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FULL PAPER

An Assessment of Electrophilic *N*-transfer of Oxaziridine with Different 2-, 3-, and 4-carbon Donor-Acceptor Substrates to Furnish Diverse *N*-containing Heterocycles in a Single Step

Asit Ghosh,[a] Vatan Chawla,[a] and Prabal Banerjee*[a]

Dedication ((optional))

Abstract: An assessment of the scopes and limitations of electrophilic *N*-transfer of oxaziridine in the presence of MgI_2 has been carried out with different donor-acceptor carbon substrates. One step access to multifunctional three-, four-, and five-membered *N*-containing heterocycles has been demonstrated. The different donor and acceptor substituents present in the carbon substrates play a crucial role in determining the feasibility of the *N*-transfer process. This study portrays the possibilities to incorporate amine functionality in the molecules required for the synthesis of useful drug or modification of drug for a particular response. In addition, the generation of new stereocenters in the *N*-containing heterocycles through this single-step process offers favorable scopes for the synthesis of valuable drug molecules.

Introduction

Development of efficient and selective protocols for the construction of novel molecular architectures always remained a formidable challenge in Organic Synthesis. [1] In this context, as the *N*-containing three-, four-, and five-membered heterocycles are prevalently represented in medicines and bio-active natural products,[2] immense attention has been made over the decades to advance the facile access to those compounds (Figure 1). Although numerous processes have been established in the recent past for the synthesis of those scaffolds, a majority of them virtually involved multi-step reactions. [3] Hence, the single-step formal incorporation of an amine functionality in a molecule is a quite challenging and fascinating alternative to the previously developed traditional strategies. Also, the electrophilic *N*-transfer can involve in ring enlargement of small rings to their next nitrogenous homolog. Subsequently, this protocol is very much useful to explore the scope to make an array of three-, four- and higher membered *N*-containing heterocycles in a quick process. In addition, as nitrogen plays the role of the crucial biological linker, chemoselective electrophilic *N*-transfer can be an excellent tool for the modification of a molecule through the selective formation of C-N bond in order to get a particular response. Inevitably, significant efforts have been initiated by the researchers in recent times to develop the most effective aminating agent.[4]

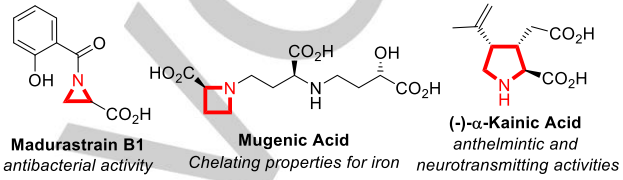
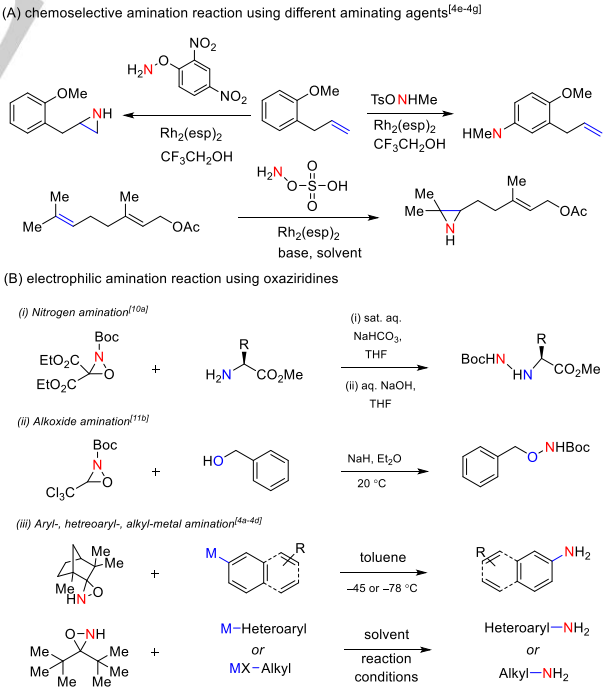


Figure 1. Representative examples of biologically active molecules bearing three-, four-, five-membered *N*-containing heterocycle.

In this perspective, Kürti and coworkers displayed the use of different hydroxylamines and hydroxylamine sulfonic acid as the valuable chemoselective aminating agents to furnish diverse arylamines and aziridines (Scheme-1A). [4e-4g] Utilizing the similar reactivity of weaker N-O bond, nitrosocarbonyl are also reported to take part in electrophilic amination reactions. [5] In addition, employing different other aminating agents such as azides, aryl amines, aziridine, etc., several ring expansion reactions also have



Scheme 1. Amination reactions using different aminating agents and oxaziridines.

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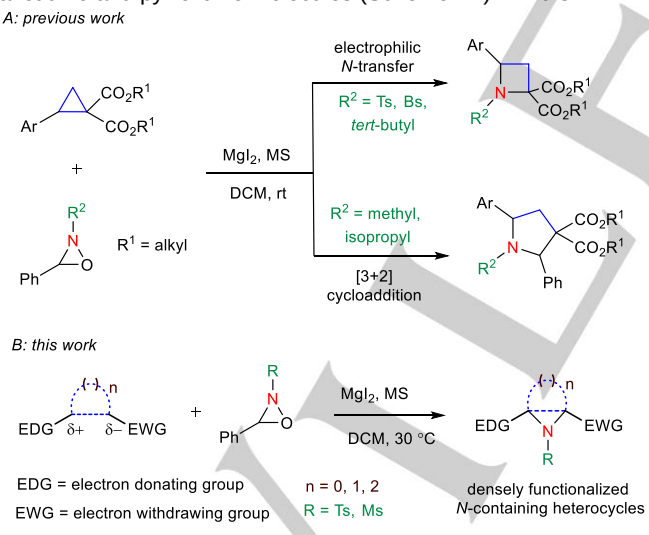
been developed in order to get an array of *N*-containing heterocycles. [6]

