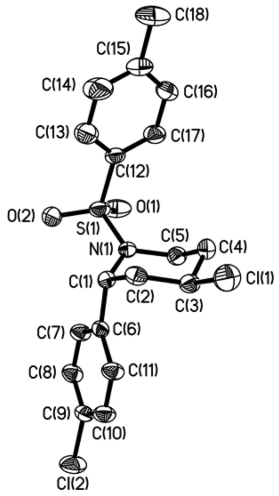


Figure 1. ORTEP drawing of **4j** with the thermal ellipsoids at 30% probability. Hydrogen atoms were omitted for clarity.

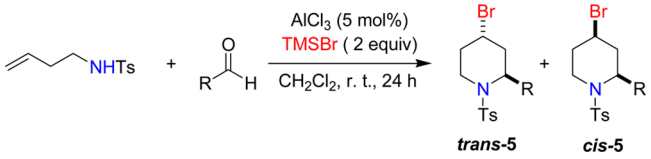
chlorophenyl group at the axial position, and the chlorine atom and *p*-toluenesulfonyl group stayed at the equatorial positions. This result is in good agreement with a related aza-Prins−Ritter reaction reported by Reddy.[5b]

Furthermore, this method was also effective for aliphatic aldehydes, and the corresponding *trans*-2-alkyl-4-chloropiperidines could be obtained in good yields (**4r**−**4y**). Also, the current reaction system was applicable to the acid-sensitive cinnamaldehyde, and product **4z** could be obtained in moderate isolated yield. This compound has been used as key intermediate for the synthesis of alkaloid natural products.[13d] *N*-Tosyl homoallylamine and picolinaldehyde failed to react under the optimized reaction conditions, possibly due to the overcoordination of the nitrogen atom to $AlCl_3$, which decreased the catalytic activity of the latter.

After the successful synthesis of *trans*-2-substituted 4-chloropiperidines, our attention turned to the synthesis of *trans*-2-substituted 4-bromopiperidines. Fache et al. showed that TMSBr or TMSI alone could be used to promote aza-Prins cyclizations of allylsulfonamides with aldehydes/ketones. The reactions were carried out under solvent- and metal-free conditions, and the products *δ*-sultams could be obtained in good isolated yields. However, mixtures of 4-halopiperidines and dihydropiperidines were obtained when *N*-tosyl homoallylamine and aldehydes were subjected to aza-Prins reactions under the same conditions.[21] In the current study, when 5 mol % of $AlCl_3$ was used as catalyst, no dihydropiperidine products were detected, and a variety of *trans*-2-substituted 4-bromopiperidines could be obtained in good isolated yields (Table 4). When different aromatic aldehydes were subjected to the reactions, electron-rich aromatic aldehydes gave higher yields than their electron-deficient counterparts. The structure and relative stereochemistry of *trans*-2-substituted 4-bromopiperidines were established by an X-ray diffraction experiment on compound **5o**.[22]

Sabitha et al. reported the preparation of 4-iodopiperidines via TMSI-promoted aza-Prins reactions. In the presence of 1 equiv of TMSI, aza-Prins reaction of *N*-tosyl homoallylamine with aliphatic aldehydes produced *trans*-2-alkyl-4-iodo-1-tosylpiperidines in good isolated yields, and good selectivity for aliphatic aldehyde was observed when both aliphatic and aromatic aldehydes were present in the reaction mixture.[23] To

Table 4. Synthesis of 4-Bromopiperidines[a]



entry	R	isolated yield (%)	*trans*:*cis*[b]
1	4-MePh	82 (**5a**)	94:6
2	3-MePh	87 (**5b**)	91:9
3	4-MeOPh	91 (**5c**)	91:9
4	3-MeOPh	87 (**5d**)	90:10
5	2-MeOPh	84 (**5e**)	97:3
6	Ph	93 (**5f**)	99:1
7	4-*i*PrPh	81 (**5g**)	94:6
8	4-*t*BuPh	87 (**5h**)	98:2
9	4-FPh	80 (**5i**)	96:4
10	2-FPh	82 (**5j**)	89:11
11	4-ClPh	78 (**5k**)	96:4
12	4-BrPh	83 (**5l**)	95:5
13	4-CNPh	60 (**5m**)	99:1
14	4-CO_2MePh	65 (**5n**)	99:1
15	4-NO_2Ph	53 (**5o**)	98:2
16	4-CF_3Ph	65 (**5p**)	92:8
17	4-HOPh	71 (**5q**)	99:1
18	2-furanyl	89 (**5r**)	99:1
19	H	90 (**5s**)	
20	C_2H_5	87 (**5t**)	88:12
21	*i*-C_3H_7	93 (**5u**)	86:14
22	*i*-C_4H_9	93 (**5v**)	92:8
23	*n*-C_5H_{11}	82 (**5w**)	90:10
24	*n*-C_6H_{13}	94 (**5x**)	88:12
25	PhCH=CH	70 (**5y**)	86:14
26	$PhCH_2$	82 (**5z**)	89:11

[a]Reaction conditions: the reactions were conducted in 0.5 mmol scale in 2 mL of CH_2Cl_2 at room temperature. [b]Diastereomeric ratios were determined by ^1H NMR.

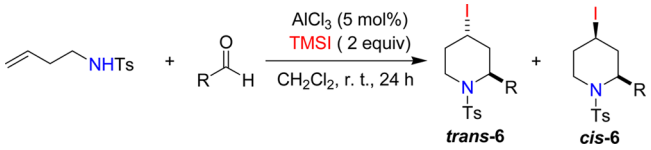
our delight, preparation of 2-aryl-4-iodopiperidine compounds could be realized via $AlCl_3$-catalyzed aza-Prins reactions of aromatic aldehydes using TMSI as the iodide source (Table 5).

As shown in Table 5, both aliphatic aldehydes and aromatic aldehydes could undergo aza-Prins reactions. The corresponding *trans*-2-substituted 4-iodopiperidines were obtained in good yields and high diastereoselectivity, and the formation of dihydropiperidines was not observed.[21] Again, electron-rich aromatic aldehydes gave products in high yields compared to the electron-deficient aromatic aldehydes.

The structure and stereochemistry of the compounds were also established by ^1H NMR and NOE experiments on compound **6n**. The major diastereomer bore a typical chair conformation where the two substituents are *trans* to each other (Figure 2). Proton H_4 has two large couplings (J = 14.5 Hz), indicating its axial position with diaxial couplings with H_{3ax} and H_{5ax}. These results indicated that the iodide atom stayed at the equatorial position at C_4. This was further confirmed by a NOESY cross-peak between H_4 and H_{6a}. A small coupling (J = 4.1 Hz) of the H_2 proton indicated that it stayed at the equatorial position, and the *p*-bromophenyl group stayed at the axial position of C_2. The axial orientation of the *p*-bromophenyl group was further confirmed by the NOESY cross-peaks between H-*ortho* and H_4. The couplings and H_{3a}/H_{5a} NOE correlation also provided additional support for the structure.

DOI: 10.1021/acs.joc.6b00725
J. Org. Chem. 2016, 81, 5144−5161

Table 5. Synthesis of 4-Iodopiperidines[a]



entry	R	isolated yield (%)	*trans*:*cis*[b]
1	4-MePh	81 (**6a**)	92:8
2	3-MePh	86 (**6b**)	94:6
3	2-MePh	79 (**6c**)	90:10
4	4-MeOPh	65 (**6d**)	90:10
5	3-MeOPh	72 (**6e**)	92:8
6	2-MeOPh	78 (**6f**)	93:7
7	Ph	73 (**6g**)	92:8
8	4-*i*PrPh	80 (**6h**)	90:10
9	4-*t*BuPh	85 (**6i**)	95:5
10	4-FPh	84 (**6j**)	96:4
11	2-FPh	88 (**6k**)	89:11
12	4-ClPh	81 (**6l**)	92:8
13	3-ClPh	88 (**6m**)	94:6
14	4-BrPh	89 (**6n**)	90:10
15	2-BrPh	77 (**6o**)	91:9
16	4-CF_3Ph	68 (**6p**)	93:7
17	4-CO_2MePh	60 (**6q**)	95:5
18	4-$PhCH_2OPh$	71 (**6r**)	94:6
19	H	86 (**6s**)	
20	C_2H_5	84 (**6t**)	87:13
21	*n*-C_3H_7	82 (**6u**)	90:10
22	*i*-C_3H_7	88 (**6v**)	91:9
23	*i*-$C_3H_7CH_2$	91 (**6w**)	89:11
24	*n*-C_5H_{11}	83 (**6x**)	88:12
25	*n*-C_6H_{13}	85 (**6y**)	88:12
26	$PhCH_2$	73 (**6z**)	90:10

[a]Reaction conditions: the reactions were conducted in 0.5 mmol scale in 2 mL of CH_2Cl_2 at room temperature. [b]Diastereomeric ratios were determined by ^1H NMR.

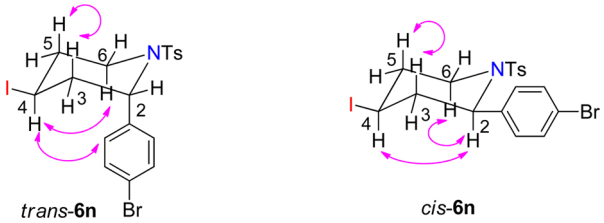


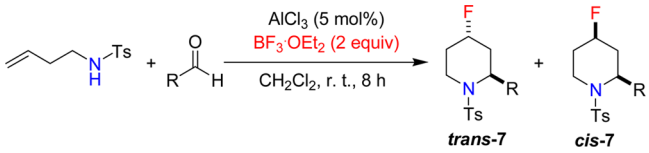
Figure 2. Characteristic NOEs of **6n**.

These results were also in agreement with X-ray diffraction experiment.[22]

The structure of minor diastereomer **6n** shown in Figure 2 was deduced from the NMR data, where the two substituents are *cis* to each other. The coupling constants observed for $J(H_4-H_{3a})$ and $J(H_{3a}-H_2)$ were all greater than 10.0 Hz, indicating that these protons stayed at axial positions, and the *p*-bromophenyl group stayed at the equatorial position of C_2. This strucuture was also confirmed by the presence of NOE cross-peaks between H_4, H_{6a}, and H_2 as well as cross-peaks between H_{3a} and H_{5a}.[22]

In addition to the synthesis of 4-chloro-, 4-bromo-, and 4-iodopiperidines, synthesis of 4-fluoropiperidines[24] could also be realized under current reaction conditions. After the screening of different fluoride sources, $BF_3{\cdot}Et_2O$ was found to be the most suitable one for the reaction, and several 4-fluoropiperidine compounds could be obtained in good isolated yields (Table 6).[25] However, poor diastereoselectivities were observed for most reactions. We reasoned that this was due to the small size of the fluoride anion, which caused poor diastereodiscrimination during the attack of the fluoride to the reaction intermediate.

Table 6. Synthesis of 4-Fluoropiperidines[a]



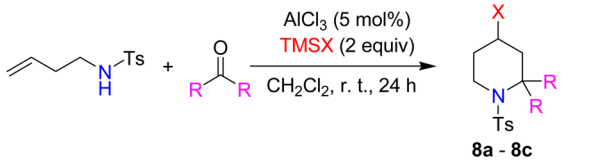
entry	R	isolated yield	*trans*:*cis*[b]
1	4-MePh	80 (**7a**)	48:52
2	4-MeOPh	82 (**7b**)	46:54
3	Ph	75 (**7c**)	44:56
4	4-FPh	76 (**7d**)	41:59
5	4-ClPh	84 (**7e**)	47:53
6	4-BrPh	81 (**7f**)	45:55
7	4-NO_2Ph	86 (**7g**)	42:58

[a]Reaction conditions: the reactions were conducted in 0.5 mmol scale in 2 mL of CH_2Cl_2 at room temperature. [b]Diastereomeric ratios were determined by ^1H NMR.

The crystal structure of the *trans*-diastereomer of the 4-fluoropiperidine **7d** was determined by X-ray crystallography.[22] Launay et al. reported the microwave-assisted aza-Prins reactions of *N*-tosyl homoallylamine to generate 4-fluoropiperidines using $BF_3{\cdot}Et_2O$ as the fluoride source.[9b] However, the yields dropped dramatically when electron-rich aromatic aldehydes were subjected to the reactions. Therefore, the current method provided a new approach that was complementary to the known methods for the synthesis of 4-fluoropiperidines.

Subsequently, ketones were also tested in $AlCl_3$-catalyzed aza-Prins reactions, and *spiro*-piperidines with quaternary centers could be obtained in moderate isolated yields when cyclic ketones were subjected to the reactions with TMSBr as the bromide source (Table 7, entries 4 and 5). TMSCl or TMSI failed to react under current conditions.

Table 7. Aza-Prins Reactions of *N*-Tosyl Homoallylamine with Various Ketones[a]



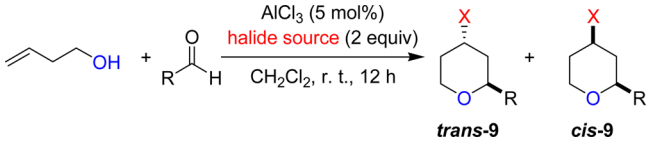
entry	TMSX	R	isolated yield (%)
1	TMSCl	Me	NR
2	TMSBr	Me	46 (**8a**)
3	TMSI	Me	<5
4	TMSBr	$-(CH_2)_4-$	51 (**8b**)
5	TMSBr	$-(CH_2)_5-$	40 (**8c**)

[a]Reaction conditions: the reactions were conducted in 0.5 mmol scale in 2 mL of CH_2Cl_2 at room temperature.

DOI: 10.1021/acs.joc.6b00725
J. Org. Chem. 2016, 81, 5144−5161

After aza-Prins cyclization of *N*-tosyl homoallylamine with a variety of aldehydes, the scope of the reaction was further extended to homoallylic alcohol. As shown in Table 8, TMSCl

Table 8. Synthesis of 4-Halotetrahydropyrans[a]



entry	halide source	X	R	isolated yield (%)	*trans*:*cis*[b]
1	TMSCl	Cl	Ph	87 (**9a**)	<1:99
2	TMSBr	Br	Ph	83 (**9b**)	10:90
3	$BF_3{\cdot}OEt_2$	F	Ph	83 (**9c**)	12:88
4	TMSCl	Cl	4-MePh	86 (**9d**)	<1:99
5	TMSCl	Cl	4-MeOPh	89 (**9e**)	<1:99
6	TMSCl	Cl	4-ClPh	90 (**9f**)	<1:99
7	TMSCl	Cl	4-BrPh	86 (**9g**)	<1:99
8	TMSCl	Cl	4-FPh	91 (**9h**)	<1:99
9	TMSCl	Cl	4-NO_2Ph	93 (**9i**)	<1:99

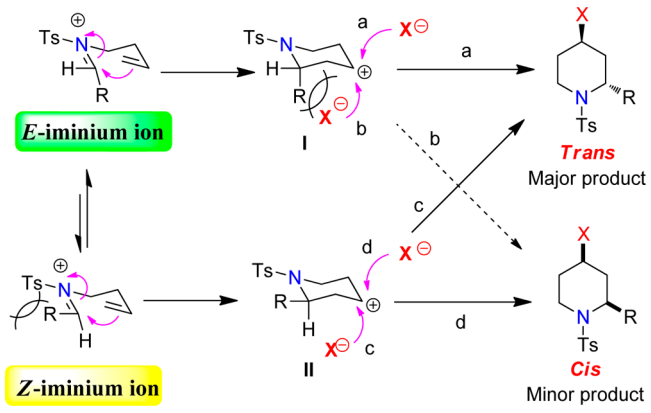
[a]Reaction conditions: the reactions were conducted in 0.5 mmol scale in 2 mL of CH_2Cl_2 at room temperature. [b]Diastereomeric ratios were determined by ^{1}H NMR.

gave the highest yields and diastereoselectivity for Prins reaction of a variety of aldehydes (entries 1−3). It was noteworthy that *cis*-halotetrahydropyrans were obtained as the major products in all cases.

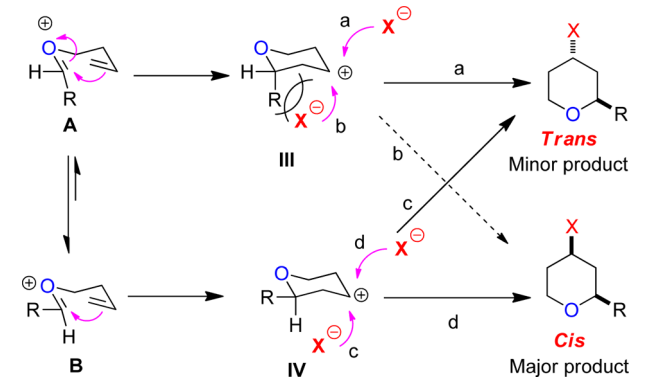
The current study showed that reactions of *N*-tosyl homoallylamine gave *trans*-halopiperidines as the major products (Tables 1−5), whereas reactions of homoallylic alcohol afforded *cis*-halotetrahydropyrans as the major isomers (Table 8). The *trans*-selectivity for aza-Prins cyclization may be attributed to the steric repulsion between Ts and R groups. Because of this repulsion, the Lewis acid assisted formation of the *E*-sulfoniminium intermediate[26] would be more favorable during the reaction. Aza-Prins cyclization proceeded via a six-membered ring transition state with the Ts group at the equatorial position and the R group at the axial position, and attack of the halide anion occurred from the equatorial direction, leading to *trans*-halopiperidine as the major product (Scheme 2, path a).[27]

In the case of the homoallylic alcohol-involved Prins reaction,[4d] the R group staying at the equatorial position of the transition state (**B**) would be more favorable, and the attack of the halide anion took place from the equatorial direction, producing *cis*-disubstituted tetrahydropyran as the major product (Scheme 3, path d).

Scheme 2. Plausible Reaction Pathway in the Aza-Prins Cyclization of *N*-Tosyl Homoallylamine



Scheme 3. Plausible Reaction Pathways in the Prins Cyclization of Homoallylic Alcohol



CONCLUSION

In summary, we have shown that $AlCl_3$ was effective to catalyze aza-Prins reactions of *N*-tosyl homoallylamine and Prins reaction of homoallylic alcohol with a variety of carbonyl compounds. Using 5 mol % of $AlCl_3$ as the catalyst and 2 equiv of trimethylsilyl halide as the halide sources, both *trans*-halopiperidines and *cis*-halotetrahydropyrans could be obtained in good isolated yields with satisfactory diastereoselectivity. The reactions could be easily carried out at ambient temperature, and air or moisture showed less effect on the course of the reactions. These features made the current reaction system a useful method for the preparation of a variety of substituted piperidines and tetrahydropyrans which could be used as useful building blocks for organic synthesis and drug synthesis.

EXPERIMENTAL SECTION

General Experimental Information. Reagents were used as received without further purification unless otherwise indicated. Solvents were dried and distilled prior to use. Reactions were monitored with thin-layer chromatography using silica gel GF_{254} plates. Organic solutions were concentrated *in vacuo* with rotavapor. Flash column chromatography was performed using silica gel (200−300 meshes). Petroleum ether used had a boiling point range of 60−90 °C. Melting points were measured on a digital melting point apparatus without correction of the thermometer. Nuclear magnetic resonance spectra were recorded at ambient temperature (unless otherwise stated) at 400 MHz (100 MHz for ^{13}C) in $CDCl_3$. Chemical shifts are reported in ppm (δ) using TMS as internal standard, and spin−spin coupling constants (J) are given in Hz. Infrared (IR) spectra were recorded with KBr pellets, and wavenumbers were given in cm^{-1}. High-resolution mass spectrometry (HRMS) analyses were carried out on 7.0T FTICR HR-ESI-MS.

General Procedure for Prins Reaction. In a 10 mL sealed tube were added *N*-tosyl homoallylamine or homoallylic alcohol (0.5 mmol), aldehyde (0.5 mmol), $AlCl_3$ (0.025 mmol), and TMSX (1 mmol) in dry CH_2Cl_2 (2 mL). The mixture was stirred at room temperature for a given time. Then, CH_2Cl_2 (10 mL) was added and the mixture was washed with H_2O, dried over $MgSO_4$, and concentrated to give a crude residue, which was purified by flash column chromatography to give the corresponding products.

The diastereomeric ratios were determined by comparing the integrations of H-2 signals of the ^{1}H NMR spectra of the products.

DOI: 10.1021/acs.joc.6b00725
J. Org. Chem. 2016, 81, 5144−5161

*4-Chloro-2-(p-tolyl)-1-tosylpiperidine (**3a**).* The compound (151 mg, 83%, *trans*:*cis* = 98:2) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-4-Chloro-2-(*p*-tolyl)-1-tosylpiperidine (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.68 (d, J = 8.1 Hz, 2H), 7.24 (d, J = 8.1 Hz, 2H), 7.11 (d, J = 8.2 Hz, 2H), 7.06 (d, J = 8.2 Hz, 2H), 5.27 (d, J = 3.9 Hz, 1H), 3.91−3.75 (m, 2H), 2.98−2.88 (m, 1H), 2.66−2.60 (m, 1H), 2.36 (s, 3H), 2.24 (s, 3H), 1.86−1.71 (m, 2H), 1.46 (dd, J = 12.8, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.6, 138.1, 137.2, 134.2, 130.0, 129.7, 127.0, 126.5, 55.9, 52.9, 41.4, 37.7, 35.2, 21.6, 21.0. NMR data were in agreement with the reported results.[26]

*4-Chloro-1-(4-methoxyphenylsulfonyl)-2-(p-tolyl)piperidine (**3b**).* The compound (167 mg, 88%, *trans*:*cis* = 91:9) was purified by flash chromatography using petroleum ether/ethyl acetate (10:1) as eluent. *trans*-4-Chloro-1-(4-methoxyphenylsulfonyl)-2-(*p*-tolyl)piperidine (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.73 (d, J = 8.1 Hz, 2H), 7.12 (d, J = 8.1 Hz, 2H), 7.07 (d, J = 8.2 Hz, 2H), 6.91 (d, J = 8.2 Hz, 2H), 5.26 (d, J = 3.8 Hz, 1H), 3.91−3.80 (m, 5H), 3.01−2.90 (m, 1H), 2.70−2.58 (m, 1H), 2.25 (s, 3H), 1.87−1.76 (m, 2H), 1.50 (qd, J = 12.8, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 162.9, 137.1, 134.3, 132.6, 129.7, 129.1, 126.5, 114.5, 55.9, 55.7, 53.0, 41.3, 37.7, 35.3, 21.0. IR: 3000, 2930, 2057, 1598, 1511, 1455, 1303, 1026, 933, 734 cm^{-1}. ^{1}HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{19}H_{22}ClNO_3S$, 380.1087; found: 380.1087.

