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Reagent-switch controlled metal-free intermolecular geminal diamination and aminooxygenation of vinylarenes

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ABSTRACT

We report here the first general method for the geminal diamination and an intermolecular metal-free, geminal aminooxygenation of vinylarenes using hypervalent iodine reagent. A new *m*-CPBA mediated geminal aminooxygenation is also reported. A novel reagent-switch for the control of migrating group by controlling the two independent geminal addition paths is developed. Deuterium labelling studies and the control studies have provided unambiguous evidences for the phenyl migration and hydride migration in the oxidative geminal difunctionalization process mediated by $PhI(OCOCF_3)_2$ and *m*-CPBA, respectively through a semi-pinacol rearrangement.

1. Introduction

To have perfect control over the closely competitive reaction pathways by selection of appropriate reagent systems is always desirable and is highly challenging in the field of organic synthesis for the installation of bonds with high precision and greater efficiency.[1] The difunctionalization of alkenes is a prominent tool in organic chemistry, which has been extensively employed and widely studied with renewed interest through many decades, due to its great potential.[2] This provides a rapid access to diversely functionalized compounds with very high step-economy. A range of methods have been developed and are much investigated for the vicinal difunctionalization of alkenes, which utilizes the unsaturation of the olefin moiety for the simple addition across C=C bond.[3]

In contrast, the methods available for the geminal difunctionalization of alkenes are really very scarce. This is due to its intricate nature, of being a process, involving the transposition of atom/group in addition to the formation of two new bonds.[4] Especially, the geminal diamination and geminal aminooxygenation pose formidable challenge and are performed through arduous multistep sequence involving condensations and addition of tethered nucleophile,[5] through the conjugate addition to Michael acceptors[6] and by cycloaddition reactions.[7] The studies of the well-known Wacker process are rather limited as an oxidation reaction and in the annulation reactions using a tethered heteroatom.[8] In this context, we have recently reported a bromonium ion mediated geminal aminooxygenation of vinylarenes.[9] More recently, the metal-free methods, which provide an environmentally benign alternative to toxic and precious metals have received significant attention from organic chemists. In particular, the utility of hypervalent iodine reagents has increased tremendously in the metal-free oxidations, α-functionalization of carbonyl compounds, cyclization reactions, vicinal difunctionalization of alkenes and in rearrangement reactions.[10]

The geminal heterodifunctionalized moieties such as imidazolidines, and oxazolidines are widely present as key structural units in a variety of bioactive natural products[11] and have found use as chiral ligands in asymmetric synthesis.[12] In spite of their greater potential, the access to these class of compounds are often hampered due to the paucity of methods available. Hence, the development of a new method for the geminal difunctionalization of alkenes, especially under the metal-free conditions would be of high significance and of greater practical utility.

To the best of our knowledge, there is no method available at present for the geminal diamination and intermolecular, metal-free geminal aminooxygenation of unfunctionalized alkenes.[6a,10u] Herein, we wish to present the first report for such a transformation on vinylarenes via semi-pinacol rearrangement using electrophilic activation strategy in a one-pot operation (Fig. 1).

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0040-4020/

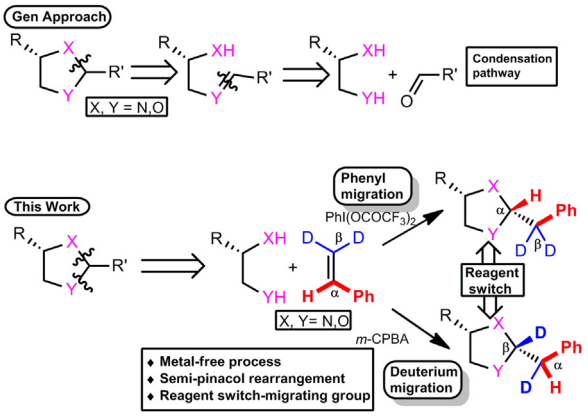


Fig. 1. Synthesis of geminally heterodifunctionalized compounds.

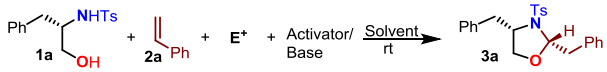
2. Results and discussion

In continuation of our interest[9] to find practically useful methods for the straightforward synthesis of 1,4-heterocycles directly from alkenes by the intermolecular vicinal difunctionalization/annulation strategy, we have examined the feasibility of the addition of a 1,2-aminoalcohol as a nucleophile [*N*-Ts-phenylalaninol, **1a**] to styrene **2a**, by the electrophilic activation of alkene using halogens (entries 1–4, Table 1) and no expected addition product formation was observed.[13] The activation using the hypervalent iodine reagents (entries 5 and 6, Table 1) also did not provide any addition product. When we attempted the addition in the presence of TMSOTf activated hypervalent iodine reagent, $PhI(OCOCF_3)_2$ (1.5 equiv) (CH_2Cl_2, 24 h, rt), we were surprised to find the formation of the geminally difunctionalized product, oxazolidine **3a** (entry 8, Table 1) as a single diastereomer in 40% yield. This turns out to be the first metal-free intermolecular geminal aminooxygenation of an alkene. To improve the efficiency of this reaction the activation of hypervalent iodine was performed using different acids (entries 7–11, Table 1). It was found that the most optimal activator for the $PhI(OCOCF_3)_2$ was PTSA·H_2O for this addition reaction conditions (entry 11, Table 1). However, the yield of the products formed was found to decrease proportionally on decreasing either the hypervalent iodine reagent or the activator, suggesting stoichiometric amount of both them are essential for mediating this reaction efficiently (entries 12 and 13, Table 1).

While, the use of anhyd. PTSA was also found to mediate this addition with same efficiency as that of PTSA·H_2O (entry 14, Table 1). The use of hydrated activator PTSA·H_2O makes this geminal difunctionalization conditions practically very attractive, in addition to that of being highly efficient. Encouraged by the novelty and potency of this method, we set out to study the scope and mechanistic details of this process further.

First, the effect of substituents on the *N*-Ts-aminoalcohol on the stereoselectivity and the efficiency of the addition were studied. The enantiopure aminoalcohols containing different substituents at the nitrogen bearing carbon (entries **1**–**5**, Table 2) were found to

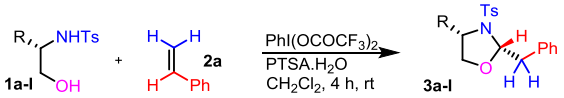
Table 1
Representative optimization

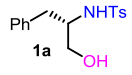
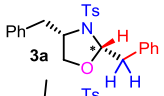
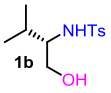
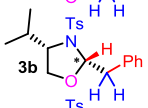
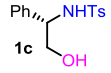
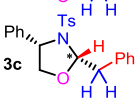
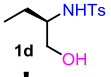
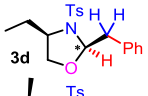
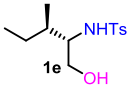
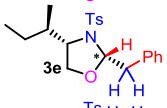
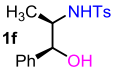
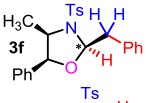
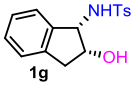
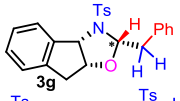
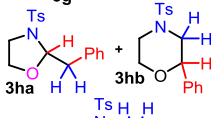
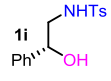
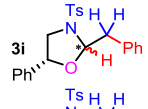
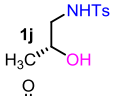
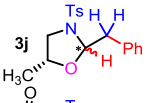
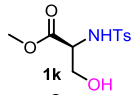
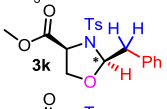
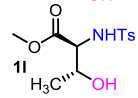
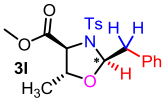


Entry	E^+(Electrophile source)	Activator/Base	Solvent	Time	Yield (%)[b]
1)	NBS	—	CH_2Cl_2	24 h	N.R.
2)	NIS	—	CH_2Cl_2	24 h	N.R.
3)	PTAB	—	CH_2Cl_2	24 h	N.R.
4)	I_2	—	CH_2Cl_2	24 h	N.R.
5)	$PhI(OAc)_2$	—	CH_2Cl_2	24 h	N.R.
6)	$PhI(OCOCF_3)_2$	—	CH_2Cl_2	24 h	N.R.
7)	$PhI(OAc)_2$	TMSOTf	CH_2Cl_2	24 h	33
8)	$PhI(OCOCF_3)_2$	TMSOTf	CH_2Cl_2	24 h	40
9)	$PhI(OCOCF_3)_2$	CF_3COOH	CH_2Cl_2	24 h	60
10)	$PhI(OCOCF_3)_2$	$HClO_4$(60%)	CH_2Cl_2	4 h	67
11)	**$PhI(OCOCF_3)_2$**	**PTSA**	**CH_2Cl_2**	**4 h**	**86**
12)	$PhI(OCOCF_3)_2$	PTSA(cat.)	CH_2Cl_2	4 h	25
13)	$PhI(OCOCF_3)_2$(cat.)	PTSA	CH_2Cl_2	4 h	15
14)	$PhI(OCOCF_3)_2$	anhyd. PTSA	CH_2Cl_2	4 h	82

The bold faces are refer to the best or the significant result.
[a]Reaction conditions: 1 equiv (0.33 mmol) of **1a**, 1.1 equiv of **2a** 1.5 equiv of electrophile source, 1.1 equiv of activator/base, 3 mL of solvent.
[b] Isolated yield.

Table 2
Effect of substituent of the aminoalcohol on the stereoselectivity and regioselectivity



Entry	Amino alcohol	Oxazolidine	Yield (%)[b]
1)			86
2)			89
3)			72
4)			80
5)			81
6)			94
7)			70
8)			58[c]
9)			90[d]
10)			65[e]
11)			71
12)			75

[a]Reaction conditions: 1 equiv (0.33 mmol) of corresponding aminoalcohol **1a**–**l**, 1.1 equiv of **2a**, 1.5 equiv of $PhI(OCOCF_3)_2$, 1.1 equiv of PTSA·H_2O, 3 mL of solvent.
[b] Isolated yield.
[c] Ratio of **3ha:3hb**=4.4:1.0.
[d] d.r.=1.1:1.0.
[e] d.r.=1.0:1.0.

render the corresponding oxazolidines with excellent stereoselectivity under the metal-free addition conditions (styrene **2a**, $PhI(OCOCF_3)_2$, $PTSA{\cdot}H_2O$, CH_2Cl_2, 4 h, rt). When norepinephrine derived *N*-Ts-aminoalcohol **1f** was reacted with the styrene **2a** under the metal-free conditions (styrene **2a**, $PhI(OCOCF_3)_2$, $PTSA{\cdot}H_2O$, CH_2Cl_2, 4 h, rt), a fully substituted oxazolidine **3f** was formed (94%) as a single diastereomer.

