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Synthesis of 4-Fluoromethylsydnones and their Participation in Alkyne Cycloaddition Reactions

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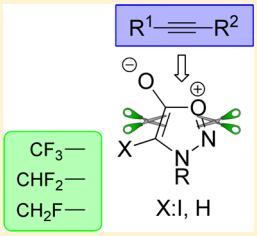
Supporting Information

ABSTRACT: We report the synthesis and some structural studies of 4-trifluoromethyl, 4-difluoromethyl-, and 4-monofluoromethylsydnones. All but the latter compounds are stable and represent effective precursors to a range of pyrazoles after cycloaddition reactions with alkynes. The cycloadditions are generally highly regioselective and provide 5-fluoromethylpyrazole products, although we have observed that Bn-substituted sydnones can provide an unexpected alkyne insertion mode that generates the 3-fluoromethyl isomer.



INTRODUCTION

The prevalence of fluorinated aromatic and heterocyclic compounds in agrochemicals and small molecule therapeutics has led to a significant interest in developing new and more convenient synthetic procedures for the preparation of these molecules. As a specific subclass, pyrazoles bearing fluorocarbon substituents are becoming increasingly prevalent as synthetic targets and building blocks within the fine chemicals sector.[1] Several bioactive fluorinated pyrazoles have emerged in recent years and have shown activity in pharmaceutical[2] and agrochemical screens.[3] Of the more established commercial fluorinated pyrazoles, particularly noteworthy examples include nonsteroidal anti-inflammatory drugs of the coxib class such as celecoxib and deracoxib,[4] as well as the herbicide fluazolate[5] (Figure 1).

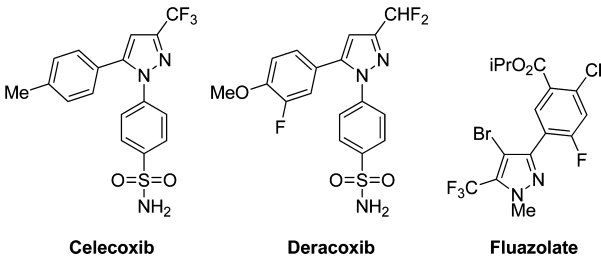


Figure 1. Bioactive fluorinated pyrazoles.

The [3 + 2] cycloaddition of nitrilimines and alkynes and the cyclocondensation of a hydrazine with 1,3-diketones or α,β-unsaturated carbonyl compounds represent the most common strategies of pyrazole ring synthesis. However, these approaches can suffer from the formation of regioisomeric mixtures with respect to substituents incorporated at the pyrazole 3- and 5-positions.[6] In the context of trifluoromethylpyrazoles, these compounds are typically synthesized by the cyclocondensation approach using 1,1,1-trifluoromethyl-1,3-diketones, as this method exploits the ready availability of trifluoroacetic acid derived precursors.[7] Such reactions also very often provide mixtures of the 3- and 5-trifluoromethyl products, although good regiocontrol for the 3-CF_3 pyrazoles can be achieved by use of fluorinated solvents.[8] Moreover, the efficient synthesis of 5-CF_3-substituted pyrazoles is further hampered by the fact that the intermediate 5-trifluoromethyl-5-hydroxypyrazolines undergo rather slow dehydration.[9] As an alternative to the cyclocondenstaion route, the cycloaddition of alkynes with sydnones represents a convenient approach for the regioselective synthesis of these azoles.[10,11] In a related study, Meazza reported the synthesis of 3- and 4-trifluoromethylpyrazoles through cycloadditions with trifluoromethylacetylenes.[12] Moreover, diazomethane functions as an effective precursor to stannylated 4-fluoro- and 4-trifluoromethylated pyrazoles.[13] However, employing cycloaddition techniques to provide the analogous 5-trifluoromethylpyrazoles is rather under-developed (Scheme 1). Recent studies in our laboratory have endeavored to develop the scope of sydnone functionalization and alkyne cycloaddition chemistry, with the goal of establishing this area as enabling chemistry for pyrazole synthesis.[14] We envisaged that this chemistry could provide a convenient and general solution to the regiocontrolled synthesis of various 5-fluoromethyl-substituted pyrazoles via the corresponding 4-fluoromethylsydnones.[15] Our studies toward this end are delineated herein.

RESULTS AND DISCUSSION

Sydnones are typically prepared in two steps by nitrosation of *N*-substituted amino acids followed by cyclodehydration of the resulting nitrosamines. Therefore, we began our investigations by developing a scalable route to the requisite 4-trifluoromethylsydnones via their respective trifluoromethylalanines.

