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New approaches to β-trifluoromethylated enone derivatives

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Abstract

β-Trifluoromethylated enaminones **1** were prepared stereospecifically or high stercoselectively in 31–92% yields from the reaction of Weinreb amides with trifluoropropynyl lithium, followed by quenching with H_2O in the presence of amine derivatives. β-Trifluoromethylated enaminone **1a** was reacted with aryl or alkynyl Grignard reagents to give Michael addition products **5** at 0 °C, whereas addition–elimination adducts, β-aryl (or alkynyl)-β-trifluoromethylated enones **6**, were obtained stereospecifically in 50–92% yields after stirring at room temperature for several hours.

Keywords: Trifluoropropynyl lithium; Weinreb amides; β-Trifluoromethylated enaminones; β-Trifluoromethylated enones

1. Introduction

Trifluoromethylated building blocks have been receiving increasing attention because of their potential to give new synthetic routes to a variety of trifluoromethylated compounds, some of which exhibit unique biological or physical properties in the areas of agrochemicals, pharmaceuticals and material science [1,2]. In the course of our synthetic studies on trifluoromethylated building blocks, we needed a facile and convenient synthetic route to β-trifluoromethylated enones, which are quite useful synthetic intermediates for the preparation of trifluoromethylated heterocyclic compounds [3–5]. However, the only several methods for the preparation of β-trifluoromethylated enones have been reported in the previous literatures. β-Trifluoromethylated enones having no substituent at α- or β-position were prepared from the reaction of methyl ketones with α-trifluoromethyl iminium trifluoroacetates [6]. Dolbier carried out the reactions of 1,1-bis(dimethylamino)-2,2,2-trifluoroethane with silyl enol ethers or ketones having α-hydrogen to afford β-trifluoromethylated enones having no substituent at α- or β-position [7]. The reactions of enol vinyl ethers with 1-bromo-1-chloro-2,2,2-trifluoroethane in the presence of sodium dithionite and sodium bicarbonate, followed by quenching with H_2O also provided β-trifluoromethylated enones having no substituent at α- or β-position [8].

β-Trifluoromethyl-β-methylated enones were also synthesized via Wittig reaction. Triphenylphosphoranyliden-2-propanone was reacted with trifluoromethylated ketones to give β-trifluoromethyl-β-methylated enones [9]. A couple of methods for the preparation of β-chloro-β-trifluoromethylated enones has been reported in the previous literatures. Eguchi prepared β-chloro-β-trifluoromethylated enones from the reaction of silyl enol ethers with CF_3CCl_3 in the presence of CuCl, followed by dehydrochlorination with Et_3N or DBN [10]. β-Chloro-β-trifluoromethylated enones were also prepared from the reaction of trifluoromethylated 1,3-diketone with Vilsmier reagent formed from DMF and oxalyl chloride [4,11]. Recently, several researchers showed β-trifluoromethyl enaminones were quite useful synthetic intermediate to give a variety of heterocyclic compounds via amine exchange reaction with nucleophiles [12–15]. β-Trifluoromethyl enaminones were prepared from the reaction of methyl ketones with trifluoroacetonitrile in the presence of *N*-ethylanilino magnesium bromide [16]. The treatment of trifluoromethylated β-diketones with ammonium acetate and ammonium bicarbonate also resulted in the formation of

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β-trifluoromethyl enaminones in a mixture of isomeric aminoenones [17]. Huang also synthesized β-trifluoromethyl enaminones from the reaction of *N*-aryl trifluoromethyl imidoyl iodides with methyl ketones in the presence of sodium hydride [12]. All of the previous methods for the preparation of β-trifluoromethylated enones had several drawbacks such as a lack of generality, low yield preparation and tedious procedure. In the present paper, we would like to describe a novel and efficient method for the preparation of several types of β-trifluoromethylated enones, such as β-trifluoromethyl enaminones [18], β-aryl-β-trifluoromethylated enones and β-alkynyl-β-trifluoromethylated enones from the same starting material.

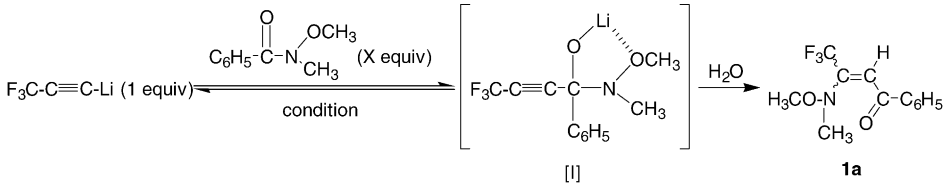
2. Results and discussion

2.1. Preparation of β-trifluoromethylated enaminones *1*

It is well known that Weinreb amides are quite useful reagents to control nucleophilic addition–elimination reaction of amine functionality by organometallic reagents [19–22]. Therefore, the reaction of trifluoropropynyl lithium with Weinreb amide may provide a nice method for the preparation of β-trifluoromethylated ynone, which cannot be easily prepared via previous methods. We first examine the influence of reaction temperature on the reaction to optimize reaction condition. The reaction of trifluoropropynyl lithium (1.0 equiv.) formed from the reaction of trifluoropropyne (1.1 equiv.) with *n*-BuLi (1.1 equiv.) was reacted with *N*-methoxy-*N*-methylbenzamide (1.0 equiv.) at −78 °C followed by warming to −30 °C and quenching with H_2O afforded an *E*- and *Z*-isomeric mixture of β-trifluoromethyl enaminone **1a** (*E*/*Z* = 13/87) in 62% yield based on 27% conversion of *N*-methoxy-*N*-methylbenzamide instead of β-trifluoromethylated ynone. When trifluoropropynyl lithium was reacted with *N*-methoxy-*N*-methylbenzamide at −78 °C followed by warming to 0 °C and quenching with H_2O, an *E*- and *Z*-isomeric mixture of **1a** was obtained in 64% yield based on 60% conversion of *N*-methoxy-*N*-methylbenzamide. It seems likely that the high reaction temperature condition makes high conversion of *N*-methoxy-*N*-methylbenzamide. Thus, the same reaction was carried out at −78 °C followed by warming to room temperature and quenching with H_2O to make a high conversion of *N*-methoxy-*N*-methylbenzamide. Unexpectively, only *N*-methoxy-*N*-methylbenzamide was recovered in 98% yield and the desired product **1a** was not obtained. The reaction temperature in this reaction is quite important to control the reaction. These experimental results indicate that low reaction temperature is not effective for the addition of trifluoropropynyl lithium toward amide functionality and also high reaction temperature cause backward process of addition intermediate [I]. To consume *N*-methoxy-*N*-methylbenzamide completely, an excess of trifluoropropynyl lithium (2.0 equiv.) was used under the optimized reaction temperature. The treatment of trifluoropropynyl lithium (2.0 equiv.) with *N*-methoxy-*N*-methylbenzamide (1.0 equiv.) at −78 °C followed by warming to 0 °C and quenching with H_2O resulted in the formation of desired product **1a** in 84% yield based on 98% conversion of *N*-methoxy-*N*-methylbenzamide. The results of these reactions are summarized in Scheme 1 and Table 1. The same reaction was performed between trifluoropropynyl lithium (2.0 equiv.) and *N*,*N*-dimethylbenzamide (1.0 equiv.) instead of *N*-methoxy-*N*-methylbenzamide under the same reaction condition, but no desired product **1a** was obtained and *N*,*N*-dimethylbenzamide was recovered quantitatively (Scheme 2). This result implies that *N*-methoxy group in Weinreb benzamide plays an important role to give lithium complex in intermediate [I]. *N*-Methoxy-*N*-methylacetamide was also reacted with trifluoropropynyl lithium under the same reaction condition to give the corresponding β-trifluoromethyl enaminone **1b** (*E*/*Z* = 14/86) in 60% yield.

