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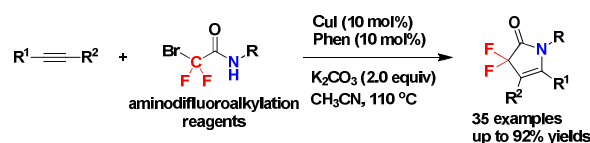
# Cu-Catalyzed Aminodifluoroalkylation of Alkynes and $\alpha$ -Bromodifluoroacetamides

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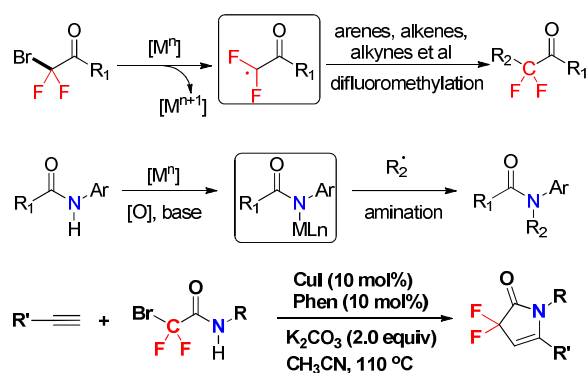


The copper-catalyzed highly regioselective aminodifluoroalkylation of alkynes and  $\alpha$ -bromodifluoroacetamides is realized for the first time. With this method, 3,3-difluoro-1*H*-pyrrol-2(3*H*)-ones could be constructed in a single step from various alkynes and  $\alpha$ -bromodifluoroacetamides substrates without using any extra oxidant.

The introduction of fluorine atoms or fluorinated moieties can alter molecular physical and chemical properties and biological activities in a dramatic way.<sup>1</sup> Nitrogen-containing heterocycles are key core of bioactive molecules.<sup>2</sup> Therefore, the efficient synthesis of fluorinated nitrogen-containing heterocycles is highly desirable for exploration of new pharmaceuticals.<sup>3</sup> As part of our ongoing study on aminofluorination reaction of alkenes and aminoarylation of alkynes using *N*-fluorobenzenesulfonimide (NFSI) as nitrogen source and the fluorine or aryl source,<sup>4</sup> we try to synthesize fluorinated nitrogen-containing heterocycles directly from alkynes by seeking a reagent with both fluorine and nitrogen moieties. Our

literature survey showed that  $\alpha$ -bromodifluoroacetamides might be a suitable reagent for this purpose.<sup>5</sup> As we know, the gem-difluoromethylene group ( $\text{CF}_2$ ) not only acts as lipophilic hydrogen bond donors and as bio-isosteres of alcohols and thiols, but also may significantly improve the biological stability.<sup>6</sup> Very recently, via reductive cleavage of C-Br bond,  $\alpha$ -bromodifluoroacetamides was successfully utilized as a fluoroalkyl radical reagent which can be trapped by a series of unsaturated compounds.<sup>5c-d</sup> On the other hand, in the presence of transition-metal, oxidant and base,  $\alpha$ -bromodifluoroacetamides may also be used as a suitable reagent for amination via cleavage of N-H bond in *N*-aryl amides.<sup>7</sup> Therefore, we reasoned that in the presence of one suitable catalyst, the above two processes could be consequentially realized to fulfill a catalytic cycle. Thus the gem-difluoro group and nitrogen atom can be simultaneously installed into an unsaturated C-C bond, which will lead a gem-difluorinated aza-heterocycle (Scheme 1).

### Scheme 1 Aminodifluoromethylation of Alkynes and Our Strategy



In contrast to the recent significant progress in the difluoromethylation of arenes<sup>5b,8</sup> and difluoromethylation difunctionalization of alkenes,<sup>5d,9</sup> efficient difluoroalkylation of less reactive alkynes are less abundant. Recently, examples of metal-catalyzed difluoromethylation difunctionalization of alkynes, such as halodifluoroalkylation, aryldifluoromethylation,

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4 cyanodifluoroalkylation, and carbodifluoroalkylation was realized to provide molecules with  
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6 important difluoroalkyl units ( $C=CCF_2R$ ).<sup>10</sup> However, to our knowledge,  
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8 aminodifluoroalkylation of simple alkynes has never been reported. Herein we report the first  
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10 example of a copper-catalyzed highly regioselective aminodifluoroalkylation of alkynes with  
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12  $\alpha$ -bromodifluoroacetamides as both fluorine and nitrogen source for facile access to a series of  
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14 fluorinated aza-heterocycles 3,3-difluoro-1*H*-pyrrol-2(3*H*)-ones<sup>11</sup> (Scheme 1).  
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19 We began our investigation utilizing the reaction between ethynylbenzene **1a** and  
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21 2-bromo-2,2-difluoro-*N*-(*p*-tolyl)acetamide **2a** as the model reaction (Table 1). With CuI as  
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23 the catalyst in the presence of  $K_2CO_3$  in MeCN, the model reaction was performed at 110 °C  
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25 for 2 hour under air, and no desired aminodifluoroalkylation product was observed (Table 1,  
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27 entry 1). When 10 mol % pyridine was added to the above reaction, intermolecular  
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29 aminodifluoroalkylation product **3a** was obtained in 18% (Table 1, entry 2). We were pleased  
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31 to discover that 1,10-phenanthroline (Phen) was an extremely efficient ligand for promoting  
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33 the reaction, affording **3a** in 92% yield (Table 1, entries 3-5). Control reactions demonstrated  
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35 that base and catalyst were essential to the reaction (Table 1, entries 6 and 7). Other bases,  
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37 such as  $KO^tBu$  and  $Et_3N$ , were not as effective as  $K_2CO_3$  (Table 1, entries 8 and 9). Further  
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39 investigation on different copper salts revealed that CuBr and CuCl was also efficient catalyst  
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41 for this transformation, affording product **3a** in a satisfying 86% and 90% yield (Table 1,  
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43 entries 10 and 11). With  $Cu(OTf)_2$  and  $Cu(OAc)_2$  as catalysts, **3a** was provided in 41% and  
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45 45% yields, respectively (Table 1, entries 12 and 13). Other solvents (e.g., EtOH, DMF,  
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47 EtOAc) have been examined but did not lead any significant improvement (Table 1, entries  
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49 14-16). When the reaction was performed at 90 °C, **3a** was isolated in 24% yield (Table 1,  
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entry 17). It should be noted that the transformation from **1a** into **3a** represents the first direct aminodifluoroalkylation from alkynes.

**Table 1 Optimization of the Reaction Conditions<sup>a</sup>**

Reaction scheme: **1a** (Ph-C≡CH) + **2a** (Br-CF<sub>2</sub>-NH-C<sub>6</sub>H<sub>4</sub>-CH<sub>3</sub>)  $\xrightarrow[\text{solvent}]{\text{copper salt / L}}$  **3a** (Ph-C(F)=C(NH-C<sub>6</sub>H<sub>4</sub>-CH<sub>3</sub>)-C(=O)-CF<sub>2</sub>-Br)

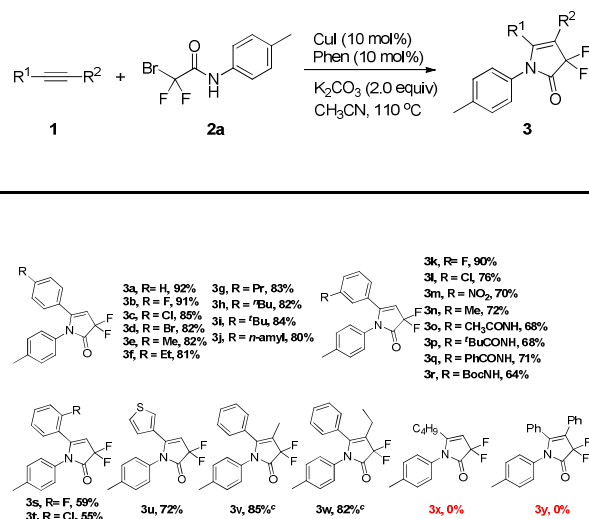
Entry	Metal	Ligand	Additive	Solvent	Yield (%) <sup>b</sup>
1	CuI	none	K <sub>2</sub> CO <sub>3</sub>	CH <sub>3</sub> CN	0
2	CuI	Pyridine	K <sub>2</sub> CO <sub>3</sub>	CH <sub>3</sub> CN	18
3	CuI	bipy	K <sub>2</sub> CO <sub>3</sub>	CH <sub>3</sub> CN	9
4	CuI	Ph <sub>3</sub> P	K <sub>2</sub> CO <sub>3</sub>	CH <sub>3</sub> CN	7
<b>5</b>	<b>CuI</b>	<b>Phen</b>	<b>K<sub>2</sub>CO<sub>3</sub></b>	<b>CH<sub>3</sub>CN</b>	<b>92</b>
6	CuI	Phen	none	CH <sub>3</sub> CN	trace
7	none	Phen	K <sub>2</sub> CO <sub>3</sub>	CH <sub>3</sub> CN	trace
8	CuI	Phen	KO <sup>t</sup> Bu	CH <sub>3</sub> CN	15
9	CuI	Phen	Et <sub>3</sub> N	CH <sub>3</sub> CN	29
10	CuBr	Phen	K <sub>2</sub> CO <sub>3</sub>	CH <sub>3</sub> CN	86
11	CuCl	Phen	K <sub>2</sub> CO <sub>3</sub>	CH <sub>3</sub> CN	90
12	Cu(OTf) <sub>2</sub>	Phen	K <sub>2</sub> CO <sub>3</sub>	CH <sub>3</sub> CN	41
13	Cu(OAc) <sub>2</sub>	Phen	K <sub>2</sub> CO <sub>3</sub>	CH <sub>3</sub> CN	45
14	CuI	Phen	K <sub>2</sub> CO <sub>3</sub>	EtOH	6
15	CuI	Phen	K <sub>2</sub> CO <sub>3</sub>	DMF	8
16	CuI	Phen	K <sub>2</sub> CO <sub>3</sub>	EtOAc	19
17 <sup>c</sup>	CuI	Phen	K <sub>2</sub> CO <sub>3</sub>	CH <sub>3</sub> CN	24

<sup>a</sup>Reactions were carried out with **1a** (0.45 mmol), **2a** (0.3 mmol), metal (10 mol %), ligand (10 mol %) and additive (2.0 equiv) in 3 mL solvent under air atmosphere at 110 °C for 2 h, unless noted otherwise. <sup>b</sup>Yield of the isolated product. <sup>c</sup>The reaction was performed at 90 °C. Phen = 1,10-phenanthroline, Tf = trifluoromethanesulfonyl, bipy=2,2'-bipyridine.

