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Nucleophilic Lewis Base Dependent Addition Reactions of Allenoates with Trifluoromethylated Cyclic Ketimines

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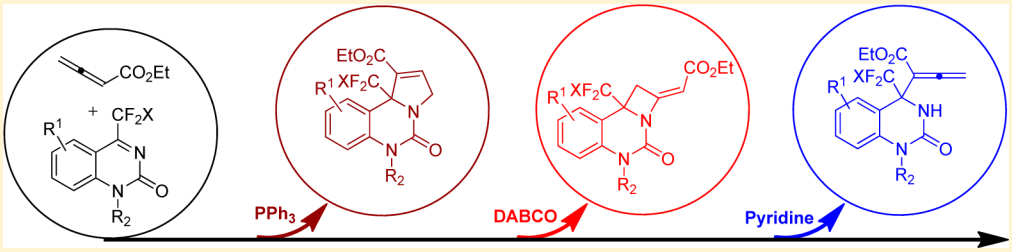
Supporting Information

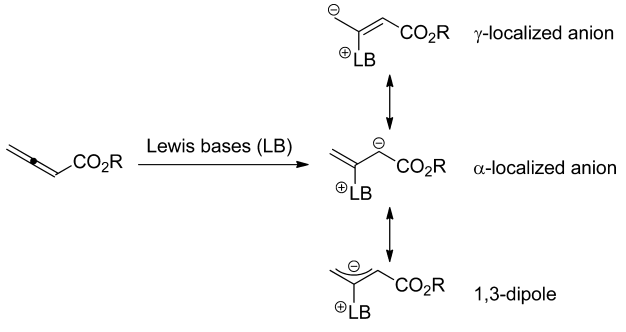


ABSTRACT: A detailed investigation on the different reactivity patterns shown by phosphorus- and nitrogen-containing Lewis base catalysts in the reactions of allenoates with cyclic trifluoromethyl ketimines was accomplished. With PPh_3, [3 + 2] annulations proceeded smoothly to afford dihydropyrrole derivatives in excellent yields. Under the catalysis of DABCO, [2 + 2] annulations occurred, producing azetidine derivatives in good to high yields. However, in the presence of pyridine, α,α'-disubstituted allenoates were obtained in very high yields via aza-Morita–Baylis–Hillman reactions. These studies provide an opportunity for diverse synthesis of a variety of *N*-heterocyclic compounds from the same starting materials.

INTRODUCTION

The Lewis base catalyzed[1] nucleophilic activation of allenoates followed by reaction with electrophiles has experienced a great expansion over the past few decades.[2] In general, such reactions are initiated with the generation of a zwitterionic intermediate upon conjugate addition of a Lewis base to an allenoate (Scheme 1). Depending on the nature of the Lewis base and different reaction conditions, the formed zwitterionic intermediate may be depicted in several ways, which include anion localization at the α carbon or γ carbon or delocalization, such as a 1,3-dipole. These structurally diverse intermediates provide an opportunity for the construction of a variety of complex scaffolds from the same starting materials.

Scheme 1. Zwitterionic Intermediates upon Conjugate Addition of Lewis Bases to Allenoates



Since Lu's pioneer work on the application of *N*-Ts aldimines in formal [3 + 2] cycloadditions with allenoates under Lewis base catalysis,[3] electron-deficient imines have become one of the most commonly employed electrophilic-coupling partners in this type of transformation to furnish nitrogen-containing molecules with complexity.[4,5] Furthermore, this strategy has been successfully applied to the synthesis of natural products and compounds of pharmaceutical significance.[6] However, unlike the widely studied aldimines, the use of less reactive ketimines as electrophiles in the Lewis base catalyzed allenoate reaction was not disclosed until recently by Ye and co-workers.[4k,l] The authors reported Lewis base catalyzed annulations of allenoates with cyclic ketimines bearing strong electron-withdrawing *N*-sulfonyl groups to give various *N*-heterocyclic compounds. Owing to the higher electrophilicity of α-trifluoromethyl ketimines[7] in comparison with their non-fluorinated analogues, we envisioned that a trifluoromethyl-substituted quinazolin-2(1*H*)-one[8,9] might be active enough to react with allenoates by using an appropriate Lewis base catalyst. Moreover, it is worth mentioning that the generated trifluoromethyl dihydroquinazoline derivatives could lead to the formation of druglike substances.[10] Very recently, we demonstrated that bisphosphine DPPP could catalyze a one-pot sequential [3 + 2]/[3 + 2] annulation process of ethyl 2,3-butadienoate **1** with cyclic trifluoromethyl ketimines **2**, providing the *N*-fused polycyclic compounds **3** in excellent

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Scheme 2. Reactions of Ethyl 2,3-Butadienoate 1 with Cyclic Trifluoromethyl Ketimines 2 Catalyzed by Lewis Bases

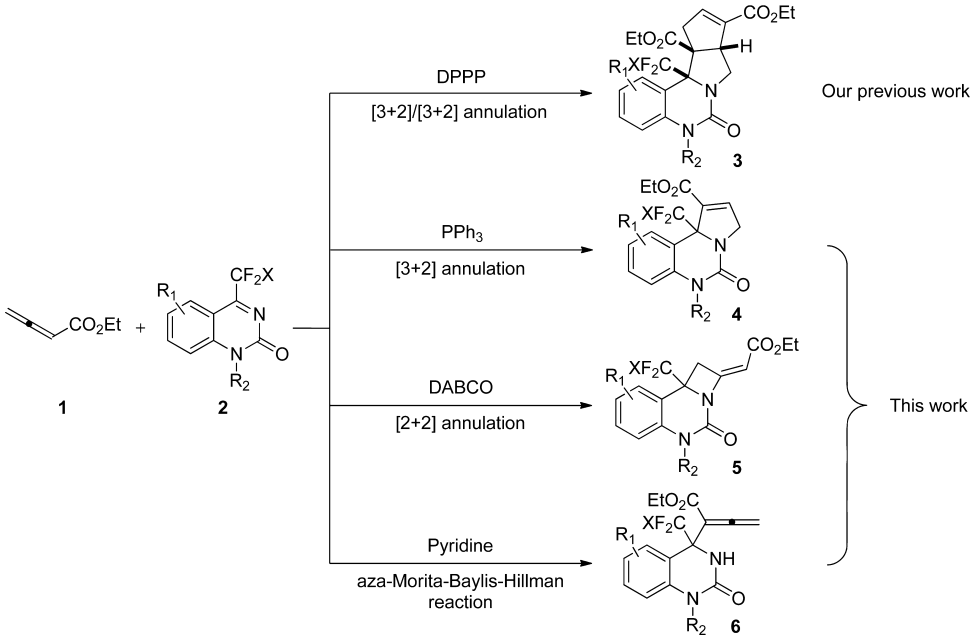
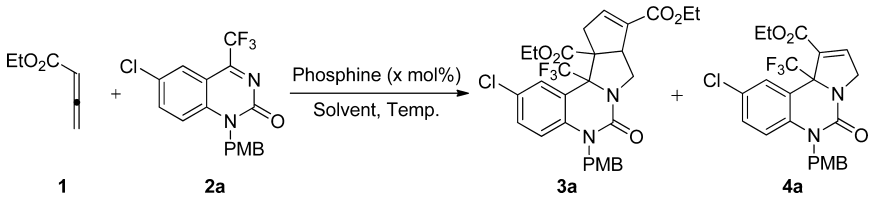


Table 1. Catalyst Screening and Reaction Optimization for the Reaction of Ethyl 2,3-Butadienoate (1) with Cyclic Trifluoromethyl Ketimine 2a Catalyzed by Monophosphine Lewis Bases[a]



				yield (%)[b]	
entry	phosphine	solvent	temp (°C)	**3a**	**4a**
1	PBu_3	toluene	25	59	28
2[c]	PCy_3	toluene	25	42	20
3	PPh_3	toluene	25	54	44
4	$P(NMe_2)_3$	toluene	25	35	31
5	$P(NEt_2)_3$	toluene	25	43	34
6	PPh_3	toluene	0	13	85
7	PPh_3	THF	0	11	86
8	PPh_3	Et_2O	0	23	66
9	PPh_3	DCM	0	8	88
10	PPh_3	CH_3CN	0	14	12
11[d]	PPh_3	DCM	0		96
12[d,e]	PPh_3	DCM	0		78

[a]Typical conditions: a mixture of **1** (0.20 mmol), **2a** (0.10 mmol), and phosphine (20 mol %) in solvent (1.0 mL) was stirred at a certain temperature for 12 h under an N_2 atmosphere. PMB = *p*-methoxybenzyl. [b]Isolated yield. [c]The reaction mixture was stirred for 24 h. [d]0.15 mmol of **1** was used. [e]10 mol % of PPh_3 was added.

regio- and diastereoselectivities (Scheme 2).[11] Considering that subtle variations about the Lewis base catalysts often give rise to different reaction outcomes, herein we wish to report our detailed investigation on the different reactivity patterns shown by phosphorus- and nitrogen-containing catalysts in the reactions of allenoate **1** with cyclic ketimines **2**.

RESULTS AND DISCUSSION

We first focused our effort on the investigation of phosphines for their ability to catalyze the reaction of ethyl 2,3-butadienoate (**1**) with cyclic ketimine **2a**. On the basis of our previous results, bis-phosphine mainly provided the sequential [3 + 2]/[3 + 2] annulation product **3a**, whereas monophosphine showed markedly different behavior, providing [3 + 2] cycloadduct **4a** together with the [3 + 2]/[3 + 2] cycloadduct **3a** (Table 1, entries 1−5). The structure of product **4a** was unambiguously established by a single-crystal X-ray analysis (see the Supporting Information).[12] Among the tested monophosphine Lewis bases, PPh_3 gave the highest yield of dihydropyrrole derivative **4a** at 44% (Table 1, entry 3). Additionally, the bulky PCy_3 showed low catalytic efficiency with 31% of the starting material **2a** recovered (Table 1, entry

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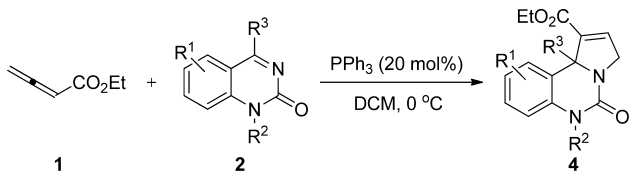
2). In the presence of $P(NMe_2)_3$ and $P(NEt_2)_3$, similar results were obtained (Table 1, entries 4 and 5). A subsequent change of the reaction temperature and the solvents revealed that the yield of **4a** could be significantly improved to 88% when the reaction was carried out in dichloromethane at 0 °C (Table 1, entry 9). To our delight, reducing the amount of ethyl 2,3-butadienoate (**1**) from 2.0 to 1.5 equiv led to the complete conversion of cyclic ketimine **2a** to [3 + 2] cycloadduct **4a** in nearly quantitative yield (Table 1, entry 11). Finally, an attempt to diminish the amount of PPh_3 to 10 mol % led to a negative result, giving **4a** in 78% isolated yield with 18% of **2a** left (Table 1, entry 12).

With the optimized reaction conditions in hand, we next tested a variety of cyclic ketimines **2** in the PPh_3-catalyzed [3 + 2] annulation. As shown in Table 2, a wide range of cyclic

Table 2. PPh_3-Catalyzed [3 + 2] Annulation Reaction of Ethyl 2,3-Butadienoate (1) with Cyclic Ketimines 2[a]



1 2 4

entry	2 (R^1, R^2, R^3)	time (h)	product 4	yield (%)[b]
1	**2a** (6-Cl, PMB, CF_3)	12	**4a**	96
2	**2b** (6-F, PMB, CF_3)	12	**4b**	94
3	**2c** (6-Br, PMB, CF_3)	12	**4c**	94
4	**2d** (5,6-F_2, PMB, CF_3)	12	**4d**	93
5	**2e** (5-F-6-Cl, PMB, CF_3)	12	**4e**	93
6	**2f** (6-CF_3, PMB, CF_3)	12	**4f**	95
7	**2g** (H, PMB, CF_3)	12	**4g**	92
8	**2h** (6-Me, PMB, CF_3)	12	**4h**	93
9	**2i** (6-^{i}Pr, PMB, CF_3)	12	**4i**	94
10	**2j** (6-MeO, PMB, CF_3)	24	**4j**	86
11	**2k** (6-Cl, 1-naphthylmethyl, CF_3)	12	**4k**	98
12	**2l** (6-Cl, TMB, CF_3)	12	**4l**	94
13	**2m** (6-Cl, H, CF_3)	24	**4m**	52
14	**2n** (6-Cl, PMB, CHF_2)	12	**4n**	97
15	**2o** (H, Bn, Ph)	24	**4o**	0
16	**2p** (6-Cl, PMB, Me)	24	**4p**	0

[a]Reaction conditions are the same as those in Table 1, entry 11. TMB = 2,4,6-trimethylbenzyl. [b]Isolated yield.

trifluoromethyl ketimines **2a–i** could readily react with ethyl 2,3-butadienoate (**1**) regardless of the steric and electronic properties of the substituents on the aromatic ring, providing the corresponding cycloadducts **4a–i** in excellent yields (Table 2, entries 1–9). In addition, ketimine **2j** showed relatively low reactivity due to its poor solubility in dichloromethane at 0 °C (Table 2, entry 10). The change of *N*-protecting groups at the cyclic ketimines did not have a significant effect on the reaction activity, giving the annulation products **4k,l** in equally excellent yields (Table 2, entries 11 and 12). A ketimine without a protecting group on the nitrogen atom (**2m**) could also be tolerated, although only a moderate yield was obtained with the requirement of a prolonged reaction time (Table 2, entry 13). When the trifluoromethyl group on the substrates was replaced with a difluoromethyl group (**2n**), the [3 + 2] annulation proceeded smoothly to afford the corresponding cycloadduct **4n** in 97% yield (Table 2, entry 14). However, when the trifluoromethyl group was replaced with a phenyl or methyl group, no annulation products were observed (Table 2, entries 15 and 16). These results indicated that the strongly electron withdrawing difluoromethyl or trifluoromethyl group is critical for the [3 + 2] annulation to occur.

