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# Synthesis of 2*H*-Azirines via Iodine-Mediated Oxidative

# **Cyclization of Enamines**

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 $R^{2} \xrightarrow{R^{3}}_{NH_{2}} R^{1} \xrightarrow{I_{2}, DBU, CH_{2}CI_{2}}_{room temperature} R^{3} \xrightarrow{R^{1}}_{N} R^{1}$   $R^{1}, R^{2} = aryl, alkyl or H 24 examples, 49-99\%$   $R^{3} = CN, CO_{2}Et or COMe gram-scale$ 

**Abstract:** A facile and practical oxidative cyclization reaction of enamines to 2H-azirines has been developed employing molecular iodine. The features of the present synthetic approach include no use of transition metals, mild reaction conditions and simplicity of operation. Under the optimal reaction conditions, a variety of 2H-azirine derivatives were synthesized from simple and readily accessible enamine precursors in an efficient and scalable fashion.

### Introduction

*H*-Azirines, containing one nitrogen atom and one double bond in a three-membered ring, are an important class of the smallest heterocyclic systems. Owing to the high reactivity enhanced by the ring strain, they can participate in many chemical transformations<sup>1</sup> as nucleophiles, electrophiles, dienophiles, or dipolarophiles. As valuable synthons, 2*H*-azirines have been extensively utilized to construct other heterocyclic skeletons such as indoles,<sup>2</sup> pyrroles,<sup>3</sup> pyridines,<sup>4</sup> oxazoles,<sup>5</sup> pyrazines,<sup>6</sup> triazoles<sup>7</sup> and azepines.<sup>8</sup> Moreover, this structural motif also occurs frequently in natural products<sup>9</sup> with diverse biological properties. For example, Azirinomycin, the first azirine-containing natural product, exhibits broad spectrum antibiotic activity.<sup>9a</sup>

Consequently, considerable efforts have been made for the construction of the 2*H*-azirine framework.<sup>1a, 1b, 1d</sup> Classical synthetic strategies include Neber rearrangement of ketoximes,<sup>10</sup> thermolysis/photolysis of vinyl azides,<sup>11</sup> oxidation/elimination of aziridines,<sup>12</sup> ring contraction of isoxazole derivatives,<sup>13</sup> and cycloaddition of carbenes with nitriles.<sup>14</sup> Moreover, direct oxidative cyclization of enamine precursors is also an attractive approach to access 2*H*-azirines in an atom- and step-economic fashion. Yet, this transformation was only achieved by Du, Zhao and coworkers using hypervalent iodine reagents.<sup>15</sup> Inspired by our previous work on I<sub>2</sub>-mediated intramolecular C–H amination,<sup>16</sup> herein we describe a simple and practical methodology for the synthesis of 2*H*-azirines from readily accessible enamines.

### Results and Discussion

The required enamine substrate 2a was readily prepared by a modified Thorpe procedure

from phenylacetonitrile with benzonitrile.<sup>17</sup> Initial solvent screening (Table 1, entries 1–6) indicated that  $CH_2Cl_2$  is the desired one for this transformation. In the presence of  $K_2CO_3$  as base, I<sub>2</sub>-mediated cyclization of substrate **2a** in  $CH_2Cl_2$  at room temperature was complete within 5 h producing the expected 2*H*-azirine **1a** in 80% yield (entry 2). Screening of various organic and inorganic bases (entries 7–15) demonstrated that DBU is the optimal one. When DBU was utilized as the base, both the conversion rate and the yield of **1a** were significantly increased (entry 10). Further optimization of the reaction conditions suggested that the complete consumption of enamine **2a** requires at least 1.2 equiv of iodine (entry 10 *vs* entry 17) with 2.5 equiv of the base DBU (entry 10 *vs* entry 16). However, excess iodine resulted in the decreased yield of the product (entry 18). Replacement of iodine with *N*-Iodosuccinimide (NIS) also afforded product **1a** but in a lower yield (entry 19). Under the optimal cyclization conditions, the synthesis of **1a** was successfully carried out on a gram scale (entry 10).

Table 1. Reaction Condition Optimization for the Synthesis of 2H-Azirine 1a.<sup>a</sup>

CN Ph	l <sub>2</sub> , base	NC Ph
NH₂	solvent, temp.	Ph N
2a		1a

entry	I <sub>2</sub> /equiv	base/equiv	solvent	temp.	time	yield <sup>b</sup>
1	1.2	K <sub>2</sub> CO <sub>3</sub> (2.5)	toluene	rt	5 h	77%
2	1.2	K <sub>2</sub> CO <sub>3</sub> (2.5)	$CH_2Cl_2$	rt	5 h	80%
3	1.2	$K_2CO_3$ (2.5)	1,4-dioxane	rt	18 h	68%
4	1.2	$K_2CO_3(2.5)$	CH <sub>3</sub> CN	rt	18 h	39%
5	1.2	K <sub>2</sub> CO <sub>3</sub> (2.5)	DMSO	rt	1 h	27%

					0/0
7 1.2	NaHCO <sub>3</sub> $(2.5)$	$CH_2Cl_2$	rt	24 h	16%
8 1.2	AcONa (2.5)	$CH_2Cl_2$	rt	24 h	12%
9 1.2	$Cs_2CO_3$ (2.5)	$CH_2Cl_2$	rt	22 h	77%
10 1.2	<b>DBU (2.5)</b>	CH <sub>2</sub> Cl <sub>2</sub>	rt	0.5 h	<b>92% (90%)</b> <sup>c</sup>
11 1.2	$E_{3N}(2.5)$	$CH_2Cl_2$	rt	5 h	0%
12 1.2	pyridine (2.5)	$CH_2Cl_2$	rt	24 h	trace
13 1.2	DMAP (2.5)	$CH_2Cl_2$	rt	24 h	trace
14 1.2	NMI (2.5)	$CH_2Cl_2$	rt	24 h	trace
15 1.2	imidazole (2.5)	$CH_2Cl_2$	rt	24 h	trace
16 1.2	DBU (1.2)	$CH_2Cl_2$	rt	3 h	80%
17 1.0	DBU (2.0)	$CH_2Cl_2$	rt	3 h	81%
18 1.5	DBU (3.0)	$CH_2Cl_2$	rt	0.5 h	74%
19 _ <sup>d</sup>	DBU (2.5)	$CH_2Cl_2$	rt	0.5 h	35%

<sup>*a*</sup> Optimal reaction conditions (entry 10): **2a** (0.5 mmol), I<sub>2</sub> (0.6 mmol), DBU (1.25 mmol), CH<sub>2</sub>Cl<sub>2</sub> (5 mL), rt. <sup>*b*</sup> Isolated yields. <sup>*c*</sup> The yield of gram-scale synthesis (6 mmol). <sup>*d*</sup> NIS (0.6 mmol) was used instead of iodine.

