Synthesis of 3,6-Dihydro-2H-1,2-oxazines via Dimethylsulfoxonium Methylide Addition to α,β-Unsaturated Nitrones

Synthesis of 3,6-Dihydro-2*H*-1,2-oxazines via Dimethylsulfoxonium Methylide Addition to *α,β*-Unsaturated Nitrones

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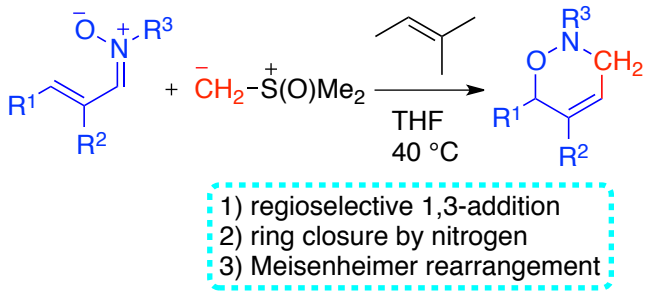
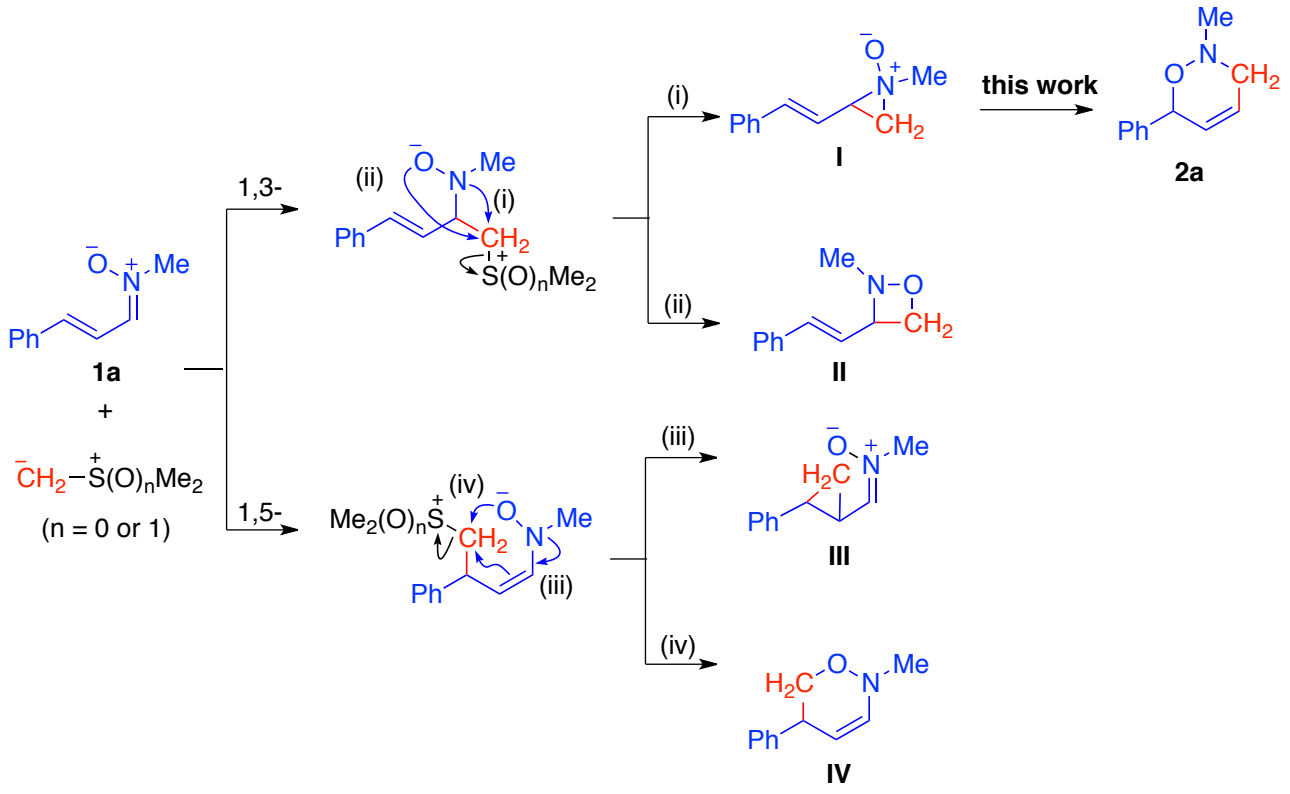


ABSTRACT: Unique and efficient formation of 3,6-dihydro-2*H*-1,2-oxazines starting from *α,β*-unsaturated nitrones has been achieved. The nucleophilic addition of dimethylsulfoxonium methylide to the C=N bond of an *α,β*-unsaturated nitrone to form an aziridine *N*-oxide followed by Meisenheimer rearrangement affords the 3,6-dihydro-2*H*-1,2-oxazine up to 70% yield. Methylene was confirmed to be incorporated at the C_3-position of the ring. A wide range of *β*-aryl-substituted *α,β*-unsaturated nitrones was applicable to this reaction.

INTRODUCTION

Sulfur ylides are one of the most important and widely applied reagents since the pioneering work of Corey and Chaykovsky in the 1960s (Corey–Chaykovsky reaction).[1] These impressive successes are attributed to the inherent properties of sulfur ylides that enable them to function as nucleophilic 1,1-dipolar species. They have long been used as one-carbon synthons in transformations with different electron-deficient unsaturated functional groups, providing a variety of significant carbocyclic and heterocyclic compounds.[2] One of the most widespread uses of sulfur ylides is the reaction with aldehydes and ketones, which yields betaine intermediates that collapse to give epoxides. In the case of *α,β*-unsaturated ketones, dimethylsulfonium methylide was reported to prefer 1,2-addition while the reaction of dimethylsulfoxonium methylide tended to give the cyclopropane derivatives via 1,4-addition.[1,2,3] In the case of imines, sulfonium and sulfoxonium ylides reacted smoothly to form aziridines.[1,2] The reaction of sulfonium ylides with *α,β*-unsaturated imine substrates preferred 1,2-addition onto imine-carbons to produce the corresponding aziridines.[4] However, 1,4-addition was dominant depending on the protecting group on the imine nitrogen and characteristics of the ylide.[5] Among the imine derivatives, the reaction of sulfur ylides to nitrones has scarcely been reported. The nucleophilic addition of dimethylsulfoxonium ylide to *o*-hydroxy-benzaldehyde-based nitrones followed by cyclization gave dihydrobenzofuran derivatives.[6] As part of our investigation into the reactions of 1,3-dipoles and sulfur ylides,[7] we planned to examine the reaction of sulfur ylides to *α,β*-unsaturated nitrones. By the 1,3-addition to an *α,β*-unsaturated nitrone, aziridine **I** or azetidine **II** formation might occur by nucleophilic substitution of dimethylsulfide or dimethylsulfoxide in the betaine intermediate (pathways (i) and (ii), respectively). In contrast, cyclopropane **III** formation or 5,6-dihydro-2*H*-1,2-oxazine **IV** formation might be possible by the addition to the *β*-carbon of the *α,β*-unsaturated nitrone (1,5-addition) via ring closure (pathways (iii) and (iv), respectively). The present report describes the unique formation of 3,6-dihydro-2*H*-1,2-oxazines by a sequential addition and rearrangement starting from *α,β*-unsaturated nitrones with dimethylsulfoxonium methylide via aziridine *N*-oxide intermediate **I** (Scheme 1).