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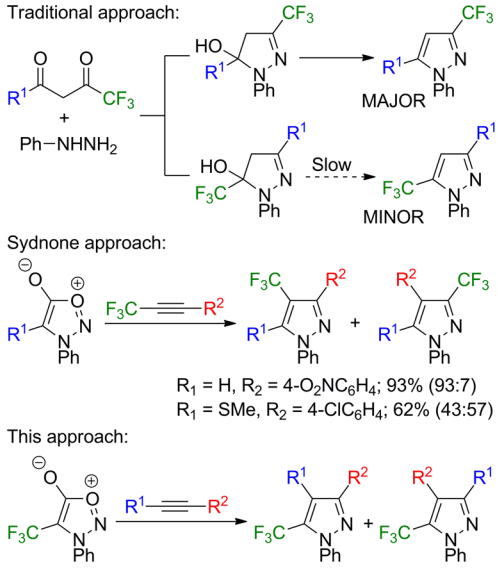
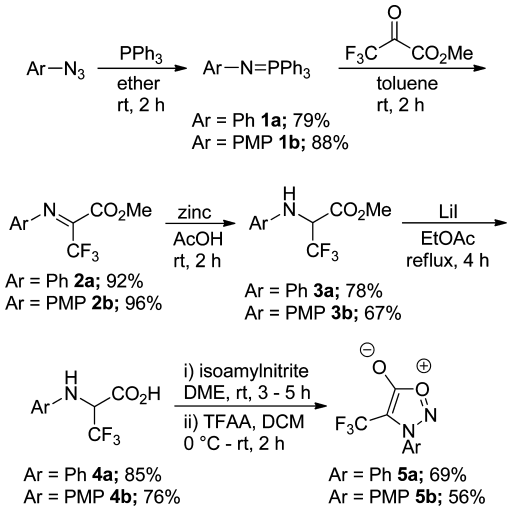
Scheme 1. Synthetic Approaches to Trifluoromethylpyrazoles



Scheme 2 shows the route employed to access compounds **5a,b**. The aza-Wittig reaction of iminophosphoranes **1a,b** and

Scheme 2. Synthesis of 4-Trifluoromethylsydnones[a]



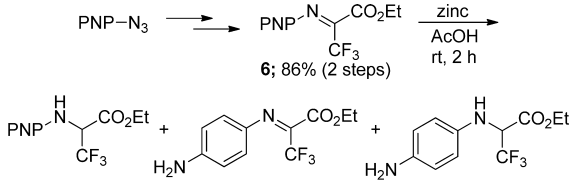
[a]PMP: 4-methoxyphenyl.

methyl trifluoromethylpyruvate furnished imines **2a,b**,[16] which were reduced to the corresponding amino esters **3a,b** using zinc metal.[17] Ester hydrolysis proved to be challenging; saponification provided a complex mixture whereas hydrolysis under acid catalysis proved to be capricious. Ultimately, however, we found that heating the amino esters at reflux with lithium iodide in ethyl acetate for 4 h[18] consistently delivered the amino acids **4a,b** in high yield. Finally, the desired 4-trifluoromethylsydnones were generated by the well-established nitrosation−cyclodehydration sequence, thereby allowing gram quantities of **5a** and **5b** to be produced in good overall yield.

Our efforts to further extend this chemistry to produce other trifluoromethylsydnones highlighted some limitations with this approach. Specifically, our attempts to reduce the PNP-imine **6** with zinc metal resulted in mixtures of the reduction products. Recourse to alternative reducing agents such as trichlorosilane only gave trace amounts of the desired amino ester.

Overall therefore, with a view to implementing a general approach to trifluoromethylsydnones, the route outlined in Scheme 2 raised some serious limitations. In addition to the potential for functional group incompatibility highlighted in Scheme 3, the synthetic sequence is lengthy, linear, and

Scheme 3. Uncontrolled Reduction of *N*-PNP Imine 6[a]

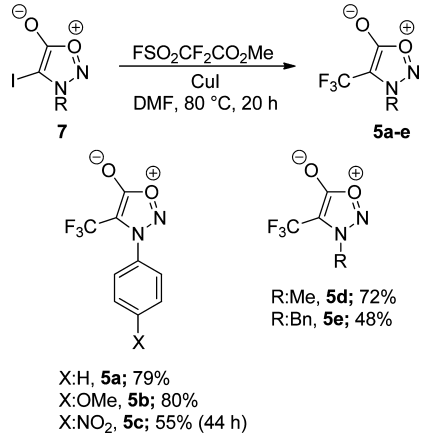


[a]PNP: 4-nitrophenyl.

incorporates the *N*-substituent at the start of the process. We envisaged that a more convenient strategy would be to develop a late-stage trifluoromethylation of sydnones, as this would provide a more direct means to incorporate a range of *N*-substituents. In this regard, we reported that the Suzuki cross-coupling of 4-bromosydnones provided a convenient method of incorporating aryl-substituents.[14b] We envisaged that an analogous strategy could prove to be an effective method for generating 4-trifluoromethyl sydnones.