With the optimized reaction conditions in hand (Table 1, entry 5), the scope of the aminodifluoroalkylation of alkynes was examined and the results are shown in Table 2. The reaction of **2a** and variety of alkynes derivatives afforded the desired aminodifluoroalkylation products **3** in 55-92% yields. Halo-substituted phenylacetylenes (**1b–1d**, **1k**, **1l**, **1s**, **1t**) were tolerated in the aminodifluoroalkylation reaction, and could be very useful for further transformations. Phenylacetylene substrates bearing electron-withdrawing substituents, such as F, Cl, Br, and nitro, were effectively converted into the corresponding products in moderate to excellent yields. Substrates with electron-donating substituents on the aromatic ring

underwent aminodifluoroalkylation smoothly to afford the desired products (**3e-3j**, **3n-3r**) in good yields. In addition, heteroaromatic alkyne such as 3-ethynylthiophene **1u** was also effective to provide **3u** in 72% yield. Internal alkynes were subsequently examined. Starting from prop-1-yn-1-ylbenzene **1v** and but-1-yn-1-ylbenzene **1w**, **3v** and **3w** could be obtained in 85% and 82% yields, respectively. However, from the substrates hex-1-yne **1x** and diphenylacetylene **1y**, no reactions occurred and the substrate **2a** was completely recovered. Remarkably, in all cases, the reactions proceeded smoothly under air and high regioselectivities were observed.

**Table 2 Reactions of Alkynes **1** with **2a**<sup>a,b</sup>**

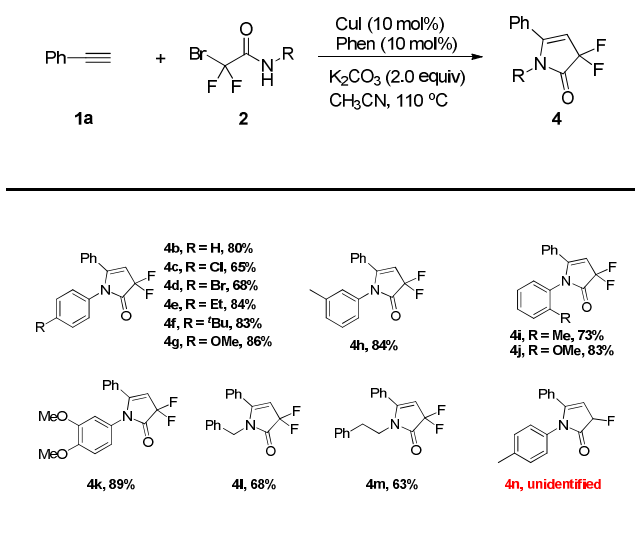


<sup>a</sup>Reactions were carried out with **1** (0.45 mmol), **2a** (0.3 mmol), CuI (10 mol %), Phen (10 mol %) and K<sub>2</sub>CO<sub>3</sub> (2.0 equiv) in CH<sub>3</sub>CN (3 mL) under air atmosphere at 110 °C for 2 h. <sup>b</sup>Yield of the isolated product. <sup>c</sup>The reaction was run for 4 h.

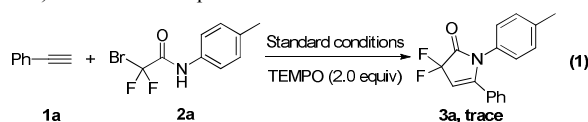
To further explore the potential of this efficient aminodifluoroalkylation reaction, a variety of  $\alpha$ -bromodifluoroacetamides were investigated. As shown in Table 3,  $\alpha$ -bromodifluoroacetamides with different substituents at the aromatic ring could be converted to the desired products **4b-4k** in moderate to good yields. Slightly decreased but acceptable

yields were also achieved for reactions starting from *ortho*-substituted aryl amides (**2i**, **2j**). Remarkably, we found that not only *N*-aryl substrates, but also *N*-alkyl substrates worked well, affording **4l** and **4m** in 68% and 63% yields. However, the desired annulation product was not observed between the reaction of ethynylbenzene with monofluoroacetamide 2-bromo-2-fluoro-*N*-(*p*-tolyl)acetamide **2n**.<sup>12</sup>

**Table 3 Reactions of Ethynylbenzene **1a** with  $\alpha$ -Bromodifluoroacetamides **2**<sup>a,b</sup>**



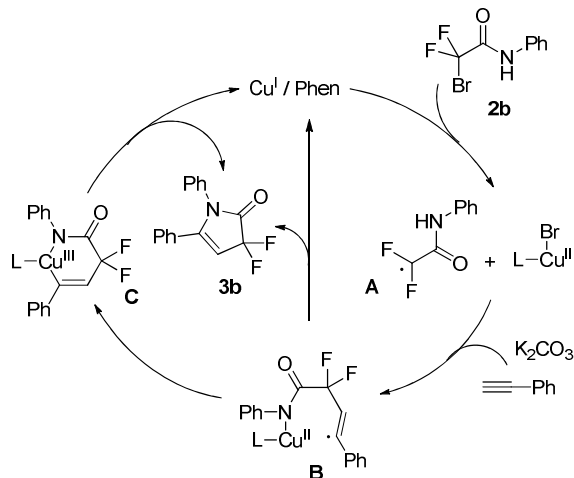
<sup>a</sup>Reactions were carried out with **1a** (0.45 mmol), **2** (0.3 mmol), CuI (10 mol %), Phen (10 mol %) and K<sub>2</sub>CO<sub>3</sub> (2.0 equiv) in CH<sub>3</sub>CN (3 mL) under air atmosphere at 110 °C for 2 h. <sup>b</sup>Yield of the isolated product.



To gain insight into the mechanism of this transformation, a radical trapping experiment was performed. When the radical scavenger 2,2,6,6-tetramethylpiperidine *N*-oxide (TEMPO, 2.0 equiv.) was added to the aminodifluoroalkylation reaction of **1a** under the optimal conditions, no desired products was isolated and 80% **2a** was recovered (eq 1). The results indicate that a radical pathway may be involved under the catalytic system. Based on the present experimental results and literature precedent, a possible mechanism was proposed as

described in Scheme 2. Initially, The reaction of CuI and **2b** gave a radical intermediate **A** and Cu<sup>II</sup> species via a single electron transfer (SET) process.<sup>5c</sup> Subsequently, addition of the in situ generated fluoroalkyl radical **A** to the C–C triple bond of alkyne leads to the formation of vinyl radical,<sup>10c,e</sup> which with Cu<sup>II</sup> species to give the intermediate **B** in the presence of K<sub>2</sub>CO<sub>3</sub>. Nitrogen atom transfer from Cu<sup>II</sup> to the adduct radical produces the aminodifluoroalkylation product and regenerates Cu<sup>I</sup>,<sup>13</sup> which enters into the next catalytic circle. On the other hand, we could not exclude another pathway: Cu<sup>II</sup>-amido species reacts with vinyl radicals to form vinyl-Cu<sup>III</sup>-amido species **C**, which then undergoes the final reductive elimination to give the desired annulation product.<sup>7a, 10c,e, 14</sup>

#### Scheme 2 Plausible Reaction Mechanism



In summary, we have developed the first example of copper-catalyzed radical aminodifluoroalkylation reaction of alkynes for the synthesis of 3,3-difluoro-1*H*-pyrrol-2(3*H*)-ones. The high regioselectivity, broad substrate scope, no extra oxidant, and low loading of the copper catalyst make the aminodifluoroalkylation reactions very attractive. We believe that it should prompt further research in the area of transition-metal catalyzed aminodifluoroalkylation reactions and related chemistry using



$\alpha$ -bromodifluoroacetamides as both difluoroalkyl source and nitrogen source.

## EXPERIMENTAL SECTION

All reagents were purchased from commercial sources and used without further treatment, unless otherwise indicated. All reactions were run under air with no precautions taken to exclude moisture.  $^1\text{H}$  NMR,  $^{13}\text{C}$  NMR and  $^{19}\text{F}$  NMR spectra were recorded at 25 °C on a Varian (400 MHz, 100 MHz and 376 MHz). Melting points were obtained with a micro melting point XT4A Beijing Keyi electrooptic apparatus and are uncorrected. High resolution mass spectra were recorded on Bruck microtof. All reactions were monitored by TLC with Taizhou GF254 silica gel coated plates. Flash column chromatography was carried out using 200-300 mesh silica gel at increased pressure.

**General procedure for the preparation of 1o-1r.** Substrates **1o-1q** were prepared by the reaction of corresponding anilines (1 mmol) and acyl chlorides (1.1 mmol) in  $\text{CH}_2\text{Cl}_2$  at room temperature. Substrates **1r** was prepared according to literature procedure.<sup>15</sup>

**General procedure for the preparation of 2 (2a as an example).** In a nitrogen-filled glovebox, *p*-toluidine (535.8 mg, 5.0 mmol), ethyl bromodifluoroacetate (785.1  $\mu\text{L}$ , 6.0 mmol), and  $\text{La}(\text{OTf})_3$  (146.5 mg, 0.25 mmol) were combined in screw-cap test tube. The reaction mixture was stirred at 50 °C and monitored by TLC. After the amine was exhausted, the mixture was purified by silica gel column chromatography to give the corresponding products **2a** (1.21 g, 92%).

**General procedure for the preparation of 3 and 4 (3a as Example).** To a solution of the 2-bromo-2,2-difluoro-*N*-(*p*-tolyl)acetamide **2a** (79.2 mg, 0.3 mmol) in  $\text{CH}_3\text{CN}$  (3.0 ml) was added the ethynylbenzene **1a** (49  $\mu\text{L}$ , 0.45 mmol), Phen (5.4 mg, 0.03 mmol),  $\text{CuI}$  (5.7 mg, 0.03 mmol),

and K<sub>2</sub>CO<sub>3</sub> (82.9 mg, 0.6 mmol) in screw-cap test tube. The reaction mixture was stirred at 110 °C for 2.0 h. After the reaction finished, the reaction mixture was cooled to room temperature and quenched by water. The mixture was extracted with EtOAc (5.0 mL×3), the combined organic phases were dried over anhydrous Na<sub>2</sub>SO<sub>4</sub> and the solvent was evaporated under vacuum. The residue was purified by column chromatography to give the corresponding products **3a** (78.7 mg, 92%).