Scheme 1. Possible Pathways for Sulfur Ylide-Mediated Transformations from *α,β*-Unsaturated Nitrone

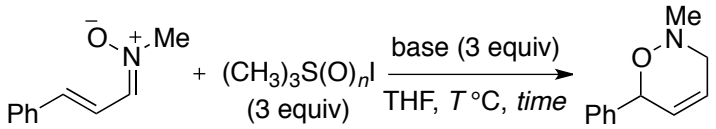


RESULTS AND DISCUSSION

The initial reaction of *α,β*-unsaturated nitrone **1a** with dimethylsulfonium methylide derived *in situ* from trimethylsulfonium iodide with NaH in THF was examined at 60 °C (oil bath temperature) for 5 h. By ^{1}H NMR analysis of the crude products, unreacted **1a** was recovered in 59% yield. Although several products were indicated by TLC analysis during the reaction, clear and sharp singlet signals, which could be assigned to the *N*-CH_3 group, were scarcely observed in the area from 2 to 4 ppm except *N*-methyl protons of **1a** in the ^{1}H NMR spectrum (Table 1, Entry 1). When dimethylsulfoxonium methylide generated *in situ* from trimethylsulfoxonium iodide and NaH was employed, most of the nitrone **1a** was consumed within 6 h. After aqueous workup, two rather sharp proton resonances were observed around 3 ppm in the ^{1}H NMR spectrum of the crude products. Purification by silica gel column chromatography furnished unexpected 3,6-dihydro-2*H*-1,2-oxazine **2a** in 33% yield (Entry 2). The structure of the product was confirmed by its ^{1}H and ^{13}C NMR spectra, which were identical to the reported data.[8] The sharp signals at 2.71 and 3.30 ppm could be assigned to methyl protons on nitrogen and C_3 methylene protons, respectively. Using NaOH as a base instead of NaH, **2a** was obtained in only 4% yield (Entry 3). The use of KOH

afforded the product in 25% yield (Entry 4). When pre-prepared dimethylsulfoxonium methylide was used,[9] the *α,β*-unsaturated nitrone **1a** remained in the reaction mixture for a longer time than in the reactions via the *in situ* ylide generation. However, the final yield was not improved (Entry 5). When the temperature was slightly decreased, the dihydrooxazine **2a** was obtained in improved chemical yield of 43% yield (Entry 6). Monitoring the reactions by TLC suggested that various by-products, whose structures were not confirmed, were gradually produced. One reason for this might be the decomposition of dimethylsulfoxonium methylide to generate a reactive carbene, which caused undesired reactions with the organic materials.[10] To prevent this interference, several alkenes were examined as scavengers to consume the methylene carbene as it was formed.[11] When 2-methyl-2-butene was employed,[12] the chemical yield was improved up to 54% yield (Entry 7).[13] The reaction proceeded well even at 25 ºC, albeit with slight decrease of the yield (Entry 8).

Table 1. Reaction of Sulfur Ylides with *α,β*-Unsaturated Nitrone 1a



1a **2a**

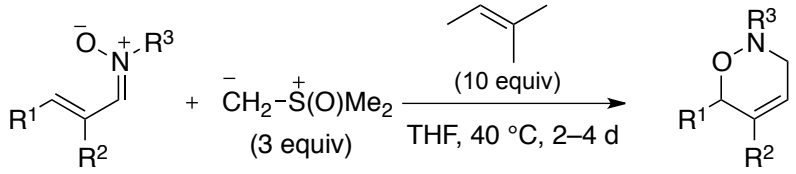
Entry	Sulfur ylide	*T*/°C	*time*	Yield/%	Recovery of **1a**/%[a]
1	$(CH_3)_3SI$ / NaH	65	5 h	--	59
2	$(CH_3)_3S(O)I$ / NaH	65	6 h	33	3
3	$(CH_3)_3S(O)I$ / NaOH	65	2 h	4	82
4	$(CH_3)_3S(O)I$ / KOH	65	6 h	25	5
5	$CH_2S(O)(CH_3)_2$[b]	65	22 h	36	2
6		40	2 d	43	3
7[c]		40	2 d	54	2
8[c]		25	3 d	49	1

[a]Recovery of **1a** was measured by ^{1}H NMR of the crude products using CH_2Br_2 as an internal standard. [b]Pre-prepared dimethylsulfoxonium methylide was used. [c]10 Equiv of 2-methyl-2-butene was added.

With the optimal reaction conditions in hand, we examined the substrate scope of the reaction as shown in Table 2. A series of *β*-tolyl-substituted *α,β*-unsaturated nitrones **1b-d** were tolerated (Entries 2-4). Notably, *β*-mesityl-substituted *α,β*-unsaturated nitrone **1e** underwent the present

addition-rearrangement transformation to afford 3,6-dihydro-2*H*-1,2-oxazine **2e** in 70% yield (Entry 5). *β*-(4-Methoxyphenyl) nitrone **1f** gave **2f** in 56% yield (Entry 6). *β*-(Di- and trimethoxyphenyl) substituted nitrones **1g-j** were tolerated to furnish the products **2g-j** in moderate yields (Entries 7–10). The structure of **2j** was unambiguously determined by X-ray crystallographic analysis (see Experimental section). *N,N*-Dimethylamino and chloro groups could be introduced to the aromatic ring of the nitrones to give 3,6-dihydro-2*H*-1,2-oxazines **2k** and **2l** in about 40% yields (Entries 11 and 12). In the case of nitrone **1m** with aliphatic substituents, the chemical yield was rather low (Entry 13). An *α*-methyl-substituted nitrone **1n** could be a substrate in the present transformation (Entry 14). Although the reaction of **1o** with a benzyl substituent on nitrogen produced several byproducts which were not observed in the case of *N*-methyl substituted nitrone **1e**, the dihydrooxazine **2o** was obtained in 42% yield (Entry 15).