With the optimized conditions in hand (Table 1, entry 10), we then examined the substrate scope of this reaction. As shown in Scheme 1, the present synthetic methodology is compatible with both electron-donating groups (EDGs) and electron-withdrawing groups (EWGs) on the benzene ring at R<sup>1</sup> position. The presence of EDGs (Me, OMe) at the *para*- position favored the formation of the expected 2*H*-azirines (**1b**–**c**). Introduction of EWGs (F, Cl, CF<sub>3</sub>) affected the yields of the corresponding

products (1d-f). The steric hinderance of the *ortho*-methyl group could be responsible for the decreased yield of 1h. Replacement of the aromatic R<sup>1</sup> group with an aliphatic one (*n*Pr) also produced the desired 2*H*-azirine (1i), but in a relatively lower yield. This could be due to the decreased stability of the imine-type intermediates caused by the alkyl substituent (cf. compounds A and B in Scheme 4A) during the transformation.

Scheme 1. Scope of R<sup>1</sup> Group.<sup>a</sup>



<sup>*a*</sup> Reaction conditions: **2** (0.5 mmol), I<sub>2</sub> (0.6 mmol), DBU (1.25 mmol), CH<sub>2</sub>Cl<sub>2</sub> (5 mL), rt. <sup>*b*</sup> With 32% of the substrate **2i** recovered.

To further investigate the generality of the present reaction, enamine substrates bearing various  $R^2$  groups were subjected to the standard cyclization conditions (Scheme 2). This synthetic process can tolerate a range of *para-*, *meta-*, *ortho-* and di-substituents on the aromatic ring at the  $R^2$  position to form the corresponding products (**1j-r**) efficiently.

The structure of 2*H*-azirine **1n** was further confirmed by X-ray crystallography. This method is also amenable to substrates bearing  $\alpha$ -naphthyl, 2-pyridyl or alkyl moieties (**1s-t**, **1v**). When R<sup>2</sup> is H, only the corresponding vinyl iodide (**1u'**) was formed (for the plausible mechanism see Scheme 4B). Furthermore, good functional group tolerance of this reaction also allows for the replacement of the cyano group at the R<sup>3</sup> position with other EWGs such as carboxylic acid ester (**1w**) and methyl ketone (**1x**). Taking **1a** as an example, the 2*H*-azirine was further converted into a 3-cyano-indole (**3a**) in the presence of palladium catalyst<sup>2a</sup> (Scheme 3).

Scheme 2. Scope of R<sup>2</sup> and R<sup>3</sup> Groups.<sup>a</sup>



Scheme 3. Formation of 3-Cyano-indole 3a via Pd-Catalyzed Rearrangement of 2*H*-Azirine 1a.



On the basis of the experimental results along with our previous work,<sup>16</sup> a tentative reaction mechanism for this I<sub>2</sub>-mediated cyclization of enamines to 2*H*-azirines is proposed in Scheme 4A. First, iodination of the enamine substrate **2** by iodine under the basic conditions generates a 2-iodo imine intermediate **B**. The imine nitrogen atom then attacks the iodo-substituted carbon in compound **B** to form a three-membered 2*H*-azirine ring (**C**). Finally, the subsequent deprotonation by base afford the product **1**. In the case of enamine substrate **2u** ( $R^2 = H$ ), the resulting iodide intermediate **A'** may directly undergo  $\beta$ -deprotonation to result in the corresponding vinyl iodide (**1u'**) (Scheme 4B).

Scheme 4. Proposed Mechanisms for the Formation of 1*H*-Azirine 1a and Vinyl Iodide 1u'.



# Conclusion

In summary, we have developed an  $I_2$ -mediated oxidative cyclization reaction for the synthesis of 2*H*-azirines under transition-metal-free conditions. The required enamine substrates were readily obtained by Thorpe reaction of benzonitrile with

phenylacetonitrile or by condensation of ammonium formate with ketones. In the presence of DBU as base, the enamine precursors were cyclized by the treatment with iodine to the 2*H*-azirine products smoothly and efficiently. Moreover, the present reaction can be successfully conducted on a gram scale. This practical methodology provided an attractive alternative for 2*H*-azirine synthesis under mild reaction conditions.

#### Experimental Section

**General Information.** <sup>1</sup>H and <sup>13</sup>C{<sup>1</sup>H} NMR spectra were recorded on a 400 MHz (100 MHz for <sup>13</sup>C{<sup>1</sup>H} NMR) spectrometer. Chemical shift values are given in ppm (parts per million) with tetramethylsilane (TMS) as an internal standard. The peak patterns are indicated as follows: s, singlet; d, doublet; t, triplet; q, quartet; quint, quintet; sext, sextet; m, multiplet; dd, doublet of doublets; dt, doublet of triplets. The coupling constants (*J*) are reported in Hertz (Hz). Melting points were determined on a micromelting point apparatus without corrections. High-resolution mass spectra (HRMS) were obtained on a Q-TOF mass spectrometer equipped with an electrospray ion source (ESI), operated in the positive mode. Flash column chromatography was performed over silica gel 200–300 mesh. Most of the enamine substrates were synthesized as a mixture of *Z*/*E* isomers. In the cases where only a small amount of the other isomer was formed, the substrate could be obtained as a single *Z* (or *E*) isomer after purification. The absolute configuration was not assigned. Substrate **2t** was synthesized as the *E*-isomer and **2w**–**x** as the *Z*-isomers due to the existence of intramolecular hydrogen bonds.

**General Procedure for the Preparation of Enamine Substrates 2a-h, 2j-u.** The synthesis was performed by a modified Thorpe procedure.<sup>17</sup> A mixture of an aliphatic

nitrile (5 mmol) and the corresponding benzonitrile (5 mmol) in 'BuOH (10 mL) was treated with 'BuOK (1.40 g, 12.5 mmol), and then stirred at room temperature for 3 h. Upon the completion of the reaction (monitored by TLC), it was quenched with H<sub>2</sub>O (20 mL) and extracted with EtOAc ( $3 \times 20$  mL). The combined organic layer was dried over anhydrous Na<sub>2</sub>SO<sub>4</sub>, concentrated, and then purified through silica gel column chromatography to afford the enamine substrate **2**.

General Procedure for the Preparation of Enamine Substrates 2i, 2v-x.<sup>15a</sup> A reaction mixture of the corresponding ketone (5 mmol), ammonium formate (1.58 g, 25 mmol) and molecular sieves (4 Å, 1 g) in anhydrous EtOH (20 mL) was heated to reflux until TLC indicated the total consumption of the ketone. After cooling to room temperature, it was filtered through a silica gel pad and the filtrate was concentrated. The resulting residue was treated with H<sub>2</sub>O (10 mL) and extracted with EtOAc (3 × 20 mL). The combined organic layer was dried over anhydrous Na<sub>2</sub>SO<sub>4</sub>, concentrated, and then purified through silica gel column chromatography to afford the enamine substrate **2**.