Similarly, oxaziridine[7] can be a useful source of the electrophilic nitrogen atom to introduce the amine functionality in the molecule (Scheme-1B). However, the reactivity of oxaziridine [8] as an *N*-transfer agent is not well established and largely depends on the nature of the substituent present on the nitrogen atom of oxaziridine. In accordance with the prior reports, oxaziridines bearing electron withdrawing substituents on nitrogen atom such as *N*-phosphinoyloxaziridines, *N*-sulfonyloxaziridines, and *N*-fluoroalkyl oxaziridine have been extensively utilized to supply their oxygen rather than their amino group to varieties of nucleophilic substrates. Unlike to the well-known reactivity, when oxaziridines contain small *N*-substituent such as *N*-H, *N*-alkyl-etc. are reported to involve in *N*-transfer reaction with different nucleophiles like sulfur, [9] nitrogen, [10] alkoxide[11] and phosphorus[12] nucleophiles. Despite these reports, there is a paucity of electrophilic amination, especially for carbon nucleophiles. Kurti et al. recently demonstrated the interesting electrophilic amination of aryl-, heteroaryl-, and alkyl-metals using *N*-H oxaziridine.[4a-4d] To the best of our knowledge, electrophilic *N*-transfer of oxaziridine to carbon nucleophiles, particularly with bulky *N*-substituent is still underdeveloped which reveals the need to diversify the *N*-transfer applicability of oxaziridine.

It has been our ambition to find a supplementary and common protocol for electrophilic *N*-transfer of oxaziridines for carbon substrates. In our previous report, we have shown the *N*-substituent controlled dual reactivity of oxaziridine to donor-acceptor cyclopropane (DAC) for the one-step access to valuable azetidine and pyrrolidine molecules (Scheme 2A). [13] It is



Scheme 2. Electrophilic *N*-transfer of oxaziridine to donor-acceptor carbon substrates.

noteworthy that even with the bulky *N*-substituent also we could able to get the corresponding *N*-transferred adduct in good yield. Indeed, the *N*-sulfonyl oxaziridines that were most commonly used as the *O*-transfer agent also followed the nonconventional and selective route of *N*-transfer reaction in the presence of magnesium iodide. The interesting phenomenon of selective *N*-transfer was well-supported by the theoretical outcomes of the mechanistic study. Hence, this new mode of reactivity of oxaziridine in the presence of Lewis acids manifests wide opportunities to utilize them as the formal source of nitrogen for a broad range of carbon nucleophiles. Making use of this concept, we insisted on exploring the sheer chance of oxaziridine to transfer the amine functionality to a variety of different other donor-acceptor carbon substrates (Scheme 2B).

Our prime focus of this investigation was to analyze the scope of *N*-transfer methodology for a broad range of carbon substrates and thereby to make it as a general benchtop synthetic tool for formal insertion of the nitrogen atom. Moreover, this single-step chemoselective C-N bond formation employing readily available oxaziridines may enhance their synthetic utility. Comprehending the significance of this distinct reactivity of oxaziridine, a series of different carbon substrates have been examined for the title transformation which helped us to make the conclusive remark on its scopes and limitations.

Results and Discussion

As the stability of phenyl-substituted *N*-tosyl oxaziridine **2a** ('Davis oxaziridine') is comparatively higher than the *N*-H oxaziridine ('Schmitz oxaziridine'), [7a] & [7c] **2a** was taken as the model substrate for the *N*-transfer reaction. In the perspective of making an array of highly functionalized three-, four-, five-, and higher membered *N*-containing heterocycles we became fascinated to check the possibility of this direct *N*-transfer approach. At the outset of our investigation, we choose two-carbon containing donor-acceptor substrates to get functionalized aziridine molecules (Table 1). When we used an activated alkene **1a** for the designed *N*-transfer reaction, we got the corresponding aminated adduct **3a** in low yield using 20 mol% of magnesium iodide (Table 1, entry 1). To improve the yield of **3a**, we further performed the reaction varying the Lewis acids. However, the *N*-transfer reaction between **1a** and **2a** failed in the presence of other Lewis acids that could only afford the respective imine *N*-benzylidene-4-methylbenzenesulfonamide obtained from **2a** (see optimization table in the Supporting Information). This phenomenon insisted us to test the transformation with the more activated alkenes such as **1b** and **1c** bearing more electronically rich donor functional groups. However, due to strong reactive nature of **1b** and **1c** in the presence of Lewis acids, they lead to the formation of undetermined complex reaction mixtures (Table 1, entry 2 and 3). Considering the marked difference in reactivity between **1a** and **1c** for electrophilic *N*-transfer, we envisioned that if we could tune the reactivity by choosing relatively less active D-A alkene [14] or less active oxaziridine, the desired transformation may become facile. To our delight, mild reactive D-A alkene **1d** afforded the corresponding *N*-transfer adduct **3b** in moderate yield (Table 1, entry 4). Similarly, oxaziridine **2b** bearing a *N*-Ms substituent instead of a *N*-Ts substituent, also took part in *N*-transfer reaction with **1d** to give the *N*-transferred adduct **3c** in good yield (Table 1, entry 5). The outcomes of these studied