Table 2. Reaction of Dimethylsulfoxonium Methylide with *α,β*-Unsaturated Nitrones



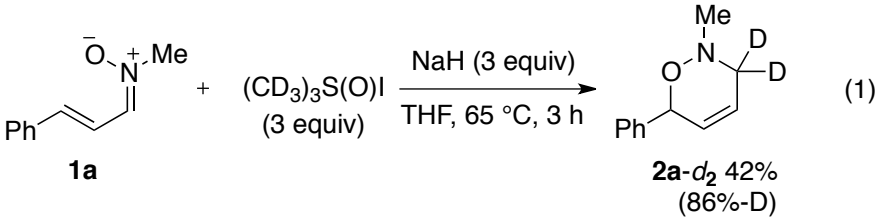
1 **2**

Entry	R^1	R^2	R^3		Yield/%
1	Ph	H	Me	**a**	54
2	2-MeC_6H_4			**b**	50
3	3-MeC_6H_4			**c**	45
4	4-MeC_6H_4			**d**	61
5[a]	2,4,6-$Me_3C_6H_2$			**e**	70
6	4-$(MeO)C_6H_4$			**f**	56
7	2,3-$(MeO)_2C_6H_3$			**g**	52
8	2,4-$(MeO)_2C_6H_3$			**h**	47
9	2,5-$(MeO)_2C_6H_3$			**i**	43
10[a]	2,4,6-$(MeO)_3C_6H_2$			**j**	55
11[a]	4-$(Me_2N)C_6H_4$			**k**	40
12	4-ClC_6H_4			**l**	42
13	$Ph(CH_2)_2$			**m**	14
14	Ph	Me	Me	**n**	54
15[b]	2,4,6-$Me_3C_6H_2$	H	$PhCH_2$	**o**	42

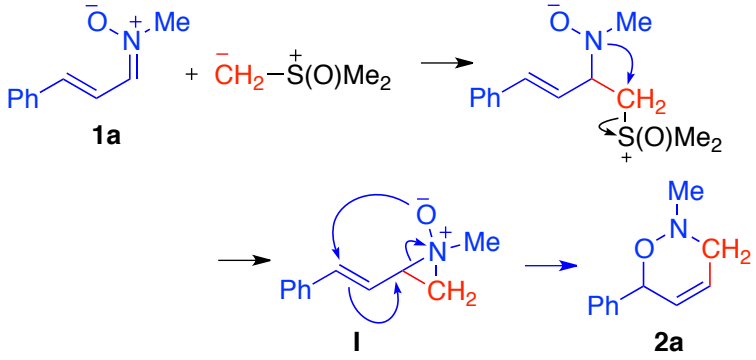
[a]Reaction was carried out at 60 °C. [b]Reaction was carried out at 25 °C using 10 equiv of dimethylsulfoxonium methylide.

In order to gain insight into the present transformation, the nitrone **1a** was treated with deuterated dimethylsulfoxonium methylide generated *in situ* from trimethylsulfoxonium-d_9 iodide and NaH in THF.[14] It was confirmed that deuterated methylene was incorporated at the C_3 position by ^{1}H NMR analysis of the obtained 3,6-dihydro-2*H*-1,2-oxazine **2a**-d_2 (eq 1). Based on this result, the present reaction was proposed to proceed via 1,3-addition of dimethylsulfoxonium methylide to the nitrone **1a** followed by ring closure by nitrogen to produce aziridine *N*-oxide **I**. The subsequent rearrangement (Meisenheimer rearrangement)[15] produced 3,6-dihydro-2*H*-1,2-oxazine **2a** as shown

in Scheme 2.



Scheme 2. Plausible Reaction Mechanism for Sulfur Ylide-Mediated Formation of 3,6-Dihydro-2*H*-1,2-oxazine 2a



In conclusion, we developed the unique synthesis of 3,6-dihydro-2*H*-1,2-oxazines via 1,3-addition of dimethylsulfoxonium methylide to *α,β*-unsaturated nitrones. 3,6-Dihydro-2*H*-1,2-oxazines, often obtained by hetero Diels-Alder reactions of nitroso compounds with 1,3-dienes,[16] are useful heterocycles especially for the synthesis of biologically active nitrogen-containing compounds.[16,17] *α,β*-Unsaturated nitrones could be readily available from *α,β*-unsaturated aldehydes and are slightly more stable than 1,3-dienes. The present method provides a useful, unique, and alternative way to provide 3,6-dihydro-2*H*-1,2-oxazines.

EXPERIMENTAL SECTION

General Method. ^{1}H NMR spectra were recorded on a 400 MHz NMR spectrometer. Chemical shifts δ are reported in ppm using TMS as an internal standard. Data are reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, quint = quintet, m = multiplet), coupling constant (*J*) and integration. ^{13}C NMR spectra were recorded on a 100 MHz NMR spectrometer. The chemical shifts are reported relative to $CDCl_3$ (δ = 77.0 ppm). The wavenumbers of maximum absorption peaks in IR spectra are presented in cm^{-1}. All of the melting points were measured with a micro melting point apparatus. HRMS (ESI and FAB) spectra were measured with

quadrupole and TOF mass spectrometers. Dehydrated solvents were purchased for the reactions and used without further desiccation.

(*Z*)-*N*-((*E*)-3-Phenylallylidene)methanamine oxide (1a):[18,19] To a stirred mixture of (*E*)-cinnamaldehyde (3.96 g, 30 mmol), triethylamine (5.58 mL, 40 mmol) and anhydrous Na_2SO_4 (14.2 g, 100 mmol) in dichloromethane (60 mL) was added *N*-methylhydroxylamine hydrochloride (1.67 g, 20 mmol) at 0 °C. After stirring for 2 d at rt, the reaction mixture was partitioned between water and $CHCl_3$. The aqueous layer was extracted with $CHCl_3$. The combined organic layers were dried over anhydrous Na_2SO_4, filtered and evaporated under reduced pressure. The residue was purified by silica gel column chromatography (AcOEt/MeOH = 6/1) to give the nitrone **1a** (2.06 g, 64% yield) as a solid. Mp. 86–87 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.52 (d, 2H, J = 6.9 Hz), 7.45 (dd, 1H, J = 16.5, 9.6 Hz), 7.38–7.29 (m, 3H), 7.25 (d, 1H, J = 9.6 Hz), 6.96 (d, 1H, J = 16.5 Hz), 3.77 (s, 3H). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): δ 138.1, 137.6, 135.9, 129.2, 128.8, 127.3, 118.4, 52.4. IR (KBr) 3056, 1591, 1403, 1191, 1139, 980, 947, 750, 697 cm^{-1}. HRMS (ESI) *m/z*: $[M+H]^+$ Calcd for $C_{10}H_{12}NO$ 162.0919; Found 162.0922.

In a similar manner, nitrones **1b**–**1o** were obtained from the corresponding *α,β*-unsaturated aldehydes.