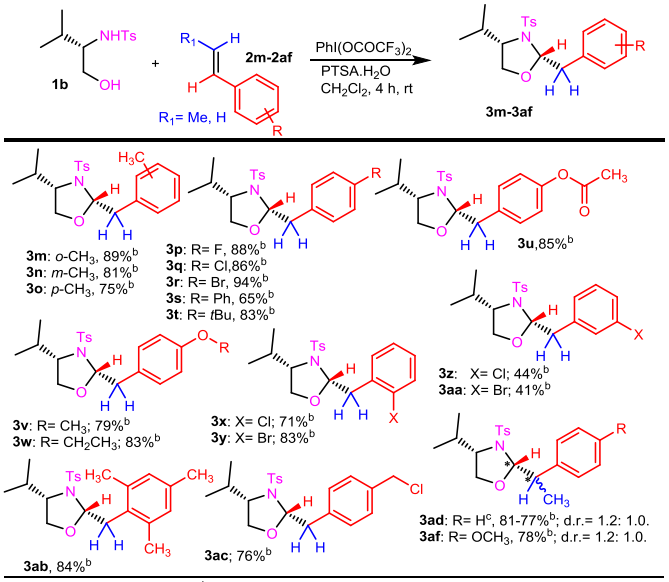
Linearly fused tricyclic oxazolidine **3g** was obtained as single diastereomer under the same conditions upon the addition of indanol derived *N*-Ts aminoalcohol **1g** to syrene **2a**. Intriguingly, in the reaction of unsubstituted *N*-Ts-2-aminoethanol **1h** with **2a**, in addition to the expected geminal addition product, oxazolidine **3ha**, formation of the vicinal addition product, morpholine **3hb** was also observed (**3ha: 3hb**=4.4: 1.0). This demonstrates the steering role of substituents on the aminoalcohol in controlling the regioselectivity of the addition, in addition to controlling the stereoselectivity. The aminoalcohol derivatives, **1i** and **1j** having a substituent on the α-carbon adjacent to hydroxyl group, on reaction with **2a** under the same conditions provided the corresponding oxazolidines **3i** and **3j** with low diastereoselectivity (entries 9 and 10, Table 2). This result illustrates the importance of the effect of substituent at the carbon bearing the amine or the hydroxyl group of the aminoalcohol on the stereochemical course of the reaction. The methodology was then applied to a rapid, straightforward, and one-pot synthesis of pseudoprolines **3k** and **3l** by the reaction of serine derived *N*-Ts-aminoalcohol **1k** and threonine derived *N*-Ts-aminoalcohol **1l**, respectively with styrene **2a** (entries 11 and 12, Table 2).

It was then decided to study the role of substituents on styrenes in the geminal aminooxygenation reaction. A variety of substituted styrenes (2**m**–**2af**) on reaction with *N*-Ts-valinol **1b** ($PhI(OCOCF_3)_2$, $PTSA{\cdot}H_2O$, CH_2Cl_2, 4 h, rt) gave the corresponding difunctionalized product, oxazolidines **3m**–**3af** as a single diastereomer in good to excellent yields (Table 3). Various alkyl (**3m**–**o**, **3t**) and aryl **3s** substituted oxazolidines were efficiently obtained by the addition of *N*-Ts-aminoalcohol **1b** to the corresponding styrenes (**2m**–**o, 2s, 2t**). The styrenes having electron withdrawing substituents at the *ortho* (**2x, 2y**) and *para* position (**2p**–**r**) were found to react more efficiently than the *meta* substituted styrenes (**2z, 2aa**) to give the corresponding oxazolidines. These results may be attributed to the ability of the substituents to stabilize the carbocationic intermediates formed in the geminal difunctionalization reaction.

The styrenes (**2u**–**w, 2af**) having acid-labile substituents, having bulkier 2,4,6-trimethyl substituent **2ab** and with chloromethyl substituent **2ac** were also found to react smoothly to provide the corresponding oxazolidines in good yields. Intriguingly, when the reaction was performed with either *trans*-β-methyl styrene **2ad** or *cis*-β-methyl styrene **2ae**, the same product (**3ad**) with the same stereoidentity was formed in good yields. This implies stereoconvergence of the intermediates formed from the two distinct diastereomeric styrenes under the conditions of addition of **1b.**

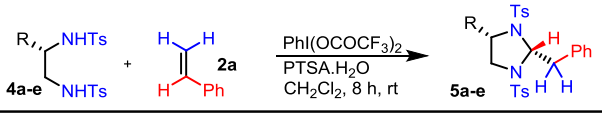
Motivated by the attractive results obtained from the geminal aminooxygenation, we then decided to investigate the feasibility of a more challenging and the unprecedented geminal diamination of styrenes under metal-free conditions. When we attempted to add the 1,2-diamine derivative **4a** to styrene **2a,** we were pleased to find that the product formed in very good yield (79%) was the geminal diaminated imidazolidine **5a** as a single diastereomer under the metal-free conditions ($PhI(OCOCF_3)_2$, $PTSA{\cdot}H_2O$, CH_2Cl_2, 8 h, rt) (entry 1, Table 4). The enantiopure diamine derivatives (**4b**–**d**) derived from the corresponding aminoacids with different substituents were also found to react with styrene **2a** smoothly to give the corresponding imidazolidines (**5b**–**d**) in good yields with very high diastereoselectivity. Interestingly, the unsubstituted diamine derivative **4e** provided the geminal addition product **5e** almost exclusively with traces of vicinal addition product (imidazolidine: piperazine=97: 3.0). It is important to note that the extent of geminal addition of diamine **4e** to **2a** is quite significant

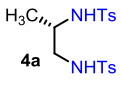
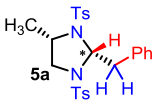
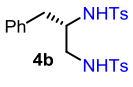
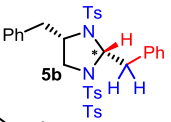
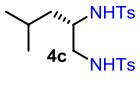
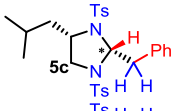
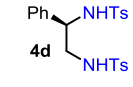
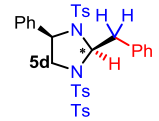
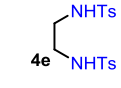
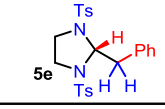
Table 3
Effect of substituent on the styrene in the geminal aminooxygenation



[a]condiitons: same as Table 2. [b]Isolated yield. [c]yield = 81%; d.r = 1.2: 1.0 for *trans-β*–methylstyrene **2ad**; yield = 77%; d.r = 1.2: 1.0 for *cis-β*–methylstyrene **2ae.**

Table 4
Geminal diamination of vinylarenes



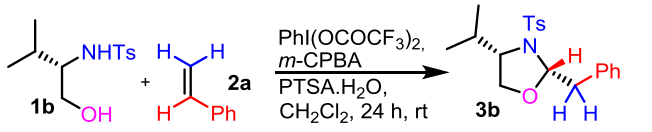
Entry	Diamine	Imidazolidine	Yield (%)[b]
1)	 **4a**	 **5a**	79
2)	 **4b**	 **5b**	92
3)	 **4c**	 **5c**	84
4)	 **4d**	 **5d**	71
5)	 **4e**	 **5e**	78[c]

[a]conditions: same as Table 2.
[b] Isolated yield.
[c] Imidazolidine: piperazine=97.0: 3.0.

compared to the geminal addition of aminoalcohol **1h** to **2a** (cf. entry 8, Table 2).

After the successful geminal diamination and aminooxygenation, we decided to develop a catalytic version of the reaction using only a catalytic amount of hypervalent iodine.[14] In the preliminary experiments (entries 1–6, Table 5), we were pleased to find that, using a catalytic amount of $PhI(OCOCF_3)_2$ (5 mol %) and *m*-CPBA[14] as an oxidant, the aminoalcohol **1b** could be added geminally to styrene **2a** (entry 6, Table 5), ($PTSA{\cdot}H_2O$, CH_2Cl_2, 24 h, rt) to give oxazolidine **3a** smoothly in good yield (74%). In the course of optimization studies, intriguingly, the formation of oxazolidines as the sole product was observed even in the absence of $PhI(OCOCF_3)_2$ indicating that *m*-CPBA alone mediates, and also competes preferentially in the geminal difunctionalization process rather than the oxidation of hypervalent iodine(III) species (entries 7 and 8, Table 5).

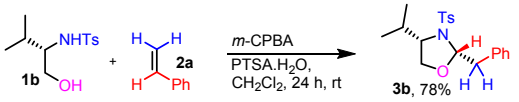
Table 5
Optimization of *m*-CPBA mediated geminal aminooxygenation



Entry	Styrene (equiv)	$PhI(OCOCF_3)_2$ (mol %)	m-CPBA (equiv)	Yield (%)[b]
1)	1.1	20	1.5	41
2)	1.1	10	1.5	48
3)	1.1	05	1.5	45
4)	2.5	05	1.5	56
5)	1.1	05	**2.0**	48
6)	**2.5**	**05**	**2.0**	**74**
7)	2.5	00	**1.5**	50
8)	2.5	00	**3.0**	**78**

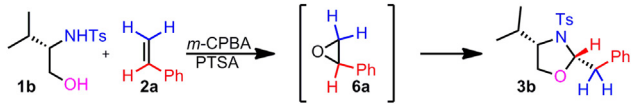
The bold faces are refer to the best or the significant result.
[a]Reaction conditions: 1 equiv (0.33 mmol) of **1b,** 1.1 equiv of $PTSA{\cdot}H_2O$, 3 mL of solvent.
[b] Isolated yield.

It is worth pointing out that, in addition to the hypervalent iodine mediated geminal addition process, we have also developed an unprecedented *m*-CPBA mediated intermolecular geminal aminooxygenation of vinlyarenes (Scheme 1).



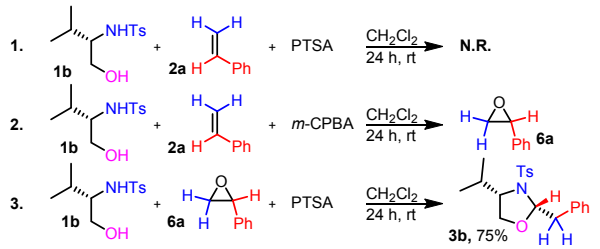
Scheme 1. *m*-CPBA mediated geminal aminooxygenation of vinylarenes.

We were interested to understand the path of oxidative activation of styrene by *m*-CPBA and $PTSA{\cdot}H_2O$ in mediating the geminal addition process to form the oxazolidine as the sole product. We supposed that the epoxide **6a** is the intermediate formed in the *m*-CPBA mediated geminal aminooxygenation. The epoxide **6a** thus formed upon ring opening by the aminoalcohol **1b** leads to the formation of oxazolidine **3b** (Scheme 2).



Scheme 2. Supposed pathway for the *m*-CPBA mediated geminal aminooxygenation of vinylarenes.

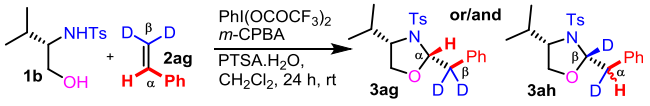
The control studies were then conducted to confirm the formation of epoxide as the intermediate in the *m*-CPBA mediated geminal aminooxygenation (Scheme 3). When the *N*-Ts aminoalcohol **1b** was added to styrene **2a** in the absence of *m*-CPBA no addition product was observed (entry 1, Scheme 3). The anticipated epoxide **6a** was formed and not the oxazolidine **3b**, when the aminoalcohol **1b** was added with styrene **2a** in the absence of $PTSA{\cdot}H_2O$ (entry 2, Scheme 3). The epoxide **6a** (styrene oxide) on reaction with *N*-Ts aminoalcohol **1b** provided the oxazolidine **3b** (entry 3, Scheme 3) in the presence of $PTSA{\cdot}H_2O$. The product **3b** formed from the addition of *N*-Ts aminoalcohol **1b** to epoxide **6a** (**3b**, Scheme 3) and the one formed from the addition to aminoalcohol **1b** to styrene **2a** (**3b**, Scheme 1) were found to be spectroscopically the same. These results prove that the epoxide is the actual intermediate formed in the *m*-CPBA mediated geminal aminooxygenation.



