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The chemical transformation of β-bromodifluoromethyl β-enaminoketones: Synthesis of difluoromethylene thioether compounds

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Abstract

A series of 2-bromodifluoromethylquinoline derivatives were synthesized by cyclization of β-bromodifluoromethyl β-enaminoketones catalyzed by polyphosphoric acid. Difluoromethylene thioether or ether derivatives of quinoline and but-2-en-1-one were obtained by the subustitute reaction of CF_2Br with thio- and oxygen nucleophiles.

Keywords: β-Bromodifluoromethyl β-enaminoketones; 2-Bromodifluoromethyl-quinoline; Difluoromethylene thioether; *Gem*-difluorinated quinolines; Thiophenols; Cyclization; Nucleophilic substitution

1. Introduction

The synthesis and reactivity of β-enaminoketones represent an active area of investigation in organic chemistry [1]. The special value of these compounds is due to their use as valuable intermediate for the synthesis of several interesting compounds [2]. They can also be used as starting materials for the stereoselective preparation of γ-amino alcohol [3]. β-Enaminoketones can usually be prepared in several ways: the direct condensation of the appropriate amine with symmetrical β-dicarbonyl compounds affording the simplest one [4], while the acylation of lithium imines with ester supplies another way for their regioselective preparation [5].

In recent years, the introduction of the difluoromethylene segment into organic compounds has been proved to be attractive, due to the potential biological properties of such molecules [6]. Bromodifluoroacetate, chlorodifluomethyl ketones and bromodifluoromethyl acetylene are widely used as reagents for introducing a CF_2 moiety into molecules [7]. In search for new CF_2-containing reactive synthetic intermediates [8], we found that β-bromodifluoromethyl β-enaminoketones showed unique properties compared with their non-fluorinated analogues because of the existence of $BrCF_2$ group [9]. Herein, we would like to report the research result of cyclization reaction of β-bromodifluoromethyl β-enaminoketones to the corresponding 2-bromodifluoromethyl quinolines by treatment with PPA and the substitution reaction of bromine in CF_2Br group by thio-nucleophiles to afford difluoromethylene thioether compounds.

Quinolines have been an exceptionally important class of heterocycles [10], and they occur in various natural products, especially in alkaloids. Since the discovery of the antiprotozoal drugmefloquine [11], the development of fluorinated quinolines has received considerable attention in recent years due to their unique biological activity [12]. Although many reports on the synthesis of fluorinated quinolines are presented in the literature [13], however, there are few reports on the synthesis of halodifluoromethyl quinolines [14], and so far as we know, no general method for preparing them was reported. Such halodifluoromethyl quinolines would be a very useful starting material to build a variety of CF_2-containging quinolines as it is anticipated that the carbon–halogen bond should be quite reactive in SET reactions, both chemically and electrochemically.

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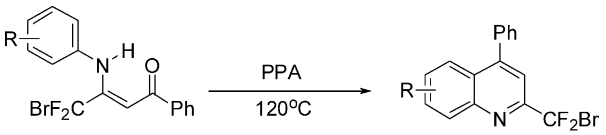
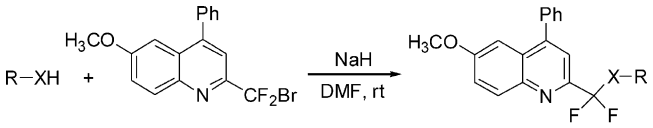
Table 1
Synthesis of 2-bromodifluoromethyl quinolines



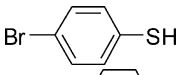
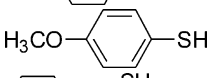
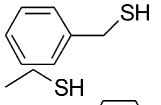
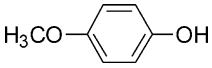
1 2

Entry	*R*	Product	Yield (%)
1	*p*-OCH_3	**2a**	77
2	*o*-Cl	**2b**	78
3	*o*-CH3, *p*-Br	**2c**	83

Table 2
Synthesis of *gem*-difluorinated quinolines



2a 3

Entry	R-XH	Product	Yield (%)
1		**3a**	98
2		**3b**	100
3		**3c**	94
4		**3d**	94
5		**3e**	88
6		**3f**	87

2. Results and discussion

N-Aryl enaminoketones are excellent precursor to quinolines [15]. Cyclization of the β-enaminoketones **1** in polyphosphoric acid at 120 °C for 5 h gave the corresponding 2-bromodifluoromethyl quinoline **2** in moderate to good yield (Table 1).