*4-Chloro-1-benzenesulfonyl-2-(p-tolyl)piperidine (**3c**).* The compound (136 mg, 78%, *trans*:*cis* = 95:5) was purified by flash chromatography using petroleum ether/ethyl acetate (30:1) as eluent. *trans*-4-Chloro-1-benzenesulfonyl-2-(*p*-tolyl)piperidine (major diastereomer, white solid, mp = 97−99 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.85−7.77 (m, 2H), 7.54−7.50 (m, 1H), 7.46 (t, J = 7.5 Hz, 2H), 7.10 (d, J = 8.3 Hz, 2H), 7.06 (d, J = 8.3 Hz, 2H), 5.30 (d, J = 4.1 Hz, 1H), 3.91−3.79 (m, 2H), 3.01−2.92 (m, 1H), 2.68−2.60 (m, 1H), 2.24 (s, 3H), 1.88−1.72 (m, 2H), 1.46 (qd, J = 12.9, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 139.9, 136.2, 133.0, 131.7, 128.6, 128.3, 125.8, 125.4, 54.9, 51.7, 40.3, 36.7, 34.2, 19.9. IR: 3054, 2964, 1514, 1448, 1371, 1159, 922, 738 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{18}H_{20}ClNO_2S$, 350.0982; found: 350.0973.

cis-4-Chloro-1-(4-methoxyphenylsulfonyl)-2-(*p*-tolyl)piperidine (minor diastereomer, white solid, mp = 161−162 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.48 (d, J = 8.9 Hz, 2H), 7.02 (d, J = 8.1 Hz, 2H), 6.96 (d, J = 8.1 Hz, 2H), 6.80 (d, J = 8.9 Hz, 2H), 4.51 (t, J = 5.9 Hz, 1H), 4.07−3.97 (m, 1H), 3.87−3.79 (m, 1H), 3.78 (s, 3H), 3.30 (ddd, J = 13.6, 6.8, 3.8 Hz, 1H), 2.39−2.30 (m, 1H), 2.23 (s, 3H), 2.17 (dt, J = 14.3, 4.3 Hz, 1H), 2.07 (ddd, J = 12.5, 8.0, 3.7 Hz, 1H), 1.83 (dtd, J = 13.8, 7.0, 3.5 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 162.7, 136.8, 136.4, 131.3, 129.4, 128.7, 126.9, 113.9, 57.7, 55.6, 54.3, 41.6, 40.0, 34.0, 21.0. IR: 3030, 2980, 2069, 1610, 1510, 1436, 1026, 955, 727 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{18}H_{20}ClNO_2S$, 350.0982; found: 350.0973.

*4-Chloro-1-(4-nitrophenylsulfonyl)-2-(p-tolyl)piperidine (**3d**).* The compound (100 mg, 51%, *trans*:*cis* = 95:5) was purified by flash chromatography using petroleum ether/ethyl acetate (15:1) as eluent. *trans*-4-Chloro-1-(4-nitrophenylsulfonyl)-2-(*p*-tolyl)piperidine (major diastereomer, white solid, mp = 158−160 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 8.29 (d, J = 8.6 Hz, 2H), 7.94 (d, J = 8.6 Hz, 2H), 7.06 (d, J = 8.1 Hz, 2H), 7.02 (d, J = 8.1 Hz, 2H), 5.31 (s, 1H), 3.94−3.85(m, 1H), 3.08 (t, J = 12.6 Hz, 1H), 2.69 (d, J = 13.6 Hz, 1H), 2.25 (s, 3H), 1.96 (d, J = 11.6 Hz, 1H), 1.85 (td, J = 13.1, 5.3 Hz, 1H), 1.63−1.47 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 148.9, 145.6, 136.6, 132.5, 128.7, 127.1, 125.4, 123.5, 55.4, 51.2, 40.8, 37.4, 34.4, 19.9. IR: 3030, 2966, 1604, 1526, 1401, 1351, 1165, 1011, 855, 755 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{18}H_{19}ClN_2O_4S$, 395.0832; found: 395.0821.

*4-Chloro-1-methanesulfonyl-2-(p-tolyl)piperidine (**3e**).* The compound (95 mg, 66%, *trans*:*cis* = 86:14) was purified by flash chromatography using petroleum ether/ethyl acetate (15:1) as eluent. *trans*-4-Chloro-1-methanesulfonyl-2-(*p*-tolyl)piperidine (major diastereomer, white solid, mp = 75−78 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.18 (d, J = 8.2 Hz, 2H), 7.13 (d, J = 8.2 Hz, 2H), 5.23 (d, J = 4.5 Hz, 1H), 3.97 (tt, J = 11.8, 4.1 Hz, 1H), 3.87−3.79 (m, 1H), 3.10−3.01 (m, 1H), 2.89 (s, 3H), 2.83−2.75 (m, 1H), 2.28 (s, 3H), 2.20−2.10 (m, 1H), 2.09−2.01 (m, 1H), 1.87−1.79 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 136.4, 133.2, 128.8, 125.5, 54.9, 51.7, 40.3, 40.0, 37.9, 35.1, 19.9. IR: 3030, 2963, 1726, 1513, 1456, 1324, 1153, 961, 854 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{13}H_{18}ClNO_2S$, 288.0825; found: 288.0817.

*4-Chloro-2-(o-tolyl)-1-tosylpiperidine (**4a**).* The compound (134 mg, 74%, *trans*:*cis* = 89:11) was purified by flash chromatography using petroleum ether/ethyl acetate (50:1) as eluent. *trans*-4-Chloro-2-(*o*-tolyl)-1-tosylpiperidine (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.26 (d, J = 8.3 Hz, 2H), 7.07−6.98 (m, 4H), 6.90 (d, J = 7.6 Hz, 1H), 6.87−6.79 (m, 1H), 5.23 (t, J = 5.2 Hz, 1H), 4.21−4.13 (m, 1H), 3.87−3.83 (m, 1H), 2.70−2.60 (m, 1H), 2.45−2.35 (m, 1H), 2.35−2.30 (m, 1H), 2.31−2.23 (m,4H), 2.21 (s, 3H), 2.05−1.97 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.0, 137.6, 136.9, 135.7, 131.0, 129.2, 129.0, 127.4, 127.0, 125.6, 54.0, 53.9, 43.5, 39.7, 34.8, 21.5, 19.6. IR: 3059, 2958, 1598, 1490, 1452, 1329, 1158, 937, 857 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{19}H_{22}ClNO_2S$, 364.1138; found: 364.1138.

*4-Chloro-2-(m-tolyl)-1-tosylpiperidine (**4b**).* The compound (140 mg, 77%, *trans*:*cis* = 87:13) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-4-Chloro-2-(*m*-tolyl)-1-tosylpiperidine (major diastereomer, white solid, mp = 98−99 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.69 (d, J = 8.2 Hz, 2H), 7.26 (d, J = 8.2 Hz, 2H), 7.16 (dd, J = 14.2, 6.2 Hz, 1H), 7.04−6.96 (m, 3H), 5.29 (d, J = 4.1 Hz, 1H), 4.00−3.73 (m, 2H), 3.08−2.84 (m, 1H), 2.69−2.60 (m, 1H), 2.38 (s, 3H), 2.24 (s, 3H), 1.87−1.76 (m, 2H), 1.50 (qd, J = 12.8, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 142.5, 137.7, 137.1, 136.2, 128.9, 127.8, 127.1, 126.2, 125.9, 122.5, 55.0, 51.9, 40.4, 36.8, 34.2, 20.6. IR: 3061, 2958, 1491, 1452, 1340, 1092, 935, 800 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{19}H_{22}ClNO_2S$, 364.1138; found: 364.1137.

*4-Chloro-2-(4-methoxyphenyl)-1-tosylpiperidine (**4c**).* The compound (165 mg, 87%, *trans*:*cis* = 96:4) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-4-Chloro-2-(4-methoxyphenyl)-1-tosylpiperidine (major diastereomer, white solid, mp = 104−105 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.68 (d, J = 8.3 Hz, 2H), 7.24 (d, J = 8.1 Hz, 2H), 7.14 (d, J = 8.3 Hz, 2H), 6.81−6.75 (m, 2H), 5.25 (d, J = 4.3 Hz, 1H), 3.89−3.79 (m, 2H), 3.70 (s, 3H), 3.00−2.85 (m, 1H), 2.63−2.55 (m, 1H), 2.36 (s, 3H), 1.85−1.78 (m, 1H), 1.78−1.71 (m, 1H), 1.46 (dd, J = 12.8, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 158.8, 143.6, 138.0, 130.0, 129.1, 127.8, 126.9, 114.3, 55.6, 55.3, 52.9, 41.3, 37.6, 35.2, 21.6. NMR data were in agreement with the reported results.[28]

*4-Chloro-2-(3-methoxyphenyl)-1-tosylpiperidine (**4d**).* The compound (161 mg, 85%, *trans*:*cis* = 95:5) was purified by flash chromatography using petroleum ether/ethyl acetate (50:1) as eluent. *trans*-4-Chloro-2-(3-methoxyphenyl)-1-tosylpiperidine (major diastereomer, white solid, mp = 106−108 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.69 (d, J = 8.1 Hz, 2H), 7.25 (d, J = 8.1 Hz, 2H), 7.19−7.11 (m, 1H), 6.81 (d, J = 7.7 Hz, 1H), 6.75−6.71 (m, 2H), 5.28 (d, J = 4.2 Hz, 1H), 3.91−3.77 (m, 2H), 3.67 (s, 3H), 3.01−2.91 (m, 1H), 2.67−2.57 (m, 1H), 2.37 (s, 3H), 1.87−1.76 (m, 2H), 1.50 (dd, J = 12.8, 4.8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 159.2, 142.6, 138.1, 136.9, 129.0, 128.9, 125.9, 117.6, 111.5, 111.5, 55.0, 54.2, 51.8, 40.4, 36.7, 34.2, 20.5. NMR data were in agreement with the reported results.[26]

*4-Chloro-2-(2-methoxyphenyl)-1-tosylpiperidine (**4e**).* The compound (174 mg, 92%, *trans*:*cis* = 87:13) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-4-Chloro-2-(2-methoxyphenyl)-1-tosylpiperidine (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.53 (d, J = 8.2 Hz, 2H), 7.17−7.10 (m, 3H), 6.99 (d, J = 7.5 Hz, 1H), 6.72 (dd, J = 14.6, 7.8 Hz, 2H), 5.50 (d, J = 3.7 Hz, 1H), 4.03−3.96 (m, 1H), 3.85−3.75 (m, 1H), 3.72 (s, 3H), 3.53−3.43 (m, 1H), 2.70−2.60 (m, 1H), 2.33 (s, 3H), 2.03 (dd, J = 8.3, 4.5 Hz, 1H), 1.83−1.78 (m, 1H), 1.61 (dd, J = 12.3, 5.1 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 155.2, 142.1, 136.5, 128.5, 127.4, 126.3, 126.1, 125.9, 119.0, 109.6, 54.1, 52.9, 52.0, 42.2, 38.3, 34.5, 20.5. IR: 3063, 2894, 1655, 1597, 1439, 1159, 937, 864, 761 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{19}H_{22}ClNO_3S$, 380.1087; found: 380.1084.

DOI: 10.1021/acs.joc.6b00725
J. Org. Chem. 2016, 81, 5144−5161

cis-4-Chloro-2-(2-methoxyphenyl)-1-tosylpiperidine (minor diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.57 (d, J = 8.0 Hz, 2H), 7.23 (d, J = 7.9 Hz, 2H), 7.16 (t, J = 7.9 Hz, 1H), 6.83 (d, J = 7.6 Hz, 1H), 6.73 (d, J = 11.5 Hz, 2H), 4.76 (t, J = 5.5 Hz, 1H), 4.14 (s, 1H), 3.90−3.78 (m, 1H), 3.72 (s, 3H), 3.58−3.42 (m, 1H), 2.50−2.36 (m, 4H), 2.27 (d, J = 14.4 Hz, 1H), 2.18−2.06 (m, 1H), 1.87 (d, J = 13.5 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 159.4, 143.4, 141.2, 129.5, 129.0, 127.3, 119.3, 112.6, 112.4, 56.9, 55.0, 54.0, 40.8, 39.1, 33.7, 21.5. IR: 3050, 2900, 1650, 1600, 1439, 1143, 950, 864, 745 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{19}H_{22}ClNO_3S$, 380.1087; found: 380.1084.

4-Chloro-2-phenyl-1-tosylpiperidine (**4f**). The compound (139 mg, 80%, *trans*:*cis* = 96:4) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-4-Chloro-2-phenyl-1-tosylpiperidine (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.68 (d, J = 8.2 Hz, 2H), 7.27−7.08 (m, 7H), 5.31 (d, J = 4.6 Hz, 1H), 3.91−3.83 (m, 1H), 3.83−3.75 (m, 1H), 2.98−2.89 (m, 1H), 2.64 (dd, J = 12.0, 1.6 Hz, 1H), 2.35 (s, 3H), 1.83−1.75 (m, 2H), 1.46 (dd, J = 12.8, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.7, 137.9, 137.3, 130.0, 129.0, 127.5, 126.9, 126.5, 56.1, 52.9, 41.4, 37.7, 35.2, 21.6. NMR data were in agreement with the reported results.[10a]

4-Chloro-2-(4-isopropylphenyl)-1-tosylpiperidine (**4g**). The compound (164 mg, 84%, *trans*:*cis* = 95:5) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-4-Chloro-2-(4-isopropylphenyl)-1-tosylpiperidine (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.68 (d, J = 8.1 Hz, 2H), 7.24 (d, J = 8.1 Hz, 2H), 7.14 (d, J = 8.5 Hz, 2H), 7.11 (d, J = 8.5 Hz, 2H), 5.28 (d, J = 4.4 Hz, 1H), 3.88−3.81 (m, 2H), 3.01−2.93 (m, 1H), 2.83−2.78 (m, 1H), 2.65 (dd, J = 7.1, 5.4 Hz, 1H), 2.36 (s, 3H), 1.86−1.73 (m, 2H), 1.49 (dd, J = 12.8, 4.7 Hz, 1H), 1.15 (d, J = 6.9 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 147.0, 142.5, 137.0, 133.5, 128.9, 126.0, 125.9, 125.5, 54.9, 51.9, 40.3, 36.7, 34.2, 32.6, 22.9, 22.9, 20.5. IR: 3029, 2960, 1597, 1457, 1340, 1159, 835, 726 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{21}H_{26}ClNO_2S$, 392.1451; found: 392.1454.

4-Chloro-2-(4-fluorophenyl)-1-tosylpiperidine (**4h**). The compound (138 mg, 75%, *trans*:*cis* = 96:4) was purified by flash chromatography using petroleum ether/ethyl acetate (50:1) as eluent. *trans*-4-Chloro-2-(4-fluorophenyl)-1-tosylpiperidine (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.68 (d, J = 8.2 Hz, 2H), 7.27 (d, J = 8.2 Hz, 2H), 7.25−7.18 (m, 2H), 6.96 (t, J = 8.6 Hz, 2H), 5.27 (d, J = 3.3 Hz, 1H), 3.94−3.75 (m, 2H), 3.00−2.80 (m, 1H), 2.63−2.59 (m, 1H), 2.38 (s, 3H), 1.89−1.72 (m, 2H), 1.46 (qd, J = 12.8, 4.7 Hz, 1H); ^{19}F NMR (376 MHz, $CDCl_3$) δ = −115.2. ^{13}C NMR (100 MHz, $CDCl_3$) δ = 161.0 (d, J = 247.0 Hz), 142.7, 136.8, 132.0, 129.0, 127.3 (d, J = 8.2 Hz), 125.9, 114.8 (d, J = 21.2 Hz), 54.5, 51.5, 40.3, 36.6, 34.0, 20.6. IR: 3045, 2961, 1600, 1507, 1456, 1159, 931, 737 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{18}H_{19}ClFNO_2S$, 368.0887; found: 368.0884.

cis-4-Chloro-2-(2-fluorophenyl)-1-tosylpiperidine (minor diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.45 (d, J = 8.2 Hz, 2H), 7.22−7.12 (m, 4H), 7.02−6.91 (m, 1H), 6.88−6.81 (m, 1H), 4.83−4.68 (m, 1H), 3.99 (ddd, J = 11.9, 8.0, 4.1 Hz, 1H), 3.44−3.28 (m, 1H). 3.95−3.88 (m, 1H), 2.44−2.32 (m, 4H), 2.16 (dt, J = 14.2, 4.3 Hz, 1H), 2.10−2.01 (m, 1H), 1.91−1.83 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ= 158.5 (d, J = 245.2 Hz), 143.4, 136.1, 129.5, 129.1 (d, J = 8.6 Hz), 128.8 (d, J = 3.9 Hz), 127.3(d, J = 12.0 Hz), 123.9 (d, J = 3.4 Hz), 115.3 (d, J = 22.2 Hz), 54.1, 52.9, 42.3, 39.3, 33.9, 21.5. ^{19}F NMR (376 MHz, $CDCl_3$) δ = −116.3. IR: 3050, 2900, 1590, 1498, 1450, 1110, 937, 736 cm^{-1}. HRMS−ESI (m/z): HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{18}H_{19}ClFNO_2S$, 368.0887; found: 368.0884.

4-Chloro-2-(2-fluorophenyl)-1-tosylpiperidine (**4i**). The compound (128 mg, 70%, *trans*:*cis* = 90:10) was purified by flash chromatography using petroleum ether/ethyl acetate (20:1) as eluent. *trans*-4-Chloro-2-(2-fluorophenyl)-1-tosylpiperidine (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.56 (d, J = 8.2 Hz, 1H), 7.17 (d, J = 8.2 Hz, 1H), 7.10 (dd, J = 12.4, 4.5 Hz, 2H), 7.03−6.88 (m, 2H), 5.39 (d, J = 2.3 Hz, 1H), 3.98−3.86 (m, 2H), 3.42−3.27 (m, 1H), 2.70 (d, J = 13.7 Hz, 1H), 2.34 (s, 3H), 2.14−1.95 (m, 2H), 1.75 (1d, J = 11.9, 4.8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 158.7 (d, J = 245.2 Hz), 142.5, 136.0, 128.6, 128.1 (d, J = 8.6 Hz), 127.5 (d, J = 3.8 Hz), 125.6, 124.7 (d, J = 12.0 Hz), 123.0 (d, J = 3.4 Hz), 115.0 (d, J = 22.6 Hz), 52.3, 43.0, 42.3, 39.3, 34.7 20.2; ^{19}F NMR (376 MHz, $CDCl_3$) δ = −114.0. IR: 3064, 2928, 1596, 1488, 1453, 1344, 1094, 938, 760 cm^{-1}. HRMS−ESI (m/z): HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{18}H_{19}ClFNO_2S$, 368.0887; found: 368.0892.

4-Chloro-2-(4-chlorophenyl)-1-tosylpiperidine (**4j**). The compound (153 mg, 80%, *trans*:*cis* = 91:9) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-4-Chloro-2-(4-chlorophenyl)-1-tosylpiperidine (major diastereomer, white solid, mp = 117−119 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.67 (d, J = 8.2 Hz, 2H), 7.29−7.21 (m, 4H), 7.17 (d, J = 8.7 Hz, 2H), 5.26 (d, J = 4.4 Hz, 1H), 3.90−3.83 (m, 1H), 3.77 (tt, J = 11.9, 4.0 Hz, 1H), 2.96−2.86 (m, 1H), 2.62−2.56 (m, 1H), 2.37 (s, 3H), 1.88−1.72 (m, 2H), 1.45 (qd, J = 12.8, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 142.8, 136.7, 134.9, 132.4, 129.0, 128.1, 127.0, 125.9, 54.6, 51.5, 40.3, 36.5, 34.0, 20.6. NMR data were in agreement with the reported results.[26]

*Crystal Data for trans-***4j**. $C_{18}H_{19}Cl_2NO_2S$, M = 384.30, triclinic, a = 9.3985(19) Å, b = 9.900(2) Å, c = 10.611(2) Å, α = 76.87(3)°, β = 83.63(3)°, γ = 74.00(3)°, V = 923.0(3) Å^3, T = 293(2) K, space group $P\bar{1}$, Z = 2, μ (Mo Kα) = 0.475 mm^{-1}, 11 457 reflections measured, 4352 independent reflections (R_{int} = 0.0429). The final R_1 values were 0.0452 ($I > 2\sigma(I)$). The final wR (F^2) values were 0.0933 ($I > 2\sigma(I)$). The final R_1 values were 0.0939 (all data). The final wR (F^2) values were 0.1064 (all data). The goodness of fit on F^2 was 1.013.

4-Chloro-2-(3-chlorophenyl)-1-tosylpiperidine (**4k**). The compound (149 mg, 78%, *trans*:*cis* = 89:11) was purified by flash chromatography using petroleum ether/ethyl acetate (50:1) as eluent. *trans*-4-Chloro-2-(3-chlorophenyl)-1-tosylpiperidine (major diastereomer, white solid, mp = 107−108 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.67 (d, J = 8.2 Hz, 2H), 7.26 (d, J = 8.2 Hz, 2H), 7.22−7.09 (m, 4H), 5.27 (d, J = 3.9 Hz, 1H), 3.95−3.86 (m, 1H), 3.78 (tt, J = 11.9, 3.9 Hz, 1H), 3.01−2.89 (m, 1H), 2.64−2.55 (m, 1H), 2.38 (s, 3H), 1.90−1.75 (m, 2H), 1.49 (qd, J = 12.8, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.9, 139.8, 137.7, 135.1, 130.3, 130.1, 127.7, 126.9, 126.8, 124.8, 55.7, 52.5, 41.5, 37.7, 35.1, 21.6. IR: 3086, 2963, 1594, 1490, 1158, 1096, 855, 734 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{18}H_{19}Cl_2NO_2S$, 384.0592; found: 384.0592.

cis-4-Chloro-2-(3-chlorophenyl)-1-tosylpiperidine (minor diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.49 (d, J = 8.3 Hz, 2H), 7.20−7.13 (m, 3H), 7.13−7.06 (m, 2H), 7.01 (s, 1H), 4.73 (t, J = 5.6 Hz, 1H), 4.13−4.05 (m, 1H), 3.74 (ddd, J = 13.0, 9.4, 3.3 Hz, 1H), 3.54−3.45 (m, 1H), 2.40−2.31 (m, 4H), 2.22−2.14 (m, 1H), 2.00 (ddd, J = 13.4, 9.1, 4.1 Hz, 1H), 1.84−1.78 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 142.6, 140.5, 135.8, 133.0, 128.6, 128.3, 126.2, 126.1, 125.9, 124.0, 55.2, 52.8, 39.4, 37.8, 32.4, 20.5. IR: 3090, 2954, 1610 1500, 1137, 1096, 837, 723 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{18}H_{19}Cl_2NO_2S$, 384.0592; found: 384.0592.

