# 2-(Arylamino)aryliminophosphoranes as Easily Available and Convenient Starting Materials in the Synthesis of 1,2,3-Benzotriazoles

Emilia Łukasik, Zbigniew Wróbel*

Institute of Organic Chemistry, Polish Academy of Sciences, Kasprzaka 44, 01-224 Warsaw 42, Poland
Fax +48(22)6326681; E-mail: zbigniew.wrobel@icho.edu.pl

*Received: 08.05.2014; Accepted after revision: 10.06.2014*

**Abstract:** 1-Aryl-1,2,3-benzotriazole systems are synthesized in the high-yielding cyclocondensation of 2-(arylamino)aryliminophosphoranes under mild conditions. The reaction concludes the three-step, halogen-free synthetic route starting from simple nitroarenes and arylamines.

**Key words:** cyclization, condensation, heterocycles, annulation, ylides

The benzotriazole motif is present in a number of bioactive molecules such as antifungal compounds,[1] antiproliferative agents and histone deacetylase inhibitors,[2] serotonine receptors,[3] as agonists for many proteins,[4] and as other active drugs,[5] for example, vorozole and alizapride (Figure 1).

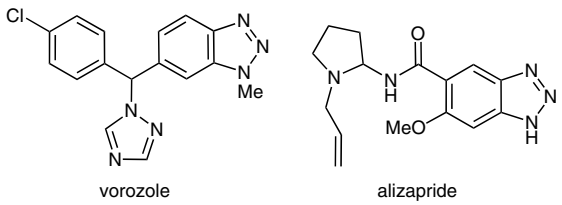



**Figure 1** Examples of drugs containing benzotriazole scaffold

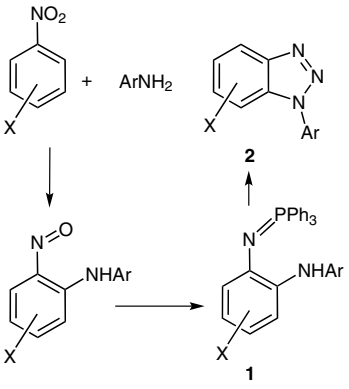
A few synthetic ways leading to 1-aryl-1,2,3-benzotriazoles were reported. The simplest one was the reaction of *N*-aryl-1,2-arylenediamines with nitrosating agent such as sodium or alkyl nitrite in acidic media.[6] More sophisticated methods included metal-catalyzed arylation of 1,2,3-benzotriazole,[7] reaction of benzobisoxadisiloles with aryl azides,[8] $S_NAr$ substitution of fluorine in activated arenes by benzotriazole nitrogen,[9] or reaction of aryl azides with in situ generated benzynes.[10]

In 2013 we reported a straightforward synthesis of 2-(arylamino)aryliminophosphoranes[11] from easily accessible *N*-aryl-2-nitrosoanilines, synthesized directly from nitroarenes and anilines.[12] Their application in the synthesis of 2-aminobenzimidazole derivatives was demonstrated.[11]

In this communication we would like to report that the title compounds could be successively used as convenient starting materials in the synthesis of benzotriazole derivatives.

When a solution of 2-(arylamino)iminophosphorane **1** in AcOH was treated with 1.1 equivalents of $NaNO_2$, the corresponding 1-aryl-1,2,3-benzotriazole **2** and triphenylphosphine oxide were formed almost immediately (Table 1).[13,14] In most cases the products were formed in high or nearly quantitative yields. The reaction seems to be insensitive for both electrophilicity of the arylamine ring (Table 1, entries 2, 9, 12, 14, and 16) and steric factor (Table 1, entries 1, 3,10, and 15). The 4-methoxy group in the arylimine ring may bring some disturbances, from lower yield of product (Table 1, entry 4) to different reaction course. Sodium nitrite was added to the reaction mixture as a solid although in one case its addition as a concentrated aqueous solution gave better results (Table 1, entry 5).

This way we completed a halogen-free (omitting $S_NAr$ displacement of a halogen in 2-halonitroarene with aniline) three-step sequence from nitroarenes and anilines via *N*-aryl-2-nitrosoanilines and 2-(arylamino)aryliminophosphoranes to 1-*N*-aryl-1,2,3-benzotriazoles (Scheme 1).