Scheme 3. Control studies for the *m*-CPBA mediated geminal aminooxygenation of vinylarenes.

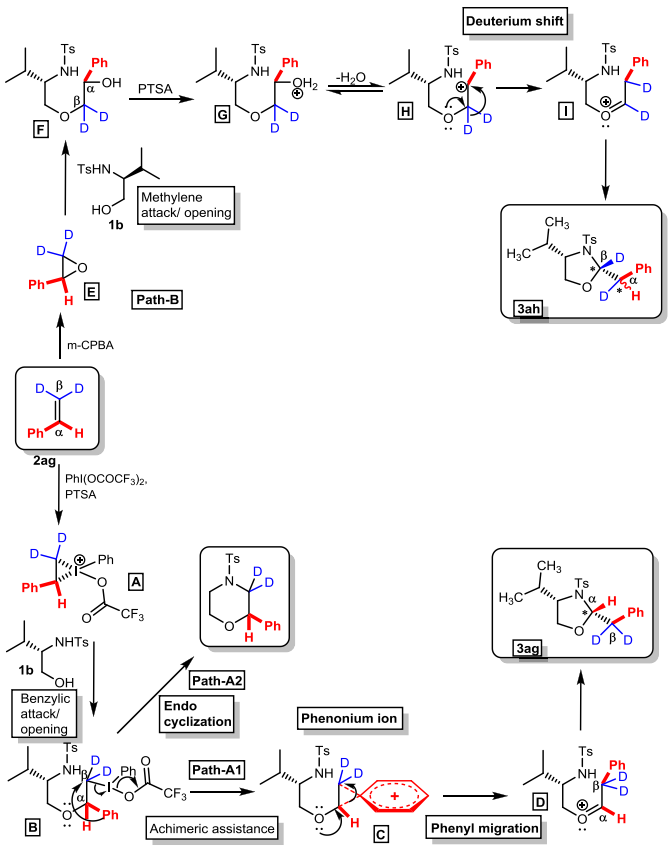
Aroused by the curiosity to understand the mechanistic details of this two intriguing oxidative geminal addition reactions mediated by $PhI(OCOCF_3)_2$ and *m*-CPBA, deuterated styrene was used as a probing tool to delineate the reaction pathways (Table 6). Interestingly, when the aminoalcohol **1b** was reacted with the β,β-dideuterated styrene **2ag** using only $PhI(OCOCF_3)_2$ as the reagent (entry 1, Table 6) it was found to furnish the dideuterated phenylmethylene (***-CD$_2$Ph***) substituted oxazolidine **3ag** as the sole product (79%). This would be the result of phenyl migration pathway (vide infra path-A1, Scheme 4). However, when the same reaction was performed using only *m*-CPBA as the reagent (entry 2, Table 6), it provided exclusively a diastereomeric mixture of oxazolidine **3ah** having deuterium attached at the hemiaminal carbon (***-CDNO***) with the stereogenic monodeuterohydrophenylmethylene (***-CHDPh***) substituent as the sole product. The formation of **3ah** could be deduced as the product obtained from the deuterium migration pathway (vide infra path-B, Scheme 4).

Table 6
Deuterium labelling studies



Entry	$PhI(OCOCF_3)_2$ (equiv)	m-CPBA (equiv)	Product ratio (**3ag: 3ah**)	Yield (%)[b]
1)	1.1	**0**	**100: 0**	79
2)	**0**	3.0	**0:100**	67
3)	0.05	2.0	**3.5: 96.5**	72
4)	0.50	2.0	**44: 56**	74

The bold faces are refer to the best or the significant result.
[a]Reaction conditions: 1 equiv (0.33 mmol) of **1b**, 1.1, 2.5, 2.0 and 2.0 equiv of **2ag** for entries 1, 2, 3 & 4, respectively. 1.1 equiv of $PTSA{\cdot}H_2O$, 3 mL of solvent.
[b] Isolated yield.



Scheme 4. Proposed mechanism for the metal-free geminal difunctionalization.

It is worth noting that in this case, the epoxide actually got opened up at the methylene site (vide infra int-**F**, Scheme 4), which is rather unusual, than the generally observed benzylic site.[15] Additionally, it was also observed that the ratio of phenyl migrated product **3ag** increases proportionally with added amount of $PhI(OCOCF_3)_2$ (entries 3 and 4, Table 6). These results indicate that the two oxazolidines **3ag** and **3ah** are the products obtained from two independently competing pathways mediated by $PhI(OCOCF_3)_2$ and *m*-CPBA, respectively.

In light of these observations, we propose a mechanism for the geminal addition pathway mediated by $PhI(OCOCF_3)_2$ and *m*-CPBA as shown in Scheme 4. In the $PhI(OCOCF_3)_2$ mediated pathway (**Path-A1**), at first the highly electrophilic hypervalent iodine species activated by $PTSA\cdot H_2O$ reacts with the π-bond of styrene **2ag** to form the hypervalent iodonium intermediate **A**. This highly active hypervalent iodonium ring gets opened up at the more reactive benzylic position by the attack of hydroxyl nucleophile of aminoalcohol **1b** to form the acylic benzylether **B**. The reduction of hypervalent iodonium species is facilitated by the anchimeric assistance rendered by the phenyl group, forming the phenonium ion[16] **C**. This species upon subsequent phenyl migration leads to the formation of the more stable oxonium ion **D**. The oxonium ion thus formed undergoes a 5-*endo*-*trig* cyclization to furnish the oxazolidine **3ag** (vide supra, entry 1, Table 6), in which the two deuterium atoms are intact with the carbon attached to them in the parent styrene throughout the process and the phenyl group has migrated to the adjacent carbon. When the aminoalcohol or the diamine is unsubstituted (entry 8, Table 2; entry 5, Table 4), the 6-*endo*-tet pathway (**Path-A2**) also competes with the phenyl migration pathway (**Path-A1**).

In the *m*-CPBA mediated reaction (**Path-B**), the epoxide **E** is first formed as a result oxidation of styrene by *m*-CPBA (entry 2, Scheme 3). The acid, $PTSA\cdot H_2O$ activates the epoxide, which gets opened up at the less hindered methylene site by the aminoalcohol (entry 3, Scheme 3) [cf. int **B**, Scheme 4] to give the dideuteromethylene ether **F.** The alkoxonium ion **G** formed upon the attack of acid ($PTSA\cdot H_2O$) on intermediate **F** gives rise to the benzylic carbocation **H**, which after the deuterium shift forms a more stable oxonium ion **I**. The oxonium ion eventually gets cyclized to give the oxazolidine **3ah**, in which one of the deuteriums of the parent styrene has migrated to the adjacent carbon in the course of the reaction. It is interesting to note that the geminal aminooxygenation of styrene **2ag** occurs through two independent, distinct oxidative difunctionalization pathways mediated by $PhI(OCOCF_3)_2$ and *m*-CPBA, respectively, thereby fulfilling the essential features of a reagent-switch.

3. Conclusions

In summary, in this article development of two new methods for the geminal oxyamination of vinylarenes and their detailed study to understand its mechanism are presented. We have developed the first general method for the geminal diamination and the first intermolecular metal-free geminal aminooxygenation of vinylarenes with excellent stereoselectivity mediated by hypervalent iodine reagent. In addition, a new *m*-CPBA mediated geminal aminooxygenation has also been developed. A novel reagent-switch for the control of migrating group by controlling the two independent, distinct pathways of the two reagent systems has been reported for this geminal addition. The control studies have clearly demonstrated the intermediacy of epoxide in the *m*-CPBA mediated geminal aminooxygenation. Deuterium labelling studies have provided unambiguous evidences for the phenyl migration and hydride migration in the semi-pinacol rearrangement and also for the unusual ring-opening at methylene site of epoxide intermediate formed.

4. Experimental section

4.1. General

All reactions were carried out in oven-dried apparatus using dry solvents under anhydrous conditions, unless otherwise noted. Reaction mixtures were stirred magnetically, unless otherwise stated. Analytical grade solvents were distilled and dried according to literature procedures.[17] Analytical TLC was performed on commercial plates coated with silica gel GF_{254} (0.25 mm). Visualization of TLC was accomplished using UV light or PMA stain. Silica gel (230–400 mesh) was used for column chromatography. NMR spectra were recorded on 400 MHz spectrometer. The chemical shifts (δ, ppm) are reported with reference to; either internal standard $SiMe_4$ (for ^1H) or the central line (77.0 ppm) of $CDCl_3$ (for ^{13}C) for $CDCl_3$; either solvent residual peak (2.05 ppm) of Acetone-d_6 (for ^1H) or the central line (29.84 ppm) of Acetone-d_6 (for ^{13}C) for Acetone-d_6; either solvent residual peak (2.50 ppm) of DMSO-d_6 (for ^1H) or the central line (39.52 ppm) of DMSO-d_6 (for ^{13}C) for DMSO-d_6. The following abbreviations explain the multiplicity s=singlet, d=doublet, t=triplet, q=quartet, dd=doublet of a doublet, quint=quintet, m=multiplet, and br=broad. IR spectra were recorded as thin films on NaCl plates on an FT-IR spectrometer. High-resolution mass spectra (HRMS) were recorded on a Micromass Q-TOF mass spectrometer. Isolated yields refer to chromatographically and spectroscopically (^1H NMR) homogeneous materials, unless otherwise stated.

All commercially available reagent grade styrenes **2a**–**2af**, **$PhI(OCOCF_3)_2$**, ***m*-CPBA** and **$PTSA\cdot H_2O$** were used as received, without further purification. The *anhyd*. **PTSA** was prepared by the dehydration of **$PTSA\cdot H_2O$** according to the literature procedure.[17] The *N*-Ts amino alcohols **1a, 1f**–**l** were prepared according to the reported procedure.[9] The amino alcohols such as (*S*)-(+)-valinol, (*R*)-(−)-phenylglycinol and (*S*)-(+)-isoleucinol were synthesized by

the reduction of the corresponding L-amino acid according to the reported literature procedure.[18] The 1,2-diamine precursors for **4b**–**d** were synthesized from corresponding amino acids according to the reported literature procedure.[19] Experimental procedure and the complete characterization data for the starting materials **1b**–**1e** (Table 2), **4a**–**4d** (Table 4) can be found in the Supplementary data.[13] *N*-Ts-aminoalchols **1a**, **1f**–**l** were prepared as previously described.[13]

4.2. PhI(OCOCF$_3$)$_2$ Mediated synthesis of oxazolidines 3a–3ag: *Method A*

*4.2.1. General procedure for the PhI(OCOCF$_3$)$_2$ mediated synthesis of oxazolidines **3a**–**3ag**: Method A.* To a colorless solution of corresponding *N*-Ts aminoalcohol (0.33 mmol) and styrene (0.36 mmol) in CH_2Cl_2 (3 mL) in a well dried Schlenk flask under argon atmosphere was added PhI(OCOCF$_3$)$_2$ (0.50 mmol) and PTSA·H$_2$O (0.36 mmol) at room temperature [25 °C]. The progress of the reaction was monitored by TLC. After stirring the reaction mixture for 4 h at room temperature 5 mL of satd soln of aq $NaHCO_3$ was added and extracted with CH_2Cl_2. The combined organic layers were dried (anhyd. Na_2SO_4), filtered and concentrated in vacuo. The crude product obtained was purified by flash chromatography (pet. ether: Et_2O, 8:1) to furnish oxazolidines in pure form.