A plausible mechanism for the formation of **1a** seems likely that the reaction of trifluoropropynyl lithium with Weinreb benzamide afforded intermediate [I] which was reacted with H_2O to give ynone intermediate [II]. Then, intermediate [II] was rapidly reacted with *N*-methoxy-*N*-methylamine formed from the reaction to give **1a** (Scheme 3). To prove the formation of intermediate [I], a trapping reaction with trimethylsilyl chloride was carried and silyl ether derivative **2** was obtained in 80% yield. The assignment of *E* and *Z* isomers of **1a** was made by the comparison of chemical shift in ^{19}F NMR spectroscopy. It has been well established that ^{19}F NMR signal in the *Z*-isomer of CF_3-trisubstituted vinylic compounds is more shielded than that in the *E*-isomer [23]. Therefore, two singlet peaks at −65.97 and 61.84 ppm in the ^{19}F NMR spectrum are due to a CF_3 group in the *Z* and *E* isomers of **1a**, respectively. Determination of the configuration of **1a** was also supported by NOE observation (1.2%) between *N*-methyl group and the vinyl proton of (*E*)-**1a**, whereas no NOE observation was detected in (*Z*)-**1a**.

Since arylamino group of enaminone was exchanged with hydrazine or amidine to give the corresponding pyrazole or



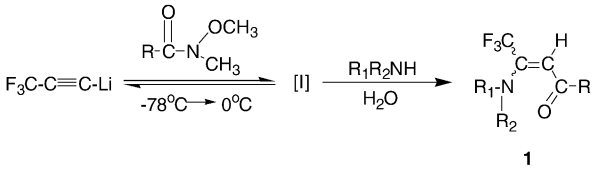
Scheme 1.

Table 1
Reaction of trifluoropropynyl lithium with *N*-methoxy-*N*-methylbenzamide

Entry	*X* (equiv.)	Condition	Recovered amide (%)	Yield (%)[a,b]
1	1	−78 °C → −30 °C	73	62
2	1	−78 °C → −10 °C	64	63
3	1	−78 °C → 0 °C	40	64
4	1	−78 °C → 10 °C	63	63
5	1	−78 °C → rt	98	0
6	0.5	−78 °C → 0 °C	<2	84

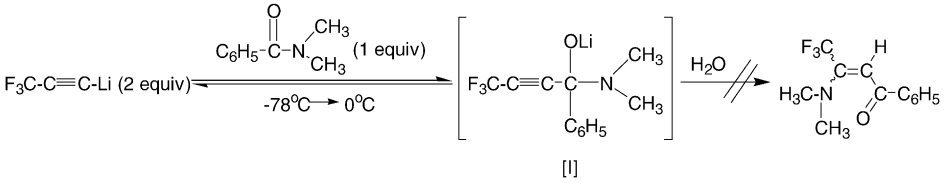
[a] Isolated yields based on the conversion of amide.
[b] An isomeric mixture of product (*E*/*Z* = 13/87) was obtained.

pyrimidine [12], **1a** was examined to figure out whether *N*-methoxy-*N*-methyl group of **1a** can be exchanged with other amines or not. The treatment of **1a** with piperidine at room temperature for 3 h in THF resulted in the formation of piperidine-substituted enaminone **1c** (only *Z*-isomer) in 97% yield stereospecifically. The similar reactions of **1a** with dimethylamine, benzylamine, *n*-butylamine, also afforded the corresponding enaminones **1d**, **1g** and **1k** in 70–99% yields. However, when **1a** was treated with bulky amines such as diisopropylamine or 2,6-dimethylpiperidine, the reaction did not proceed at all and **1a** was recovered in quantitative yield. The reaction of **1a** with aniline under the same reaction condition provided a trace amount of desire product **1h**. These results indicate that steric effect is quite important in this exchange reaction. The formation of intermediate [II] and successful exchange reaction of *N*-methoxy-*N*-methyl group of **1a** with amines stimulated us to carry out the reaction of intermediate [I] with H_2O in the presence of a variety of amines. Therefore, treatment of intermediate [I] with H_2O in the presence of the same equivalence of piperidine at 0 °C and then stirring at room temperature for 1 h resulted in the formation of **1c** (*Z*-isomer only) in 92% yield. The similar reactions of intermediate [I] with *N*,*N*-dimethylamine, *N*-benzyl-*N*-methylamine, morpholine and benzylamine afforded the only *Z*-isomer of corresponding enaminones **1d**, **1e**, **1f** and **1g** in 77–89% yields (Scheme 4 and Table 2). The reaction of intermediate [I] with H_2O in the presence of aniline provided the corresponding enaminone **1h** (*Z*-isomer only) in 31% yield along with **1a** (*E*/*Z* = 13/97, 50% yield). It is postulated that the formation of **1a** could be due to the low reactivity of aniline toward intermediate [II] as compare with *N*-methoxy-*N*-methylamine. The stereospecificity for the formation of **1c–h** can be rationalized by hydrogen bond interaction between hydrogen of amine group and oxygen of carbonyl group after addition of amine group to ynone intermediate [II].

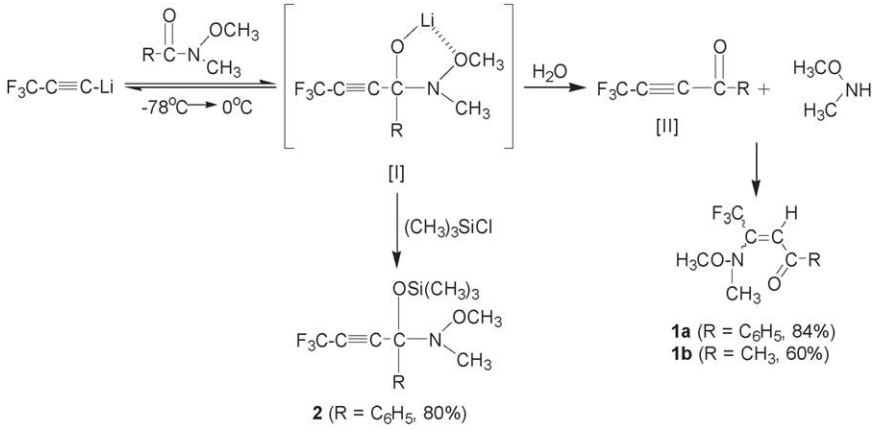


Scheme 4.

Similarly, an isomeric mixture of enaminones **1i** (*E*/*Z* = 25/75) and **1j** (*E*/*Z* = 17/83) were obtained in 55% and 74% yields from the reaction of intermediate [I] with H_2O in



Scheme 2.



Scheme 3.