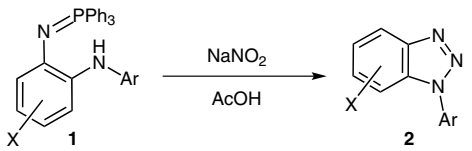

**Scheme 1** Three steps from nitroarenes to 1-arylbenzotriazoles

For the sake of this work a number of new 2-(arylamino)aryliminophosphoranes were synthesized proving the generality and versatility of the previously reported protocol (see Supporting Information).[11]

It should be mentioned that 2-(arylamino)aryliminophosphoranes are much more stable than the corresponding 2-arylaminoanilines. Although no quantitative investigations were undertaken so far, we observed that the former could be stored at room temperature for months without

*SYNLETT* 2014, 25, 1987–1990
Advanced online publication: 28.07.2014
DOI: 10.1055/s-0034-1378448; Art ID: st-2014-b0399-l

**Table 1** Synthesis of 1-Aryl-1,2,3-benzotriazoles from **1**[a]

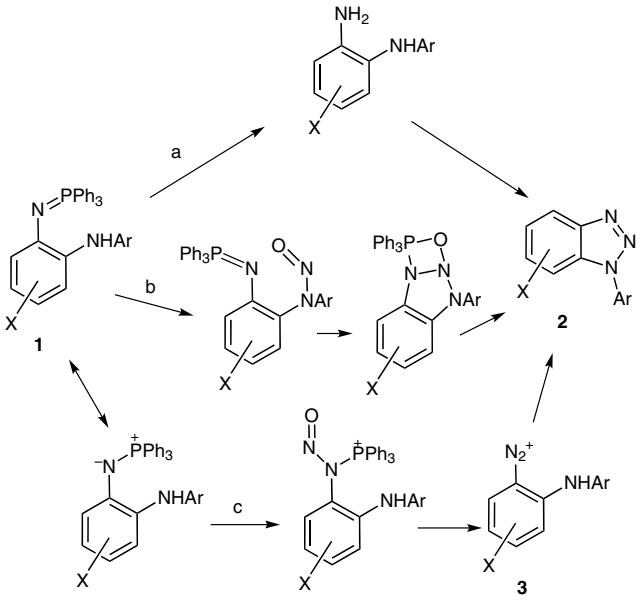



| Entry | 1 | X | Ar | Product | Yield (%)[b,c] |
|---|---|---|---|---|---|
| 1 | **1a** | 4-Cl | 2,6-$Me_2C_6H_3$ | **2a** | 99 |
| 2 | **1b** | 4-Cl | 4-$MeC_6H_4$ | **2b** | 90 |
| 3 | **1c** | 4-Cl-6-MeO | 2,6-$Me_2C_6H_3$ | **2c** | 93 |
| 4 | **1d** | 4-MeO | 4-$MeC_6H_4$ | **4** | 50 (0) |
| 5 | **1e** | 4-Ph | 4-$MeC_6H_4$ | **2e** | 50 (74) |
| 6 | **1f** | 4-Cl-6-MeO | 4-$EtOC_6H_4$ | **2f** | 97 |
| 7 | **1g** | 4-F | 4-$MeC_6H_4$ | **2g** | 85 |
| 8 | **1h** | 4-Ph | 4-$MeC_6H_4$ | **2h** | 92 |
| 9 | **1i** | 4-Cl | 4-py | **2i** | 96 |
| 10 | **1j** | 4-Cl | 2-$MeC_6H_4$ | **2j** | 96 |
| 11 | **1k** | 4-F | 4-$ClC_6H_4$ | **2k** | 84 |
| 12 | **1l** | 4-Cl | 4-$CNC_6H_4$ | **2l** | 66 |
| 13 | **1m** | 4-Cl | 4-$MeOC_6H_4$ | **2m** | 69 |
| 14 | **1n** | 4-Cl | 2-Br-4-$ClC_6H_3$ | **2n** | 97 |
| 15 | **1o** | 4-F | 2,6-$Me_2C_6H_3$ | **2o**/**5** | 41/30 |
| 16 | **1p** | 4-Cl | 3,5-$(MeO)_2C_6H_3$ | **2p** | 73 |
| 17 | **1q** | 4-Br | 4-$MeC_6H_4$ | **2q** | 77 |