*4.2.2. (2S,4S)-2,4-Dibenzyl-3-tosyloxazolidine (**3a**).*[9] White solid (115 mg, 86%); R_f 0.50 (pet. ether: EtOAc, 9:1); mp 80–81 °C (lit.[9] mp 76–79 °C); $[\alpha]_D^{21}$ +23.9 (*c* 1.0, $CHCl_3$) [lit.[9] $[\alpha]_D^{21}$+23.5 (*c* 1.0, $CHCl_3$)]; ^{1}H NMR (400 MHz, $CDCl_3$) δ; 7.76 (d, *J*=8.1 Hz, 2H), 7.33–7.18 (m, 10H), 7.09 (d, *J*=7.3 Hz, 2H), 5.09, (dd, *J*=6.8, 1.6 Hz 1H), 3.78–3.74 (m, 1H), 3.61 (dd, *J*=9.0, 2.3 Hz, 1H), 3.28 (dd, *J*=14.0, 1.5 Hz, 1H), 3.08–2.99 (m, 2H), 2.92 (dd, *J*=13.6, 3.5 Hz, 1H), 2.41 (s, 3H), 2.25 (dd, *J*=13.3, 10.9 Hz, 1H).

*4.2.3. (2S,4S)-2-Benzyl-4-isopropyl-3-tosyloxazolidine (**3b**).* Colorless oil (76 mg, 89%); R_f 0.50 (pet. ether: EtOAc, 9:1); $[\alpha]_D^{21}$ –63.0 (*c* 1.0, $CHCl_3$); IR (cm^{-1}): 3030, 2962, 2874, 1599, 1493, 1467, 1455, 1351, 1158, 1090, 1009, 816, 755, 706, 668; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, *J*=8.1 Hz, 2H), 7.33–7.22 (m, 7H), 5.03 (dd, *J*=8.2, 2.3 Hz, 1H), 3.75 (dd, *J*=8.9, 1.8 Hz, 1H), 3.37–3.30 (m, 2H), 3.03–2.96 (m, 2H), 2.42 (s, 3H), 1.70–1.61 (m, 1H), 0.98 (d, *J*=6.8 Hz, 3H), 0.89 (d, *J*=6.7 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.1, 136.4, 134.1, 129.90, 129.85, 128.2, 128.0, 126.7, 92.9, 67.7, 65.2, 42.6, 31.1, 21.5, 19.7, 18.7; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{20}H_{25}NO_3SNa$, 382.1453; found, 382.1454.

*4.2.4. (2S,4S)-2-Benzyl-4-phenyl-3-tosyloxazolidine (**3c**).* White solid (94 mg, 72%); R_f 0.50 (pet. ether: EtOAc, 9:1); mp 81–82 °C; $[\alpha]_D^{21}$ +20.8 (*c* 2.0, $CHCl_3$); IR (cm^{-1}): 3783, 3702, 3661, 3432, 3031, 2925, 2871, 1597, 1351, 1161, 1089, 1000, 770, 701, 669; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 (d, *J*=8.1 Hz, 2H), 7.31–7.24 (m, 12H), 5.31 (dd, *J*=8.4, 2.1 Hz, 1H), 4.69 (dd, *J*=6.3, 5.0 Hz, 1H), 3.93 (dd, *J*=8.9, 4.6 Hz, 1H), 3.77 (dd, *J*=8.8, 6.9 Hz, 1H), 3.39 (dd, *J*=14.0, 2.1 Hz, 1H), 3.11 (dd, *J*=14.0, 8.5 Hz, 1H), 2.42 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.2, 139.2, 136.3, 133.9, 129.90, 129.87, 128.5, 128.4, 128.0, 127.8, 126.8, 126.6, 93.6, 72.6, 62.2, 42.3, 21.5; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{23}H_{23}NO_3SNa$, 416.1296; found, 416.1295.

*4.2.5. (2S,4R)-2-Benzyl-4-ethyl-3-tosyloxazolidine (**3d**).* White solid (91 mg, 80%); R_f 0.50 (pet. ether: EtOAc, 9:1); mp 81–83 °C; $[\alpha]_D^{21}$ +39.8 (*c* 1.0, $CHCl_3$); IR (cm^{-1}): 2871, 1598, 1494, 1455, 1347, 1215, 1187, 1163, 1088, 1005; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.74 (d, *J*=8.2 Hz, 2H), 7.33–7.21 (m, 7H), 5.07 (dd, *J*=7.4, 2.2 Hz, 1H), 3.58 (dd, *J*=8.7, 2.5 Hz, 1H), 3.54–3.49 (m, 1H), 3.28 (dd, *J*=14.0, 2.2 Hz, 1H), 3.17 (dd, *J*=8.6, 6.0 Hz, 1H), 3.03 (dd, *J*=14.0, 7.4 Hz, 1H), 2.42 (s, 3H), 1.54–1.44 (m, 1H), 1.36–1.25 (m, 1H), 0.85 (t, *J*=7.4 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.1, 136.1, 134.2, 130.2, 129.9, 128.1, 127.9, 126.7, 92.6, 69.7, 60.8, 42.6, 27.5, 21.5, 10.4; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{19}H_{23}NO_3SNa$, 368.1296; found, 368.1294.

*4.2.6. (2S,4S,6S)-2-Benzyl-4-2-butyl-3-tosyloxazolidine (**3e**).* Colorless oil (102 mg, 81%); R_f 0.50 (pet. ether: EtOAc, 9:1); $[\alpha]_D^{21}$ –53.8 (*c* 2.0, $CHCl_3$); IR (cm^{-1}): 2964, 2930, 2873, 1599, 1495, 1456, 1350, 1164, 1089, 997, 972; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, *J*=7.9 Hz, 2H), 7.33–7.23 (m, 7H), 5.02 (d, *J*=7.7 Hz, 1H), 3.76 (d, *J*=8.9 Hz, 1H), 3.43 (t, *J*=5.7 Hz, 1H), 3.31 (d, *J*=13.9 Hz, 1H), 3.08–2.99 (m, 2H), 2.42 (s, 3H), 1.65–1.55 (m, 1H), 1.53–1.46 (m, 1H), 1.15–1.03 (m, 1H), 0.87 (s, 3H), 0.86 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.1, 136.4, 133.9, 129.94, 129.87, 128.3, 128.0, 126.7, 92.9, 67.3, 64.0, 42.4, 37.4, 26.1, 21.5, 14.8, 11.7; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{21}H_{27}NO_3SNa$, 396.1609; found, 396.1607.

*4.2.7. (2R,4R,5S)-2-Benzyl-4-methyl-5-phenyl-3-tosyloxazolidine (**3f**).*[9] Colorless solid (126 mg, 94%); R_f 0.50 (pet. ether: EtOAc, 9:1); mp 112–114 °C (lit.[9] mp 123–124 °C); $[\alpha]_D^{21}$ +2.4 (*c* 1.0, $CHCl_3$) [lit.[9] $[\alpha]_D^{21}$ +2.8 (*c* 2.0, $CHCl_3$)]; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84 (d, *J*=8.0 Hz, 2H), 7.45–7.22 (m, 10H). 7.07 (d, *J*=7.1 Hz, 2H), 5.21 (d, *J*=4.8 Hz, 1H), 4.18 (d, *J*=5.4 Hz, 1H), 3.92–3.86 (m, 1H), 3.42 (d, *J*=13.9 Hz, 1H), 3.25 (dd, *J*=14.0, 6.0, Hz, 1H), 2.46 (s, 3H), 0.40 (d, *J*=6.7 Hz, 3H).

*4.2.8. (2S,3aS,8aR)-2-Benzyl-3-tosyl-indanooxazolidine (**3g**).*[9] Colorless crystals (94 mg, 70%); R_f 0.50 (pet. ether: EtOAc, 9:1); mp 120–122 °C (lit.[9] mp 123–124 °C); $[\alpha]_D^{21}$ –46.6 (*c* 1.0, $CHCl_3$) [lit.[9] $[\alpha]_D^{21}$ –38.8 (*c* 1.0, $CHCl_3$)]; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80 (d, *J*=8.0 Hz, 2H), 7.49 (d, *J*=6.3 Hz, 1H), 7.35–7.03 (m, 10H), 5.33 (dd, *J*=7.7, 2.9 Hz, 1H), 5.24 (d, *J*=5.4 Hz, 1H), 4.17 (t, *J*=5.1 Hz, 1H), 3.10–2.90 (m, 3H), 2.49 (dd, *J*=14.0, 8.0 Hz, 1H), 2.44 (s, 3H).

4.2.9. Mixture of 2-phenyl-4-tosylmorpholine (3ha[9]) and 2-benzyl-3-tosyloxazolidine (3hb[9]). Mixture of oxazolidine ***A***[9] and morpholine ***B***[9] (**4.4**:**1.0**): white solid (61 mg, 58%); *R* 0.30 (pet. ether: EtOAc, 9:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, *J*=7.8 Hz, 2H, 2*A*), 7.62 (d, *J*=8.1 Hz, 0.44H, 2*B*), 7.33–7.14 (m, 8.6H, 7*A*+7*B*), 5.27 (d, *J*=5.5 Hz, 1H, 1*A*), 4.6 (d, *J*=10.1 Hz, 0.23H, 1*B*), 4.1 (d, *J*=11.4 Hz, 0.24H, 1*B*), 3.89–3.72 (m, 1.52H, 1*A*+2*B*), 3.64 (d, *J*=11.3 Hz, 0.24H, 1*B*), 3.43–3.38 (m, 1H, 1*A*), 3.26 (dd, *J*=14.5, 7.2 Hz, 1H, 1*A*), 3.20–3.14 (m, 2H, 2*A*), 3.0 (dd, *J*=13.9, 6.8 Hz, 1H, 1*A*), 2.54–2.43 (m, 3.9H, 3*A*+3*B*+1*B*), 2.24 (t, *J*=10.9 Hz, 0.26H, 1*B*).

*4.2.10. (5R)-2-Benzyl-5-phenyl-3-tosyloxazolidine (**3i**).*[9] [Mixture of diastereomers; d.r.=1.0: 1.0] white solid (117 mg, 90%); R_f 0.50 (pet. ether: EtOAc, 9:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.79 (d, *J*=8.1 Hz, 1H), 7.66 (d, *J*=8.1 Hz, 1H), 7.39–7.14 (m, 10H), 7.02–7.0 (m, 1H), 6.85 (d, *J*=7.2 Hz, 1H), 5.5 (t, *J*=4.9 Hz, 0.5H), 5.43 (dd, *J*=5.4, 2.9 Hz, 0.5H), 4.94 (t, *J*=7.1 Hz, 0.5H), 4.05 (dd, *J*=10.2, 5.4 Hz, 0.5H), 3.79 (dd, *J*=11.9, 5.4 Hz, 0.5H), 3.70 (dd, *J*=9.6, 6.3 Hz, 0.5H), 3.29–3.16 (m, 2H), 3.08 (t, *J*=8.8 Hz, 0.5H), 2.83 (t, *J*=11.0 Hz, 0.5H), 2.45 (s, 1.5H), 2.4 (s, 1.5H).