***N*-(3-ethynylphenyl)acetamide 1o**

White solid (149.5 mg, 94%). petroleum ether/ethyl acetate = 40:1 as eluent for the column chromatography. mp: 86-88 °C. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): δ = 2.13 (s, 3H), 3.04 (s, 1H), 7.20 (d, *J* = 6.8 Hz, 2H), 7.48-7.49 (m, 1H), 7.67 (s, 1H), 8.60 (s, 1H); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>): δ = 24.2, 77.4, 83.1, 120.7, 122.5, 123.6, 127.8, 128.8, 138.0, 169.4. HRMS (ESI-TOF). Calcd for C<sub>10</sub>H<sub>10</sub>NO, [M+H]<sup>+</sup> *m/z* 160.0762, Found 160.0764.

***N*-(3-ethynylphenyl)pivalamide 1p**

White solid (189.0 mg, 94%). petroleum ether/ethyl acetate = 40:1 as eluent for the column chromatography. mp: 144-146 °C. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): δ = 1.27 (s, 9H), 3.03 (s, 1H), 7.17-7.20 (m, 2H), 7.50-7.53 (m, 1H), 7.56 (s, 1H), 7.64 (s, 1H); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>): δ = 27.4, 39.5, 77.3, 83.1, 120.8, 122.5, 123.7, 127.7, 128.7, 138.0, 176.8. HRMS (ESI-TOF). Calcd for C<sub>13</sub>H<sub>16</sub>NO, [M+H]<sup>+</sup> *m/z* 202.1232, Found 202.1230.

***N*-(3-ethynylphenyl)benzamide 1q**

White solid (198.9 mg, 90%). petroleum ether/ethyl acetate = 40:1 as eluent for the column chromatography. mp: 122-124 °C. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): δ = 3.08 (s, 1H), 7.26-7.31 (m, 2H), 7.44 (t, *J* = 7.2 Hz, 2H), 7.53 (t, *J* = 7.2 Hz, 1H), 7.68 (d, *J* = 7.2 Hz, 1H), 7.77 (s, 1H), 7.84 (d, *J* = 7.6

Hz, 2H), 8.12 (s, 1H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 77.5, 83.1, 120.9, 122.8, 123.8, 127.0, 128.2, 128.7, 129.0, 131.9, 134.6, 138.0, 166.0. HRMS (ESI-TOF). Calcd for  $\text{C}_{15}\text{H}_{12}\text{NO}$ ,  $[\text{M}+\text{H}]^+$   $m/z$  222.0919, Found 222.0926.

***tert*-butyl (3-ethynylphenyl)carbamate 1r**

White solid (173.7 mg, 80%). petroleum ether/ethyl acetate = 40:1 as eluent for the column chromatography. mp: 70-72 °C.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 1.50 (s, 9H), 3.04 (s, 1H), 6.75 (s, 1H), 7.13 (d,  $J$  = 7.6 Hz, 1H), 7.20 (t,  $J$  = 7.6 Hz, 1H), 7.34 (d,  $J$  = 7.6 Hz, 1H), 7.53 (s, 1H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 28.2, 77.1, 80.6, 83.3, 119.0, 121.9, 122.6, 126.6, 128.8, 138.4, 152.6. HRMS (ESI-TOF). Calcd for  $\text{C}_{13}\text{H}_{16}\text{NO}_2$ ,  $[\text{M}+\text{H}]^+$   $m/z$  218.1181, Found 218.1171.

**2-bromo-2,2-difluoro-*N*-(*p*-tolyl)acetamide 2a**

White solid (1.21 g, 92%). petroleum ether/ethyl acetate = 90:1 as eluent for the column chromatography. mp: 118-120 °C.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 2.35 (s, 3H), 7.18 (d,  $J$  = 8.4 Hz, 2H), 7.45 (d,  $J$  = 8.4 Hz, 2H), 7.97 (s, 1H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 20.9, 111.6 (t,  $J$  = 315.0 Hz), 120.5, 129.8, 132.7, 136.1, 157.4 (t,  $J$  = 28.0 Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta$  = -60.4. HRMS (ESI-TOF) Calcd for  $\text{C}_9\text{H}_9\text{BrF}_2\text{NO}$ ,  $[\text{M}+\text{H}]^+$   $m/z$  263.9836, Found 263.9828.

**2-bromo-2,2-difluoro-*N*-phenylacetamide 2b**

White solid (1.12 g, 90%). petroleum ether/ethyl acetate = 90:1 as eluent for the column chromatography. mp: 46-48 °C.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 7.23 (d,  $J$  = 7.6 Hz, 1H), 7.40 (t,  $J$  = 8.0 Hz, 2H), 7.57 (d,  $J$  = 8.0 Hz, 2H), 7.86 (s, 1H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 111.4 (t,  $J$  = 315.0 Hz), 120.6, 126.2, 129.3, 135.2, 157.6 (t,  $J$  = 28.0 Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta$  = -60.6. HRMS (ESI-TOF) Calcd for  $\text{C}_8\text{H}_7\text{BrF}_2\text{NO}$ ,  $[\text{M}+\text{H}]^+$   $m/z$  249.9679, Found 249.9680.

**2-bromo-*N*-(4-chlorophenyl)-2,2-difluoroacetamide 2c**

White solid (1.16 g, 82%). petroleum ether/ethyl acetate = 90:1 as eluent for the column chromatography. mp: 136-138 °C.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 7.37 (d,  $J$  = 8.8 Hz, 2H), 7.53 (d,  $J$  = 8.8 Hz, 2H), 7.88 (s, 1H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 111.3 (t,  $J$  = 315.0 Hz), 121.7, 129.5, 131.6, 133.8, 157.5 (t,  $J$  = 28.0 Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta$  = -60.7. HRMS (ESI-TOF) Calcd for  $\text{C}_8\text{H}_6\text{BrClF}_2\text{NO}$ ,  $[\text{M}+\text{H}]^+ m/z$  283.9289, Found 283.9287.

**2-bromo-*N*-(4-bromophenyl)-2,2-difluoroacetamide 2d**

White solid (1.36 g, 83%). petroleum ether/ethyl acetate = 90:1 as eluent for the column chromatography. mp: 144-146 °C.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 7.47 (d,  $J$  = 8.8 Hz, 2H), 7.52 (d,  $J$  = 8.8 Hz, 2H), 7.87 (s, 1H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 111.3 (t,  $J$  = 315.0 Hz), 119.2, 122.0, 132.4, 134.3, 157.4 (t,  $J$  = 28.0 Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta$  = -60.7. HRMS (ESI-TOF) Calcd for  $\text{C}_8\text{H}_6\text{Br}_2\text{F}_2\text{NO}$ ,  $[\text{M}+\text{H}]^+ m/z$  329.8764, Found 329.8770.

**2-bromo-*N*-(4-ethylphenyl)-2,2-difluoroacetamide 2e**

White solid (1.26 g, 91%). petroleum ether/ethyl acetate = 90:1 as eluent for the column chromatography. mp: 98-99 °C.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 1.24 (t,  $J$  = 7.6 Hz, 3H), 2.65 (q,  $J$  = 7.6 Hz, 2H), 7.22 (d,  $J$  = 8.4 Hz, 2H), 7.47 (d,  $J$  = 8.4 Hz, 2H), 7.84 (s, 1H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 15.5, 28.3, 111.6 (t,  $J$  = 315.0 Hz), 120.5, 128.7, 132.9, 142.4, 157.4 (t,  $J$  = 28.0 Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta$  = -60.4. HRMS (ESI-TOF). Calcd for  $\text{C}_{10}\text{H}_{11}\text{BrF}_2\text{NO}$ ,  $[\text{M}+\text{H}]^+ m/z$  277.9992, Found 277.9999.

**2-bromo-*N*-(4-(*tert*-butyl)phenyl)-2,2-difluoroacetamide 2f**

White solid (1.37 g, 90%). petroleum ether/ethyl acetate = 90:1 as eluent for the column chromatography. mp: 115-117 °C.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 1.32 (s, 9H), 7.41 (d,  $J$  = 8.4 Hz, 2H), 7.49 (d,  $J$  = 8.8 Hz, 2H), 7.81 (s, 1H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 31.2, 34.5, 111.5 (t,  $J$  =

315.0 Hz), 120.3, 126.1, 132.6, 149.4, 157.6 (t,  $J = 27.0$  Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta = -60.4$ .

HRMS (ESI-TOF). Calcd for  $\text{C}_{12}\text{H}_{15}\text{BrF}_2\text{NO}$ ,  $[\text{M}+\text{H}]^+ m/z$  306.0305, Found 306.0309.

**2-bromo-2,2-difluoro-*N*-(4-methoxyphenyl)acetamide 2g**

White solid (1.31 g, 94%). petroleum ether/ethyl acetate = 90:1 as eluent for the column chromatography. mp: 117-119 °C.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta = 3.81$  (s, 3H), 6.91 (d,  $J = 8.8$  Hz, 2H), 7.47 (d,  $J = 8.8$  Hz, 2H), 7.84 (s, 1H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta = 55.5$ , 111.7 (t,  $J = 315.0$  Hz), 114.5, 122.2, 128.1, 157.4 (t,  $J = 28.0$  Hz), 157.7;  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta = -60.4$ . HRMS (ESI-TOF) Calcd for  $\text{C}_9\text{H}_9\text{BrF}_2\text{NO}_2$ ,  $[\text{M}+\text{H}]^+ m/z$  279.9785, Found 279.9782.

**2-bromo-2,2-difluoro-*N*-(*m*-tolyl)acetamide 2h**

White solid (1.18 g, 90%). petroleum ether/ethyl acetate = 90:1 as eluent for the column chromatography. mp: 60-61 °C.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta = 2.36$  (s, 3H), 7.06 (d,  $J = 7.2$  Hz, 1H), 7.27 (t,  $J = 8.0$  Hz, 1H), 7.39 (d,  $J = 8.0$  Hz, 1H), 7.43 (s, 1H), 8.14 (s, 1H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta = 21.3$ , 111.5 (t,  $J = 315.0$  Hz), 117.7, 121.2, 127.0, 129.0, 135.1, 139.3, 157.6 (t,  $J = 28.0$  Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta = -60.5$ . HRMS (ESI-TOF) Calcd for  $\text{C}_9\text{H}_9\text{BrF}_2\text{NO}$ ,  $[\text{M}+\text{H}]^+ m/z$  263.9836, Found 263.9833.