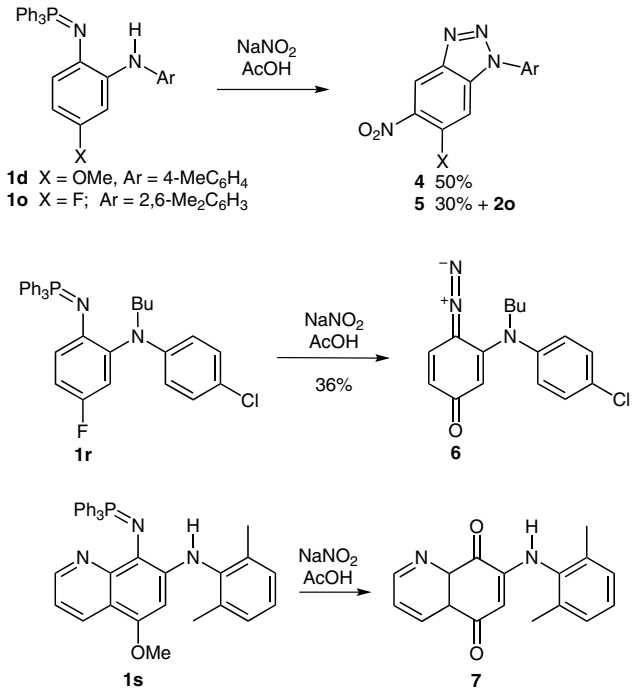
[a] Iminophosphorane (1 mmol) in AcOH (5mL) at 0 °C, treated with powdered $NaNO_2$ in one portion.
[b] The yields when $NaNO_2$ was added as a concentrated aqueous solution are shown in parentheses.
[c] Isolated yields.

any noticeable changes, whereas the later underwent slow decomposition observed on TLC plate. This implies the use of 2-(arylamino)aryliminophosphoranes as stable and convenient 2-arylaminoaniline equivalents.

Concerning the mechanistic pathway of the reaction we considered three possibilities (Scheme 2). In situ hydrolysis of substrate **1** to arylenediamine followed by the reaction of the latter with nitrous acid (pathway a) was ruled out since the 2-(arylamino)iminophosphoranes were stable in acetic acid under the reaction conditions. Pathway b seems to be very likely, comprising well-documented N-nitrosation of diarylamines followed by intramolecular condensation of iminophoshoryl group with a nitroso group, a process analogous to the aza Wittig reaction. Pathway c, although without any precedence in the literature, apparently takes place in a few cases when the reaction occurs differently. Although it appears to be of general character some exceptions were observed (Scheme 3).




**Scheme 2** Possible mechanistic routes of the reaction




**Scheme 3** Some uncommon products of the reaction

The presence of +M substituents (**1d**) made the arene ring prone to nitrosation/oxidation resulting in the formation of nitro compound **4**. On the other hand, formation of **6** from **1r** with blocked arylamine position as well as **7** from **1s** suggest pathway b, that is, nitrosation of the imine nitrogen followed by formation of intermediate diazonium

derivative **3** (Scheme 2). The latter, in turn, bearing a very strong electron-withdrawing diazonium group, was susceptible to aromatic nucleophilic substitution of a leaving group in position *para* with water (for **1r**) followed by deprotonation to form diazoketone **6**. For **1s** the nucleophilic demethylation of appropriate **3** via an intermediate similar to **6** proceeded, followed by hydrolysis of diazoketone to quinone **7**.[15] Structures **4**–**7** were fully characterized by NMR, MS, and IR spectra.

Since the presented method enables smooth synthesis of 1-aryl-1,2,3-benzotriazoles in three steps, an efficient sequence via a 'halogen-free' way could be regarded as valuable alternative to other known methods.

**Supporting Information** for this article is available online at http://www.thieme-connect.com/products/ejournals/journal/10.1055/s-00000083.