2-(4-Bromophenyl)-4-chloro-1-tosylpiperidine (**4l**). The compound (166 mg, 78%, *trans*:*cis* = 90:10) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-2-(4-Bromophenyl)-4-chloro-1-tosylpiperidine (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.66 (d, J = 8.6 Hz, 2H), 7.37 (d, J = 8.6 Hz, 2H), 7.25 (d, J = 8.0 Hz, 2H), 7.11 (d, J = 8.0 Hz, 2H), 5.23 (d, J = 4.2 Hz, 1H), 3.89−3.84 (m, 1H), 3.80−3.72 (m, 1H), 2.96−2.84 (m, 1H), 2.60−2.54 (m, 1H), 2.36 (s, 3H), 1.89−1.78 (m, 2H), 1.79−1.70 (m, 1H), 1.44 (dd, J = 12.8, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.8, 137.7, 136.6, 132.1, 130.1, 128.4, 126.9, 121.5, 55.7, 52.5, 41.4, 37.5, 35.1, 21.7. IR: 3087, 2968, 1649, 1595, 1490, 1333, 1257, 1197, 1093, 935, 837 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{18}H_{19}BrClNO_2S$, 428.0087; found: 428.0073.

cis-2-(4-Bromophenyl)-4-chloro-1-tosylpiperidine (minor diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.48 (d, J = 8.0 Hz, 2H), 7.17 (d, J = 8.0 Hz, 2H), 7.12 (d, J = 8.5 Hz, 2H), 7.08 (d, J = 8.5 Hz, 2H), 4.67 (t, J = 5.4 Hz, 1H), 4.17−4.02 (m, 1H), 3.84−3.65 (m, 1H), 3.54−3.34 (m, 1H), 2.41−2.29 (m, 4H), 2.24−2.12 (m, 1H), 2.02−1.92 (m, 1H), 1.79 (dd, J = 13.8, 3.3 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.6, 138.0, 136.8, 132.9, 129.7, 128.5, 128.2,

DOI: 10.1021/acs.joc.6b00725
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127.4, 56.4, 53.9, 40.6, 38.9, 33.5, 21.5. IR: 3090, 2970, 1649, 1589, 1477, 1260, 1190, 1093, 944, 821 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{18}H_{19}BrClNO_2S$, 428.0087; found: 428.0073.

*2-(4-tert-Butylphenyl)-4-chloro-1-tosylpiperidine (**4m**).* The compound (170 mg, 84%, *trans*:*cis* = 96:4) was purified by flash chromatography using petroleum ether/ethyl acetate (30:1) as eluent. *trans*-2-(4-*tert*-Butylphenyl)-4-chloro-1-tosylpiperidine (major diastereomer, oil): ^1H NMR (400 MHz, $CDCl_3$) δ = 7.69 (d, J = 8.2 Hz, 2H), 7.28 (d, J = 8.2 Hz, 2H), 7.25 (d, J = 8.2 Hz, 2H), 7.15 (d, J = 8.2 Hz, 2H), 5.29 (d, J = 4.3 Hz, 1H), 3.90−3.83 (m, 2H), 3.03−2.94 (m, 1H), 2.69−2.62 (m, 1H), 2.38 (s, 3H), 1.88−1.76 (m, 2H), 1.50 (qd, J = 12.7, 4.7 Hz, 1H), 1.23 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 150.4, 143.5, 138.1, 134.2, 130.0, 127.0, 126.2, 125.9, 55.9, 53.0, 41.4, 37.7, 35.2, 34.5, 31.3, 21.6. IR: 3033, 2961, 1597, 1511, 1453, 1406, 1340, 1158, 1093, 855, 723 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{22}H_{28}ClNO_2S$, 406.1608; found: 406.1611.

*4-(4-Chloro-1-tosylpiperidin-2-yl)benzonitrile (**4n**).* The compound (118 mg, 63%, *trans*:*cis* = 96:4) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-4-(4-Chloro-1-tosylpiperidin-2-yl)benzonitrile (major diastereomer, white solid, mp = 156−158 °C): ^1H NMR (400 MHz, $CDCl_3$) δ = 7.67 (d, J = 8.2 Hz, 2H), 7.57 (d, J = 8.2 Hz, 2H), 7.39 (d, J = 8.1 Hz, 2H), 7.28 (d, J = 8.1 Hz, 2H), 5.32 (d, J = 3.7 Hz, 1H), 3.89 (d, J = 14.9 Hz, 1H), 3.71 (tt, J = 11.8, 3.8 Hz, 1H), 2.97−2.82 (m, 1H), 2.62 (d, J = 13.2 Hz, 1H), 2.39 (s, 3H), 1.88−1.77 (m, 2H), 1.45 (qd, J = 12.7, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 144.1, 143.3, 137.4, 132.8, 130.2, 127.5, 126.9, 118.5, 111.5, 56.0, 52.2, 41.6, 37.5, 34.8, 21.7. IR: 3051, 2988, 2224, 1603, 1502, 1451, 1156, 1092, 851, 727 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{19}H_{19}ClN_2O_2S$, 375.0934; found: 375.0933.

*Methyl 4-(4-Chloro-1-tosylpiperidin-2-yl)benzoate (**4o**).* The compound (122 mg, 60%, *trans*:*cis* = 99:1) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-Methyl 4-(4-chloro-1-tosylpiperidin-2-yl)benzoate (major diastereomer, white solid, mp = 117−119 °C): ^1H NMR (400 MHz, $CDCl_3$) δ = 7.93 (d, J = 8.2 Hz, 2H), 7.69 (d, J = 8.2 Hz, 2H), 7.31 (d, J = 8.0 Hz, 2H), 7.26 (d, J = 8.0 Hz, 2H), 5.34 (d, J = 3.6 Hz, 1H), 3.90 (d, J = 14.8 Hz, 1H), 3.84 (s, 3H), 3.79−2.72 (m, 1H), 2.97−2.89 (m, 1H), 2.66 (d, J = 13.7 Hz, 1H), 2.38 (s, 3H), 1.90−1.74 (m, 2H), 1.48 (dd, J = 12.7, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 165.5, 142.8, 141.7, 136.6, 129.1, 129.0, 128.3, 125.8, 125.5, 55.0 51.4, 51.1, 40.5, 36.6, 33.9, 20.5. IR: 3063, 2960, 1811, 1720, 1610, 1493, 1447, 1104, 862, 731 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{20}H_{22}ClNO_4S$, 408.1036; found: 408.1036.

*4-Chloro-2-(4-nitrophenyl)-1-tosylpiperidine (**4p**).* The compound (101 mg, 51%, *trans*:*cis* = 99:1) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-4-Chloro-2-(4-nitrophenyl)-1-tosylpiperidine (major diastereomer, white solid, mp = 130−132 °C): ^1H NMR (400 MHz, $CDCl_3$) δ = 8.11 (d, J = 8.4 Hz, 2H), 7.68 (d, J = 8.2 Hz, 2H), 7.44 (d, J = 8.4 Hz, 2H), 7.28 (d, J = 8.2 Hz, 2H), 5.35 (d, J = 3.7 Hz, 1H), 3.95−3.89 (m, 1H), 3.77−2.70 (m, 1H), 3.00−2.90 (m, 1H), 2.65 (d, J = 13.9 Hz, 1H), 2.39 (s, 3H), 1.93−1.79 (m, 2H), 1.48 (qd, J = 12.7, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 147.3, 145.4, 144.2, 137.3, 130.2, 127.7, 126.9, 124.1, 55.9, 52.2, 41.7, 37.8, 34.8, 21.7. NMR data were in agreement with the reported results.[26]

*4-Chloro-2-(furan-2-yl)-1-tosylpiperidine (**4q**).* The compound (143 mg, 84%, *trans*:*cis* = 96:4) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-4-Chloro-2-(furan-2-yl)-1-tosylpiperidine (major diastereomer, oil): ^1H NMR (400 MHz, $CDCl_3$) δ = 7.53 (d, J = 8.1 Hz, 2H), 7.22−7.12 (m, 3H), 6.18 (dd, J = 3.2, 1.9 Hz, 1H), 6.04 (d, J = 3.2 Hz, 1H), 5.29 (d, J = 5.7 Hz, 1H), 4.08 (tt, J = 12.1, 4.2 Hz, 1H), 3.83−3.65 (m, 1H), 3.11−3.01 (m, 1H), 2.46 (ddt, J = 13.1, 3.9, 1.9 Hz, 1H), 2.33 (s, 3H), 2.09−2.00 (m, 1H), 2.01−1.93 (m, 1H), 1.69 (qd, J = 12.7, 4.8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 150.8, 142.3, 141.2, 135.8, 128.6, 126.1, 109.3, 107.2, 52.0, 50.4, 40.9, 37.8, 34.5, 20.5. IR: 3147, 3033, 2960, 1597, 1498, 1451, 1344, 1160, 855, 733 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{16}H_{18}ClNO_3S$, 340.0774; found: 340.0767.

*4-Chloro-1-tosylpiperidine (**4r**).* The compound (123 mg, 90%) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. White solid, mp = 125−127 °C; ^1H NMR (400 MHz, $CDCl_3$) δ = 7.65 (d, J = 8.1 Hz, 2H), 7.34 (d, J = 8.1 Hz, 2H), 4.18−4.08 (m, 1H), 3.23−3.15 (m, 2H), 3.14−3.04 (m, 2H), 2.44 (s, 3H), 2.14 (ddd, J = 12.0, 7.7, 3.7 Hz, 2H), 1.97−1.90 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.8, 133.1, 129.8, 127.6, 55.4, 42.9, 34.0, 21.6. NMR data were in agreement with the reported results.[10a]

*4-Chloro-2-ethyl-1-tosylpiperidine (**4s**).* The compound (129 mg, 86%, *trans*:*cis* = 89:11) was purified by flash chromatography using petroleum ether/ethyl acetate (60:1) as eluent. *trans*-4-Chloro-2-ethyl-1-tosylpiperidine (major diastereomer, oil): ^1H NMR (400 MHz, $CDCl_3$) δ = 7.64 (d, J = 8.1 Hz, 2H), 7.23 (d, J = 8.1 Hz, 2H), 4.04−3.91 (m, 2H), 3.84−3.77 (m, 1H), 3.01−2.91 (m, 1H), 2.36 (s, 3H), 1.99−1.88 (m, 2H), 1.61−1.50 (m, 2H), 1.47−1.34 (m, 2H), 0.81 (t, J = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 142.3, 137.2, 128.8, 125.9, 54.5, 52.0, 39.2, 37.1, 34.3, 22.3, 20.5, 10.0. NMR data were in agreement with the reported results.[10a]

*4-Chloro-2-propyl-1-tosylpiperidine (**4t**).* The compound (128 mg, 81%, *trans*:*cis* = 86:14) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-4-Chloro-2-propyl-1-tosylpiperidine (major diastereomer, oil): ^1H NMR (400 MHz, $CDCl_3$) δ = 7.64 (d, J = 8.0 Hz, 2H), 7.23 (d, J = 8.0 Hz, 2H), 4.06 (dd, J = 13.5, 6.5 Hz, 1H), 4.02−3.91 (m, 1H), 3.85−3.76 (m, 1H), 3.06−2.91 (m, 1H), 2.36 (s, 3H), 1.97−1.86 (m, 2H), 1.58 (dd, J = 13.0, 5.5 Hz, 1H), 1.50−1.41 (m, 1H), 1.37−1.16 (m, 4H), 0.82 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 142.3, 137.1, 128.8, 125.9, 52.8, 52.1, 39.3, 37.4, 34.3, 31.4, 20.5, 18.6, 12.7. IR: 3030, 2958, 1655, 1597, 1493, 1454, 1159, 867, 816 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{15}H_{22}ClNO_2S$, 316.1138; found: 316.1137.

cis-4-Chloro-2-propyl-1-tosylpiperidine (minor diastereomer, oil): δ = 7.62 (d, J = 8.0 Hz, 2H), 7.20 (d, J = 8.0 Hz, 2H), 4.28−4.14 (m, 2H), 3.54−3.45 (m, 1H), 3.12−3.02 (m, 1H), 2.33 (s, 3H), 1.93−1.86 (m, 2H), 1.62−1.53 (m, 1H), 1.47−1.40 (m, 1H), 1.30−1.19 (m, 4H), 0.82 (t, J = 7.1 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.2, 137.1, 128.7, 126.0, 52.8, 52.1, 39.3, 37.4, 34.2, 31.4, 21.0, 18.6, 12.5. IR: 3040, 2955, 1650, 1600, 1492, 1455, 1160, 867, 739 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{15}H_{22}ClNO_2S$, 316.1138; found: 316.1137.

*4-Chloro-2-isopropyl-1-tosylpiperidine (**4u**).* The compound (145 mg, 92%, *trans*:*cis* = 98:2) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-4-Chloro-2-isopropyl-1-tosylpiperidine (major diastereomer, white solid, mp = 88−89 °C): ^1H NMR (400 MHz, $CDCl_3$) δ = 7.65 (d, J = 8.1 Hz, 2H), 7.23 (d, J = 8.1 Hz, 2H), 3.93 (tt, J = 12.2, 4.2 Hz, 1H), 3.87−2.79 (m, 1H), 3.59 (dd, J = 11.0, 5.2 Hz, 1H), 2.98−2.85 (m, 1H), 2.35 (s, 3H), 2.15−2.09 (m, 1H), 1.88−1.78 (m, 2H), 1.44−1.34 (m, 1H), 1.32 (dd, J = 12.4, 4.9 Hz, 1H), 0.88 (d, J = 6.6 Hz, 3H), 0.83 (d, J = 6.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 142.3, 137.4, 128.8, 125.9, 59.5, 52.0, 39.7, 34.9, 33.9, 26.0, 20.5, 19.1, 19.0. NMR data were in agreement with the reported results.[10a]

*4-Chloro-2-isobutyl-1-tosylpiperidine (**4v**).* The compound (148 mg, 90%, *trans*:*cis* = 89:11) was purified by flash chromatography using petroleum ether/ethyl acetate (50:1) as eluent. *trans*-4-Chloro-2-isobutyl-1-tosylpiperidine (major diastereomer, oil): ^1H NMR (400 MHz, $CDCl_3$) δ = 7.64 (d, J = 8.2 Hz, 2H), 7.23 (d, J = 8.2 Hz, 2H), 4.14 (dd, J = 13.6, 6.8 Hz, 1H), 3.98 (tt, J = 12.2, 4.3 Hz, 1H), 3.82−3.76 (m, 1H), 3.03−2.92 (m, 1H), 2.36 (s, 3H), 1.93−1.85 (m, 2H), 1.62 (dd, J = 12.6, 5.5 Hz, 1H), 1.57−1.41 (m, 1H), 1.45−1.35 (m, 2H), 1.17 (dt, J = 14.1, 7.2 Hz, 1H), 0.83 (d, J = 6.6 Hz, 3H), 0.81 (d, J = 6.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.4, 138.1, 129.9, 127.0, 53.1, 52.2, 40.3, 39.3, 38.7, 35.3, 24.8, 22.7, 22.3, 21.6. NMR data were in agreement with the reported results.[10a]

cis-4-Chloro-2-isobutyl-1-tosylpiperidine (minor diastereomer, oil): ^1H NMR (400 MHz, $CDCl_3$) δ = 7.64 (d, J = 6.0 Hz, 2H), 7.23 (d, J = 8.5 Hz, 2H), 4.39 (p, J = 3.8 Hz, 1H), 4.20−4.18 (m, 1H), 3.67−3.54 (m, 1H), 3.40−3.35 (m, 3H), 2.36 (s, 3H), 2.16−1.99 (m, 3H), 1.93−1.89 (m, 1H), 1.61−1.48 (m, 2H), 1.24−1.17 (m, 1H), 0.83 (d, J = 4.2 Hz, 3H), 0.80 (d, J = 4.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ =

DOI: 10.1021/acs.joc.6b00725
J. Org. Chem. 2016, 81, 5144−5161

143.4, 138.1, 129.9, 127.0, 53.1, 52.2, 40.3, 39.3, 38.7, 35.3, 24.8, 22.7, 22.3, 21.6. NMR data were in agreement with the reported results.[10a]

*4-Chloro-2-pentyl-1-tosylpiperidine (**4w**).* The compound (159 mg, 93%, *trans*:*cis* 97:3) was purified by flash chromatography using petroleum ether/ethyl acetate (50:1) as eluent. *trans*-4-Chloro-2-pentyl-1-tosylpiperidine (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.64 (d, J = 8.2 Hz, 2H), 7.22 (d, J = 8.2 Hz, 2H), 4.06−3.92 (m, 2H), 3.84−3.77 (m, 1H), 3.00−2.92 (m, 1H), 2.35 (s, 3H), 1.96−1.88 (m, 2H), 1.58 (td, J = 12.9, 5.5 Hz, 1H), 1.49−1.40 (m, 2H), 1.37−1.28 (m, 1H), 1.22−1.16 (m, 6H), 0.79 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.4, 138.2, 129.8, 126.9, 54.1, 53.1, 40.3, 38.5, 35.4, 31.4, 30.3, 26.1, 22.5, 21.5, 14.0. IR: 3033, 2955, 2858, 1596, 1492, 1379, 1304, 1159, 863, 772 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{17}H_{26}ClNO_2S$, 344.1451; found: 344.1450.

*4-Chloro-2-hexyl-1-tosylpiperidine (**4x**).* The compound (162 mg, 91%, *trans*:*cis* = 92:8) was purified by flash chromatography using petroleum ether/ethyl acetate (50:1) as eluent. *trans*-4-Chloro-2-hexyl-1-tosylpiperidine (major diastereomer, white solid, mp = 48−49 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.63 (d, J = 8.2 Hz, 2H), 7.22 (d, J = 8.2 Hz, 2H), 4.06−3.92 (m, 2H), 3.83−3.78 (m, 1H), 3.01−2.92 (m, 1H), 2.35 (s, 3H), 1.93 (ddd, J = 9.4, 4.1, 2.1 Hz, 2H), 1.58 (td, J = 12.9, 5.5 Hz, 1H), 1.50−1.40 (m, 2H), 1.39−1.28 (m, 1H), 1.23−1.11 (m, 8H), 0.80 (t J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.3, 138.2, 129.8, 126.9, 54.1, 53.1, 40.3, 38.5, 35.4, 31.7, 30.3, 28.9, 26.3, 22.6, 21.5, 14.1. NMR data were in agreement with the reported results.[26]

*2-Benzyl-4-chloro-1-tosylpiperidine (**4y**).* The compound (150 mg, 83%, *trans*:*cis* = 91:9) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-2-Benzyl-4-chloro-1-tosylpiperidine (major diastereomer, white solid, mp = 110−112 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.48 (d, J = 8.3 Hz, 2H), 7.24−7.15 (m, 5H), 7.05 (d, J = 6.8 Hz, 2H), 4.33 (dd, J = 14.4, 7.0 Hz, 1H), 4.13 (tt, J = 12.2, 4.3 Hz, 1H), 3.80 (d, J = 12.9 Hz, 1H), 3.12−3.03 (m, 1H), 2.79−2.66 (m, 2H), 2.33 (s, 3H), 2.06 (dd, J = 12.9, 2.2 Hz, 1H), 1.98−1.91 (m, 1H), 1.71−1.55 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.4, 137.6, 137.6, 129.8, 129.0, 128.8, 127.0, 126.8, 55.4, 52.8, 40.6, 37.1, 36.7, 35.7, 21.5. NMR data were in agreement with the reported results.[10a]

*(E)-4-Chloro-2-styryl-1-tosylpiperidine (**4z**).* The compound (126 mg, 67%, *trans*:*cis* = 97:3) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-(*E*)-4-Chloro-2-styryl-1-tosylpiperidine (major diastereomer, white solid, mp = 126−128 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.61 (d, J = 8.1 Hz, 2H), 7.24−7.15 (m, 5H), 7.11 (d, J = 7.0 Hz, 2H), 6.34 (d, J = 16.0 Hz, 1H), 5.82 (dd, J = 16.1, 5.7 Hz, 1H), 4.79 (s, 1H), 3.99 (ddd, J = 15.1, 7.6, 3.8 Hz, 1H), 3.80 (d, J = 13.6 Hz, 1H), 3.10−2.97 (m, 1H), 2.31 (s, 3H), 2.22 (d, J = 13.2 Hz, 1H), 2.04 (d, J = 11.4 Hz, 1H), 1.92 (td, J = 12.6, 5.3 Hz, 1H), 1.69 (qd, J = 12.4, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 142.5, 136.0, 134.9, 131.8, 128.7, 127.5, 127.0, 126.3, 125.3, 124.0, 54.5, 52.0, 40.4, 39.6, 34.6, 20.5. NMR data were in agreement with the reported results.[26]

*4-Bromo-2-(p-tolyl)-1-tosylpiperidine (**5a**).* The compound (167 mg, 82%, *trans*:*cis* = 94:6) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-4-Bromo-2-(*p*-tolyl)-1-tosylpiperidine (major diastereomer, white solid, mp = 125−126 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.69 (d, J = 8.2 Hz, 2H), 7.26 (d, J = 8.2 Hz, 2H), 7.11 (d, J = 8.3 Hz, 2H), 7.07 (d, J = 8.3 Hz, 2H), 5.23 (d, J = 3.5 Hz, 1H), 3.96 (tt, J = 12.2, 3.9 Hz, 1H), 3.86−3.78 (m, 1H), 3.01−2.88 (m, 1H), 2.75 (d, J = 13.5 Hz, 1H), 2.38 (s, 3H), 2.25 (s, 3H), 2.01−1.91 (m, 2H), 1.66 (qd, J = 12.7, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.6, 138.0, 137.2, 134.1, 130.0, 129.7, 127.0, 126.5, 56.7, 43.9, 42.2, 38.5, 36.1, 21.6, 21.0. IR: 3049, 2877, 1654, 1598, 1451, 1372, 1155, 842, 735 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{19}H_{22}BrNO_2S$, 408.0633; found: 408.0630.