**2-bromo-2,2-difluoro-*N*-(*o*-tolyl)acetamide 2i**

White solid (1.12 g, 85%). petroleum ether/ethyl acetate = 90:1 as eluent for the column chromatography. mp: 72-74 °C.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta = 2.35$  (s, 3H), 7.06 (d,  $J = 7.6$  Hz, 1H), 7.27 (t,  $J = 7.6$  Hz, 1H), 7.41 (t,  $J = 7.6$  Hz, 2H), 8.29 (s, 1H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta = 21.2$ , 111.5 (t,  $J = 315.0$  Hz), 117.8, 121.3, 127.0, 129.0, 135.1, 139.2, 157.7 (t,  $J = 28.0$  Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta = -60.4$ . HRMS (ESI-TOF). Calcd for  $\text{C}_9\text{H}_9\text{BrF}_2\text{NO}$ ,  $[\text{M}+\text{H}]^+ m/z$  263.9836, Found 263.9830.

**2-bromo-2,2-difluoro-*N*-(2-methoxyphenyl)acetamide 2j**

White solid (1.26 g, 90%). petroleum ether/ethyl acetate = 90:1 as eluent for the column chromatography. mp: 78-79 °C. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): δ = 3.93 (s, 3H), 6.93 (d, *J* = 8.0 Hz, 1H), 7.01 (t, *J* = 8.0 Hz, 1H), 7.16 (t, *J* = 8.0 Hz, 1H), 8.31 (d, *J* = 8.0 Hz, 1H), 8.54 (s, 1H); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>): δ = 55.9, 110.2, 111.6 (t, *J* = 315.0 Hz), 120.0, 121.2, 125.2, 125.8, 148.4, 157.0 (t, *J* = 27.0 Hz); <sup>19</sup>F NMR (376 MHz, CDCl<sub>3</sub>): δ = -60.2. HRMS (ESI-TOF). Calcd for C<sub>9</sub>H<sub>9</sub>BrF<sub>2</sub>NO<sub>2</sub>, [M+H]<sup>+</sup> *m/z* 279.9785, Found 279.9778.

**2-bromo-*N*-(3,4-dimethoxyphenyl)-2,2-difluoroacetamide 2k**

White solid (1.45 g, 94%). petroleum ether/ethyl acetate = 90:1 as eluent for the column chromatography. mp: 138-140 °C. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): δ = 3.89 (s, 3H), 3.91 (s, 3H), 6.86 (d, *J* = 8.8 Hz, 1H), 6.98 (dd, *J*<sub>1</sub> = 2.4 Hz, *J*<sub>2</sub> = 8.8 Hz, 1H), 7.32 (d, *J* = 2.4 Hz, 1H), 7.72 (s, 1H); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>): δ = 55.9, 56.0, 105.0, 111.3, 111.6 (t, *J* = 315.0 Hz), 112.8, 128.7, 147.2, 149.2, 157.4 (t, *J* = 28.0 Hz); <sup>19</sup>F NMR (376 MHz, CDCl<sub>3</sub>): δ = -60.3. HRMS (ESI-TOF). Calcd for C<sub>10</sub>H<sub>11</sub>BrF<sub>2</sub>NO<sub>3</sub>, [M+H]<sup>+</sup> *m/z* 309.9890, Found 309.9881.

***N*-benzyl-2-bromo-2,2-difluoroacetamide 2l**

White solid (1.25 g, 95%). petroleum ether/ethyl acetate = 100:1 as eluent for the column chromatography. mp: 44-45 °C. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): δ = 4.49 (d, *J* = 6.0 Hz, 2H), 6.98 (s, 1H), 7.28-7.31 (m, 2H), 7.33-7.39 (m, 3H); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>): δ = 43.9, 111.7 (t, *J* = 314.0 Hz), 127.7, 128.0, 128.9, 136.1, 160.0 (t, *J* = 27.0 Hz); <sup>19</sup>F NMR (376 MHz, CDCl<sub>3</sub>): δ = -60.5. HRMS (ESI-TOF). Calcd for C<sub>9</sub>H<sub>9</sub>BrF<sub>2</sub>NO, [M+H]<sup>+</sup> *m/z* 263.9836, Found 263.9831.

**2-bromo-2,2-difluoro-*N*-phenethylacetamide 2m**

White solid (1.32 g, 95%). petroleum ether/ethyl acetate = 100:1 as eluent for the column chromatography. mp: 92-94 °C. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): δ = 2.91 (t, *J* = 6.8 Hz, 2H), 3.62 (q, *J* = 6.8 Hz, 2H), 6.50 (s, 1H), 7.22 (d, *J* = 6.8 Hz, 2H), 7.26-7.29 (m, 1H), 7.35 (t, *J* = 6.8 Hz, 2H); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>): δ = 34.9, 41.3, 111.7 (t, *J* = 314.0 Hz), 126.9, 128.7, 128.8, 137.7, 160.0 (t, *J* = 27.0 Hz); <sup>19</sup>F NMR (376 MHz, CDCl<sub>3</sub>): δ = -60.4. HRMS (ESI-TOF). Calcd for C<sub>10</sub>H<sub>11</sub>BrF<sub>2</sub>NO, [M+H]<sup>+</sup> *m/z* 277.9992, Found 277.9983.

### 3,3-difluoro-5-phenyl-1-(*p*-tolyl)-1*H*-pyrrol-2(3*H*)-one 3a

White solid (78.7 mg, 92%). petroleum ether/ethyl acetate = 50:1 as eluent for the column chromatography. mp: 106-108 °C. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): δ = 2.32 (s, 3H), 5.63 (t, *J* = 1.2 Hz, 1H), 6.91 (d, *J* = 8.4 Hz, 2H), 7.11 (d, *J* = 8.0 Hz, 2H), 7.18 (d, *J* = 7.6 Hz, 2H), 7.29 (t, *J* = 7.6 Hz, 2H), 7.38 (t, *J* = 7.6 Hz, 1H); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>): δ = 21.1, 99.8 (t, *J* = 23.0 Hz), 112.9 (t, *J* = 244.0 Hz), 126.5, 127.9, 128.5, 128.8, 129.6, 130.6, 130.9, 137.9, 154.6 (t, *J* = 11.0 Hz), 166.9 (t, *J* = 30.0 Hz); <sup>19</sup>F NMR (376 MHz, CDCl<sub>3</sub>): δ = -110.1. HRMS (ESI-TOF). Calcd for C<sub>17</sub>H<sub>14</sub>F<sub>2</sub>NO, [M+H]<sup>+</sup> *m/z* 286.1043, Found 286.1042.

### 3,3-difluoro-5-(4-fluorophenyl)-1-(*p*-tolyl)-1*H*-pyrrol-2(3*H*)-one 3b

Colorless oil (82.7 mg, 91%). petroleum ether/ethyl acetate = 70:1 as eluent for the column chromatography. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): δ = 2.33 (s, 3H), 5.61 (d, *J* = 1.6 Hz, 1H), 6.90 (d, *J* = 8.4 Hz, 2H), 6.98 (t, *J* = 8.4 Hz, 2H), 7.13 (d, *J* = 8.0 Hz, 2H), 7.16-7.20 (m, 2H); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>): δ = 21.1, 99.7 (t, *J* = 23.0 Hz), 112.8 (t, *J* = 244.0 Hz), 115.8 (d, *J* = 22.0 Hz), 124.9 (d, *J* = 3.0 Hz), 126.6, 129.8, 130.1 (d, *J* = 8.0 Hz), 130.8, 138.1, 153.5 (t, *J* = 11.0 Hz), 163.8 (d, *J* = 251.0 Hz), 166.7 (t, *J* = 30.0 Hz); <sup>19</sup>F NMR (376 MHz, CDCl<sub>3</sub>): δ = -110.0, -108.3. HRMS (ESI-TOF). Calcd for C<sub>17</sub>H<sub>13</sub>F<sub>3</sub>NO, [M+H]<sup>+</sup> *m/z* 304.0949, Found 304.0944.

**5-(4-chlorophenyl)-3,3-difluoro-1-(*p*-tolyl)-1*H*-pyrrol-2(3*H*)-one 3c**

Colorless oil (81.3 mg, 85%). petroleum ether/ethyl acetate = 70:1 as eluent for the column chromatography.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 2.33 (s, 3H), 5.64 (s, 1H), 6.90 (d,  $J$  = 8.0 Hz, 2H), 7.11-7.14 (m, 4H), 7.27 (d,  $J$  = 8.4 Hz, 2H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 21.1, 100.1 (t,  $J$  = 23.0 Hz), 112.7 (t,  $J$  = 244.0 Hz), 126.5, 127.2, 128.9, 129.2, 129.8, 130.7, 136.9, 138.2, 153.4 (t,  $J$  = 11.0 Hz), 166.7 (t,  $J$  = 30.0 Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta$  = -110.1. HRMS (ESI-TOF). Calcd for  $\text{C}_{17}\text{H}_{13}\text{ClF}_2\text{NO}$ ,  $[\text{M}+\text{H}]^+$   $m/z$  320.0654, Found 320.0649.

**5-(4-bromophenyl)-3,3-difluoro-1-(*p*-tolyl)-1*H*-pyrrol-2(3*H*)-one 3d**

Colorless oil (89.3 mg, 82%). petroleum ether/ethyl acetate = 60:1 as eluent for the column chromatography.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 2.33 (s, 3H), 5.64 (s, 1H), 6.90 (d,  $J$  = 8.0 Hz, 2H), 7.05 (d,  $J$  = 8.0 Hz, 2H), 7.13 (d,  $J$  = 8.0 Hz, 2H), 7.43 (d,  $J$  = 8.4 Hz, 2H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 21.1, 100.1 (t,  $J$  = 23.0 Hz), 112.6 (t,  $J$  = 244.0 Hz), 125.2, 126.5, 127.7, 129.4, 129.8, 130.7, 131.9, 138.2, 153.5 (t,  $J$  = 11.0 Hz), 166.7 (t,  $J$  = 30.0 Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta$  = -110.2. HRMS (ESI-TOF). Calcd for  $\text{C}_{17}\text{H}_{13}\text{BrF}_2\text{NO}$ ,  $[\text{M}+\text{H}]^+$   $m/z$  364.0149, Found 364.0156.