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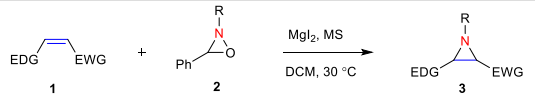
Table 1. Scope of electrophilic *N*-transfer reaction with two-carbon D-A substrates. [a]



entry	D-A carbon substrate (**1**)	oxaziridine (**2**)	product (**3**)	time (h)	yield (%)
1	**1a**	**2a**	**3a**	5	38
2	**1b**	**2a**	complex mixture	3	--
3	**1c**	**2a**	complex mixture	4	--
4	**1d**	**2a**	**3b**	8	57
5	**1d**	**2b**	**3c**	12	64

[a] Unless otherwise specified, all reactions were carried out in DCM at 30 °C with 1 equivalent of **1** and 1.5 equivalent of **2** in presence of MgI_2 (20 mol%) and 4Å MS; isolated yields are reported.

reactions with different D-A alkenes imply that the electrophilic *N*-transfer with two-carbon D-A substrates is more feasible when both the D-A alkenes and oxaziridines are less reactive in nature. The significant difference in viability of strongly reactive alkenes like **1b** and **1c** for the *N*-transfer reaction can be rationalized with the fact that the aziridine compounds might obtain from those alkenes would be highly unstable due to the presence of strongly destabilizing donor and acceptor functional groups at vicinal positions. Although the scope of electrophilic *N*-transfer of oxaziridine with DAC was studied in our previous report, we further wanted to explore the generality of this transformation with other differently substituted three-carbon donor-acceptor substrates (Table 2). Our focus was to check the feasibility of the transformation both in terms of the number and the nature of the attached donor and acceptor groups to cyclopropane. We first took a heteroaryl containing DAC. Thiophene-substituted DAC **4a** gave the aminated adduct **5a** in good yield (Table 2, entry 1). We were curious to check the reaction with the DAC bearing only one carboxylate acceptor group such as **4b** and got the respective aminated adduct **5b** where an additional chiral center was generated adjacent to *N*-atom (Table 2, entry 2). Interestingly, the cyclopropane **4c** bearing no donor substituents not worked in this reaction (Table 2, entry 3). Similarly, to check the workability of this transformation with the highly substituted one, the tetra-substituted DAC **4d** was taken which gave the corresponding

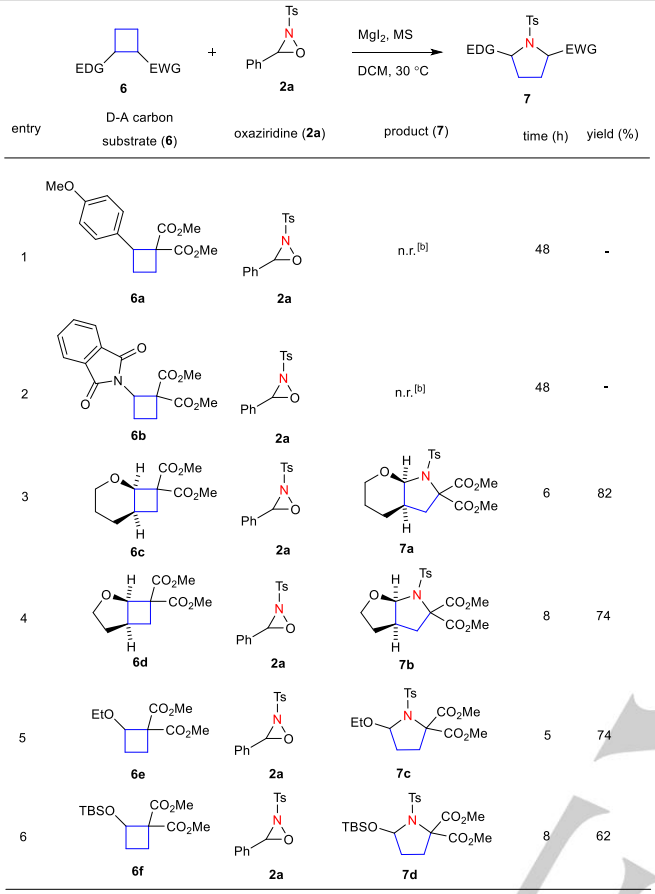
Table 2. Scope of electrophilic *N*-transfer reaction with three-carbon D-A substrates. [a]

entry	D-A carbon substrate (**4**)	oxaziridine (**2a**)	product (**5**)	time (h)	yield (%)
1	**4a**	**2a**	**5a**	7	68
2	**4b**	**2a**	**5b**[b]	12	56
3	**4c**	**2a**	n.r.[c]	48	-
4	**4d**	**2a**	**5c**	24[d]	52

[a] Unless otherwise specified, all reactions were carried out in DCM at 30 °C with 1 equivalent of **4** and 1.5 equivalent of **2a** in presence of MgI_2 (20 mol%) and 4Å MS; isolated yields are reported. [b] diastereomeric ratio of **5b** = (trans: cis = 1 :1). [c] n.r. = no reaction. [d] Reaction was carried out at 40 °C in DCM while the other conditions remained the same.