**3-Amino-2,3-diphenylacrylonitrile (2a).**<sup>17</sup> Eluent: EtOAc/PE 20:80; yield: 727 mg, 66%; yellow solid, mp 132–137 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.69–7.67 (m, 2H), 7.53–7.41 (m, 7H), 7.31–7.27 (m, 1H), 4.80 (s, 2H); HRMS (ESI-TOF) m/z: [M + H]<sup>+</sup> calcd for C<sub>15</sub>H<sub>13</sub>N<sub>2</sub> 221.1073, found 221.1065.

**3-Amino-2-phenyl-3-**(*p*-tolyl)acrylonitrile (2b).<sup>17</sup> EtOAc/PE 20:80; yield: 726 mg, 66% (minor:major = 1:6.3); yellow solid, mp 131–133 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): major isomer: δ 7.59 (d, *J* = 8.0 Hz, 2H), 7.54–7.52 (m, 2H), 7.43 (t, *J* = 7.6 Hz, 2H), 7.31–7.27 (m, 3H), 4.77 (s, 2H), 2.41 (s, 3H); minor isomer: δ 7.19–7.17 (m, 2H), 7.11–7.03 (m, 5H), 7.01–6.99 (m, 2H), 4.95 (s, 2H), 2.34 (s, 3H); HRMS (ESI-TOF) m/z: [M + H]<sup>+</sup>

calcd for C<sub>16</sub>H<sub>15</sub>N<sub>2</sub> 235.1230, found 235.1231.

**3-Amino-3-(4-methoxyphenyl)-2-phenylacrylonitrile (2c).** EtOAc/PE 20:80; yield: 713 mg, 57% (minor:major = 1:2.3); white solid, mp 174–175 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): major isomer:  $\delta$  7.65 (d, *J* = 8.8 Hz, 2H), 7.53–7.51 (m, 2H), 7.43 (t, *J* = 8.0 Hz, 2H), 7.02–6.96 (m, 3H), 4.76 (s, 2H), 3.85 (s, 3H); minor isomer:  $\delta$  7.29 (d, *J* = 7.6 Hz, 2H), 7.22 (d, *J* = 8.8 Hz, 2H), 7.14–7.10 (m, 2H), 7.07–7.05 (m, 1H), 6.79 (d, *J* = 8.8 Hz, 2H), 4.95 (s, 2H), 3.79 (s, 3H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>): major isomer:  $\delta$  161.4, 156.8, 134.23, 129.6, 129.4, 128.6, 128.2, 125.8, 122.6, 114.2, 81.3, 55.4; minor isomer:  $\delta$  161.0, 157.7, 134.15, 130.4, 129.1, 128.1, 127.3, 126.8, 121.1, 114.1, 80.5, 55.3; HRMS (ESI-TOF) m/z: [M + H]<sup>+</sup> calcd for C<sub>16</sub>H<sub>15</sub>N<sub>2</sub>O 251.1179, found 251.1177.

**3-Amino-3-(4-fluorophenyl)-2-phenylacrylonitrile (2d).** EtOAc/PE 20:80; yield: 845 mg, 71%; yellow solid, mp 135–138 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.69–7.66 (m, 2H), 7.51–7.49 (m, 2H), 7.43 (t, *J* = 8.0 Hz, 2H), 7.32–7.28 (m, 1H), 7.14 (t, *J* = 8.8 Hz, 2H), 4.81 (s, 2H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  163.9 (d, *J*<sub>C-F</sub> = 249.4 Hz), 156.0, 133.7, 132.0 (d, *J*<sub>C-F</sub> = 3.3 Hz), 130.3 (d, *J*<sub>C-F</sub> = 8.6 Hz), 129.5, 128.6, 127.6, 122.1, 116.0 (d, *J*<sub>C-F</sub> = 21.7 Hz), 82.1; HRMS (ESI-TOF) m/z: [M + H]<sup>+</sup> calcd for C<sub>15</sub>H<sub>12</sub>FN<sub>2</sub> 239.0979, found 239.0977.

**3-Amino-3-(4-chlorophenyl)-2-phenylacrylonitrile (2e).**<sup>18</sup> EtOAc/PE 20:80; yield: 916 mg, 72%; white solid, mp 150–153 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.64–7.60 (m, 2H), 7.51–7.49 (m, 2H), 7.46–7.42 (m, 4H), 7.30 (tt, *J* = 7.6, 1.2 Hz, 7H), 4.79 (m, 2H); HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>15</sub>H<sub>11</sub>ClN<sub>2</sub>Na 277.0503, found 277.0501. **3-Amino-2-phenyl-3-(4-(trifluoromethyl)phenyl)acrylonitrile (2f).** EtOAc/PE 20:80;

yield: 980 mg, 68%; white solid, mp 147–148 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.83 (d,

J = 8.4 Hz, 2H), 7.74 (d, J = 8.0 Hz, 2H), 7.53–7.51 (m, 2H), 7.48–7.44 (m, 2H), 7.35–7.31 (m, 1H), 4.81 (s, 2H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  155.3, 139.4, 133.3, 132.5 (q,  $J_{C-F} = 32.6$  Hz), 129.6, 128.7, 128.6, 127.9, 126.0 (q,  $J_{C-F} = 3.7$  Hz), 123.7 (q,  $J_{C-F} = 270.8$  Hz), 121.5, 83.2; HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>16</sub>H<sub>11</sub>F<sub>3</sub>N<sub>2</sub>Na 311.0767, found 311.0767.

**3-Amino-2-phenyl-3-(***m***-tolyl)acrylonitrile (2g).** EtOAc/PE 20:80; yield: 872 mg, 75%; yellow solid, mp 131–133 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.53–7.47 (m, 4H), 7.45–7.41 (m, 2H), 7.37–7.33 (m, 1H), 7.31–7.27 (m, 2H), 4.78 (s, 2H), 2.42 (s, 3H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>) δ 157.2, 138.7, 136.0, 134.1, 131.4, 129.4, 128.8, 128.7, 128.6, 127.4, 125.2, 122.2, 81.7, 21.4; HRMS (ESI-TOF) m/z: [M + H]<sup>+</sup> calcd for C<sub>16</sub>H<sub>15</sub>N<sub>2</sub> 235.1230, found 235.1230.

**3-Amino-2-phenyl-3-(***o***-tolyl)acrylonitrile (2h).**<sup>19</sup> EtOAc/PE 20:80; yield: 948 mg, 81%; yellow oil; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.54–7.48 (m, 4H), 7.44 (t, *J* = 7.6 Hz, 2H), 7.38–7.34 (m, 1H), 7.31–7.27 (m, 2H), 4.77 (s, 2H), 2.42 (s, 3H); HRMS (ESI-TOF) m/z: [M + H]<sup>+</sup> calcd for C<sub>16</sub>H<sub>15</sub>N<sub>2</sub> 235.1230, found 235.1228.