Copper-promoted trifluoromethylations using Ruppert's reagent are one of the most widely used techniques for the direct incorporation of a CF_3 group,[19] although the use of organoboron-based coupling partners is also well established.[20] In the event, however, successful trifluoromethylation of **7** was achieved by the Cu-promoted addition of methyl fluorosulfonyldifluoroacetate[21] in DMF at 80 °C. The scope of the trifluoromethylation was examined, and the results are summarized in Scheme 4. The reaction of **4**-iodo-*N*-phenyl-

Scheme 4. Trifluoromethylation of 4-Iodosydnones



sydnone **7** (R = Ph) provided trifluoromethylsydnone **5a** in 79% yield. The presence of an electron-donating PMP group was also highly efficient, giving **5b** in similar yield. However, the electron-withdrawing PNP group required a much longer reaction time but provided the previously inaccessible compound **5c** in acceptable yield. Nonaromatic groups were also tolerated, delivering the methyl and benzyl protected sydnones **5d** and **5e**. Overall, therefore, the direct trifluor-

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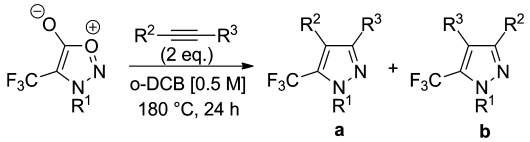
omethylation described in Scheme 4 complements and improves upon the stepwise procedure described earlier (Scheme 2) and in our preliminary report of this work[15] and offers a practical approach to a selection of fluorous sydnone analogues.

Having developed effective routes to CF_3-substituted sydnones, we next turned our attention to their cycloaddition reaction with alkynes to form pyrazoles. We were particularly interested in establishing the effect of the trifluoromethyl group on cycloaddition regioselectivity, and our results are summarized in Table 1. Alkyne cycloaddition reactions with *N*-Ph

Table 1. Synthesis of 5-Trifluoromethylpyrazoles[a]

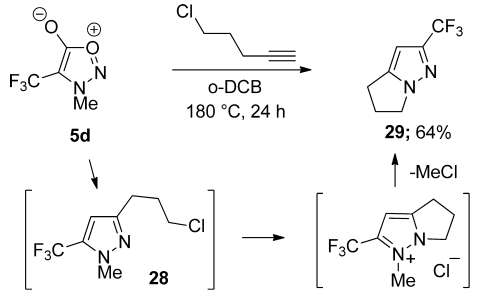


entry	R^1	R^2	R^3	yield (%)	a:b
1	Ph; **5a**	H	Ph	**8**: 87	96:4
2	Ph; **5a**	H	Bu	**9**: 78	>98:2
3	Ph; **5a**	H	Me_3Si	**10**: 75	>98:2
4	Ph; **5a**	H		**11**: 84	95:5
5	Ph; **5a**	H		**12**: 89	98:2
6	Ph; **5a**	H		**13**: 88	>98:2
7	Ph; **5a**	H	CH_2OBn	**14**: 84	96:4
8	Ph; **5a**	H	$(CH_2)_3Cl$	**15**: 70	98:2
9	Ph; **5a**	Ph	Bu	**16**: 62	48:52[b]
10	Ph; **5a**	CO_2Me	Me	**17**: 90	85:15
11	Ph; **5a**	Ph	Ph	**18**: 53	-
12	PMP; **5b**	H	Ph	**19**: 85	>98:2
13	PMP; **5b**	H	Bu	**20**: 71	>98:2
14	PMP; **5b**	H		**21**: 75	>98:2
15[a]	PNP; **5c**	H	Ph	**22**: 85	>98:2
16[a]	PNP; **5c**	H	$(CH_2)_3Cl$	**23**: 68	>98:2
17	Me; **5d**	H	Ph	**24**: 95	98:2
18	Me; **5d**	H		**25**: 82	98:2
19	Me; **5d**	H	CH_2OBn	**26**: 89	>98:2
20	Me; **5d**	H	CO_2Et	**27**: 94	93:7[b]

[a]Reaction complete within 8 h. PMP: 4-methoxyphenyl. PNP: 4-nitrophenyl. [b]Product isolated as an inseparable mixture of isomers.