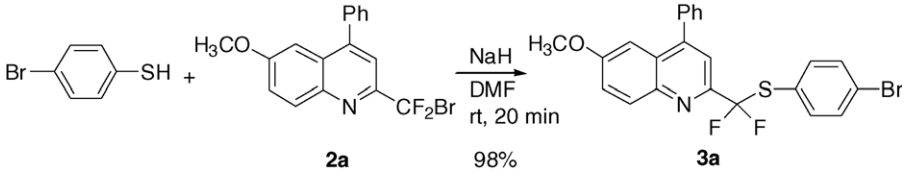
Expected with CF_2Br group in **2** would be reactive with sulfur nucleophiles. Initial experiments with **2a** and sodium 4-bromobenzenthiolate in DMF at room temperature led to the observation that the reaction was rapid and cleanly affording the desired product **3a** in high yield. It was soon discovered that a variety of anions derived from thiols, phenolic compounds and ethyl alcohol were able to successfully react with **2a** giving the desired products in high yield (Scheme 1). The results are shown in Table 2.

The displacement of bromide from the CF_2Br group does not occur by a simple S_N2 mechanism due to the presence of the alpha fluorines. Instead, it proceeds by a $S_{RN}1$ mechanism involving a SET chain process. The inhibition by 1,4-dinitrobenzene is the evidence for the $S_{RN}1$ mechanism.

One can envision that when a thio-nucleophole was added to β-bromodifluoromethyl β-enaminoketones **1**, a SET or halophilic substitution also would occur. We carried out the reaction using a mixture of **1a** and benzenethiol in dried DMF with NaOH as the base at room temperature. The desired substitute product **4a** was obtained in 76% yield together with the reductive product **5** in 16% yield (Scheme 2). Screening a variety of solvents (DMA, THF, CH_3CN and DMSO) to minimize the reduction product only met with failure.

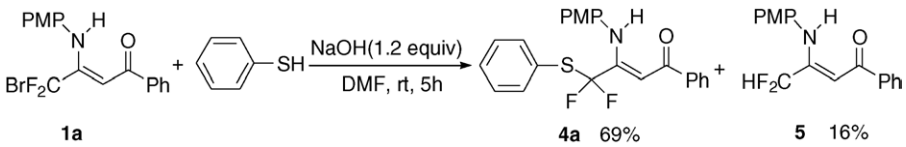
The results of the reaction with other nucleophiles are illustrated in Table 3.

As shown in Table 3, the substitution reaction of **1** with various anions derived from thiophenols proceeded readily with satisfactory yields (Entries 1,2,3,4,5). However, when sodium *p*-methoxylphenolate was used as the nucleophile, a competing reaction occurred. The desired intermolecular product **4e** was isolated in 18% yield (Entry 5) together with the intramolecular product[9] in 35% yield in CH_3CN after 24 h at room temperature, while the product **3a** was obtained as the sole product when the reaction was carried out in dried DMF. The reaction of **1a** with the anions from ethanethiol or α-toluenethiol gave the sole reductive product **5**, this might be due to the low nucleophility of the thio-reagents. The fact that 1,4-dinitrobenzene could not inhibit this transformation indicated that halophilic process was involved.



2a 98% 3a

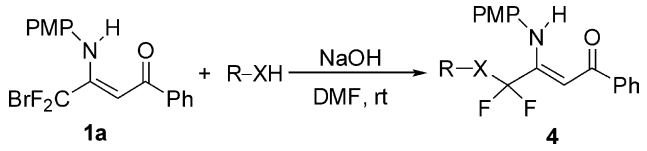
Scheme 1.