aminated compound **5c** in moderate yield (Table 2, entry 4). Most importantly, a quaternary center was generated in **5c** by this transformation. After exploring the generality of the *N*-transfer reactions with two- and three-carbon D-A substrates, we stepped to their next homolog donor-acceptor cyclobutanes in order to get six-membered *N*-containing heterocycles (Table 3). In this section of the study, 4- methoxyphenyl-substituted donor-acceptor cyclobutane **6a** was taken first, but no reaction was noticed (Table 3, entry 1) in the same reaction conditions using 20 mol% of magnesium iodide. Modification of cyclobutane **6b** with *N*-phthalimide-substituent caused no change to enable this transformation (Table 3, entry 2) which prompted us to optimize the reaction conditions altering Lewis acids and other parameters. However, the amination reaction did not proceed with these cyclobutanes **6a** and **6b** in changed reaction conditions as well and produced the rearranged product in some cases (see optimization table in the Supporting Information). The unusual reactivity of these cylobutanes for the designed *N*-transfer reaction can be rationalized with the fact that the C-C bond attached to donor and acceptor groups in **6a** and **6b** is not sufficiently polarized due to less electron donating ability of aryl and phthalimido groups. Hence, we paid further attention to modify the donor substituent of cyclobutane. Interestingly, the replacement of the cyclobutane with the strong electron donating substituent such as alkoxy group [15] resulted the desired aminated compounds effectively. For example, the cyclobutanes bearing *O*-atom at the adjacent position like **6c**, **6d** and **6e** afforded the corresponding *N*-transferred adduct **7a**, **7b**, and **7c** respectively

Table 3. Scope of electrophilic *N*-transfer reaction with four-carbon D-A substrates. [a]



[a] Unless otherwise specified, all reactions were carried out in DCM at 30 °C with 1 equivalent of **6** and 1.5 equivalent of **2a** in presence of MgI_2 (20 mol%) and 4Å MS; isolated yields are reported. [b] n.r. = no reaction.

in excellent yield (Table 3, entries 3–5). The structure of **7c** was confirmed unambiguously using single crystal X-ray analysis (Figure 2; also see the Supporting Information). [16] Another

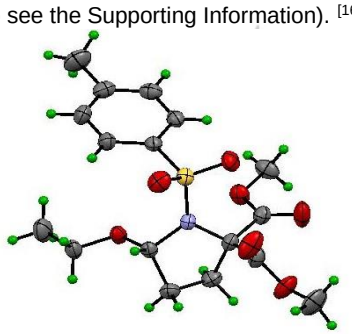
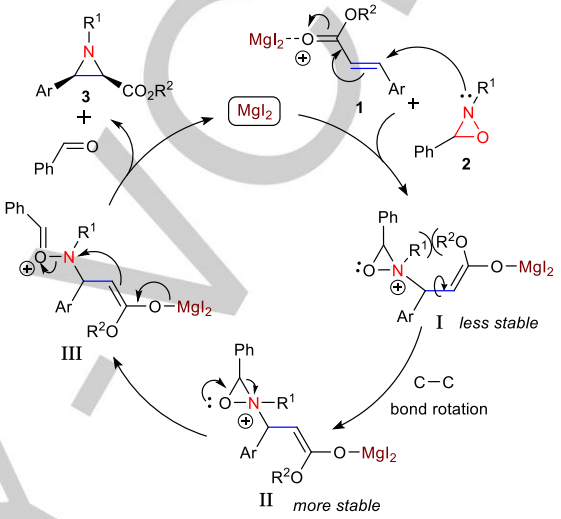


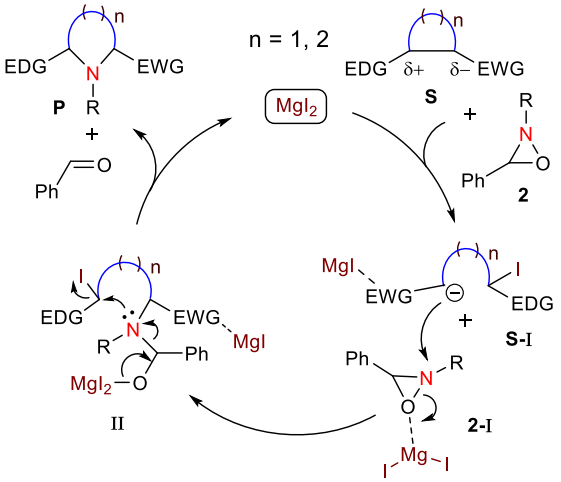
Figure 2. Single crystal X-ray structure of **7c**.

cyclobutane **6f** bearing *O-tert*-butyldimethylsilyl-substituent was also tested for this transformation for two reasons, first to check the effect of the bulky substituent on *O*-atom and secondly, *tert*-butyldimethylsilyl- group can be easily removed for further synthetic application from the aminated compound. Gratifyingly, the **6f** gave the respective aminated adduct **7d** with 62% yield (Table 3, entry 6). Based on the mode of reactivity of both D-A alkenes **1** and oxaziridine **2** in the presence of magnesium iodide and the stereochemistry of the obtained aziridines **3**, a plausible mechanism for the formation of aziridines **3** is represented in Scheme 3. The nitrogen lone pair of oxaziridine can act as a nucleophile to attack at the *β*-position of the activated alkene **1** to form the intermediate **I**. Steric repulsion between the ester group



Scheme 3. Plausible mechanism of formation aziridine from D-A alkene and oxaziridine.

of alkene and the bulky substituent present at the nitrogen atom of oxaziridine destabilizes the intermediate **I.** Subsequently, the intermediate **I** undergoes C-C single bond rotation to convert into the more stable conformation **II**. Finally, In conformer **II** successive bond rearrangement and ring-closing reaction take place to form aziridine **3** in *cis*-conformation. The mechanism of *N*-transfer reaction in the case of DAC was studied in detail in our



Scheme 4. General mechanism of electrophilic *N*-transfer of oxaziridine for DAC and D-A cyclobutane.

previous report (supported by experimental as well as theoretical analysis). [13] Also, the reactivity pattern of D-A cyclobutane in the presence of Lewis acid is similar to DAC as reported in the literature. [17] Thus, a plausible general mechanism of *N*-transfer for both the DAC and D-A cyclobutane is depicted in Scheme 4. The reaction starts with the magnesium iodide assisted activation of donor-acceptor carbon substrates **S** and oxaziridine **2** that lead to the formation of reactive intermediates **S-I** and **2-I**. When both the activated substrates **S-I** and **2-I** are present in the reaction medium, the nucleophilic attack by the anion of **S-I** to the *N*-atom of **2-I** takes place to form the intermediate **II**. The intermediate **II** can subsequently undergo cyclization to form the corresponding *N*-transferred adduct **P**.