**3,3-difluoro-1,5-di-*p*-tolyl-1*H*-pyrrol-2(3*H*)-one 3e**

Colorless oil (73.6 mg, 82%). petroleum ether/ethyl acetate = 70:1 as eluent for the column chromatography.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 2.33 (s, 6H), 5.58 (s, 1H), 6.91-6.93 (m, 2H), 7.07-7.13 (m, 6H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 21.1, 21.4, 99.1 (t,  $J$  = 23.0 Hz), 113.0 (t,  $J$  = 244.0 Hz), 125.9, 126.6, 127.9, 129.2, 129.6, 131.1, 137.8, 141.0, 154.6 (t,  $J$  = 11.0 Hz), 167.0 (t,  $J$  = 30.0 Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta$  = -109.8. HRMS (ESI-TOF). Calcd for  $\text{C}_{18}\text{H}_{16}\text{F}_2\text{NO}$ ,  $[\text{M}+\text{H}]^+$   $m/z$  300.1200, Found 300.1218.

**5-(4-ethylphenyl)-3,3-difluoro-1-(*p*-tolyl)-1*H*-pyrrol-2(3*H*)-one 3f**



Colorless oil (76.1 mg, 81%). petroleum ether/ethyl acetate = 70:1 as eluent for the column chromatography.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 1.21 (t,  $J$  = 7.6 Hz, 3H), 2.33 (s, 3H), 2.63 (q,  $J$  = 7.6 Hz, 2H), 5.59 (s, 1H), 6.93 (d,  $J$  = 8.0 Hz, 2H), 7.08-7.13 (m, 6H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 15.0, 21.1, 28.6, 99.1 (t,  $J$  = 23.0 Hz), 113.0 (t,  $J$  = 244.0 Hz), 126.1, 126.6, 127.9, 128.0, 129.6, 131.1, 137.8, 147.2, 154.6 (t,  $J$  = 11.0 Hz), 167.0 (t,  $J$  = 30.0 Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta$  = -109.7. HRMS (ESI-TOF). Calcd for  $\text{C}_{19}\text{H}_{18}\text{F}_2\text{NO}$ ,  $[\text{M}+\text{H}]^+$   $m/z$  314.1356, Found 314.1353.

**3,3-difluoro-5-(4-propylphenyl)-1-(*p*-tolyl)-1*H*-pyrrol-2(3*H*)-one 3g**

Colorless oil (81.4 mg, 83%). petroleum ether/ethyl acetate = 70:1 as eluent for the column chromatography.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 0.91 (t,  $J$  = 7.2 Hz, 3H), 1.57-1.63 (m, 2H), 2.33 (s, 3H), 2.56 (t,  $J$  = 7.6 Hz, 2H), 5.59 (s, 1H), 6.92 (d,  $J$  = 8.0 Hz, 2H), 7.08-7.12 (m, 6H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 13.7, 21.1, 24.1, 37.8, 99.1 (t,  $J$  = 23.0 Hz), 113.0 (t,  $J$  = 244.0 Hz), 126.1, 126.6, 127.9, 128.6, 129.6, 131.1, 137.8, 145.8, 154.6 (t,  $J$  = 11.0 Hz), 167.0 (t,  $J$  = 30.0 Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta$  = -109.8. HRMS (ESI-TOF). Calcd for  $\text{C}_{20}\text{H}_{20}\text{F}_2\text{NO}$ ,  $[\text{M}+\text{H}]^+$   $m/z$  328.1513, Found 328.1506.

**5-(4-butylphenyl)-3,3-difluoro-1-(*p*-tolyl)-1*H*-pyrrol-2(3*H*)-one 3h**

Colorless oil (83.9 mg, 82%). petroleum ether/ethyl acetate = 70:1 as eluent for the column chromatography.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 0.91 (t,  $J$  = 7.6 Hz, 3H), 1.30-1.37 (m, 2H), 1.52-1.60 (m, 2H), 2.33 (s, 3H), 2.56 (t,  $J$  = 7.6 Hz, 2H), 5.90 (d,  $J$  = 1.2 Hz, 1H), 6.92 (d,  $J$  = 8.4 Hz, 2H), 7.06-7.12 (m, 6H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 13.8, 21.1, 22.3, 33.1, 35.4, 99.1 (t,  $J$  = 23.0 Hz), 113.0 (t,  $J$  = 244.0 Hz), 126.0, 126.5, 127.8, 128.5, 129.6, 131.1, 137.8, 146.0, 154.6 (t,  $J$  = 11.0 Hz), 167.0 (t,  $J$  = 30.0 Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta$  = -109.8. HRMS (ESI-TOF). Calcd for  $\text{C}_{21}\text{H}_{22}\text{F}_2\text{NO}$ ,  $[\text{M}+\text{H}]^+$   $m/z$  342.1669, Found 342.1677.

**5-(4-(*tert*-butyl)phenyl)-3,3-difluoro-1-(*p*-tolyl)-1*H*-pyrrol-2(3*H*)-one 3i**

Yellow oil (85.9 mg, 84%). petroleum ether/ethyl acetate = 70:1 as eluent for the column chromatography. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): δ = 1.28 (s, 9H), 2.34 (s, 3H), 5.59 (s, 1H), 6.93 (d, *J* = 8.4 Hz, 2H), 7.11 (t, *J* = 8.4 Hz, 4H), 7.29 (d, *J* = 8.4 Hz, 2H); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>): δ = 21.1, 31.1, 34.9, 99.2 (t, *J* = 23.0 Hz), 113.0 (t, *J* = 244.0 Hz), 125.4, 125.8, 126.6, 127.7, 129.6, 131.2, 137.8, 154.2, 154.5 (t, *J* = 11.0 Hz), 167.0 (t, *J* = 30.0 Hz); <sup>19</sup>F NMR (376 MHz, CDCl<sub>3</sub>): δ = -109.8. HRMS (ESI-TOF). Calcd for C<sub>21</sub>H<sub>22</sub>F<sub>2</sub>NO, [M+H]<sup>+</sup> *m/z* 342.1669, Found 342.1664.

**3,3-difluoro-5-(4-pentylphenyl)-1-(*p*-tolyl)-1*H*-pyrrol-2(3*H*)-one 3j**

Yellow oil (85.2 mg, 80%). petroleum ether/ethyl acetate = 70:1 as eluent for the column chromatography. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): δ = 0.89 (t, *J* = 6.8 Hz, 3H), 1.28-1.35 (m, 4H), 1.55-1.62 (m, 2H), 2.33 (s, 3H), 2.58 (t, *J* = 7.6 Hz, 2H), 5.60 (s, 1H), 6.93 (d, *J* = 8.0 Hz, 2H), 7.09-7.19 (m, 6H); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>): δ = 13.9, 21.1, 22.4, 30.6, 31.4, 35.7, 99.1 (t, *J* = 23.0 Hz), 113.0 (t, *J* = 244.0 Hz), 126.0, 126.5, 127.8, 128.5, 129.6, 131.1, 137.8, 146.0, 154.6 (t, *J* = 11.0 Hz), 167.0 (t, *J* = 30.0 Hz); <sup>19</sup>F NMR (376 MHz, CDCl<sub>3</sub>): δ = -109.7. HRMS (ESI-TOF). Calcd for C<sub>22</sub>H<sub>24</sub>F<sub>2</sub>NO, [M+H]<sup>+</sup> *m/z* 356.1826, Found 356.1821.

**3,3-difluoro-5-(3-fluorophenyl)-1-(*p*-tolyl)-1*H*-pyrrol-2(3*H*)-one 3k**

White solid (81.8 mg, 90%). petroleum ether/ethyl acetate = 60:1 as eluent for the column chromatography. mp: 109-110 °C. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>): δ = 2.33 (s, 3H), 5.66 (d, *J* = 1.6 Hz, 1H), 6.89-6.92 (m, 3H), 6.97 (d, *J* = 8.0 Hz, 1H), 7.06-7.10 (m, 1H), 7.13 (d, *J* = 8.4 Hz, 2H), 7.24-7.30 (m, 1H); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>): δ = 21.1, 100.6 (t, *J* = 23.0 Hz), 112.6 (t, *J* = 244.0 Hz), 115.1 (d, *J* = 23.0 Hz), 117.7 (d, *J* = 21.0 Hz), 123.8 (d, *J* = 1.0 Hz), 126.4, 129.8, 130.3 (d, *J* = 9.0 Hz), 130.7, 130.8 (d, *J* = 8.0 Hz), 138.2, 153.3 (t, *J* = 11.0 Hz), 162.3 (d, *J* = 246.0 Hz), 166.6 (t, *J* = 30.0

Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta$  = -111.3, -110.4. HRMS (ESI-TOF). Calcd for  $\text{C}_{17}\text{H}_{13}\text{F}_3\text{NO}$ ,  $[\text{M}+\text{H}]^+$   $m/z$  304.0949, Found 304.0939.

**5-(3-chlorophenyl)-3,3-difluoro-1-(*p*-tolyl)-1*H*-pyrrol-2(3*H*)-one 3l**

Colorless oil (72.7 mg, 76%). petroleum ether/ethyl acetate = 60:1 as eluent for the column chromatography.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 2.32 (s, 3H), 5.65 (s, 1H), 6.91 (d,  $J$  = 8.4 Hz, 2H), 6.98 (d,  $J$  = 8.0 Hz, 1H), 7.13 (d,  $J$  = 8.0 Hz, 2H), 7.20 (t,  $J$  = 8.0 Hz, 1H), 7.26 (s, 1H), 7.35 (d,  $J$  = 8.0 Hz, 1H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 21.1, 100.7 (t,  $J$  = 23.0 Hz), 112.6 (t,  $J$  = 245.0 Hz), 126.1, 126.5, 128.0, 129.7, 129.8, 130.5, 130.6, 130.7, 134.7, 138.2, 153.1 (t,  $J$  = 11.0 Hz), 166.6 (t,  $J$  = 30.0 Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta$  = -110.4. HRMS (ESI-TOF). Calcd for  $\text{C}_{17}\text{H}_{13}\text{ClF}_2\text{NO}$ ,  $[\text{M}+\text{H}]^+$   $m/z$  320.0654, Found 320.0649.