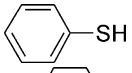
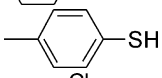
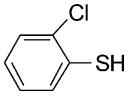
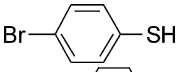
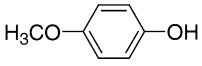


1a 4a 69% 5 16%

Scheme 2.

Table 3
The reaction of β-bromodifluoromethyl β-enaminoketones **1** with thio-nucleophiles



Entry	R-XH	Sovlent	Product	Yield(%)
1		DMF	**4a**	69
2		DMF	**4b**	71
3		DMF	**4c**	76
4		DMF	**4d**	78
5		CH_3CN	**4e**	18

3. Conclusion

In conclusion, we have developed a general method for the synthesis of 2-bromodifluoromethyl quinolines by the cyclization of the β-bromodifluoromethyl enaminoketones catalyzed by PPA. The CF_2Br group in quinolines and β-bromodifluoromethyl β-enaminoketones **1** can be converted to the corresponding difluoromethylene thioether or ether compounds by the substitution reaction with thiopehnol and phenol anions.

4. Experimental

Unless otherwise noted, solvents and reagents were commercial available and used as received. ^{1}H NMR spectra were recorded on a Brucker AM-300 (300 MHz) spectrometer with Me_4Si as internal standard. ^{19}F NMR spectra were taken on Brucher AM-300 (282 MHz) spectrometer with $CFCl_3$ as external standard, downfield shifts being designed as positive. The ^{13}C NMR spectra were measured at Brucker AM-300 (75 MHz) spectrometer with all protons decoupled, and the chemical shifts are reported in ppm downfield of $SiMe_4$. Mass spectra were taken on a HP 5989a spectrometer, and accurate mass measurements were performed on Finnigan MAT instrument, while elemental analysis were performed by this institute.

*4.1. Preparation of 2-bromodifluoromethyl quinolines **2***

General procedure: A mixture of β-bromodifluoromethyl enaminoketone **1a** (191 mg, 0.5 mmol), polyphosphoric acid (4 ml) was stirred at 120 °C for 3 h. The cooled mixture was then neutralized with aqueous 5 N NaOH with ice bath cooling. The mixture was extracted with ethyl ether (3 × 15 ml). The combined organic layers were dried over Mg_2SO_4. Filtration and subsequent concentration and column chromatography (3% ethyl acetate in petroleum) gave **2a** (140 mg, 77%).

*4.2. 2-(Bromodifluoromethyl)-6-methoxyl-4-phenyl-quinoline (**2a**)*

Yield: 77%; white solid, mp 97–98 °C; ^{1}H NMR (300 Hz, $CDCl_3$) δ 8.18 (d, J = 9.60 Hz, 1H), 7.62 (s, 1H), 7.53–7.57 (m, 5H), 7.25 (dd, J^1 = 9.60, 2.70 Hz, 1H), 7.23 (d, J = 2.70 Hz, 1H), 3.82 (s, 3H); ^{19}F NMR (282 Hz, $CDCl_3$) δ−50.17 (s); IR (film, cm^{-1}) 2964, 1620, 1509, 1474, 1222, 1085; *m/z* (EI) 363 (6.16), 284 (100.00), 268 (6.38), 234 (1.73), 75 (1.87), 51 (1.80); Anal. Calcd for $C_{17}H_{12}BrF_2NO$: C, 56.07; H, 3.32; N, 3.85; Found C, 56.27; H, 3.62; N, 3.81.

*4.3. 2-(Bromodifluoromethyl) -8-chloro-4-phenyl-quinoline (**2b**)*

Yield: 78%; yellow solid, mp 94–96 °C; ^{1}H NMR (300 Hz, $CDCl_3$) δ 7.90–7.96 (m, 2H), 7.42 (s, 1H), 7.51–7.59 (m, 6H); ^{19}F NMR(282 Hz, $CDCl_3$) δ–50.99 (s); IR (film, cm^{-1}) 1760, 1607, 1556, 1489, 1228, 1097, 823; *m/z* (EI) 369 (11.48), 288 (100.00), 238 (19.60), 203 (32.18); HRMS (EI): M^+, found 366.9580650. $C_{16}H_9BrClF_2N$ requires 366.95749.