**3-Amino-2-phenylhex-2-enenitrile (2i).** EtOAc/PE 10:90; yield: 717 mg, 77% (with a small amount of the other isomer); white solid, mp 58–59 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.39–7.37 (m, 4H), 7.25–7.22 (m, 1H), 4.67 (s, 2H), 2.54 (t, *J* = 7.8 Hz, 2H), 1.73 (sext, *J* = 7.6 Hz, 2H), 1.06 (t, *J* = 7.2 Hz, 3H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  158.8, 133.7, 129.3, 128.6, 127.1, 122.0, 80.9, 36.7, 21.6, 13.5; HRMS (ESI-TOF) m/z: [M + H]<sup>+</sup> calcd for C<sub>12</sub>H<sub>15</sub>N<sub>2</sub> 187.1230, found 187.1228.

**3-Amino-3-phenyl-2-(***p***-tolyl)acrylonitrile (2j).** CH<sub>2</sub>Cl<sub>2</sub>/PE 60:40; yield: 878 mg, 75%; white solid, mp 150–152 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.70–7.68 (m, 2H),

7.49–7.46 (m, 3H), 7.43–7.41 (m, 2H), 7.26–7.24 (m, 2H, overlapped with the peak of chloroform), 4.74 (s, 2H), 2.38 (s, 3H);  ${}^{13}C{}^{1}H{}$  NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  156.6, 137.4, 136.1, 130.9, 130.5, 130.1, 128.9, 128.5, 128.0, 122.2, 82.0, 21.2; HRMS (ESI-TOF) m/z: [M + H]<sup>+</sup> calcd for C<sub>16</sub>H<sub>15</sub>N<sub>2</sub> 235.1230, found 235.1222.

**3-Amino-2-(4-methoxyphenyl)-3-phenylacrylonitrile (2k).** CH<sub>2</sub>Cl<sub>2</sub>/PE 60:40; yield: 901 mg, 72% (minor:major = 1:7.1); yellow solid, mp 170–173 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): major isomer:  $\delta$  7.70–7.67 (m, 2H), 7.48–7.43 (m, 5H), 6.99–6.95 (m, 2H), 4.68 (s, 2H), 3.83 (s, 3H); minor isomer:  $\delta$  7.36–7.33 (m, 1H), 7.28 (d, *J* = 4.4 Hz, 4H), 6.92–6.88 (m, 2H), 6.66–6.64 (m, 2H), 4.89 (s, 2H), 3.72 (s, 3H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>): major isomer:  $\delta$  158.9, 156.5, 136.0, 130.5, 130.1, 128.9, 128.0, 126.0, 122.3, 114.8, 81.6, 55.4; minor isomer:  $\delta$  157.9, 157.0, 135.1, 130.4, 130.0, 128.7, 126.1, 120.9, 113.7, 80.9, 55.2; HRMS (ESI-TOF) m/z: [M + H]<sup>+</sup> calcd for C<sub>16</sub>H<sub>15</sub>N<sub>2</sub>O 251.1179, found 251.1177.

**3-Amino-2-(4-chlorophenyl)-3-phenylacrylonitrile (21).** CH<sub>2</sub>Cl<sub>2</sub>/PE 60:40; yield: 840 mg, 66% (with a small amount of the other isomer); yellow solid, mp 165–167 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.69–7.67 (m, 2H), 7.51–7.46 (m, 5H), 7.43–7.40 (m, 2H), 4.78 (s, 2H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  157.2, 135.7, 133.2, 132.5, 130.8, 130.0, 129.6, 129.0, 128.0, 121.7, 81.0; HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>15</sub>H<sub>11</sub>ClN<sub>2</sub>Na 277.0503, found 277.0501.

**3-Amino-2,3-bis(4-chlorophenyl)acrylonitrile (2m).**<sup>15a</sup> EtOAc/PE 10:90; yield: 751 mg, 52% (with a small amount of the other isomer); white solid, mp 179–183 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.64–7.61 (m, 2H), 7.47–7.41 (m, 6H), 4.78 (s, 2H); HRMS (ESI-TOF) m/z: [M + H]<sup>+</sup> calcd for C<sub>15</sub>H<sub>11</sub>Cl<sub>2</sub>N<sub>2</sub> 289.0294, found 289.0292.

**3-Amino-2,3-bis(4-bromophenyl)acrylonitrile (2n).** EtOAc/PE 10:90; yield: 1474 mg, 78%; yellow solid, mp 185–186 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.63 (d, *J* = 8.4 Hz, 2H), 7.59–7.55 (m, 4H), 7.40 (d, *J* = 8.4 Hz, 2H), 4.76 (m, 2H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  156.0, 134.5, 132.7, 132.6, 132.3, 130.3, 129.6, 125.3, 121.5, 121.3, 81.6; HRMS (ESI-TOF) m/z: [M + H]<sup>+</sup> calcd for C<sub>15</sub>H<sub>11</sub>Br<sub>2</sub>N<sub>2</sub> 378.9263, found 378.9262.

**3-Amino-3-phenyl-2-(3-(trifluoromethyl)phenyl)acrylonitrile (20).** CH<sub>2</sub>Cl<sub>2</sub>/PE 50:50; yield: 850 mg, 59% (with a small amount of the other isomer); white solid, mp 100–104 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>):  $\delta$  7.44–7.39 (m, 1H), 7.35–7.31 (m, 2H), 7.29–7.26 (m, 3H, overlapped with the peak of chloroform), 7.21 (t, *J* = 7.6 Hz, 1H), 7.18–7.15 (m, 2H), 5.16 (s, 2H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>): major isomer:  $\delta$  159.3, 134.8, 134.2, 132.0, 130.7, 130.5 (q, *J*<sub>C-F</sub> = 32.0 Hz), 129.1, 128.7, 128.6, 125.6 (q, *J*<sub>C-F</sub> = 3.8 Hz), 123.8 (q, *J*<sub>C-F</sub> = 270.9 Hz), 122.4 (q, *J*<sub>C-F</sub> = 3.8 Hz), 120.1, 79.9; HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>16</sub>H<sub>11</sub>F<sub>3</sub>N<sub>2</sub>Na 311.0767, found 311.0761.

**3-Amino-2-(3-chlorophenyl)-3-phenylacrylonitrile (2p).**<sup>20</sup> EtOAc/PE 10:90; yield: 891 mg, 70% (minor:major = 1:12.6); yellow oil; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): major isomer: δ 7.66–7.63 (m, 2H), 7.53–7.51 (m, 2H), 7.48–7.43 (m, 4H), 7.34–7.30 (m, 1H), 4.76 (s, 2H); minor isomer: δ 7.28–7.22 (m, 4H, overlapped with the peak of chloroform), 7.16–7.07 (m, 3H), 7.00–7.6.98 (m, 2H), 4.94 (s, 2H); HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>15</sub>H<sub>11</sub>ClN<sub>2</sub>Na 277.0503, found 277.0501.