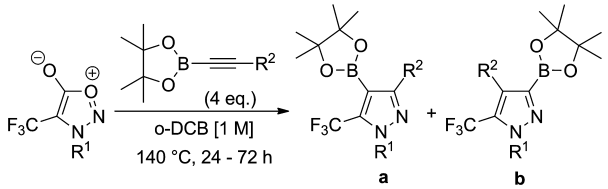
sydnone **5a** were generally complete within 24 h when conducted at 180 °C in a sealed vessel. We were pleased to find that the cycloaddition of **5a** with a range of terminal alkynes proceeded in good to excellent yields and with almost complete regiocontrol in each case (entries 1–8). Indeed, the selectivity of formation of **11** is notable; cycloadditions of 4-Me- and 4-Pr^i-substituted sydnones with 2-ethynylpyridine proceed with lower levels of regiocontrol (<6:1)[14f] suggesting that the CF_3 group can also enhance cycloaddition regioselectivity in some cases. Moreover, disubstituted alkynes also participated in the reaction, but with generally lower levels of regiocontrol (entries 9–11). These general trends were continued with *N*-arylsydnones **5b** and **5c**, although cycloadditions of PNP-sydnone **5c** needed only 8 h, in accord with the documented increased reactivity of these mesoionic compounds (entries 12–16).[14c] Finally, the cycloaddition of *N*-Me-sydnone **5d** also provided the corresponding pyrazoles in excellent yield and regiocontrol (entries 17–20). However, in extending this method to the cycloaddition with 5-chloropent-1-yne, we were surprised to recover the bicyclic 3-trifluoromethyl pyrazole **29**. In this case, we believe that pyrazole **28** is formed initially but then undergoes a cyclization to provide **29** upon demethylation (Scheme 5).

Scheme 5. Unexpected Formation of 3-Trifluoromethyl Pyrazole 29



The study highlighted in Table 1 suggested that the chemistry would have limited use in the direct synthesis of tetrasubstituted pyrazoles, as the observed regioselectivities were found to be rather low (entries 9 and 10). Related work in our laboratories has highlighted the potential of alkynylboronates in the synthesis of these compounds,[14] as they typically afford high selectivites for the 4-borylated isomer. We therefore decided to investigate the cycloaddition of these substrates, and our results are summarized in Table 2. In the event, the reactions required heating at 140 °C over a period of 24–72 h; however, the corresponding products **30**–**34** were generated in good yield and with useful levels of regiocontrol. Notably, the terminal alkyne exhibited the opposite regiochemical insertion mode and follow the trend whereby the sterically more

Table 2. Synthesis of 5-Trifluoromethylpyrazole Boronic Esters



entry	R^1	R^2	time (h)	yield (%)	a/b
1	Ph; **5a**	H	72	**30**: 69	7:93[a]
2	Me; **5d**	H	72	**31**: 44	4:96
3	Ph; **5a**	Me_3Si	48	**32**: 64	90:10
4	PNP; **5c**	Me_3Si	24	**33**: 55	>98:2
5	Ph; **5a**	Bu	72	**34**: 55	95:5

[a]Product isolated as an inseparable mixture of regioisomers. *o*-DCB: 1,2-dichlorobenzene.

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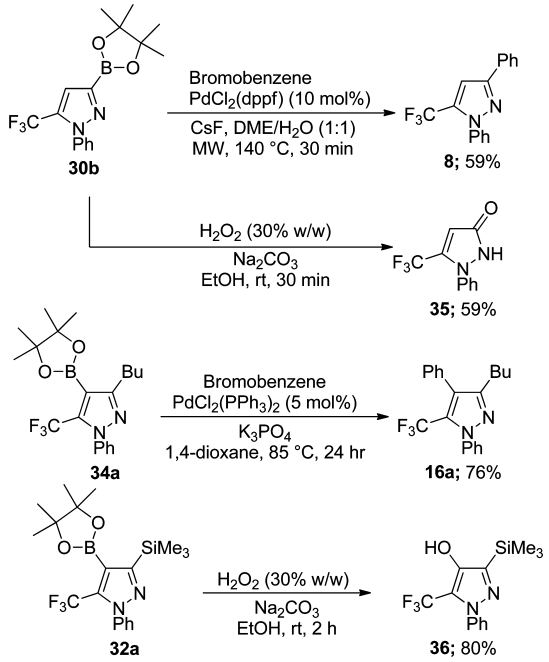
demanding group is placed adjacent to the nitrogen atom, in line with our previous observations.[14c]