In comparison to phosphines, amines display a markedly different behavior in the reactions of allenoates with electrophilic partners. However, the amine-catalyzed reaction of ethyl 2,3-butadienoate (**1**) with cyclic ketimines **2** has not been documented yet. Our further studies focused on the investigation of several commonly used nitrogen-containing Lewis bases for their ability to catalyze this reaction. Ketimine **2a** was chosen as the model substrate, and the reaction was initially performed in toluene at room temperature (25 °C) for 12 h. As shown in Table 3, DMAP and DABCO could promote a [2 + 2] annulation under the standard conditions, affording the corresponding cyclization product **5a** containing an azetidine ring in isolated yields of 25% and 50%, respectively (Table 3, entries 1 and 2). The structure of **5a**, including the assignment of the olefin as the *E* isomer, was determined by single-crystal X-ray structural analysis (see the Supporting Information).[13] Neither DBU nor Et_3N provided any reactivity in this reaction (Table 3, entries 3 and 4). Notably, pyridine was found to undergo a mechanistically divergent pathway, rather than giving [2 + 2] cyclization product **5a**, leading to the formation of the aza-MBH adduct **6a** in an extremely high yield (Table 3, entry 5).

We then chose DABCO as the [2 + 2] annulation catalyst and examined the solvent effects (Table 3, entries 6–11). Among the tested solvents, 1,4-dioxane was found to be the solvent of choice, improving the yield of **5a** to 81% (Table 3, entry 11). The next investigation showed that there was no positive effect observed when increasing the catalyst loading from 20 to 30 mol % (Table 3, entry 12), whereas reducing the catalyst amount to 10 mol % resulted in a slight decrease of the product yield (Table 3, entry 13). Finally, in order to maximize the yield of **5a**, we also attempted to elevate the reaction temperature to 60 °C; however, no expected improvement was obtained (Table 3, entry 14).

Next, we turned to study the catalytic behavior of pyridine in the aza-MBH reaction of ethyl 2,3-butadienoate (**1**) with cyclic ketimine **2a**. The reaction was performed with 20 mol % of pyridine at room temperature for 24 h in various solvents (Table 3, entries 15–19). Similar to the DABCO-catalyzed annulation, solvent also played an important role in this reaction. Toluene was proved to be the best solvent (Table 3, entry 5). Other solvents, such as dichloromethane, THF, and ether, gave product **6a** in lower yields (Table 3, entries 15–17). The reaction could hardly occur in acetonitrile or DMF (Table 3, entries 18 and 19). To our delight, the reaction could be performed at as low as 10 mol % catalyst loading without compromising the reactivity (Table 3, entries 20 and 21). Decreasing the amount of ethyl 2,3-butadienoate (**1**) from 2.0 to 1.5 equiv did not affect the yield of product **6a** (Table 3, entry 22).

Having identified the optimal reaction conditions, we set out to examine the scope and the limitations of the Lewis base catalyzed [2 + 2] annulation, as well as the aza-MBH reaction. Table 4 gives the results of DABCO-catalyzed [2 + 2] annulation of ethyl 2,3-butadienoate (**1**) with a series of cyclic ketimines **2**. Ketimines bearing electron-withdrawing groups at the 5- and/or 6-position of the aromatic ring (**2a–f**) showed superior activities, affording the cycloadducts **5a–f** in very high

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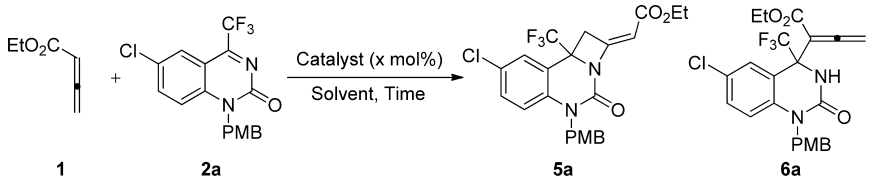
Table 3. Catalyst Screening and Reaction Optimization for the Reaction of Ethyl 2,3-Butadienoate (1) with Cyclic Trifluoromethyl Ketimine 2a Catalyzed by Nitrogen-Containing Lewis Bases[a]



1 2a 5a 6a

entry	Lewis base (x (mol %))	solvent	time (h)	yield (%)[b] 5a	yield (%)[b] 6a
1	DMAP (20)	toluene	12	25	
2	DABCO (20)	toluene	12	50	
3	DBU (20)	toluene	12		
4	Et_3N (20)	toluene	12		
5	pyridine (20)	toluene	24		95
6	DABCO (20)	DCM	12	32	
7	DABCO (20)	THF	12	63	
8	DABCO (20)	Et_2O	12	55	
9	DABCO (20)	MeCN	12	30	
10	DABCO (20)	DMF	12	27	
11	DABCO (20)	dioxane	12	81	
12	DABCO (30)	dioxane	12	79	
13	DABCO (10)	dioxane	12	72	
14[c]	DABCO (20)	dioxane	12	80	
15	pyridine (20)	DCM	24		82
16	pyridine (20)	THF	24		93
17	pyridine (20)	Et_2O	24		87
18	pyridine (20)	MeCN	24		7
19	pyridine (20)	DMF	24		
20	pyridine (10)	toluene	24		96
21	pyridine (5)	toluene	24		71
22[d]	pyridine (10)	toluene	24		95

[a]Typical conditions: a mixture of **1** (0.20 mmol), **2a** (0.10 mmol), and amine (5−30 mol %) in solvent (1.0 mL) was stirred at 25 °C for the stated time under an N_2 atmosphere. PMB = *p*-methoxybenzyl. [b]Isolated yield. [c]Reaction was carried out at 60 °C. [d]0.15 mmol of **1** was used.

yields within 12 h (Table 4, entries 1−6). In contrast, ketimine **2g** and those bearing electron-donating groups at the 6-position of the aromatic ring (**2h−j**) only gave products **5g−j** in moderate to good yields even with prolonged reaction times (Table 4, entries 7−10). The *N*-(1-naphthylmethyl)-protected and the *N*-TMB-protected cyclic ketimines (**2k,l**) were found to be equally effective substrates, delivering **5k,l** in isolated yields of 80% and 79%, respectively (Table 4, entries 11 and 12). However, a dramatic decrease in yield was observed when an *N*-protecting-group-free substrate (**2m**) was subjected to the reaction (Table 4, entry 13). This result indicated that the protecting group on the nitrogen atom of cyclic ketimines was indispensable in this reaction. In addition, a ketimine that replaced the trifluoromethyl group on the quinazolin-2(1*H*)-one ring with a difluoromethyl group (**2n**) or a phenyl group (**2o**) was not a suitable substrate (Table 4, entries 14 and 15). These results revealed that the strongly electron withdrawing trifluoromethyl group is also critical for the [2 + 2] annulation to proceed smoothly.

As shown in Table 5, the pyridine-catalyzed aza-MBH reaction was proved to be efficient for a range of cyclic ketimines **2**. Extremely high yields of the corresponding α,α'-disubstituted allenoates **6a−f** were obtained with the ketimines bearing electron-withdrawing groups (**2a−f**; Table 5, entries 1−6). In the case of the substrates bearing electron-neutral or electron-donating groups on the aromatic ring (**2g−j**), very high yields could still be obtained, although an extended reaction time was required (Table 5, entries 7−10). Ketimines with different *N*-protecting groups (**2k,l**) also proceeded efficiently to produce the aza-MBH adducts **6k,l** in excellent yields (Table 5, entries 11 and 12). Surprisingly, the reaction also tolerated the *N*-protecting-group-free ketimine (**2m**), although resulting in a reduced yield in comparison with the previous examples (Table 5, entry 13). A ketimine with a difluoromethyl group instead of the trifluoromethyl moiety on the quinazolin-2(1*H*)-one ring (**2n**) was well tolerated in the reaction (Table 5, entry 14); however, the analogous substrate that possesses a phenyl group (**2o**) was completely unreactive under the reaction conditions (Table 5, entry 15). These results once again clearly proved that the strongly electron withdrawing difluoromethyl or trifluoromethyl group in the substrates was indispensable.

The aza-MBH products **6** can be readily converted into various *N*-heterocyclic compounds (Scheme 3). Under the catalysis of 20 mol % DPPP, an intramolecular cyclization of allenoate **6a** could occur to afford dihydropyrrole derivative **4a** in 98% yield (Scheme 3a). In the presence of 20 mol % DPPP and 1.5 equiv of ethyl 2,3-butadienoate (**1**), the *N*-fused polycyclic compound **3a** was obtained through a one-pot sequential intramolecular cyclization/intermolecular [3 + 2] annulation process (Scheme 3b).

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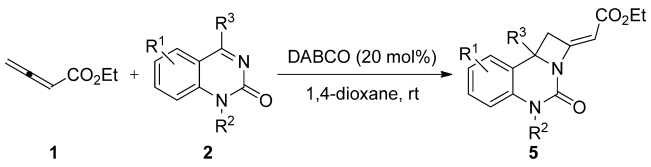
Table 4. DABCO-Catalyzed [2 + 2] Annulation Reaction of Ethyl 2,3-Butadienoate (1) with Cyclic Ketimines 2[a]

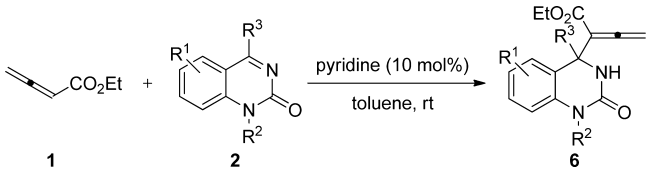


1 2 5

entry	2 (R^1, R^2, R^3)	time (h)	product 5	yield (%)[b]
1	**2a** (6-Cl, PMB, CF_3)	12	**5a**	81
2	**2b** (6-F, PMB, CF_3)	12	**5b**	85
3	**2c** (6-Br, PMB, CF_3)	12	**5c**	78
4	**2d** (5,6-F_2, PMB, CF_3)	12	**5d**	87
5	**2e** (5-F-6-Cl, PMB, CF_3)	12	**5e**	88
6	**2f** (6-CF_3, PMB, CF_3)	12	**5f**	77
7	**2g** (H, PMB, CF_3)	24	**5g**	64
8	**2h** (6-Me, PMB, CF_3)	24	**5h**	53
9	**2i** (6-^{i}Pr, PMB, CF_3)	24	**5i**	57
10	**2j** (6-MeO, PMB, CF_3)	24	**5j**	62
11	**2k** (6-Cl, 1-naphthylmethyl, CF_3)	12	**5k**	80
12	**2l** (6-Cl, TMB, CF_3)	12	**5l**	79
13	**2m** (6-Cl, H, CF_3)	48	**5m**	13
14	**2n** (6-Cl, PMB, CHF_2)	48	**5n**	18
15	**2o** (H, Bn, Ph)	48	**5o**	0

[a]Reaction conditions are the same as those in Table 3, entry 11. TMB = 2,4,6-trimethylbenzyl. [b]Isolated yield.

Table 5. Pyridine-Catalyzed Aza-Morita–Baylis–Hillman Reaction of Ethyl 2,3-Butadienoate (1) with Cyclic Ketimines 2[a]



1 2 6

entry	2 (R^1, R^2, R^3)	time (h)	product 6	yield (%)[b]
1	**2a** (6-Cl, PMB, CF_3)	24	**6a**	95
2	**2b** (6-F, PMB, CF_3)	24	**6b**	92
3	**2c** (6-Br, PMB, CF_3)	24	**6c**	90
4	**2d** (5,6-F_2, PMB, CF_3)	24	**6d**	94
5	**2e** (5-F-6-Cl, PMB, CF_3)	24	**6e**	96
6	**2f** (6-CF_3, PMB, CF_3)	24	**6f**	93
7	**2g** (H, PMB, CF_3)	60	**6g**	80
8	**2h** (6-Me, PMB, CF_3)	60	**6h**	74
9	**2i** (6-^{i}Pr, PMB, CF_3)	60	**6i**	75
10	**2j** (6-MeO, PMB, CF_3)	60	**6j**	78
11	**2k** (6-Cl, 1-naphthylmethyl, CF_3)	24	**6k**	89
12	**2l** (6-Cl, TMB, CF_3)	24	**6l**	93
13	**2m** (6-Cl, H, CF_3)	60	**6m**	70
14	**2n** (6-Cl, PMB, CHF_2)	60	**6n**	88
15	**2o** (H, Bn, Ph)	60	**6o**	0

[a]Reaction conditions are the same as those in Table 3, entry 22. TMB = 2,4,6-trimethylbenzyl. [b]Isolated yield.

On the basis of earlier reports[14] and our experimental results, possible mechanism processes under the catalysis of phosphorus- and nitrogen-containing Lewis bases are proposed in Scheme 4. Each catalytic cycle involves initial attack of the nucleophilic catalyst on the electrophilic β carbon of ethyl 2,3-butadienoate (**1**) to form the zwitterionic intermediate **IA**, **IB**, or **IC**. In the PPh_3-catalyzed pathway, cycloaddition of 1,3-dipole **IA** with ketimine **2** gives ylide intermediate **IIA**, which is stabilized by the phosphonium moiety. This ylide **IIA** then undergoes proton transfer and catalyst regeneration to afford dihydropyrrole derivative **4**. In the case of DABCO, the allylic carbanion **IB** reacts with ketimine **2** through γ addition to give the intermediate **IIB**. Subsequent intramolecular nucleophilic attack gives the zwitterionic intermediate **IIIB**, which then undergoes catalyst elimination along with double-bond formation to produce azetidine derivative **5** with concomitant regeneration of DABCO. With the aid of pyridine, the formed enolate intermediate **IC** may be stabilized by the pyridyl aromatic system and it can undergo α addition with ketimine **2**. The newly generated **IIC** cannot undergo a second C–C bond-formation step because the ammonium ion cannot similarly stabilize the ylide. Therefore, a proton transfer of the most acidic proton followed by a catalyst regeneration step yields the aza-MBH adduct **6**.