*4.2.11. (5R)-2-Benzyl-5-methyl-3-tosyloxazolidine (**3j**).*[9] [Mix of diastereomers; d.r.=1.0: 1.0]: colorless oil (72 mg, 65%); R_f 0.50 (pet. ether: EtOAc, 9:1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 (dd, *J*=8.2, 2.3 Hz, 2H), 7.40–7.22 (m, 7H), 5.28 (dd, *J*=7.1, 3.0 Hz, 0.5H), 5.24 (dd, *J*=6.0, 2.5 Hz, 0.5H), 4.16–1.09 (m, 0.5H), 3.51 (dd, *J*=11.6, 5.3 Hz, 0.5H), 3.45 (dd, *J*=9.3, 5.7 Hz, 0.5H), 3.25–2.98 (m, 2.5H), 2.75 (dd, *J*=9.0, 8.0 Hz, 0.5H), 2.47 (t, *J*=10.9 Hz, 0.5H), 2.42 (s, 3H), 1.02 (d, *J*=5.9 Hz, 1.5H), 0.92 (d, *J*=6.1 Hz, 3H).

*4.2.12. (2R,4S)-Methyl-2-benzyl-3-tosyloxazolidine-4-carboxylate (**3k**).*[9] Colorless oil (88 mg, 71%); R_f 0.40 (pet. ether: EtOAc, 4:1);

$[\alpha]_D^{21}$ +12.8 (*c* 1.0, $CHCl_3$) [lit.[9] $[\alpha]_D^{21}$ +11.1 (*c* 1.0, $CHCl_3$)]; ^1H NMR (400 MHz, $CDCl_3$) δ 7.75 (d, *J*=8.2 Hz, 2H), 7.34–7.21 (m, 7H), 5.25 (dd, *J*=8.3, 2.9 Hz, 1H), 4.38 (dd, *J*=7.0, 3.4 Hz, 1H), 4.16 (dd, *J*=9.0, 3.4 Hz, 1H), 3.73 (s, 3H), 3.60 (dd, *J*=8.9, 7.1 Hz, 1H), 3.27 (dd, *J*=14.1, 2.9 Hz, 1H), 3.05 (dd, *J*=14.1, 8.3 Hz, 1H), 2.43 (s, 3H).

4.2.13. (2R,4S,5R)-Methyl-2-benzyl-5-methyl-3-tosyloxazolidine-4-carboxylate[9] (***3l***). Colorless oil (97 mg, 75%); R_f 0.40 (pet. ether: EtOAc, 4:1); $[\alpha]_D^{21}$ −3.7 (*c* 3.0, $CHCl_3$) [lit.[9] $[\alpha]_D^{21}$ −4.4 (*c* 1.0, $CHCl_3$)]; ^1H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, *J*=8.2 Hz, 2H), 7.33–7.21 (m, 7H), 5.41 (dd, *J*=8.2, 3.9 Hz, 1H), 4.93–4.36 (m, 1H), 3.84 (d, *J*=6.2 Hz, 1H), 3.78 (s, 3H), 3.18–3.06 (m, 2H), 2.43 (s, 3H), 1.09 (d, *J*=6.1 Hz, 3H).

4.2.14. (2S,4S)-4-Isopropyl-2-(2-methylbenzyl)-3-tosyloxazolidine (***3m***). Colorless oil (110 mg, 89%); R_f 0.50 (pet. ether: EtOAc, 9:1); $[\alpha]_D^{21}$ −72.1 (*c* 1.0, $CHCl_3$); IR (cm^{-1}): 2962, 2871, 1349, 1163; ^1H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, *J*=8.2 Hz, 2H), 7.32–7.12 (m, 6H), 5.03 (dd, *J*=8.8, 2.0 Hz, 1H), 3.75 (dd, *J*=9.0, 1.8 Hz, 1H), 3.42–3.37 (m, 2H), 3.00–0.8.93 (m, 2H), 2.42 (s, 6H), 1.83–1.4 (m, 1H), 1.04 (d, *J*=6.8 Hz, 3H), 0.95 (d, *J*=6.7 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.1, 136.9, 134.9, 134.1, 130.7, 130.2, 129.9, 127.9, 126.9, 125.8, 92.4, 67.6, 65.2, 40.1, 31.2, 21.5, 19.8, 19.7, 18.7; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{21}H_{27}NO_3SNa$, 396.1609; found, 396.1620.

4.2.15. (2S,4S)-4-Isopropyl-2-(3-methylbenzyl)-3-tosyloxazolidine (***3n***). Colorless oil (100 mg, 81%); R_f 0.50 (pet. ether: EtOAc, 9:1); $[\alpha]_D^{21}$ −66.8 (*c* 2.0, $CHCl_3$); IR (cm^{-1}): 2961, 2870, 1350, 1162; ^1H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, *J*=8.0 Hz, 2H), 7.33–7.04 (m, 6H), 5.03 (d, *J*=8.2 Hz, 1H), 3.75 (d, *J*=8.9 Hz, 1H), 3.37–3.27 (m, 2H), 3.02 (dd, *J*=8.7, 6.2 Hz, 1H), 2.93 (dd, *J*=13.9, 8.4 Hz, 1H), 2.42 (s, 3H), 2.34 (s, 3H), 1.73–1.64 (m, 1H), 1.0 (d, *J*=6.8 Hz, 3H), 0.90 (d, *J*=6.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.1, 137.8, 136.3, 134.2, 130.6, 129.9, 128.2, 128.0, 127.4, 126.8, 93.0, 67.7, 65.2, 42.7, 31.1, 21.5, 21.4, 19.7, 18.8; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{21}H_{27}NO_3SNa$, 396.1609; found, 396.1608.

4.2.16. (2S,4S)-4-Isopropyl-2-(4-methylbenzyl)-3-tosyloxazolidine (***3o***). Colorless oil (93 mg, 75%); R_f 0.50 (pet. ether: EtOAc, 9:1); $[\alpha]_D^{21}$ −70.0 (*c* 1.0, $CHCl_3$); IR (cm^{-1}): 2961, 1348, 1163, 1090, 1012; ^1H NMR (400 MHz, $CDCl_3$) δ 7.22 (d, *J*=8.2 Hz, 2H), 7.31 (d, *J*=8.0 Hz, 2H), 7.17 (d, *J*=7.9 Hz, 2H), 7.11 (d, *J*=7.8 Hz, 2H), 5.0 (dd, *J*=8.5, 2.3 Hz,1H), 3.74 (dd, *J*=8.9, 1.8 Hz, 1H), 3.28–3.34 (m, 1H), 3.29 (dd, *J*=13.9, 2.0 Hz, 1H), 3.0 (dd, *J*=8.9, 6.0 Hz, 1H), 2.92 (dd, *J*=13.9, 8.5 Hz, 1H), 2.41 (s, 3H), 2.32 (s, 3H), 1.78–1.70 (m, 1H), 1.0 (d, *J*=6.8 Hz, 3H), 0.91 (d, *J*=6.7 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.0, 136.2, 134.2, 133.4, 129.8, 129.7, 129.0, 128.0, 93.1, 67.7, 65.2, 42.4, 31.2, 21.5, 21.0,19.7, 18.7; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{21}H_{27}NO_3SNa$, 396.1609; found, 396.1609.

4.2.17. (2S,4S)-4-Isopropyl-2-(4-fluorobenzyl)-3-tosyloxazolidine (***3p***). Colorless oil (110 mg, 88%); R_f 0.50 (pet. ether: EtOAc, 9:1); $[\alpha]_D^{21}$ −52.5 (*c* 1.0, $CHCl_3$); IR (cm^{-1}): 1510, 1348, 1222, 1163, 1093, 1013; ^1H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, *J*=7.9 Hz, 2H), 7.33–7.23 (m, 4H), 6.98 (t, *J*=8.4 Hz, 2H), 4.98 (d, *J*=6.2 Hz, 1H), 3.73 (d, *J*=8.7 Hz, 1H), 3.35–3.24 (m, 2H), 3.02–2.96 (m, 2H), 2.43 (s, 3H), 1.59–1.54 (m, 1H), 0.95 (d, *J*=6.7 Hz, 3H), 0.86 (d, *J*=6.5 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.9 (d, $^1J_{C-F}$=243.2 Hz), 144.2, 134.1, 131.93 (d, $^4J_{C-F}$=3.4 Hz), 131.56 (d, $^3J_{C-F}$=7.7 Hz), 129.9, 128.0, 115.2 (d, $^2J_{C-F}$=21.2 Hz), 92.8, 67.8, 65.2, 41.6, 31.1, 21.5, 19.7, 18.8; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{20}H_{24}FNO_3SNa$, 400.1359; found, 400.1357.

4.2.18. (2S,4S)-4-Isopropyl-2-(4-chlorobenzyl)-3-tosyloxazolidine (***3q***). Colorless oil (112 mg, 86%); R_f 0.50 (pet. ether: EtOAc, 9:1); $[\alpha]_D^{21}$ −62.5 (*c* 2.0, $CHCl_3$); IR (cm^{-1}): 2963, 2872, 1598, 1493, 1349, 1163, 1090, 1012; ^1H NMR (400 MHz, $CDCl_3$) δ 7.2 (d, *J*=8.0 Hz, 2H), 7.34–7.20 (m, 6H), 4.98 (d, *J*=6.1 Hz, 1H), 3.75 (d, *J*=8.9 Hz, 1H), 3.34 (t, *J*=6.8 Hz, 1H), 3.26 (d, *J*=12.9 Hz, 1H), 3.03–2.95 (m, 2H), 2.43 (s, 3H), 1.64–1.55 (m, 1H), 0.96 (d, *J*=6.8 Hz, 3H), 0.87 (d, *J*=6.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.2, 134.7, 134.0, 132.6, 131.4, 129.9, 128.3, 128.0, 92.6, 67.8, 65.2, 41.3, 31.1, 21.5, 19.7, 18.7; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{20}H_{24}ClNO_3SNa$, 416.1063; found, 416.1060.

4.2.19. (2S,4S)-4-Isopropyl-2-(4-bromobenzyl)-3-tosyloxazolidine (***3r***). Colorless oil (136 mg, 94%); R_f 0.50 (pet. ether: EtOAc, 9:1); $[\alpha]_D^{21}$ −61.5 (*c* 1.0, $CHCl_3$); IR (cm^{-1}): 2961, 2872, 1488, 1348, 1163, 1010; ^1H NMR (400 MHz, $CDCl_3$) δ 7.71 (d, *J*=8.2 Hz, 2H), 7.42 (d, *J*=8.2 Hz, 1H), 7.33 (d, *J*=8.0 Hz, 2H), 7.16 (d, *J*=8.2 Hz, 2H), 4.97 (dd, *J*=7.7, 2.2 Hz, 1H), 3.73 (dd, *J*=8.9, 1.5 Hz, 1H), 3.36–3.32 (m, 1H), 3.25 (dd, *J*=14.0, 2.0 Hz, 1H), 3.02–2.94 (m, 2H), 2.43 (s, 3H), 1.64–1.55 (m, 1H), 0.96 (d, *J*=6.8 Hz, 3H), 0.88 (d, *J*=6.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.2, 135.2, 134.0, 131.8, 131.3, 129.9, 128.0, 120.7, 92.5, 67.8, 65.2, 41.9, 31.1, 21.5, 19.7, 18.7; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{20}H_{24}BrNO_3SNa$, 460.0558; found, 460.0560.