Representative functionalization reactions confirmed the potential of the pyrazole boronic esters for the divergent synthesis of 5-CF_3 pyrazoles (Scheme 6). Both 3- and 4-

Scheme 6. Functionalization of 5-Trifluoromethylpyrazole Boronic Esters

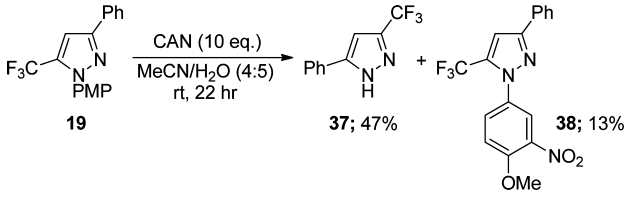


borylated compounds underwent Suzuki coupling in good yields. Of particular note is the regioselective synthesis of **16a**, which was produced as a 1:1 mixture by reaction of **5a** with 1-phenyl-1-hexyne (see Table 1, entry 9). Similarly, both 3- and 4-borylated **30b** and **32a** underwent oxidation with hydrogen peroxide at ambient temperature to provide **35** and **36** in good yields. The product pyrazoles offer the opportunity to access the bioactive pyrazole phenyl ether series.[22]

A limitation of the sydnone cycloaddition route to pyrazoles is the requirement for a substituent to be present at nitrogen. However, we envisaged that PMP-substituted sydnone **5b** offered the opportunity to generate pyrazoles bearing a free *N*-H after oxidative cleavage using ceric ammonium nitrate (CAN).[23] To ensure full conversion a large excess of CAN was required[24] which not only gave the expected pyrazole **37** in 47% yield but also 13% of the nitrated product **38**, which appears to be deactivated toward oxidation (Scheme 7).

The low yield observed in the CAN deprotection of **19** prompted us to explore other systems that could offer more efficient deprotection strategies. In this respect, we decided to

Scheme 7. CAN Deprotection of *N*-PMP-Protected 5-Trifluoromethylpyrazole 19



examine the cycloaddition of 4-trifluoromethyl-*N*-benzylsydnone **5e**, with a view to studying Bn hydrogenolysis of the product pyrazoles. To our surprise, however, the reaction of **5e** with both phenylacetylene and 1-hexyne yielded a mixture of the expected 5-CF_3-substituted pyrazoles **39a** and **40a**, together with the corresponding 3-CF_3 isomers **39b** and **40b**[25] (Table 3). We were able to improve the selectivity to favor regioisomer

Table 3. Synthesis of 3- and 5-Trifluoromethyl-*N*-benzylpyrazoles

5e a b

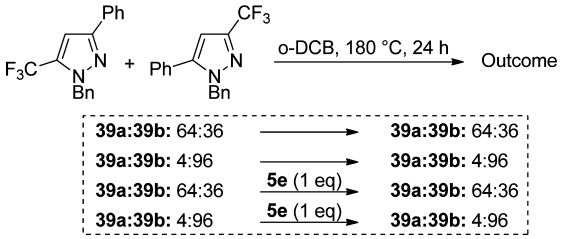
entry	R[b]	temp (°C)	time (h)	yield (%)	a/b
1	Ph (2)	180	24	**39a,b**: 61	64:36
2	Bu (2)	180	24	**40a,b**: 48	72:28
3[a]	Ph (2)	140	24	**39a,b**: 34	96:4
4	Ph (2)	140	48	**39a,b**: 66	88:12
5	Ph (10)	180	24	**39a,b**: 64	88:12

[a]48% conversion. [b]The values in parentheses refer to the equivalents of alkyne used.

a by lowering the reaction temperature (entries 3 and 4) or using a large excess of alkyne (entry 5), but in each case a small amount of the 3-trifluoromethyl isomer remained.

The observation that sydnones can incorporate alkynes into the 4,5-position of a pyrazole under thermal conditions is unprecedented to the best of our knowledge. In order to explain this curious result, we decided to first explore the potential for Bn-migration in the pyrazole products. As outlined in Scheme 8, subjecting samples of **39a,b** containing different

Scheme 8. Probing Product Isomerization



ratios of regioisomers to heating under the reaction conditions resulted in recovery of the pyrazoles with no detectable changes in regioisomer ratios. We speculated that sydnone **5e** could function as an electrophilic source of Bn-cation, thereby promoting product isomerization by a benzylation−debenzylation mechanism along similar lines to the process highlighted in Scheme 5. Again, however, heating mixtures of **39a,b** in the presence of sydnone **5e** resulted in no detectable changes in pyrazole isomer ratios.