Table 2
Preparation of a variety of β-trifluoromethyl enaminones

Compound no.	R	R_1R_2NH	Yield (%)[a]	*E*/*Z*[b]
1c	C_6H_5	$-(CH_2)_5NH-$	92	0/100
1d	C_6H_5	$(CH_3)_2NH$	77	0/100
1e	C_6H_5	$Bn(CH_3)NH$	89	0/100
1f	C_6H_5	$-(CH_2)_2O(CH_2)_2NH-$	82	0/100
1g	C_6H_5	$BnNH_2$	83	0/100
1h	C_6H_5	$C_6H_5NH_2$	31 (50[c])	0/100
1i	C_6H_5	$[(CH_3)_2CH]_2NH$	55 (20[d])	25/75
1j	C_6H_5	$-CH(CH_3)(CH_2)_3CH(CH_3)NH-$	74 (5[e])	17/83

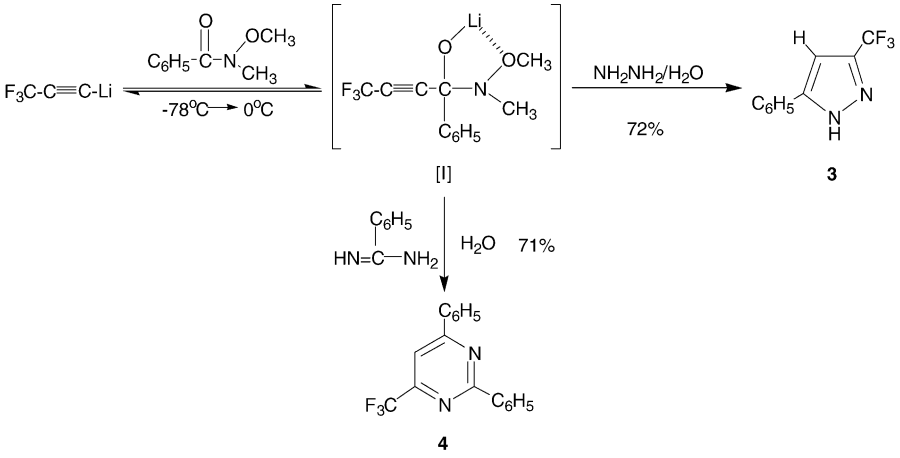
[a] Isolated yield.
[b] The ratio was determined by analysis of the ^1H NMR and ^{19}F NMR spectra and NOE of the ^1H NMR.
[c] **1a** was obtained in 50% yield.
[d] **1a** was obtained in 20% yield.
[e] **1a** was obtained in 5% yield.

the presence of sterically hindered amines such as diisopropyl amine and 2,6-dimethylpiperidine. Especially, the reactions of intermediate [I] with 2,2,6,6-tetramethylpiperidine and hexamethyldisilazane did not provide enaminones, but only **1a** was obtained in 60% and 61% yields from each reaction.

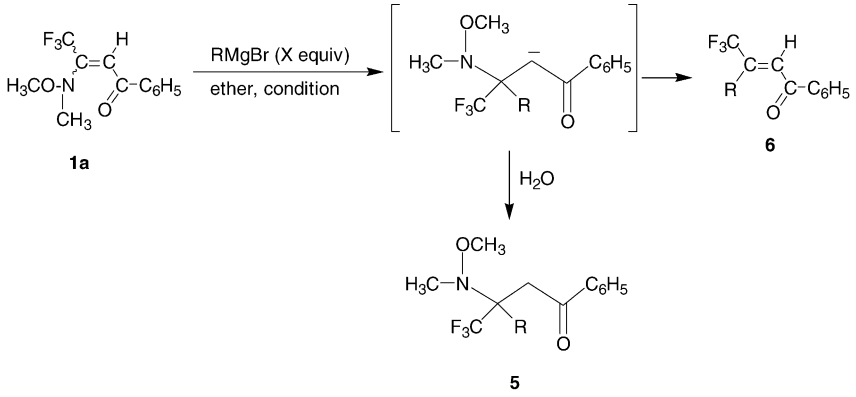
Treatment of intermediate [I] with H_2O in the presence of bidendate amines such as hydrazine or benzamidine resulted in the formation of heterocyclic compounds, pyrazole **3** or pyrimidine **4**, in 72% and 71% yields, respectively (Scheme 5). No other regioisomer was observed in the formation of **3**.

2.2. Preparation of β-aryl (or alkynyl)-β-trifluoromethylated enones 6

The synthetic methods for the preparation of β-aryl-β-trifluoromethylated enones and β-alkynyl-β trifluoromethylated enones have been quite limited and only one paper described the preparation of β-methyl-β-trifluoromethylated enones and β-phenyl-β-trifluoromethylated enones [9]. There was no report on the synthesis of β-alkynyl-β-trifluoromethylated enones. Although addition–elimination reactions of β-trifluoromethylated enaminones [12–15] or β-chloro (or fluoro)-β-trifluoromethylated enones [4–5,24] with heteroatom nucleophiles (N, O, S) have been well established in the previous literatures, there was no report on the addition–elimination reactions of β-trifluoromethylated enaminones or β-chloro-β-trifluoromethylated enones with carbon nucleophiles such as Grignard reagents or organolithium reagents. Therefore, we first examined on the reaction of **1a** with phenyllithium. When **1a** (1 equiv.) was reacted with phenyllithium (1 equiv.) at −78 °C in THF, a messy reaction mixture was obtained. The reaction of **1a** (1 equiv.) with phenylmagnesium bromide (1 equiv.) in ether at −78 °C followed by warming to 0 °C did not undergo at all and thus **1a** was recovered quantitatively. When **1a** was reacted with 2 equiv. of phenylmagnesium bromide under the same reaction condition, however, 1,4-addition product **5a** was obtained in 45% yield. The use of 3 equiv. of phenylmagnesium bromide in this reaction caused to increase the formation of **5a** to 76% yield. Then, we examined this reaction on the influence of reaction temperature. Treatment of **1a** with 3 equiv. of phenylmagnesium bromide in ether at −78 °C followed by warming to room temperature and then stirring at room temperature for



Scheme 5.

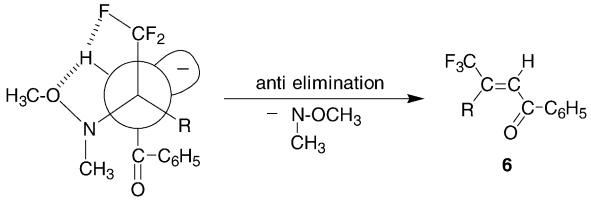


Scheme 6.

Table 3
Preparation of β-aryl (or alkynyl)-β-trifluoromethylated enones **6**

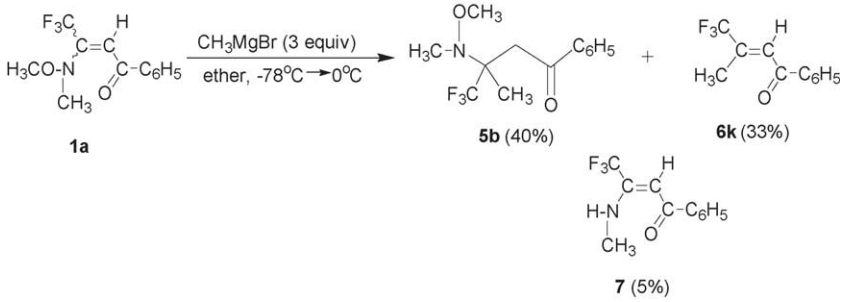
Compound no.	R	*X*	Condition	Yield (%)[a]
6a	C_6H_5	3	−78 °C → rt, 4 h	72
6b	4-CH_3O–C_6H_4	3	−78 °C → rt, 3 h	71
6c	4-CF_3–C_6H_4	3	−78 °C → rt, 12 h	76
6d	3-CF_3–C_6H_4	3	−78 °C → rt, 12 h	74
6e	3,4-OCH_2O–C_6H_3	3	−78 °C → rt, 4 h	67
6f	C_4H_3S	3	−78 °C → rt, 7 h	84
6g	$CH_3C{\equiv}C$	3	−78 °C → rt, 9 h	90
6h	$C_6H_5C{\equiv}C$	3	−78 °C → rt, 15 h	92
6i	$CH_3(CH_2)_3C{\equiv}C$	3	−78 °C → rt, 1 h	50
6j	$(CH_3)_3SiC{\equiv}C$	3	−78 °C → rt, 13 h	80

[a] Isolated yield.