4.2.20. (2S,4S)-4-Isopropyl-2-(4-phenylbenzyl)-3-tosyloxazolidine (***3s***). White solid (94 mg, 65%); R_f 0.50 (pet. ether: EtOAc, 9:1); mp 93–96 °C; $[\alpha]_D^{21}$ −94.5 (*c* 1.0, $CHCl_3$); IR (cm^{-1}): 2961, 1348, 1187, 1163; ^1H NMR (400 MHz, $CDCl_3$) δ 7.75 (d, *J*=8.0 Hz, 2H), 7.58–7.31 (m, 11H), 5.06 (d, *J*=6.4 Hz, 1H), 3.77 (d, *J*=8.7 Hz, 1H), 3.38–3.35 (m, 2H), 3.05–3.00 (m, 2H), 2.42 (s, 3H), 1.73–1.65 (m, 1H), 1.0 (d, *J*=6.7 Hz, 3H), 0.90 (d, *J*=6.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.1, 141.0, 139.7, 135.5, 134.1, 130.3, 129.9, 128.7, 128.0, 127.1, 127.0; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{26}H_{29}NO_3SNa$, 458.1766; found, 458.1766.

4.2.21. (2S,4S)-4-Isopropyl-2-(4-tert-butylbenzyl)-3-tosyloxazolidine (***3t***). Colorless oil (114 mg, 83%); R_f 0.50 (pet. ether: EtOAc, 9:1); $[\alpha]_D^{21}$ −60.9 (*c* 1.0, $CHCl_3$); IR (cm^{-1}) 2961, 2871, 1598, 1514, 1468, 1351, 1164, 1091, 1009, 888;^1H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, *J*=8.0 Hz, 2H), 7.33–7.20 (m, 6H), 5.02 (d, *J*=8.0 Hz, 1H), 3.74 (d, *J*=8.9 Hz, 1H), 3.36–3.27 (m, 2H), 3.02–2.91 (m, 2H), 2.41 (s, 3H), 1.67–1.59 (m, 1H), 1.30 (s, 9H), 0.97 (d, *J*=6.8 Hz, 3H), 0.89 (d, *J*=6.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 149.4, 144.0, 134.2, 133.3, 129.9, 129.5, 128.0, 125.2, 92.9, 67.7, 65.2, 42.1, 34.4, 31.3, 31.1, 21.5, 19.8, 18.7; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{24}H_{33}NO_3SNa$, 438.2079; found, 438.2079.

4.2.22. (2S,4S)-4-Isopropyl-2-(4-acetylbenzyl)-3-tosyloxazolidine (***3u***). Pale yellow oil (117 mg, 85%); R_f 0.45 (pet. ether: EtOAc, 4:1); $[\alpha]_D^{21}$ −54.7 (*c* 2.0, $CHCl_3$); IR (cm^{-1}): 3462, 3310, 3026, 2963, 2930, 2873, 1757, 1598, 1512, 1468, 1442, 1346, 1219, 1164, 1090, 1010, 971, 913; ^1H NMR (400 MHz, $CDCl_3$) δ 7.72 (d, *J*=7.9 Hz, 2H), 734–7.26 (m, 5H), 7.0 (d, *J*=8.2 Hz, 2H), 5.0 (d, *J*=7.4 Hz, 1H), 3.73 (d, *J*=8.8 Hz, 1H), 3.35–3.27; (m, 2H), 3.02–2.98 (m, 2H), 2.43 (s, 3H), 2.29 (s, 3H),1.63–1.56 (m, 1H), 0.96 (d, *J*=6.7 Hz, 3H), 0.87 (d, *J*=6.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 169.6, 149.5, 144.1, 134.0, 133.9, 131.0, 129.9, 128.0, 121.3, 92.7, 65.7, 65.2, 41.8, 31.0, 21.5, 21.1, 19.7, 18.7; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{22}H_{27}NO_5SNa$, 440.1508; found, 440.1507.

4.2.23. (2S,4S)-4-Isopropyl-2-(4-methoxybenzyl)-3-tosyloxazolidine (***3v***). Colorless oil (102 mg, 79%); R_f 0.35 (pet. ether: EtOAc, 9:1); $[\alpha]_D^{21}$ −61.2 (*c* 1.5, $CHCl_3$); IR (cm^{-1}): 3439, 1611, 1513, 1465, 1348, 1300, 1248, 1163, 1090, 1036; ^1H NMR (400 MHz, $CDCl_3$) δ 7.72 (d, *J*=8.2 Hz, 2H), 7.32 (d, *J*=8.0 Hz, 2H), 7.20 (d, *J*=8.5 Hz, 2H), 6.84 (d, *J*=8.5 Hz, 2H), 4.98 (dd, *J*=8.1, 2.2 Hz, 1H), 3.78 (s, 3H), 3.74 (dd, *J*=8.9, 1.7 Hz, 1H), 3.37–3.33 (m, 2H), 3.25 (dd, *J*=14.1, 2.0 Hz, 1H), 3.02 (dd, *J*=8.9, 6.1 Hz, 1H), 2.93 (dd, *J*=14.1, 8.1 Hz, 1H), 2.42 (s, 3H), 1.72–1.61 (m, 1H), 0.98 (d, *J*=6.8 Hz, 3H), 0.89 (d, *J*=56.7 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.4, 144.0, 134.2, 130.9, 129.8, 128.5, 128.0,

113.7, 93.1, 67.7, 65.2, 55.2, 41.7, 31.1, 21.5, 19.7, 18.7; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{21}H_{27}NO_4SNa$, 412.1558; found, 412.1556.

*4.2.24. (2S,4S)-4-Isopropyl-2-(4-ethoxybenzyl)-3-tosyloxazolidine (**3w**).* Colorless oil (111 mg, 83%); R_f 0.35 (pet. ether: EtOAc, 9:1); $[\alpha]_D^{21}$ −68.7 (*c* 1.0, $CHCl_3$); IR (cm^{-1}): 2963, 2927, 2872, 1609, 1512, 1348, 1245, 1215, 1187, 1115, 1089, 1047, 1014; ^1H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, *J*=8.1 Hz, 2H), 7.3 (d, *J*=8.0 Hz, 2H), 7.19 (d, *J*=8.4 Hz, 2H), 6.83 (d, *J*=8.5 Hz, 2H), 4.98 (dd, *J*=8.1, 2.2 Hz, 1H). 4.01 (q, *J*=7.0 Hz, 2H), 3.74 (dd, *J*=8.9, 1.7 Hz, 1H), 3.37−3.3 (m, 1H), 3.24 (dd, *J*=14.1, 2.1 Hz, 1H), 3.01 (dd, *J*=8.9, 6.0 Hz, 1H), 2.92 (dd, *J*=14.1, 8.2 Hz, 1H), 2.42 (s, 3H), 1.71−1.60 (m, 1H), 1.40 (t, *J*=7.0 Hz, 3H), 0.98 (d, *J*=6.8 Hz, 3H), 0.89 (d, *J*=6.7 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.8, 144.0, 134.2, 130.9, 129.8, 128.3, 128.0, 114.3, 93.1, 67.1, 65.2, 63.4, 41.7, 31.1, 21.5, 19.8, 18.8, 14.8; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{22}H_{29}NO_4SNa$, 426.1715; found, 426.1715.

*4.2.25. (2S,4S)-4-Isopropyl-2-(2-chlorobenzyl)-3-tosyloxazolidine (**3x**).* Colorless oil (92 mg, 71%); R_f 0.50 (pet. ether: EtOAc, 9:1); $[\alpha]_D^{21}$ −68.7 (*c* 1.0, $CHCl_3$); IR (cm^{-1}): 2963, 1474, 1350, 1164, 1090, 1058; ^1H NMR (400 MHz, $CDCl_3$) δ 7.75 (d, *J*=7.8 Hz, 2H), 7.37−7.19 (m, 6H), 5.16 (d, *J*=8.6 Hz, 1H), 3.77 (d, *J*=8.8 Hz, 1H), 3.55 (d, *J*=13.8 Hz, 1H), 3.44 (t, *J*=11.4 Hz, 1H), 3.08−3.01 (m, 2H), 2.42 (s, 3H), 1.91−1.83 (m, 1H), 1.06 (d, *J*=6.7 Hz, 3H), 0.97 (d, *J*=6.5 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.1, 134.4, 134.3, 134.0, 132.2, 130.0, 129.4, 128.2, 128.0, 126.6; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{20}H_{24}ClNO_3SNa$, 416.1063; found, 416.1064.

*4.2.26. (2S,4S)-4-Isopropyl-2-(2-bromobenzyl)-3-tosyloxazolidine (**3y**).* Colorless oil (120 mg, 83%); R_f 0.50 (pet. ether: EtOAc, 9:1); $[\alpha]_D^{21}$ −62.5 (*c* 1.0 $CHCl_3$); IR (cm^{-1}): 2963, 2873, 1598, 1472, 1439, 1351, 1164, 1091; ^1H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J*=8.2 Hz, 2H), 7.55 (d, *J*=7.9 Hz, 1H), 7.33−7.23 (m, 4H), 7.12−7.08 (m, 1H), 5.17 (dd, *J*=8.8, 2.9 Hz, 1H), 3.78 (dd, *J*=8.9, 2.3 Hz, 1H), 3.56 (dd, *J*=13.8, 2.9 Hz, 1H), 3.46−3.42 (m, 1H), 3.09−303 (m, 2H), 2.41 (s, 3H), 1.94−1.85 (m, 1H), 1.07 (d, *J*=6.8 Hz, 3H), 0.98 (d, *J*=6.7 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.1, 136.1, 134.0, 132.8, 132.3, 129.9, 128.5, 128.0, 127.3, 124.8, 96.2, 67.7, 65.3, 42.7, 31.4, 21.5, 19.8, 18.7; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{20}H_{24}BrNO_3SNa$, 460.0558; found, 460.0557.

*4.2.27. (2S,4S)-4-Isopropyl-2-(3-chorobenzyl)-3-tosyloxazolidine (**3z**).* Colorless oil (57 mg, 44%); R_f 0.50 (pet. ether: EtOAc, 9:1); $[\alpha]_D^{21}$ −61.6 (*c* 1.0, $CHCl_3$); IR (cm^{-1}): 1349, 1163; ^1H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, *J*=8.0 Hz, 1H), 7.34−7.18 (m, 6H), 5.0 (d, *J*=6.2 Hz, 1H), 3.75 (d, *J*=8.9 Hz, 1H), 3.36−3.25 (m, 2H), 3.64−2.96 (m, 2H), 2.43 (s, 3H), 1.62−1.53 (m, 1H), 0.96 (d, *J*=6.8 Hz, 3H), 0.88 (d, *J*=6.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.2, 138.2, 134.0, 133.9, 130.1, 129.9, 129.4, 128.3, 128.0, 126.9, 92.4, 67.8, 65.2, 42.1, 31.1, 21.5, 19.7, 18.8; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{20}H_{24}ClO_3SNa$, 416.1063; found, 416.1065.