The control experiments outlined in Scheme 8 suggested that the 3-CF_3 isomer did not originate via pyrazole isomerization, and we began to consider pathways under which the 3-trifluoromethyl isomer could originate from the sydnone. In this regard, **41** has been proposed to undergo a disrotary electrocyclic ring closure under photolytic conditions to give a bicyclic intermediate **43** which evolves CO_2 to produce a nonisolable nitrile imine **44**.[26] Alkyne cycloaddition of **44** with

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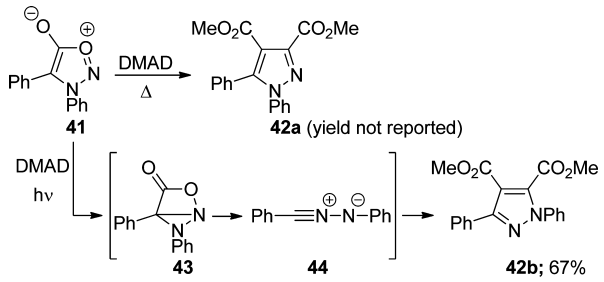
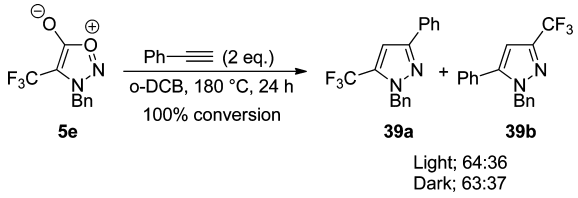
dimethyl acetylenedicarboxylate (DMAD) gave pyrazole **42b** in 67% yield. In contrast, the thermally promoted reaction of sydnone **41** with DMAD provides isomeric pyrazole **42a** (Scheme 9).

Scheme 9. Photolytic and Thermal Reactions of Sydnones with DMAD



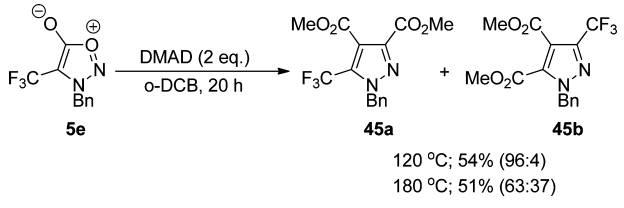
In order to test whether the formation of **39b** was occurring via a visible light promoted nitrile imine formation, the cycloaddition with phenyl acetylene was conducted simultaneously in the presence and absence of light (Scheme 10). However, both reactions yielded approximately the same ratio of isomers under these conditions.

Scheme 10. Visible Light Dependence on the Cycloaddition of Sydnone 5e



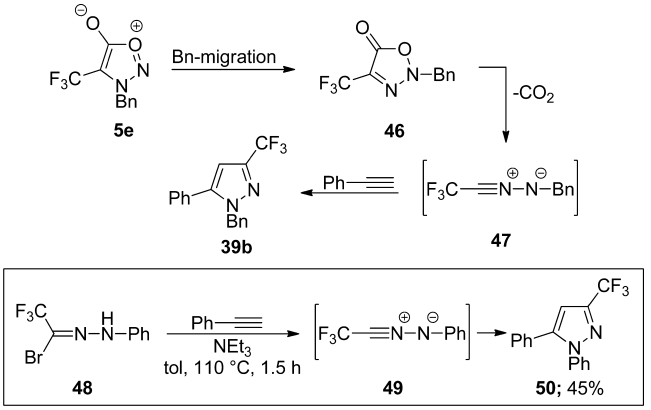
In order to establish the effect of reaction temperature on product distribution, we exploited the enhanced reactivity of DMAD in sydnone cycloadditions so that **5e** could be reacted with DMAD at 120 and 180 °C. At the lower temperature, the reaction produced 5-CF_3 pyrazole **45a** in 54% yield and essentially as a single regioisomer. In contrast, conducting the reaction at 180 °C produced a mixture of **45a** and **45b** in a ratio of 63:37 (Scheme 11).