CONCLUSION

In summary, a detailed investigation on the different reactivity patterns shown by phosphorus- and nitrogen-containing catalysts in the reactions of allenoates with cyclic ketimines was accomplished. With PPh_3, [3 + 2] annulations proceeded smoothly to afford dihydropyrrole derivatives in excellent yields. Nitrogen-containing Lewis bases were applied to the reactions of allenoates and cyclic ketimines for the first time. Under the catalysis of DABCO, [2 + 2] annulations occurred instead of [3 + 2] annulations, producing azetidine derivatives in good to high yields. In the presence of pyridine, α,α'-disubstituted allenoates were obtained in very high yields via aza-Morita-Baylis-Hillman reactions. These studies provide an opportunity for diverse synthesis of a variety of *N*-heterocyclic compounds from same starting materials. Detailed mechanistic investigations and the development of enantioselective variants of these protocols are currently ongoing in our laboratory.

EXPERIMENTAL SECTION

General Information. ^{1}H, ^{13}C, and ^{19}F NMR were recorded at 400 or 600 MHz (^{1}H NMR), 100 or 150 MHz (^{13}C NMR), and 376 or 565 MHz (^{19}F NMR). Chemical shifts were reported in ppm downfield from internal Me_4Si and external CCl_3F, respectively. Multiplicity is indicated as follows: s (singlet), d (doublet), t (triplet), q (quartet), m (multiplet), dd (doublet of doublets), br (broad). Coupling constants are reported in hertz (Hz).

Materials. Tetrahydrofuran (THF), ether, toluene, and 1,4-dioxane were distilled from sodium/benzophenone; CH_2Cl_2 (DCM) and DMF were distilled from CaH_2; CH_3CN was distilled from P_2O_5. All commercially available reagents were used without further purification. Analytical thin-layer chromatography was performed on 0.20 mm silica gel plates. Silica gel (200–300 mesh) was used for flash chromatography. Ethyl 2,3-butadienoate was prepared according to the literature.[15] The ketimines were synthesized according to the literature.[10]

General Procedure for the [3 + 2] Annulation of Ethyl 2,3-Butadienoate (1) with Cyclic Ketimines 2 in the Presence of PPh_3. Under a N_2 atmosphere, a mixture of cyclic ketimine **2** (0.10 mmol), ethyl 2,3-butadienoate (**1**; 0.15 mmol), and PPh_3 (0.02 mmol) in DCM (1.0 mL) was stirred at 0 °C. After completion of the reaction (monitored by TLC), the resulting residue was purified on a silica gel column (1.3 × 20 cm) with the eluent (petroleum ether/ethyl acetate 8/1 to 4/1) to give the product **4**.

Ethyl 9-chloro-6-(4-methoxybenzyl)-5-oxo-10b-(trifluoromethyl)-3,5,6,10b-tetrahydropyrrolo[1,2-c]quinazoline-1-carboxylate (***4a***):

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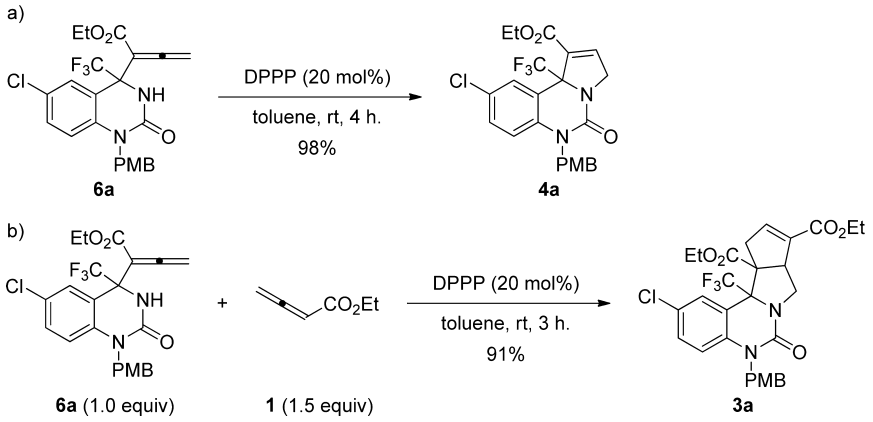
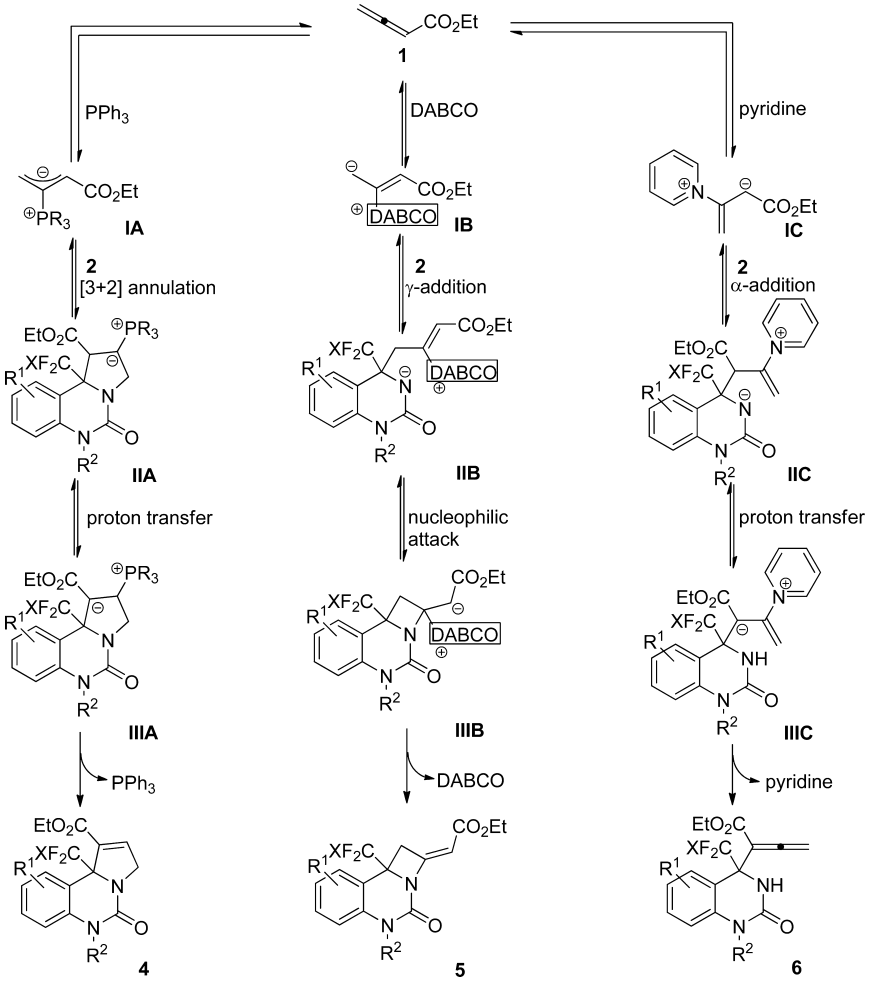
Scheme 3. Further Transformation of aza-MBH Product 6a



Scheme 4. Proposed Mechanisms for the Lewis Base Catalyzed Reactions of Ethyl 2,3-Butadienoate (1) with Cyclic Ketimines 2



46.2 mg; 96% yield; white solid; mp 128−130 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.28 (d, J = 1.2 Hz, 1H), 7.46 (s, 1H), 7.21−7.14 (m, 3H), 6.84 (d, J = 8.6 Hz, 2H), 6.81 (d, J = 9.0 Hz, 1H), 5.23 (d, J = 16.4 Hz, 1H), 4.96 (d, J = 16.4 Hz, 1H), 4.69 (d, J = 18.4 Hz, 1H), 4.52 (d, J = 18.4 Hz, 1H), 4.40 (d, J = 7.0 Hz, 1H), 4.37 (d, J = 7.0 Hz, 1H), 3.77 (s, 3H), 1.40 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.3, 159.0, 151.9, 146.4, 136.9, 133.0, 130.3, 128.5, 128.4, 128.1, 128.0, 124.8 (q, J = 289.5 Hz), 118.7, 116.3, 114.4, 72.4 (q, J = 32.0 Hz), 62.1, 55.4, 53.8, 46.6, 14.2; ^{19}F NMR (376 MHz, $CDCl_3$) δ −77.67; IR (KBr) ν 3096, 2982, 2936, 2362, 1725, 1677, 1619, 1507, 1425, 1247, 1177, 1095, 1030, 945, 811, 760, 545 cm^{-1}; HRMS (Supporting Information) found m/z 503.0950 [M + Na]$^+$, calcd for $C_{23}H_{20}ClF_3N_2O_4$ + Na 503.0956.

*Ethyl 9-fluoro-6-(4-methoxybenzyl)-5-oxo-10b-(trifluoromethyl)-3,5,6,10b-tetrahydropyrrolo[1,2-c]quinazoline-1-carboxylate (**4b**):* 43.6 mg; 94% yield; white solid; mp 123−125 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.08 (dd, J = 9.6, 2.2 Hz, 1H), 7.47 (s, 1H), 7.18 (d, J = 8.4 Hz, 2H), 6.96−6.92 (m, 1H), 6.86−6.81 (m, 3H), 5.22 (d, J = 16.4 Hz, 1H), 4.98 (d, J = 16.4 Hz, 1H), 4.70 (d, J = 18.6 Hz, 1H), 4.53 (d, J = 18.6 Hz, 1H), 4.38 (d, J = 7.1 Hz, 1H), 4.36 (d, J = 7.1 Hz, 1H), 3.77 (s, 3H), 1.38 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.3, 159.0, 158.2 (d, J = 240.5 Hz), 152.0, 146.4, 134.6,

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133.0, 128.6, 128.0, 124.9 (q, J = 289.0 Hz), 118.6 (d, J = 8.9 Hz), 117.0 (d, J = 22.6 Hz), 116.2 (d, J = 7.8 Hz), 115.7 (d, J = 26.5 Hz), 114.4, 72.4 (q, J = 32.0 Hz), 62.0, 55.4, 53.7, 46.7, 14.2; ^{19}F NMR (376 MHz, $CDCl_3$) δ −77.65 (s, 3F), −119.73 to −119.81 (m, 1F); IR (KBr) ν 2932, 2361, 1725, 1675, 1511, 1444, 1247, 1183, 1093, 1028, 818, 757, 670 cm^{-1}; HRMS (Supporting Information) found m/z 487.1248 [M + Na]$^+$, calcd for $C_{23}H_{20}F_4N_2O_4$ + Na 487.1251.

Ethyl 9-bromo-6-(4-methoxybenzyl)-5-oxo-10b-(trifluoromethyl)-3,5,6,10b-tetrahydropyrrolo[1,2-c]quinazoline-1-carboxylate ***(4c):*** 49.4 mg; 94% yield; white solid; mp 128−130 °C; ^{1}H NMR (400 MHz, DMSO) δ 8.30 (d, J = 1.5 Hz, 1H), 7.66 (s, 1H), 7.55 (d, J = 8.8 Hz, 1H), 7.19 (d, J = 8.5 Hz, 2H), 6.96 (d, J = 8.9 Hz, 1H), 6.87 (d, J = 8.5 Hz, 2H), 5.19 (d, J = 16.4 Hz, 1H), 4.96 (d, J = 16.4 Hz, 1H), 4.68 (d, J = 18.0 Hz, 1H), 4.44 (d, J = 18.0 Hz, 1H), 4.35 (d, J = 7.1 Hz, 1H), 4.31 (d, J = 7.1 Hz, 1H), 3.71 (s, 3H), 1.31 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.3, 159.1, 151.9, 146.3, 137.4, 133.3, 133.1, 131.3, 128.4, 128.0, 124.8 (q, J = 289.7 Hz), 119.1, 116.7, 115.4, 114.5, 72.3 (q, J = 32.0 Hz), 62.1, 55.4, 53.8, 46.6, 14.3; ^{19}F NMR (376 MHz, $CDCl_3$) δ −77.64; IR (KBr) ν 2918, 2848, 2362, 1725, 1676, 1619, 1509, 1397, 1247, 1177, 1095, 1028, 942, 808, 740, 537 cm^{-1}; HRMS (Supporting Information) found m/z 547.0458 [M + Na]$^+$, calcd for $C_{23}H_{20}BrF_3N_2O_4$ + Na 547.0451.

Ethyl 9,10-difluoro-6-(4-methoxybenzyl)-5-oxo-10b-(trifluoromethyl)-3,5,6,10b-tetrahydropyrrolo[1,2-c]quinazoline-1-carboxylate ***(4d):*** 44.9 mg; 93% yield; white solid; mp 116−118 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.16 (d, J = 8.5 Hz, 2H), 7.06 (q, J = 9.0 Hz, 1H), 6.93 (s, 1H), 6.84 (d, J = 8.5 Hz, 2H), 6.65−6.60 (m, 1H), 5.19 (d, J = 16.4 Hz, 1H), 4.97 (d, J = 16.4 Hz, 1H), 4.63 (d, J = 17.6 Hz, 1H), 4.52 (d, J = 17.6 Hz, 1H), 4.36 (d, J = 7.1 Hz, 1H), 4.32 (d, J = 7.1 Hz, 1H), 3.77 (s, 3H), 1.35 (t, J = 7.1 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 163.5 (d, J = 2.5 Hz), 159.0, 151.9, 147.8 (dd, J = 248.9 Hz, J = 15.2 Hz), 146.3 (dd, J = 243.9 Hz, J = 14.6 Hz) 140.2, 133.1 (d, J = 3.4 Hz), 128.1, 128.0, 124.3 (q, J = 288.7 Hz), 118.7 (d, J = 17.9 Hz), 114.5 (d, J = 3.0 Hz), 114.4, 110.5, 107.4 (d, J = 15.3 Hz), 71.7 (q, J = 33.3 Hz), 61.9, 55.3, 54.1, 47.0, 14.0; ^{19}F NMR (376 MHz, $CDCl_3$) δ −77.10 (d, J = 5.6 Hz, 3F), −133.53 to −133.63 (m, 1F), −144.14 to −144.24 (m, 1F); IR (KBr) ν: 2934, 2362, 1740, 1681, 1508, 1472, 1391, 1283, 1249, 1175, 1116, 1030, 828, 618 cm^{-1}; HRMS (Supporting Information) found m/z 505.1163 [M + Na]$^+$, calcd for $C_{23}H_{19}F_5N_2O_4$ + Na 505.1157.