Scheme 7.

4 h resulted in the formation of β-phenyl-β-trifluoromethylated enones **6a** (only *E*-isomer) in 72% yield. The reaction of **1a** with *p*-methoxyphenylmagnesium bromide, *p*-trifluoromethylphenylmagnesium bromide, *m*-trifluoromethylphenylmagnesium bromide, 3,4-(methylenedioxy)-phenylmagnesium bromide and thiophen-2-ylmagnesium bromide under the similar reaction condition afforded the corresponding enones **6b–f** (only *E*-isomer) in 67–84% yields. We also carried out the reaction of **1a** with alkynylmagnesium bromides such as propynylmagnesium bromide, phenylethynylmagnesium bromide, hexynylmagnesium bromide and trimethylethynylmagnesium bromide to afford the corresponding β-alkynyl-β-trifluoromethylated enones **6g–j** in 50–92% yields. The results of these reactions are summarized in Scheme 6 and Table 3. The stereospecific formation of **6** can be rationalized by hydrogen bond interaction between oxygen of *N*-methoxy group or fluorine of trifluoromethyl group and hydrogen in addition intermediate [III] which provides *E*-isomer of enone by anti-elimination of *N*-methoxy-*N*-methyl group (Scheme 7).



Scheme 8.

The reaction of **1a** with methylmagnesium bromide at −78 °C followed by warming to 0 °C afforded a desired product **6k** in only 33% yield along with 1,4-addition product **5b** (40%)and reducing product **7** (5%) (Scheme 8). When **1a** was treated with Grignard reagent having longer alkyl chain such as ethylmagnesium bromide or cyclohexylmagnesium bromide, however, only reducing product **7** was obtained in 63% and 70% yields, respectively.

3. Conclusions

The reaction of *N*-methoxy-*N*-methylbenzamide (1 equiv.) with trifluoropropynyl lithium (2 equiv.) at −78 °C and then 0 °C, followed by quenching with H_2O afforded stereoselectively β-trifiuoromethylated enaminone **1a** in 84% yield. Enaminone **1a** was treated with sterically less hindered amine derivatives to give amine exchange products in high yields stereospecifically. When the reaction mixture formed from the reaction of *N*-methoxy-*N*-methylbenzamide (1 equiv.) with trifluoropropynyl lithium (2 equiv.) at −78 °C and then 0 °C was quenched with H_2O in the presence of amine derivatives, β-trifiuoromethylated enaminones **1** were obtained in good yields stereospecifically. β-Trifluoromethylated enaminone **1a** was reacted with aryl or alkynyl Grignard reagents (3 equiv.) at room temperature for several hours to give β-aryl (or alkynyl)-β-trifluoromethylated enones **6**. However, the reaction of **1a** with alkylmagnesium bromide yielded reducing products as a major product.

4. Experimental

^{1}H NMR were recorded on a 200 MHz Gemini-200 NMR spectrometer and ^{19}F NMR spectra were recorded on a 100 MHz Bruker AC-100F NMR spectrometer with tetramethylsilane (TMS) and $CFCl_3$ as an internal standard, respectively and the upfield as negative. All chemical shifts (δ) are expressed in parts per million and coupling constant (J) are given in Hertz. Infrared spectra were determined on a Mattson Genesis series FT High Resolution Spectrophotometer. Mass spectra were obtained by using GC/MS-Qp1000-Shimadzu (El, 70 eV). Melting points were determined in open capillary tubes and are unconnected.

Commercially available reagents were purchased from Aldrich, Lancaster, Tokyo Kasei and Fluorochem. All solvents were dried by general purification method.

*4.1. General procedure for the preparation of enaminones **1***

A 25 mL two-neck round-bottomed flask equipped with a magnetic stirrer bar, septum and dry ice condenser connected to an argon source was charged with THF (10 mL) and then cooled to −78 °C. After a dry ice condenser was filled with slush of dry ice and isopropyl alcohol, 3,3,3-trifluoropropyne (0.564 g, 6.0 mmol) was slowly added into flask by condensation via dry ice condenser. To a THF solution of 3,3,3-trifluoropropyne was added *n*-BuLi (6.0 mmol) at −78 °C and the reaction mixture was stirred at −78 °C for 0.5 h under argon atmosphere. *N*-Methoxy-*N*-methylbenzamide (0.495 g, 3.0 mmol) or *N*-methoxy-*N*-methylacetamide (0.309 g, 3.0 mmol) was added into a mixture at −78 °C and then warmed to 0 °C. H_2O (5 mL) or a mixture of H_2O (5 mL) and amine (3.0 mmol) was added into a mixture and then allowed to stir for 1 h at 0 °C. The reaction mixture was extracted with ether twice. The ether solution was dried and chromatographed on SiO_2 column. Elution with a mixture of hexane and ethyl acetate (9:1) provided enaminones **1**.

*4.1.1. 4,4,4-Trifluoro-3-(N-methoxy-N-methyl)amino-1-phenyl-2-buten-1-one **1a***

1a (*E*/*Z* = 13/87) was prepared in 84% yield according to the general procedure (addition of *N*-methoxy-*N*-methylbenzamide followed by quenching with H_2O). **1a**: oil; ^{1}H NMR ($CDCl_3$) *Z*-isomer δ 7.95–7.90 (m, 2H), 7.57–7.47 (m, 3H), 6.19 (s, 1H), 3.32 (s, 3H), 3.04 (s, 3H), *E*-isomer δ 7.95–7.90 (m, 2H), 7.57–7.47 (m, 3H), 6.44 (s, 1H), 3.64 (s, 3H), 2.99 (s, 3H); ^{19}F NMR ($CDCl_3$) δ −65.97 (s, 3F, *Z*-isomer), −61.84 (s, 3F, *E*-isomer); MS, *m*/*z* (relative intensity) 259 (M^+, 7), 228 (81), 130 (21), 105 (67), 91 (100), 77 (58), 69 (6), 51 (13); IR (neat) 3062, 2938, 1673, 1599, 1580, 1561, 1450, 1281, 1180, 752, 690 cm^{-1}. Anal. Calcd. for $C_{12}H_{12}F_3NO_2$: C, 55.60; H, 4.67. Found: C, 55.38; H, 4.62.

*4.1.2. 5,5,5-Trifluoro-4-(N-methoxy-N-methyl)amino-3-penten-2-one **1b***

1b (*E*/*Z* = 14/86) was prepared in 60% yield according to the general procedure (addition of *N*-methoxy-*N*-methylacetamide followed by quenching with H_2O). **1b**: oil; ^{1}H NMR ($CDCl_3$) *Z*-isomer δ 5.79 (s, 1H), 3.56 (s, 3H), 3.11 (s, 3H), 2.29 (s, 3H), *E*-isomer δ 6.05 (s, 1H), 3.58 (s, 3H), 2.92 (s, 3H), 2.30 (s, 3H); ^{19}F NMR ($CDCl_3$) δ −65.59 (s, 3F, *Z*-isomer), −61.30 (s, 3F, *E*-isomer); MS, *m*/*z* (relative intensity) 197 (M^+, 2), 166 (21), 157 (16), 155 (17), 148 (7), 110 (5), 82 (9), 69 (7), 43 (100); IR (neat) 3048, 2979, 1721, 1574, 1558, 1372, 1281, 1188 cm^{-1}. Anal. Calcd. for $C_7H_{10}F_3NO_2$: C, 42.65; H, 5.11. Found: C, 42.51; H, 5.06.