(*Z*)-*N*-((*E*)-3-(*o*-Tolyl)allylidene)methanamine oxide (1b): The compound **1b** (2.00 g, 68% yield, 17 mmol scale) was obtained as a solid after purification by silica gel column chromatography (AcOEt/MeOH = 6/1). Mp. 85–86 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.69–7.66 (m, 1H), 7.38 (dd, 1H, J = 16.0, 9.6 Hz), 7.28 (d, 1H, J = 9.6 Hz), 7.23–7.15 (m, 4H), 3.76 (s, 3H), 2.37 (s, 3H). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): δ 137.8, 136.4, 135.3, 134.6, 130.6, 129.0, 126.3, 125.6, 119.0, 52.3, 19.7. IR (KBr) 3043, 1561, 1407, 1184, 1146, 971, 955, 746 cm^{-1}. HRMS (ESI) *m/z*: $[M+H]^+$ Calcd for $C_{11}H_{14}NO$ 176.1075; Found 176.1074.

(*Z*)-*N*-((*E*)-3-(*m*-Tolyl)allylidene)methanamine oxide (1c): The compound **1c** (2.95 g, 99% yield, 16 mmol scale) was obtained as an oil after purification by silica gel column chromatography (AcOEt/MeOH = 6/1). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.43 (dd, 1H, J = 16.0, 9.6 Hz), 7.36 (s, 1H), 7.31 (d, 1H, J = 7.8 Hz), 7.26–7.22 (m, 2H), 7.13 (d, 1H, J = 7.3 Hz), 6.93 (d, 1H, J = 16.0 Hz), 3.76 (s, 3H), 2.35 (s, 3H). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): δ 138.4, 138.3, 137.7, 135.9, 130.1, 128.7, 127.8, 124.6, 118.2, 52.3, 21.3. IR (neat) 2943, 1560, 1484, 1395, 957, 778, 691 cm^{-1}. HRMS (ESI) *m/z*: $[M+H]^+$ Calcd for $C_{11}H_{14}NO$ 176.1075; Found 176.1076.

(*Z*)-*N*-((*E*)-3-(*p*-Tolyl)allylidene)methanamine oxide (1d):[19,20] The compound **1d** (0.11 g, 60% yield, 1.0 mmol scale) was obtained as a solid after purification by silica gel column chromatography (AcOEt/MeOH = 6/1). Mp. 121–123 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.42–7.36 (m, 1H), 7.41 (d, 2H, J = 7.8 Hz), 7.22 (d, 1H, J = 9.6 Hz), 7.15 (d, 2H, J = 7.8 Hz), 6.92 (d, 1H, J = 16.0 Hz), 3.74 (s, 3H), 2.34 (s, 3H). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): δ 139.4, 138.2, 137.8, 133.1, 129.5, 127.2, 117.3, 52.1, 21.3. IR (KBr) 3013, 1553, 1510, 1392, 1174, 1144, 982, 789 cm^{-1}. HRMS (ESI) *m/z*: $[M+H]^+$ Calcd for $C_{11}H_{14}NO$ 176.1075; Found 176.1072.

(*Z*)-*N*-((*E*)-3-Mesitylallylidene)methanamine oxide (1e): The compound **1e** (2.25 g, 73% yield, 15.2 mmol scale) was obtained as a solid after purification by silica gel column chromatography (AcOEt/MeOH = 6/1). Mp. 130–131 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.26 (d, 1H, J = 8.2 Hz), 7.09 (d, 1H, J = 16.9 Hz), 7.02 (dd, 1H, J = 16.9, 8.2 Hz), 6.88 (s, 2H), 3.76 (s, 3H), 2.34 (s, 6H), 2.27 (s, 3H). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): δ 138.1, 137.7, 136.5, 131.92, 131.85, 129.2, 123.3, 52.3, 21.3, 21.0. IR (KBr) 3002, 1574, 1398, 1194, 1141, 979, 855, 724 cm^{-1}. HRMS (ESI) *m/z*: $[M+Na]^+$ Calcd for $C_{13}H_{17}NONa$ 226.1208; Found 226.1223.

(*Z*)-*N*-((*E*)-3-(4-Methoxyphenyl)allylidene)methanamine oxide (1f):[19,20] The compound **1f** (1.46 g, 51% yield, 15.0 mmol scale) was obtained as a solid by recrystalization (AcOEt/hexane). Mp. 101–102 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.47 (d, 2H, J = 8.7 Hz), 7.31 (dd, 1H, J = 16.0, 9.6 Hz), 7.24 (d, 1H, J = 9.6 Hz), 6.93 (d, 1H, J = 16.0 Hz), 6.88 (d, 2H, J = 8.7 Hz), 3.83 (s, 3H), 3.76 (s, 3H). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): δ 160.9, 138.7, 138.2, 129.0, 128.6, 116.0, 114.3, 55.4, 52.0. IR (KBr) 2950, 1599, 1510, 1401, 1301, 1257, 1172, 1140, 1026, 974, 946, 812 cm^{-1}. HRMS (ESI) *m/z*: $[M+H]^+$ Calcd for $C_{11}H_{14}NO_2$ 192.1025; Found 192.1029.

(*Z*)-*N*-((*E*)-3-(2,3-Dimethoxyphenyl)allylidene)methanamine oxide (1g): The compound **1g** (1.23 g, 34% yield, 16.6 mmol scale) was obtained as a solid after purification by silica gel column chromatography (AcOEt/MeOH = 6/1). Mp. 85–86 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.45 (dd, 1H, J = 16.0, 9.6 Hz), 7.33 (d, 1H, J = 16.0 Hz), 7.32–7.29 (m, 2H), 7.06 (t, 1H, J = 8.0 Hz), 6.89 (d, 1H, J = 7.8 Hz), 3.88 (s, 3H), 3.83 (s, 3H), 3.77 (s, 3H). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): δ 152.9, 147.3, 138.2, 132.3, 130.1, 124.3, 119.2, 118.1, 112.8, 61.3, 55.8, 52.3. IR (KBr) 2940, 1557, 1476, 1387, 1268, 1178, 1146, 1061, 998, 983, 744 cm^{-1}. HRMS (ESI) *m/z*: $[M+Na]^+$ Calcd for $C_{12}H_{15}NO_3Na$ 244.0950; Found 244.0963.

(*Z*)-*N*-((*E*)-3-(2,4-Dimethoxyphenyl)allylidene)methanamine oxide (1h): The compound **1h** (2.29 g, 65% yield, 15.9 mmol scale) was obtained as a solid after purification by silica gel column chromatography (AcOEt/MeOH = 3/1). Mp. 99–100 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.58 (d, 1H, J = 8.2 Hz), 7.35 (dd, 1H, J = 15.6, 9.6 Hz), 7.27–7.20 (m, 2H), 6.51 (d, 1H, J = 8.2 Hz), 6.43 (s, 1H), 3.85 (s, 3H), 3.83 (s, 3H), 3.73 (s, 3H). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): δ 161.9, 158.6, 138.9, 133.0, 128.2, 118.1, 116.3, 105.3, 98.3, 55.5, 55.4, 52.0. IR (KBr) 3004, 1594, 1505, 1450, 1391, 1315, 1274, 1297, 1181, 1027, 945, 828 cm^{-1}. HRMS (FAB$^+$) *m/z*: $[M+H]^+$ Calcd for $C_{12}H_{16}NO_3$ 222.1130; Found 222.1131.