**3-Amino-2-(2-chlorophenyl)-3-phenylacrylonitrile (2q).** EtOAc/PE 10:90; yield: 967 mg, 76% (minor:major = 1:5.5); white solid, mp 117–122 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): major isomer:  $\delta$  7.74–7.72 (m, 2H), 7.52–7.45 (m, 5H), 7.37–7.30 (m, 2H), 4.50 (s, 2H); minor isomer:  $\delta$  7.29–7.28 (m, 2H), 7.23–7.18 (m, 4H), 7.09 (td, *J* = 7.2, 1.6 Hz,

1H), 6.96 (td, J = 7.6, 0.8 Hz, 1H), 6.91–6.89 (m, 1H), 5.07 (s, 2H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>): major isomer:  $\delta$  158.4, 135.2, 135.0, 132.55, 131.6, 130.8, 130.6, 130.0, 128.9, 128.1, 127.8, 121.1, 79.1; minor isomer:  $\delta$  159.9, 134.6, 133.7, 132.50, 130.2, 129.7, 128.7, 128.5, 128.4, 126.6, 78.5; HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>15</sub>H<sub>11</sub>ClN<sub>2</sub>Na 277.0503, found 277.0501.

**3-Amino-2-(2,4-dichlorophenyl)-3-phenylacrylonitrile (2r).** CH<sub>2</sub>Cl<sub>2</sub>/PE 40:60; yield: 1156 mg, 81% (minor:major = 1:1.8); white solid, mp 130–133 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): major isomer:  $\delta$  7.36–7.31 (m, 2H, peaks of two isomers overlapped), 7.27–7.23 (m, 2H, overlapped with the peak of chloroform), 7.20–7.18 (m, 2H), 6.95 (dd, *J* = 8.4, 2.0 Hz, 1H), 6.82 (d, *J* = 8.0 Hz, 1H), 5.13 (s, 2H); minor isomer:  $\delta$  7.74–7.71 (m, 2H,), 7.55–7.44 (m, 5H), 7.36–7.31 (m, 1H, peaks of two isomers overlapped) 4.52 (s, 2H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>): major isomer:  $\delta$  160.3, 134.3, 133.8, 133.4, 131.0, 130.46, 129.5, 128.7, 128.3, 128.2, 127.0, 118.9, 78.0; minor isomer:  $\delta$  158.7, 135.9, 135.2, 135.0, 131.2, 130.49, 130.2, 129.0, 128.1, 120.7, 78.6; HRMS (ESI-TOF) m/z: [M + H]<sup>+</sup> calcd for C<sub>15</sub>H<sub>11</sub>Cl<sub>2</sub>N<sub>2</sub> 289.0294, found 289.0292.

**3-Amino-2-(naphthalen-1-yl)-3-phenylacrylonitrile (2s).** CH<sub>2</sub>Cl<sub>2</sub>/PE 50:50; yield: 838 mg, 58%; white solid, mp 188–190 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 8.11–8.09 (m, 1H), 7.93–7.88 (m, 2H), 7.83–7.80 (m, 2H), 7.66–7.64 (m, 1H), 7.59–7.48 (m, 6H), 4.39 (m, 2H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>) δ 158.3, 135.5, 134.3, 131.1, 130.8, 130.2, 129.2, 129.1, 129.0, 128.8, 128.1, 127.0, 126.5, 126.1, 125.0, 122.1, 78.9; HRMS (ESI-TOF) m/z: [M + H]<sup>+</sup> calcd for C<sub>19</sub>H<sub>15</sub>N<sub>2</sub> 271.1230, found 271.1230.

(*E*)-3-Amino-3-phenyl-2-(pyridin-2-yl)acrylonitrile (2t). MeOH/CH<sub>2</sub>Cl<sub>2</sub> 2:98; yield: 796 mg, 72%; white solid, mp 112–115 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 11.10 (s, 1H),

8.47–8.45 (m, 1H), 7.72–7.63 (m, 4H), 7.52–7.46 (m, 3H), 7.06–7.02 (m, 1H), 5.38 (s, 1H);  $^{13}C{^{1}H}$  NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  163.2, 156.6, 146.7, 137.1, 136.8, 130.6, 128.8, 127.9, 121.7, 120.6, 119.0, 78.8; HRMS (ESI-TOF) m/z: [M + H]<sup>+</sup> calcd for C<sub>14</sub>H<sub>12</sub>N<sub>3</sub> 222.1026, found 222.1024.

**3-Amino-3-phenylacrylonitrile (2u).**<sup>18</sup> EtOAc/PE 30:70; yield: 375 mg, 52% (with a small amount of the other isomer); yellow solid, mp 81–84 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.52–7.40 (m, 5H), 5.00 (s, 2H), 4.24 (s, 1H); HRMS (ESI-TOF) m/z: [M + H]<sup>+</sup> calcd for C<sub>9</sub>H<sub>9</sub>N<sub>2</sub> 145.0760, found 145.0759.

**2-(Amino(phenyl)methylene)octanenitrile (2v).** Eluent: EtOAc/PE 5:95; yield: 672 mg, 59% (minor:major = 1:1.8); yellow oil; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): major isomer:  $\delta$  7.57–7.53 (m, 1H), 7.43–7.38 (m, 4H, peaks of two isomers overlapped), 4.53 (s, 2H), 1.97 (t, *J* = 7.6 Hz, 2H), 1.35–1.30 (m, 2H), 1.28–1.11 (m, 6H), 0.83 (t, *J* = 7.2 Hz, 3H); minor isomer:  $\delta$  7.43–7.38 (m, 1H, peaks of two isomers overlapped), 7.35–7.31 (m, 4H), 4.39 (s, 2H), 2.15 (t, *J* = 7.6 Hz, 2H), 1.67–1.59 (m, 2H), 1.48–1.38 (m, 6H), 0.91 (t, *J* = 7.2 Hz, 3H); <sup>13</sup>C {<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>): major isomer:  $\delta$  157.3, 135.5, 129.7, 128.68, 127.96, 121.1, 79.3, 31.5, 29.7, 28.4, 28.1, 22.56, 14.06; minor isomer:  $\delta$  156.1, 136.5, 130.0, 128.65, 128.01, 122.8, 80.3, 31.7, 29.0, 27.9, 27.8, 22.64, 14.12; HRMS (ESI-TOF) m/z; [M + Na]<sup>+</sup> calcd for C<sub>15</sub>H<sub>20</sub>N<sub>2</sub>Na 251.1519, found 251.1519.

Ethyl (*Z*)-3-amino-2,3-diphenylacrylate (2w).<sup>21</sup> EtOAc/PE 5:95; yield: 655 mg, 49%; yellow oil; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.19–7.11 (m, 5H), 7.06–7.97 (m, 5H), 4.17 (q, J = 6.8 Hz, 2H), 1.21 (t, J = 6.8 Hz, 3H); HRMS (ESI-TOF) m/z: [M + H]<sup>+</sup> calcd for C<sub>17</sub>H<sub>18</sub>NO<sub>2</sub> 268.1332, found 268.1333.