## References and Notes


(1) (a) Sudhir, M. S. A.; Nadh, R. V.; Radhika, S. *Drug Invent. Today* **2013**, *5*, 126.
(2) Li, X.; Fu, J.; Shi, W.; Luo, Y.; Zhang, X.; Zhu, H.; Yu, H. *Bull. Korean Chem. Soc.* **2013**, *34*, 2387.
(3) Boido, A.; Boido, C. C.; Sparatore, F. *Farmaco* **2001**, *56*, 263.
(4) Kale, R. R.; Prasad, V.; Mohapatra, P. P.; Tiwari, V. K. *Monatsh. Chem.* **2010**, *141*, 1159.
(5) Piccionello, A. P.; Guarcello, A. *Curr. Bioact. Compd.* **2010**, *6*, 266.
(6) (a) Znoiko, S. A.; Kambolova, A. S.; Maizlish, V. E.; Shaposhnikov, G. P.; Abramov, I. G.; Filimonov, S. I. *Russ. J. Gen. Chem.* **2009**, *79*, 1735. (b) Nolan, K. A.; Humphries, M. P.; Barnes, J.; Doncaster, J. R.; Caraher, M. C.; Tirelli, N.; Bryce, R. A.; Whitehead, R. C.; Stratford, I. J. *Bioorg. Med. Chem.* **2010**, *18*, 696. (c) Fujiwara, C.; Hagaya, M.; Kakuta, H.; Kawata, K.; Nakayama, M.; Ohsawa, F.; Ohta, Y.; Shinozaki, R.; Yakushiji, N.; Yamada, Sh.; Makishima, M.; Uno, Sh.; Tai, A.; Maehara, A.; Nakayama, M.; Oohashi, T.; Yasui, H.; Yoshikawa, Y. *ACS Med. Chem. Lett.* **2012**, *3*, 427. (d) Barnes, J.; Bryce, R. A.; Caraher, M. C.; Doncaster, J. R.; Humphries, M. P.; Nolan, K. A.; Stratford, I. J.; Tirelli, N.; Barnes, J.; Doncaster, J. R.; Whitehead, R. C. *Bioorg. Med. Chem.* **2010**, *18*, 696. (e) Kulagowski, J. J.; Moody, C. J.; Rees, C. W. *J. Chem. Soc., Perkin Trans. 1* **1985**, 2733.
(7) (a) Beletskaya, I. P.; Davydov, D. V.; Moreno-Mañas, M. *Tetrahedron Lett.* **1998**, *39*, 5617. (b) Mukhopadhyay, C.; Tapaswi, P. K. *Synth. Commun.* **2012**, *42*, 2217. (c) Antilla, J. C.; Barder, T. E.; Baskin, J. M.; Buchwald, S. L. *J. Org. Chem.* **2004**, *69*, 5578. (d) Alakonda, L.; Periasamy, M. *Synthesis* **2012**, *44*, 1063. (e) Jena, A. K.; Mohapatra, S.; Panda, N.; Rout, S. R. *Tetrahedron Lett.* **2011**, *52*, 1924.
(8) (a) Cao, W.; Chen, J.; Chen, Y.; Lin, Y.; Ma, X.; Xu, D. *Tetrahedron* **2011**, *67*, 856. (b) Chen, Y.-L.; Sun, J.-Q.; Wei, X.; Wong, W.-Y.; Lee, A. W. M. *J. Org. Chem.* **2004**, *69*, 7190.
(9) (a) Song, T.; Xu, L.; Zhao, J.; Zhao, J.; Zhu, S. *Tetrahedron* **2011**, *67*, 910. (b) Rosevear, J.; Wilshire, J. F. K. *Aust. J. Chem.* **1991**, *44*, 1097.
(10) (a) Ankati, H.; Biehl, E. *Tetrahedron Lett.* **2009**, *50*, 4677. (b) Moses, J. E.; Zhang, F. *Org. Lett.* **2009**, *11*, 1587. (c) Chen, Y.; Larock, R. C.; Shi, F.; Waldo, J. P. *Org. Lett.* **2008**, *10*, 2409.
(11) Łukasik, E.; Wróbel, Z. *Synlett* **2014**, *25*, 217.
(12) (a) Wróbel, Z.; Kwast, A. *Synlett* **2007**, 1525. (b) Wróbel, Z.; Kwast, A. *Synthesis* **2010**, 3865.
(13) **Synthesis of 1-Aryl-1,2,3-benzotriazoles 2 – General Procedure**
Iminophosphorane **1** (1 mmol) was dissolved in AcOH (5 mL), cooled down to 0 °C, and $NaNO_2$ (1.1 mmol) was added portionwise with stirring. The reaction was stirred until completion (TLC control, usually 5–20 min). The mixture was poured into $H_2O$, extracted with EtOAc, dried with $Na_2SO_4$, and the solvent was evaporated. The crude product was purified by column chromatography.
(14) **Analytical Data for Representative Products**