*4.2.28. (2S,4S)-4-Isopropyl-2-(3-bromobenzyl)-3-tosyloxazolidine (**3aa**).* Colorless oil (59 mg, 41%); R_f 0.50 (pet. ether: EtOAc, 9:1); $[\alpha]_D^{21}$ −54.0 (*c* 1.0, $CHCl_3$); IR (cm^{-1}): 2962, 2872, 1597, 1349, 1163; ^1H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, *J*=8.1 Hz, 2H), 7.44−7.14 (m, 6H), 5.0 (dd, *J*=7.6 Hz, 1.7 Hz, 1H), 3.75 (d, *J*=8.9 Hz, 1H), 3.35−3.24 (m, 2H), 3.04−2.95 (m, 2H), 2.43 (s, 3H), 1.60−1.53 (m, 1H), 0.96 (d, *J*=6.8 Hz, 3H), 0.87 (d, *J*=6.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.2, 138.6, 134.0, 133.0, 129.9, 129.8, 129.7, 128.8, 128.0, 122.2, 92.4, 67.8, 65.2, 42.1, 31.1, 21.5, 19.7, 18.8; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{20}H_{24}BrNO_3SNa$, 460.0558; found, 460.0552.

*4.2.29. (2S,4S)-4-Isopropyl-2-(2,4,6-trimethylbenzyl)-3-tosyloxazolidine (**3 ab**).* Colorless oil (111 mg, 84%); R_f 0.60 (pet. ether: EtOAc, 9:1); $[\alpha]_D^{21}$ −74.1 (*c* 1.0, $CHCl_3$); IR (cm^{-1}): 2961, 2872, 1350, 1163, 1090, 1073, 1031, 1004; ^1H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, *J*=8.2 Hz, 2H), 7.30 (d, *J*=8.0 Hz, 2H), 6.85 (s, 2H), 5.0 (dd, *J*=9.9, 2.0 Hz, 1H), 3.73 (dd, *J*=9.0, 1.72 Hz, 1H), 3.44−3.41 (m, 1H), 3.37 (dd, *J*=14.1, 1.6 Hz, 1H), 3.03 (dd, *J*=14.0, 10.0 Hz, 1H), 2.94 (dd, *J*=8.9, 1.6 Hz, 1H), 2.41 (s, 3H), 2.38 (s, 6H), 2.23 (s, 3H),1.99−1.90 (m, 1H), 1.1 (d, *J*=6.8 Hz, 3H), 1.01 (d, *J*=6.7 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.1, 137.3, 136.1, 134.2, 130.5, 129.8, 129.0, 127.9, 92.2, 67.5, 65.2, 36.5, 31.5, 21.5, 20.8, 20.6, 19.7, 18.7; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{23}H_{31}NO_3SNa$, 424.1922; found, 424.1922.

*4.2.30. (2S,4S)-4-Isopropyl-2-(2-choromethylbenzyl)-3-tosyloxazolidine (**3ac**).* White solid (103 mg, 76%); mp 136−140 °C; R_f 0.50 (pet. ether: EtOAc, 9:1); $[\alpha]_D^{21}$ −76.1 (*c* 1.0, $CHCl_3$); IR (cm^{-1}): 2961, 2928, 1348, 1216, 1187, 1163, 1013; ^1H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, *J*=8.1 Hz, 2H), 7.40−7.21 (m, 6H), 5.0 (dd, *J*=7.9, 2.0 Hz, 1H), 4.57 (s, 2H), 3.75−3.70 (m, 1H), 3.35−3.29 (m, 2H), 303−3.00 (m, 2H), 2.42 (s, 3H), 1.64−1.58 (m, 1H), 0.96 (d, *J*=6.8 Hz, 3H), 0.88 (d, *J*=6.7 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.2, 136.7, 135.9, 134.1, 130.4, 129.9, 128.5, 128.0, 92.7, 67.8, 65.2,46.1, 42.3, 31.1, 21.5, 19.7, 18.7; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{21}H_{26}ClNO_3SNa$, 430.1220; found, 430.1220.

*4.2.31. (2S,4S)-4-Isopropyl-2-(1-phenylethyl)-3-tosyloxazolidine (**3ad**).* [Mixture of diastereomers ***A*** and **B**; d.r.=1.2: 1.0]: colorless oil (100 mg, 81%); R_f 0.50 (pet. ether: EtOAc, 9:1); IR (cm^{-1}): 1451, 1440, 1355, 1163, 1090, 1021; ^1H NMR (400 MHz, $CDCl_3$) δ 7.74 (d, *J*=8.0 Hz, 2H, 2*A*), 7.67 (d, *J*=8.0 Hz, 1.7H, 2*B*), 7.33−7.21 (m, 13H, 7*A*+7*B*), 5.07 (d, *J*=6.2 Hz, 1H, 1*A*), 4.90 (d, *J*=3.0 Hz, 0.86H, 1*B*), 3.76 (d, *J*=8.8 Hz, 0.86H, 1*B*), 3.61 (dd, *J*=8.6, 2.3 Hz, 1H, 1*A*), 3.49−3.43 (m, 0.86H, 1*B*), 3.31 (d, *J*=9.8, 5.8 Hz, 0.86H, 1*B*), 3.24−3.13 (m, 2H, 2*A*), 3.04 (t, *J*=7.5 Hz, 1H, 1*A*), 2.96 (dd, *J*=8.6, 6.0 Hz, 0.86H, 1*B*), 2.42−2.40 (s, 5.6H, 3*A*+3*B*), 1.88−1.79 (m, 0.86H,1*B*), 1.46 (d, *J*=7.3 Hz, 3H, 3*A*), 1.35 (d, *J*=7.1 Hz, 2.6H, 3*B*), 1.19−1.12 (m, 3.6H, 1*A*+3*B*), 0.93 (d, *J*=6.5 Hz, 2.6H, 3*B*), 0.84 (d, *J*=6.6 Hz, 3H, 3*A*), 0.72 (d, *J*=6.5 Hz, 3H, 3*A*); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.0, 142.6, 141.3, 134.4, 134.2, 129.83, 129.80, 128.9, 128.3, 128.2, 128.14, 128.07, 127.99, 126.74, 126.71, 96.2, 95.9, 68.5, 68.0, 65.8, 65.7, 44.3, 43.7, 31.2, 31.0, 21.51, 21.49, 20.04, 19.8, 19.6, 19.2, 17.7, 13.2; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{21}H_{27}NO_3SNa$, 396.1609; found, 396.1609.

*4.2.32. (2S,4S)-4-Isopropyl-2-(1-(p-acetoxy-phenyl)-ethyl)-3-tosyloxazolidine (**3af**).* [Mixture of diastereomers ***A*** and **B**; d.r.=1.0: 1.2]: colorless oil (104 mg, 78%); R_f 0.50 (pet. ether: EtOAc, 9:1); IR (cm^{-1}): 2963, 2873, 1610, 1513, 1464, 1349, 1247, 1165, 1120, 1066, 1030, 946; ^1H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, *J*=8.1 Hz, 2H, 2*A*), 7.67 (d, *J*=8.1 Hz, 2.4H, 2*B*), 7.32−7.20 (m, 8.8H, 4*A*+4*B*), 6.88−6.28 (m, 4.4H, 2*A*+2*B*), 5.02 (d, *J*=6.2 Hz, 1H, 1*A*), 4.86 (d, *J*=3.2 Hz, 1.2H. 1*B*), 3.79−3.74 (m, 7.8H, 3*A*+3*B*+1*B*), 3.6 (dd, *J*=9.1, 3.0 Hz, 1.2H, 1*B*), 3.43−3.37 (m, 1.2H, 1*B*), 3.30 (dd, *J*=9.9, 5.7 Hz, 1.2H, 1*B*), 3.24−3.19 (m, 1H, 1*A*) 3.16−3.09 (m, 1H, 1*A*), 3.03 (dd, *J*=8.4, 6.6 Hz, 1H, 1*A*), 2.95 (dd, *J*=8.8, 6.0 Hz, 1H, 1*A*), 2.41 (s, 3H, 3*A*), 2.40 (s, 3.6H, 3*B*), 1.88−1.78 (m, 1.2H, 1*B*), 1.43 (d, *J*=7.2 Hz, 3H, 3*A*), 1.32 (d, *J*=7.1 Hz, 3.6H, 3*B*), 1.21−1.12 (m, 4.6H, 3*B*+1*A*), 0.93 (d, *J*=6.5 Hz, 3.6H, 3*B*), 0.88 (d, *J*=6.7 Hz, 3*A*), 0.73 (d, *J*=6.6 Hz, 3H, 3*A*); ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.4, 158.3, 144.0, 134.6, 134.4, 134.1, 133.3, 130.4, 129.80, 129.79, 129.15, 129.14, 128.06, 113.7, 113.4, 96.3, 96.0, 68.4, 68.0, 65.8, 65.7, 55.24, 55.18, 43.4, 42.8, 31.2, 31.0, 21.51, 21.49, 20.0, 19.9, 19.6, 19.2, 17.8, 13.2; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{22}H_{29}NO_4SNa$, 426.1715; found, 426.1715.

*4.2.33. (2S,4S)-4-Isopropyl-2-(phenylmethyl-d_2)-3-tosyloxazolidine (**3 ag**).* Colorless oil (94 mg, 79%); R_f 0.50 (pet. ether: EtOAc, 9:1); $[\alpha]_D^{21}$ −25.1 (*c* 1.0, $CHCl_3$); IR (cm^{-1}): 1349, 1163, 1098, 1015; ^1H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, *J*=8.0 Hz, 2H), 7.33−7.24 (m, 7H), 5.02 (s, 1H, *H*C-CD_2Ph), 3.75 (d, *J*=8.9 Hz, 1H), 3.35 (t, *J*=6.7 Hz, 1H), 3.02 (dd, *J*=8.7, 6.2 Hz, 1H), 2.42 (s, 3H), 1.69−1.62 (m, 1H), 0.98 (d, *J*=6.8 Hz, 3H), 0.89 (d, *J*=6.7 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.1, 136.3,

134.2, 129.90, 129.86, 128.2, 128.0, 126.7, 92.8, 67.7, 65.2, 42.0 (quint, $^1J_{C-D}$=19.45 Hz), 31.1, 21.5, 19.7, 18.7; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{20}H_{23}D_2NO_3SNa$, 384.1578; found, 384.1578.

4.3. *m-CPBA* mediated geminal oxyamination: *Method B*

4.3.1. Synthesis of oxazolidine 3b through the m-CPBA mediated geminal oxyamination: Method B. To a colorless solution of *N*-Ts valinol **1b** (84 mg, 0.33 mmol) and styrene **2a** (85 mg, 0.82 mmol) in CH_2Cl_2 (3 mL) in a well dried Schlenk flask under argon atmosphere was added *m*-CPBA (173 mg, 1.0 mmol) and PTSA·H_2O (69 mg, 0.36 mmol) at room temperature [25 °C]. The progress of the reaction was monitored by TLC. After stirring the reaction mixture for 24 h at room temperature 5 mL of satd soln of aq $NaHCO_3$ and 5 mL of satd soln of aq $Na_2S_2O_3$ were added in succession and extracted with CH_2Cl_2. The combined organic layers were dried (anhyd. Na_2SO_4), filtered and concentrated in vacuo. The crude product obtained was purified by flash chromatography (pet. ether: Et_2O, 8:1) to furnish oxazolidine **3b** as a colorless oil (93 mg, 78%) in pure form.