*4-Bromo-2-(m-tolyl)-1-tosylpiperidine (**5b**).* The compound (177 mg, 87%, *trans*:*cis* = 91:9) was purified by flash chromatography using petroleum ether/ethyl acetate (20:1) as eluent. *trans*-4-Bromo-2-(*m*-tolyl-1)-tosylpiperidine (major diastereomer, white solid, mp = 117−119 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.68 (d, J = 8.2 Hz, 2H), 7.25 (d, J = 8.2 Hz, 2H), 7.15 (dd, J = 14.5, 6.9 Hz, 1H), 6.98 (dd, J = 12.6, 5.5 Hz, 3H), 5.23 (d, J = 4.3 Hz, 1H), 3.95 (tt, J = 12.2, 4.0 Hz, 1H), 3.88−3.79 (m, 1H), 3.05−2.89 (m, 1H), 2.78−2.72 (m, 1H), 2.37 (s, 3H), 2.22 (s, 3H), 2.04−1.91 (m, 2H), 1.68 (qd, J = 12.7, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.6, 138.7, 138.0, 137.2, 130.0, 128.9, 128.2, 127.2, 127.0, 123.6, 56.8, 43.9, 42.4, 38.7, 36.1, 21.6. IR: 3058, 2928, 1926, 1600, 1490, 1452, 1340, 1156, 870, 661 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{19}H_{22}BrNO_2S$, 408.0633; found: 408.0629.

*4-Bromo-2-(4-methoxyphenyl)-1-tosylpiperidine (**5c**).* The compound (192 mg, 91%, *trans*:*cis* = 91:9) was purified by flash chromatography using petroleum ether/ethyl acetate (10:1) as eluent. *trans*-4-Bromo-2-(4-methoxyphenyl)-1-tosylpiperidine (major diastereomer, white solid, mp = 114−116 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.68 (d, J = 8.1 Hz, 2H), 7.25 (d, J = 8.1 Hz, 2H), 7.13 (d, J = 8.7 Hz, 2H), 6.79 (d, J = 8.7 Hz, 2H), 5.20 (d, J = 3.8 Hz, 1H), 3.97 (tt, J = 12.1, 3.8 Hz, 1H), 3.84−3.77 (m, 1H), 3.71 (s, 3H), 2.99−2.87 (m, 1H), 2.71 (d, J = 13.5 Hz, 1H), 2.37 (s, 3H), 2.00−1.88 (m, 2H), 1.64 (qd, J = 12.7, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 158.8, 143.6, 138.0, 130.0, 129.0, 127.8, 127.0, 114.3, 56.4, 55.4, 43.9, 42.1, 38.5, 36.0, 21.6. IR: 3083, 2999, 1513, 1454, 1184, 1092, 928, 731 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{19}H_{22}BrNO_3S$, 424.0582; found: 424.0571.

*4-Bromo-2-(3-methoxyphenyl)-1-tosylpiperidine (**5d**).* The compound (184 mg, 87%, *trans*:*cis* = 90:10) was purified by flash chromatography using petroleum ether/ethyl acetate (10:1) as eluent. *trans*-4-Bromo-2-(3-methoxyphenyl)-1-tosylpiperidine (major diastereomer, white solid, mp = 126−128 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.53 (d, J = 8.3 Hz, 2H), 7.17−7.09 (m, 3H), 6.98 (d, J = 7.5 Hz, 1H), 6.72 (dd, J = 9.7, 8.0 Hz, 2H), 5.46 (d, J = 3.9 Hz, 1H), 3.99−3.84 (m, 2H), 3.72 (s, 3H), 3.52−3.42 (m, 1H), 2.79−2.68 (m, 1H), 2.33 (s, 3H), 2.15−2.09 (m, 1H), 1.99 (ddd, J = 13.3, 12.1, 6.2 Hz, 1H), 1.77 (qd, J = 12.1, 4.9 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 156.2, 143.2, 137.6, 129.6, 128.5, 127.4, 127.3, 127.0, 120.1, 110.6, 55.2, 53.7, 45.3, 44.1, 40.2, 36.4, 21.56. IR: 3041, 2972, 1599, 1494, 1430, 1340, 1199, 1159, 1040, 931, 879 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{19}H_{22}BrNO_3S$, 424.0582; found: 424.0575.

cis-4-Bromo-2-(3-methoxyphenyl)-1-tosylpiperidine (minor diastereomer, white solid, mp = 156−160 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.57 (d, J = 8.0 Hz, 2H), 7.20 (d, J = 8.0 Hz, 2H), 7.20−7.13 (m, 1H), 6.83 (d, J = 7.6 Hz, 1H), 6.73 (d, J = 11.5 Hz, 2H), 4.81−4.72(m, 1H), 4.14 (s, 1H), 3.92−3.78 (m, 1H), 3.72 (s, 3H), 3.58−3.42 (m, 1H), 2.50−2.36 (m, 4H), 2.27 (d, J = 14.4 Hz, 1H), 2.20−2.08 (m, 1H), 1.87 (d, J = 13.5 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 156.5, 143.5, 141.6, 129.7, 129.2, 127.5, 119.5, 112.7, 112.6, 57.1, 55.6, 54.2, 41.0, 39.3, 33.9, 21.7. IR: 3060, 2933, 1604, 1500, 1431, 1199, 1040, 931, 884, 739 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{19}H_{22}BrNO_3S$, 424.0582; found: 424.0575.

*4-Bromo-2-(2-methoxyphenyl)-1-tosylpiperidine (**5e**).* The compound (178 mg, 84%, *trans*:*cis* = 97:3) was purified by flash chromatography using petroleum ether/ethyl acetate (20:1) as eluent. *trans*-4-Bromo-2-(2-methoxyphenyl)-1-tosylpiperidine (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.68 (d, J = 8.2 Hz, 2H), 7.25 (d, J = 8.2 Hz, 2H), 7.18 (dd, J = 9.5, 6.3 Hz, 1H), 6.79 (d, J = 7.5 Hz, 1H), 6.75−6.68 (m, 2H), 5.22 (d, J = 4.1 Hz, 1H), 3.95 (tt, J = 12.2, 3.9 Hz, 1H), 3.85−3.80 (m, 1H), 3.66 (s, 3H), 3.01−2.91 (m, 1H), 2.77−2.71 (m, 1H), 2.36 (s, 3H), 2.04−1.90 (m, 2H), 1.68 (qd, J = 12.7, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 160.3, 143.7, 139.0, 137.9, 130.1, 130.0, 127.0, 118.7, 112.6, 56.8, 55.2, 43.8, 42.4, 38.7, 36.0, 21.6. IR: 3057, 2953, 1598, 1488, 1454, 1337, 1162, 842, 715 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{19}H_{22}BrNO_3S$, 424.0582; found: 424.0577.

*4-Bromo-2-phenyl-1-tosylpiperidine (**5f**).* The compound (183 mg, 93%, *trans*:*cis* = 99:1) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-4-Bromo-2-phenyl-1-tosylpiperidine (major diastereomer, white solid, mp = 113−114 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.68 (d, J = 8.2 Hz, 2H), 7.31−7.15 (m, 7H), 5.26 (d, J = 4.6 Hz, 1H), 3.97−3.90 (m, 1H), 3.86−3.77 (m, 1H), 3.02−2.88 (m, 1H), 2.81−2.72 (m, 1H), 2.36 (s, 3H), 2.03−1.87 (m, 2H), 1.65 (qd, J = 12.8, 4.7 Hz, 1H); ^{13}C NMR

DOI: 10.1021/acs.joc.6b00725
J. Org. Chem. 2016, 81, 5144−5161

(100 MHz, $CDCl_3$) δ = 143.7, 138.0, 137.2, 130.0, 129.0, 127.5, 127.0, 126.6, 56.8, 43.8, 42.3, 38.5, 36.0, 21.6. NMR data were in agreement with the reported results.[10a]

*4-Bromo-2-(4-isopropylphenyl)-1-tosylpiperidine (**5g**).* The compound (176 mg, 81%, *trans*:*cis* = 94:6) was purified by flash chromatography using petroleum ether/ethyl acetate (50:1) as eluent. *trans*-4-Bromo-2-(4-isopropylphenyl)-1-tosylpiperidine (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.67 (d, J = 8.2 Hz, 2H), 7.24 (d, J = 8.2 Hz, 2H), 7.18−7.08 (m, 4H), 5.23 (d, J = 4.6 Hz, 1H), 4.03−3.92 (m, 1H), 3.85−3.77 (m, 1H), 3.04−2.91 (m, 1H), 2.86−2.71 (m, 2H), 2.36 (s, 3H), 2.02−1.91 (m, 2H), 1.67 (qd, J = 12.8, 4.7 Hz, 1H), 1.16 (s, 3H), 1.14 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 148.1, 143.6, 138.0, 134.5, 130.0 127.1, 127.0, 126.6, 56.7, 44.0, 42.3, 38.6, 36.1, 33.7, 24.0, 24.0, 21.6. IR: 3028, 2960, 1597, 1511, 1453, 1339, 1158, 724, 657 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{21}H_{26}BrNO_2S$, 436.0946; found: 436.0946.

*4-Bromo-2-(4-tert-butylphenyl)-1-tosylpiperidine (**5h**).* The compound (195 mg, 87%, *trans*:*cis* = 98:2) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-4-Bromo-2-(4-*tert*-butylphenyl)-1-tosylpiperidine (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.68 (d, J = 8.3 Hz, 2H), 7.27 (d, J = 8.3 Hz, 2H), 7.24 (d, J = 8.1 Hz, 2H), 7.14 (d, J = 8.1 Hz, 2H), 5.23 (d, J = 3.0 Hz, 1H), 3.98 (tt, J = 12.2, 3.9 Hz, 1H), 3.86−3.75 (m, 1H), 3.02−2.91 (m, 1H), 2.78−2.73 (m, 1H), 2.37 (s, 3H), 2.03−1.92 (m, 2H), 1.69 (qd, J = 12.8, 4.7 Hz, 1H), 1.22 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 150.4, 143.5, 138.0, 134.1, 123.0, 127.0, 126.3, 125.9, 56.7, 44.0, 42.2, 38.6, 36.1, 34.5, 31.3, 21.6. IR: 3032, 2960, 1597, 1513, 1454, 1158, 847, 719 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{22}H_{28}BrNO_2S$, 450.1102; found: 450.1093.

*4-Bromo-2-(4-fluorophenyl)-1-tosylpiperidine (**5i**).* The compound (164 mg, 80%, *trans*:*cis* = 96:4) was purified by flash chromatography using petroleum ether/ethyl acetate (30:1) as eluent. *trans*-4-Bromo-2-(4-fluorophenyl)-1-tosylpiperidine (major diastereomer, white solid, mp = 95−98 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.68 (d, J = 8.1 Hz, 2H), 7.26 (d, J = 8.1 Hz, 2H), 7.20 (dd, J = 8.1, 5.2 Hz, 2H), 6.95 (t, J = 8.6 Hz, 2H), 5.22 (d, J = 3.1 Hz, 1H), 3.92 (tt, J = 12.1, 3.9 Hz, 1H), 3.85−3.76 (m, 1H), 2.98−2.88 (m, 1H), 2.76−2.67 (m, 1H), 2.37 (s, 3H), 1.99−1.92 (m, 2H), 1.64 (qd, J = 12.7, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 162.0 (d, J = 246.6 Hz), 143.8, 137.8, 132.9, 130.1, 128.4 (d, J = 8.0 Hz), 126.9, 115.9 (d, J = 21.5 Hz), 56.3, 43.4, 42.2, 38.5, 35.9, 21.6; ^{19}F NMR (376 MHz, $CDCl_3$) δ = −115.1. IR: 3087, 2945, 1600, 1507, 1454, 1158, 1001, 927, 739 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{18}H_{19}BrFNO_2S$, 412.0382; found: 412.0377.

*4-Bromo-2-(2-fluorophenyl)-1-tosylpiperidine (**5j**).* The compound (169 mg, 82%, *trans*:*cis* = 89:11) was purified by flash chromatography using petroleum ether/ethyl acetate (30:1) as eluent. *trans*-4-Bromo-2-(2-fluorophenyl)-1-tosylpiperidine (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.57 (d, J = 8.2 Hz, 1H), 7.19 (d, J = 8.2 Hz, 1H), 7.13 (dd, J = 12.4, 4.7 Hz, 2H), 7.00−6.85 (m, 2H), 5.40 (d, J = 2.3 Hz, 1H), 3.98−3.84 (m, 2H), 3.44−3.29 (m, 1H), 2.72 (d, J = 13.7 Hz, 1H), 2.35 (s, 3H), 2.15−1.96 (m, 2H), 1.77 (1d, J = 11.9, 4.8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 158.9 (d, J = 245.2 Hz), 142.6, 136.1, 128.8, 128.3 (d, J = 8.6 Hz), 127.6 (d, J = 3.8 Hz), 125.9, 124.9 (d, J = 12.0 Hz), 123.1 (d, J = 3.4 Hz), 115.2 (d, J = 22.6 Hz), 52.4, 43.1, 42.4, 39.4, 34.9 20.5; ^{19}F NMR (376 MHz, $CDCl_3$) δ = −114.0. IR: 3051, 2901, 1595, 1486, 1451, 1347, 1161, 844, 660 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{18}H_{19}BrFNO_2S$, 412.0382; found: 412.0378.

cis-4-Bromo-2-(2-fluorophenyl)-1-tosylpiperidine (minor diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.43 (d, J = 8.0 Hz, 2H), 7.25 (t, J = 7.4 Hz, 1H), 7.14 (d, J = 7.8 Hz, 3H), 6.97 (t, J = 7.4 Hz, 1H), 6.86−6.79 (m, 1H), 4.67 (dd, J = 7.4, 5.0 Hz, 1H), 4.10−3.99 (m, 1H), 4.00−3.87 (m, 1H), 3.30−3.07 (m, 1H), 2.57−2.42 (m, 1H), 2.33 (s, 3H), 2.30−2.21 (m, 1H), 2.15 (dd, J = 13.6, 3.8 Hz, 1H), 2.04 (dd, J = 11.4, 7.6 Hz, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 159.0 (d, J = 245.2 Hz), 143.5, 129.5, 129.2, 129.1 (d, J = 3.8 Hz), 127.4, 123.9 (d, J = 3.4 Hz), 115.4 (d, J = 22.3 Hz), 54.1, 45.0, 43.9, 40.4, 34.9, 21.6. ^{19}F NMR (376 MHz, $CDCl_3$) δ = −116.4. IR: 3060, 2995, 1601, 1456, 1330, 1133, 845, 670 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{18}H_{19}BrFNO_2S$, 412.0382; found: 412.0378.

*4-Bromo-2-(4-chlorophenyl)-1-tosylpiperidine (**5k**).* The compound (167 mg, 78%, *trans*:*cis* = 96:4) was purified by flash chromatography using petroleum ether/ethyl acetate (30:1) as eluent. *trans*-4-Bromo-2-(4-chlorophenyl)-1-tosylpiperidine (major diastereomer, white solid, mp = 108−109 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.67 (d, J = 8.2 Hz, 2H), 7.26 (d, J = 8.2 Hz, 2H), 7.23 (d, J = 8.7 Hz, 2H), 7.16 (d, J = 8.0 Hz, 2H), 5.21 (d, J = 4.2 Hz, 1H), 3.96−3.79 (m, 2H), 2.96−2.87 (m, 1H), 2.72−2.66 (m, 1H), 2.38 (s, 3H), 1.94 (tt, J = 31.0, 15.5 Hz, 2H), 1.63 (qd, J = 12.7, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.9, 137.7, 135.9, 133.4, 130.1, 129.2, 128.1, 126.9, 56.4, 43.3, 42.3, 38.4, 35.9, 21.6. IR: 3056, 2934, 1596, 1496, 1160, 841, 717 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{18}H_{19}BrClNO_2S$, 428.0087; found: 428.0072.

*4-Bromo-2-(4-bromophenyl)-1-tosylpiperidine (**5l**).* The compound (195 mg, 83%, *trans*:*cis* = 95:5) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-4-Bromo-2-(4-bromophenyl)-1-tosylpiperidine (major diastereomer, white solid, mp = 113−115 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.67 (d, J = 8.2 Hz, 2H), 7.39 (d, J = 8.5 Hz, 2H), 7.26 (d, J = 8.2 Hz, 2H), 7.11 (d, J = 8.2 Hz, 2H), 5.19 (d, J = 4.1 Hz, 1H), 3.98−3.79 (m, 2H), 2.99−2.87 (m, 1H), 2.70 (d, J = 13.7 Hz, 1H), 2.38 (s, 3H), 2.02−1.89 (m, 2H), 1.64 (qd, J = 12.7, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.9, 137.7, 136.4, 132.1, 130.1, 128.5, 126.9, 121.6, 56.4, 43.3, 42.3, 38.4, 35.9, 21.7. IR: 3086, 2963, 1651, 1595, 1490, 1155, 778, 656 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{18}H_{19}Br_2NO_2S$, 471.9581; found: 471.9578.

*4-(4-Bromo-1-tosylpiperidin-2-yl)benzonitrile (**5m**).* The compound (125 mg, 60%, *trans*:*cis* = 99:1) was purified by flash chromatography using petroleum ether/ethyl acetate (20:1) as eluent. *trans*-4-(4-Bromo-1-tosylpiperidin-2-yl)benzonitrile (major diastereomer, white solid, mp = 146−149 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.68 (d, J = 8.2 Hz, 2H), 7.58 (d, J = 8.1 Hz, 2H), 7.38 (d, J = 8.2 Hz, 2H), 7.29 (d, J = 8.1 Hz, 2H), 5.27 (d, J = 4.0 Hz, 1H), 3.93−3.77 (m, 2H), 2.99−2.86 (m, 1H), 2.75 (s, 3H), 2.40 (s, 1H), 2.05−1.91 (m, 2H), 1.64 (qd, J = 12.7, 4.5 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 144.1, 143.2, 137.4, 132.8, 130.2, 127.5, 126.9, 118.4, 111.6, 56.7, 42.7, 42.5, 38.4, 35.6, 21.7. IR: 2954, 2872, 2224, 1602, 1502, 1449, 1155, 931, 657 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{19}H_{19}BrN_2O_2S$, 419.0429; found: 419.0420.

*Methyl 4-(4-Bromo-1-tosylpiperidin-2-yl)benzoate (**5n**).* The compound (147 mg, 65%, *trans*:*cis* = 99:1) was purified by flash chromatography using petroleum ether/ethyl acetate (20:1) as eluent. *trans*-methyl 4-(4-Bromo-1-tosylpiperidin-2-yl)benzoate (major diastereomer, white solid, mp = 92−93 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.93 (d, J = 8.2 Hz, 2H), 7.68 (d, J = 8.2 Hz, 2H), 7.30 (d, J = 8.2 Hz, 2H), 7.26 (d, J = 8.2 Hz, 2H), 5.29 (d, J = 4.1 Hz, 1H), 3.92−3.80 (m, 5H), 2.97−2.89 (m, 1H), 2.77 (d, J = 13.7 Hz, 1H), 2.38 (s, 3H), 2.05−1.93 (m, 2H), 1.66 (qd, J = 12.7, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 166.6, 143.9, 142.7, 137.7, 130.3, 130.1, 129.4, 127.0, 126.7, 56.8, 52.3, 43.2, 42.4, 38.6, 35.8, 21.6. IR: 3290, 3053, 2880, 1718, 1610, 1448, 1341, 1286, 1155, 859, 658 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{20}H_{22}BrNO_4S$, 452.0531; found: 452.0526.

*4-Bromo-2-(4-nitrophenyl)-1-tosylpiperidine (**5o**).* The compound (116 mg, 53%, *trans*:*cis* = 98:2) was purified by flash chromatography using petroleum ether/ethyl acetate (10:1) as eluent. *trans*-4-Bromo-2-(4-nitrophenyl)-1-tosylpiperidine (major diastereomer, white solid, mp = 134−135 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 8.14 (d, J = 8.7 Hz, 2H), 7.69 (d, J = 8.2 Hz, 2H), 7.44 (d, J = 8.7 Hz, 2H), 7.30 (d, J = 8.2 Hz, 2H), 5.31 (d, J = 3.8 Hz, 1H), 3.97−3.79 (m, 2H), 2.98−2.86 (m, 1H), 2.76 (d, J = 13.9 Hz, 1H), 2.41 (s, 3H), 2.09−1.94 (m, 2H), 1.66 (qd, J = 12.7, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 147.3, 145.2, 144.2, 137.4, 130.2, 127.7, 127.0, 124.2, 56.6, 42.6, 42.5, 38.6, 35.6, 21.7. IR: 3077, 2983, 1599, 1517, 1447, 1348, 1155, 814, 692 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{18}H_{19}BrN_2O_4S$, 439.0327; found: 439.0314.

*Crystal Data for trans-**5o**.* $C_{18}H_{19}BrN_2O_4S$, M = 439.32, a = 6.4043(13) Å, b = 7.3316(15) Å, c = 19.670(4) Å, α = 92.49(3)°, β =

DOI: 10.1021/acs.joc.6b00725
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92.80(3)°, γ = 91.60(3)°, V = 921.2(3) Å^3, T = 113(2) K, space group $P\bar{1}$, Z = 2, μ (Mo Kα) = 2.371 mm^{-1}, 7019 reflections measured, 4161 independent reflections (R_{int} = 0.0603). The final R_1 values were 0.0785 ($I > 2\sigma(I)$). The final wR (F^2) values were 0.2315 ($I > 2\sigma(I)$). The final R_1 values were 0.0996 (all data). The final wR (F^2) values were 0.2674 (all data). The goodness of fit on F^2 was 1.048.