Compound **2a**: white solid; mp 152–154 °C. $^1$H NMR (400 MHz, $CDCl_3$): δ = 1.92 (s, 6 H), 7.21 (d, *J* = 2.0 Hz, 1 H), 7.25 (s, 1 H), 7.27 (s, 1 H), 7.37–7.42 (m, 2 H), 8.08 (d, *J* = 8.8 Hz, 1 H). $^{13}$C NMR (100 MHz, $CDCl_3$): δ = 17.5, 112.3, 118.3, 127.0, 129.1, 131.1, 132.9, 134.8, 136.3, 142.6, 145.2. MS (EI): *m/z* (%) = 259 (13), 257 (40), 228 (39), 216 (13), 214 (39), 194 (100), 193 (22). HRMS (EI): *m/z* calcd for $C_{14}H_{12}N_3{}^{35}Cl$: 257.0720; found: 257.0730.
Compound **2b**: pink crystals; mp 136–138 °C. $^1$H NMR (500 MHz, $CDCl_3$):[16] δ = 2.40 (s, 3 H), 7.30 (dd, *J* = 8.8, 1.8 Hz, 1 H), 7.33–7.36 (m, 2 H), 7.52–7.55 (m, 2 H), 7.65 (d, *J* = 1.8 Hz, 1 H), 7.98 (d, *J* = 8.8 Hz, 1 H). $^{13}$C NMR (125 MHz, $CDCl_3$): δ = 21.2, 110.2, 121.1, 122.9, 125.5, 130.5, 133.0, 134.0, 134.6, 139.2, 150.0. MS (EI): *m/z* (%) = 245 (16), 243 (51), 216 (29), 215 (44), 214 (76), 180 (100), 179 (12). HRMS (EI): *m/z* calcd for $C_{13}H_{10}N_3{}^{35}Cl$: 243.0563; found: 243.0563.
Compound **2c**: white solid; mp 92–95 °C. $^1$H NMR (400 MHz, DMSO-$d_6$): δ = 1.84 (s, 6 H), 4.11 (s, 3 H), 6.94–7.01 (m, 2 H), 7.33–7.39 (m, 2 H), 7.45–7.51 (m, 1 H). $^{13}$C NMR (100 MHz, DMSO-$d_6$): δ = 16.9, 56.9, 101.5, 105.9, 128.8, 130.6, 133.3, 134.9, 135.4, 135.8, 135.9, 151.7. MS (EI): *m/z* (%) = 289 (51), 288 (29), 287 (100), 258 (24), 246 (37), 245 (23), 224 (78), 218 (16), 217 (10), 216 (51), 209 (39), 201 (21), 181 (52), 180 (39). HRMS (EI): *m/z* calcd for $C_{15}H_{14}N_3O^{35}Cl$: 287.0825; found: 287.0828.
Compound **2e**: yellow solid; mp 110–112 °C. $^1$H NMR (400 MHz, DMSO-$d_6$): δ = 3.87 (s, 3 H), 7.19–7.25 (m, 2 H), 7.40–7.44 (m, 1 H), 7.46–7.2 (m, 2 H), 7.76–7.80 (m, 3 H), 7.81–7.86 (m, 2 H), 7.93 (s, 1 H), 8.19–8.25 (m, 1 H). $^{13}$C NMR (100 MHz, DMSO-$d_6$): δ = 55.6, 108.2, 115.1, 119.9, 124.4, 124.8, 127.6, 128.0, 129.0, 129.3, 132.8, 139.6, 140.8, 145.0, 159.4. MS (EI): *m/z* (%) = 301 (20), 273 (45), 259 (22), 258 (100), 231 (14), 230 (68), 228 (10). HRMS (EI): *m/z* calcd for $C_{19}H_{15}N_3O$: 301.1215; found: 301.1219.
Compound **2f**: white solid; mp 116–119 °C. $^1$H NMR (500 MHz, DMSO-$d_6$): δ = 1.36 (t, *J* = 7.0 Hz, 3 H), 4.06 (s, 3 H), 4.11 (q, *J* = 7.0 Hz, 2 H), 6.96 (d, *J* = 1.5 Hz, 1 H), 7.14–7.17 (m, 2 H), 7.35 (d, *J* = 1.5 Hz, 1 H), 7.67–7.70 (m, 2 H). $^{13}$C NMR (125 MHz, DMSO-$d_6$): δ = 15.0, 57.2, 64.1, 102.9, 106.1, 115.9, 125.3, 129.1, 134.6, 134.9, 136.8, 151.8, 159.4. MS (EI): *m/z* (%) = 305 (39), 304 (21), 303 (82), 248 (53), 247 (49), 246 (100), 240 (58), 232 (37), 218 (37), 212 (87), 211 (12), 204 (51), 203 (26), 188 (20). HRMS (EI): *m/z* calcd for $C_{15}H_{14}N_3O_2{}^{35}Cl$: 303.0775; found: 303.0769.
Compound **2g**: orange solid; mp 123–126 °C. $^1$H NMR (500 MHz, DMSO-$d_6$): δ = 2.41 (s, 3 H), 7.36-7.41 (m, 1 H), 7.44–7.47 (m, 2 H), 7.70–7.73 (m, 3 H), 8.20–8.23 (m, 1 H). $^{13}$C NMR (125 MHz, DMSO-$d_6$): δ = 21.1, 97.4 (d, $J_{CF}$ = 29 Hz), 114.8 (d, $J_{CF}$ = 27 Hz), 122.0 (d, $J_{CF}$ = 7 Hz), 123.1, 130.9, 132.7 (d, $J_{CF}$ = 14 Hz), 134.1, 139.1, 143.1, 162.6 (d, $J_{CF}$ = 244 Hz). MS (EI): *m/z* (%) = 227 (48), 199 (50), 198 (100), 184 (25). HRMS (EI): *m/z* calcd for $C_{13}H_{10}N_3F$: 227.0859; found: 227.0859.