Conclusions

In conclusion, a consistent and careful investigation of electrophilic *N*-transfer with three different classes of donor-acceptor carbon substrates has been carried out. For two-carbon D-A substrates, moderately reactive substrates like **1d** and **2b** are found effective for this transformation. In the case of DACs, this reaction is quite facile where we can play with the substituents of DAC to get differently substituted azetidine molecules. In this context, the potentiality of the tetra-substituted DAC **4d** to led the desired *N*-transferred adduct **5c** is quite impressive. Interestingly, with donor-acceptor cyclobutane, this is the new exhibition of this methodology which gives access to a number of valuable monocyclic as well as bicyclic heterocycles with stereocenters and quaternary stereocenters. Overall this study reveals the ability of oxaziridine towards the single step facile access to a different array of *N*-functionalized heterocycles.

Experimental Section

General Information: All reactions were carried out under inert atmosphere with oven-dried glassware. All solvents and reagents were obtained from commercial sources and were purified following the standard procedure prior to use. Powdered molecular sieves 4Å (MS 4Å) was activated at 200 °C under vacuum prior to use. The developed chromatogram was visualized by UV lamp (254 nm) or *p*-anisaldehyde solution. Products were purified by flash chromatography on silica gel (mesh size 230–400). The ^{1}H NMR and ^{13}C NMR spectra were recorded in $CDCl_3$. Chemical shifts of ^{1}H and ^{13}C NMR spectra are expressed in parts per million (ppm). All coupling constants are absolute values and are expressed in Hertz. The description of the signals includes the following: s = singlet, d = doublet, dd = doublet of doublet, t = triplet, dt = doublet of triplet, q = quartet, br = broad, and m = multiplet.

All the starting materials were prepared following the literature reported procedure, and the NMR spectra are consistent with the reported.

Synthesis of Alkenes: Alkene **1a** was prepared following Knovenegal condensation reaction, spectroscopic data were identical to those previously reported. [18] **1b** was prepared according to the previously reported procedure reported and spectroscopic data were identical to those. [19] **1c** was synthesized following the previously reported procedure, and spectroscopic data were identical to those. [20] Alkene **1d** was prepared following HWE olefination reaction, spectroscopic data were identical to those previously reported. [21]

Synthesis of Cyclopropanes: 4a was synthesized following the previously reported procedure, and spectroscopic data were identical to those. [22] **4b** was prepared following the previously reported procedure, and spectroscopic data were identical to those. [23] **4c** was commercially purchased from Sigma Aldrich, and **4d** was synthesized according to the previously reported procedure, and spectroscopic data were identical to those. [24]

Synthesis of Cyclobutanes: Cyclobutanes **6a**, **6c**, **6d,** and **6e** were prepared following the previously reported procedure, and spectroscopic data were identical to those. [25] **6b** was synthesized following the previously reported procedure, and spectroscopic data were identical to those. [26] **6f** was synthesized according to the previously reported procedure, and spectroscopic data were identical to those. [19]

Synthesis of Oxaziridine: 2a and **2b** were prepared following the previously reported procedure, and spectroscopic data were identical to those. [27]

General Experimental Procedure for Electrophilic *N*-transfer Reaction: To a round-bottom flask equipped with a magnetic stir bar were added with respective D-A carbon substrate (1 equiv), Oxaziridine (1.5 equiv), activated 4 Å MS (200 mol%), and MgI_2 (0.2 equiv) under nitrogen atmosphere. DCM was added as a solvent to the reaction mixture and stirred at room temperature until completion of the reaction (as monitored by TLC). The reaction mixture was passed through a small pad of celite, and the solvent was evaporated on a rotary evaporator. The crude mixture was further purified by flash column chromatography on silica gel with EtOAc/hexane as eluent.

Diethyl 3-phenyl-1-tosylaziridine-2,2-dicarboxylate (3a). Reaction time: 5 h, **1a** (0.25 g, 1.00 mmol), **2a** (0.42 g, 1.50 mmol), colorless oil, 0.16 g, yield: 38%, R_f value: 0.53 (EtOAc/hexane) = 4:6 (v/v).

(3a). ^{1}H-NMR (400 MHz): δ 7.96 (d, J = 8.3 Hz, 2H), 7.34 (d, J = 8.1 Hz, 2H) 7.27–7.21 (m, 5H), 4.88 (s, 1H), 4.41–4.36 (m, 2H), 3.97–3.92 (q, J = 7.1 Hz, 2H), 2.44 (s, 3H), 1.36 (t, J = 7.0 Hz, 3H), 0.87 (t, J = 7.0 Hz, 3H). ^{13}C-NMR (100 MHz): δ 163.2, 162.6, 144.8, 136.6, 131.1, 129.8, 128.9, 128.4, 127.8, 127.0, 63.5, 62.2, 57.5, 49.8, 21.8, 13.9, 13.7. IR (neat): 2981, 1745, 1597, 1496, 1454, 1390, 1340, 1257, 1222, 1163, 1107,1089, 1037, 941, 860, 813, 769, 678, 605, 547 cm^{-1}. HRMS (ESI, Q-TOF) m/z: $[M + H]^+$ calculated for $C_{21}H_{24}NO_6S$ 418.1324, found 418.1296.