4-Bromo-1-tosyl-2-(4-(trifluoromethyl)phenyl)piperidine (**5p**). The compound (150 mg, 65%, *trans*:*cis* = 92:8) was purified by flash chromatography using petroleum ether/ethyl acetate (10:1) as eluent. *trans*-4-Bromo-1-tosyl-2-(4-(trifluoromethyl)phenyl)piperidine (major diastereomer, white solid, mp = 102−103 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.68 (d, J = 8.2 Hz, 2H), 7.53 (d, J = 8.2 Hz, 2H), 7.36 (d, J = 8.2 Hz, 2H), 7.27 (d, J = 8.2 Hz, 2H), 5.28 (s, 1H), 3.90−3.84 (m, 2H), 2.99−2.89 (m, 1H), 2.76 (dd, J = 12.2, 1.6 Hz, 1H), 2.38 (s, 3H), 2.07−1.92 (m, 2H), 1.67 (qd, J = 12.7, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 144.0, 141.7, 137.6, 130.1, 130.0, 129.7, 127.1, 126.9, 126.0, 56.6, 43.0, 42.4, 38.6, 35.8, 21.6; ^{19}F NMR (376 MHz, $CDCl_3$) δ = −62.6. IR: 3064, 2965, 1620, 1597, 1493, 1332, 1167, 854, 734 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{19}H_{19}BrF_3NO_2S$, 462.0350; found: 462.0344.

4-(4-Bromo-1-tosylpiperidin-2-yl)phenol (**5q**). The compound (145 mg, 71%, *trans*:*cis* = 99:1) was purified by flash chromatography using petroleum ether/ethyl acetate (5:1) as eluent. *trans*-4-(4-Bromo-1-tosylpiperidin-2-yl)phenol (major diastereomer, white solid, mp = 98−100 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.69 (d, J = 8.2 Hz, 2H), 7.27 (d, J = 8.2 Hz, 2H), 7.08 (d, J = 8.4 Hz, 2H), 6.74 (d, J = 8.4 Hz, 2H), 5.74 (brs, 1H), 5.19 (d, J = 3.9 Hz, 1H), 3.96 (tt, J = 12.2, 3.9 Hz, 1H), 3.80 (dd, J = 12.7, 2.0 Hz, 1H), 3.02−2.91 (m, 1H), 2.69 (d, J = 13.6 Hz, 1H), 2.39 (s, 3H), 1.94−1.87 (m, 2H), 1.60 (qd, J = 12.8, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 155.2, 143.8, 137.8, 130.1, 128.7, 128.0, 126.9, 115.9, 56.5, 43.8, 42.2, 38.4, 35.9, 21.6. IR: 3443, 3047, 2959, 1619, 1511, 1454, 1159, 740, 657 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{18}H_{20}BrNO_3S$, 410.0426; found: 410.0407.

4-Bromo-2-(furan-2-yl)-1-tosylpiperidine (**5r**). The compound (170 mg, 89%, *trans*:*cis* = 99:1) was purified by flash chromatography using petroleum ether/ethyl acetate (30:1) as eluent. *trans*-4-Bromo-2-(furan-2-yl)-1-tosylpiperidine (major diastereomer, white solid, mp = 98−100 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.53 (d, J = 8.3 Hz, 2H), 7.21−7.13 (m, 3H), 6.19 (dd, J = 3.2, 1.9 Hz, 1H), 6.04 (d, J = 3.2 Hz, 1H), 5.23 (d, J = 5.3 Hz, 1H), 4.24−4.13 (m, 1H), 3.77−3.67 (m, 1H), 3.05 (td, J = 13.3, 2.7 Hz, 1H), 2.61−2.53 (m, 1H), 2.34 (s, 3H), 2.21−2.06 (m, 2H), 1.87 (qd, J = 12.7, 4.8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 151.8, 143.4, 142.3, 136.8, 129.6, 127.1, 110.4, 108.3, 52.1, 43.8, 42.8, 39.7, 36.4, 21.6. IR: 3062, 2961, 1597, 1495, 1330, 1160, 933, 729, 658 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{16}H_{18}BrNO_3S$, 384.0269; found: 384.0252.

4-Bromo-1-tosylpiperidine (**5s**). The compound (143 mg, 90%) was purified by flash chromatography using petroleum ether/ethyl acetate (15:1) as eluent. White solid, mp = 132−134 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.57 (d, J = 8.2 Hz, 2H), 7.26 (d, J = 8.2 Hz, 2H),4.20−4.11 (m, 1H),3.17−3.07 (m, 2H), 3.04−2.91 (m, 2H), 2.36 (s, 3H), 2.16−2.04 (m, 2H), 2.00−1.92 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.8, 133.1, 129.8, 127.6, 47.9, 43.9, 34.7, 21.6. NMR data were in agreement with the reported results.[26]

4-Bromo-2-ethyl-1-tosylpiperidine (**5t**). The compound (150 mg, 87%, *trans*:*cis* = 88:12) was purified by flash chromatography using petroleum ether/ethyl acetate (15:1) as eluent. *trans*-4-Bromo-2-ethyl-1-tosylpiperidine (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.65 (d, J = 8.2 Hz, 2H), 7.24 (d, J = 8.2 Hz, 2H), 4.09 (ddd, J = 16.6, 8.3, 4.2 Hz, 1H), 3.93−3.87 (m, 1H), 3.79−3.73 (m, 1H), 3.02−2.91 (m, 1H), 2.37 (s, 3H), 2.10−1.98 (m, 1H), 1.86−1.73 (m, 1H), 1.67−1.51 (m, 3H), 1.47−1.39 (m, 1H), 0.81 (t, J = 7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.4, 138.2, 129.9, 126.9, 56.3, 44.1, 41.2, 39.0, 36.2, 23.2, 21.6, 11.0. IR: 3027, 2966, 1597, 1493, 1452, 1336, 1158, 927, 652 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{14}H_{20}BrNO_2S$, 346.0476; found: 346.0471.

cis-4-Bromo-2-ethyl-1-tosylpiperidine (minor diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.66 (d, J = 8.2 Hz, 2H), 7.22 (d, J = 8.2 Hz, 2H) 4.35−4.29 (m, 1H), 3.97 (dt, J = 16.4, 6.4 Hz, 1H), 3.67−3.61 (m, 1H), 3.41 (dt, J = 14.6, 7.4 Hz, 1H), 2.34 (s, 3H), 2.09−2.04 (m, 1H), 1.77−1.72 (m, 1H), 1.65−1.49 (m, 3H), 1.46−1.33 (m, 1H), 0.80 (t, J = 7.4 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 144.0, 138.3, 130.0, 127.1, 56.3, 44.1, 41.4, 39.1, 36.2, 23.1, 21.4, 11.1. IR: 3050, 2990, 1610, 1490, 1440, 1167, 937, 655 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{14}H_{20}BrNO_2S$, 346.0476; found: 346.0471.

4-Bromo-2-isopropyl-1-tosylpiperidine (**5u**). The compound (167 mg, 93%, *trans*:*cis* = 86:14) was purified by flash chromatography using petroleum ether/ethyl acetate (30:1) as eluent. *trans*-4-Bromo-2-isopropyl-1-tosylpiperidine (major diastereomer, white solid, mp = 100−102 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.65 (d, J = 8.2 Hz, 2H), 7.24 (d, J = 8.2 Hz, 2H), 4.10−4.01 (m, 1H),3.81−3.73 (m, 1H), 3.53 (dd, J = 10.9, 5.2 Hz, 1H), 2.98−2.86 (m, 1H), 2.36 (s, 3H), 2.27−2.21 (m, 1H), 1.95 (dd, J = 12.9, 2.1 Hz, 1H), 1.88−1.81 (m, 1H), 1.64−1.49 (m, 2H), 0.88 (d, J = 6.6 Hz, 3H), 0.82 (d, J = 6.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.4, 138.4, 129.9, 126.9, 61.2, 44.2, 41.6, 36.8, 35.8, 26.8, 21.6, 20.1, 20.0. IR: 3069, 2963, 1598, 1494, 1158, 1095, 972, 752 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{15}H_{22}BrNO_2S$, 360.0633; found: 360.0631.

cis-4-Bromo-2-isopropyl-1-tosylpiperidine (minor diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ= 7.62 (d, J = 8.2 Hz, 2H), 7.22 (d, J = 8.2 Hz, 2H), 4.35−4.26 (m, 1H), 3.95 (dt, J = 11.3, 3.8 Hz, 1H), 3.71−3.67 (m, 1H), 3.38−3.29 (m, 1H), 2.34 (s, 3H), 2.15−2.09 (m, 1H), 1.93−1.88 (m, 1H), 1.75−1.68 (m, 1H), 1.49−1.40 (m, 2H), 0.88 (d, J = 6.6 Hz, 3H), 0.82 (d, J = 6.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.4, 138.4, 130.0, 126.9, 61.3, 44.1, 41.5, 36.8, 36.0, 26.8, 21.7, 20.2, 20.1. IR: 3050, 2952, 1610, 1490, 1143, 1105, 985, 734 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{15}H_{22}BrNO_2S$, 360.0633; found: 360.0631.

4-Bromo-2-isobutyl-1-tosylpiperidine (**5v**). The compound (173 mg, 93%, *trans*:*cis* = 92:8) was purified by flash chromatography using petroleum ether/ethyl acetate (30:1) as eluent. *trans*-4-Bromo-2-isobutyl-1-tosylpiperidine (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.64 (d, J = 8.2 Hz, 2H), 7.24 (d, J = 8.2 Hz, 2H), 4.18−4.02 (m, 2H), 3.76−3.70 (m, 1H), 3.03−2.93 (m, 1H), 2.37 (s, 3H), 2.02−1.98 (m, 2H), 1.80 (td, J = 12.9, 5.4 Hz, 1H), 1.62 (td, J = 12.9, 4.8 Hz, 1H), 1.53−1.45 (m, 1H), 1.44−1.33 (m, 1H), 1.18 (td, J = 8.9, 5.4 Hz, 1H), 0.82 (d, J = 6.3 Hz, 3H), 0.81 (d, J = 6.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.4, 138.1, 129.9, 127.0, 52.9, 44.2, 41.2, 39.6, 39.1, 36.1, 24.8, 22.7, 22.3, 21.9. NMR data were in agreement with the reported results.[26]

4-Bromo-2-pentyl-1-tosylpiperidine (**5w**). The compound (159 mg, 82%, *trans*:*cis* = 90:10) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-4-Bromo-2-pentyl-1-tosylpiperidine (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 (d, J = 8.0 Hz, 2H), 7.23 (d, J = 8.0 Hz, 2H), 4.11 (tt, J = 12.3, 4.2 Hz, 1H), 3.97 (dd, J = 13.5, 6.9 Hz, 1H), 3.80−3.71 (m, 1H), 3.01−2.92 (m, 1H), 2.36 (s, 3H), 2.03 (td, J = 11.5, 2.1 Hz, 2H), 1.78 (td, J = 13.0, 5.4 Hz, 1H), 1.62 (qd, J = 12.8, 4.7 Hz, 1H), 1.46 (ddd, J = 12.9, 12.1, 6.1 Hz, 1H), 1.39−1.29 (m, 1H), 1.25−1.09 (m, 6H), 0.79 (t, J = 6.7 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.4, 138.2, 129.8, 127.0, 54.8, 44.2, 41.2 39.4, 36.3, 31.4, 30.1, 26.0, 22.5, 21.6, 14.0. IR: 3032, 2955, 1596, 1465, 1378, 1158, 1040, 861, 711 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{17}H_{26}BrNO_2S$, 388.0946; found: 388.0935.

4-Bromo-2-hexyl-1-tosylpiperidine (**5x**). The compound (189 mg, 94%, *trans*:*cis* = 88:12) was purified by flash chromatography using petroleum ether/ethyl acetate (50:1) as eluent. *trans*-4-Bromo-2-hexyl-1-tosylpiperidine (major diastereomer, white solid, mp = 62−64 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.64 (d, J = 8.3 Hz, 2H), 7.23 (d, J = 8.3 Hz, 2H), 4.11 (tt, J = 12.3, 4.2 Hz, 1H), 3.96 (dd, J = 13.5, 6.9 Hz, 1H), 3.80−3.72 (m, 1H), 3.01−2.92 (m, 1H), 2.36 (s, 3H), 2.07−1.98 (m, 2H), 1.83−1.73 (m, 1H), 1.62 (qd, J = 12.8, 4.7 Hz, 1H), 1.50−1.43 (m, 1H), 1.36−1.31 (m, 1H), 1.24−1.12 (m, 8H), 0.80 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.4, 138.2, 129.8, 127.0, 54.8, 44.17, 41.2, 39.4, 36.2, 31.7, 30.1, 28.1, 26.3, 22.6, 21.6, 14.1. IR: 3027, 2956, 1595, 1491, 1377, 1157, 929, 825, 649 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{18}H_{28}BrNO_2S$, 402.1102; found: 402.1104.

DOI: 10.1021/acs.joc.6b00725
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cis-4-Bromo-2-hexyl-1-tosylpiperidine (minor, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.64 (d, J = 8.0 Hz, 2H), 7.22 (d, J = 8.0 Hz, 2H), 4.43−4.29 (m, 1H), 4.01−3.88 (m, 1H), 3.70−3.58 (m, 1H), 3.48−3.28 (m, 1H), 2.35 (s, 3H), 2.06−1.99 (m, 2H), 1.86−1.78 (m, 4H), 1.24−1.09 (m, 8H), 0.80 (t, J = 6.9 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ= 142.1, 137.3, 128.6, 126.0, 51.9, 45.4, 35.8, 33.3, 32.5, 31.4, 30.6, 27.9, 25.7, 21.5, 20.5, 13.0. IR: 3033, 2950, 1600, 1490, 1452, 1120, 929, 846, 673 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{18}H_{28}BrNO_2S$, 402.1102; found: 402.1104.

*(E)-4-Bromo-2-styryl-1-tosylpiperidine (**5y**).* The compound (147 mg, 70%, *trans*:*cis* = 86:14) was purified by flash chromatography using petroleum ether/ethyl acetate (50:1) as eluent. *trans*-(*E*)-4-Bromo-2-styryl-1-tosylpiperidine (major diastereomer, white solid, mp = 144−146 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.61 (d, J = 7.7 Hz, 2H), 7.22−7.16 (m, 5H), 7.11 (d, J = 6.8 Hz, 2H), 6.34 (d, J = 15.9 Hz, 1H), 5.82 (dd, J = 16.0, 5.4 Hz, 1H), 4.75 (s, 1H), 4.10 (t, J = 11.7 Hz, 1H), 3.76 (d, J = 13.0 Hz, 1H), 3.04 (t, J = 12.6 Hz, 1H), 2.37−2.31 (m, 4H), 2.41−2.05 (m, 2H), 1.92−1.81 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.6, 137.0, 135.9, 133.0, 129.8, 128.6, 128.1, 127.4, 126.4, 124.9, 56.3, 44.0, 42.3, 41.47, 36.5, 21.5. IR: 3058, 2957, 1595, 1494, 1447, 1156, 935, 758 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{20}H_{22}BrNO_2S$, 420.0633; found: 420.0625.

cis-(*E*)-4-Bromo-2-styryl-1-tosylpiperidine (minor diastereomer, oil): ^{1}H NMR ($CDCl_3$, 400 MHz) δ = 7.60 (d, J = 8.2 Hz, 2H), 7.30−7.16 (m, 7H), 6.31−6.28 (m, 2H), 4.46−4.42 (m, 1H), 4.35−4.30 (m, 1H), 3.62−3.56 (m, 1H), 3.50−3.46 (m, 1H), 2.34−2.28 (m, 4H), 2.19−2.10 (m, 2H), 2.01−1.96 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.3, 136.6, 136.0, 132.5, 123.1, 128.4, 127.8, 127.7, 127.6, 126.4, 56.1, 54.2, 40.0, 38.9, 34.8, 21.3. IR: 3060, 2955, 1599, 1501, 1450, 1220, 1165, 945, 758, 624 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{20}H_{22}BrNO_2S$, 420.0633; found: 420.0625.

*2-Benzyl-4-bromo-1-tosylpiperidine (**5z**).* The compound (167 mg, 82%, *trans*:*cis* = 89:11) was purified by flash chromatography using petroleum ether/ethyl acetate (30:1) as eluent. *trans*-2-Benzyl-4-bromo-1-tosylpiperidine (major diastereomer, white solid, mp = 112−114 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.47 (d, J = 8.1 Hz, 2H), 7.23−7.14 (m, 5H), 7.04 (d, J = 6.9 Hz, 2H), 4.28−4.21 (m, 2H), 3.74 (d, J = 14.2 Hz, 1H), 3.15−3.02 (m, 1H), 2.72 (d, J = 8.0 Hz, 2H), 2.33 (s, 3H), 2.15 (d, J = 12.5 Hz, 1H), 2.06 (d, J = 13.3 Hz, 1H), 1.82 (qd, J = 13.3, 5.2 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.4, 137.6, 137.5, 129.79, 129.0, 128.8, 127.0, 126.8, 56.1, 43.6, 41.5, 38.0, 36.5, 36.4, 21.6. NMR data were in agreement with the reported results.[26]

cis-2-Benzyl-4-bromo-1-tosylpiperidine (minor diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.50 (d, J = 8.1 Hz, 2H), 7.25−7.15 (m, 5H), 7.08 (d, J = 6.9 Hz, 2H), 4.41−4.36 (m, 1H), 3.51−3.37 (m, 1H), 3.33 (dd, J = 13.5, 9.7 Hz, 1H), 3.04−2.92 (m, 2H), 2.74−2.66 (m, 1H), 2.33 (s, 3H), 2.22 (dd, J = 17.1, 15.1 Hz, 1H), 2.17−2.11 (m, 1H), 2.08−2.01 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 144.4, 138.0, 137.5, 129.8, 129.1, 128.8, 127.0, 126.8, 56.1, 43.6, 41.5, 38.1, 37.0, 36.3, 21.6. NMR data were in agreement with the reported results.[26]

*4-Iodo-2-(p-tolyl)-1-tosylpiperidine (**6a**).* The compound (184 mg, 81%, *trans*:*cis* = 92:8) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-4-Iodo-2-(*p*-tolyl)-1-tosylpiperidine (major diastereomer, white solid, mp = 145−146 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.68 (d, J = 8.2 Hz, 2H), 7.25 (d, J = 8.2 Hz, 2H), 7.10−7.03 (m, 4H), 5.08 (d, J = 3.5 Hz, 1H), 4.05 (tt, J = 12.5, 3.7 Hz, 1H), 3.75−3.59 (m, 1H), 2.99−2.89 (m, 1H), 2.83 (d, J = 13.7 Hz, 1H), 2.37 (s, 3H), 2.24 (s, 3H), 2.16 (td, J = 13.3, 5.3 Hz, 1H), 2.00 (d, J = 11.1 Hz, 1H), 1.84 (qd, J = 12.7, 4.6 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.6, 138.0, 137.1, 134.1, 130.0, 129.7, 127.0, 126.6, 57.5, 43.4, 40.6, 38.0, 21.7, 21.0, 19.4. NMR data were in agreement with the reported results.[12]

*4-Iodo-2-(m-tolyl)-1-tosylpiperidine (**6b**).* The compound (196 mg, 86% *trans*:*cis* = 94:6) was purified by flash chromatography using petroleum ether/ethyl acetate (20:1) as eluent. *trans*-4-Iodo-2-(*m*-tolyl)-1-tosylpiperidine (major diastereomer, white solid, mp = 127−129 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.67 (d, J = 8.2 Hz, 2H), 7.25 (d, J = 8.2 Hz, 2H), 7.19−7.10 (m, 1H), 6.96−6.93 (m, 3H), 5.09 (d, J = 4.2 Hz, 1H), 4.10−4.01 (m, 1H),3.77−3.61 (m, 1H), 3.05−2.92 (m, 1H), 2.90−2.79 (m, 1H), 2.37 (s, 3H), 2.26−2.12 (m, 4H), 2.03 (dd, J = 12.9, 2.0 Hz, 1H), 1.87 (qd, J = 12.7, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.6, 138.7, 138.0, 137.1, 130.0, 128.9, 128.2, 127.3, 127.0, 123.6, 57.7, 43.5, 40.8, 38.1, 21.7, 19.4. IR: 3053, 2922, 2872, 1654, 1602, 1491, 1337, 1282, 1157, 730, 657 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{19}H_{22}INO_2S$, 456.0494; found: 456.0487.

*4-Iodo-2-(o-tolyl)-1-tosylpiperidine (**6c**).* The compound (180 mg, 79% *trans*:*cis* = 90:10) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-4-Iodo-2-(*o*-tolyl)-1-tosylpiperidine (major diastereomer, white solid, mp = 103−104 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.26 (d, J = 8.3 Hz, 2H), 7.03−6.95 (m, 4H), 6.93 (d, J = 7.6 Hz, 1H), 6.87−6.81 (m, 1H), 5.12 (t, J = 4.9 Hz, 1H), 4.39−4.31 (m, 1H), 3.74−3.65 (m, 1H), 3.60 (ddd, J = 13.5, 10.0, 3.6 Hz, 1H), 2.43 (dt, J = 12.6, 3.5 Hz, 1H), 2.36−2.30 (m, 1H), 2.31−2.23 (m,4H), 2.21 (s, 3H), 2.14−2.03 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.0, 137.7, 136.8, 135.6, 131.1, 129.3, 127.3, 127.0, 125.6, 55.5, 45.4, 42.5, 37.5, 22.0, 21.5, 19.7. IR: 3053, 3024, 2917, 1652, 1599, 1490, 1261, 1093, 931, 843, 675 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{19}H_{22}INO_2S$, 456.0494; found: 456.0496.