Compound **2h**: orange solid; mp 109–111 °C. $^1$H NMR (400 MHz, $CDCl_3$): δ = 2.52 (s, 3 H), 7.37–7.42 (m, 3 H), 7.43–7.50 (m, 2 H), 7.61–7.64 (m, 2 H), 7.65–7.69 (m, 3 H), 7.82–7.84 (m, 1 H), 8.15–8.19 (m, 1 H). $^{13}$C NMR (100 MHz, $CDCl_3$): δ = 21.4, 108.5, 120.5, 123.2, 124.9, 127.9, 128.2, 129.1, 130.6, 133.3, 134.7, 139.1, 140.8, 142.1, 146.0. MS (EI): *m/z* (%) = 285 (21), 258 (21), 257 (100), 256 (64), 140 (16), 139 (17). HRMS (EI): *m/z* calcd for $C_{19}H_{15}N_3$: 285.1266; found: 285.1266.

Compound **2i**: white solid, mp 155–158 °C. $^1$H NMR (500 MHz, DMSO-$d_6$): δ = 7.58–7.62 (m, 1 H), 8.02–8.04 (m, 2 H), 8.24–8.29 (m, 1 H), 8.30–8.33 (m, 1 H), 8.84–8.87 (m, 2 H). $^{13}$C NMR (125 MHz, DMSO-$d_6$): δ = 111.9, 116.3, 121.9, 126.5, 132.3, 135.0, 143.1, 145.3, 152.1. MS (EI): *m/z* (%) = 232 (31), 230 (68), 204 (46), 203 (20), 202 (91), 167 (48), 140 (53). HRMS (EI): *m/z* calcd for $C_{11}H_7N_4{}^{35}Cl$: 230.0359; found: 230.0359.

Compound **2j**: orange oil. $^1$H NMR (500 MHz, $CDCl_3$): δ = 2.13 (s, 3 H), 7.35–7.44 (m, 4 H), 7.46–7.54 (m, 2 H), 8.08 (d, *J* = 8.8 Hz, 1 H). $^{13}$C NMR (125 MHz, DMSO-$d_6$): δ = 17.7, 109.9, 121.0, 125.4, 126.8, 127.1, 130.3, 131.8, 134.5, 134.6, 134.7, 135.3, 144.2. MS (EI): *m/z* (%) = 245 (20), 243 (43), 217 (19), 216 (36), 215 (40), 214 (74), 200 (21), 180 (100). HRMS (EI): *m/z* calcd for $C_{13}H_{10}N_3{}^{35}Cl$: 243.0563; found: 243.0562.

Compound **2k**: white solid; mp 200–202 °C. $^1$H NMR (400 MHz, $CDCl_3$): δ = 7.19–7.25 (m, 1 H), 7.34–7.37 (m, 1 H), 7.57–7.62 (m, 2 H), 7.68–7.72 (m, 2 H), 8.09–8.13 (m, 1 H). $^{13}$C NMR (100 MHz, $CDCl_3$): δ = 96.3 (d, $J_{CF}$ = 29 Hz), 114.6 (d, $J_{CF}$ = 26 Hz), 122.1 (d, $J_{CF}$ = 11 Hz), 124.0, 130.4, 132.7 (d, $J_{CF}$ = 14 Hz), 134.9, 135.3, 143.5, 163.1 (d, $J_{CF}$ = 248 Hz). MS (EI): *m/z* (%) = 247 (24), 219 (47), 185 (15), 184 (100), 158 (13), 157 (11). HRMS (EI): *m/z* calcd for $C_{12}H_7N_3{}^{35}ClF$: 247.0313; found: 247.0322.

Compound **2l**: white solid; mp 224–226 °C. IR (film; $CH_2Cl_2$): $\nu_{max}$ = 2226 (CN) cm$^{-1}$. $^1$H NMR (400 MHz, $CDCl_3$): δ = 7.47 (dd, *J* = 8.8, 2.8 Hz, 1 H), 7.96 (d, *J* = 2.8 Hz, 1 H), 7.93–7.99 (m, 4 H), 8.11 (d, *J*= 8.8 Hz, 1 H). $^{13}$C NMR (100 MHz, $CDCl_3$): δ = 110.2, 112.7, 117.9, 121.9, 122.7, 125.0, 126.4, 132.5, 134.2, 136.0, 140.1. MS (EI): *m/z* (%) = 256 (17), 254 (49), 228 (44), 226 (99), 192 (23), 191 (100), 102 (56). HRMS (EI): *m/z* calcd for $C_{13}H_7N_4{}^{35}Cl$: 254.0359; found: 254.0358.