(*Z*)-*N*-((*E*)-3-(2,5-Dimethoxyphenyl)allylidene)methanamine oxide (1i): The compound **1i** (2.33 g, 81% yield, 13.0 mmol scale) was obtained as a solid after purification by silica gel column chromatography (AcOEt/MeOH = 6/1). Mp. 68–70 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.43 (dd, 1H, J = 16.5, 9.6 Hz), 7.32 (d, 1H, J = 16.5 Hz), 7.27 (d, 1H, J = 9.6 Hz), 7.17 (d, 1H, J = 2.8 Hz), 6.86 (dd, 1H, J = 9.2, 2.8 Hz), 6.82 (d, 1H, J = 9.2 Hz), 3.83 (s, 3H), 3.80 (s, 3H), 3.76 (s, 3H). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): δ 153.7, 151.8, 138.5, 132.7, 125.4, 118.4, 116.9, 112.4, 110.6, 56.1, 55.8, 52.3. IR (KBr) 2943, 1563, 1496, 1413, 1281, 1221, 1188, 1039, 969, 824, 801, 707 cm^{-1}. HRMS (ESI) *m/z*: $[M+Na]^+$ Calcd for $C_{12}H_{15}NO_3Na$ 244.0950; Found 244.0965.

(*Z*)-*N*-((*E*)-3-(2,4,6-Trimethoxyphenyl)allylidene)methanamine oxide (1j): The compound **1j** (0.94 g, 53% yield, 7.1 mmol scale) was obtained as a solid after purification by silica gel column chromatography (AcOEt/MeOH = 6/1, 3/1). Mp. 147–148 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.69 (dd, 1H, J = 16.5, 10.1 Hz), 7.26 (d, 1H, J = 16.5 Hz), 7.17 (d, 1H, J = 10.1 Hz), 6.11 (s, 2H), 3.87 (s, 6H), 3.84 (s, 3H), 3.71 (s, 3H). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): δ 161.8, 160.3, 140.8, 130.0, 119.2, 107.2, 90.3, 55.7, 55.3, 51.9. IR (KBr) 2943, 1593, 1463, 1408, 1319, 1200, 1119, 1038, 976, 949, 822 cm^{-1}. HRMS (ESI) *m/z*: $[M+Na]^+$ Calcd for $C_{13}H_{17}NO_4Na$ 274.1055; Found 274.1074.

(*Z*)-*N*-((*E*)-3-(4-(Dimethylamino)phenyl)allylidene)methanamine oxide (1k): The compound **1k** (0.82 g, 86% yield, 4.7 mmol scale) was obtained as a solid by recrystalization (MeOH/hexane). Mp. 105–106 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.42 (d, 2H, J = 8.7 Hz), 7.27–7.16 (m, 2H), 6.87 (d, 1H, J = 15.6 Hz), 6.66 (d, 2H, J = 8.7 Hz), 3.73 (s, 3H), 3.01 (s, 6H). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): δ 151.0, 139.3, 138.8, 128.9, 123.9, 113.7, 111.9, 51.8, 40.1. IR (KBr) 1598, 1325, 1371, 1173, 809 cm^{-1}. HRMS (ESI) *m/z*: $[M+Na]^+$ Calcd for $C_{12}H_{16}N_2ONa$ 227.1160; Found 227.1173.

(*Z*)-*N*-((*E*)-3-(4-Chlorophenyl)allylidene)methanamine oxide (1l):[20,21] The compound **1l** (1.26 g, 77% yield, 8.4 mmol scale) was obtained as a solid after purification by silica gel column chromatography (AcOEt/MeOH = 6/1). Mp. 130–132 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.44 (d, 2H, J = 8.7 Hz), 7.40 (dd, 1H, J = 16.0, 10.1 Hz), 7.32 (d, 2H, J = 8.7 Hz), 7.25 (d, 1H, J = 10.1 Hz), 6.93 (d, 1H, J = 16.0 Hz), 3.77 (s, 3H). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): δ 137.6, 136.8, 135.0, 134.5, 129.1, 128.4, 118.8, 52.4. IR (KBr) 3034, 1557, 1488, 1391, 1186, 1140, 972, 956, 803 cm^{-1}. HRMS (ESI) *m/z*: $[M+H]^+$ Calcd for $C_{10}H_{11}NOCl$ 196.0529; Found 196.0524.

(*Z*)-*N*-((*E*)-5-Phenylpent-2-en-1-ylidene)methanamine oxide (1m): The compound **1m** (0.59 g, 18% yield, 17.5 mmol scale) was obtained as an oil after purification by silica gel column chromatography (AcOEt/MeOH = 20/1, 10/1, 6/1). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.32–7.13 (m, 5H), 7.03 (d, 1H, J = 9.6 Hz), 6.80 (dd, 1H, J = 16.0, 9.6 Hz), 6.24 (dt, 1H, J = 16.0, 6.9 Hz), 3.68 (s, 3H), 2.77 (t, 2H, J = 7.3 Hz), 2.55 (td, 2H, J = 7.3, 6.9 Hz). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): δ 141.9, 140.9, 137.4, 128.4, 128.3, 126.1, 121.4, 52.0, 34.89, 34.86. IR (neat) 3026, 2926, 1631, 1603, 1571, 1454, 1407, 1149, 977, 748, 701 cm^{-1}; HRMS (ESI) *m/z*: $[M+H]^+$ Calcd for $C_{12}H_{16}NO$ 190.1232; Found 190.1237.

(*Z*)-*N*-((*E*)-2-Methyl-3-phenylallylidene)methanamine oxide (1n):[22] The compound **1n** (1.40 g, 53% yield, 15.0 mmol scale) was obtained as an oil after purification by silica gel column chromatography (AcOEt/MeOH = 10/1, 6/1). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.26 (s, 1H), 7.36–7.19 (m, 5H), 6.93 (s, 1H), 3.78 (s, 3H), 2.18 (s, 3H). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): δ 137.9, 137.0, 134.5, 129.5, 128.1, 127.7, 127.4, 54.4, 17.7. IR (KBr) 3056, 1587, 1558, 1167, 957, 751, 699 cm^{-1}. HRMS (ESI) *m/z*: $[M+H]^+$ Calcd for $C_{11}H_{14}NO$ 176.1075; Found 176.1074.