Ethyl 9-chloro-10-fluoro-6-(4-methoxybenzyl)-5-oxo-10b-(trifluoromethyl)-3,5,6,10b-tetrahydropyrrolo[1,2-c]quinazoline-1-carboxylate ***(4e):*** 46.4 mg; 93% yield; white solid; mp 141−143 °C; ^{1}H NMR (600 MHz, DMSO) δ 7.61 (t, J = 8.4 Hz, 1H), 7.24−7.16 (m, 3H), 6.93−6.87 (m, 3H), 5.19 (d, J = 16.1 Hz, 1H), 4.98 (d, J = 16.1 Hz, 1H), 4.63 (d, J = 17.5 Hz, 1H), 4.42 (d, J = 17.5 Hz, 1H), 4.36−4.14 (m, 2H), 3.70 (s, 3H), 1.27 (t, J = 6.9 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 163.5 (d, J = 3.2 Hz), 159.1, 155.0 (d, J = 248.3 Hz), 151.9, 139.9, 138.8 (d, J = 4.8 Hz), 133.5 (d, J = 3.2 Hz), 132.0, 128.0, 127.9, 124.4 (q, J = 289.3 Hz), 115.5 (d, J = 19.7 Hz), 114.5, 111.6 (d, J = 3.5 Hz), 107.0 (d, J = 19.2 Hz), 72.2 (q, J = 31.7 Hz), 61.9, 55.4, 54.2, 47.1, 14.1; ^{19}F NMR (376 MHz, $CDCl_3$) δ −77.16 (d, J = 5.6 Hz, 3F), −110.38 to −110.41 (m, 1F); IR (KBr) ν 2983, 2935, 2361, 1739, 1682, 1613, 1489, 1389, 1248, 1174, 1112, 1027, 949, 805, 766, 583 cm^{-1}; HRMS (Supporting Information) found m/z 521.0859 [M + Na]$^+$, calcd for $C_{23}H_{19}ClF_4N_2O_4$ + Na 521.0862.

Ethyl 6-(4-methoxybenzyl)-5-oxo-9,10b-bis(trifluoromethyl)-3,5,6,10b-tetrahydropyrrolo[1,2-c]quinazoline-1-carboxylate ***(4f):*** 48.9 mg; 95% yield; white solid; mp 54−56 °C; ^{1}H NMR (400 MHz, DMSO) δ 8.54 (s, 1H), 7.73 (d, J = 8.4 Hz, 1H), 7.69 (s, 1H), 7.25−7.17 (m, 3H), 6.88 (d, J = 8.5 Hz, 2H), 5.25 (d, J = 16.4 Hz, 1H), 5.04 (d, J = 16.4 Hz, 1H), 4.71 (d, J = 18.2 Hz, 1H), 4.47 (d, J = 18.2 Hz, 1H), 4.36−4.27 (m, 2H), 3.70 (s, 3H), 1.29 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.3, 159.2, 151.7, 146.3, 141.1, 133.1, 128.2, 128.0, 127.6 (d, J = 3.3 Hz), 126.0 (d, J = 3.6 Hz), 124.9 (q, J = 33.3 Hz), 124.8 (q, J = 289.3 Hz), 124.1 (q, J = 269.8 Hz), 117.6, 115.2, 114.5, 72.5 (q, J = 32.1 Hz), 62.2, 55.4, 53.9, 46.8, 14.2; ^{19}F NMR (376 MHz, $CDCl_3$) δ −62.08 (s, 3F), −77.83 (s, 3F); IR (KBr) ν 2937, 2912, 2362, 1726, 1681, 1621, 1514, 1333, 1247, 1169, 1093, 1025, 818, 673, 516 cm^{-1}; HRMS (Supporting Information) found m/z 537.1219 [M + Na]$^+$, calcd for $C_{24}H_{20}F_6N_2O_4$ + Na 537.1220.

Ethyl 6-(4-methoxybenzyl)-5-oxo-10b-(trifluoromethyl)-3,5,6,10b-tetrahydropyrrolo[1,2-c]quinazoline-1-carboxylate ***(4g):*** 41.1 mg; 92% yield; white solid; mp 51−53 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.18 (d, J = 7.7 Hz, 1H), 7.44 (s, 1H), 7.27 (d, J = 9.1 Hz, 1H), 7.22 (d, J = 8.2 Hz, 2H), 7.05 (t, J = 7.4 Hz, 1H), 6.92 (d, J = 8.3 Hz, 1H), 6.86 (d, J = 8.2 Hz, 2H), 5.26 (d, J = 16.4 Hz, 1H), 5.03 (d, J = 16.4 Hz, 1H), 4.72 (d, J = 18.6 Hz, 1H), 4.55 (d, J = 18.6 Hz, 1H), 4.40 (d, J = 7.0 Hz, 1H), 4.37 (d, J = 7.0 Hz, 1H), 3.78 (s, 3H), 1.40 (t, J = 7.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.6, 158.9, 152.2, 145.8, 138.2, 133.4, 130.3, 129.0, 128.2, 128.0, 126.5, 125.0 (q, J = 289.2 Hz), 117.3, 115.1, 114.3, 72.6 (q, J = 32.0 Hz), 61.8, 55.4, 53.8, 46.5, 14.3; ^{19}F NMR (376 MHz, $CDCl_3$) δ −77.67; IR (KBr) ν 2933, 2362, 1727, 1674, 1511, 1463, 1402, 1246, 1177, 1095, 1029, 930, 758, 673 cm^{-1}; HRMS (Supporting Information) found m/z 469.1349 [M + Na]$^+$, calcd for $C_{23}H_{21}F_3N_2O_4$ + Na 469.1346.

Ethyl 6-(4-methoxybenzyl)-9-methyl-5-oxo-10b-(trifluoromethyl)-3,5,6,10b-tetrahydropyrrolo[1,2-c]quinazoline-1-carboxylate ***(4h):*** 42.8 mg; 93% yield; white solid; mp 60−62 °C; ^{1}H NMR (400 MHz, DMSO) δ 7.76 (s, 1H), 7.55 (s, 1H), 7.18 (d, J = 8.4 Hz, 2H), 7.14 (d, J = 7.9 Hz, 1H), 6.89 (d, J = 8.6 Hz, 1H), 6.86 (d, J = 8.4 Hz, 2H), 5.17 (d, J = 16.4 Hz, 1H), 4.94 (d, J = 16.4 Hz, 1H), 4.66 (d, J = 18.2 Hz, 1H), 4.41 (d, J = 18.2 Hz, 1H), 4.34 (d, J = 7.0 Hz, 1H), 4.31 (d, J = 7.0 Hz, 1H), 3.70 (s, 3H), 2.21 (s, 3H), 1.31 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.7, 158.9, 152.3, 145.7, 135.8, 133.5, 132.2, 130.9, 129.2, 128.5, 128.0, 125.1 (q, J = 289.5 Hz), 117.2, 115.0, 114.3, 72.6 (q, J = 31.9 Hz), 61.8, 55.4, 53.8, 46.4, 20.8, 14.3; ^{19}F NMR (376 MHz, $CDCl_3$) δ −77.59; IR (KBr) ν 2933, 2362, 1773, 1729, 1677, 1513, 1247, 1176, 1029, 815, 672, 511 cm^{-1}; HRMS (Supporting Information) found m/z 483.1498 [M + Na]$^+$, calcd for $C_{24}H_{23}F_3N_2O_4$ + Na 483.1502.

Ethyl 9-isopropyl-6-(4-methoxybenzyl)-5-oxo-10b-(trifluoromethyl)-3,5,6,10b-tetrahydropyrrolo[1,2-c]quinazoline-1-carboxylate ***(4i):*** 45.9 mg; 94% yield; white solid; mp 70−72 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.04 (s, 1H), 7.39 (s, 1H), 7.21 (d, J = 8.4 Hz, 2H), 7.10 (d, J = 8.5 Hz, 1H), 6.87−6.79 (m, 3H), 5.21 (d, J = 16.3 Hz, 1H), 4.99 (d, J = 16.3 Hz, 1H), 4.69 (d, J = 18.5 Hz, 1H), 4.52 (d, J = 18.5 Hz, 1H), 4.45−4.38 (m, 1H), 4.37−4.30 (m, 1H), 3.76 (s, 3H), 2.89−2.79 (m, 1H), 1.38 (t, J = 7.1 Hz, 3H), 1.20 (d, J = 4.0 Hz, 3H), 1.18 (d, J = 4.0 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.8, 158.9, 152.3, 145.5, 143.3, 136.0, 133.6, 129.2, 128.3, 128.1, 126.1, 125.1 (q, J = 288.7 Hz), 117.1, 114.9, 114.3, 72.7 (q, J = 30.5 Hz), 61.8, 55.4, 53.8, 46.4, 33.5, 24.1, 24.0, 14.3; ^{19}F NMR (376 MHz, $CDCl_3$) δ −77.67; IR (KBr) ν 2962, 2362, 1727, 1672, 1619, 1512, 1401, 1247, 1176, 1098, 1029, 816, 759, 672 cm^{-1}; HRMS (Supporting Information) found m/z 511.1822 [M + Na]$^+$, calcd for $C_{26}H_{27}F_3N_2O_4$ + Na 511.1815.

Ethyl 9-methoxy-6-(4-methoxybenzyl)-5-oxo-10b-(trifluoromethyl)-3,5,6,10b-tetrahydropyrrolo[1,2-c]quinazoline-1-carboxylate ***(4j):*** 41.0 mg; 86% yield; white solid; mp 54−56 °C; ^{1}H NMR (400 MHz, DMSO) δ 7.69 (s, 1H), 7.60 (s, 1H), 7.19 (d, J = 8.5 Hz, 2H), 6.97−6.90 (m, 2H), 6.86 (d, J = 8.5 Hz, 2H), 5.17 (d, J = 16.3 Hz, 1H), 4.93 (d, J = 16.3 Hz, 1H), 4.67 (d, J = 18.2 Hz, 1H), 4.42 (d, J = 18.2 Hz, 1H), 4.35−4.26 (m, 2H), 3.70 (s, 3H), 3.67 (s, 3H), 1.30 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.7, 158.9, 155.2, 152.2, 146.2, 133.3, 131.7, 129.2, 128.0, 125.1 (q, J = 289.7 Hz), 118.2, 116.1, 116.0, 114.3, 113.7, 72.6 (q, J = 31.7 Hz), 61.9, 55.7, 55.4, 53.7, 46.5, 14.3; ^{19}F NMR (376 MHz, $CDCl_3$) δ −77.64; IR (KBr) ν 2920, 2843, 2362, 1725, 1670, 1619, 1512, 1457, 1401, 1247, 1178, 1096, 1027, 814, 737 cm^{-1}; HRMS (Supporting Information) found m/z 499.1455 [M + Na]$^+$, calcd for $C_{24}H_{23}F_3N_2O_5$ + Na 499.1451.

Ethyl 9-chloro-6-(naphthalen-1-ylmethyl)-5-oxo-10b-(trifluoromethyl)-3,5,6,10b-tetrahydropyrrolo[1,2-c]quinazoline-1-carboxylate ***(4k):*** 49.1 mg; 98% yield; white solid; mp 207−209 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 8.37 (s, 1H), 8.06 (d, J = 8.3 Hz, 1H), 7.92 (d, J = 8.0 Hz, 1H), 7.77 (d, J = 8.1 Hz, 1H), 7.61 (t, J = 7.4 Hz, 1H), 7.56 (t, J = 7.4 Hz, 1H), 7.52 (s, 1H), 7.34 (t, J = 7.6 Hz, 1H), 7.14−7.08 (m, 2H), 6.62 (d, J = 8.9 Hz, 1H), 5.68 (d, J = 17.2 Hz, 1H), 5.57 (d, J = 17.2 Hz, 1H), 4.75 (d, J = 18.6 Hz, 1H), 4.57 (d, J = 18.6 Hz, 1H), 4.41 (q, J = 6.3 Hz, 2H), 1.42 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100

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MHz, $CDCl_3$) δ 162.3, 151.7, 146.5, 137.0, 134.1, 133.1, 130.7, 130.6, 130.4, 129.2, 128.5, 128.2, 127.9, 126.6, 126.1, 125.6, 124.9 (q, J = 289.3 Hz), 123.2, 122.5, 118.5, 116.5, 72.5 (q, J = 31.7 Hz), 62.1, 53.8, 45.2, 14.3; ^{19}F NMR (376 MHz, $CDCl_3$) δ −77.59; IR (KBr) ν 3056, 2980, 2362, 1725, 1679, 1500, 1401, 1277, 1244, 1181, 1094, 1016, 945, 795, 758 cm^{-1}; HRMS (Supporting Information) found m/z 523.1009 [M + Na]$^+$, calcd for $C_{26}H_{20}ClF_3N_2O_3$ + Na 523.1007.

Ethyl 9-chloro-5-oxo-10b-(trifluoromethyl)-6-(2,4,6-trimethylbenzyl)-3,5,6,10b-tetrahydropyrrolo[1,2-c]quinazoline-1-carboxylate (**4l**): 46.3 mg; 94% yield; white solid; mp 151−153 °C; ^{1}H NMR (400 MHz, DMSO) δ 8.18 (d, J = 1.8 Hz, 1H), 7.60 (s, 1H), 7.53 (d, J = 8.9 Hz, 1H), 7.36 (d, J = 9.0 Hz, 1H), 6.78 (s, 2H), 5.05 (d, J = 15.1 Hz, 1H), 4.90 (d, J = 15.1 Hz, 1H), 4.59 (d, J = 18.3 Hz, 1H), 4.37−4.28 (m, 3H), 2.23 (s, 6H), 2.17 (s, 3H), 1.30 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.3, 152.0, 146.3, 137.8, 137.2, 137.1, 130.4, 129.9, 129.8, 129.0, 128.7, 127.9, 124.5 (q, J = 288.4 Hz), 118.5, 115.4, 72.5 (q, J = 32.0 Hz), 62.1, 53.9, 43.6, 30.8, 20.2, 14.2; ^{19}F NMR (376 MHz, $CDCl_3$) δ −77.09; IR (KBr) ν 2962, 2929, 2362, 1726, 1678, 1498, 1399, 1245, 1179, 1094, 1018, 808, 757, 554 cm^{-1}; HRMS (Supporting Information) found m/z 515.1314 [M + Na]$^+$, calcd for $C_{25}H_{24}ClF_3N_2O_3$ + Na 515.1320.