*4.1.3. (Z)-4,4,4-Trifluoro-1-phenyl-3-(1-piperidinyl)-2-buten-1-one **1c***

1c was prepared in 92% yield according to the general procedure (addition of *N*-methoxy-*N*-methylbenzamide followed by quenching with a mixture of H_2O and piperidine). **1c**: oil; ^{1}H NMR ($CDCl_3$) δ 7.91–7.87 (m, 2H), 7.51–7.39 (m, 3H), 6.22 (s, 1H), 3.24 (s, 4H), 1.68 (s, 6H); ^{19}F NMR ($CDCl_3$) δ −64.46 (s, 3F); MS, *m*/*z* (relative intensity) 283 (M^+, 37), 266 (52), 131 (21), 105 (33), 103 (17), 91 (11), 83 (100), 77 (25), 69 (11); IR (neat) 3062, 2941, 1645, 1599, 1581, 1564, 1470, 1279, 1180, 1126, 771,

632 cm^{-1}. Anal. Calcd. for $C_{15}H_{16}F_3NO$: C, 63.60; H, 5.69. Found: C, 63.45; H, 5.63.

4.1.4. (Z)-4,4,4-Trifluoro-3-(dimethylamino)-1-phenyl-2-buten-1-one **1d**

1d was prepared in 77% yield according to the general procedure (addition of *N*-methoxy-*N*-methylbenzamide followed by quenching with a mixture of H_2O and dimethylamine). **1d**: oil; ^1H NMR ($CDCl_3$) δ 7.93–7.88 (m, 2H), 7.51–7.44 (m, 3H), 6.23 (s, 1H), 3.05 (s, 6H); ^{19}F NMR ($CDCl_3$) δ −65.10 (s, 3F); MS, *m*/*z* (relative intensity) 243 (M^+, 19), 226 (100), 166 (30), 138 (16), 105 (46), 91 (32), 77 (54), 69 (12); IR (neat) 3064, 2973, 1678, 1575, 1550, 1470, 1290, 1174, 1100, 748, 690 cm^{-1} Anal. Calcd. for $C_{12}H_{12}F_3NO$: C, 59.26; H, 4.97. Found: C, 59.13; H, 4.93.

4.1.5. (Z)-4,4,4-Trifluoro-3-(N-benzyl-N-methylamino)-1-phenyl-2-buten-1-one **1e**

1e was prepared in 89% yield according to the general procedure (addition of *N*-methoxy-*N*-methylbenzamide followed by quenching with a mixture of H_2O and *N*-benzyl-*N*-methylamine). **1e**: oil; ^1H NMR ($CDCl_3$) δ 7.91–7.86 (m, 2H), 7.51–7.23 (m, 8H), 6.37 (s, 1H), 4.47 (s, 2H), 2.88 (s, 3H); ^{19}F NMR ($CDCl_3$) δ −64.35 (s, 3F); MS, *m*/*z* (relative intensity) 319 (M^+, 18), 302 (22), 214 (25), 120 (17), 110 (22), 105 (37), 91 (100), 77 (28), 62 (25); IR (neat) 3062, 2926, 1643, 1572, 1540, 1468, 1282, 1178, 748, 688 cm^{-1}. Anal. Calcd. for $C_{18}H_{16}F_3NO$: C, 67.70; H, 5.05. Found: C, 67.85; H, 5.10.

4.1.6. (Z)-4,4,4-Trifluoro-3-morpholino-1-phenyl-2-buten-1-one **1f**

1f was prepared in 82% yield according to the general procedure (addition of *N*-methoxy-*N*-methylbenzamide followed by quenching with a mixture of H_2O and morpholine). **1f**: mp 62–63 °C; ^1H NMR ($CDCl_3$) δ 7.92–7.87 (m, 2H), 7.57–7.41 (m, 3H), 6.30 (s, 1H), 3.82–3.77 (m, 4H), 3.34–3.29 (m, 4H); ^{19}F NMR ($CDCl_3$) δ −64.30 (s, 3F); MS, *m*/*z* (relative intensity) 285 (M^+, 40), 268 (50), 180 (28), 131 (23), 105 (96), 91 (100), 86 (27), 77 (50); IR (KBr) 3063, 2931, 1648, 1575, 1535, 1472, 1279, 1180, 1126, 751, 692 cm^{-1}. Anal. Calcd. for $C_{14}H_{14}F_3NO_2$: C, 58.95; H, 4.95. Found: C, 58.76; H, 4.88.

4.1.7. (Z)-3-(Benzylamino)-4,4,4-trifluoro-1-phenyl-2-buten-1-one **1g**

1g was prepared in 83% yield according to the general procedure (addition of *N*-methoxy-*N*-methylbenzamide followed by quenching with a mixture of H_2O and benzylamine). **1g**: oil; ^1H NMR ($CDCl_3$) δ 11.01 (s, 1H), 7.91–7.87 (m, 2H), 7.51–7.25 (m, 8H), 6.29 (s, 1H), 4.61 (d, J = 6.3 Hz, 2H); ^{19}F NMR ($CDCl_3$) δ −66.80 (s, 3F); MS, *m*/*z* (relative intensity) 305 (M^+, 49), 236 (6), 200 (10), 131 (9), 105 (27), 91 (100), 77 (20), 65 (17); IR (neat) 3033, 2885, 1630, 1599, 1572, 1520, 1325, 1190, 1138, 755, 685 cm^{-1}. Anal. Calcd. for $C_{17}H_{14}F_3NO$: C, 66.88; H, 4.62. Found: C, 66.71; H, 4.58.

4.1.8. (Z)-4,4,4-Trifluoro-1-phenyl-3-(phenylamino)-2-buten-1-one **1h**

1h was prepared in 31% yield according to the general procedure (addition of *N*-methoxy-*N*-methylbenzamide followed by quenching with a mixture of H_2O and aniline), **1h**: oil; ^1H NMR ($CDCl_3$) δ 12.52 (s, 1H), 7.98–7.93 (m, 2H), 7.55–7.24 (m, 8H), 6.44 (s, 1H); ^{19}F NMR ($CDCl_3$) δ −63.59 (s, 3F); MS, *m*/*z* (relative intensity) 291 (M^+, 61), 222 (36), 186 (18), 144 (14), 105 (76), 77 (100), 69 (2), 51 (44); IR (neat) 3064, 2960, 1630, 1599, 1570, 1530, 1292, 1189, 1143, 754, 687 cm^{-1}. Anal. Calcd. for $C_{16}H_{12}F_3NO$: C, 65.98; H, 4.15. Found: C, 65.71; H, 4.13.

4.1.9. 3-(Diisopropylamino)-4,4,4-trifluoro-1-phenyl-2-buten-1-one **1i**

1i (*E*/*Z* = 25/75) was prepared in 55% yield according to the general procedure (addition of *N*-methoxy-*N*-methylbenzamide followed by quenching with a mixture of H_2O and diisopropylamine). **1i**: oil; ^1H NMR ($CDCl_3$) *Z*-isomer δ 7.94–7.88 (m, 2H), 7.57–7.24 (m, 3H), 6.80 (s, 1H), 3.70–3.64 (m, 2H), 1.25 (d, J = 6.7 Hz, 6H), *E*-isomer δ 7.95–7.90 (m, 2H), 7.57–7.47 (m, 3H), 6.13 (s, 1H), 3.80–3.69 (m, 2H), 1.31 (d, J = 6.7 Hz, 6H); ^{19}F NMR ($CDCl_3$) δ −64.63 (s, 3F, *Z*-isomer), −60.52 (s, 3F, *E*-isomer); MS, *m*/*z* (relative intensity) 299 (M^+, 12), 256 (19), 105 (21), 88 (14), 86 (72), 84 (100), 77 (10), 74 (17), 59 (17); IR (neat) 3061, 2978, 1668, 1634, 1596, 1581, 1480, 1273, 1176, 755, 697 cm^{-1}. Anal. Calcd. for $C_{16}H_{20}F_3NO$: C, 64.20; H, 6.74. Found: C, 64.38; H, 6.80.