Compound **2m**: white solid, mp 170–172 °C. $^1$H NMR (400 MHz, $CDCl_3$): δ = 3.91 (s, 3 H), 7.09–7.13 (m, 2 H), 7.37 (dd, *J* = 8.8, 1.6 Hz, 1 H), 7.60–7.64 (m, 2 H), 7.65 (d, *J* = 1.6 Hz, 1 H), 8.04 (d, *J* = 8,8 Hz, 1 H). $^{13}$C NMR (100 MHz, $CDCl_3$): δ = 55.8, 110.2, 115.2, 121.2, 124.7, 125.5, 129.6, 133.4, 134.6, 144.9, 160.2. MS (EI): *m/z* (%) = 261 (13), 259 (39), 218 (34), 216 (100), 196 (90), 190 (21), 189 (10), 188 (66), 181 (20), 153 (35). HRMS (EI): *m/z* calcd for $C_{13}H_{10}N_3O^{35}Cl$: 259.0512; found: 259.0513.

Compound **2n**: white solid, mp 135–138 °C. $^1$H NMR (400 MHz, $CDCl_3$): δ = 7.36 (d, *J* = 2 Hz, 1 H), 7.41 (dd, *J* = 8.8, 2.4 Hz, 1 H), 7.45–7.49 (m, 1 H), 7.54–7.57 (m, 1 H), 7.86 (d, *J* = 2.4 Hz, 1 H), 8.08 (d, *J* = 8.8 Hz, 1 H). $^{13}$C NMR (100 MHz, $CDCl_3$): δ = 110.3, 121.4, 121.6, 125.8, 129.2, 130.2, 134.1, 134.3, 135.2, 137.5, 144.4 (one signal not visible). MS (EI): *m/z* (%) = 343 (25), 340 (13), 314 (16), 279 (21), 277 (16), 236 (65), 234 (100), 199 (20), 198 (18), 164 (26). HRMS (EI): *m/z* calcd for $C_{12}H_6N_3{}^{35}Cl_2{}^{79}Br$: 340.9122; found: 340.9127.

Compound **2o**: colorless oil. $^1$H NMR (400 MHz, $CDCl_3$): δ = 1.93 (s, 6 H), 6.84–6.87 (m, 1 H), 7.17–7.22 (m, 1 H), 7.25–7.27 (m, 2 H), 7.37–7.41 (m, 1 H), 8.10–8.14 (m, 1 H). $^{13}$C NMR (100 MHz, $CDCl_3$): δ = 17.6, 95.5 (d, $J_{CF}$ = 27 Hz), 114.2 (d, $J_{CF}$ = 27 Hz), 121.8 (d, $J_{CF}$ = 11 Hz), 128.9, 130.6, 133.9, 134.4 (d, $J_{CF}$ = 14 Hz), 136.6, 142.5, 163.0 (d, $J_{CF}$ = 248 Hz). MS (EI): *m/z* (%) = 241 (68), 213 (36), 212 (100), 211 (17), 199 (24), 198 (83). HRMS (EI): *m/z* calcd for $C_{14}H_{12}N_3F$: 241.1015; found: 241.1013.

Compound **2p**: white solid; mp 134–137 °C. $^1$H NMR (400 MHz, $CDCl_3$): δ = 3.88 (s, 6 H), 6.59 (t, *J* = 2.0 Hz, 1 H), 6.88–6.90 (m, 2 H), 7.49 (dd, *J* = 8.8, 1.6 Hz, 1 H), 7.77 (d, *J* = 1.6 Hz, 1 H), 8.05 (d, *J* = 8.8 Hz, 1 H). $^{13}$C NMR (100 MHz, $CDCl_3$): δ = 55.9, 100.8, 101.5, 110.6, 121.3, 125.8, 133.0, 134.9, 138.2, 145.2, 161.8. MS (EI): *m/z* (%) = 291 (32), 290 (16), 289 (83), 261 (33), 246 (28), 227 (22), 226 (100), 218 (49), 203 (44), 183 (18). HRMS (EI): *m/z* calcd for $C_{14}H_{12}N_3O_2{}^{35}Cl$: 289.0618; found: 289.0623.

Compound **2q**: white solid; mp 142–144 °C. $^1$H NMR (400 MHz, $CDCl_3$): δ = 2.48 (s, 3 H), 7.39–7.44 (m, 2 H), 7.52 (dd, *J* = 8.8, 1.6 Hz, 1 H), 7.58–7.63 (m, 2 H), 7.88 (d, *J* = 1.6 Hz, 1 H), 8.00 (d, *J* = 8.8 Hz, 1 H). $^{13}$C NMR (100 MHz, $CDCl_3$): δ = 21.3, 113.5, 121.5, 122.6, 123.1, 128.1, 130.6, 133.6, 134.2, 139.4, 145.4. MS (EI): *m/z* (%) = 289 (24), 287 (24), 261 (21), 260 (31), 259 (22), 258 (29), 181 (26), 180 (100), 179 (23), 178 (11). HRMS (EI): *m/z* calcd for $C_{13}H_{10}N_3{}^{79}Br$: 287.0058; found: 287.0061.