Ethyl 9-chloro-5-oxo-10b-(trifluoromethyl)-3,5,6,10b-tetrahydropyrrolo[1,2-c]quinazoline-1-carboxylate (**4m**): 18.8 mg; 52% yield; white solid; mp 106−108 °C; ^{1}H NMR (600 MHz, DMSO) δ 10.25 (s, 1H), 8.14 (s, 1H), 7.61 (s, 1H), 7.43 (d, J = 8.3 Hz, 1H), 7.04 (d, J = 8.5 Hz, 1H), 4.58 (d, J = 18.8 Hz, 1H), 4.36−4.26 (m, 3H), 1.29 (t, J = 6.9 Hz, 3H); ^{13}C NMR (100 MHz, DMSO) δ 162.1, 150.6, 148.5, 136.8, 130.4, 130.3, 127.1, 125.3, 124.9 (q, J = 289.5 Hz), 116.5, 115.4, 72.6 (q, J = 31.2 Hz), 61.5, 53.0, 13.8; ^{19}F NMR (376 MHz, DMSO) δ −77.61; IR (KBr) ν 3525, 3441, 3122, 1718, 1700, 1682, 1653, 1400, 1167, 1086, 945, 767, 530 cm^{-1}; HRMS (Supporting Information) found m/z 383.0380 [M + Na]$^+$, calcd for $C_{15}H_{12}ClF_3N_2O_3$ + Na 383.0386.

Ethyl 9-chloro-10b-(difluoromethyl)-6-(4-methoxybenzyl)-5-oxo-3,5,6,10b-tetrahydropyrrolo[1,2-c]quinazoline-1-carboxylate (**4n**): 44.9 mg; 97% yield; white solid; mp 142−144 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.74 (d, J = 2.1 Hz, 1H), 7.24 (s, 1H), 7.19 (d, J = 8.5 Hz, 2H), 7.14 (d, J = 8.8 Hz, 1H), 6.83 (d, J = 8.5 Hz, 2H), 6.78 (d, J = 8.9 Hz, 1H), 6.29 (t, J = 55.4 Hz, 1H), 5.30 (d, J = 16.4 Hz, 1H), 4.88 (d, J = 16.4 Hz, 1H), 4.70 (dd, J = 18.5, 1.7 Hz, 1H), 4.56 (dd, J = 18.5, 1.7 Hz, 1H), 4.42 (d, J = 7.1 Hz, 1H), 4.38 (d, J = 7.1 Hz, 1H), 3.76 (s, 3H), 1.40 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.0, 158.9, 152.7, 143.7, 137.2, 133.6 (d, J = 4.0 Hz), 129.7, 128.7, 128.1 (d, J = 1.7 Hz), 127.7, 126.2, 120.9 (d, J = 4.3 Hz), 116.3, 115.6 (t, J = 250.7 Hz), 114.3, 72.3 (t, J = 19.8 Hz), 62.1, 55.4, 54.7, 46.5, 14.3; ^{19}F NMR (376 MHz, $CDCl_3$) δ −128.44 (dd, J = 269.2, 55.3 Hz, 1F), δ −134.39 (dd, J = 269.2, 55.6 Hz, 1F); IR (KBr) ν 2962, 2935, 2362, 1712, 1674, 1505, 1398, 1247, 1078, 1029, 812, 767, 674, 525 cm^{-1}; HRMS (Supporting Information) found m/z 485.1055 [M + Na]$^+$, calcd for $C_{23}H_{21}ClF_2N_2O_4$ + Na 485.1050.

General Procedure for the [2 + 2] Annulation of Ethyl 2,3-Butadienoate (1) with Cyclic Ketimines 2 in the Presence of DABCO. Under an N_2 atmosphere, a mixture of cyclic ketimine **2** (0.10 mmol), ethyl 2,3-butadienoate (**1**; 0.20 mmol), and DABCO (0.02 mmol) in 1,4-dioxane (1.0 mL) was stirred at room temperature (25 °C). After completion of the reaction (monitored by TLC), the resulting residue was purified on a silica gel column (1.3 × 20 cm) with the eluent (petroleum ether/ethyl acetate 20/1 to 8/1) to give the product **5**.

(E)-Ethyl 2-(8-chloro-5-(4-methoxybenzyl)-4-oxo-9b-(trifluoromethyl)-4,5-dihydro-1H-azeto[1,2-c]quinazolin-2(9bH)-ylidene)-acetate (**5a**): 39.0 mg; 81% yield; white solid; mp 74−76 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.22 (d, J = 8.5 Hz, 2H), 7.14 (d, J = 8.5 Hz, 2H), 6.87−6.80 (m, 3H), 6.06 (s, 1H), 5.26 (d, J = 16.2 Hz, 1H), 4.79 (d, J = 16.2 Hz, 1H), 4.17 (d, J = 7.0 Hz, 1H), 4.14 (d, J = 7.0 Hz, 1H), 3.92 (d, J = 16.6 Hz, 1H), 3.79 (d, J = 16.6 Hz, 1H), 3.76 (s, 3H), 1.27 (t, J = 7.1 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 166.4, 158.9, 155.6, 149.4, 137.4, 130.7, 128.8, 127.7, 127.2, 126.3, 123.8 (q, J = 282.3 Hz), 119.1, 117.3, 114.2, 98.0, 66.5 (q, J = 32.9 Hz), 59.8, 54.9, 45.9, 40.5, 14.1; ^{19}F NMR (376 MHz, $CDCl_3$) δ −81.36; IR (KBr) ν 2838, 1719, 1663, 1514, 1493, 1359, 1337, 1251, 1179, 1033, 836 cm^{-1}; HRMS (Supporting Information) found m/z 503.0955 [M + Na]$^+$, calcd for $C_{23}H_{20}ClF_3N_2O_4$ + Na 503.0961.

(E)-Ethyl 2-(8-fluoro-5-(4-methoxybenzyl)-4-oxo-9b-(trifluoromethyl)-4,5-dihydro-1H-azeto[1,2-c]quinazolin-2(9bH)-ylidene)-acetate (**5b**): 39.5 mg; 85% yield; white solid; mp 123−125 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.15 (d, J = 8.4 Hz, 2H), 7.03−6.94 (m, 2H), 6.87 (d, J = 4.8 Hz, 1H), 6.84 (d, J = 8.4 Hz, 2H), 6.06 (s, 1H), 5.26 (d, J = 16.3 Hz, 1H), 4.80 (d, J = 16.3 Hz, 1H), 4.16 (q, J = 7.1 Hz, 2H), 3.92 (d, J = 16.5 Hz, 1H), 3.82−3.73 (m, 4H), 1.27 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.0, 159.3, 158.8 (d, J = 244.6 Hz), 155.8, 150.0, 135.3 (d, J = 2.4 Hz), 128.0, 127.6, 124.1 (q, J = 282.5 Hz), 119.5 (d, J = 7.4 Hz), 117.8 (d, J = 30.5 Hz), 117.7, 114.6, 113.7 (d, J = 24.1 Hz), 98.3, 66.9 (q, J = 32.6 Hz), 60.2, 55.4, 46.4, 40.8, 14.5; ^{19}F NMR (376 MHz, $CDCl_3$) δ −81.32 (s, 3F), −118.44 to −118.49 (m, 1F); IR (KBr) ν 2980, 1719, 1661, 1514, 1491, 1358, 1336, 1250, 1178, 1033, 835, 743 cm^{-1}; HRMS (Supporting Information) found m/z 487.1253 [M + Na]$^+$, calcd for $C_{23}H_{20}F_4N_2O_4$ + Na 487.1257.

(E)-Ethyl 2-(8-bromo-5-(4-methoxybenzyl)-4-oxo-9b-(trifluoromethyl)-4,5-dihydro-1H-azeto[1,2-c]quinazolin-2(9bH)-ylidene)-acetate (**5c**): 41.0 mg; 78% yield; white solid; mp 58−60 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.41−7.33 (m, 2H), 7.14 (d, J = 8.5 Hz, 2H), 6.84 (d, J = 8.5 Hz, 2H), 6.77 (d, J = 9.5 Hz, 1H), 6.06 (s, 1H), 5.26 (d, J = 16.3 Hz, 1H), 4.79 (d, J = 16.3 Hz, 1H), 4.16 (q, J = 7.1 Hz, 2H), 3.92 (d, J = 16.5 Hz, 1H), 3.82−3.74 (m, 4H), 1.27 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.9, 159.3, 155.7, 149.8, 138.2, 133.9, 129.5, 128.0, 127.4, 124.0 (q, J = 282.1 Hz), 119.8, 117.8, 116.5, 114.6, 98.5, 66.8 (q, J = 32.8 Hz), 60.2, 55.4, 46.3, 40.9, 14.5; ^{19}F NMR (376 MHz, $CDCl_3$) δ −81.36; IR (KBr) ν 2961, 1719, 1662, 1506, 1446, 1361, 1251, 1180, 1035, 838 cm^{-1}; HRMS (Supporting Information) found m/z 547.0453 [M + Na]$^+$, calcd for $C_{23}H_{20}BrF_3N_2O_4$ + Na 547.0456.

(E)-Ethyl 2-(8,9-difluoro-5-(4-methoxybenzyl)-4-oxo-9b-(trifluoromethyl)-4,5-dihydro-1H-azeto[1,2-c]quinazolin-2(9bH)-ylidene)-acetate (**5d**): 42.0 mg; 87% yield; white solid; mp 43−45 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.14 (d, J = 8.0 Hz, 2H), 7.09 (d, J = 8.7 Hz, 1H), 6.83 (d, J = 8.0 Hz, 2H), 6.64 (d, J = 7.9 Hz, 1H), 6.05 (s, 1H), 5.26 (d, J = 16.2 Hz, 1H), 4.77 (d, J = 16.2 Hz, 1H), 4.16 (dd, J = 13.2, 6.3 Hz, 2H), 3.94 (q, J = 16.9 Hz, 2H), 3.75 (s, 3H), 1.27 (t, J = 6.6 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 166.7, 159.2, 155.9, 149.5, 147.5 (dd, J = 250.8 Hz, J = 15.5 Hz), 146.6 (dd, J = 246.2 Hz, J = 11.9 Hz), 135.9, 128.0, 127.2, 124.0 (q, J = 282.8 Hz), 119.3 (d, J = 18.0 Hz), 114.5, 111.7, 107.9 (d, J = 16.5 Hz), 98.5, 65.0 (q, J = 34.7 Hz), 60.2, 55.3, 46.5, 39.9, 14.4; ^{19}F NMR (376 MHz, $CDCl_3$) δ −81.35 (d, J = 11.3 Hz, 3F), −137.23 to −137.40 (m, 1F), −142.69 to −142.78 (m, 1F); IR (KBr) ν 2979, 1721, 1665, 1506, 1359, 1337, 1252, 1180, 1114, 1034, 836, 807 cm^{-1}; HRMS (Supporting Information) found m/z 505.1157 [M + Na]$^+$, calcd for $C_{23}H_{19}F_5N_2O_4$ + Na 505.1163.

(E)-Ethyl 2-(8-chloro-9-fluoro-5-(4-methoxybenzyl)-4-oxo-9b-(trifluoromethyl)-4,5-dihydro-1H-azeto[1,2-c]quinazolin-2(9bH)-ylidene)acetate (**5e**): 43.9 mg; 88% yield; white solid; mp 65−67 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35−7.27 (m, 1H), 7.14 (d, J = 8.5 Hz, 2H), 6.84 (d, J = 8.5 Hz, 2H), 6.67 (d, J = 9.0 Hz, 1H), 6.06 (s, 1H), 5.27 (d, J = 16.3 Hz, 1H), 4.78 (d, J = 16.3 Hz, 1H), 4.17 (q, J = 7.1 Hz, 2H), 4.01−3.86 (m, 2H), 3.77 (s, 3H), 1.28 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.7, 159.4, 155.9, 155.1 (d, J = 250.4 Hz), 149.5, 139.3 (d, J = 4.5 Hz), 132.6, 128.0, 127.2, 124.0 (q, J = 282.3 Hz), 116.3 (d, J = 17.3 Hz), 114.6, 112.5 (d, J = 3.7 Hz), 107.4 (d, J = 19.8 Hz), 98.7, 65.3 (q, J = 34.0 Hz), 60.3, 55.4, 46.6, 40.0, 14.5; ^{19}F NMR (376 MHz, $CDCl_3$) δ −81.29 (d, J = 11.7 Hz, 3F), −115.05 to −115.16 (m, 1F); IR (KBr) ν 2961, 1721, 1664, 1615, 1515, 1495, 1357, 1337, 1251, 1183, 1037, 836, 743 cm^{-1}; HRMS (Supporting Information) found m/z 521.0862 [M + Na]$^+$, calcd for $C_{23}H_{19}ClF_4N_2O_4$ + Na 521.0867.