*4.3.2. (2S,4S)-4-Isopropyl-2-(phenylmethyl-d)-3-tosyloxazolidine-2-d (**3ah**): Method B.* [Mixture of diastereomers]: colorless oil (80 mg, 67%); R_f 0.50 (pet. ether: EtOAc, 9:1); $[\alpha]_D^{21}$ −64.7 (*c* 1.0, $CHCl_3$); IR (cm^{-1}): 2961, 2871, 1350, 1163, 1088; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.74 (d, *J*=8.1 Hz, 4H, 2*A*+2*B*), 7.33–7.22 (m, 14H, 7*A*+7*B*), 3.75 (d, *J*=9.0 Hz, 2H, 1*A*+1*B*), 3.38–3.33 (m, 2H, 1*A*+1*B*), 3.29 (s, 1H, 1A, *H*CDPh), 3.05–3.00 (m, 2H, 1*A*+1*B*), 2.97 (s, 1H, 1*B*, *H*CDPh), 2.42 (s, 6H, 3*A*+3*B*), 1.72–1.60 (m, 2H, 1*A*+1*B*), 0.98 (d, *J*=6.6 Hz, 6H, 3*A*+3*B*), 0.90 (d, *J*=6.6 Hz, 6H, 3*A*+3*B*); ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.07, 144.04, 136.40, 136.37, 136.35, 134.3, 129.90, 129.85, 128.2, 128.0, 126.6, 92.5 (*t*, $^1J_{C-D}$=24.0 Hz, *C*DNO), 67.7, 65.2, 42.22 (*t*, $^1J_{C-D}$=19.5 Hz, *C*HDPh of *diast.* ***A***), 42.17 (*t*, $^1J_{C-D}$=19.6 Hz, *C*HDPh of *diast.* ***B***), 31.1, 21.5, 19.7, 18.7; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{20}H_{23}D_2NO_3SNa$, 384.1579; found, 384.1578.

4.4. Synthesis of oxazolidine 3b by the addition of *N*-Ts-aminoalcohol and epoxide 6a: *Method C*

PTSA·H_2O (69 mg, 0.36 mmol) was added to a colorless solution of *N*-Ts valinol **1b** (85 mg, 0.33 mmol) and styrene oxide **6a** (52 mg, 0.43 mmol) in CH_2Cl_2 (3 mL) in a well dried Schlenk flask under argon atmosphere at room temperature [25 °C]. The progress of the reaction was monitored by TLC. After stirring the reaction mixture for 24 h at room temperature 5 mL of satd soln of aq $NaHCO_3$ was added and extracted with CH_2Cl_2. The combined organic layers were dried (anhyd. Na_2SO_4), filtered and concentrated in vacuo. The crude product obtained was purified by flash chromatography (pet. ether: Et_2O, 8:1) to furnish oxazolidine **3b** as a colorless oil (89 mg, 75%) in pure form.

4.5. Synthesis of imidazolidines 5a–5e

*4.5.1. General procedure for the synthesis of imidazolidines **5a**–**5e**.* To a colorless solution of corresponding *N, N′*-di Ts-diamine (0.33 mmol) and styrene (0.36 mmol) in CH_2Cl_2 (3 mL) in a well dried Schlenk flask under argon atmosphere was added PhI(O-$COCF_3)_2$ (0.50 mmol) and PTSA·H_2O (0.36 mmol) at room temperature [25 °C]. The progress of the reaction was monitored by TLC. After stirring the reaction mixture for 8 h at room temperature 5 mL of satd soln of aq $NaHCO_3$ was added and extracted with CH_2Cl_2. The combined organic layers were dried (anhyd. Na_2SO_4), filtered and concentrated in vacuo. The crude product obtained was purified by flash chromatography (pet. ether: EtOAc, 7:1) to furnish imidazolidines in pure form.

*4.5.2. (±)-2-Benzyl-4-methyl-1,3-ditosylimidazolidine (**5a**).* White solid (126 mg, 79%); R_f 0.45 (pet. ether: EtOAc, 4:1); mp 157–159 °C; IR (cm^{-1}): 3029, 2930, 2870, 1598, 1494, 1453, 1347, 1212, 1165, 1092; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 (d, *J*=8.0 Hz, 2H), 7.33–7.26 (m, 9H), 7.14 (d, *J*=8.0 Hz, 2H), 5.50 (t, *J*=9.0 Hz, 1H), 3.33–3.25 (m, 3H), 3.14 (dd, *J*=13.8, 5.5 Hz, 1H), 2.44 (t, *J*=5.8 Hz, 1H), 2.44 (s, 3H), 2.41 (s, 3H), 0.97 (d, *J*=5.6 Hz, 3H) ^{13}C NMR (100 MHz, $CDCl_3$) δ 144.0, 143.9, 135.2, 134.7, 133.7, 131.1, 129.7, 129.6, 128.1, 127.9, 127.5, 126.9, 76.4, 55.1, 52.8, 43.3, 21.62, 21.57, 19.5; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{25}H_{28}N_2O_4S_2Na$, 507.1388; found, 507.1384.

*4.5.3. (2R,4S)-2,4-Dibenzyl-1,3-ditosylimidazolidine (**5b**).* White solid (170 mg, 92%); R_f 0.45 (pet. ether: EtOAc, 4:1); mp 219–220 °C; $[\alpha]_D^{21}$ +1.8 (*c* 0.5, Acetone); IR (cm^{-1}): 3639 (br), 3381 (br), 3080 (br), 3020 (br), 1514 (br), 1351, 1271, 1177, 1129, 1068, 1021; ^{1}H NMR (400 MHz, Acetone-d_6) δ 7.68 (d, *J*=8.1 Hz, 2H), 7.38–7.18 (m, 14H), 7.0 (d, *J*=7.2 Hz, 2H), 5.27 (dd, *J*=5.0, 3.6 Hz, 1H), 3.65–3.58 (m, 1H), 3.42 (dd, *J*=13.8, 3.3 Hz, 2H), 3.11 (dd, *J*=13.8, 5.3 Hz, 1H), 2.93–2.71 (m, 3H), 2.45 (s, 3H), 2.43 (s, 3H), 1.90 (dd, *J*=13.5, 10.7 Hz, 1H); ^{13}C NMR (100 MHz, Acetone-d_6) δ 145.10, 145.06, 138.08, 136.6, 135.0, 134.7, 132.3, 130.8, 130.6, 130.0, 129.5, 129.0, 128.7, 128.6, 127.8, 127.6, 77.3, 60.6, 51.2, 43.2, 40.9, 21.6; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{31}H_{32}N_2O_4S_2Na$, 583.1701; found, 583.1705.

*4.5.4. (2R,4S)-2-Benzyl-4-isobutyl-1,3-ditosylimidazolidine (**5c**).* White solid (146 mg, 84%); R_f 0.45 (pet. ether: EtOAc, 4:1); mp 171–173 °C; $[\alpha]_D^{21}$ −0.80 (*c* 1.0, Acetone); IR (cm^{-1}): 3634 (br), 3383 (br), 3080 (br), 3017 (br), 2822, 1512 (br), 1485, 1352, 1271, 1176, 1030, 1069; ^{1}H NMR (400 MHz, Acetone-d_6) δ 7.52 (d, *J*=8.2 Hz, 2H), 7.49 (d, *J*=8.2 Hz, 2H), 7.38–7.24 (m, 9H), 5.10 (t, *J*=4.0 Hz, 1H), 3.48–3.41 (m, 2H), 3.24 (dd, *J*=13.8, 4.6 Hz, 1H), 2.85–2.81 (m, 2H), 2.56 (s, 3H), 2.42 (s, 3H), 1.39–1.29 (m, 1H), 1.23–1.17 (m, 1H), 0.74–0.67 (m, 7H); ^{13}C NMR (100 MHz, Acetone-d_6) δ 145.1, 144.8, 136.5, 135.1, 134.2, 132.3, 130.7, 128.8, 128.5, 127.6, 77.0, 57.8, 52.9, 44.2, 42.9, 25.4, 23.3, 22.2, 21.7, 21.6; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{28}H_{34}N_2O_4S_2Na$, 549.1858; found, 549.1856.

*4.5.5. (2R,4S)-2-Benzyl-4-phenyl-1,3-ditosylimidazolidine (**5d**).* White solid (129 mg, 71%); R_f 0.45 (pet. ether: EtOAc, 4:1); mp 65–67 °C; $[\alpha]_D^{21}$ −23.3 (*c* 1.0, Acetone); IR (cm^{-1}): 3670, 3382, 3080, 3015, 2832, 1512, 1484, 1357, 1131, 1067; ^{1}H NMR (400 MHz, Acetone-d_6) δ 7.53 (d, *J*=8.2 Hz, 2H), 7.44 (d, *J*=8.2 Hz, 2H), 7.34–7.21 (m, 12H), 7.08–7.06 (m, 2H), 5.70 (dd, *J*=10.6, 4.0 Hz, 1H), 4.20 (dd, *J*=9.4, 7.1 Hz, 1H), 3.90 (dd, *J*=12.7, 6.9 Hz, 1H), 3.40–3.29 (m, 2H), 3.12 (dd, *J*=12.6, 9.5 Hz, 1H), 2.45 (s, 3H), 2.43 (s, 3H); ^{13}C NMR (100 MHz, Acetone-d_6) δ 145.6, 145.0, 138.6, 136.8, 136.2, 135.2, 131.6, 130.7, 130.6, 129.13, 129.09, 129.01, 128.7, 128.4, 128.3, 127.7, 77.6, 64.2, 54.8, 44.0, 21.59, 21.56; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{30}H_{30}N_2O_4S_2Na$, 569.1545; found, 569.1544.

*4.5.6. 2-Benzyl-1,3-ditosylimidazolidine (**5e**).* [*Contains 3% of piperazine*]: white solid (121 mg, 78%); R_f 0.45 (pet. ether: EtOAc, 4:1); mp 157–159 °C; IR (cm^{-1}): 3031, 1580, 1348, 1162, 1091, 1028; ^{1}H NMR (400 MHz, Acetone-d_6) δ 7.51 (d, *J*=8.1 Hz, 4H), 7.36–7.28 (m, 9H), 5.25 (t, *J*=4.0 Hz, 1H), 3.27 (d, *J*=4.0 Hz, 2H), 3.03–2.90 (m, 4H), 2.46 (s, 6H); ^{13}C NMR (100 MHz, Acetone-d_6) δ 145.0, 136.5, 135.4, 132.0, 130.9, 129.0, 128.5, 127.7, 75.8, 47.3, 43.5, 21.7; HRMS (ESI-QTOF) *m/z*: $[M+Na]^+$ calcd for $C_{24}H_{26}N_2O_4S_2Na$, 493.1232; found, 493.1235.

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Supplementary data

Supplementary data associated with this article can be found in the online version, at http://dx.doi.org/10.1016/j.tet.2016.01.005.

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