(Z)-4-Amino-3-(2-bromophenyl)-4-phenylbut-3-en-2-one (2x). EtOAc/PE 5:95; yield:

550 mg, 58%; yellow solid, mp 190–192 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  11.09 (s, 1H), 7.49 (d, J = 8.0 Hz, 1H), 7.20–7.18 (m, 2H), 7.16–7.06 (m, 5H), 7.03–6.98 (m, 1H), 5.56 (s, 1H), 1.81 (s, 3H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  193.0, 163.2, 142.4, 140.5, 134.8, 132.5, 128.6, 128.4, 127.3, 127.2, 109.1, 22.3; HRMS (ESI-TOF) m/z: [M + H]<sup>+</sup> calcd for C<sub>16</sub>H<sub>15</sub>BrNO 316.0332, found 316.0330.

General Procedure for the Synthesis of Products 1. A solution of the enamine substrate 2 (0.5 mmol) in  $CH_2Cl_2$  (5 mL) was treated with iodine (152 mg, 0.6 mmol) and DBU (190 mg, 1.25 mmol) in sequence, and then stirred at room temperature until the disappearance of the substrate (monitored by TLC). Upon the completion of the reaction, it was quenched with 5% Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> (8 mL) and extracted with  $CH_2Cl_2$  (3 × 15 mL). The combined organic layer was dried over anhydrous Na<sub>2</sub>SO<sub>4</sub>, concentrated, and then purified through silica gel column chromatography to afford the product 1.

**2,3-Diphenyl-2***H***-azirine-2-carbonitrile (1a).** 0.5 h; eluent: EtOAc/PE 10:90; yield: 100 mg, 92% (0.5 mmol scale); 1.18 g, 90% (6 mmol scale); white solid, mp 42–43 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.95–7.93 (m, 2H), 7.74–7.71 (m, 1H), 7.64–7.61 (m, 2H), 7.40–7.32 (m, 5H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>) δ 158.1, 135.1, 134.2, 130.9, 129.9, 128.9, 128.7, 125.8, 119.9, 119.1, 29.2; HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>15</sub>H<sub>10</sub>N<sub>2</sub>Na 241.0736, found 241.0745.

**2-Phenyl-3-**(*p*-tolyl)-2*H*-azirine-2-carbonitrile (1b). 0.5 h; eluent: EtOAc/PE 10:90; yield: 115 mg, 99%; colorless oil; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.83–7.81 (m, 2H), 7.43–7.41 (m, 2H), 7.39–7.31 (m, 5H), 2.49 (s, 3H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  157.5, 146.5, 134.5, 130.9, 130.6, 128.8, 128.6, 125.8, 119.2, 117.0, 29.0, 22.1; HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>16</sub>H<sub>12</sub>N<sub>2</sub>Na 255.0893, found 255.0894.

**3-(4-Methoxyphenyl)-2-phenyl-2***H***-azirine-2-carbonitrile (1c).** 0.5 h; eluent: EtOAc/PE 10:90; yield: 123 mg, 99%; white solid, mp 68–69 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.88–7.86 (m, 2H), 7.38–7.31 (m, 5H), 7.10–7.08 (m, 2H), 3.91 (s, 3H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  164.9, 156.5, 134.6, 133.0, 128.7, 128.5, 125.7, 119.4, 115.4, 111.8, 55.8, 28.8; HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>16</sub>H<sub>12</sub>N<sub>2</sub>NaO 271.0842, found 271.0839.

**3-(4-Fluorophenyl)-2-phenyl-2***H***-azirine-2-carbonitrile (1d).** 0.5 h; eluent: EtOAc/PE 10:90; yield: 95 mg, 81%; white solid, mp 58–59 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.99–7.96 (m, 2H), 7.40–7.31 (m, 7H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  166.6 (d,  $J_{C-F} = 257.7$  Hz), 157.1, 133.9, 133.4 (d,  $J_{C-F} = 9.7$  Hz), 128.9, 128.8, 125.7, 118.9, 117.6 (d,  $J_{C-F} = 22.5$  Hz), 116.2 (d,  $J_{C-F} = 3.2$  Hz), 29.3; HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>15</sub>H<sub>9</sub>FN<sub>2</sub>Na 259.0642, found 259.0645.

**3-(4-Chlorophenyl)-2-phenyl-2***H***-azirine-2-carbonitrile (1e).** 0.5 h; eluent: EtOAc/PE 10:90; yield: 107 mg, 85%; colorless oil; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.90–7.87 (m, 2H), 7.63–7.60 (m, 2H), 7.40–7.36 (m, 3H), 7.33–7.30 (m, 2H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>) δ 157.5, 141.8, 133.9, 131.9, 130.4, 128.92, 128.89, 125.8, 118.8, 118.4, 29.5; HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>15</sub>H<sub>9</sub>ClN<sub>2</sub>Na 275.0346, found 275.0342.

**2-Phenyl-3-(4-(trifluoromethyl)phenyl)**-2*H*-azirine-2-carbonitrile (1f). 0.5 h; eluent: EtOAc/PE 10:90; yield: 80 mg, 56%; colorless oil; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$ 8.10–8.08 (m, 2H), 7.91–7.89 (m, 2H), 7.41–7.38 (m, 3H), 7.33–7.31 (m, 2H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  158.2, 136.3 (q,  $J_{C-F}$  = 33.0 Hz), 133.5, 131.1, 129.1, 129.0, 126.8 (q,  $J_{C-F}$  = 3.7 Hz), 125.8, 123.4, 123.1(q,  $J_{C-F}$  = 271.5 Hz), 118.5, 29.9; HRMS (ESI-TOF) m/z:  $[M + H]^+$  calcd for  $C_{16}H_{10}F_3N_2$  287.0791, found 287.0799.

**2-Phenyl-3-**(*m*-tolyl)-2*H*-azirine-2-carbonitrile (1g). 1 h; eluent: EtOAc/PE 10:90; yield: 100 mg, 86%; colorless oil; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.76–7.73 (m, 2H), 7.54–7.49 (m, 2H), 7.40–7.32 (m, 5H), 2.46 (m, 3H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>) δ 158.0, 140.0, 135.9, 134.3, 131.2, 129.7, 128.8, 128.6, 128.0, 125.8, 119.7, 119.1, 29.1, 21.2; HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>16</sub>H<sub>12</sub>N<sub>2</sub>Na 255.0893, found 255.0896.

**2-Phenyl-3-**(*o*-tolyl)-2*H*-azirine-2-carbonitrile (1h). 1 h; eluent: EtOAc/PE 10:90; yield: 58 mg, 50%; colorless oil; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.74–7.72 (m, 1H), 7.61–7.57 (m, 1H), 7.45–7.31 (m, 7H), 2.72 (s, 3H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>) δ 157.2, 142.5, 134.7, 134.6, 132.5, 131.6, 128.9, 128.6, 126.9, 125.7, 119.4, 118.7, 27.8, 20.1; HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>16</sub>H<sub>12</sub>N<sub>2</sub>Na 255.0893, found 255.0898.