*4-Iodo-2-(4-methoxyphenyl)-1-tosylpiperidine (**6d**).* The compound (153 mg, 65% *trans*:*cis* = 90:10) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-4-Iodo-2-(4-methoxyphenyl)-1-tosylpiperidine (major diastereomer, white solid, mp = 119−120 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.69 (d, J = 8.2 Hz, 2H), 7.27 (d, J = 8.2 Hz, 2H), 7.13 (d, J = 8.5 Hz, 2H), 6.80 (d, J = 8.5 Hz, 2H), 5.07 (d, J = 3.5 Hz, 1H), 4.09 (tt, J = 12.7, 3.8 Hz, 1H), 3.73 (s, 3H), 3.65 (dd, J = 12.6, 2.1 Hz, 1H), 3.03−2.90 (m, 1H), 2.82 (d, J = 13.7 Hz, 1H), 2.39 (s, 3H), 2.16 (td, J = 13.3, 5.2 Hz, 1H), 2.02 (d, J = 10.1 Hz, 1H), 1.85 (qd, J = 12.7, 4.6 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 158.8, 143.6, 138.0, 130.0, 128.9, 127.9, 127.0, 114.3, 57.2, 55.4, 43.3, 40.6, 38.0, 21.6, 19.4. NMR data were in agreement with the reported results.[12]

cis-4-Iodo-2-(4-methoxyphenyl)-1-tosylpiperidine (minor diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.50 (d, J = 8.9 Hz, 2H), 7.03 (d, J = 8.1 Hz, 2H), 6.97 (d, J = 8.1 Hz, 2H), 6.81 (d, J = 8.9 Hz, 2H), 4.51 (t, J = 5.9 Hz, 1H), 4.06−3.99 (m, 1H), 3.88−3.80 (m, 1H), 3.79 (s, 3H), 3.34−3.27 (m, 1H), 2.39−2.30 (m, 1H), 2.23 (s, 3H), 2.17 (dt, J = 14.3, 4.3 Hz, 1H), 2.10−2.03 (m, 1H), 1.87−179 (m, 1H), ^{13}C NMR (100 MHz, $CDCl_3$) δ = 161.7, 135.8, 135.4, 128.4, 127.6, 125.9, 112.9, 56.7, 54.6, 53.3, 40.6, 39.0, 33.0, 20.0. NMR data were in agreement with the reported results.[12]

*4-Iodo-2-(3-methoxyphenyl)-1-tosylpiperidine (**6e**).* The compound (170 mg, 72% *trans*:*cis* = 92:8) was purified by flash chromatography using petroleum ether/ethyl acetate (20:1) as eluent. *trans*-4-Iodo-2-(3-methoxyphenyl)-1-tosylpiperidine (major diastereomer, white solid, mp = 134−136 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.69 (d, J = 8.2 Hz, 2H), 7.26 (d, J = 8.1 Hz, 2H), 7.22−7.14 (m, 1H), 6.78 (d, J = 7.8 Hz, 1H), 6.73−6.71 (m, 2H), 5.09 (d, J = 4.3 Hz, 1H), 4.06 (tt, J = 12.6, 3.8 Hz, 1H), 3.74−3.64 (m, 4H), 3.04−2.92 (m, 1H), 2.84 (d, J = 13.8 Hz, 1H), 2.38 (s, 3H), 2.20 (td, J = 13.4, 5.3 Hz, 1H), 2.04 (dd, J = 12.9, 2.0 Hz, 1H), 1.88 (qd, J = 12.7, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 160.3, 143.6, 139.0, 138.0, 130.1, 130.0, 127.0, 118.8, 112.7, 112.6, 57.6, 55.2, 43.5, 40.7, 38.0, 21.6, 19.1. IR: 3053, 2933, 2869, 1656, 1599, 1492, 1339, 1264, 1092, 964, 760, 657 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{19}H_{22}INO_3S$, 472.0443; found: 472.0436.

*4-Iodo-2-(2-methoxyphenyl)-1-tosylpiperidine (**6f**).* The compound (184 mg, 78% *trans*:*cis* = 93:7) was purified by flash chromatography using petroleum ether/ethyl acetate (20:1) as eluent. *trans*-4-Iodo-2-(2-methoxyphenyl)-1-tosylpiperidine (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.53 (d, J = 8.2 Hz, 2H), 7.18−7.10 (m, 3H), 6.98 (d, J = 7.5 Hz, 1H), 6.75 (d, J = 8.1 Hz, 1H), 6.70 (t, J = 7.5 Hz, 1H), 5.34 (d, J = 4.7 Hz, 1H), 3.99 (tt, J = 12.7, 3.6 Hz, 1H), 3.84−3.76 (m, 1H), 3.73 (s, 3H), 3.52−3.41 (m, 1H), 2.88−2.78 (m, 1H), 2.34 (s, 3H), 2.19 (td, J = 13.1, 6.2 Hz, 2H), 1.95 (qd, J = 12.7, 4.6 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 156.2, 143.2, 137.6, 129.6, 128.4, 127.5, 127.3, 127.0, 120.1, 110.7, 55.2

DOI: 10.1021/acs.joc.6b00725
J. Org. Chem. 2016, 81, 5144−5161

54.5, 45.2, 42.3, 38.4, 21.6, 21.0. IR: 3084, 3058, 2951, 1714, 1598, 1489, 1337, 1244, 1158, 951, 810, 695 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{19}H_{22}INO_3S$, 472.0443; found: 472.0432.

*4-Iodo-2-phenyl-1-tosylpiperidine (**6g**).* The compound (161 mg, 73% *trans*:*cis* = 92:8) was purified by flash chromatography using petroleum ether/ethyl acetate (45:1) as eluent. *trans*-4-Iodo-2-phenyl-1-tosylpiperidine (major diastereomer, oil): ^1H NMR (400 MHz, $CDCl_3$) δ = 7.69 (d, J = 8.2 Hz, 2H), 7.29−7.215 (m, 3H), 7.22−7.17 (m, 3H), 5.13 (d, J = 4.1 Hz, 1H), 4.05 (tt, J = 12.7, 3.7 Hz, 1H), 3.73−3.57 (m, 1H), 3.01−2.91 (m, 1H), 2.87 (d, J = 13.7 Hz, 1H), 2.38 (s, 3H), 2.19 (td, J = 13.3, 5.3 Hz, 1H), 2.02 (dd, J = 12.9, 1.8 Hz, 1H), 1.86 (qd, J = 12.7, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.6, 138.0, 137.2, 130.0, 129.0, 127.4, 127.0, 126.6, 57.7, 43.5, 40.6, 38.0, 21.6, 19.1. NMR data were in agreement with the reported results.[12]

*4-Iodo-2-(4-isopropylphenyl)-1-tosylpiperidine (**6h**).* The compound (193 mg, 80% *trans*:*cis* = 90:10) was purified by flash chromatography using petroleum ether/ethyl acetate (45:1) as eluent. *trans*-4-Iodo-2-(4-isopropylphenyl)-1-tosylpiperidine (major diastereomer, white solid, mp = 107−108 °C): ^1H NMR (400 MHz, $CDCl_3$) δ = 7.68 (d, J = 8.2 Hz, 2H), 7.25 (d, J = 8.2 Hz, 2H), 7.11 (s, 4H), 5.09 (d, J = 4.8 Hz, 1H), 4.09 (tt, J = 12.7, 3.8 Hz, 1H), 3.71−3.61 (m, 1H), 3.05−2.92 (m, 1H), 2.88−2.75 (m, 2H), 2.38 (s, 3H), 2.19 (td, J = 13.3, 5.3 Hz, 1H), 2.03 (dd, J = 12.8, 1.9 Hz, 1H), 1.88 (qd, J = 12.7, 4.7 Hz, 1H), 1.17 (s, 3H), 1.15 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 148.1, 143.5, 138.0, 134.4, 129.9, 127.1, 127.0, 126.6, 57.6, 43.4, 40.7, 38.1, 33.7, 24.0, 24.0, 21.6, 19.5. IR: 3063, 2957, 1663, 1595, 1508, 1453, 1339, 1158, 1093, 928, 816, 653 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{21}H_{26}INO_2S$, 484.0807; found: 484.0799.

cis-4-Iodo-2-(4-isopropylphenyl)-1-tosylpiperidine (minor, oil): ^1H NMR (400 MHz, $CDCl_3$) δ= 7.40 (d, J = 7.9 Hz, 2H), 7.09 (d, J = 7.8 Hz, 2H), 7.03 (d, J = 7.8 Hz, 2H), 6.96 (d, J = 7.9 Hz, 2H), 4.55 (t, J = 5.8 Hz, 1H), 4.02 (s, 1H), 3.89−3.76 (m, 1H), 3.33 (dd, J = 12.4, 5.1 Hz, 1H), 2.77 (dt, J = 13.7, 6.8 Hz, 1H), 2.42−2.27 (m, 4H), 2.17 (d, J = 14.2 Hz, 1H), 2.10−2.02 (m, 1H), 1.83 (d, J = 6.9 Hz, 1H), 1.15 (d, J = 6.9 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 146.8, 142.0, 136.1, 135.5, 128.4, 126.3, 126.1, 125.0, 56.9, 53.2, 40.7, 38.9, 33.1, 32.6, 23.0, 22.9, 20.5. IR: 3051, 3000, 1660, 1590, 1508, 1448, 1153, 947, 836, 642 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{21}H_{26}INO_2S$, 484.0807; found: 484.0799.

*2-(4-tert-Butylphenyl)-4-iodo-1-tosylpiperidine (**6i**).* The compound (211 mg, 85% *trans*:*cis* = 95:5) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-2-(4-*tert*-Butylphenyl)-4-iodo-1-tosylpiperidine (major diastereomer, white solid, mp = 148−149 °C): ^1H NMR (400 MHz, $CDCl_3$) δ = 7.67 (d, J = 8.1 Hz, 2H), 7.27 (d, J = 8.3 Hz, 2H), 7.25 (d, J = 8.3 Hz, 2H), 7.12 (d, J = 8.1 Hz, 2H), 5.09 (s, 1H), 4.14−4.03 (m, 1H), 3.66 (d, J = 14.5 Hz, 1H), 2.98 (t, J = 12.6 Hz, 1H), 2.86 (d, J = 13.4 Hz, 1H), 2.38 (s, 3H), 2.20 (td, J = 13.3, 5.2 Hz, 1H), 2.03 (d, J = 11.7 Hz, 1H), 1.88 (qd, J = 12.7, 4.5 Hz, 1H), 1.23 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 150.3, 143.5, 138.0, 134.1, 129.9, 127.0, 126.4, 125.9, 57.5, 43.4, 40.7, 38.1, 34.5, 31.3, 21.6, 19.5. IR: 3087, 2957, 2867, 1656, 1595, 1445, 1341, 1155, 1093, 849, 719, 657 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{22}H_{28}INO_2S$, 498.0964; found: 498.0958.

*2-(4-Fluorophenyl)-4-iodo-1-tosylpiperidine (**6j**).* The compound (193 mg, 84% *trans*:*cis* = 96:4) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-2-(4-Fluorophenyl)-4-iodo-1-tosylpiperidine (major diastereomer, white solid, mp = 130−132 °C): ^1H NMR (400 MHz, $CDCl_3$) δ = 7.68 (d, J = 8.0 Hz, 2H), 7.28 (d, J = 8.0 Hz, 2H), 7.18 (d, J = 8.3 Hz, 2H), 6.98 (d, J = 8.3 Hz, 2H), 5.09 (s, 1H), 4.03 (tt, J = 12.7, 3.5 Hz, 1H), 3.67 (d, J = 14.6 Hz, 1H), 3.01−2.88 (m, 1H), 2.81 (d, J = 13.9 Hz, 1H), 2.40 (s, 3H), 2.17 (td, J = 13.4, 5.3 Hz, 1H), 2.03 (d, J = 11.4 Hz, 1H), 1.84 (qd, J = 12.7, 4.6 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 162.0 (d, J = 246.5 Hz), 143.8, 137.8, 132.9 (d, J = 3.1 Hz), 130.0, 128.5 (d, J = 8.1 Hz), 127.0, 115.9 (d, J = 21.2 Hz), 57.2, 43.4, 40.6, 37.9, 21.6, 18.6; ^{19}F NMR (376 MHz, $CDCl_3$) δ= −115.2. IR: 3048, 2964, 2876, 1658, 1601, 1509, 1453, 1333, 1285, 1158, 929, 741, 685 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{18}H_{19}FINO_2S$, 460.0243; found: 460.0238.

*2-(2-Fluorophenyl)-4-iodo-1-tosylpiperidine (**6k**).* The compound (202 mg, 88% *trans*:*cis* = 89:11) was purified by flash chromatography using petroleum ether/ethyl acetate (50:1) as eluent. *trans*-2-(2-Fluorophenyl)-4-iodo-1-tosylpiperidine (major diastereomer, white solid, mp = 118−119 °C): ^1H NMR (400 MHz, $CDCl_3$) δ = 7.57 (d, J = 8.1 Hz, 2H), 7.19 (d, J = 8.0 Hz, 2H), 7.18−7.08 (m, 2H), 6.94 (dd, J = 13.7, 7.2 Hz, 2H), 5.29 (d, J = 3.6 Hz, 1H), 4.01 (tt, J = 12.1, 3.5 Hz, 1H), 3.77 (t, J = 15.7 Hz, 1H), 3.39−3.25 (m, 1H), 2.79 (d, J = 13.4 Hz, 1H), 2.35 (s, 3H), 2.31−2.13 (m, 2H), 1.93 (qd, J = 12.1, 4.8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 158.9 (d, J = 246 Hz), 142.5, 136.2, 128.7, 128.2 (d, J = 8.4 Hz), 127.7 (d, J = 3.5 Hz), 125.9, 124.9 (d, J = 12.3 Hz), 123.1 (d, J = 3.4 Hz), 115.2 (d, J = 22.8 Hz), 53.2, 43.6, 41.4, 41.4, 36.9, 20.5, 18.4; ^{19}F NMR (376 MHz, $CDCl_3$) δ = −114.0. IR: 3087, 2957, 1593, 1486, 1449, 1354, 1262, 1160, 995, 813, 748 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{18}H_{19}FINO_2S$, 460.0243; found: 460.0233.

cis-2-(2-Fluorophenyl)-4-iodo-1-tosylpiperidine (minor, oil): ^1H NMR (400 MHz, $CDCl_3$) δ = 7.40 (d, J = 7.8 Hz, 2H), 7.27 (t, J = 7.3 Hz, 1H), 7.14 (d, J = 7.5 Hz,3H), 6.98 (t, J = 7.4 Hz, 1H), 6.87−6.77 (m, 1H), 4.51 (d, J = 4.3 Hz, 1H), 4.03 (s, 1H), 3.87−3.79 (m, 1H), 3.19−2.97 (m, 1H), 2.64−2.43 (m, 1H), 2.37−2.26 (m, 4H), 2.28−2.16 (m, 2H).^{13}C NMR (100 MHz, $CDCl_3$) δ = 159.0 (d, J = 245.2 Hz), 143.5, 129.5, 129.3, 129.2 (d, J = 3.8 Hz), 127.4, 123.9 (d, J = 3.4 Hz), 115.4 (d, J = 22.3 Hz), 54.1, 45.0, 44.0, 40.4, 35.0, 21.6. IR: 3093, 2995, 1590, 1456, 1450, 1262, 150, 893, 844, 743 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{18}H_{19}FINO_2S$, 460.0243; found: 460.0233.

*2-(4-Chlorophenyl)-4-iodo-1-tosylpiperidine (**6l**).* The compound (192 mg, 81% *trans*:*cis* = 92:8) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-2-(4-Chlorophenyl)-4-iodo-1-tosylpiperidine (major diastereomer, white solid, mp = 132−133 °C): ^1H NMR (400 MHz, $CDCl_3$) δ = 7.67 (d, J = 8.1 Hz, 2H), 7.27 (d, J = 8.1 Hz, 2H), 7.24 (d, J = 8.3 Hz, 2H), 7.14 (d, J = 8.3 Hz, 2H), 5.08 (d, J = 3.2 Hz, 1H), 3.99 (tt, J = 12.7, 3.6 Hz, 1H), 3.66 (d, J = 14.7 Hz, 1H), 2.98−2.86 (m, 1H), 2.80 (d, J = 13.8 Hz, 1H), 2.39 (s, 3H), 2.16 (td, J = 13.4, 5.3 Hz, 1H), 2.02 (d, J = 11.4 Hz, 1H), 1.83 (qd, J = 12.7, 4.6 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.8, 137.8, 135.8, 133.4, 130.1, 129.2, 128.2, 127.0, 57.2, 43.4, 40.5, 37.8, 21.7, 18.4. IR: 3036, 2948, 1660, 1595, 1492, 1400, 1155, 1002, 931, 839, 650 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{18}H_{19}ClINO_2S$, 475.9948; found: 475.9943.

*2-(3-Chlorophenyl)-4-iodo-1-tosylpiperidine (**6m**).* The compound (209 mg, 88% *trans*:*cis* = 94:6) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-2-(3-Chlorophenyl)-4-iodo-1-tosylpiperidine (major diastereomer, white solid, mp = 143−144 °C): ^1H NMR (400 MHz, $CDCl_3$) δ = 7.66 (d, J = 8.3 Hz, 2H), 7.27 (d, J = 8.3 Hz, 2H), 7.23−7.13 (m, 2H), 7.10 (dd, J = 4.7, 1.4 Hz, 2H), 5.08 (d, J = 4.5 Hz, 1H), 3.99 (tt, J = 12.7, 3.9 Hz, 1H), 3.73−3.64 (m, 1H), 2.99−2.90 (m, 1H), 2.84−2.77 (m, 1H), 2.38 (s, 3H), 2.24−2.14 (m, 1H), 2.05 (dd, J = 13.0, 2.1 Hz, 1H), 1.86 (qd, J = 12.7, 4.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.9, 139.6, 137.7, 135.1, 130.3, 130.1, 127.7, 126.9, 126.9, 124.9, 57.3, 43.6, 40.6, 37.8, 21.6, 18.4. IR: 3064, 2924, 1659, 1595, 1478, 1339, 1280, 1158, 1094, 993, 790, 715 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{18}H_{19}ClINO_2S$, 475.9948; found: 475.9942.

*2-(4-Bromophenyl)-4-iodo-1-tosylpiperidine (**6n**).* The compound (230 mg, 89% *trans*:*cis* = 90:10) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-2-(4-Bromophenyl)-4-iodo-1-tosylpiperidine (major diastereomer, white solid, mp = 120−121 °C): ^1H NMR (400 MHz, $CDCl_3$) δ = 7.67 (d, J = 7.4 Hz, 2H), 7.40 (d, J = 8.0 Hz, 2H), 7.27 (d, J = 7.4 Hz, 2H), 7.09 (d, J = 8.0 Hz, 2H), 5.05 (s, 1H), 3.99 (td, J = 12.7, 3.2 Hz, 1H), 3.71−3.63 (m, 1H), 2.92 (t, J = 13.7 Hz, 1H), 2.79 (d, J = 13.8 Hz, 1H), 2.40 (s, 3H), 2.17 (td, J = 12.7, 4.8 Hz, 1H), 2.03 (d, J = 13.0 Hz, 1H), 1.91−1.76 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.8, 137.8, 136.4, 132.1, 130.1, 128.5, 127.0, 121.5, 57.3, 43.4, 40.4, 37.8, 21.7, 18.4. NMR data were in agreement with the reported results.[12]

DOI: 10.1021/acs.joc.6b00725
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cis-2-(4-Bromophenyl)-4-iodo-1-tosylpiperidine (minor, white solid, mp = 190−191 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.36 (d, J = 8.2 Hz, 2H), 7.25 (d, J = 8.5 Hz, 2H), 7.15 (d, J = 8.2 Hz, 2H), 6.99 (d, J = 8.5 Hz, 2H), 4.28 (dd, J = 8.1, 4.6 Hz, 1H), 4.07 (dq, J = 13.2, 4.3 Hz, 1H), 3.76 (ddd, J = 13.3, 6.5, 4.1 Hz, 1H), 3.20−3.08 (m, 1H), 2.45−2.38 (m, 1H), 2.35 (s, 3H), 2.27 (dt, J = 14.1, 4.1 Hz, 1H), 2.21−2.08 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.6, 138.1, 136.0, 131.1, 129.5, 129.1, 127.4, 121.5, 60.5, 45.4, 43.6, 37.0, 21.5, 19.9. NMR data were in agreement with the reported results.[12]

*2-(2-Bromophenyl)-4-iodo-1-tosylpiperidine (**6o**).* The compound (199 mg, 77% *trans*:*cis* = 91:9) was purified by flash chromatography using petroleum ether/ethyl acetate (20:1) as eluent. *trans*-2-(2-Bromophenyl)-4-iodo-1-tosylpiperidine (major diastereomer, white solid, mp = 131−132 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.47−7.39 (m, 3H), 7.13 (dd, J = 9.5, 4.9 Hz, 3H), 7.05−6.96 (m, 2H), 5.23 (dd, J = 5.5, 4.2 Hz, 1H), 4.13 (tt, J = 10.7, 3.6 Hz, 1H), 3.74 (dt, J = 13.6, 4.6 Hz, 1H), 3.62 (ddd, J = 13.7, 10.4, 3.5 Hz, 1H), 2.58 (dt, J = 6.1, 3.5 Hz, 1H), 2.32 (s, 3H), 2.26 (ddd, J = 13.7, 10.7, 5.9 Hz, 2H), 2.07−1.97 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.4, 139.2, 136.3, 133.6, 129.6, 128.8, 128.4, 127.2, 127.1, 122.6, 57.9, 45.4, 42.4, 37.5, 21.6, 20.3. IR: 3052, 2975, 1597, 1442, 1340, 1260, 1158, 1022, 936, 843, 691, 569 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{18}H_{19}BrINO_2S$, 519.9443; found: 519.9435.

*4-Iodo-1-tosyl-2-(4-(trifluoromethyl)phenyl)piperidine (**6p**).* The compound (173 mg, 68% *trans*:*cis* = 93:7) was purified by flash chromatography using petroleum ether/ethyl acetate (20:1) as eluent. *trans*-4-Iodo-1-tosyl-2-(4-(trifluoromethyl)phenyl)piperidine (major diastereomer, white solid, mp = 129−130 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.67 (d, J = 8.0 Hz, 2H), 7.53 (d, J = 8.0 Hz, 2H), 7.34 (d, J = 8.0 Hz, 2H), 7.27 (d, J = 8.0 Hz, 2H), 5.15 (s, 1H), 4.06−3.91 (m, 1H), 3.69 (d, J = 14.4 Hz, 1H), 3.01−2.77 (m, 2H), 2.39 (s, 3H), 2.22 (td, J = 13.3, 5.2 Hz, 1H), 2.04 (d, J = 12.1 Hz, 1H), 1.85 (qd, J = 12.6, 4.5 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.9, 141.6, 137.6, 130.1, 129.9, 129.6, 127.2, 127.0, 126.0, 57.5, 43.6, 40.6, 37.8, 21.6, 18.0; ^{19}F NMR (376 MHz, $CDCl_3$) δ = −62.6. NMR data were in agreement with the reported results.[29]

*Methyl 4-(4-Iodo-1-tosylpiperidin-2-yl)benzoate (**6q**).* The compound (149 mg, 60% *trans*:*cis* = 95:5) was purified by flash chromatography using petroleum ether/ethyl acetate (20:1) as eluent. *trans*-Methyl 4-(4-iodo-1-tosylpiperidin-2-yl)benzoate (major diastereomer, white solid, mp = 117−119 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.93 (d, J = 8.2 Hz, 2H), 7.68 (d, J = 8.2 Hz, 2H), 7.29 (d, J = 8.1 Hz, 2H), 7.27 (d, J = 8.1 Hz, 2H), 5.16 (d, J = 3.9 Hz, 1H), 3.97 (tt, J = 12.7, 3.7 Hz, 1H), 3.85 (s, 3H), 3.69 (dd, J = 12.7, 2.0 Hz, 1H), 2.99−2.78 (m, 2H), 2.39 (s, 3H), 2.22 (td, J = 13.4, 5.4 Hz, 1H), 2.04 (d, J = 11.2 Hz, 1H), 1.86 (qd, J = 12.7, 4.6 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 166.6, 143.9, 142.6, 137.7, 130.3, 130.1, 129.4, 127.0, 126.7, 57.6, 52.3, 43.6, 40.6, 37.8, 21.6, 18.3. IR:3091, 2962, 2227, 1598, 1503, 1456, 1338, 1155, 1095, 994, 814, 724, 663, 550 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{20}H_{22}INO_4S$, 500.0392; found: 500.0388.