4.1.10. 4,4,4-Trifluoro-3-(2,6-dimethyl-1-piperidinyl)-1-phenyl-2-buten-1-one **1j**

1j (*E*/*Z* = 17/83) was prepared in 74% yield according to the general procedure (addition of *N*-methoxy-*N*-methylbenzamide followed by quenching with a mixture of H_2O and 2,6-dimethylpiperidine). **1j**: mp 43–44 °C; ^1H NMR ($CDCl_3$) *Z*-isomer δ 7.92–7.87 (m, 2H), 7.58–7.43 (m, 3H), 7.02 (s, 1H), 3.11–3.07 (m, 2H), 1.69–1.19 (m, 6H), 1.07 (d, J = 6.5 Hz, 6H), *E*-isomer δ 7.92–7.87 (m, 2H), 7.58–7.43 (m, 3H), 6.45 (s, 1H), 3.11–3.07 (m, 2H), 1.69–1.19 (m, 6H), 1.07 (d, J = 6.5 Hz, 6H); ^{19}F NMR ($CDCl_3$) δ −64.28 (s, 3F, *Z*-isomer), −62.14 (s, 3F, *E*-isomer); MS, *m*/*z* (relative intensity) 311 (M^+, 35), 206 (28), 131 (28), 111 (23), 105 (100), 96 (33), 77 (55), 55 (43); IR (KBr) 3060, 2935, 1681, 1596, 1581, 1480, 1315, 1263, 1184, 1119, 759, 701 cm^{-1}. Anal. Calcd. for $C_{17}H_{20}F_3NO$: C, 65.58; H, 6.48. Found: C, 65.51; H, 6.46.

4.2. Preparation of 4,4,4-trifluoro-1-(N-methoxy-N-methylamino)-1-phenyl-1-trimethylsiloxyl-2-butyne **2**

A 25 mL two-neck round-bottomed flask equipped with a magnetic stirrer bar, septum and dry ice condenser connected to an argon source was charged with THF (10 mL) and then cooled to −78 °C. After a dry ice condenser was filled with slush of dry ice and isopropyl

alcohol, 3,3,3-trifluoropropyne (0.564 g, 6.0 mmol) was slowly added into flask by condensation via dry ice condenser. To a THF solution of 3,3,3-trifluoropropyne was added *n*-BuLi (6.0 mmol) at −78 °C and the reaction mixture was stirred at −78 ° C for 0.5 h under argon atmosphere. *N*-Methoxy-*N*-methylbenzamide (0.495 g, 3.0 mmol) was added into a mixture at −78 °C and then warmed to 0 °C. Trimethylsilyl chloride (0.347 g, 3.2 mmol) was added into a mixture and then allowed to stir for 1 h at room temperature followed by quenching with H_2O. The reaction mixture was extracted with ether twice. The ether solution was dried and chromatographed on SiO_2 column. Elution with a mixture of hexane and ethyl acetate (19:1) provided **2** in 80% yield. **2**: oil; ^{1}H NMR ($CDCl_3$) δ 7.65–7.60 (m, 2H), 7.38–7.35 (m, 3H), 3.46 (s, 3H), 2.40 (s, 3H), 0.20 (s, 9H); ^{19}F NMR ($CDCl_3$) δ −51.20 (s, 3F); MS, *m*/*z* (relative intensity) 271 (M^+ −60, 100), 242 (36), 208 (12), 179 (11), 151 (23), 105 (27), 77 (10), 73 (47); IR (neat) 3067, 2960, 2262, 1450, 1273, 1214, 1147, 1087, 1024, 892, 844 cm^{-1}. Anal. Calcd. for $C_{15}H_{20}F_3NO_2Si$: C, 54.36; H, 6.08. Found: C, 54.49; H, 5.99.

4.3. Preparation of 3-trifluoromethyl-5-phenyl-1H-pyrazole **3**

A 25 mL two-neck round-bottomed flask equipped with a magnetic stirrer bar, septum and dry ice condenser connected to an argon source was charged with THF (10 mL) and then cooled to −78 °C. After a dry ice condenser was filled with slush of dry ice and isopropyl alcohol, 3,3,3-trifluoropropyne (0.564 g, 6.0 mmol) was slowly added into flask by condensation via dry ice condenser. To a THF solution of 3,3,3-trifluoropropyne was added *n*-BuLi (6.0 mmol) at −78 °C and the reaction mixture was stirred at −78 °C for 0.5 h under argon atmosphere. *N*-Methoxy-*N*-methylbenzamide (0.495 g, 3.0 mmol) was added into a mixture at −78 °C and then warmed to 0 °C. A mixture of H_2O (10 mL) and hydrazine hydrate (0.368 g, 6.5 mmol) was added into a mixture and then allowed to stir for 1 h at 0 °C. The reaction mixture was extracted with ether twice. The ether solution was dried and chromatographed on SiO_2 column. Elution with a mixture of hexane and ethyl acetate (1:2) provided **3** in 72% yield. **3**: mp 105–106 °C; ^{1}H NMR ($CDCl_3$) δ 12.58 (s, 1H), 7.60–7.40 (m, 5H), 6.75 (s, 1H); ^{19}F NMR ($CDCl_3$) δ −62.78 (s, 3F); MS, *m*/*z* (relative intensity) 212 (M^+, 100), 164 (26), 142 (21), 115 (41), 105 (17), 86 (25), 77 (16), 69 (20), 62 (25); IR (KBr) 3420, 3118, 3024, 1279, 1167, 1153 cm^{-1}. Anal. Calcd. for $C_{10}H_7F_3N_2$: C, 56.61; H, 3.33. Found: C, 56.50; H, 3.35.

4.4. Preparation of 4-trifluoromethyl-2,6-diphenylpyrimidine **4**

A 25 mL two-neck round-bottomed flask equipped with a magnetic stirrer bar, septum and dry ice condenser connected to an argon source was charged with THF (10 mL) and then cooled to −78 °C. After a dry ice condenser was filled with slush of dry ice and isopropyl alcohol, 3,3,3-trifluoropropyne (0.564 g, 6.0 mmol) was slowly added into flask by condensation via dry ice condenser. To a THF solution of 3,3,3-trifluoropropyne was added *n*-BuLi (6.0 mmol) at −78 °C and the reaction mixture was stirred at −78 °C for 0.5 h under argon atmosphere. *N*-Methoxy-*N*-methylbenzamide (0.495 g, 3.0 mmol) was added into a mixture at −78 °C and then warmed to 0 °C. A mixture of H_2O (10 mL) and benzamidine hydrochloride hydrate (1.027 g, 6.5 mmol) was added into a mixture and then allowed to stir for 1 h at 0 °C. The reaction mixture was extracted with ether twice. The ether solution was dried and chromatographed on SiO_2 column. Elution with a mixture of hexane and ethyl acetate (1:2) provided **4** in 71% yield. **4**: mp 74–75 °C; ^{1}H NMR ($CDCl_3$) δ 8.66–8.61 (m, 2H), 8.30–8.25 (m, 2H), 7.90 (s, 1H), 7.60–7.52 (m, 6H); ^{19}F NMR ($CDCl_3$) δ −70.53 (s, 3F); MS, *m*/*z* (relative intensity) 300 (M^+, 68), 231 (8), 197 (13), 128 (100), 103 (92), 77 (88), 51 (53); IR (KBr) 3066, 2945, 1591, 1377, 1184, 1140 cm^{-1}. Anal. Calcd. for $C_{17}H_{11}F_3N_2$: C, 68.00; H, 3.69. Found: C, 67.88; H, 3.65.