*4.4. 6-Bromo-2-(bromodifluoromethyl)-8-methyl-4-phenyl-quinoline (**2c**)*

Yield: 83%; white solid, mp 97–99 °C; ^{1}H NMR (300 Hz, $CDCl_3$) δ 7.94 (d, J = 1.80 Hz, 1H), 7.77–7.78 (m, 1H), 7.67 (s, 1H), 7.56–7.59 (m, 3H), 7.49–7.52 (m, 2H), 2.88 (s, 3H); ^{19}F NMR (282 Hz, $CDCl_3$) δ−50.37 (s); IR (film, cm^{-1}) 2964, 1620, 1509, 1474, 1222, 1085, 869, 761; *m/z* (EI) 427 (32.81), 346 (100.00), 298 (5.40), 217 (26.62), 75 (2.96); Anal. Calcd

for $C_{17}H_{11}Br_2F_2N$: C, 47.81; H, 2.60; N, 3.28; Found C, 48.05; H, 2.63; N, 3.18.

4.5. Preparation of gem-difluorinated quinolines 3

Sodium *p*-bromobenzenethiolate (46 mg, 0.22 mmol) in DMF (1 ml) was added to 2-bromodifluoromethyl quinoline **2a** at room temperature. Half saturated NaCl (5 ml) was added after 20 min. The mixture was extracted with ethyl ether (2 × 10 ml). The combined organic layers were dried over Mg_2SO_4. Filtration and subsequent concentration and column chromatography (10% ethyl acetate in petroleum) gave **3a** (87 mg, 98%).

4.6. 2-[(4-Bromophenylsulfanyl)-difluoromethyl]-6-methoxyl-4-phenyl-quinoline (3a)

Yield: 98%; white solid, mp 150–151 °C; ^{1}H NMR (300 Hz, $CDCl_3$) δ 8.18 (d, J = 9.00 Hz, 1H), 7.43–7.58 (m, 11H), 7.21 (d, = 3.00 Hz, 1H), 3.81 (s, 3H); ^{19}F NMR (282 Hz, $CDCl_3$) δ−73.03 (s); IR (film, cm^{-1}) 3053, 2833, 1622, 1587, 1492, 1474, 1220, 1043, 954; *m/z* (EI) 471 (1.24), 284 (100.00), 268 (4.00), 252 (1.64), 241 (5.24), 191 (6.81); Anal. Calcd for $C_{23}H_{16}BrF_2NOS$: C, 58.48; H, 3.44; N, 2.97; Found C, 58.57; H, 3.45; N, 2.84.

4.7. 2- (4-Methoxylphenylsulfanyl) difluoromethyl-6-methoxyl-4-phenylquinoline (3b)

Yield: 100%; white solid, mp 106–107 °C; ^{1}H NMR (300 Hz, $CDCl_3$) δ 8.22 (d, J = 9.00 Hz, 1H), 7.62 (d, J = 9.00 Hz, 2H), 7.48–7.54 (m, 6H), 7.45 (dd, J = 9.30, 2.70 Hz, 1H), 7.20 (d, J = 2.70 Hz, 1H), 6.91 (dd, J = 9.30, 1.80 Hz, 2H), 3.83 (s, 3H), 3.81 (s, 3H); ^{19}F NMR (282 Hz, $CDCl_3$) δ−74.89 (s); IR (film, cm^{-1}) 3010, 2944, 1622, 1589, 1494, 1474, 1251, 1221, 1069, 954; *m/z* (EI) 423 (6.55), 284 (100.00), 268 (4.21), 268 (3.83), 252 (1.73), 241 (5.40), 191 (8.33); Anal. Calcd for $C_{24}H_{19}F_2NO_2S$: C, 68.07; H, 4.52; N, 3.31; Found C, 68.05; H, 4.78; N, 3.23.