*2-(4-Benzyloxyphenyl)-4-iodo-1-tosylpiperidine (**6r**).* The compound (194 mg, 71% *trans*:*cis* = 94:6) was purified by flash chromatography using petroleum ether/ethyl acetate (15:1) as eluent. *trans*-2-(4-Benzyloxyphenyl)-4-iodo-1-tosylpiperidine (major diastereomer, white solid, mp = 133−134 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.68 (d, J = 8.2 Hz, 2H), 7.35−7.30 (m, 4H), 7.28−7.28 (m, 3H), 7.12 (d, J = 8.5 Hz, 2H), 6.87 (d, J = 8.8 Hz, 2H), 5.07 (d, J = 4.2 Hz, 1H), 4.98 (s, 2H), 4.08 (tt, J = 12.7, 3.8 Hz, 1H), 3.72−3.59 (m, 1H), 3.02−2.88 (m, 1H), 2.81 (d, J = 13.7 Hz, 1H), 2.39 (s, 3H), 2.15 (td, J = 13.4, 5.3 Hz, 1H), 2.02 (dd, J = 12.9, 2.0 Hz, 1H), 1.84 (qd, J = 12.7, 4.6 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 157.0, 142.5, 137.0, 135.8, 128.9, 128.2, 127.6, 127.0, 126.9, 126.4, 125.9, 114.2, 69.0, 56.2, 42.2, 39.5, 37.0, 20.6, 18.2. IR: 3059, 2962, 1606, 1510, 1453, 1335, 1289, 1154, 937, 808, 741, 654 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{25}H_{26}INO_3S$, 548.0756; found: 548.0750.

*4-Iodo-1-tosylpiperidine (**6s**).* The compound (157 mg, 86%) was purified by flash chromatography using petroleum ether/ethyl acetate (25:1) as eluent, white solid. mp = 143−146 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.57 (d, J = 8.2 Hz, 2H), 7.27 (d, J = 8.2 Hz, 2H), 4.26−4.17 (m, 1H), 3.15−3.06 (m, 2H), 2.94−2.82 (m, 2H), 2.37 (s, 3H), 2.11−1.98 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.8, 133.1, 129.8, 127.6, 45.7, 36.5, 25.6, 21.6. NMR data were in agreement with the reported results.[30]

*2-Ethyl-4-iodo-1-tosylpiperidine (**6t**).* The compound (165 mg, 84% *trans*:*cis* = 87:13) was purified by flash chromatography using petroleum ether/ethyl acetate (50:1) as eluent. *trans*-2-Ethyl-4-iodo-1-tosylpiperidine (major diastereomer, white solid, mp = 97−99 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.64 (d, J = 8.2 Hz, 2H), 7.24 (d, J = 8.2 Hz, 2H), 4.21 (tt, J = 12.7, 4.1 Hz, 1H), 3.75 (dd, J = 13.8, 7.1 Hz, 1H), 3.62−3.55 (m, 1H), 3.01−2.90 (m, 1H), 2.37 (s, 3H), 2.20−2.08 (m, 2H), 1.98 (td, J = 13.1, 5.4 Hz, 1H), 1.81 (qd, J = 12.7, 4.8 Hz, 1H), 1.60−1.47 (m, 1H), 1.49−1.36 (m, 1H), 0.80 (t, J = 7.4 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 142.3, 137.1, 128.8, 125.9, 56.0, 41.2, 40.1, 37.1, 21.7, 20.5, 18.4, 9.9. NMR data were in agreement with the reported result.[23]

*4-Iodo-2-propyl-1-tosylpiperidine (**6u**).* The compound (167 mg, 82% *trans*:*cis* = 90:10) was purified by flash chromatography using petroleum ether/ethyl acetate (50:1) as eluent. *trans*-4-Iodo-2-propyl-1-tosylpiperidine (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.64 (d, J = 8.3 Hz, 2H), 7.24 (d, J = 8.0 Hz, 2H), 4.23 (tt, J = 12.7, 4.1 Hz, 1H), 3.85 (dd, J = 13.6, 6.9 Hz, 1H), 3.60−3.53 (m, 1H), 3.03−2.91 (m, 1H), 2.37 (s, 3H), 2.17−2.06 (m, 2H), 2.03−1.94 (m, 1H), 1.80 (td, J = 12.9, 4.8 Hz, 1H), 1.53−1.42 (m, 1H), 1.40−1.30 (m, 1H), 1.29−1.15 (m, 2H), 0.82 (t, J = 7.3 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 142.3, 137.1, 128.8, 125.9, 54.2, 41.3, 40.4, 37.1, 30.8, 20.5, 18.5, 12.7. NMR data were in agreement with the reported results.[23]

cis-2-Ethyl-4-iodo-1-tosylpiperidine (minor diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.74 (d, J = 8.2 Hz, 2H), 7.21 (d, J = 8.2 Hz, 2H), 4.33 (p, J = 4.3 Hz, 1H), 3.95−3.81 (m, 3H), 3.38 (ddd, J = 14.3, 11.1, 2.9 Hz, 1H), 3.29−3.16 (m, 1H), 2.35 (s, 3H), 2.21−2.12 (m, 2H), 2.02−1.98 (m, 1H), 1.83−1.76 (m, 1H), 1.55−1.47 (m, 1H), 1.43−1.35 (m, 1H), 0.82 (t, J = 7.3 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 142.1, 137.1, 128.7, 126.0, 54.2, 41.3, 40.4, 37.1, 31.0, 20.5, 18.6, 12.5. NMR data were in agreement with the reported results.[23]

*4-Iodo-2-isopropyl-1-tosylpiperidine (**6v**).* The compound (179 mg, 88% *trans*:*cis* = 91:9) was purified by flash chromatography using petroleum ether/ethyl acetate (50:1) as eluent. *trans*-4-Iodo-2-isopropyl-1-tosylpiperidine (major diastereomer, white solid, mp = 85−86 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.65 (d, J = 8.2 Hz, 2H), 7.25 (d, J = 8.2 Hz, 2H), 4.19 (tt, J = 12.8, 4.0 Hz, 1H), 3.64−3.56 (m, 1H), 3.38 (dd, J = 10.9, 5.0 Hz, 1H), 2.98−2.89 (m, 1H), 2.41−2.29 (m, 4H), 2.05 (dd, J = 13.0, 1.8 Hz, 1H), 1.96−1.67 (m, 3H), 0.87 (d, J = 6.6 Hz, 3H), 0.82 (d, J = 6.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.3, 138.4, 129.8, 127.0, 61.9, 42.8, 39.0, 37.7, 26.4, 21.6, 20.1, 20.0, 19.6. NMR data were in agreement with the reported results.[23]

*4-Iodo-2-isobutyl-1-tosylpiperidine (**6w**).* The compound (192 mg, 91% *trans*:*cis* = 89:11) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *trans*-4-Iodo-2-isobutyl-1-tosylpiperidine (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.64 (d, J = 8.1 Hz, 2H), 7.24 (d, J = 8.1 Hz, 2H), 4.23 (tt, J = 12.5, 4.2 Hz, 1H), 3.93 (dd, J = 12.9, 6.7 Hz, 1H), 3.61−3.52 (m, 1H), 3.03−2.93 (m, 1H), 2.37 (s, 3H), 2.13−1.96 (m, 3H), 1.82 (qd, J = 12.9, 4.7 Hz, 1H), 1.51−1.34 (m, 2H), 1.19 (dt, J = 14.0, 7.2 Hz, 1H), 0.81 (d, J = 4.3 Hz, 3H), 0.80 (d, J = 4.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.4, 138.1, 129.8, 127.1, 53.6, 42.3, 41.7, 38.7, 38.1, 24.8, 22.7, 22.4, 21.6, 19.6. NMR data were in agreement with the reported results.[12]

cis-4-Iodo-2-isobutyl-1-tosylpiperidine (minor diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.64 (d, J = 6.0 Hz, 2H), 7.22 (d, J = 8.5 Hz, 2H), 4.38 (p, J = 3.8 Hz, 1H), 4.06 (q, J = 8.3 Hz, 1H), 3.65 (dt, J = 7.4, 4.0 Hz, 1H), 3.37 (ddd, J = 14.4, 11.5, 2.8 Hz, 1H). 2.36 (s, 3H), 2.16−1.99 (m, 3H), 1.91 (dd, J = 14.8, 2.9 Hz, 1H), 1.61−1.48 (m, 2H), 1.24−1.17 (m, 1H), 0.82 (d, J = 4.2 Hz, 3H), 0.79 (d, J = 4.2 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ= 143.4, 129.8, 127.0, 53.5, 42.3, 41.6, 38.6, 38.1, 24.7, 22.6, 22.3, 21.5, 19.6. NMR data were in agreement with the reported results.[12]

DOI: 10.1021/acs.joc.6b00725
J. Org. Chem. 2016, 81, 5144−5161

*4-Iodo-2-pentyl-1-tosylpiperidine (**6x**).* The compound (180 mg, 83% *trans*:*cis* = 88:12) was purified by flash chromatography using petroleum ether/ethyl acetate (50:1) as eluent. *trans*-4-Iodo-2-pentyl-1-tosylpiperidine (major diastereomer, white solid, mp = 102−104 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.64 (d, J = 8.2 Hz, 2H), 7.24 (d, J = 8.2 Hz, 2H), 4.23 (tt, J = 12.7, 4.1 Hz, 1H), 3.82 (dd, J = 13.4, 7.0 Hz, 1H), 3.63−3.54 (m, 1H), 3.02−2.91 (m, 1H), 2.37 (s, 3H), 2.13 (ddd, J = 13.7, 8.1, 2.0 Hz, 2H), 1.99 (tt, J = 17.9, 8.9 Hz, 1H), 1.83 (qd, J = 12.7, 4.8 Hz, 1H), 1.51−1.42 (m, 1H), 1.33 (dd, J = 14.2, 7.2 Hz, 1H), 1.17 (dd, J = 12.4, 8.6 Hz, 6H), 0.79 (t, J = 6.8 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.4, 138.2, 129.8, 127.0, 55.5, 42.6, 41.5, 38.2, 31.4, 29.6, 26.0, 22.5, 21.6, 19.6, 14.0. NMR data were in agreement with the reported results.[23]

*Crystal Data for trans-**6x**.* $C_{17}H_{26}INO_2S$, M = 435.35, orthorhombic, a = 14.265(3) Å, b = 13.867(3) Å, c = 9.5232(19) Å, α = 90.00°, β = 90.00°, γ = 90.00°, V = 1883.8(7) Å^3, T = 113(2) K, space group *Pna*2 (1), Z = 4, μ (Mo Kα) = 1.817 mm^{-1}, 18 593 reflections measured, 4397 independent reflections (R_{int} = 0.0430). The final R_1 values were 0.0394 ($I > 2\sigma(I)$). The final wR (F^2) values were 0.0918 ($I > 2\sigma(I)$). The final R_1 values were 0.0470 (all data). The final wR (F^2) values were 0.0974 (all data). The goodness of fit on F^2 was 1.081. Flack parameter = 0.0 (10).

cis-4-Iodo-2-pentyl-1-tosylpiperidine (minor diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.64 (d, J = 8.2 Hz, 2H), 7.22 (d, J = 8.2 Hz, 2H), 4.38−4.31 (m, 1H), 3.83−3.75 (m, 1H), 3.63−3.60 (m, 1H), 3.38 (t, J = 11.7 Hz, 1H), 2.35 (s, 3H), 2.13 (t, J = 11.9 Hz, 2H), 2.00 (dd, J = 13.9, 8.6 Hz, 1H), 1.84−1.80 (m, 1H), 1.49−1.45 (m, 1H), 1.38−1.34 (m, 1H), 1.20−1.12 (m, 6H), 0.78 (d, J = 6.6 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.3, 138.2, 130.0, 127.0, 55.6, 42.6, 41.5, 38.2, 31.4, 30.0, 261, 22.6, 21.6, 20.0, 14.1. NMR data were in agreement with the reported results.[23]

*2-Hexyl-4-iodo-1-tosylpiperidine (**6y**).* The compound (191 mg, 85% *trans*:*cis* = 88:12) was purified by flash chromatography using petroleum ether/ethyl acetate (50:1) as eluent. *trans*-2-Hexyl-4-iodo-1-tosylpiperidine (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.63 (d, J = 8.3 Hz, 2H), 7.23 (d, J = 8.0 Hz, 2H), 4.23 (tt, J = 12.7, 4.1 Hz, 1H), 3.81 (dd, J = 13.4, 6.9 Hz, 1H), 3.62−3.55 (m, 1H), 3.00−2.91 (m, 1H), 2.36 (s, 3H), 2.13 (ddd, J = 13.1, 7.6, 2.1 Hz, 2H), 2.00 (td, J = 13.1, 5.3 Hz, 1H), 1.82 (qd, J = 12.7, 4.7 Hz, 1H), 1.52−1.41 (m, 1H), 1.39−1.28 (m, 1H), 1.20−1.11 (m, 8H), 0.80 (t, J = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 142.3, 137.1, 128.8, 125.9, 54.5, 41.3, 40.5, 37.2, 30.6, 28.6, 27.9, 25.2, 21.5, 20.5, 18.6, 13.1. IR: 2955, 2856, 1668, 1595, 1491, 1377, 1259, 1156, 926, 822, 645 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{18}H_{28}INO_2S$, 450.0964; found: 450.0963.

cis-2-Hexyl-4-iodo-1-tosylpiperidine (minor diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.63 (d, J = 8.3 Hz, 2H), 7.22 (d, J = 8.3 Hz, 2H), 4.35 (p, J = 4.0 Hz, 1H), 3.95−3.86 (m, 1H), 3.69−3.57 (m, 1H), 3.42−3.34 (m, 1H), 2.35 (s, 3H), 2.03 (t, J = 4.5 Hz, 1H), 1.94−1.72 (m, 4H), 1.27−1.09 (m, 8H), 0.80 (t, J = 6.9 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ = 141.1, 136.3, 127.7, 125.0, 50.9, 44.4, 34.8, 32.3, 31.5, 30.4, 29.6, 26.9, 24.7, 20.5, 19.5, 12.0. IR: 3050, 2903, 1660, 1600, 1482, 1237, 1156, 955, 843, 651 cm^{-1}. HRMS−ESI (m/z): [M + H]$^+$ calcd for $C_{18}H_{28}INO_2S$, 450.0964; found: 450.0963.

*2-Benzyl-4-iodo-1-tosylpiperidine (**6z**).* The compound (166 mg, 73% *trans*:*cis* = 90:10) was purified by flash chromatography using petroleum ether/ethyl acetate (20:1) as eluent. *trans*-2-Benzyl-4-iodo-1-tosylpiperidine (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.46 (d, J = 8.1 Hz, 2H), 7.24−7.12 (m, 5H), 7.03 (d, J = 8.1 Hz, 2H), 4.40−4.33 (m, 1H), 4.20−4.08 (m, 1H), 3.57 (d, J = 14.5 Hz, 1H), 3.12−3.01 (m, 1H), 2.78−2.63 (m, 2H), 2.33 (s, 3H), 2.24 (d, J = 14.8 Hz, 1H), 2.14 (d, J = 13.4 Hz, 1H), 2.07−1.95 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 142.3, 136.5, 128.7, 127.9, 127.8, 127.5, 126.0, 125.7, 55.9, 41.6, 39.1, 37.4, 34.9, 20.5, 17.6. NMR data were in agreement with the reported results.[23]

*4-Fluoro-2-(p-tolyl)-1-tosylpiperidine (**7a**).* The compound (139 mg, 80% *trans*:*cis* = 48:52) was purified by flash chromatography using petroleum ether/ethyl acetate (30:1) as eluent. *cis*-4-Fluoro-2-(*p*-tolyl)-1-tosylpiperidine (white solid, 114−117 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.69 (d, J = 8.1 Hz, 2H), 7.25 (d, J = 8.1 Hz, 2H), 7.15 (d, J = 7.9 Hz, 2H), 7.07 (d, J = 7.9 Hz, 2H), 5.37−5.26 (m, 1H), 4.70−4.39 (m, 1H), 3.97−3.81 (m, 1H), 3.02−2.87 (m, 1H), 2.64−2.49 (m, 1H), 2.37 (s, 3H), 2.25 (s, 3H), 1.83−1.69 (m, 1H), 1.67−1.56 (m, 1H), 1.41−1.28 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 142.5, 137.0, 136.1, 133.6, 128.9, 128.5, 125.9, 125.3, 85.7 (d, J = 174.0 Hz), 54.3 (d, J = 13.2 Hz), 38.8 (d, J = 12.0 Hz), 32.5 (d, J = 19.2 Hz), 30.0 (d, J = 18.6 Hz), 20.6, 19.9; ^{19}F NMR (376 MHz, $CDCl_3$) δ = −174.9. NMR data were in agreement with the reported results.[31]

*4-Fluoro-2-(4-methoxyphenyl)-1-tosylpiperidine (**7b**).* The compound (149 mg, 82% *trans*:*cis* = 46:54) was purified by flash chromatography using petroleum ether/ethyl acetate (10:1) as eluent. *cis*-4-Fluoro-2-(4-methoxyphenyl)-1-tosylpiperidine (white solid, 94−96 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.80−7.74 (m, 2H), 7.37−7.31 (m, 2H), 7.30- 7.23 (m, 2H), 6.90−6.85 (m, 2H), 5.38 (s, 1H), 4.64 (m, 1H), 4.02−3.91 (m, 1H), 3.81 (s, 3H), 3.08−2.99 (m, 1H), 2.67−2.58 (m, 1H), 2.46 (s, 3H), 1.91−1.81 (m, 1H), 1.72−1.65 (m, 1H),1.47−1.40 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 158.7, 143.5, 138.0, 129.9, 129.5, 127.7, 126.9, 114.2, 87.8 (d, J = 176.8 Hz), 55.3, 55.1 (d, J = 12.9 Hz), 39.8 (d, J = 12.5 Hz), 33.5 (J = 19.6 Hz), 31.1 (d, J = 18.3 Hz,), 21.5; ^{19}F NMR (376 MHz, $CDCl_3$) δ = −174.5. NMR data were in agreement with the reported results.[31]

trans-4-Fluoro-2-(4-methoxyphenyl)-1-tosylpiperidine (white solid, 53−54 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.88 (d, J = 8.4 Hz, 2H), 7.66 (d, J = 8.2 Hz, 2H), 7.30 (d, J = 8.2 Hz, 2H), 7.22 (d, J = 8.2 Hz, 2H), 5.23 (d, J = 6.3 Hz, 1H), 4.80 (d, $J_{H,F}$ = 47.3 Hz, 1H), 3.83 (s, 3H), 3.74 (d, J = 11.9 Hz, 1H), 3.35−3.23 (m, 1H), 2.65−2.57 (m, 1H), 2.36 (s, 3H), 2.03−1.85 (m, 1H), 1.76−1.54 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 145.0, 143.7, 137.8, 129.9, 129.6, 128.7, 127.0, 126.5, 86.0 (d, J = 172.3 Hz), 53.12, 52.1, 36.7, 32.2 (d, J = 19.3 Hz), 29.0 (d, J = 21.2 Hz), 21.6; ^{19}F NMR (376 MHz, $CDCl_3$) δ = −181.8. NMR data were in agreement with the reported results.[9b]

*4-Fluoro-2-phenyl-1-tosylpiperidine (**7c**).* The compound (125 mg, 75%, *trans*:*cis* = 44:56) was purified by flash chromatography using petroleum ether/ethyl acetate (20:1) as eluent. *cis*-4-Fluoro-2-phenyl-1-tosylpiperidine (white solid, 106−108 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.78−7.75 (m, 2 H), 7.35−7.22 (m, 7 H), 5.43 (m, 1 H), 4.73−4.44 (m, 1 H), 4.02−3.95 (m, 1 H), 3.07−2.96 (m, 1 H), 2.70−2.60 (m, 1 H), 2.44 (s, 3 H), 1.87−1.82 (m, 1 H), 1.76−1.62 (m, 1 H), 1.52−1.33 (m, 1 H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.6, 138.0, 137.8, 130.0, 128.9, 127.4, 127.0, 126.5, 86.6 (d, J = 173.1 Hz), 55.5 (d, J = 12.6 Hz), 39.9 (d, J = 12.3 Hz), 33.5 (d, J = 19.1 Hz), 31.1 (d, J = 19.0 Hz), 21.6; ^{19}F NMR (376 MHz, $CDCl_3$) δ = −174.9. NMR data were in agreement with the reported results.[31]

*4-Fluoro-2-(4-fluorophenyl)-1-tosylpiperidine (**7d**).* The compound (133 mg, 76%, *trans*:*cis* = 41:59) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *cis*-4-Fluoro-2-(4-fluorophenyl)-1-tosylpiperidine (white solid, 105−107 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.80−7.73 (m, 2H), 7.37−7.30 (m, 4H), 7.07- 7.01 (m, 2H), 5.38 (brs, 2H), 4.60 (dtt, J = 48.5, 10.9, 4.5, 1H), 4.03−3.93 (m, 1H), 3.08−3.00 (m, 1H), 2.66−2.56 (m, 1H), 2.46 (s, 3H), 1.92−1.83 (m, 1H), 1.74−1.67 (m, 1H), 1.44 (ttd, J = 12.6, 10.3, 4.8, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 162.0 (d, J = 249.8 Hz), 143.8, 137.8, 133.5, 130.0, 128.3, 127.0, 115.7, 86.5, 55.1 (d, J = 13.1 Hz), 39.9 (d, J = 13.5 Hz,), 33.6 (d, J = 19.6 Hz), 31.0 (d, J = 19.6 Hz), 21.6; ^{19}F NMR (376 MHz, $CDCl_3$) δ = −115.7, −175.8. NMR data were in agreement with the reported results.[9b]

trans-4-Fluoro-2-(4-fluorophenyl)-1-tosylpiperidine (white solid, 131−133 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.65 (d, J = 8.2 Hz, 2H), 7.50 (d, J = 8.2 Hz, 2H), 7.38 (d, J = 8.2 Hz, 2H), 7.23 (t, J = 8.2 Hz, 2H), 5.23 (d, J = 6.5 Hz, 1H), 4.80 (d, $J_{H,F}$ = 47.3 Hz, 1H), 3.75 (dd, J = 14.5, 4.3 Hz, 1H), 3.29−3.20 (m, 1H), 2.60−2.51 (m, 1H), 2.37 (s, 3H), 1.94−1.79 (m, 1H), 1.71−1.45 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 161.6 (d, J = 249.8 Hz), 143.7, 137.8, 133.5, 130.0, 128.3 (d, J = 8.3 Hz), 126.9 (d, J = 21.3 Hz), 86.5 (d, J = 173.9 Hz), 54.1 (d, J = 12.3 Hz), 38.6 (d, J = 12.0 Hz), 32.4 (d, J = 19.0 Hz), 30.1 (d, J = 19.0 Hz), 20.6; ^{19}F NMR (376 MHz, $CDCl_3$) δ = −118.9, −179.9. NMR data were in agreement with the reported results.[9b]

*Crystal Data for trans-**7d**.* $C_{18}H_{19}F_2NO_2S$, M = 351.40, monoclinic, a = 12.814(3) Å, b = 9.4243(19) Å, c = 14.152(3) Å, α = 90.00°, β = 95.24(3)°, γ = 90.00°, V = 1701.9(6) Å^3, T = 113(2) K,

DOI: 10.1021/acs.joc.6b00725
J. Org. Chem. 2016, 81, 5144−5161

space group $P2(1)/n$, $Z = 4$, μ (Mo Kα) = 0.221 mm^{-1}, 20 844 reflections measured, 4068 independent reflections (R_{int} = 0.0410). The final R_1 values were 0.0423 ($I > 2\sigma(I)$). The final wR (F^2) values were 0.1124 ($I > 2\sigma(I)$). The final R_1 values were 0.0527 (all data). The final wR (F^2) values were 0.1196 (all data). The goodness of fit on F^2 was 1.071.