(*Z*)-*N*-((*E*)-3-Mesitylallylidene)-1-phenylmethanamine oxide (1o): The compound **1o** (0.59 g, 88% yield, 2.4 mmol scale) was obtained as a solid after purification by silica gel column chromatography (hexane/AcOEt = 2/1, 1/1, AcOEt only, then AcOEt/MeOH = 10/1). Mp. 180–182 °C. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.49–7.39 (m, 5H), 7.24–7.21 (m, 1H), 7.06–7.04 (m, 2H), 6.86 (s, 2H), 4.95 (s, 2H), 2.32 (s, 6H), 2.26 (s, 3H). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): δ 137.7, 136.9, 136.8, 136.6, 132.9, 131.9, 129.4, 129.2, 128.9, 123.2, 69.2, 21.4, 21.0; one signal overlaps. IR (KBr) 3061, 1608, 1556, 1433, 1331, 1205, 1185, 1119, 984, 938, 864, 765, 701 cm^{-1}. HRMS (ESI) *m/z*: $[M+H]^+$ Calcd for $C_{19}H_{22}NO$ 280.1701; Found 280.1699.

Representative Procedure for Synthesis of 3,6-Dihydro-2*H*-1,2-oxazines for 2d.

Under an Ar atmosphere, a mixture of *α*,*β*-unsaturated nitrone **1d** (175 mg, 1.0 mmol), dimethylsulfoxonium methylide[9] (4.8 mL, 0.63 M in THF, 3.0 mmol), and 2-methyl-2-butene (1.1 mL, 10 mmol) in THF (1.2 mL) was stirred at 40 °C (oil bath temperature) for 2 d. After cooling to rt, brine was added and extracted with $CHCl_3$. Combined organic layers were dried over Na_2SO_4 and concentrated. The residue was purified by column chromatography on silica gel (hexane/AcOEt = 15/1, 10/1, 6/1) to give **2d** (115 mg, 61% yield).

In a similar manner, syntheses of 3,6-dihydro-2*H*-1,2-oxazines **2a**–**2c**, and **2e**–**2o** were carried out.

2-Methyl-6-phenyl-3,6-dihydro-2*H*-1,2-oxazine (2a):[8] The compound **2a** (47 mg, 54% yield, 0.5 mmol scale) was obtained as an oil after purification by silica gel column chromatography (hexane/AcOEt = 6/1). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.40–7.28 (m, 5H), 6.02–5.87 (m, 2H), 5.45 (brs, 1H), 3.30 (brs, 2H), 2.71 (s, 3H). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): δ 139.2, 128.8, 128.4, 128.1, 127.8, 124.1, 79.5, 56.3, 46.1. IR (neat) 3033, 2953, 2919, 2852, 2805, 1656, 1493, 1454, 1436, 1274, 1097, 1056, 994, 957, 924, 884, 792, 753, 700, 680 cm^{-1}. HRMS (ESI) *m/z*: $[M+H]^+$ Calcd for $C_{11}H_{14}NO$ 176.1075; Found 176.1080.

2-Methyl-6-(*o*-tolyl)-3,6-dihydro-2*H*-1,2-oxazine (2b): The compound **2b** (47 mg, 50% yield, 0.5 mmol scale) was obtained as an oil after purification by silica gel column chromatography (hexane/AcOEt = 6/1). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.33 (d, 1H, J = 6.4 Hz), 7.24–7.06 (m, 3H), 6.05–5.97 (m, 1H), 5.93 (d, 1H, J = 10.1 Hz), 5.71 (br, 1H), 3.31 (brs, 2H), 2.71 (s, 3H), 2.43 (s, 3H). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): δ 150.0, 136.9, 130.5, 128.6, 128.2, 127.8, 125.9, 124.3, 76.6, 56.3, 46.1, 19.0. IR (neat) 2953, 2853, 2804, 1652, 1490, 1462, 1437, 1096, 1058, 995, 952, 888, 751, 670 cm^{-1}. HRMS (ESI) *m/z*: $[M+H]^+$ Calcd for $C_{12}H_{16}NO$ 190.1232; Found 190.1233.

2-Methyl-6-(*m*-tolyl)-3,6-dihydro-2*H*-1,2-oxazine (2c): The compound **2c** (43 mg, 45% yield, 0.5 mmol scale) was obtained as an oil after purification by silica gel column chromatography (hexane/AcOEt = 6/1). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.30–7.10 (m, 4H), 6.06–5.86 (m, 2H), 5.43 (br, 1H), 3.31 (brs, 2H), 2.72 (s, 3H), 2.35 (s, 3H). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): δ 150.0, 138.1, 137.6, 129.0, 128.5, 128.3, 124.9, 124.0, 79.8, 56.3, 46.1, 21.4. IR (neat) 2953, 2920, 2853, 2805, 1657, 1608, 1489, 1461, 1437, 1098, 1058, 994, 967, 853, 785, 761, 702, 677 cm^{-1}. HRMS (ESI) *m/z* Calcd for $C_{12}H_{16}NO$ $[M+H]^+$ 190.1232; Found 190.1231.

2-Methyl-6-(*p*-tolyl)-3,6-dihydro-2*H*-1,2-oxazine (2d): The compound **2d** (115 mg, 61% yield, 1.0 mmol scale) was obtained as an oil after purification by silica gel column chromatography

(hexane/AcOEt = 6/1). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.27 (d, 2H, J = 8.1 Hz), 7.15 (d, 2H, J = 8.1 Hz), 6.00–5.83 (m, 2H), 5.42 (br, 1H), 3.29 (brs, 2H), 2.70 (s, 3H), 2.33 (s, 3H). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): δ 138.0, 136.1, 129.1, 127.9, 124.1, 79.5, 56.3, 46.1, 21.2. IR (neat) 2953, 2920, 2852, 1654, 1615, 1514, 1436, 1097, 1057, 994, 957, 888, 813, 659 cm^{-1}. HRMS (ESI) *m/z*: $[M+H]^+$ Calcd for $C_{12}H_{16}NO$ 190.1232; Found 190.1227.

6-Mesityl-2-methyl-3,6-dihydro-2*H*-1,2-oxazine (2e): The compound **2e** (76 mg, 70% yield, 0.5 mmol scale) was obtained as an oil after purification by silica gel column chromatography (hexane/AcOEt = 6/1). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 6.74 (s, 2H), 5.92–5.81 (m, 2H), 5.74 (d, 1H, J = 10.1 Hz), 3.40–3.18 (m, 2H), 2.66 (s, 3H), 2.30 (s, 6H), 2.15 (s, 3H). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): δ 137.6, 137.5, 131.4, 129.8, 128.9, 123.1, 76.2, 56.1, 46.2, 20.7, 20.6. IR (neat) 2952, 2918, 2852, 1658, 1611, 1459, 1435, 994, 869, 797 cm^{-1}. HRMS (ESI) *m/z*: $[M+H]^+$ Calcd for $C_{14}H_{20}NO$ 218.1545; Found 218.1548.