**3,3-difluoro-5-(3-nitrophenyl)-1-(*p*-tolyl)-1*H*-pyrrol-2(3*H*)-one 3m**

Colorless oil (69.3 mg, 70%). petroleum ether/ethyl acetate = 60:1 as eluent for the column chromatography.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 2.32 (s, 3H), 5.78 (t,  $J$  = 1.2 Hz, 1H), 6.92 (d,  $J$  = 8.0 Hz, 2H), 7.14 (d,  $J$  = 8.4 Hz, 2H), 7.45-7.51 (m, 2H), 8.12 (s, 1H), 8.22-8.24 (m, 1H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 21.1, 101.6 (t,  $J$  = 23.0 Hz), 112.3 (t,  $J$  = 245.0 Hz), 123.0, 125.2, 126.2, 129.7, 130.1, 130.2, 130.4, 133.5, 138.7, 148.1, 152.1 (t,  $J$  = 11.0 Hz), 166.3 (t,  $J$  = 30.0 Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta$  = -110.6. HRMS (ESI-TOF). Calcd for  $\text{C}_{17}\text{H}_{13}\text{F}_2\text{N}_2\text{O}_3$ ,  $[\text{M}+\text{H}]^+$   $m/z$  331.0894, Found 331.0903.

**3,3-difluoro-5-(*m*-tolyl)-1-(*p*-tolyl)-1*H*-pyrrol-2(3*H*)-one 3n**

Colorless oil (64.6 mg, 72%). petroleum ether/ethyl acetate = 60:1 as eluent for the column chromatography.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 2.28 (s, 3H), 2.32 (s, 3H), 5.61 (s, 1H), 6.88-6.93 (m, 3H), 7.07-7.19 (m, 5H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 21.1, 21.3, 99.6 (t,  $J$  = 23.0 Hz), 112.9 (t,

$J = 244.0$  Hz), 125.1, 126.5, 128.2, 128.5, 128.7, 129.6, 131.0, 131.4, 137.8, 138.4, 154.7 (t,  $J = 11.0$  Hz), 166.9 (t,  $J = 30.0$  Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta = -110.1$ . HRMS (ESI-TOF). Calcd for  $\text{C}_{18}\text{H}_{16}\text{F}_2\text{NO}$ ,  $[\text{M}+\text{H}]^+$   $m/z$  300.1200, Found 300.1193.

***N*-(3-(4,4-difluoro-5-oxo-1-(*p*-tolyl)-4,5-dihydro-1*H*-pyrrol-2-yl)phenyl)acetamide 3o**

White solid (69.8 mg, 68%). petroleum ether/ethyl acetate = 40:1 as eluent for the column chromatography. mp: 136-138 °C.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta = 2.12$  (s, 3H), 2.29 (s, 3H), 5.60 (s, 1H), 6.75 (d,  $J = 7.2$  Hz, 1H), 6.89 (d,  $J = 8.0$  Hz, 2H), 7.08 (d,  $J = 7.6$  Hz, 2H), 7.15 (t,  $J = 8.0$  Hz, 1H), 7.49 (d,  $J = 8.0$  Hz, 1H), 7.56 (s, 1H), 7.69 (s, 1H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta = 21.0$ , 24.4, 100.2 (t,  $J = 23.0$  Hz), 112.8 (t,  $J = 244.0$  Hz), 118.9, 121.6, 123.5, 126.4, 129.0, 129.4, 129.7, 130.8, 138.0, 138.5, 154.2 (t,  $J = 11.0$  Hz), 167.0 (t,  $J = 30.0$  Hz), 168.6;  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta = -110.2$ . HRMS (ESI-TOF). Calcd for  $\text{C}_{19}\text{H}_{17}\text{F}_2\text{N}_2\text{O}_2$ ,  $[\text{M}+\text{H}]^+$   $m/z$  343.1258, Found 343.1251.

***N*-(3-(4,4-difluoro-5-oxo-1-(*p*-tolyl)-4,5-dihydro-1*H*-pyrrol-2-yl)phenyl)pivalamide 3p**

White solid (78.4 mg, 68%). petroleum ether/ethyl acetate = 40:1 as eluent for the column chromatography. mp: 178-179 °C.  $^1\text{H}$  NMR (400 MHz, DMSO):  $\delta = 1.21$  (s, 9H), 2.27 (s, 3H), 6.07 (s, 1H), 6.70 (d,  $J = 7.6$  Hz, 1H), 7.03 (d,  $J = 8.0$  Hz, 2H), 7.18 (t,  $J = 8.0$  Hz, 3H), 7.67 (d,  $J = 8.0$  Hz, 1H), 7.89 (s, 1H), 9.34 (s, 1H);  $^{13}\text{C}$  NMR (100 MHz, DMSO):  $\delta = 25.8$ , 32.3, 44.4, 104.5 (t,  $J = 23.0$  Hz), 118.5 (t,  $J = 243.0$  Hz), 124.8, 127.2, 127.7, 132.3, 133.6, 133.8, 134.7, 136.0, 142.9, 145.0, 160.0 (t,  $J = 11.0$  Hz), 171.6 (t,  $J = 30.0$  Hz), 181.8;  $^{19}\text{F}$  NMR (376 MHz, DMSO):  $\delta = -108.9$ . HRMS (ESI-TOF). Calcd for  $\text{C}_{22}\text{H}_{23}\text{F}_2\text{N}_2\text{O}_2$ ,  $[\text{M}+\text{H}]^+$   $m/z$  385.1728, Found 385.1729.

***N*-(3-(4,4-difluoro-5-oxo-1-(*p*-tolyl)-4,5-dihydro-1*H*-pyrrol-2-yl)phenyl)benzamide 3q**

White solid (86.1 mg, 71%). petroleum ether/ethyl acetate = 40:1 as eluent for the column chromatography. mp: 170-171 °C.  $^1\text{H}$  NMR (400 MHz, DMSO):  $\delta = 2.28$  (s, 3H), 6.10 (s, 1H), 6.82 (d,

$J = 7.6$  Hz, 1H), 7.06 (d,  $J = 8.0$  Hz, 2H), 7.19 (d,  $J = 8.0$  Hz, 2H), 7.28 (t,  $J = 8.0$  Hz, 1H), 7.55 (t,  $J = 7.6$  Hz, 2H), 7.61 (t,  $J = 7.2$  Hz, 1H), 7.79 (d,  $J = 8.0$  Hz, 1H), 7.94 (d,  $J = 7.2$  Hz, 2H), 8.00 (s, 1H), 10.39 (s, 1H);  $^{13}\text{C}$  NMR (100 MHz, DMSO):  $\delta = 21.0$ , 99.9 (t,  $J = 23.0$  Hz), 113.8 (t,  $J = 243.0$  Hz), 120.1, 122.7, 123.6, 127.5, 128.1, 128.9, 129.2, 129.3, 130.0, 131.3, 132.2, 135.1, 138.1, 140.0, 155.2 (t,  $J = 11.0$  Hz), 166.2, 166.9 (t,  $J = 30.0$  Hz);  $^{19}\text{F}$  NMR (376 MHz, DMSO):  $\delta = -108.8$ . HRMS (ESI-TOF). Calcd for  $\text{C}_{24}\text{H}_{19}\text{F}_2\text{N}_2\text{O}_2$ ,  $[\text{M}+\text{H}]^+$   $m/z$  405.1415, Found 405.1423.

***tert*-butyl (3-(4,4-difluoro-5-oxo-1-(*p*-tolyl)-4,5-dihydro-1*H*-pyrrol-2-yl)phenyl)carbamate 3r**

White solid (76.8 mg, 64%). petroleum ether/ethyl acetate = 40:1 as eluent for the column chromatography. mp: 147-148 °C.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta = 1.51$  (s, 9H), 2.31 (s, 3H), 5.63 (s, 1H), 6.48 (s, 1H), 6.69 (d,  $J = 7.6$  Hz, 1H), 6.92 (d,  $J = 8.0$  Hz, 2H), 7.10 (d,  $J = 8.0$  Hz, 2H), 7.15 (d,  $J = 8.0$  Hz, 1H), 7.29 (d,  $J = 8.0$  Hz, 1H), 7.45 (s, 1H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta = 21.1$ , 28.3, 81.1, 100.1 (t,  $J = 23.0$  Hz), 112.8 (t,  $J = 244.0$  Hz), 117.6, 120.3, 122.4, 126.5, 129.0, 129.7, 130.9, 137.8, 138.8, 152.4, 154.3 (t,  $J = 11.0$  Hz), 166.9 (t,  $J = 30.0$  Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta = -110.2$ . HRMS (ESI-TOF). Calcd for  $\text{C}_{22}\text{H}_{23}\text{F}_2\text{N}_2\text{O}_3$ ,  $[\text{M}+\text{H}]^+$   $m/z$  401.1677, Found 401.1676.

**3,3-difluoro-5-(2-fluorophenyl)-1-(*p*-tolyl)-1*H*-pyrrol-2(3*H*)-one 3s**

Colorless oil (53.6 mg, 59%). petroleum ether/ethyl acetate = 60:1 as eluent for the column chromatography.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta = 2.29$  (s, 3H), 5.70 (s, 1H), 6.91 (d,  $J = 8.0$  Hz, 2H), 7.00 (t,  $J = 9.2$  Hz, 1H), 7.07 (d,  $J = 8.4$  Hz, 2H), 7.11 (d,  $J = 7.6$  Hz, 1H), 7.20 (t,  $J = 6.8$  Hz, 1H), 7.35-7.40 (m, 1H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta = 21.1$ , 102.5 (dt,  $J_1 = 3.0$  Hz,  $J_2 = 23.0$  Hz), 112.5 (t,  $J = 245.0$  Hz), 116.2 (d,  $J = 21.0$  Hz), 117.3 (d,  $J = 14.0$  Hz), 124.3 (d,  $J = 3.0$  Hz), 126.1, 129.5, 130.2 (d,  $J = 2.0$  Hz), 130.7, 132.6 (d,  $J = 8.0$  Hz), 137.9, 149.7 (t,  $J = 11.0$  Hz), 159.5 (d,  $J = 251.0$

Hz), 166.1 (t,  $J = 30.0$  Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta = -111.2, -110.0$ . HRMS (ESI-TOF). Calcd for  $\text{C}_{17}\text{H}_{13}\text{F}_3\text{NO}$ ,  $[\text{M}+\text{H}]^+ m/z$  304,0949, Found 304,0950.