(E)-Ethyl 2-(5-(4-methoxybenzyl)-4-oxo-8,9b-bis(trifluoromethyl)-4,5-dihydro-1H-azeto[1,2-c]quinazolin-2(9bH)-ylidene)acetate (**5f**): 39.6 mg; 77% yield; white solid; mp 64−66 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54 (d, J = 8.8 Hz, 1H), 7.50 (s, 1H), 7.16 (d, J = 8.5 Hz, 2H), 7.01 (d, J = 8.7 Hz, 1H), 6.86 (d, J = 8.5 Hz, 2H), 6.09 (s, 1H), 5.31 (d, J = 16.3 Hz, 1H), 4.86 (d, J = 16.3 Hz, 1H), 4.17 (q, J = 7.1

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Hz, 2H), 3.98 (d, J = 16.5 Hz, 1H), 3.84 (d, J = 16.5 Hz, 1H), 3.77 (s, 3H), 1.28 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.8, 159.4, 155.5, 149.7, 142.0, 128.3 (q, J = 3.7 Hz), 128.0, 127.1, 126.1 (q, J = 33.4 Hz), 124.0 (q, J = 282.0 Hz), 123.9 (q, J = 3.4 Hz), 123.6 (q, J = 270.2 Hz), 118.4, 116.5, 114.7, 98.9, 67.0 (q, J = 33.4 Hz), 60.3, 55.4, 46.6, 41.0, 14.5; ^{19}F NMR (376 MHz, $CDCl_3$) δ −62.28 (s, 3F), −81.53 (s, 3F); IR (KBr) ν 2963, 1721, 1664, 1624, 1513, 1358, 1332, 1255, 1176, 1131, 1088, 1033, 834, 741 cm^{-1}; HRMS (Supporting Information) found m/z 537.1215 [M + Na]$^+$, calcd for $C_{24}H_{20}F_6N_2O_4$ + Na 537.1225.

*(E)-Ethyl 2-(5-(4-methoxybenzyl)-4-oxo-9b-(trifluoromethyl)-4,5-dihydro-1H-azeto[1,2-c]quinazolin-2(9bH)-ylidene)acetate (**5g**):* 28.6 mg; 64% yield; white solid; mp 42−44 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.25−7.21 (m, 2H), 7.15 (d, J = 8.4 Hz, 2H), 7.09 (t, J = 7.4 Hz, 1H), 6.88 (d, J = 8.3 Hz, 1H), 6.82 (d, J = 8.4 Hz, 2H), 6.03 (s, 1H), 5.25 (d, J = 16.2 Hz, 1H), 4.81 (d, J = 16.2 Hz, 1H), 4.14 (d, J = 7.0 Hz, 1H), 4.12 (d, J = 7.0 Hz, 1H), 3.90 (d, J = 16.6 Hz, 1H), 3.77 (d, J = 16.6 Hz, 1H), 3.74 (s, 3H), 1.24 (t, J = 7.2 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 167.1, 159.1, 156.3, 150.2, 138.9, 131.0, 129.0, 128.0, 126.6, 124.2 (q, J = 282.0 Hz), 123.8, 117.9, 116.2, 114.4, 98.0, 67.1 (q, J = 32.8 Hz), 60.1, 55.4, 46.2, 40.8, 14.5; ^{19}F NMR (376 MHz, $CDCl_3$) δ −81.49; IR (KBr) ν 2963, 1717, 1661, 1513, 1383, 1250, 1175, 1148, 752 cm^{-1}; HRMS (Supporting Information) found m/z 469.1351 [M + Na]$^+$, calcd for $C_{23}H_{21}F_3N_2O_4$ + Na 469.1351.

*(E)-Ethyl 2-(5-(4-methoxybenzyl)-8-methyl-4-oxo-9b-(trifluoromethyl)-4,5-dihydro-1H-azeto[1,2-c]quinazolin-2(9bH)-ylidene)acetate (**5h**):* 24.4 mg; 53% yield; white solid; mp 45−47 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.16 (d, J = 8.3 Hz, 2H), 7.09−7.02 (m, 2H), 6.83 (d, J = 8.3 Hz, 2H), 6.79 (d, J = 8.2 Hz, 1H), 6.05 (s, 1H), 5.26 (d, J = 16.2 Hz, 1H), 4.81 (d, J = 16.2 Hz, 1H), 4.16 (d, J = 7.0 Hz, 1H), 4.14 (d, J = 7.0 Hz, 1H), 3.91 (d, J = 16.7 Hz, 1H), 3.78 (d, J = 16.7 Hz, 1H), 3.75 (s, 3H), 2.29 (s, 3H), 1.27 (t, J = 7.0 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 167.2, 159.0, 156.5, 150.3, 136.5, 133.7, 131.5, 128.0, 128.0, 127.0, 124.3 (q, J = 281.7 Hz), 117.8, 116.0, 114.4, 97.7, 67.1 (q, J = 32.6 Hz), 60.1, 55.4, 46.1, 40.8, 20.6, 14.5; ^{19}F NMR (376 MHz, $CDCl_3$) δ −81.39; IR (KBr) ν 2927, 1717, 1660, 1622, 1575, 1513, 1362, 1251, 1174, 1035, 838, 750 cm^{-1}; HRMS (Supporting Information) found m/z 483.1502 [M + Na]$^+$, calcd for $C_{24}H_{23}F_3N_2O_4$ + Na 483.1508.

*(E)-Ethyl 2-(8-isopropyl-5-(4-methoxybenzyl)-4-oxo-9b-(trifluoromethyl)-4,5-dihydro-1H-azeto[1,2-c]quinazolin-2(9bH)-ylidene)acetate (**5i**):* 27.8 mg; 57% yield; white solid; mp 44−46 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.18 (d, J = 8.4 Hz, 2H), 7.13 (d, J = 8.4 Hz, 1H), 7.08 (s, 1H), 6.87−6.80 (m, 3H), 6.05 (s, 1H), 5.25 (d, J = 16.2 Hz, 1H), 4.82 (d, J = 16.2 Hz, 1H), 4.17 (d, J = 7.1 Hz, 1H), 4.14 (d, J = 7.1 Hz, 1H), 3.93 (d, J = 16.5 Hz, 1H), 3.80 (d, J = 16.5 Hz, 1H), 3.76 (s, 3H), 2.89−2.82 (m, 1H), 1.27 (t, J = 7.1 Hz, 3H), 1.20 (s, 3H), 1.19 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.2, 159.1, 156.5, 150.3, 144.7, 136.8, 128.9, 128.2, 128.1, 124.5, 124.3 (q, J = 282.1 Hz), 117.8, 116.1, 114.5, 97.7, 67.2 (q, J = 32.7 Hz), 60.1, 55.4, 46.2, 40.8, 33.4, 24.0, 14.5; ^{19}F NMR (376 MHz, $CDCl_3$) δ −81.43; IR (KBr) ν 2962, 1717, 1659, 1615, 1462, 1362, 1251, 1174, 1034, 834, 743 cm^{-1}; HRMS (Supporting Information) found m/z 511.1821 [M + Na]$^+$, calcd for $C_{26}H_{27}F_3N_2O_4$ + Na 511.1821.

*(E)-Ethyl 2-(8-methoxy-5-(4-methoxybenzyl)-4-oxo-9b-(trifluoromethyl)-4,5-dihydro-1H-azeto[1,2-c]quinazolin-2(9bH)-ylidene)acetate (**5j**):* 29.5 mg; 62% yield; white solid; mp 121−123 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.16 (d, J = 8.3 Hz, 2H), 6.83 (d, J = 8.3 Hz, 2H), 6.82−6.76 (m, 3H), 6.04 (s, 1H), 5.25 (d, J = 16.3 Hz, 1H), 4.79 (d, J = 16.3 Hz, 1H), 4.16 (d, J = 7.1 Hz, 1H), 4.13 (d, J = 7.1 Hz, 1H), 3.91 (d, J = 16.5 Hz, 1H), 3.78 (d, J = 16.5 Hz, 1H), 3.75 (s, 3H), 3.74 (s, 3H), 1.26 (t, J = 7.1 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 167.2, 159.1, 156.3, 156.0, 150.2, 132.3, 128.1, 128.0, 124.2 (q, J = 281.5 Hz), 119.0, 117.3, 116.0, 114.5, 112.2, 97.7, 67.1 (q, J = 32.6 Hz), 60.1, 55.8, 55.4, 46.2, 40.8, 14.5; ^{19}F NMR (376 MHz, $CDCl_3$) δ −81.19; IR (KBr) ν 2921, 1716, 1660, 1509, 1459, 1365, 1250, 1176, 1035, 837, 744 cm^{-1}; HRMS (Supporting Information) found m/z 499.1448 [M + Na]$^+$, calcd for $C_{24}H_{23}F_3N_2O_5$ + Na 499.1457.

*(E)-Ethyl 2-(8-chloro-5-(naphthalen-1-ylmethyl)-4-oxo-9b-(trifluoromethyl)-4,5-dihydro-1H-azeto[1,2-c]quinazolin-2(9bH)-ylidene)acetate (**5k**):* 40.1 mg; 80% yield; white solid; mp 179−181 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.89 (d, J = 8.3 Hz, 1H), 7.80 (d, J = 8.0 Hz, 1H), 7.66 (d, J = 8.1 Hz, 1H), 7.49 (t, J = 7.4 Hz, 1H), 7.44 (t, J = 7.4 Hz, 1H), 7.23 (t, J = 7.6 Hz, 1H), 7.18 (s, 1H), 7.03 (d, J = 7.0 Hz, 2H), 6.56 (d, J = 8.9 Hz, 1H), 6.00 (s, 1H), 5.67 (d, J = 17.1 Hz, 1H), 5.23 (d, J = 17.1 Hz, 1H), 4.08 (q, J = 7.2 Hz, 2H), 3.87 (d, J = 16.5 Hz, 1H), 3.76 (d, J = 16.5 Hz, 1H), 1.18 (t, J = 7.2 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 166.9, 155.7, 149.7, 137.7, 134.0, 131.1, 130.6, 129.6, 129.4, 129.3, 128.2, 126.7, 126.6, 126.2, 125.5, 124.0 (q, J = 282.0 Hz), 123.4, 122.3, 119.2, 117.6, 98.5, 66.9 (q, J = 33.0 Hz), 60.2, 44.6, 40.9, 14.5; ^{19}F NMR (376 MHz, $CDCl_3$) δ −81.22; IR (KBr) ν 3056, 2981, 1719, 1662, 1494, 1359, 1335, 1183, 1038, 795, 738 cm^{-1}; HRMS (Supporting Information) found m/z 523.1008 [M + Na]$^+$, calcd for $C_{26}H_{20}ClF_3N_2O_3$ + Na 523.1012.

*(E)-Ethyl 2-(8-chloro-4-oxo-9b-(trifluoromethyl)-5-(2,4,6-trimethylbenzyl)-4,5-dihydro-1H-azeto[1,2-c]quinazolin-2(9bH)-ylidene)-acetate (**5l**):* 38.9 mg; 79% yield; white solid; mp 155−157 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.34 (d, J = 8.9 Hz, 1H), 7.24 (s, 1H), 7.04 (d, J = 9.0 Hz, 1H), 6.84 (s, 2H), 6.06 (s, 1H), 5.32 (d, J = 14.9 Hz, 1H), 4.62 (d, J = 14.9 Hz, 1H), 4.14 (qd, J = 7.0, 1.8 Hz, 2H), 3.89 (d, J = 17.1 Hz, 1H), 3.74 (d, J = 17.1 Hz, 1H), 2.34 (s, 6H), 2.25 (s, 3H), 1.26 (t, J = 7.1 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 166.8, 155.8, 150.2, 138.7, 137.6, 137.4, 131.0, 129.8, 129.1, 128.8, 126.8, 123.8 (q, J = 282.0 Hz), 119.5, 116.4, 98.8, 67.1 (q, J = 32.9 Hz), 60.1, 43.0, 41.3, 21.0, 20.0, 14.5; ^{19}F NMR (376 MHz, $CDCl_3$) δ −80.59; IR (KBr) ν 3132, 1720, 1663, 1493, 1398, 1336, 1178, 1038, 884, 837 cm^{-1}; HRMS (Supporting Information) found m/z 515.1319 [M + Na]$^+$, calcd for $C_{25}H_{24}ClF_3N_2O_3$ + Na 515.1325.

*(E)-Ethyl 2-(8-chloro-4-oxo-9b-(trifluoromethyl)-4,5-dihydro-1H-azeto[1,2-c]quinazolin-2(9bH)-ylidene)acetate (**5m**):* 4.7 mg; 13% yield; white solid; mp 216−218 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 9.24 (s, 1H), 7.28 (d, J = 7.6 Hz, 1H), 7.17 (s, 1H), 6.86 (d, J = 8.2 Hz, 1H), 5.95 (s, 1H), 4.13−4.05 (m, 2H), 3.82 (d, J = 16.4 Hz, 1H), 3.71 (d, J = 16.4 Hz, 1H), 1.20 (t, J = 6.6 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 166.7, 155.8, 151.1, 136.3, 131.4, 129.5, 126.3, 124.0 (q, J = 283.0 Hz), 117.7, 116.8, 98.9, 68.1 (q, J = 33.4 Hz), 60.4, 40.7, 14.5; ^{19}F NMR (376 MHz, $CDCl_3$) δ −81.72; IR (KBr) ν 3672, 2954, 1724, 1662, 1493, 1363, 1178, 1035, 834, 744 cm^{-1}; HRMS (Supporting Information) found m/z 383.0384 [M + Na]$^+$, calcd for $C_{15}H_{12}ClF_3N_2O_3$ + Na 383.0386.

*(E)-Ethyl 2-(8-chloro-9b-(difluoromethyl)-5-(4-methoxybenzyl)-4-oxo-4,5-dihydro-1H-azeto[1,2-c]quinazolin-2(9bH)-ylidene)acetate (**5n**):* 8.3 mg; 18% yield; white solid; mp 63−65 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.22−7.17 (m, 2H), 7.15 (d, J = 8.4 Hz, 2H), 6.84 (d, J = 8.4 Hz, 2H), 6.80 (d, J = 8.7 Hz, 1H), 6.03 (s, 1H), 6.07−5.84 (m, 2H), 5.22 (d, J = 16.2 Hz, 1H), 4.81 (d, J = 16.2 Hz, 1H), 4.16 (d, J = 7.0 Hz, 1H), 4.14 (d, J = 7.0 Hz, 1H), 3.79 (d, J = 16.8 Hz, 1H), 3.76 (s, 3H), 3.73 (d, J = 16.8 Hz, 1H), 1.27 (t, J = 7.1 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 167.1, 159.2, 156.3, 150.1, 137.6, 130.4, 129.1, 128.0, 127.6, 126.4, 120.6, 117.3, 114.6, 114.5 (t, J = 246.9 Hz), 98.1, 66.8 (t, J = 24.5 Hz), 60.1, 55.4, 46.2, 39.9, 14.5; ^{19}F NMR (565 MHz, $CDCl_3$) δ −129.19 (dd, J = 287.6, 55.4 Hz, 1F), δ −130.70 (dd, J = 287.6, 54.8 Hz, 1F); IR (KBr) ν 2979, 1715, 1656, 1514, 1494, 1360, 1335, 1250, 1206, 1133, 1034, 815, 740 cm^{-1}; HRMS (Supporting Information) found m/z 485.1049 [M + Na]$^+$, calcd for $C_{23}H_{21}ClF_2N_2O_4$ + Na 485.1056.