Ethyl 3-(4-methoxyphenyl)-1-tosylaziridine-2-carboxylate (3b). Reaction time: 8 h, **1d** (0.12 g, 0.58 mmol), **2a** (0.24 g, 0.87 mmol), colourless viscous oil, 0.12 g, yield: 57%, R_f value: 0.25 (acetone/hexane) = 3:7 (v/v).

(3b). ^{1}H-NMR (400 MHz): δ 7.91 (d, J = 8.3 Hz, 2H), 7.35 (d, J = 8.4 Hz, 2H), 7.22 (d, J = 8.4 Hz, 2H), 6.78 (d, J = 8.6 Hz, 2H), 4.03 (d, J = 7.5 Hz, 1H), 4.01–3.90 (m, 2H), 3.75 (s, 3H), 3.64 (d, J = 7.3 Hz, 1H), 2.44 (s, 3H), 1.00 (t, J = 7.3 Hz, 3H). ^{13}C-NMR (100 MHz): δ 164.6, 159.8, 145.2, 134.2, 130.0, 128.9, 128.2, 123.2, 113.7, 61.7, 55.3, 45.2, 43.6, 21.8, 14.0. IR (neat): 2982, 2838, 1750, 1612, 1515, 1331, 1250, 1158, 1090, 1030, 895, 813, 679, 550 cm^{-1}. HRMS (ESI, Q-TOF) m/z: $[M + H]^+$ calculated for $C_{19}H_{22}NO_5S$ 376.1219, found 376.1220.

Ethyl 3-(4-methoxyphenyl)-1-(methylsulfonyl)aziridine-2-carboxylate (3c). Reaction time: 12 h, **1d** (0.10 g, 0.58 mmol), **2b** (0.14 g, 0.72 mmol),

colourless viscous oil, 0.09 g, yield: 64%, R_f value: 0.40 (EtOAc/hexane) = 5:5 (v/v).

(3c). ^{1}H-NMR (400 MHz): δ 7.33 (d, J = 8.7 Hz, 2H), 6.85 (d, J = 8.7 Hz, 2H), 4.09–3.99 (m, 2H), 4.02 (d, J = 7.0 Hz, 1H), 3.79 (s, 3H), 3.68 (d, J = 7.5 Hz, 1H), 3.20 (s, 3H), 1.07 (t, J = 7.3 Hz, 3H). ^{13}C-NMR (100 MHz): δ 164.5, 160.0, 128.9, 128.2, 122.9, 113.9, 61.9, 55.4, 44.7, 43.7, 40.0, 14.0. IR (neat): 2934, 2840, 1748, 1612, 1584, 1515, 1463, 1445, 1374, 1322, 1250, 1200, 1149, 1029, 953, 897, 819, 708, 513 cm^{-1}. HRMS (ESI, Q-TOF) m/z: [M + H]$^+$ calculated for $C_{13}H_{17}NO_5SNa$ 322.0725, found 322.0752.

Diethyl 4-(thiophen-2-yl)-1-tosylazetidine-2,2-dicarboxylate (5a). Reaction time: 7 h, **4a** (0.20 g, 0.74 mmol), **2a** (0.30 g, 1.11 mmol), yellow viscous oil, 0.22 g, yield: 68%, R_f value: 0.35 (EtOAc/hexane) = 2:8 (v/v).

(5a). ^{1}H-NMR (400 MHz): δ 7.48 (d, J = 8.2 Hz, 2H), 7.22 (d, J = 5.0 Hz, 1H), 7.10 (d, J = 8.1 Hz, 2H), 7.03 (d, J = 3.9 Hz, 1H), 6.90 (dd, J = 5.4, 3.7 Hz, 1H), 5.92 (t, J = 7.8 Hz, 1H), 4.45–4.37 (m, 2H), 4.32–4.20 (m, 2H), 3.09 (dd, J = 11.7, 8.5 Hz, 1H), 2.64 (dd, J = 11.8, 7.2 Hz, 1H), 2.34 (s, 3H), 1.42 (t, J = 7.1 Hz, 3H), 1.23 (t, J = 7.0 Hz, 3H). ^{13}C-NMR (100 MHz): δ 168.9, 168.4, 143.7, 143.2, 138.5, 128.9, 127.4, 127.1, 126.8. 126.6, 70.3, 63.1, 62.1, 57.8, 35.6, 21.6, 14.1, 14.0. IR (neat): 2981, 1732, 1598, 1440, 1369, 1340, 1290, 1155, 1091, 1018, 972, 852, 812, 763, 705, 678, 596, 543, 518 cm^{-1}. HRMS (ESI, Q-TOF) m/z: [M + Na]$^+$ calculated for $C_{20}H_{23}NO_6S_2Na$ 460.0864, found 460.0825.

Ethyl 4-(4-methoxyphenyl)-1-tosylazetidine-2-carboxylate (5b). Reaction time: 12 h, **4b** (0.30 g, 1.36 mmol), **2a** (0.57 g, 2.04 mmol), yellow viscous oil, 0.29 g (trans: cis = 1 :1 as determined from ^{1}H-NMR spectra), yield: 56%, R_f value: 0.58 (EtOAc/hexane) = 4:6 (v/v).