**2-Phenyl-3-propyl-2***H***-azirine-2-carbonitrile (1i).** 2 h; eluent: EtOAc/PE 10:90; yield: 45 mg, 49%; colorless oil; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.41–7.35 (m, 3H), 7.25–7.22 (m, 2H), 2.92 (t, *J* = 7.2 Hz, 2H), 1.86 (sext, *J* = 7.6 Hz, 2H), 1.12 (t, *J* = 7.2 Hz, 3H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  162.3, 134.5, 128.8, 128.4, 125.2, 119.3, 27.9, 27.5, 17.9, 13.8; HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>12</sub>H<sub>12</sub>N<sub>2</sub>Na 207.0893, found 207.0899.

**3-Phenyl-2-**(*p*-tolyl)-2*H*-azirine-2-carbonitrile (1j). 0.5 h; eluent: EtOAc/PE 10:90; yield: 109 mg, 94%; colorless oil; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.94–7.92 (m, 2H), 7.73–7.69 (m, 1H), 7.64–7.60 (m, 2H), 7.23–7.16 (m, 4H), 2.35 (s, 3H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>) δ 158.3, 138.8, 134.9, 131.2, 130.7, 129.8, 129.5, 125.7, 120.1, 119.2, 29.1, 21.1; HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>16</sub>H<sub>12</sub>N<sub>2</sub>Na 255.0893, found

255.0901.

**2-(4-Methoxyphenyl)-3-phenyl-2***H***-azirine-2-carbonitrile (1k).** 0.5 h; eluent: EtOAc/PE 10:90; yield: 114 mg, 92%; colorless oil; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$ 7.95–7.93 (m, 2H), 7.74–7.70 (m, 1H), 7.64–7.60 (m, 2H), 7.27–7.23 (m, 2H, overlapped with the peak of chloroform), 6.91–6.87 (m, 2H), 3.80 (s, 3H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  160.1, 158.7, 134.9, 130.7, 129.8, 127.2, 126.1, 120.3, 119.3, 114.3, 55.4, 29.0; HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>16</sub>H<sub>12</sub>N<sub>2</sub>NaO 271.0842, found 271.0848.

**2-(4-Chlorophenyl)-3-phenyl-2***H***-azirine-2-carbonitrile (11).** 0.5 h; eluent: EtOAc/PE 10:90; yield: 120 mg, 95%; colorless oil; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.94–7.92 (m, 2H), 7.76–7.72 (m, 1H), 7.66–7.62 (m, 2H), 7.36–7.33 (m, 2H), 7.28–7.24 (m, 3H, overlapped with the peak of chloroform); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  158.0, 135.3, 134.9, 132.9, 130.9, 129.9, 129.1, 127.1, 119.6, 118.7, 28.7; HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>15</sub>H<sub>9</sub>ClN<sub>2</sub>Na 275.0346, found 275.0348.

**2,3-Bis(4-chlorophenyl)-2***H***-azirine-2-carbonitrile (1m).<sup>15a</sup>** 0.5 h; eluent: EtOAc/PE 10:90; yield: 132 mg, 92%; white solid, mp 126–127 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.89–7.86 (m, 2H), 7.64–7.61 (m, 2H), 7.37–7.34 (m, 2H), 7.26–7.22 (m, 2H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  157.4, 142.0, 135.0, 132.5, 131.9, 130.5, 129.1, 127.0, 118.4, 118.0, 28.9; HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>15</sub>H<sub>8</sub>Cl<sub>2</sub>N<sub>2</sub>Na 308.9957, found 308.9968.

**2,3-Bis(4-bromophenyl)-2***H***-azirine-2-carbonitrile (1n).** 0.5 h; eluent: EtOAc/PE 10:90; yield: 158 mg, 84%; white solid, mp 140–141 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.79 (s, 4H), 7.52–7.49 (m, 2H), 7.19–7.16 (m, 2H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>) δ 157.6, 133.5, 133.1, 132.1, 132.0, 130.8, 127.3, 123.2, 118.4, 29.0; HRMS (ESI-TOF) m/z: [M

 $+ Na]^+$  calcd for  $C_{15}H_8Br_2N_2Na$  398.8926, found 398.8926.

**3-Phenyl-2-(3-(trifluoromethyl)phenyl)**-2*H*-azirine-2-carbonitrile (10). 0.5 h; eluent: EtOAc/PE 10:90; yield: 120 mg, 84%; white solid, mp 29–30 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.96–7.94 (m, 2H), 7.78–7.74 (m, 1H), 7.67–7.62 (m, 3H), 7.57–7.50 (m, 3H); <sup>13</sup>C {<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  157.8, 135.6, 135.5, 131.5 (q, *J*<sub>C-F</sub> = 32.6 Hz), 131.0, 130.0, 129.5, 129.0, 125.5 (q, *J*<sub>C-F</sub> = 3.7 Hz), 123.6 (q, *J*<sub>C-F</sub> = 270.9 Hz), 122.4 (q, *J*<sub>C-F</sub> = 3.8 Hz), 119.3, 118.4, 28.8; HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>16</sub>H<sub>9</sub>F<sub>3</sub>N<sub>2</sub>Na 309.0610, found 309.0607.

**2-(3-Chlorophenyl)-3-phenyl-2***H***-azirine-2-carbonitrile (1p).** 0.5 h; eluent: EtOAc/PE 10:90; yield: 114 mg, 90%; colorless oil; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.95–7.92 (m, 2H), 7.77–7.73 (m, 1H), 7.66–7.63 (m, 2H), 7.34–7.31 (m, 2H), 7.30–7.24 (m, 2H, overlapped with the peak of chloroform); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>) δ 157.8, 136.5, 135.3, 135.1, 131.0, 130.1, 130.0, 129.0, 125.8, 124.0, 119.4, 118.6, 28.7; HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>15</sub>H<sub>9</sub>ClN<sub>2</sub>Na 275.0346, found 275.0350.

**2-(2-Chlorophenyl)-3-phenyl-2***H***-azirine-2-carbonitrile (1q).** 0.5 h; eluent: EtOAc/PE 10:90; yield: 119 mg, 95%; white solid, mp 71–72 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 8.11–8.09 (m, 2H), 7.74–7.70 (m, 1H), 7.65–7.61 (m, 2H), 7.46–7.42 (m, 2H), 7.35–7.27 (m, 2H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>) δ 164.4, 135.1, 133.7, 132.0, 130.8, 130.6, 130.1, 129.7, 128.5, 127.5, 120.5, 119.2, 27.3; HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>15</sub>H<sub>9</sub>ClN<sub>2</sub>Na 275.0346, found 275.0352.