**5-(2-chlorophenyl)-3,3-difluoro-1-(*p*-tolyl)-1*H*-pyrrol-2(3*H*)-one 3t**

Colorless oil (52.6 mg, 55%). petroleum ether/ethyl acetate = 60:1 as eluent for the column chromatography.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta = 2.26$  (s, 3H), 5.64 (d,  $J = 1.2$  Hz, 1H), 6.90 (d,  $J = 6.8$  Hz, 2H), 7.03 (d,  $J = 7.6$  Hz, 2H), 7.24-7.32 (m, 4H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta = 21.0, 102.5$  (t,  $J = 23.0$  Hz), 112.6 (t,  $J = 245.0$  Hz), 126.3, 126.9, 128.5, 129.4, 130.0, 130.4, 130.7, 131.6, 133.1, 137.9, 152.4 (t,  $J = 11.0$  Hz), 165.9 (t,  $J = 30.0$  Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta = -111.7$ . HRMS (ESI-TOF). Calcd for  $\text{C}_{17}\text{H}_{13}\text{ClF}_2\text{NO}$ ,  $[\text{M}+\text{H}]^+ m/z$  320.0654, Found 320.0652.

**3,3-difluoro-5-(thiophen-3-yl)-1-(*p*-tolyl)-1*H*-pyrrol-2(3*H*)-one 3u**

White solid (62.9 mg, 72%). petroleum ether/ethyl acetate = 60:1 as eluent for the column chromatography. mp: 76-78 °C.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta = 2.39$  (s, 3H), 5.66 (s, 1H), 6.95 (d,  $J = 5.2$  Hz, 1H), 6.99 (s, 1H), 7.04 (d,  $J = 8.0$  Hz, 2H), 7.21 (d,  $J = 8.0$  Hz, 2H), 7.28 (d,  $J = 2.4$  Hz, 1H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta = 21.2, 98.0$  (t,  $J = 23.0$  Hz), 113.0 (t,  $J = 244.0$  Hz), 126.4, 126.6, 127.3, 127.5, 129.4, 129.9, 131.1, 138.7, 149.2 (t,  $J = 11.0$  Hz), 166.9 (t,  $J = 30.0$  Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta = -109.6$ . HRMS (ESI-TOF). Calcd for  $\text{C}_{15}\text{H}_{12}\text{F}_2\text{NOS}$ ,  $[\text{M}+\text{H}]^+ m/z$  292.0608, Found 292.0610.

**3,3-difluoro-5-phenyl-1-(*p*-tolyl)-1*H*-pyrrol-2(3*H*)-one 3v**

White solid (76.3 mg, 85%). petroleum ether/ethyl acetate = 60:1 as eluent for the column chromatography. mp: 112-113 °C.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta = 1.91$  (t,  $J = 2.4$  Hz, 3H), 2.27 (s, 3H), 6.84 (d,  $J = 8.4$  Hz, 2H), 7.04 (d,  $J = 8.0$  Hz, 2H), 7.11-7.13 (m, 2H), 7.28-7.36 (m, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta = 7.1, 21.0, 108.5$  (t,  $J = 22.0$  Hz), 113.0 (t,  $J = 246.0$  Hz), 126.4, 128.0,

128.4, 129.1, 129.5, 129.7, 131.0, 137.4, 146.2 (t,  $J = 10.0$  Hz), 166.3 (t,  $J = 30.0$  Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta = -116.8$ . HRMS (ESI-TOF). Calcd for  $\text{C}_{18}\text{H}_{16}\text{F}_2\text{NO}$ ,  $[\text{M}+\text{H}]^+$   $m/z$  300.1200, Found 300.1200.

**3,3-difluoro-5-phenyl-1-(*p*-tolyl)-1*H*-pyrrol-2(3*H*)-one 3w**

Colorless oil (77.0 mg, 82%). petroleum ether/ethyl acetate = 60:1 as eluent for the column chromatography.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta = 1.20$  (t,  $J = 7.6$  Hz, 3H), 2.26 (s, 3H), 2.34 (q,  $J = 7.6$  Hz, 3H), 6.85 (d,  $J = 8.0$  Hz, 2H), 7.03 (d,  $J = 8.0$  Hz, 2H), 7.13 (d,  $J = 6.4$  Hz, 2H), 7.28-7.36 (m, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta = 13.8$ , 16.4, 21.0, 113.8 (t,  $J = 246.0$  Hz), 113.9 (t,  $J = 20.0$  Hz), 126.4, 128.1, 128.4, 128.9, 129.4, 129.7, 130.9, 137.4, 146.6 (t,  $J = 10.0$  Hz), 166.2 (t,  $J = 30.0$  Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta = -114.4$ . HRMS (ESI-TOF). Calcd for  $\text{C}_{19}\text{H}_{18}\text{F}_2\text{NO}$ ,  $[\text{M}+\text{H}]^+$   $m/z$  314.1356, Found 314.1356.

**3,3-difluoro-1,5-diphenyl-1*H*-pyrrol-2(3*H*)-one 4b**

Colorless oil (65.1 mg, 80%). petroleum ether/ethyl acetate = 60:1 as eluent for the column chromatography.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta = 5.66$  (s, 1H), 7.04 (d,  $J = 6.8$  Hz, 2H), 7.18 (d,  $J = 7.2$  Hz, 2H), 7.27-7.33 (m, 5H), 7.38 (t,  $J = 7.6$  Hz, 1H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta = 100.0$  (t,  $J = 23.0$  Hz), 112.8 (t,  $J = 244.0$  Hz), 126.7, 127.8, 127.9, 128.5, 128.7, 129.0, 130.7, 133.5, 154.5 (t,  $J = 11.0$  Hz), 166.7 (t,  $J = 30.0$  Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta = -109.9$ . HRMS (ESI-TOF). Calcd for  $\text{C}_{16}\text{H}_{12}\text{F}_2\text{NO}$ ,  $[\text{M}+\text{H}]^+$   $m/z$  272.0887, Found 272.0888.

**1-(4-chlorophenyl)-3,3-difluoro-5-phenyl-1*H*-pyrrol-2(3*H*)-one 4c**

Colorless oil (59.5 mg, 65%). petroleum ether/ethyl acetate = 60:1 as eluent for the column chromatography.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta = 5.66$  (s, 1H), 6.96 (d,  $J = 8.4$  Hz, 2H), 7.17 (d,  $J = 7.6$  Hz, 2H), 7.27-7.34 (m, 4H), 7.41 (d,  $J = 7.6$  Hz, 1H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta = 100.4$  (t,  $J$

= 24.0 Hz), 112.7 (t,  $J = 244.0$  Hz), 127.8, 127.9, 128.4, 128.7, 129.2, 130.9, 132.1, 133.6, 154.0 (t,  $J = 11.0$  Hz), 166.5 (t,  $J = 30.0$  Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta = -109.7$ . HRMS (ESI-TOF). Calcd for  $\text{C}_{16}\text{H}_{11}\text{ClF}_2\text{NO}$ ,  $[\text{M}+\text{H}]^+$   $m/z$  306.0497, Found 306.0487.

**1-(4-bromophenyl)-3,3-difluoro-5-phenyl-1*H*-pyrrol-2(3*H*)-one 4d**

Colorless oil (71.0 mg, 68%). petroleum ether/ethyl acetate = 60:1 as eluent for the column chromatography.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta = 5.66$  (s, 1H), 6.90 (d,  $J = 8.8$  Hz, 2H), 7.17 (d,  $J = 7.6$  Hz, 2H), 7.32 (d,  $J = 7.6$  Hz, 2H), 7.40-7.45 (m, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta = 100.5$  (t,  $J = 24.0$  Hz), 112.7 (t,  $J = 244.0$  Hz), 121.6, 127.9, 128.1, 128.4, 128.7, 130.9, 132.2, 132.6, 154.0 (t,  $J = 11.0$  Hz), 166.5 (t,  $J = 30.0$  Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta = -109.7$ . HRMS (ESI-TOF). Calcd for  $\text{C}_{16}\text{H}_{11}\text{BrF}_2\text{NO}$ ,  $[\text{M}+\text{H}]^+$   $m/z$  349.9992, Found 349.9987.

**1-(4-ethylphenyl)-3,3-difluoro-5-phenyl-1*H*-pyrrol-2(3*H*)-one 4e**

Colorless oil (75.3 mg, 84%). petroleum ether/ethyl acetate = 60:1 as eluent for the column chromatography.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta = 1.21$  (t,  $J = 7.6$  Hz, 3H), 2.62 (q,  $J = 7.6$  Hz, 2H), 5.63 (s, 1H), 6.94 (d,  $J = 8.4$  Hz, 2H), 7.14 (d,  $J = 8.0$  Hz, 2H), 7.19 (d,  $J = 7.6$  Hz, 2H), 7.29 (t,  $J = 7.6$  Hz, 2H), 7.38 (t,  $J = 7.6$  Hz, 1H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta = 15.2$ , 28.4, 99.8 (t,  $J = 23.0$  Hz), 112.9 (t,  $J = 244.0$  Hz), 126.5, 127.9, 128.4, 128.5, 128.8, 130.6, 131.1, 144.1, 154.6 (t,  $J = 11.0$  Hz), 166.9 (t,  $J = 30.0$  Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta = -110.0$ . HRMS (ESI-TOF). Calcd for  $\text{C}_{18}\text{H}_{16}\text{F}_2\text{NO}$ ,  $[\text{M}+\text{H}]^+$   $m/z$  300.1200, Found 300.1190.