(5b). (trans: cis = 1 :1) ^{1}H-NMR (400 MHz): δ 7.55 (d, J = 8.1 Hz, 2H), 7.50 (d, J = 8.0 Hz, 2H), 7.16 (d, J = 8.6 Hz, 2H), 7.10 (d, J = 7.8 Hz, 2H), 6.89 (d, J = 8.4 Hz, 2H), 6.84 (d, J = 8.5 Hz, 2H), 6.68 (d, J = 8.6 Hz, 2H), 6.65 (d, J = 8.5 Hz, 2H), 4.87 (dd, J = 15.4, 8.0 Hz, 2H), 4.39–4.32 (m, 2H), 4.32–4.27 (m, 1H), 4.19–4.12 (m, 1H), 3.74 (s, 3H), 3.73 (s, 3H), 2.65–2.56 (m, 1H), 2.48–2.40 (m, 1H), 2.37 (s, 3H), 2.35 (s, 3H), 2.38–2.25 (m, 2H) 1.29 (t, J = 7.2 Hz, 3H), 1.25 (t, J = 7.0 Hz, 3H).. ^{13}C-NMR (100 MHz): δ 171.9, 171.1, 159.4, 159.3, 143.4, 143.3, 137.4, 137.2, 131.6, 130.9, 129.6, 129.5, 127.6, 127.4, 127.2, 127.2, 114.3, 114.2, 62.2, 62.1, 57.6, 57.5, 55.4, 43.9, 43.2, 21.6, 21.6, 16.4, 13.8, 13.8. IR (neat): 3275, 2956, 2360, 1726, 1514, 1323, 1305, 1247, 1155, 1118, 1062, 829, 812, 750, 705, 665, 580, 559 cm^{-1}. HRMS (ESI, Q-TOF) m/z: [M + Na]$^+$ Calculated for $C_{20}H_{23}NO_5SNa$ 412.1195, found 412.1165.

Dimethyl 4-(4-methoxyphenyl)-4-methyl-1-tosylazetidine-2,2-dicarboxylate (5c). Reaction time: 24 h, **4d** (0.22 g, 0.79 mmol), **2a** (0.32 g, 1.18 mmol), yellow viscous oil, 0.18 g, yield: 52%, R_f value: 0.48 (EtOAc/hexane) = 4:6 (v/v).

(5c). ^{1}H-NMR (400 MHz): δ 7.42 (d, J = 9.0 Hz, 2H), 7.23 (d, J = 8.9 Hz, 2H), 7.09 (d, J = 8.2 Hz, 2H), 6.71 (d, J = 8.9 Hz, 2H), 3.93 (s, 3H), 3.78 (s, 3H), 3.70 (s, 3H), 2.86 (d, J = 11.4 Hz, 1H), 2.73 (d, J = 11.7 Hz, 1H), 2.35 (s, 3H), 2.24 (s, 3H). ^{13}C-NMR (100 MHz): δ 169.3, 143.0, 135.3, 128.7, 128.0, 127.9, 127.5, 113.6, 71.7, 55.4, 53.8, 53.0, 43.0, 32.0, 25.8, 21.6. IR (neat): 3354, 3257, 2924, 1739, 1608, 1514, 1436, 1379, 1340, 1294, 1253, 1184, 1155, 1087, 1028, 902, 815, 771, 707, 680, 615, 557 cm^{-1}. HRMS (ESI, Q-TOF) m/z: [M + Na]$^+$ calculated for $C_{22}H_{25}NO_7SNa$ 470.1249, found 470.1242.

Dimethyl 7-tosylhexahydropyrano[2,3-b]pyrrole-6,6(2H)-dicarboxylate (7a). Reaction time: 6 h, **6c** (0.15 g, 0.65 mmol), **2a** (0.27 g, 0.98 mmol), colorless viscous oil, 0.21 g, yield: 82%, R_f value: 0.40 (EtOAc/hexane) = 4:6 (v/v).

(7a). ^{1}H-NMR (400 MHz): δ 7.93 (d, J = 8.4 Hz, 2H), 7.26 (d, J = 8.2 Hz, 2H), 4.56 (d, J = 8.5 Hz, 1H), 4.06 – 4.03 (m, 1H), 3.80 (s, 3H), 3.76 (s, 3H), 3.61–3.55 (m, 1H), 2.84 (dd, J = 12.1, 5.6 Hz, 1H), 2.40 (s, 3H), 2.11 (dd, J = 14.5, 11.9 Hz, 1H), 1.96 –1.92 (m, 1H), 1.66 –1.52 (m, 3H), 1.48 –1.39 (m, 1H). ^{13}C-NMR (100 MHz): δ 170.2, 169.3, 143.4, 138.6, 129.0, 128.9, 128.6, 127.8, 95.1, 74.1, 67.6, 53.7, 53.3, 41.5, 37.9, 26.8, 24.8, 21.7. IR (neat): 2951, 2856, 1739, 1597, 1458, 1433, 1342, 1280, 1255, 1159, 1136, 1111, 1066, 1041, 977, 923, 808, 732, 704, 671, 588, 545, 464 cm^{-1}. HRMS (ESI, Q-TOF) m/z: [M + H]$^+$ calculated for $C_{18}H_{24}NO_7S$ 398.1273, found 398.1260.

Dimethyl 6-tosylhexahydro-5H-furo[2,3-b]pyrrole-5,5-dicarboxylate (7b). Reaction time: 8 h, **6d** (0.15 g, 0.70 mmol), **2a** (0.29 g, 1.05 mmol), colorless viscous oil, 0.20 g, yield: 74%, R_f value: 0.26 (EtOAc/hexane) = 3:7 (v/v).