4.8. 2-Benzylsulfanyldifluoromethyl-6-methoxyl-4-phenyl-quinoline (3c)

Yield: 94%, oil; ^{1}H NMR (300 Hz, $CDCl_3$) 8.18 (d, J = 9.60 Hz, 1H), 7.64 (s, 1H), 7.52–7.56 (m, 5H), 7.26–7.46 (m, 6H), 7.21 (d, J = 2.70 Hz, 1H), 4.29 (s, 2H), 3.81 (s, 3H); ^{19}F NMR (282 Hz, $CDCl_3$) δ−74.12 (s); IR (neat, cm^{-1}) 3061, 2936, 2832, 1621, 1589, 1494, 1474, 1268, 1079; *m/z* (EI) 408 (6.95), 316 (0.80), 285 (100.00), 270 (9.11), 253 (2.69), 234 (4.31); Anal. Calcd for $C_{24}H_{19}BrF_2NOS$: C, 70.74; H, 4.70; N, 3.44; Found C, 70.67; H, 4.84; N, 3.30.

4.9. 2-Ethylsulfanyldifluoromethyl-6-methoxyl-4-phenyl-quinoline (3d)

Yield: 94%; white solid, mp 102–103 °C; ^{1}H NMR (300 Hz, $CDCl_3$) δ 8.20 (d, J = 9.30 Hz, 1H), 7.63 (s, 1H), 7.52–7.55 (m, 5H), 7.43 (dd, J = 9.30, 3.00 Hz, 1H), 7.20 (d, J = 2.70 Hz, 1H), 3.79 (s, 3H), 3.05 (q, J = 7.50 Hz, 2H), 1.42 (t, J = 7.50 Hz, 3H); ^{19}F NMR (282 Hz, $CDCl_3$) δ−74.36 (s); IR (film, cm^{-1}) 3049, 2974, 1624, 1587, 1494, 1475, 1266, 1222, 1086; *m/z* (EI) 326 (0.30), 285 (100.00), 270 (9.25), 253 (3.14), 241 (4.91), 191 (14.34); Anal. Calcd for $C_{19}H_{17}F_2NOS$: C, 66.07; H, 4.96; N, 4.06; Found C, 66.04; H, 4.93; N, 4.01.

4.10. 2-[(4-Methoxylphenoxy)difluoromethyl]-6-methoxy-4-phenyl-quinoline (3e)

Yield: 88%; white solid, mp 110–112 °C; ^{1}H NMR (300 Hz, $CDCl_3$) δ 8.31 (d, J = 9.30 Hz, 1H), 7.61 (s, 1H), 7.56 (s, 5H), 7.47 (dd, J = 9.30, 2.70 Hz, 1H), 7.30 (d, J = 9.00 Hz, 2H), 7.23 (d, J = 2.70 Hz, 1H), 6.89 (d, J = 9.00 Hz, 2H), 3.82 (s, 3H), 3.81 (s, 3H); ^{19}F NMR (282 Hz, $CDCl_3$) δ−70.14 (s); IR (film, cm^{-1}) 3004, 2960, 2833, 1620, 1594, 1505, 1475, 1265, 1168; *m/z* (EI) 407 (13.80), 388 (0.56), 341 (0.85), 284 (100.00), 252 (1.88); Anal. Calcd. for $C_{24}H_{19}F_2NO_3$: C, 70.75; H, 4.70; N, 3.44; Found C, 70.77; H, 4.71; N, 3.42.

4.11. 2-Ethoxydifluoromethyl-6-methoxy-4-phenyl-quinoline (3f)

Yield: 87%; white solid, mp 99–100 °C; ^{1}H NMR (300 Hz, $CDCl_3$) δ 8.23 (d, J = 9.30 Hz, 1H), 7.65 (s, 1H), 7.54–7.56 (m, 5H), 7.43 (dd, J = 9.30, 2.70 Hz, 1H), 7.20 (d, J = 2.70 Hz, 1H), 4.21 (q, J = 7.50 Hz, 2H), 3.80 (s, 3H), 1.41 (t, J = 7.50 Hz, 3H); ^{19}F NMR (282 Hz, $CDCl_3$) δ−73.82 (s); IR (film, cm^{-1}) 3055, 2984, 2836, 1624, 1591, 1494, 1283, 1172, 1108; *m/z* (EI) 329 (0.30), 285 (100.00), 270 (25.34), 242 (5.44), 190 (14.68), 126 (3.60); Anal. Calcd for $C_{19}H_{17}F_2NO_2$: C, 69.29; H, 5.20; N, 4.25; Found C, 69.58; H, 5.10; N, 4.19.