Compound **4**: white solid; mp 122–124 °C. IR (film; $CH_2Cl_2$): $\nu_{max}$ = 1531 ($NO_2$) cm$^{-1}$. $^1$H NMR (500 MHz, $CDCl_3$): δ = 2.50 (s, 3 H), 4.00 (s, 3 H), 7.11 (s, 1 H), 7.44–7.47 (m, 2 H), 7.57–7.60 (m, 2 H), 8.56 (s, 1 H). $^{13}$C NMR (125 MHz, $CDCl_3$): δ = 21.3, 57.0, 92.2, 118.0, 123.2, 130.7, 133.6, 134.4, 138.9, 139.5, 139.8, 153.3. MS (EI): *m/z* (%) = 284 (100), 241 (41), 211 (21), 210 (90), 196 (11), 183 (33), 181 (28), 180 (80). HRMS (EI): *m/z* calcd for $C_{14}H_{12}N_4O_3$: 284.0909; found: 284.0918.

Compound **5**: colorless oil. $^1$H NMR (400 MHz, $CDCl_3$): δ = 1.93 (s, 6 H), 7.08 (d, *J* = 9.2 Hz, 1 H), 7.29–7.31 (m, 2 H), 7.43–7.47 (m, 1 H), 8.95 (d, *J* = 6.4 Hz, 1 H). $^{13}$C NMR (100 MHz, $CDCl_3$): δ = 17.6, 98.2 (d, $J_{CF}$ = 26 Hz), 119.8, 129.2, 131.2, 133.1, 135.6 (d, $J_{CF}$ = 12 Hz), 136.4, 139.4, 140.2, 155.5. MS (EI): *m/z* (%) = 286 (86), 241 (15), 228 (13), 213 (34), 212 (100), 211 (70), 210 (38), 209 (21), 185 (21). HRMS (EI): *m/z* calcd for $C_{14}H_{11}N_4O_2F$: 286.0866; found: 286.0869.

Compound **6**: brown oil. IR (film; $CH_2Cl_2$): $\nu_{max}$ = 2094 (>=N=N), 1713 (C=O stretching) cm$^{-1}$. $^1$H NMR (400 MHz, $CDCl_3$): δ = 0.89–0.94 (m, 3 H), 1.28–1.38 (m, 2 H), 1.57–1.66 (m, 2 H), 3.62–3.66 (m, 2 H), 6.21 (d, *J* = 1.6 Hz, 1 H), 6.30 (dd, *J* = 9.6, 1.6 Hz, 1 H), 6.99–7.02 (m, 2 H), 7.05 (d, *J* = 9.6 Hz, 1 H), 7.30–7.33 (m, 2 H). $^{13}$C NMR (100 MHz, $CDCl_3$): δ = 13.9, 20.3, 29.3, 54.6, 109.5, 113.6, 124.8, 125.0, 129.0, 130.3, 130.7, 144.7, 150.0, 183.1.

Compound **7**: orange solid; mp 199–200 °C. IR (film; $CH_2Cl_2$): $\nu_{max}$ = 3253 (NH), 1693 (C=O stretching) cm$^{-1}$. $^1$H NMR (400 MHz, $CDCl_3$): δ = 2.22 (s, 6 H), 5.45 (s, 1 H), 7.14–7.23 (m, 3 H), 7.28 (s, 1 H), 7.66–7.69 (m, 1 H), 8.41–8.44 (m, 1 H), 8.96–8.98 (m, 1 H). $^{13}$C NMR (100 MHz, $CDCl_3$): δ = 18.1, 102.4, 128.4, 128.6, 129.0, 130.9, 133.3, 134.4, 135.8, 147.0, 147.2, 153.3, 180.4, 182.2. MS: *m/z* = 279.2 [M + H]. Anal. Calcd (%) for $C_{17}H_{14}N_2O_2$: C, 73.37; H, 5.07; N, 10.06. Found: C, 73.22; H, 5.26; N, 9.95.

(15) (a) Sundberg, R. J.; Baxter, E. W.; Pitts, W. J.; Ahmed-Schofield, R.; Nishiguchi, T. *J. Org. Chem.* **1988**, *53*, 5097. (b) Adam, W.; Hadjiarapoglou, L.; Mielke, K.; Treiber, A. *Tetrahedron Lett.* **1994**, 5625.

(16) Mukhopadhyay, C.; Tapaswi, P. K.; Butcher, R. J. *Org. Biomol. Chem.* **2010**, *8*, 4720.