**1-(4-(*tert*-butyl)phenyl)-3,3-difluoro-5-phenyl-1*H*-pyrrol-2(3*H*)-one 4f**

White solid (81.4 mg, 83%). petroleum ether/ethyl acetate = 60:1 as eluent for the column chromatography. mp: 121-123 °C.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta = 1.29$  (s, 9H), 5.65 (s, 1H), 6.96 (d,  $J = 8.4$  Hz, 2H), 7.20 (d,  $J = 7.6$  Hz, 2H), 7.28-7.34 (m, 4H), 7.39 (t,  $J = 7.6$  Hz, 1H);  $^{13}\text{C}$  NMR (100



MHz, CDCl<sub>3</sub>):  $\delta$  = 31.2, 34.6, 99.8 (t,  $J$  = 23.0 Hz), 112.9 (t,  $J$  = 244.0 Hz), 125.9, 126.1, 127.9, 128.4, 128.8, 130.6, 130.8, 151.0, 154.6 (t,  $J$  = 11.0 Hz), 166.9 (t,  $J$  = 30.0 Hz); <sup>19</sup>F NMR (376 MHz, CDCl<sub>3</sub>):  $\delta$  = -110.0. HRMS (ESI-TOF). Calcd for C<sub>20</sub>H<sub>20</sub>F<sub>2</sub>NO, [M+H]<sup>+</sup>  $m/z$  328.1513, Found 328.1518.

**3,3-difluoro-1-(4-methoxyphenyl)-5-phenyl-1*H*-pyrrol-2(3*H*)-one 4g**

White solid (77.7 mg, 86%). petroleum ether/ethyl acetate = 60:1 as eluent for the column chromatography. mp: 142-143 °C. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>):  $\delta$  = 3.78 (s, 3H), 5.62 (s, 1H), 6.82 (d,  $J$  = 8.8 Hz, 2H), 6.96 (d,  $J$  = 8.8 Hz, 2H), 7.18 (d,  $J$  = 7.6 Hz, 2H), 7.29 (t,  $J$  = 7.6 Hz, 2H), 7.38 (t,  $J$  = 7.6 Hz, 1H); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>):  $\delta$  = 55.4, 99.6 (t,  $J$  = 23.0 Hz), 112.8 (t,  $J$  = 244.0 Hz), 114.3, 126.2, 128.0, 128.0, 128.5, 128.7, 130.6, 154.6 (t,  $J$  = 11.0 Hz), 159.0, 167.0 (t,  $J$  = 30.0 Hz); <sup>19</sup>F NMR (376 MHz, CDCl<sub>3</sub>):  $\delta$  = -110.2. HRMS (ESI-TOF). Calcd for C<sub>17</sub>H<sub>14</sub>F<sub>2</sub>NO<sub>2</sub>, [M+H]<sup>+</sup>  $m/z$  302.0993, Found 302.0984.

**3,3-difluoro-5-phenyl-1-(*m*-tolyl)-1*H*-pyrrol-2(3*H*)-one 4h**

Colorless oil (71.9 mg, 84%). petroleum ether/ethyl acetate = 60:1 as eluent for the column chromatography. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>):  $\delta$  = 2.30 (s, 3H), 5.65 (s, 1H), 6.77 (d,  $J$  = 7.6 Hz, 1H), 6.94 (s, 1H), 7.10 (d,  $J$  = 7.2 Hz, 1H), 7.16-7.21 (m, 3H), 7.30 (t,  $J$  = 7.6 Hz, 2H), 7.39 (t,  $J$  = 7.2 Hz, 1H); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>):  $\delta$  = 21.2, 99.8 (t,  $J$  = 23.0 Hz), 112.8 (t,  $J$  = 244.0 Hz), 123.7, 127.3, 127.9, 128.4, 128.7, 128.8, 130.6, 133.5, 139.1, 154.6 (t,  $J$  = 11.0 Hz), 166.8 (t,  $J$  = 30.0 Hz); <sup>19</sup>F NMR (376 MHz, CDCl<sub>3</sub>):  $\delta$  = -110.0. HRMS (ESI-TOF). Calcd for C<sub>17</sub>H<sub>14</sub>F<sub>2</sub>NO, [M+H]<sup>+</sup>  $m/z$  286.1043, Found 286.1033.

**3,3-difluoro-5-phenyl-1-(*o*-tolyl)-1*H*-pyrrol-2(3*H*)-one 4i**

Colorless oil (62.4 mg, 73%). petroleum ether/ethyl acetate = 60:1 as eluent for the column chromatography. <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>):  $\delta$  = 2.19 (s, 3H), 5.66 (d,  $J$  = 2.0 Hz, 1H), 6.95 (d,  $J$  =

8.0 Hz, 1H), 7.14 (d,  $J = 7.2$  Hz, 3H), 7.23-7.27 (m, 4H), 7.35 (t,  $J = 7.6$  Hz, 1H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta = 17.9, 99.3$  (t,  $J = 23.0$  Hz), 112.8 (t,  $J = 244.0$  Hz), 126.8, 127.6, 128.5, 128.5, 128.8, 129.1, 130.7, 131.3, 132.8, 136.3, 154.9 (t,  $J = 11.0$  Hz), 166.7 (t,  $J = 30.0$  Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta = -110.6$ . HRMS (ESI-TOF). Calcd for  $\text{C}_{17}\text{H}_{14}\text{F}_2\text{NO}$ ,  $[\text{M}+\text{H}]^+$   $m/z$  286.1043, Found 286.1045.

**1-(3,4-dimethoxyphenyl)-3,3-difluoro-5-phenyl-1H-pyrrol-2(3H)-one 4j**

Colorless oil (75.0 mg, 83%). petroleum ether/ethyl acetate = 60:1 as eluent for the column chromatography.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta = 3.52$  (s, 3H), 5.59 (s, 1H), 6.80 (d,  $J = 8.4$  Hz, 1H), 6.98 (t,  $J = 7.6$  Hz, 1H), 7.19-7.35 (m, 7H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta = 55.3, 98.5$  (t,  $J = 23.0$  Hz), 112.1, 113.0 (t,  $J = 244.0$  Hz), 120.8, 122.5, 127.1, 128.1, 129.5, 129.6, 130.2, 130.2, 154.9, 155.7 (t,  $J = 11.0$  Hz), 167.2 (t,  $J = 30.0$  Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta = -111.1$  (d,  $J = 304.6$  Hz, 1F), -109.4 (d,  $J = 300.8$  Hz, 1F). Calcd for  $\text{C}_{17}\text{H}_{14}\text{F}_2\text{NO}_2$ ,  $[\text{M}+\text{H}]^+$   $m/z$  302.0993, Found 302.0991.

**1-(3,4-dimethoxyphenyl)-3,3-difluoro-5-phenyl-1H-pyrrol-2(3H)-one 4k**

White solid (88.4 mg, 89%). petroleum ether/ethyl acetate = 60:1 as eluent for the column chromatography. mp: 130-131 °C.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta = 3.68$  (s, 3H), 3.84 (s, 3H), 5.63 (d,  $J = 2.0$  Hz, 1H), 6.51 (d,  $J = 2.4$  Hz, 1H), 6.61 (dd,  $J_1 = 2.4$  Hz,  $J_2 = 8.8$  Hz, 1H), 6.77 (d,  $J = 8.4$  Hz, 1H), 7.19 (t,  $J = 7.2$  Hz, 2H), 7.29 (t,  $J = 7.6$  Hz, 2H), 7.38 (t,  $J = 7.6$  Hz, 1H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta = 55.9, 55.9, 99.5$  (t,  $J = 23.0$  Hz), 110.4, 110.9, 112.8 (t,  $J = 244.0$  Hz), 119.3, 126.3, 127.9, 128.4, 128.8, 130.5, 148.5, 149.0, 154.6 (t,  $J = 11.0$  Hz), 166.8 (t,  $J = 30.0$  Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta = -110.2$ . HRMS (ESI-TOF). Calcd for  $\text{C}_{18}\text{H}_{16}\text{F}_2\text{NO}_3$ ,  $[\text{M}+\text{H}]^+$   $m/z$  332.1098, Found 332.1096.

**1-benzyl-3,3-difluoro-5-phenyl-1H-pyrrol-2(3H)-one 4l**

Colorless oil (58.2 mg, 68%). petroleum ether/ethyl acetate = 70:1 as eluent for the column chromatography.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 4.65 (s, 2H), 5.42 (s, 1H), 6.89-6.92 (m, 2H), 7.20-7.23 (m, 5H), 7.38 (t,  $J$  = 7.2 Hz, 2H), 7.47 (t,  $J$  = 7.2 Hz, 1H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 44.4, 100.0 (t,  $J$  = 23.0 Hz), 113.0 (t,  $J$  = 244.0 Hz), 127.2, 127.7, 127.9, 128.7, 128.7, 129.0, 130.7, 135.8, 155.0 (t,  $J$  = 11.0 Hz), 168.1 (t,  $J$  = 30.0 Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta$  = -112.2. HRMS (ESI-TOF). Calcd for  $\text{C}_{17}\text{H}_{14}\text{F}_2\text{NO}$ ,  $[\text{M}+\text{H}]^+$   $m/z$  286.1043, Found 286.1037.

### 3,3-difluoro-1-phenethyl-5-phenyl-1*H*-pyrrol-2(3*H*)-one 4m

Colorless oil (56.6 mg, 63%). petroleum ether/ethyl acetate = 70:1 as eluent for the column chromatography.  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 2.68 (t,  $J$  = 7.2 Hz, 2H), 3.70 (t,  $J$  = 7.2 Hz, 2H), 5.33 (s, 1H), 6.91-6.93 (m, 2H), 7.20-7.26 (m, 5H), 7.43-7.53 (m, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ):  $\delta$  = 34.3, 42.3, 99.7 (t,  $J$  = 23.0 Hz), 112.8 (t,  $J$  = 244.0 Hz), 126.7, 127.7, 128.6, 128.8, 128.9, 129.0, 130.6, 137.3, 154.9 (t,  $J$  = 11.0 Hz), 167.9 (t,  $J$  = 30.0 Hz);  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ ):  $\delta$  = -112.8. HRMS (ESI-TOF). Calcd for  $\text{C}_{18}\text{H}_{16}\text{F}_2\text{NO}$ ,  $[\text{M}+\text{H}]^+$   $m/z$  300.1200, Found 300.1204.

## ASSOCIATED CONTENT

**Supporting Information.**  $^1\text{H}$  NMR,  $^{13}\text{C}$  NMR and  $^{19}\text{F}$  NMR spectra for compounds **1**, **2**, **3** and **4**.

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### Notes

The authors declare no competing financial interests.

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