General Procedure for the Aza-MBH Reaction of Ethyl 2,3-Butadienoate (1) with Cyclic Ketimines 2 in the Presence of Pyridine. Under a N_2 atmosphere, a mixture of cyclic ketimine **2** (0.10 mmol), ethyl 2,3-butadienoate (**1**; 0.15 mmol), and pyridine (0.01 mmol) in toluene (1.0 mL) was stirred at room temperature (25 °C). After completion of the reaction (monitored by TLC), the resulting residue was purified on a silica gel column (1.3 × 20 cm) with the eluent (petroleum ether/ethyl acetate 6/1 to 3/1) to give the product **6**.

*Ethyl 2-(6-chloro-1-(4-methoxybenzyl)-2-oxo-4-(trifluoromethyl)-1,2,3,4-tetrahydroquinazolin-4-yl)buta-2,3-dienoate (**6a**):* 45.7 mg; 95% yield; yellow solid; mp 177−179 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.24−7.18 (m, 3H), 7.15 (d, J = 8.8 Hz, 1H), 6.86 (d, J = 8.5

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Hz, 2H), 6.74 (d, J = 8.9 Hz, 1H), 6.40 (s, 1H), 5.55 (d, J = 15.0 Hz, 1H), 5.46 (d, J = 15.0 Hz, 1H), 5.20 (d, J = 11.9 Hz, 1H), 5.05 (d, J = 11.9 Hz, 1H), 4.15−4.10 (m, 1H), 4.09−4.03 (m, 1H), 3.77 (s, 3H), 1.13 (t, J = 7.1 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 212.8, 163.2, 158.9, 152.2, 136.9, 130.2, 128.4, 127.6, 127.3, 126.8, 124.1 (q, J = 285.9 Hz), 118.1, 115.9, 114.4, 98.5, 83.3, 64.5 (q, J = 27.3 Hz), 61.6, 55.3, 45.4, 14.0; ^{19}F NMR (376 MHz, $CDCl_3$) δ −77.18; IR (KBr) ν 3431, 3077, 2936, 1975, 1720, 1682, 1511, 1428, 1393, 1249, 1181, 1027, 811, 553 cm^{-1}; HRMS (Supporting Information) found m/z 503.0956 [M + Na]$^+$, calcd for $C_{23}H_{20}ClF_3N_2O_4$ + Na 503.0961.

*Ethyl 2-(6-fluoro-1-(4-methoxybenzyl)-2-oxo-4-(trifluoromethyl)-1,2,3,4-tetrahydroquinazolin-4-yl)buta-2,3-dienoate (**6b**):* 42.7 mg; 92% yield; yellow solid; mp 164−166 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.22 (d, J = 8.4 Hz, 2H), 7.00 (d, J = 7.8 Hz, 1H), 6.92−6.88 (m, 1H), 6.86 (d, J = 8.4 Hz, 2H), 6.77 (dd, J = 9.1, 4.5 Hz, 1H), 6.74 (s, 1H), 5.50 (d, J = 15.0 Hz, 1H), 5.42 (d, J = 15.0 Hz, 1H), 5.21 (d, J = 15.2 Hz, 1H), 5.05 (d, J = 15.2 Hz, 1H), 4.14−4.09 (m, 1H), 4.09−4.03 (m, 1H), 3.76 (s, 3H), 1.11 (t, J = 7.1 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 212.8, 163.2, 158.9, 157.8 (d, J = 240.5 Hz), 152.3, 134.5, 128.6, 127.6, 124.1 (q, J = 285.9 Hz), 117.9 (d, J = 7.2 Hz), 117.0 (d, J = 22.2 Hz), 116.0 (d, J = 7.6 Hz), 114.4, 114.1 (d, J = 25.2 Hz), 98.6, 83.3, 64.6 (q, J = 28.2 Hz), 61.7, 55.4, 45.6, 14.0; ^{19}F NMR (376 MHz, $CDCl_3$) δ −77.15 (s, 3F), −121.16 to −121.26 (m, 1F); IR (KBr) ν 3435, 3132, 1972, 1720, 1683, 1514, 1401, 1387, 1249, 1169, 1065, 814, 556 cm^{-1}; HRMS (Supporting Information) found m/z 487.1250 [M + Na]$^+$, calcd for $C_{23}H_{20}F_4N_2O_4$ + Na 487.1257.

*Ethyl 2-(6-bromo-1-(4-methoxybenzyl)-2-oxo-4-(trifluoromethyl)-1,2,3,4-tetrahydroquinazolin-4-yl)buta-2,3-dienoate (**6c**):* 47.3 mg; 90% yield; yellow solid; mp 170−172 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.35 (s, 1H), 7.28 (d, J = 8.8 Hz, 1H), 7.20 (d, J = 8.4 Hz, 2H), 6.85 (d, J = 8.4 Hz, 2H), 6.69 (d, J = 9.2 Hz, 2H), 5.53 (d, J = 15.0 Hz, 1H), 5.43 (d, J = 15.0 Hz, 1H), 5.19 (d, J = 14.7 Hz, 1H), 5.04 (d, J = 14.7 Hz, 1H), 4.15−4.10 (m, 1H), 4.09−4.03 (m, 1H), 3.77 (s, 3H), 1.12 (t, J = 7.1 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 212.8, 163.2, 158.9, 152.0, 137.4, 133.2, 129.6, 128.3, 127.6, 124.1 (q, J = 285.7 Hz), 118.4, 116.4, 114.6, 114.4, 98.6, 83.5, 64.5 (q, J = 27.7 Hz), 61.7, 55.4, 45.5, 14.0; ^{19}F NMR (376 MHz, $CDCl_3$) δ −77.21; IR (KBr) ν 3430, 3093, 1973, 1720, 1682, 1510, 1424, 1390, 1248, 1179, 1026, 530 cm^{-1}; HRMS (Supporting Information) found m/z 547.0453 [M + Na]$^+$, calcd for $C_{23}H_{20}BrF_3N_2O_4$ + Na 547.0456.

*Ethyl 2-(5,6-difluoro-1-(4-methoxybenzyl)-2-oxo-4-(trifluoromethyl)-1,2,3,4-tetrahydroquinazolin-4-yl)buta-2,3-dienoate (**6d**):* 45.3 mg; 94% yield; yellow solid; mp 162−164 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.19 (d, J = 8.4 Hz, 2H), 7.02 (dd, J = 17.5, 8.9 Hz, 1H), 6.96 (s, 1H), 6.86 (d, J = 8.4 Hz, 2H), 6.56 (d, J = 6.8 Hz, 1H), 5.49 (d, J = 14.8 Hz, 1H), 5.37 (d, J = 14.8 Hz, 1H), 5.22 (d, J = 14.4 Hz, 1H), 5.02 (d, J = 14.4 Hz, 1H), 4.16−4.11 (m, 1H), 4.11−4.07 (m, 1H), 3.77 (s, 3H), 1.15 (t, J = 7.1 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 212.7 (d, J = 1.8 Hz), 163.5, 159.0, 152.1, 148.2 (dd, J = 250.6 Hz, J = 14.4 Hz), 146.3 (dd, J = 242.1 Hz, J = 13.1 Hz), 135.3, 128.2, 127.6, 124.3 (q, J = 287.4 Hz), 118.2 (d, J = 18.0 Hz), 114.5, 109.9 (d, J = 3.9 Hz), 107.1 (d, J = 10.5 Hz), 97.7, 83.5, 62.8 (q, J = 29.4 Hz), 61.6, 55.4, 45.8, 14.1; ^{19}F NMR (376 MHz, $CDCl_3$) δ −77.51 (d, J = 18.0 Hz, 3F), −135.16 to −135.38 (m, 1F), −144.87 to −144.96 (m, 1F); IR (KBr) ν 3431, 3080, 1981, 1718, 1683, 1514, 1473, 1399, 1249, 1191, 1027, 804, 532 cm^{-1}; HRMS (Supporting Information) found m/z 505.1157 [M + Na]$^+$, calcd for $C_{23}H_{19}F_5N_2O_4$ + Na 505.1163.

*Ethyl 2-(6-chloro-5-fluoro-1-(4-methoxybenzyl)-2-oxo-4-(trifluoromethyl)-1,2,3,4-tetrahydroquinazolin-4-yl)buta-2,3-dienoate (**6e**):* 47.9 mg; 96% yield; yellow solid; mp 172−174 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.22 (d, J = 8.3 Hz, 1H), 7.19 (d, J = 8.4 Hz, 2H), 7.02 (s, 1H), 6.86 (d, J = 8.4 Hz, 2H), 6.60 (d, J = 9.0 Hz, 1H), 5.49 (d, J = 14.8 Hz, 1H), 5.36 (d, J = 14.8 Hz, 1H), 5.23 (d, J = 13.8 Hz, 1H), 5.03 (d, J = 13.8 Hz, 1H), 4.16−4.11 (m, 1H), 4.11−4.06 (m, 1H), 3.77 (s, 3H), 1.15 (t, J = 7.1 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 212.7 (d, J = 1.9 Hz), 163.5, 159.0, 155.3 (d, J = 250.6 Hz), 152.0 (d, J = 6.9 Hz), 138.6 (d, J = 3.6 Hz), 131.5, 128.1, 127.6, 124.2 (q, J = 286.4 Hz), 115.2 (d, J = 18.9 Hz), 114.5, 111.1 (d, J = 3.4 Hz), 106.6 (d, J = 14.2 Hz), 97.8, 83.5, 62.9 (q, J = 29.1 Hz), 61.6, 55.4, 45.8, 14.1; ^{19}F NMR (376 MHz, $CDCl_3$) δ −77.43 (d, J = 17.3 Hz, 3F), −111.71 to −111.88 (m, 1F); IR (KBr) ν 3432, 3080, 2989, 1971, 1717, 1685, 1612, 1587, 1513, 1498, 1451, 1397, 1249, 1173, 1025, 750, 614 cm^{-1}; HRMS (Supporting Information) found m/z 521.0862 [M + Na]$^+$, calcd for $C_{23}H_{19}ClF_4N_2O_4$ + Na 521.0867.

*Ethyl 2-(1-(4-methoxybenzyl)-2-oxo-4,6-bis(trifluoromethyl)-1,2,3,4-tetrahydroquinazolin-4-yl)buta-2,3-dienoate (**6f**):* 47.8 mg; 93% yield; yellow solid; mp 173−175 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.48 (s, 1H), 7.45 (d, J = 8.7 Hz, 1H), 7.23 (d, J = 8.5 Hz, 2H), 6.99 (s, 1H), 6.92 (d, J = 8.7 Hz, 1H), 6.87 (d, J = 8.5 Hz, 2H), 5.55 (d, J = 15.0 Hz, 1H), 5.44 (d, J = 15.0 Hz, 1H), 5.25 (d, J = 14.5 Hz, 1H), 5.11 (d, J = 14.5 Hz, 1H), 4.13−4.08 (m, 1H), 4.08−4.03 (m, 1H), 3.77 (s, 3H), 1.11 (t, J = 7.1 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 212.9, 163.2, 159.1, 152.1, 141.1, 128.1, 127.7, 127.5 (d, J = 3.6 Hz), 124.2 (q, J = 33.3 Hz), 124.1, 124.1 (q, J = 285.3 Hz), 123.9 (q, J = 269.9 Hz), 117.0, 114.9, 114.5, 98.5, 83.6, 64.7 (q, J = 27.6 Hz), 61.8, 55.4, 45.6, 14.0; ^{19}F NMR (376 MHz, $CDCl_3$) δ −62.00 (s, 3F), −77.39 (s, 3F); IR (KBr) ν 3411, 3078, 2938, 1968, 1719, 1687, 1625, 1515, 1396, 1332, 1250, 1175, 1124, 530 cm^{-1}; HRMS (Supporting Information) found m/z 537.1217 [M + Na]$^+$, calcd for $C_{24}H_{20}F_6N_2O_4$ + Na 537.1225.

*Ethyl 2-(1-(4-methoxybenzyl)-2-oxo-4-(trifluoromethyl)-1,2,3,4-tetrahydroquinazolin-4-yl)buta-2,3-dienoate (**6g**):* 35.7 mg; 80% yield; yellow solid; mp 139−141 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.27 (d, J = 7.9 Hz, 1H), 7.23 (d, J = 8.2 Hz, 2H), 7.20 (d, J = 7.7 Hz, 1H), 6.96 (t, J = 7.4 Hz, 1H), 6.86 (d, J = 8.2 Hz, 2H), 6.82 (d, J = 8.3 Hz, 1H), 6.11 (s, 1H), 5.52 (d, J = 14.9 Hz, 1H), 5.46 (d, J = 14.9 Hz, 1H), 5.23 (d, J = 3.6 Hz, 1H), 5.08 (d, J = 3.6 Hz, 1H), 4.14−4.07 (m, 1H), 4.07−4.00 (m, 1H), 3.77 (s, 3H), 1.09 (t, J = 7.0 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 212.8, 163.4, 158.9, 152.2, 138.1, 130.4, 128.9, 127.7, 127.1, 124.3 (q, J = 285.9 Hz), 122.1, 116.2, 114.8, 114.4, 99.1, 83.2, 64.8 (q, J = 28.4 Hz), 61.6, 55.4, 45.4, 14.0; ^{19}F NMR (376 MHz, $CDCl_3$) δ −77.22; IR (KBr) ν 3438, 1964, 1718, 1680, 1636, 1510, 1429, 1397, 1250, 1080, 746, 553 cm^{-1}; HRMS (Supporting Information) found m/z 469.1345 [M + Na]$^+$, calcd for $C_{23}H_{21}F_3N_2O_4$ + Na 469.1351.