4.12. Preparation of γ, γ-difluorinated β-enaminoketones 4

A mixture of β-bromodifluoromethyl enaminoketone **1a** (191 mg, 0.5 mmol), benzenethiol (77 mg, 0.7 mmol) and NaOH (32 mg, 0.8 mmol) in dried DMF (2 ml) was stirred at room temperature for 5 h. Then saturated NaCl (5 ml) was added. The mixture was extracted with ethyl ether (2 × 10 ml). The combined organic layers were dried over Mg_2SO_4. Filtration and subsequent concentration and column chromatography (10% ethyl acetate in petroleum) gave **4a** (142 mg, 69%) and **5** (24 mg, 16%).

4.13. 4,4-Difluoro-4-phenylsulfanyl-3-(4-methoxylphenylamino)-1-phenylbut-2-en-1-one (4a)

Yield: 69%; yellow solid, mp 102–103 °C; ^{1}H NMR (300 Hz, $CDCl_3$) δ 12.41 (s, 1H), 7.83–7.86 (m, 2H), 7.28–7.51 (m, 10H), 6.91 (d, J = 9.00 Hz, 2H), 6.16 (s, 1H), 3.85 (s, 3H); ^{19}F NMR (282 Hz, $CDCl_3$) δ−72.45 (s); IR (film, cm^{-1}) 2996, 2836, 1609, 1584, 1512, 1247, 1088, 964; *m/z* (EI) 411 (13.36), 282 (3.29), 252 (59.62), 105 (97.25), 77 (100.00);

Anal. Calcd for $C_{23}H_{19}F_2NO_2S$: C, 67.14; H, 4.65; N, 3.40; Found C, 67.01; H, 4.63; N, 3.32.

*4.14. 4,4-Difluoro-4-(4-methylphenylsulfanyl)-3-(4-methoxyphenylamino)-1-phenylbut-2-en-1-one (**4b**)*

Yield: 71%; yellow solid, mp 98–100 °C; ^{1}H NMR (300 Hz, $CDCl_3$) δ 12.41 (s, 1H), 7.882–7.85 (m, 2H), 7.28–7.51 (m, 7H), 7.15 (d, J = 8.40 Hz, 2H), 6.90 (d, J = 8.40 Hz, 2H), 6.11 (s, 1H), 3.85 (s, 3H), 2.33 (s, 3H); ^{19}F NMR (282 Hz, $CDCl_3$) δ−72.97 (s); ^{13}C NMR δ 190.56, 158.42, 154.93 (t, J = 24.5 Hz), 140.94, 139.29, 136.71, 131.78, 131.15, 129.97, 128.52, 128.43, 127.37, 123.89 (t, J = 283.7 Hz), 122.41, 113.74, 91.77 (m), 55.47, 21.27; IR (film, cm^{-1}) 3007, 2971, 2839, 1608, 1561, 1511, 1278, 1089, 963; *m/z* (EI) 425 (21.75), 302 (3.76), 282 (6.87), 270 (3.42), 252 (94.56), 105 (100.00); HRMS (MALDI): $M^+ + H^+$, found 426.1309. $C_{24}H_{22}F_2NO_2S^+$ requires 426.13393.