Scheme 11. Comparison of Thermal Cycloaddition Reactions of Sydnone 5e



Taken together, these results suggest that the benzylsydnone **5e** undergoes transformation to a new intermediate at elevated temperatures and that this undergoes cycloaddition to provide a 3-CF_3 pyrazole product. We propose that a Bn migration takes place to form an intermediate 1,2,3-oxadiazolidin-5-one **46** that undergoes decarboxylation to generate nitrile imine **47** and that this dipolar intermediate is the reactive species in the 3-CF_3 pyrazole-forming reaction. Indeed, Tanaka has demonstrated that a closely related intermediate trifluoroacetonitrile imine **49** undergoes cycloaddition with phenylacetylene to give 3-CF_3-pyrazole **50** (Scheme 12).[27] Studies aimed at providing

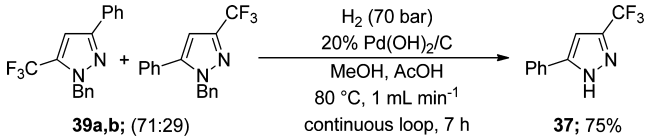
Scheme 12. Proposed Mechanism of Formation of 3-CF_3 Pyrazoles



experimental evidence for intermediates **46** and **47** and to explore other such migration reactions in 3,4-disubstituted pyrazoles are ongoing and will be reported in due course.

From a synthetic standpoint, our initial goal was to undertake cycloadditions of **5e** so that we could carry out a subsequent debenzylation to furnish *N*-unsubstituted pyrazoles. In this regard, it is unimportant that we observe compound mixtures in this particular case as both isomers converge to a single pyrazole upon hydrogenolysis. For example, compounds **39a,b** provided pyrazole **37** in 75% yield (Scheme 13).[28]

Scheme 13. Catalytic Hydrogenolysis of Bn-Protected 3- and 5-Trifluoromethylpyrazoles



Having established a robust method for the introduction of the trifluoromethyl group into pyrazoles, we wondered if the concept could be extended to include monofluoromethyl and difluoromethyl substituents. While monofluoromethyl pyrazoles are rather rare, difluoromethyl-substituted analogues can be prepared via hydrazine condensation reactions with the respective difluoromethyl-1,3-diketones. As with the trifluoromethyl analogues, the 3-fluoromethyl isomer predominates.[29] Therefore, as an extension to the synthesis and cycloadditions of trifluoromethyl sydnones, we envisioned that the known 4-formyl- and 4-hydroxymethylsydnones[30] could be transformed into the corresponding fluoromethylsydnones using deoxofluor. These sydnones could then be utilized as novel precursors to diverse 5-fluoromethyl- and 5-difluoromethylpyrazoles.

Although the direct synthesis of 4-formyl-*N*-phenylsydnone is reported,[30] we had difficulties reproducing the published methods. However, we were able to generate the 4-ethyl ester **52** via lithiation of *N*-phenylsydnone **51**, followed by addition to ethyl chloroformate. Sydnone **52** was then reduced to the alcohol **53** in excellent yield by stirring with lithium borohydride overnight, and this alcohol could subsequently

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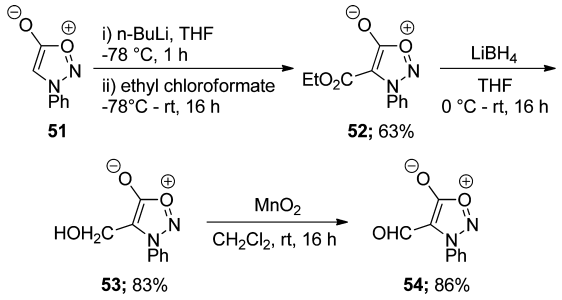
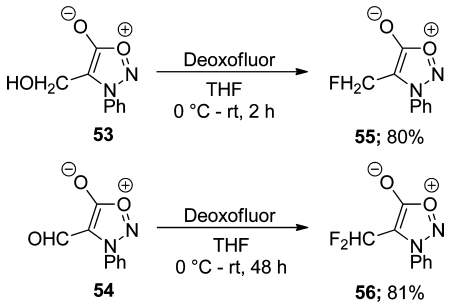
be oxidized to the 4-formyl sydnone **54** using MnO_2 (Scheme 14).

Scheme 14. Synthesis of Sydnones 53 and 54



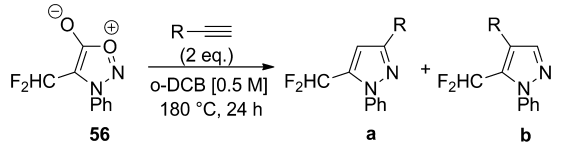
Deoxofluorination of the hydroxymethyl sydnone **53** was highly efficient, providing 4-fluoromethyl-*N*-phenylsydnone **55** in 80% yield after stirring at ambient temperature for 2 h. The same reaction with 4-formyl-*N*-phenylsydnone **54** required significantly more forceful conditions (5 equiv of $[(CH_3OCH_2CH_2)_2NSF_3]$ deoxofluor, 48 h), but 4-difluoromethyl-*N*-phenylsydnone **56** was isolated in 81% yield (Scheme 15).