**2-(2,4-Dichlorophenyl)-3-phenyl-2***H***-azirine-2-carbonitrile (1r).** 0.5 h; eluent: EtOAc/PE 10:90; yield: 137 mg, 96%; white solid, mp 69–70 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  8.09–8.06 (m, 2H), 7.76–7.72 (m, 1H), 7.66–7.63 (m, 2H), 7.47 (d, *J* = 2.0 Hz, 1H), 7.37–7.35 (m, 1H), 7.28–7.25 (m, 1H, overlapped with the peak of chloroform);  ${}^{13}C{}^{1}H{}$  NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  164.1, 136.0, 135.3, 134.4, 130.9, 130.7, 129.9, 129.8, 129.4, 127.9, 120.1, 118.8, 26.7; HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>15</sub>H<sub>8</sub>Cl<sub>2</sub>N<sub>2</sub>Na 308.9957, found 308.9945.

**2-(Naphthalen-1-yl)-3-phenyl-2***H***-azirine-2-carbonitrile (1s).** 0.5 h; eluent: EtOAc/PE 10:90; yield: 110 mg, 82%; white solid, mp 150–151 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  8.79 (d, J = 8.4 Hz, 1H), 8.08–8.06 (m, 2H), 7.93–7.87 (m, 2H), 7.78–7.70 (m, 2H), 7.66–7.59 (m, 3H), 7.50–7.48 (m, 1H), 7.40–7.37 (m, 1H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  163.9, 134.9, 133.9, 131.3, 130.5, 130.3, 130.1, 129.8, 129.0, 127.4, 126.6, 125.7, 125.2, 123.9, 121.1, 120.5, 27.0; HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>19</sub>H<sub>12</sub>N<sub>2</sub>Na 291.0893, found 291.0893.

**3-Phenyl-2-(pyridin-2-yl)-2***H***-azirine-2-carbonitrile (1t).** 0.5 h; eluent: CH<sub>2</sub>Cl<sub>2</sub>/PE 65:35; yield: 68 mg, 62%; colorless oil; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  8.56–8.55 (m, 1H), 7.97–7.94 (m, 2H), 7.75–7.70 (m, 2H), 7.64–6.60 (m, 2H), 7.51–7.49 (m, 1H), 7.28–7.25 (m, 1H, overlapped with the peak of chloroform); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  157.1, 153.6, 149.8, 136.9, 135.0, 131.1, 129.7, 123.3, 120.8, 119.8, 118.8, 30.9; HRMS (ESI-TOF) m/z: [M + H]<sup>+</sup> calcd for C<sub>14</sub>H<sub>10</sub>N<sub>3</sub> 220.0869, found 220.0866.

(*Z*)-3-Amino-2-iodo-3-phenylacrylonitrile (1u'). 0.5 h; eluent: EtOAc/PE 20:80; yield: 107 mg, 80%; white solid, mp 112–113 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ 7.58–7.54 (m, 2H), 7.51–7.42 (m, 3H), 5.19 (s, 2H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>) δ 161.2, 133.0, 131.1, 129.0, 127.9, 120.5, 24.6; HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>9</sub>H<sub>7</sub>IN<sub>2</sub>Na 292.9546, found 292.9549.

2-Hexyl-3-phenyl-2H-azirine-2-carbonitrile (1v). Eluent: EtOAc/PE 5:95; yield: 66 mg,

58%; colorless oil; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.91–7.89 (m, 2H), 7.73–7.69 (m, 1H), 7.65–7.61 (m, 2H), 1.96–1.82 (m, 2H), 1.58–1.46 (m, 2H), 1.40–1.33 (m, 2H), 1.32–1.22 (m, 4H), 0.89–0.86 (m, 3H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  164.7, 134.6, 130.2, 129.7, 121.6, 120.8, 33.7, 31.5, 28.7, 26.8, 26.2, 22.5, 14.0; HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>15</sub>H<sub>18</sub>N<sub>2</sub>Na 249.1362, found 249.1342.

Ethyl 2,3-diphenyl-2*H*-azirine-2-carboxylate (1w). 0.5 h; eluent: EtOAc/PE 10:90; yield: 90 mg, 68%; white solid, mp 42–43 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.97–7.95 (m, 2H), 7.66–7.64 (m, 1H), 7.62–7.58 (m, 2H), 7.53–7.51 (m, 2H), 7.37–7.30 (m, 3H), 4.26 (q, *J* = 6.8 Hz, 2H), 1.26 (t, *J* = 7.2 Hz, 3H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  171.2, 160.8, 136.4, 133.9, 130.4, 129.5, 128.2, 127.7, 122.1, 61.7, 41.2, 14.2; HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>17</sub>H<sub>15</sub>NNaO<sub>2</sub> 288.0995, found 288.1003.

**1-(2-(2-Bromophenyl)-3-phenyl-2H-azirin-2-yl)ethan-1-one** (**1x**). 0.5 h; eluent: EtOAc/PE 7:93; yield: 140 mg, 89%; white solid, mp 85–86 °C; <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.67–7.65 (m, 2H), 7.54–7.52 (m, 1H), 7.45–7.36 (m, 3H), 7.32–7.28 (m, 2H, overlapped with the peak of chloroform), 7.19–7.15 (m, 1H), 2.69 (s, 3H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  200.2, 165.9, 139.0, 137.6, 132.7, 131.9, 129.63, 129.62, 128.7, 128.0, 127.9, 124.6, 46.8, 12.6; HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>16</sub>H<sub>12</sub>BrNNaO 335.9994, found 335.9990.

**Preparation of 2-Phenyl-1***H***-indole-3-carbonitrile (3a).**<sup>2a</sup> A reaction mixture of compound 1a (109 mg, 0.5 mmol) and Pd(MeCN)<sub>2</sub>Cl<sub>2</sub> (26 mg, 0.1 mmol) in *o*-xylene (5 mL) in a dry sealed tube was heated to 140 °C under a nitrogen atmosphere for 2 h. After cooling to room temperature, it was quenched with H<sub>2</sub>O (10 mL) and extracted with EtOAc (3 × 10 mL). The combined organic layer was dried over anhydrous Na<sub>2</sub>SO<sub>4</sub>,

concentrated, and then purified through silica gel column chromatography to afford 1*H*-indole **3a**. Eluent: EtOAc/PE 20:80; yield: 71 mg, 65%; white solid, mp 247–248 °C (lit.<sup>22</sup> mp 248-249 °C); <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$  8.75 (s, 1H), 7.91–7.88 (m, 2H), 7.79–7.77 (m, 1H), 7.57–7.46 (m, 4H), 7.36–7.29 (m, 2H); <sup>13</sup>C{<sup>1</sup>H} NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$  144.8, 135.0, 130.1, 129.5, 129.4, 128.9, 126.9, 124.4, 122.5, 119.6, 116.9, 111.7, 84.0; HRMS (ESI-TOF) m/z: [M + Na]<sup>+</sup> calcd for C<sub>15</sub>H<sub>10</sub>N<sub>2</sub>Na 241.0736, found 241.0732.

## Associated Content

## **Supporting Information**

Copies of NMR spectra of compounds **1**, **2** and **3a** (PDF), and X-ray structure and data of compound **1n** (CIF). This material is available free of charge via the Internet at http://pubs.acs.org.

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#### Notes

The authors declare no competing financial interest.

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