*4.15. 4-(2-Chlorophenylsulfanyl)-4,4-difluoro-3-(4-methoxy-phenylamino)-1-phenylbut-2-en-1-one (**4c**)*

Yield: 76%; yellow solid, mp 71–72 °C; ^{1}H NMR (300 Hz, $CDCl_3$) δ 12.42 (s, 1H), 7.86 (dd, J = 8.40, 1.20 Hz, 2H), 7.60 (dd, J = 7.80, 1.20 Hz, 1H), 7.42–7.52 (m, 4H), 7.25–7.32 (m, 3H), 7.25–7.28 (m, 1H), 6.90 (d, J = 9.00 Hz, 2H), 6.18 (s, 1H), 3.84 (s, 3H); ^{19}F NMR (282 Hz, $CDCl_3$) δ−72.24 (s); IR (film, cm^{-1}) 3011, 2968, 2835, 1609, 1585, 1562, 1514, 1275, 1120; *m/z* (EI) 445 (10.45), 302 (2.50), 282 (2.80), 252 (61.08), 105 (71.71); Anal. Calcd for $C_{23}H_{18}ClF_2NO_2S$: C, 61.95; H, 4.07; N, 3.14; Found C, 61.81; H, 3.92; N, 3.10.

*4.16. 4-(4-Bromophenylsulfanyl)-4,4-difluoro-3-(4-methoxy-phenylamino)-1-phenylbut-2-en-1-one (**4d**)*

Yield: 78%; yellow solid, mp 105–107 °C; ^{1}H NMR (300 Hz, $CDCl_3$) δ 12.38 (s, 1H), 7.83–7.86 (m, 2H), 7.46–7.52 (m, 5H), 7.29–7.34 (m, 4H), 6.90 (d, J = 9.00 Hz, 2H), 6.15 (s, 1H), 3.85 (s, 3H); ^{19}F NMR (282 Hz, $CDCl_3$) δ−72.28 (s); IR (film, cm^{-1}) 2954, 2835, 1609, 1583, 1507, 1471, 1273, 1243; *m/z* (EI) 489 (12.08), 302 (4.81), 282 (5.85), 252 (100.00), 105 (84.68); Anal. Calcd for $C_{23}H_{18}BrF_2NO_2S$: C, 56.34; H, 3.70; N, 2.86; Found C, 56.59; H, 3.69; N, 2.76.

*4.17. 4,4-Difluoro-4-(4-methoxy-phenoxy)-3-(4-methoxyphenylamino)-1-phenylbut-2-en-1-one (**4e**)*

Yield: 18%; yellow solid, mp 66–67 °C; ^{1}H NMR (300 Hz, $CDCl_3$) δ 12.40 (s, 1H), 7.96–7.99 (m, 2H), 7.47–7.53 (m, 3H), 7.26–7.29 (m, 3H), 6.89 (d, J = 8.70 Hz, 2H), 6.72–6.79 (m, 4H), 6.50 (s, 1H), 3.83 (s, 3H), 3.76 (s, 3H); ^{19}F NMR (282 Hz, $CDCl_3$) δ−67.08 (s); IR (film, cm^{-1}) 3010, 2838, 1625, 1593, 1517, 1503, 1321, 1295, 1151, 1035; *m/z* (EI) 425 (6.67), 405 (4.81), 300 (6.76), 252 (25.08), 105 (100.00); HRMS (EI): M^+, found 426.1502. $C_{24}H_{22}F_2NO_4$ requires 426.15114.

*4.18. 4,4-Difluoro-3-(4-methoxyphenylamino)-1-phenylbut-2-en-1-one (**5**)*

Yield: 16%; yellow solid, mp 59–60 °C; ^{1}H NMR (300 Hz, $CDCl_3$) δ 12.29 (s, 1H), 7.98 (dd, J = 8.10, 1.50 Hz, 2H), 7.48–7.52 (m, 3H), 7.19 (d, J = 8.70 Hz, 2H), 6.93 (d, J = 8.70 Hz, 2H), 6.37 (s, 1H), 6.26 (t, J = 53.0 Hz, 1H), 3.85 (s, 3H); ^{19}F NMR (282 Hz, $CDCl_3$) δ−118.00 (d, J = 53.0 Hz, 2F); IR (film, cm^{-1}) 3066, 2910, 2837, 1615, 1585, 1558, 1507, 1380, 1276, 1246, 1116; *m/z* (EI) 303 (100.00), 252 (89.24), 198 (12.34), 174 (6.80), 146 (9.61); Anal. Calcd for $C_{17}H_{15}F_2NO_2$: C, 67.32; H, 4.98; N, 4.62; Found C, 67.28; H, 5.00; N, 4.50.

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