6-(4-Methoxyphenyl)-2-methyl-3,6-dihydro-2*H*-1,2-oxazine (2f): The compound **2f** (57 mg, 56% yield, 0.5 mmol scale) was obtained as an oil after purification by silica gel column chromatography (hexane/AcOEt = 6/1). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.30 (d, 2H, J = 8.2 Hz), 6.87 (d, 2H, J = 8.2 Hz), 6.02–5.95 (m, 1H), 5.90 (d, 1H, J = 10.1 Hz), 5.41 (br, 1H), 3.79 (s, 3H), 3.29 (brs, 2H), 2.70 (s, 3H). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): δ 159.5, 131.3, 129.3, 128.9, 124.1, 113.8, 79.1, 56.3, 55.2, 46.1. IR (neat) 2953, 2836, 1653, 1611, 1513, 1462, 1248, 1173, 1096, 1056, 1035, 995, 887, 833, 660 cm^{-1}. HRMS (ESI) *m/z*: $[M+H]^+$ Calcd for $C_{12}H_{16}NO_2$ 206.1181; Found 206.1178.

6-(2,3-Dimethoxyphenyl)-2-methyl-3,6-dihydro-2*H*-1,2-oxazine (2g): The compound **2g** (61 mg, 52% yield. 0.5 mmol scale) was obtained as an oil after purification by silica gel column chromatography (hexane/AcOEt = 3/1). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.06–6.95 (m, 2H), 6.87 (d, 1H, J = 7.8 Hz), 5.99–5.81 (m, 3H), 3.88 (s, 3H), 3.86 (s, 3H), 3.30 (brs, 2H), 2.71 (s, 3H). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): 152.6, 147.1, 133.1, 128.9, 124.0, 123.8, 120.2, 112.1, 73.4, 61.3, 56.3, 55.7, 46.1. IR (neat) 2936, 2834, 1657, 1586, 1480, 1431, 1277, 1055, 1008, 858, 574, 665 cm^{-1}. HRMS (ESI) *m/z*: $[M+H]^+$ Calcd for $C_{13}H_{18}NO_3$ 236.1287; Found 236.1292.

6-(2,4-Dimethoxyphenyl)-2-methyl-3,6-dihydro-2*H*-1,2-oxazine (2h): The compound **2h** (56 mg, 47% yield, 0.5 mmol scale) was obtained as an oil after purification by silica gel column chromatography (hexane/AcOEt = 3/1). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.30–7.25 (m, 1H), 6.48–6.45 (m, 1H), 6.45 (s, 1H), 5.97–5.83 (m, 3H), 3.81 (s, 3H), 3.79 (s, 3H), 3.28 (brs, 2H), 2.70 (s,

3H). $^{13}C\{^1H\}$ NMR ($CDCl_3$, 100 MHz): δ 160.6, 158.1, 129.4, 123.5, 120.0, 104.2, 98.4, 72.6, 56.4, 55.5, 55.3, 46.1. IR (neat) 2953, 2834, 1613, 1588, 1506, 1464, 1288, 1208, 1157, 1038, 832, 665 cm^{-1}. HRMS (FAB^+) *m/z*: $[M+H]^+$ Calcd for $C_{13}H_{18}NO_3$ 236.1287; Found 236.1280.

6-(2,5-Dimethoxyphenyl)-2-methyl-3,6-dihydro-2*H*-1,2-oxazine (2i): The compound **2i** (51 mg, 43% yield, 0.5 mmol scale) was obtained as an oil after purification by silica gel column chromatography (hexane/AcOEt = 3/1). ^1H NMR ($CDCl_3$, 400 MHz): δ 7.03–6.93 (m, 1H), 6.81 (d, 1H, J = 9.2 Hz), 6.78 (dd, 1H, J = 9.2, 2.8 Hz), 5.96–5.81 (m, 3H), 3.80 (s, 3H), 3.76 (s, 3H), 3.29 (brs, 2H), 2.73 (s, 3H). $^{13}C\{^1H\}$ NMR ($CDCl_3$, 100 MHz): δ 153.5, 151.0, 138.3, 129.0, 123.5, 114.1, 113.3, 111.9, 73.1, 56.3, 56.2, 55.6, 46.1. IR (neat) 2952, 2839, 1591, 1497, 1278, 1219, 1048, 806, 715 cm^{-1}. HRMS (ESI) *m/z*: $[M+H]^+$ Calcd for $C_{13}H_{18}NO_3$ 236.1287; Found 236.1282.

6-(2,4,6-Trimethoxyphenyl)-2-methyl-3,6-dihydro-2*H*-1,2-oxazine (2j): The compound **2j** (73 mg, 55% yield, 0.5 mmol scale) was obtained as a solid after purification by silica gel column chromatography (hexane/AcOEt = 3/1). Mp 113–114 °C. ^1H NMR ($CDCl_3$, 400 MHz): δ 6.02 (s, 2H), 5.98 (brs, 1H), 5.72 (brs, 2H), 3.71 (s, 3H), 3.69 (s, 6H), 3.22 (brs, 2H), 2.65 (s, 3H). $^{13}C\{^1H\}$ NMR ($CDCl_3$, 100 MHz): δ 161.4, 160.5, 130.2, 120.6, 107.6, 91.3, 71.0, 56.2, 55.9, 55.2, 46.2. IR (KBr) 2909, 2800, 1606, 1459, 1204, 1125, 957, 806 cm^{-1}. HRMS (ESI) *m/z*: $[M+H]^+$ Calcd for $C_{14}H_{20}NO_4$ 266.1392; Found 266.1394.

Recrystallization from hexane/AcOEt gave the crystal **2j**. Crystal data: $C_{14}H_{19}NO_4$, M_r = 265.30, monoclinic, $P2_1/c$, a = 10.5750(5), b = 8.7937(4), c = 14.6350(7) Å, β = 91.4380(10). V = 1360.53(11) $Å^3$, Z = 4, D_{calcd} = 1.295 g cm^{-3}, R = 0.0419 (R_w = 0.1726) for 2658 reflections. CCDC 1991113 (**2j**) contains the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre via www.ccdc.cam.ac.uk/data_request/cif.