*2-(4-Chlorophenyl)-4-fluoro-1-tosylpiperidine (**7e**).* The compound (154 mg, 84%, *trans*:*cis* = 47:53) was purified by flash chromatography using petroleum ether/ethyl acetate (30:1) as eluent. *cis*-2-(4-Chlorophenyl)-4-fluoro-1-tosylpiperidine (white solid, 146−148 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.69 (d, J = 8.3 Hz, 2H), 7.28−7.19 (m, 7H), 5.29 (s, 1H),4.53−4.46 (m, 1H), 3.90 (d, J = 11.2 Hz, 1H), 2.93 (t, J = 13.0 Hz, 1H), 2.63−2.48 (m, 1H), 2.38 (s, 3H), 1.83−1.75 (m, 1H), 1.68−1.56 (m, 1H), 1.45−1.28 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 142.7, 136.6, 135.3, 132.3, 129.0, 128.0, 126.9, 125.9, 120.5. 85.4 (d, J = 174.2 Hz), 54.1 (d, J = 12.6 Hz), 38.9 (d, J = 11.9 Hz), 32.5 (d, J = 19.2 Hz), 30.0 (d, J = 18.7 Hz), 20.6; ^{19}F NMR (376 MHz, $CDCl_3$) δ = −175.3. NMR data were in agreement with the reported results.[31]

*2-(4-Bromophenyl)-4-fluoro-1-tosylpiperidine (**7f**).* The compound (166 mg, 81%, *trans*:*cis* = 45:55) was purified by flash chromatography using petroleum ether/ethyl acetate (30:1) as eluent. *cis*-2-(4-Bromophenyl)-4-fluoro-1-tosylpiperidine (white solid, 148−150 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.78−7.68 (m, 2H), 7.50−7.44 (m, 2H), 7.37- 7.31 (m, 2H), 7.26−7.20 (m, 2H), 5.35 (s, 1H), 4.57 (m, 1H), 4.02−3.92 (m, 1H), 3.06−2.97 (m, 1H), 2.64−2.55 (m, 1H), 2.46 (s, 3H), 1.92−1.83 (m, 1H), 1.76−1.65 (m, 1H), 1.51−1.40 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 142.8, 136.6, 135.9, 10, 129.0, 127.3, 125.9, 120.5, 85.4 (d, J = 174.6 Hz), 54.2 (d, J = 12.4 Hz), 38.9 (d, J = 12.4 Hz), 32.5 (d, J = 20.2 Hz,), 29.9 (d, J = 18.9 Hz), 20.6; ^{19}F NMR (376 MHz, $CDCl_3$) δ = −175.3. NMR data were in agreement with the reported results.[31]

trans-2-(4-Bromophenyl)-4-fluoro-1-tosylpiperidine (white solid, 124−126 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.66 (d, J = 8.3 Hz, 2H), 7.52 (d, J = 8.3 Hz, 2H), 7.38 (d, J = 8.1 Hz, 2H), 7.24 (d, J = 8.1 Hz, 2H), 5.23 (d, J = 6.6 Hz, 1H), 4.80 (d, $J_{H,F}$ = 47.4 Hz, 1H), 3.75 (dd, J = 14.5, 4.4 Hz, 1H), 3.30−3.19 (m, 1H), 2.61−2.52 (m, 1H), 2.38 (s, 3H), 1.99−1.81 (m, 1H), 1.70−1.44 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 145.4, 137.7, 132.1, 130.0, 127.3, 127.3, 126.9, 118.8, 110.9, 85.6 (d, J = 171.9 Hz), 53.0, 36.6, 31.8 (d, J = 19.2 Hz), 28.8 (d, J = 20.9 Hz), 21.6; ^{19}F NMR (376 MHz, $CDCl_3$) δ = −182.0. NMR data were in agreement with the reported results.[9b]

*4-Fluoro-2-(4-nitrophenyl)-1-tosylpiperidine (**7g**).* The compound (163 mg, 86%, *trans*:*cis* = 42:58) was purified by flash chromatography using petroleum ether/ethyl acetate (10:1) as eluent. *cis*-4-Fluoro-2-(4-nitrophenyl)-1-tosylpiperidine (white solid, 123−126 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 8.28−8.18 (m, 2H), 7.79−7.73 (m, 2H), 7.58−7.52 (m, 2H), 7.40−7.34 (m, 2H), 5.42 (s, 1H), 4.57−4.52 (m, 1H), 4.03−3.94 (m, 1H), 3.10−2.99 (m, 1H), 2.68−2.58 (m, 1H), 2.47 (s, 3H), 1.98−1.86 (m, 1H), 1.83−1.76 (m, 1H), 1.50−1.40 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 147.3, 145.8, 144.2, 137.2, 130.1, 127.6, 127.0, 124.1, 86.0 (d, J = 174.5 Hz), 55.4 (d, J = 12.5 Hz,), 40.2 (d, J = 11.7 Hz), 34.0 (d, J = 20.3 Hz), 30.8 (d, J = 19.5 Hz), 21.6; ^{19}F NMR (376 MHz, $CDCl_3$) δ = −176.2. NMR data were in agreement with the reported results.[31]

trans-4-Fluoro-2-(4-nitrophenyl)-1-tosylpiperidine (white solid, 158−156 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 8.06 (d, J = 8.6 Hz, 2H), 7.66 (d, J = 8.2 Hz, 2H), 7.43 (d, J = 8.6 Hz, 2H), 7.24 (d, J = 8.2 Hz, 2H), 5.27 (d, J = 6.5 Hz, 1H), 4.80 (d, $J_{H,F}$ = 47.3 Hz, 1H), 3.77 (dd, J = 14.5, 4.2 Hz, 1H), 3.27 (dd, J = 14.5, 12.2 Hz, 1H), 2.65−2.59 (m, 1H), 2.36 (s, 3H), 2.01−1.87 (m, 1H), 1.71−1.37 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 147.5, 146.8, 144.0, 137.6, 130.1, 127.4, 127.4, 126.9, 123.5, 85.7 (d, J = 171.8 Hz), 53.0, 36.7, 32.1 (d, J = 19.5 Hz), 28.7 (d, J = 21.1 Hz), 21.6; ^{19}F NMR (376 MHz, $CDCl_3$) δ = −182.2. NMR data were in agreement with the reported results.[9b]

*4-Bromo-2,2-dimethyl-1-tosylpiperidine (**8a**).* The compound (80 mg, 46%) was purified by flash chromatography using petroleum ether/ethyl acetate (30:1) as eluent. White solid, mp = 90−91 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.60 (d, J = 8.1 Hz, 2H), 7.21 (d, J = 8.1 Hz, 2H), 4.18−4.07 (m, 1H), 4.04−3.97 (m, 1H), 3.12−3.00 (m, 1H), 2.35 (s, 3H), 2.28 (d, J = 10.9 Hz, 1H), 2.00−1.86 (m, 3H), 1.36 (s, 3H), 1.09 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.1, 139.9, 129.6, 126.9, 59.7, 51.7, 44.8, 44.0, 37.7, 30.3, 22.1, 21.5. IR: 3034, 2930, 1597, 1493, 1334, 1264, 1156, 1092, 901, 807, 683 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{14}H_{20}BrNO_2S$, 346.0476; found: 346.0471.

*9-Bromo-6-tosyl-6-azaspiro[4.5]decane (**8b**).* The compound (95 mg, 51%) was purified by flash chromatography using petroleum ether/ethyl acetate (30:1) as eluent. White solid, mp = 101−103 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.60 (d, J = 8.2 Hz, 2H), 7.20 (d, J = 8.2 Hz, 2H), 4.30−4.13 (m, 2H), 3.11−3.03 (m, 1H), 2.34 (s, 3H), 2.24 (dd, J = 13.1, 2.5 Hz, 1H), 2.17−1.97 (m, 4H), 1.91−1.82 (m, 1H), 1.64−1.30 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 143.0, 140.8, 129.6, 126.7, 69.8, 46.0, 45.8, 45.8, 37.6, 37.4, 35.1, 22.9, 22.1, 21.5. IR: 3058, 2964, 1594, 1490, 1317, 1086, 985, 879, 813, 664 cm^{-1}. HRMS−ESI (m/z): $[M + H]^+$ calcd for $C_{16}H_{22}BrNO_2S$, 372.0633; found: 372.0624.

*4-Bromo-1-tosyl-1-azaspiro[5.5]undecane (**8c**).* The compound (77 mg, 40%) was purified by flash chromatography using petroleum ether/ethyl acetate (30:1) as eluent. White solid, mp = 95−96 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.60 (d, J = 8.2 Hz, 2H), 7.20 (d, J = 8.2 Hz, 2H), 4.20−4.07 (m, 2H), 3.28−3.19 (m, 1H), 2.63 (dd, J = 13.5, 2.5 Hz, 1H), 2.35 (s, 3H), 2.30−2.24 (m, 1H), 2.14−1.96 (m, 3H), 1.69 (t, J = 12.8 Hz, 1H), 1.58−1.43 (m, 4H), 1.38−1.10 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 141.9, 140.2, 128.6, 125.7, 62.9, 44.1, 41.9, 41.7, 36.9, 35.4, 29.2, 24.1, 21.5, 21.3, 20.5. IR: 3060, 2925, 1595, 1446, 1325, 1153, 1019, 930, 810, 686 cm^{-1}. HRMS−ESI (m/z): $[M + Na]^+$ calcd for $C_{17}H_{24}BrNO_2S$, 408.0609; found: 408.0601.

*4-Chloro-2-phenyltetrahydro-2H-pyran (**9a**).* The compound (85 mg, 87%, *trans*:*cis* < 1:99) was purified by flash chromatography using petroleum ether/ethyl acetate (30:1) as eluent. *cis*-4-Chloro-2-phenyltetrahydro-2*H*-pyran (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.32−7.15 (m, 5H), 4.22 (d, J = 11.3 Hz, 1H), 4.10−4.02 (m, 2H), 3.48 (t, J = 12.8 Hz, 1H), 2.28 (dd, J = 13.0, 1.9 Hz, 1H), 2.06 (dd, J = 12.9, 1.9 Hz, 1H), 1.95−1.74 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 141.3, 128.6, 127.9, 125.9, 79.4, 67.4, 55.8, 44.7, 36.9. NMR data were in agreement with the reported results.[32]

*4-Bromo-2-phenyltetrahydro-2H-pyran (**9b**).* The compound (100 mg, 83%, *trans*:*cis* = 10:90) was purified by flash chromatography using petroleum ether/ethyl acetate (30:1) as eluent. *cis*-4-Bromo-2-phenyltetrahydro-2*H*-pyran (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.29−7.15 (m, 5H), 4.26−4.13 (m, 2H), 4.04 (dd, J = 11.9, 4.2 Hz, 1H), 3.47 (t, J = 11.9 Hz, 1H), 2.37 (dd, J = 13.0, 2.0 Hz, 1H), 2.20−1.91 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 141.3, 128.6, 127.9, 125.9, 80.2, 68.3, 46.6, 45.6, 37.7. NMR data were in agreement with the reported results.[33]

*4-Fluoro-2-phenyltetrahydro-2H-pyran (**9c**).* The compound (75 mg, 83%, *trans*:*cis* = 12:88) was purified by flash chromatography using petroleum ether/ethyl acetate (50:1) as eluent. *cis*-4-Fluoro-2-phenyltetrahydro-2*H*-pyran (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.34−7.17 (m, 5H), 4.25 (dd, J = 11.3, 1.5 Hz, 1H), 4.14−4.05 (m, 2H), 3.56−3.47 (m, 1H), 2.34−2.27 (m, 1H), 2.13−2.06 (m, 1H), 1.97−1.91 (m, 1H),1.83 (d, J = 12.1 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 141.3, 128.5, 127.9, 125.9, 79.4, 67.4, 55.8, 44.6, 36.9; ^{19}F NMR (376 MHz, $CDCl_3$) δ = −169.7. NMR data were in agreement with the reported results.[8d]

*4-Chloro-2-p-tolyltetrahydro-2H-pyran (**9d**).* The compound (90 mg, 86%, *trans*:*cis* < 1:99) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *cis*-4-Chloro-2-(*p*-tolyl)tetrahydro-2*H*-pyran (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.14 (d, J = 7.7 Hz, 2H), 7.07 (d, J = 7.7 Hz, 2H), 4.19 (d, J = 11.2 Hz, 1H), 4.11−4.01 (m, 2H), 3.48 (t, J = 11.7 Hz, 1H), 2.25 (s, 4H), 2.05 (d, J = 11.1 Hz, 1H), 1.96−1.74 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 138.4, 137.6, 129.2, 125.9, 79.3, 67.4, 55.9, 44.6, 36.9, 21.2. NMR data were in agreement with the reported results.[34]

*4-Chloro-2-(4-methoxyphenyl)tetrahydro-2H-pyran (**9e**).* The compound (100 mg, 88%, *trans*:*cis* < 1:99) was purified by flash chromatography using petroleum ether/ethyl acetate (30:1) as eluent.

DOI: 10.1021/acs.joc.6b00725
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cis-4-Chloro-2-(4-methoxyphenyl)tetrahydro-2*H*-pyran (major diastereomer, white solid, mp = 62−63 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.16 (d, J = 8.6 Hz, 2H), 6.78 (d, J = 8.6 Hz, 2H), 4.18−4.13 (m, 1H), 4.03 (ddd, J = 15.9, 6.7, 2.9 Hz, 2H), 3.68 (s, 3H), 3.46 (td, J = 12.2, 1.9 Hz, 1H), 2.32−2.18 (m, 1H), 2.08−2.00 (m, 1H), 1.93−1.73 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$). δ = 159.3, 133.5, 127.2, 113.9, 79.0, 67.4, 55.9, 55.3, 44.6, 36.9. NMR data were in agreement with the reported results.[33]

*4-Chloro-2-(4-chlorophenyl)tetrahydro-2H-pyran (**9f**).* The compound (104 mg, 90%, *trans*:*cis* < 1:99) was purified by flash chromatography using petroleum ether/ethyl acetate (30:1) as eluent. *cis*-4-Chloro-2-(4-chlorophenyl)tetrahydro-2*H*-pyran (major diastereomer, white solid, mp = 50−51 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.23 (d, J = 8.5 Hz, 2H), 7.18 (d, J = 8.5 Hz, 2H), 4.21 (d, J = 11.3 Hz, 1H), 4.15−3.98 (m, 2H), 3.49 (td, J = 12.3, 1.8 Hz, 1H), 2.31−2.20 (m, 1H), 2.07 (dd, J = 13.0, 2.2 Hz, 1H), 1.88 (qd, J = 12.4, 4.8 Hz, 1H), 1.82−1.69 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 139.8, 133.5, 128.7, 127.2, 78.6, 67.4, 55.5, 44.6, 36.8. NMR data were in agreement with the reported results.[35]

*2-(4-Bromophenyl)-4-chlorotetrahydro-2H-pyran (**9g**).* The compound (118 mg, 86%, *trans*:*cis* < 1:99) was purified by flash chromatography using petroleum ether/ethyl acetate (30:1) as eluent. *cis*-2-(4-Bromophenyl)-4-chlorotetrahydro-2*H*-pyran (major diastereomer, white solid, mp = 64−65 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.36 (d, J = 8.4 Hz, 2H), 7.09 (d, J = 8.3 Hz, 2H), 4.14 (d, J = 11.2 Hz, 1H), 4.08−3.93 (m, 2H), 3.43 (td, J = 12.2, 1.7 Hz, 1H), 2.24−2.17 (m, 1H), 2.02 (dd, J = 12.9, 2.1 Hz, 1H), 1.84 (qd, J = 12.4, 4.8 Hz, 1H), 1.72−1.67 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 140.5, 131.6, 127.6, 121.6, 78.5, 67.3, 55.5, 44.6, 36.8. NMR data were in agreement with the reported results.[34]

*4-Chloro-2-(4-fluorophenyl)tetrahydro-2H-pyran (**9h**).* The compound (97 mg, 91%, *trans*:*cis* < 1:99) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *cis*-4-Chloro-2-(4-fluorophenyl)tetrahydro-2*H*-pyran (major diastereomer, oil): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 7.21 (dd, J = 8.5, 5.5 Hz, 2H), 6.94 (t, J = 8.7 Hz, 2H), 4.26−4.15 (m, 1H), 4.12−3.97 (m, 2H), 3.55−3.41 (m, 1H), 2.30−2.21 (m, 1H), 2.06 (td, J = 4.2, 2.0 Hz, 1H), 1.88 (qd, J = 12.5, 4.9 Hz, 1H), 1.80−1.72 (m, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 162.3 (d, J = 245.6 Hz), 137.2 (d, J = 3.1 Hz), 127.6 (d, J = 8.3 Hz), 115.4 (d, J = 21.3 Hz), 78.7, 67.4, 55.6, 44.7, 36.8; ^{19}F NMR (376 MHz, $CDCl_3$) δ = −114.4. NMR data were in agreement with the reported results.[36]

*4-Chloro-2-(4-nitrophenyl)tetrahydro-2H-pyran (**9i**).* The compound (112 mg, 93%, *trans*:*cis* < 1:99) was purified by flash chromatography using petroleum ether/ethyl acetate (40:1) as eluent. *cis*-4-Chloro-2-(4-nitrophenyl)tetrahydro-2*H*-pyran (major diastereomer, white solid, 112 mg, 93%, mp = 84−86 °C): ^{1}H NMR (400 MHz, $CDCl_3$) δ = 8.18 (d, J = 8.4 Hz, 2H), 7.48 (d, J = 8.3 Hz, 2H), 4.42 (d, J = 11.3 Hz, 1H), 4.20−4,13 (m, 2H), 3.59 (t, J = 12.2 Hz, 1H), 2.39 (d, J = 12.8 Hz, 1H), 2.17 (d, J = 12.9 Hz, 1H), 1.96 (q, J = 12.1 Hz, 1H), 1.77 (q, J = 11.8 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ = 148.5, 147.4, 126.5, 123.8, 78.1, 67.3, 55.1, 44.5, 36.6. NMR data were in agreement with the reported results.[33]

*Crystal Data for cis-**9i**.* $C_{11}H_{12}ClNO_3$, M = 241.67, triclinic, a = 6.903(2) Å, b = 8.862(3) Å, c = 9.524(3) Å, α = 74.756(17)°, β = 84.10(2)°, γ = 82.37(2)°, V = 555.7(3) Å^3, T = 113(2) K, space group $P\bar{1}$, Z = 2, 6541 reflections measured, 2393 independent reflections (R_{int} = 0.0537). The final R_1 values were 0.0490 ($I > 2\sigma(I)$). The final $wR(F^2)$ values were 0.1665 ($I > 2\sigma(I)$). The final R_1 values were 0.0521 (all data). The final $wR(F^2)$ values were 0.1737 (all data). The goodness of fit on F^2 was 1.072.

■ ASSOCIATED CONTENT

Supporting Information

The Supporting Information is available free of charge on the ACS Publications website at DOI: 10.1021/acs.joc.6b00725.

Copies of NMR spectra for the obtained compounds, X-ray structure and crystal information for compounds *trans*-**4j**, *trans*-**5o**, *trans*-**6x**, *trans*-**7d**, and *cis*-**9i** (PDF)

X-ray structure and crystal information for compounds *trans*-**4j**, *trans*-**5o**, *trans*-**6x**, *trans*-**7d**, and *cis*-**9i** (CIF)

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Notes

The authors declare no competing financial interest.

■ ACKNOWLEDGMENTS

We acknowledge the financial support from the National Natural Science Foundation of China (NSFC 21272121). G.-Q.L. acknowledges the support from The Ph.D. Student Innovative Research Program of Nankai University (68140001).

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DOI: 10.1021/acs.joc.6b00725
J. Org. Chem. 2016, 81, 5144−5161

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