4.5. Preparation of 4,4,4-trifluoro-3-(N-methoxy-N-methyl)amino-1,3-diphenyl-1-butanone **5a**

To a dry ether (5 mL) solution of phenylmagnesium bromide (3.0 mmol) was added **1a** (0.259 g, 1.0 mmol) at −78 °C and the reaction mixture was slowly warmed at 0 °C. The reaction mixture was quenched with saturated NH_4Cl solution and then extracted with ether twice. The solution was dried and chromatographed on SiO_2 column. Elution with a mixture of hexane and ethyl acetate (1:19) provided **5a** in 76% yield. **5a**: oil; ^{1}H NMR ($CDCl_3$) δ 7.99–7.94 (m, 2H), 7.60–7.20 (m, 8H), 3.99 (s, 2H), 3.58 (s, 3H), 2.58 (s, 3H); ^{19}F NMR ($CDCl_3$) δ −67.37 (s, 3F); MS, *m*/*z* (relative intensity) 337 (M^+, 9), 306 (5), 268 (22), 218 (47), 118 (9), 105 (100), 77 (22); IR (neat) 3062, 2963, 1743, 1560, 1541, 1507, 1248, 1177, 1036, 742, 699 cm^{-1}. Anal. Calcd. for $C_{18}H_{18}F_3NO_2$: C, 64.09; H, 5.38. Found: C, 64.02; H, 5.37.

4.6. General procedure for the preparation of β-aryl (or alkynyl)-β-trifluoromethylated enones **6**

To a dry ether (5 mL) solution of aryl (or alkynyl)magnesium bromide (3.0 mmol) was added **1a** (0.259 g, 1.0 mmol) at −78 °C and the reaction mixture was warmed at room temperature. The reaction mixture was stirred at room temperature for several hours and then quenched with saturated NH_4Cl solution. The reaction mixture was extracted with ether twice. The solution was dried and chromatographed on SiO_2 column. Elution with a mixture of hexane and ethyl acetate (1:19) provided **6**.

*4.6.1. (E)-4,4,4-Trifluoro-1,3-diphenyl-2-buten-1-one **6a***

6a was prepared in 72% yield according to the general procedure (stirring at room temperature for 4 h). **6a**: oil; ^{1}H NMR ($CDCl_3$) δ 7.85–7.80 (m, 2H), 7.57–7.35 (m, 3H), 7.27 (s, 6H); ^{19}F NMR ($CDCl_3$) δ −66.78 (s, 3F); MS, *m/z* (relative intensity) 276 (M^+, 68), 275 (100), 257 (4), 207 (9), 178 (8), 151 (18), 128 (4), 105 (35), 95 (7), 77 (55), 51 (12); IR (neat) 3062, 2934, 1677, 1598, 1581, 1470, 1316, 1281, 1129, 743, 691 cm^{-1}. Anal. Calcd. for $C_{16}H_{11}F_3O$: C, 69.56; H, 4.01. Found: C, 69.65; H, 3.97.

*4.6.2. (E)-4,4,4-Trifluoro-3-(4-methoxyphenyl)-1-phenyl-2-buten-1-one **6b***

6b was prepared in 71% yield according to the general procedure (stirring at room temperature for 3 h). **6b**: oil; ^{1}H NMR ($CDCl_3$) δ 7.85–7.80 (m, 2H), 7.57–7.35 (m, 3H), 7.26–7.19 (m, 3H), 6.80–6.75 (m, 2H), 3.74 (s, 3H); ^{19}F NMR ($CDCl_3$) δ −66.67 (s, 3F); MS, *m/z* (relative intensity) 306 (M^+, 100), 291 (19), 275 (85), 237 (18), 228 (23), 165 (13), 131 (13), 105 (56), 77 (68); IR (neat) 3060, 2960, 1674, 1609, 1480, 1279, 1174, 1033 cm^{-1}. Anal. Calcd. for $C_{17}H_{13}F_3O_2$: C, 66.67; H, 4.28. Found: C, 66.55; H, 4.24.

*4.6.3. (E)-4,4,4-Trifluoro-3-(4-trifluoromethylphenyl)-1-phenyl-2-buten-1-one **6c***

6c was prepared in 76% yield according to the general procedure (stirring at room temperature for 12 h). **6c**: oil; ^{1}H NMR ($CDCl_3$) δ 7.86–7.81 (m, 2H), 7.71–7.39 (m, 8H); ^{19}F NMR ($CDCl_3$) δ −63.54 (s, 3F), −66.92 (s, 3F); MS, *m/z* (relative intensity) 344 (M^+, 49), 325 (10), 275 (100), 219 (11), 169 (9), 138 (13), 105 (54), 77 (49); IR (neat) 3063, 2934, 1679, 1598, 1480, 1327, 1280, 1171, 1069 cm^{-1}. Anal. Calcd. for $C_{17}H_{10}F_6O$: C, 59.31; H, 2.93. Found: C, 59.17; H, 2.95.

*4.6.4. (E)-4,4,4-Trifluoro-3-(3-trifluoromethylphenyl)-1-phenyl-2-buten-1-one **6d***

6d was prepared in 76% yield according to the general procedure (stirring at room temperature for 12 h). **6d**: oil; ^{1}H NMR ($CDCl_3$) δ 8.00–7.38 (m, 10H); ^{19}F NMR ($CDCl_3$) δ −63.43 (s, 3F), −66.94 (s, 3F); MS, *m/z* (relative intensity) 344 (M^+, 4), 275 (5), 251 (5), 167 (38), 149 (100), 119 (24), 105 (61), 91 (13); IR (neat) 3078, 2930, 1667, 1598, 1482, 1337, 1269, 1170, 1075 cm^{-1}. Anal. Calcd. for $C_{17}H_{10}F_6O$: C, 59.31; H, 2.93. Found: C, 59.21; H, 2.94.

*4.6.5. (E)-3-(Benzo[d][1,3]dioxol-5-yl)-4,4,4-trifluoro-1-phenyl-2-buten-1-one **6e***

6e was prepared in 67% yield according to the general procedure (stirring at room temperature for 4 h). **6e**: oil; ^{1}H NMR ($CDCl_3$) δ 7.92–7.78 (m, 2H), 7.71 (s, 1H), 7.56–7.35 (m, 3H), 6.74–6.61 (m, 3H), 5.89 (s, 2H); ^{19}F NMR ($CDCl_3$) δ −66.77 (s, 3F); MS, *m/z* (relative intensity) 320 (M^+, 76), 290 (19), 262 (25), 251 (52), 213 (14), 165 (17), 143 (13), 118 (13), 105 (100), 77 (82); IR (neat) 3065, 2912, 1673, 1598, 1282, 1178, 1039 cm^{-1}. Anal. Calcd. for $C_{17}H_{11}F_3O_3$: C, 63.76; H, 3.46. Found: C, 63.61; H, 3.42.