(7b). ^{1}H-NMR (400 MHz): δ 7.90 (d, J = 8.1 Hz, 2H), 7.27 (d, J = 6.5 Hz, 2H), 5.91 (d, J = 6.0 Hz, 1H), 3.86 (s, 3H), 3.82–3.75 (m, 1H), 3.74 (s, 3H), 3.60–3.54 (m, 1H), 3.00–2.93 (m, 1H), 2.71 (dd, J = 13.7, 8.6 Hz, 1H), 2.41 (s, 3H), 2.34 (dd, J = 12.9, 7.7 Hz, 1H), 2.00 –1.90 (m, 1H), 1.61 –1.57 (m, 1H). ^{13}C-NMR (100 MHz): δ 169.9, 168.9, 143.2, 138.9, 129.0, 128.0, 127.9, 95.8, 75.4, 66.1, 53.6, 53.3, 41.0, 40.4, 31.8, 21.7. IR (neat): 2953, 1739, 1597, 1435, 1340, 1267, 1242, 1155, 1070, 1031, 875, 813, 732, 704, 669, 586, 576, 542 cm^{-1}. HRMS (ESI, Q-TOF) m/z: [M + H]$^+$ calculated for $C_{17}H_{22}NO_7S$ 384.1117, found 384.1093.

Dimethyl 5-ethoxy-1-tosylpyrrolidine-2,2-dicarboxylate (7c). Reaction time: 5 h, **6e** (0.22 g, 1.01 mmol), **2a** (0.42 g, 1.52 mmol), colorless solid, m.p. 118 °C, 0.33 g, yield: 84%, R_f value: 0.48 (EtOAc/hexane) = 4:6 (v/v).

(7c). ^{1}H-NMR (400 MHz): δ 7.90 (d, J = 8.2 Hz, 2H), 7.27 (d, J = 8.0 Hz, 2H), 5.34 (d, J = 5.0 Hz, 1H), 3.83 (s, 3H), 3.72 (s, 3H), 3.46–3.38 (m, 1H), 3.33–3.26 (m, 1H), 2.72–2.64 (m, 1H), 2.48 (dd, J = 13.2, 8.2 Hz, 1H), 2.40 (s, 3H), 2.15–2.04 (m, 1H), 1.91 (dd, J = 12.7, 6.8 Hz, 1H), 0.97 (t, J = 6.8 Hz, 3H). ^{13}C-NMR (100 MHz): δ 170.1, 169.4, 143.4, 138.6, 129.1, 128.1, 91.3, 74.4, 62.9, 53.5, 53.1, 35.5, 31. 2, 21.6, 15.0. IR (neat): 2924, 1753, 1737, 1597, 1431, 1342, 1267, 1153, 1097, 1087, 1037, 1022, 991, 935, 856, 775, 740, 675, 590, 543 cm^{-1}. HRMS (ESI, Q-TOF) m/z: [M + Na]$^+$ calculated for $C_{17}H_{23}NO_7SNa$ 408.1093, found 408.1087.

Dimethyl 5-((tert-butyldimethylsilyl)oxy)-1-tosylpyrrolidine-2,2-dicarboxylate (7d). Reaction time: 8 h, **6f** (0.18 g, 0.59 mmol), **2a** (0.24 g, 0.89 mmol), light yellow oil, 0.17 g, yield: 62%, R_f value: 0.37 (EtOAc/hexane) = 2:8 (v/v).

(7d). ^{1}H-NMR (400 MHz): δ 7.91 (d, J = 8.3 Hz, 2H), 7.25 (d, J = 8.3 Hz, 2H), 5.63 (d, J = 4.5 Hz, 1H), 3.83 (s, 3H), 3.63 (s, 3H), 2.90–2.82 (m, 1H), 2.50–2.43 (m, 1H), 2.39 (s, 3H), 2.21–2.12 (m, 1H), 1.79 (dd, J = 12.2, 6.4 Hz, 1H), 0.78 (s, 9H), 0.02 (s, 3H), -0.03 (s, 3H). ^{13}C-NMR (100 MHz): δ 170.2, 169.4, 143.1, 139.0, 129.2, 128.1, 127.7, 85.7, 73.8, 53.5, 52.9, 35.0, 34. 6, 25.9, 25.6, 21.6, -4.7, -4.9. IR (neat): 2951, 2854, 2362, 1739, 1597, 1435, 1342, 1257, 1159, 1103, 1029, 1004, 939, 900, 835, 779, 705, 675, 596, 547 cm^{-1}. HRMS (ESI, Q-TOF) m/z: [M + Na]$^+$ calculated for $C_{21}H_{33}NO_7SSiNa$ 494.1645, found 494.1635.

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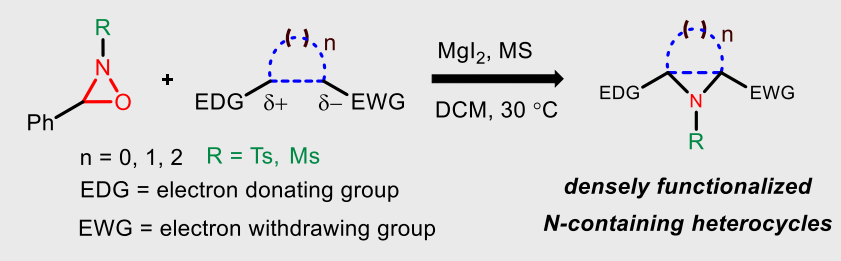

Electrophilic *N*-transfer of Oxaziridine*

*Asit Ghosh, Vatan Chawla, Prabal Banerjee**

1 – 6.

An Assessment of Electrophilic *N*-transfer of Oxaziridine with Different 2-, 3-, and 4-carbon Donor-Acceptor Substrates to Furnish Diverse *N*-containing Heterocycles in a Single Step

*Exhibition of the electrophilic *N*-transfer ability of oxaziridine as a complementary approach for direct access to an array of diversely functionalized *N*-containing heterocycles from readily available oxaziridines and carbon substrates. The electronic factor of different donor substituents present on different push-pull carbon substrates significantly influences the feasibility of the amination reaction.