***N*,*N*-Dimethyl-4-(2-methyl-3,6-dihydro-2*H*-1,2-oxazin-6-yl)aniline (2k):** The compound **2k** (44 mg, 40% yield, 0.5 mmol scale) was obtained as an oil after purification by silica gel column chromatography (hexane/AcOEt = 3/1). ^1H NMR ($CDCl_3$, 400 MHz): δ 7.24 (d, 2H, J = 8.7 Hz), 6.70 (d, 2H, J = 8.7 Hz), 6.02–5.84 (m, 2H), 5.38 (br, 1H), 3.28 (brs, 2H), 2.93 (s, 6H), 2.69 (s, 3H). $^{13}C\{^1H\}$ NMR ($CDCl_3$, 100 MHz): 150.7, 129.4, 129.1, 126.8, 123.9, 112.4, 79.5, 56.3, 46.1, 40.6. IR (neat) 2850, 2802, 1614, 1523, 1351, 1165, 1053, 812 cm^{-1}. HRMS (ESI) *m/z*: $[M+H]^+$ Calcd for $C_{13}H_{19}N_2O$ 219.1497; Found 219.1494.

6-(4-Chlorophenyl)-2-methyl-3,6-dihydro-2*H*-1,2-oxazine (2l): The compound **2l** (44 mg, 42% yield, 0.5 mmol scale) was obtained as an oil after purification by silica gel column chromatography (hexane/AcOEt = 6/1). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.32 (s, 4H), 6.01 (d, 1H, J = 9.6 Hz), 5.96–5.84 (m, 1H), 5.41 (br, 1H), 3.30 (brs, 2H), 2.70 (s, 3H). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): δ 149.8, 137.8, 133.8, 129.2, 128.6, 124.6, 78.9, 56.2, 46.1. IR (neat) 2954, 2922, 2852, 1653, 1596, 1491, 1436, 1408, 1260, 1092, 1059, 1015, 995, 887, 807, 720 cm^{-1}. HRMS (ESI) *m/z*: $[M+H]^+$ Calcd for $C_{11}H_{13}NOCl$ 210.0686; Found 210.0685.

2-Methyl-6-phenethyl-3,6-dihydro-2*H*-1,2-oxazine (2m): The compound **2m** (14 mg, 14% yield, 0.5 mmol scale) was obtained as an oil after purification by silica gel column chromatography (hexane/AcOEt = 6/1). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.30–7.07 (m, 5H), 5.87–5.81 (m, 1H), 5.75 (d, 1H, J = 10.1 Hz), 4.45 (br, 1H), 3.25–3.14 (m, 2H), 2.82–2.67 (m, 2H), 2.70 (s, 3H), 1.84–1.72 (m, 2H). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): 142.0, 129.4, 128.5, 128.3, 125.7, 123.7, 76.1, 56.4, 46.0, 35.3, 31.5. IR (neat) 3027, 2922, 2852, 1604, 1496, 1455, 1436, 1103, 1055, 993, 750, 699 cm^{-1}. HRMS (ESI) *m/z*: $[M+H]^+$ Calcd for $C_{13}H_{18}NO$ 204.1388; Found 204.1389.

2,5-Dimethyl-6-phenyl-3,6-dihydro-2*H*-1,2-oxazine (2n): The compound **2n** (51 mg, 54% yield, 0.5 mmol scale) was obtained as an oil after purification by silica gel column chromatography (hexane/AcOEt = 6/1). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.35–7.28 (m, 5H), 5.71 (s, 1H), 5.25 (br, 1H), 3.38–3.20 (m, 2H), 2.67 (s, 3H), 1.45 (s, 3H). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): δ 138.4, 135.1, 128.7, 128.33, 128.26, 119.6, 83.4, 56.6, 46.0, 18.7. IR (neat) 2916, 2852, 2801, 1493, 1454, 1437, 1379, 1270, 1087, 1039, 995, 942, 900, 850, 755, 701 cm^{-1}. HRMS (ESI) *m/z*: $[M+H]^+$ Calcd for $C_{12}H_{16}NO$ 190.1232; Found 190.1235.

2-Benzyl-6-mesityl-3,6-dihydro-2*H*-1,2-oxazine (2o): The compound **2o** (16 mg, 42% yield, 0.13 mmol scale) was obtained as an oil after purification by preparative TLC (hexane/AcOEt = 10/1). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.38 (d, 2H, J = 6.9 Hz), 7.32–7.20 (m, 3H), 6.79 (s, 2H), 5.95 (brs, 1H), 5.94–5.81 (m, 2H), 4.12 (d, 1H, J = 13.7 Hz), 3.87 (d, 1H, J = 13.7 Hz), 3.45–3.31 (m, 2H), 2.34 (s, 6H), 2.22 (s, 3H). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): δ 137.9, 137.5, 136.9, 131.6, 129.8, 129.5, 128.9, 128.7, 128.1, 128.0, 127.1, 123.2, 76.3, 62.7, 53.9, 20.8, 20.7. IR (neat) 3033, 2919, 2859, 2799, 1610, 1494, 1454, 1378, 1339, 1085, 1030, 970, 742, 698 cm^{-1}. HRMS (FAB$^+$) *m/z*: $[M+H]^+$ Calcd for $C_{20}H_{24}NO$ 294.1858; Found 294.1853.

2-Methyl-6-phenyl-3,6-dihydro-2*H*-(3,3-D_2)1,2-oxazine (2a–d_2): Under an Ar atmosphere, a mixture of trimethylsulfoxonium-d_9 iodide[14] (344 mg, 1.50 mmol) and NaH (60 mg, 60% w/w dispersion in mineral oil, 1.50 mmol) in THF (3 mL) was refluxed for 2 h. After cooling to 0 °C, *α,β*-unsaturated nitrone **1a** (81 mg, 0.50 mmol) in THF (2 mL) was added and the resulting mixture was stirred for 3 h at 70 °C (oil bath temperature). After cooling to rt, sat aqueous NH_4Cl solution was added and extracted with $CHCl_3$. Combined organic layers were dried over Na_2SO_4 and concentrated. The residue was purified by column chromatography on silica gel (hexane/AcOEt = 15/1, 12/1, 8/1) to give a deuterated 3,6-dihydro-2*H*-1,2-oxazine **2a**–d_2 as an oil (37 mg, 42% yield, 86%-D). ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.45–7.28 (m, 5H), 6.04–5.88 (m, 2H), 5.45 (brs, 1H), 3.32–3.27 (m, 0.27H), 2.72 (s, 3H). ^{13}C{^{1}H} NMR ($CDCl_3$, 100 MHz): δ 138.9, 128.7, 128.4, 128.2, 127.8, 124.0, 79.6, 55.7 (quint, J = 18 Hz), 46.1. IR (neat) 3033, 2953, 2185, 2059, 1493, 1454, 1274, 1095, 1044, 921, 893, 748, 699 cm^{-1}. HRMS (ESI) Calcd for $C_{11}H_{12}D_2NO$ $[M+H]^+$: 178.1201, found 178.1201.

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SUPPORTING INFORMATION

Copies of ^{1}H NMR and ^{13}C NMR spectra of products, cif files.

REFERENCES AND NOTES

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