*4.6.6. (E)-4,4,4-Trifluoro-1-phenyl-3-(thiophen-2-yl)-2-buten-1-one **6f***

6f was prepared in 84% yield according to the general procedure (stirring at room temperature for 7 h). **6f**: oil; ^{1}H NMR ($CDCl_3$) δ 7.90–7.84 (m, 2H), 7.59–7.42 (m, 3H), 7.39–7.29 (m, 1H), 7.17–7.12 (m, 2H), 6.98–6.87 (m, 1H); ^{19}F NMR ($CDCl_3$) δ −66.86 (s, 3F); MS, *m/z* (relative intensity) 282 (M^+, 13), 213 (100), 185 (15), 105 (28), 77 (62), 63 (10), 51 (31); IR (neat) 3066, 2931, 1672, 1598, 1324, 1279, 1180, 1035 cm^{-1}. Anal. Calcd. for $C_{14}H_9F_3OS$: C, 59.57; H, 3.21. Found: C, 59.38; H, 3.26.

*4.6.7. (E)-3-Trifluoromethyl-1-phenyl-2-hexen-4-yn-1-one **6g***

6g was prepared in 90% yield according to the general procedure (stirring at room temperature for 9 h). **6g**: oil; ^{1}H NMR ($CDCl_3$) δ 7.97–7.92 (m, 2H), 7.66–7.46 (m, 3H), 7.45 (s, 1H), 2.04 (s, 3H); ^{19}F NMR ($CDCl_3$) δ −68.13 (s, 3F); MS, *m/z* (relative intensity) 238 (M^+, 50), 210 (13), 169 (18), 141 (18), 115 (18), 105 (100), 77 (82), 51 (32); IR (neat) 3064, 2922, 2223, 1675, 1600, 1325, 1288, 1187, 1015 cm^{-1}. Anal. Calcd. for $C_{13}H_9F_3O$: C, 65.55; H, 3.81. Found: C, 65.48; H, 3.80.

*4.6.8. (E)-3-Trifluoromethyl-1,5-diphenyl-2-penten-4-yn-1-one **6h***

6h was prepared in 92% yield according to the general procedure (stirring at room temperature for 15 h). **6h**: oil; ^{1}H NMR ($CDCl_3$) δ 8.02–7.97 (m, 2H), 7.68–7.28 (m, 9H); ^{19}F NMR ($CDCl_3$) δ −67.56 (s, 3F); MS, *m/z* (relative intensity) 300 (M^+, 58), 251 (21), 231 (47), 202 (44), 126 (42), 102 (61), 77 (100), 51 (36); IR (neat) 3064, 2929, 2205, 1673, 1599, 1317, 1230, 1145, 1047 cm^{-1}. Anal. Calcd. for $C_{18}H_{11}F_3O$: C, 72.00; H, 3.69. Found: C, 71.83; H, 3.73.

*4.6.9. (E)-3-Trifluoromethyl-1-phenyl-2-nonen-4-yn-1-one **6i***

6i was prepared in 50% yield according to the general procedure (stirring at room temperature for 1 h). **6i**: oil; ^{1}H NMR($CDCl_3$) δ 7.97–7.92 (m, 2H), 7.62–7.46 (m, 3H), 7.37 (s, 1H), 2.35 (t, J = 6.7 Hz, 2H), 1.54–1.21 (m, 4H), 0.86 (t, J = 7.1 Hz, 3H); ^{19}F NMR ($CDCl_3$) δ −68.15 (s, 3F); MS, *m/z* (relative intensity) 280 (M^+, 9), 251 (61), 238 (82), 183 (30), 144 (26), 115 (27), 105 (91), 77 (100); IR (neat) 3066, 2961, 2215, 1675, 1598, 1287, 1186, 1014 cm^{-1}. Anal. Calcd. for $C_{16}H_{15}F_3O$: C, 68.56; H, 5.39. Found: C, 68.67; H, 5.34.

*4.6.10. (E)-3-Trifluoromethyl-5-trimethylsilyl-1-phenyl-2-penten-4-yn-1-one **6j***

6j was prepared in 80% yield according to the general procedure (stirring at room temperature for 13 h). **6j**: oil; ^{1}H NMR ($CDCl_3$) δ 7.96–7.91 (m, 2H), 7.67–7.46 (m, 3H), 7.36 (s, 1H), 0.10 (m, 9H); ^{19}F NMR ($CDCl_3$) δ −67.73 (s, 3F); MS, *m/z* (relative intensity) 296 (M^+, 6), 222 (9), 187 (35), 152 (34), 105 (59), 77 (100); IR (neat) 3064, 2936, 2154,

1648, 1600, 1285, 1186, 1063 cm^{-1}. Anal. Calcd. for $C_{15}H_{15}F_3OSi$: C, 60.79; H, 5.10. Found: C, 60.72; H, 5.08.

4.6.11. (E)-4,4,4-Trifluoro-3-methyl-1-phenyl-2-buten-1-one ***6k***

To a dry ether (5 mL) solution of methylmagnesium bromide (3.0 mmol) was added **1a** (0.259 g, 1.0 mmol) at −78 °C and the reaction mixture was warmed at 0 °C followed by quenching with saturated NH_4Cl solution. The reaction mixture was extracted with ether twice. The solution was dried and chromatographed on SiO_2 column. Elution with a mixture of hexane and ethyl acetate (1:19) provided **6k** in 33% yield along with **5b** (40%) and **7** (5%). **6k**: oil; ^1H NMR ($CDCl_3$) δ 7.98–7.92 (m, 2H), 7.67–7.44 (m, 3H), 7.23 (q, J = 1.4 Hz, 1H), 2.16 (d, J = 1.4 Hz, 3H); ^{19}F NMR ($CDCl_3$) δ −71.36 (s, 3F); MS, *m*/*z* (relative intensity) 214 (M^+, 4), 145 (7), 118 (6), 105 (100), 77 (70); IR (neat) 3064, 2933, 1679, 1598, 1369, 1295, 1179, 1100 cm^{-1}. Anal. Calcd. for $C_{11}H_9F_3O$: C, 61.69; H, 4.24. Found: C, 61.57; H, 4.20. **5b**: oil; ^1H NMR ($CDCl_3$) δ 8.01–7.90 (m, 2H), 7.62–7.42 (m, 3H), 3.48 (d, J = 15.1 Hz, 1H), 3.42 (s, 3H), 3.27 (d, J = 15.1 Hz, 1H), 2.70 (s, 3H), 1.55 (s, 3H); ^{19}F NMR ($CDCl_3$) δ −74.65 (s, 3F); MS, *m*/*z* (relative intensity) 275 (M^+, 6), 244 (24), 206 (35), 156 (35), 124 (16), 105 (100), 91 (18), 77 (79), 56 (46); IR (neat) 3063, 2958, 1682, 1599, 1323, 1295, 1147, 1097 cm^{-1}. Anal. Calcd. for $C_{13}H_{16}F_3NO_2$: C, 56.72; H, 5.86. Found: C, 56.81; H, 5.88. **7**: mp 77–78 °C; ^1H NMR ($CDCl_3$) δ 10.74 (s, 1H), 7.99–7.86 (m, 2H), 7.59–7.39 (m, 3H), 6.22 (s, 1H), 3.12 (d, J = 5.7 Hz, 3H); ^{19}F NMR ($CDCl_3$) δ −67.73 (s, 3F); MS, *m*/*z* (relative intensity) 229 (M^+, 77), 212 (24), 152 (20), 118 (12), 105 (100), 84 (16), 77 (70); IR (KBr) 3067, 2953, 1743, 1600, 1324, 1295, 1183, 1140 cm^{-1}. Anal. Calcd. for $C_{11}H_{10}F_3NO$: C, 57.64; H, 4.40. Found: C, 57.58; H, 4.41.

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