*Ethyl 2-(1-(4-methoxybenzyl)-6-methyl-2-oxo-4-(trifluoromethyl)-1,2,3,4-tetrahydroquinazolin-4-yl)buta-2,3-dienoate (**6h**):* 34.1 mg; 74% yield; yellow solid; mp 160−162 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.22 (d, J = 8.4 Hz, 2H), 7.04 (s, 1H), 6.99 (d, J = 8.3 Hz, 1H), 6.84 (d, J = 8.4 Hz, 2H), 6.71 (d, J = 8.4 Hz, 1H), 6.11 (s, 1H), 5.53 (d, J = 14.8 Hz, 1H), 5.47 (d, J = 14.8 Hz, 1H), 5.20 (d, J = 15.5 Hz, 1H), 5.05 (d, J = 15.5 Hz, 1H), 4.13−4.08 (m, 1H), 4.08−4.01 (m, 1H), 3.76 (s, 3H), 2.23 (s, 3H), 1.09 (t, J = 7.1 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 212.8, 163.4, 158.8, 152.2, 135.7, 131.6, 131.0, 129.0, 127.6, 127.4, 124.3 (q, J = 285.4 Hz), 116.0, 114.7, 114.3, 99.2, 83.2, 64.8 (q, J = 27.8 Hz), 61.6, 55.4, 45.4, 20.7, 14.0; ^{19}F NMR (376 MHz, $CDCl_3$) δ −77.13; IR (KBr) ν 3425, 3080, 2935, 1968, 1722, 1679, 1514, 1433, 1399, 1248, 1183, 1028, 809, 534 cm^{-1}; HRMS (Supporting Information) found m/z 483.1506 [M + Na]$^+$, calcd for $C_{24}H_{23}F_3N_2O_4$ + Na 483.1508.

*Ethyl 2-(6-isopropyl-1-(4-methoxybenzyl)-2-oxo-4-(trifluoromethyl)-1,2,3,4-tetrahydroquinazolin-4-yl)buta-2,3-dienoate (**6i**):* 36.6 mg; 75% yield; yellow solid; mp 63−65 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.24 (d, J = 8.4 Hz, 2H), 7.09−7.03 (m, 2H), 6.86 (d, J = 8.4 Hz, 2H), 6.79−6.64 (m, 2H), 5.51 (d, J = 14.7 Hz, 1H), 5.41 (d, J = 14.7 Hz, 1H), 4.13−4.06 (m, 1H), 4.04−3.98 (m, 1H), 5.35−5.15 (m, 1H), 5.15−4.90 (m, 1H), 3.76 (s, 3H), 2.83−2.76 (m, 1H), 1.15 (s, 3H), 1.14 (s, 3H), 1.03 (t, J = 7.0 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 212.8, 163.5, 158.7, 152.5 (d, J = 6.5 Hz), 142.6, 135.7, 129.0 (d, J = 1.4 Hz), 128.0, 127.6, 125.1, 124.3 (q, J = 285.9 Hz), 116.0 (d, J = 4.1 Hz), 114.5, 114.2, 99.0, 83.2, 64.7 (q, J = 27.6 Hz), 61.5, 55.3, 45.3, 33.2, 23.9, 14.0; ^{19}F NMR (565 MHz, $CDCl_3$) δ −77.09; IR (KBr) ν 3432, 3138, 2935, 1711, 1646, 1514, 1400, 1246, 1112, 1027, 874, 434 cm^{-1}; HRMS (Supporting Information) found m/z 511.1819 [M + Na]$^+$, calcd for $C_{26}H_{27}F_3N_2O_4$ + Na 511.1821.

*Ethyl 2-(6-methoxy-1-(4-methoxybenzyl)-2-oxo-4-(trifluoromethyl)-1,2,3,4-tetrahydroquinazolin-4-yl)buta-2,3-dienoate (**6j**):* 37.2 mg; 78% yield; yellow solid; mp 143−145 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.22 (d, J = 8.0 Hz, 2H), 6.85 (d, J = 8.0 Hz, 2H), 6.82 (s,

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1H), 6.77−6.69 (m, 2H), 6.47 (s, 1H), 5.49 (d, J = 14.8 Hz, 1H), 5.41 (d, J = 14.8 Hz, 1H), 5.19 (d, J = 10.5 Hz, 1H), 5.03 (d, J = 10.5 Hz, 1H), 4.14−4.07 (m, 1H), 4.06−4.01 (m, 1H), 3.76 (s, 3H), 3.70 (s, 3H), 1.09 (t, J = 6.9 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 212.8, 163.3, 158.8, 154.6, 152.1, 131.8, 129.1, 127.7, 124.3 (q, J = 286.6 Hz), 117.4, 115.6, 114.8, 114.3, 113.6, 99.0, 83.1, 64.8 (q, J = 28.1 Hz), 61.6, 55.7, 55.4, 45.4, 14.0; ^{19}F NMR (376 MHz, $CDCl_3$) δ −76.94; IR (KBr) ν 3415, 3077, 2935, 1968, 1722, 1677, 1516, 1438, 1402, 1297, 1248, 1181, 1024, 740, 621 cm^{-1}; HRMS (Supporting Information) found m/z 499.1449 [M + Na]$^+$, calcd for $C_{24}H_{23}F_3N_2O_5$ + Na 499.1457.

Ethyl 2-(6-chloro-1-(naphthalen-1-ylmethyl)-2-oxo-4-(trifluoromethyl)-1,2,3,4-tetrahydroquinazolin-4-yl)buta-2,3-dienoate (**6k**): 44.6 mg; 89% yield; yellow solid; mp 238−240 °C; ^{1}H NMR (600 MHz, DMSO) δ 8.77 (s, 1H), 8.22 (d, J = 8.2 Hz, 1H), 7.98 (d, J = 8.0 Hz, 1H), 7.83 (d, J = 8.1 Hz, 1H), 7.64 (t, J = 7.2 Hz, 1H), 7.59 (t, J = 7.3 Hz, 1H), 7.38 (t, J = 7.6 Hz, 1H), 7.34 (s, 1H), 7.25 (d, J = 8.7 Hz, 1H), 7.17 (d, J = 6.9 Hz, 1H), 6.70 (d, J = 8.9 Hz, 1H), 6.07 (d, J = 15.4 Hz, 1H), 5.87 (d, J = 15.4 Hz, 1H), 5.61 (s, 2H), 4.15 (dt, J = 17.8, 7.1 Hz, 1H), 4.09 (dt, J = 17.8, 7.1 Hz, 1H), 1.14 (t, J = 7.0 Hz, 3H); ^{13}C NMR (150 MHz, DMSO) δ 212.3, 163.0, 150.8, 137.4, 133.4, 131.3, 130.3, 130.2, 128.6, 127.2 (d, J = 3.3 Hz), 126.3 (d, J = 2.1 Hz), 126.1 (d, J = 1.6 Hz), 126.0, 125.5, 125.3, 124.2 (q, J = 286.5 Hz), 123.0, 121.7, 117.8, 116.1 (d, J = 4.9 Hz), 97.0, 84.2, 63.8 (q, J = 27.2 Hz), 61.0, 43.1, 13.9 (d, J = 4.0 Hz); ^{19}F NMR (376 MHz, DMSO) δ −76.43; IR (KBr) ν 3410, 3118, 2987, 1968, 1718, 1686, 1506, 1425, 1399, 1249, 1171, 1027, 796, 773 cm^{-1}; HRMS (Supporting Information) found m/z 523.1007 [M + Na]$^+$, calcd for $C_{26}H_{20}ClF_3N_2O_3$ + Na 523.1012.

Ethyl 2-(6-chloro-2-oxo-4-(trifluoromethyl)-1-(2,4,6-trimethylbenzyl)-1,2,3,4-tetrahydroquinazolin-4-yl)buta-2,3-dienoate (**6l**): 45.8 mg; 93% yield; yellow solid; mp 172−174 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.22 (s, 1H), 7.10 (d, J = 8.9 Hz, 1H), 6.83 (s, 2H), 6.67 (s, 1H), 6.64 (d, J = 8.9 Hz, 1H), 5.60 (d, J = 16.3 Hz, 1H), 5.51 (q, J = 15.0 Hz, 2H), 4.92 (d, J = 16.3 Hz, 1H), 4.15−4.10 (m, 1H), 4.10−4.05 (m, 1H), 2.35 (s, 6H), 2.25 (s, 3H), 1.17 (t, J = 7.1 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 212.7, 163.3, 152.0, 137.4, 136.8, 136.4, 130.3, 130.3, 130.0, 127.2, 126.9, 123.9 (q, J = 285.6 Hz), 117.7, 115.6, 99.1, 83.4, 64.6 (q, J = 27.6 Hz), 61.7, 42.9, 20.9, 20.2, 14.1; ^{19}F NMR (376 MHz, $CDCl_3$) δ −76.61; IR (KBr) ν 3441, 3202, 3132, 1968, 1723, 1681, 1423, 1400, 1385, 1248, 1186, 1172, 1035, 1022, 548 cm^{-1}; HRMS (Supporting Information) found m/z 515.1318 [M + Na]$^+$, calcd for $C_{25}H_{24}ClF_3N_2O_3$ + Na 515.1325.

Ethyl 2-(6-chloro-2-oxo-4-(trifluoromethyl)-1,2,3,4-tetrahydroquinazolin-4-yl)buta-2,3-dienoate (**6m**): 25.2 mg; 70% yield; yellow solid; mp 66−68 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 9.92 (s, 1H), 7.19 (s, 1H), 7.16 (d, J = 8.4 Hz, 1H), 6.83 (s, 1H), 6.76 (d, J = 8.3 Hz, 1H), 5.54 (d, J = 15.1 Hz, 1H), 5.48 (d, J = 15.1 Hz, 1H), 4.12−4.01 (m, 2H), 1.12 (t, J = 6.8 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 212.6, 163.4, 153.7, 135.5, 130.6, 127.6, 126.7, 124.0 (q, J = 285.2 Hz), 116.4, 116.0, 98.5, 83.6, 65.3 (q, J = 27.6 Hz), 61.8, 13.9; ^{19}F NMR (376 MHz, $CDCl_3$) δ −77.00; IR (KBr) ν 3430, 3210, 3125, 1968, 1694, 1501, 1436, 1398, 1251, 1176, 1020, 824 cm^{-1}; HRMS (Supporting Information) found m/z 383.0377 [M + Na]$^+$, calcd for $C_{15}H_{12}ClF_3N_2O_3$ + Na 383.0386.

Ethyl 2-(6-chloro-4-(difluoromethyl)-1-(4-methoxybenzyl)-2-oxo-1,2,3,4-tetrahydroquinazolin-4-yl)buta-2,3-dienoate (**6n**): 40.7 mg; 88% yield; yellow solid; mp 138−140 °C; ^{1}H NMR (600 MHz, $CDCl_3$) δ 7.22 (d, J = 1.7 Hz, 1H), 7.18 (d, J = 8.4 Hz, 2H), 7.12 (d, J = 8.8 Hz, 1H), 6.84 (d, J = 8.4 Hz, 2H), 6.73 (d, J = 8.9 Hz, 1H), 6.24 (t, J = 55.3 Hz, 1H), 6.00 (s, 1H), 5.41 (d, J = 15.0 Hz, 1H), 5.37 (d, J = 15.0 Hz, 1H), 5.15 (d, J = 13.5 Hz, 1H), 5.04 (d, J = 13.5 Hz, 1H), 4.21−4.16 (m, 1H), 4.16−4.11 (m, 1H), 3.76 (s, 3H), 1.20 (t, J = 7.1 Hz, 3H); ^{13}C NMR (150 MHz, $CDCl_3$) δ 213.2, 164.2, 158.9, 152.7, 136.9, 129.7, 128.5, 127.6, 127.2, 126.6, 119.2, 116.0, 114.6 (t, J = 252.6 Hz), 114.4, 101.6, 83.6 (t, J = 6.5 Hz), 62.2 (t, J = 21.9 Hz), 61.8 (t, J = 6.7 Hz), 55.4 (d, J = 6.3 Hz), 45.5, 14.1; ^{19}F NMR (376 MHz, $CDCl_3$) δ −127.99 (dd, J = 274.1, 54.9 Hz, 1F), δ −130.85 (dd, J = 274.1, 55.6 Hz, 1F); IR (KBr) ν 3201, 3078, 2960, 2933, 1968, 1722, 1680, 1607, 1513, 1457, 1404, 1248, 1183, 1024, 753 cm^{-1}; HRMS (Supporting Information) found m/z 485.1048 [M + Na]$^+$, calcd for $C_{23}H_{21}ClF_2N_2O_4$ + Na 485.1056.

Procedure for the Synthesis of Dihydropyrrole Derivative 4a from 6a. Under a N_2 atmosphere, a mixture of allenoate **6a** (0.10 mmol) and DPPP (0.02 mmol) in toluene (1.0 mL) was stirred at room temperature (25 °C). After completion of the reaction (monitored by TLC), the resulting residue was purified on a silica gel column (1.3 × 20 cm) with the eluent (petroleum ether/ethyl acetate 8/1 to 4/1) to give the product **4a** (47.2 mg, yield 98%) as a white solid.

Procedure for the Synthesis of *N*-Fused Polycyclic Compound 3a from 6a. Under a N_2 atmosphere, a mixture of allenoate **6a** (0.10 mmol), ethyl 2,3-butadienoate (**1**; 0.15 mmol), and dppp (0.02 mmol) in toluene (1.0 ml) was stirred at room temperature (25 °C). After completion of the reaction (monitored by TLC), the resulting residue was purified on a silica gel column (1.3 × 20 cm) with the eluent (petroleum ether/ethyl acetate 10/1 to 5/1) to give the product **3a** (54.0 mg, yield 91%) as a white solid.

■ ASSOCIATED CONTENT

Ⓢ Supporting Information

Figures giving ^{1}H, ^{19}F, and ^{13}C NMR spectra for the products **4a−n**, **5a−n**, and **6a−n** and figures and CIF files giving crystallographic data for compounds **4a** and **5a**. This material is available free of charge via the Internet at http://pubs.acs.org.

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Notes

The authors declare no competing financial interest.

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