Scheme 15. Synthesis of Fluorinated Sydnones by Deoxofluorination



The cycloaddition of difluoromethylsydnone **56** with a selection of alkynes was undertaken, and the results are summarized in Table 4. The reaction was found to be generally very efficient and provided the corresponding 5-difluoromethylpyrazoles in high yield with good regioselectivities. Notably, the sterically less demanding difluoromethyl group provides lower selectivities in the case of 2-ethynylpyridine and ethyl propiolate, in comparison to the trifluoromethyl analogue (compare entries 2 and 5 in Table 4 with entries 4 and 20 in Table 1).

Table 4. Synthesis of 5-Difluoromethylpyrazoles

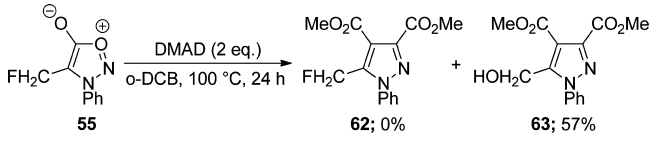


entry	R	yield (%)	a:b
1	Ph	**57**: 93	98:2
2		**58**: 90	83:17[a]
3		**59**: 76	98:2
4	$(CH_2)_3Cl$	**60**: 58	>98:2
5	CO_2Et	**61**: 95	77:23

[a]Product isolated as an inseparable mixture of regioisomers. *o*-DCB: 1,2-dichlorobenzene.

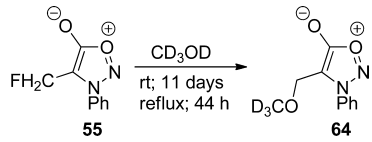
We next turned our attention to the alkyne cycloaddition reactions of 4-fluoromethyl-*N*-phenylsydnone **55**. To our disappointment, the reaction of phenylacetylene resulted in decomposition. The situation could not be improved by reducing the temperature to 120 °C. We next opted to exploit the reactivity of DMAD and were pleased to find that cycloaddition could be achieved by conducting the reaction at 100 °C. However, as illustrated in Scheme 16, we discovered that the resulting pyrazole was actually the 5-hydroxymethyl analogue **63**.

Scheme 16. Fluoromethyl Sydnone 55 Cycloaddition



We decided to explore the susceptibility of sydnone **55** to hydrolysis by exposing this compound to deuteromethanol, allowing the reaction progress to be conveniently monitored by ^1H NMR spectroscopy. At room temperature, full conversion to sydnone **64** occurred over several days but this time was reduced to 44 h if the reaction mixture was heated at reflux (Scheme 17).

Scheme 17. Solvolysis Studies of 55 in CD_3OD



As we were unable to productively use fluoromethylsydnone **55** in our cycloaddition reactions, we synthesized 1,3-diphenyl-5-hydroxymethylpyrazole **65** from 4-hydroxymethyl-*N*-phenylsydnone **53** in 72% yield. The subsequent reaction with deoxofluor appeared to proceed to full conversion within 2 h.[31] Unfortunately, however, upon workup either by quenching with $NaHCO_{3(aq)}$ or submitting directly to flash chromatography on silica gel, a significant proportion of the desired fluorinated pyrazole **66** was found to have hydrolyzed to pyrazole **65**, showing the susceptibility of this compound to hydrolysis (Scheme 18).

Finally, the 4-fluoromethylated sydnones **5a** and **56** were crystalline, and we therefore decided to analyze these compounds by X-ray diffraction; the structures of both compounds are shown in Figure 2. The crystal structure of difluoromethyl sydnone **56** shows an alignment of the C−H and C−O bonds. The conformation may simply reflect reduced A(1,3) strain, or favorable C−O and C−F bond dipole alignments (or a combination of both). Curiously however, the trifluoromethyl-substituted sydnone **5a** highlights a similar alignment in the solid phase resulting in a close contact between the oxygen and fluorine atoms.[32]

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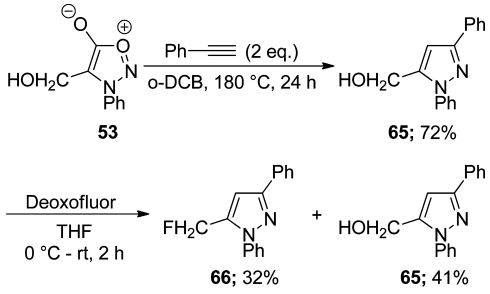
Scheme 18. Attempted Synthesis of 5-Fluoromethylpyrazole 66



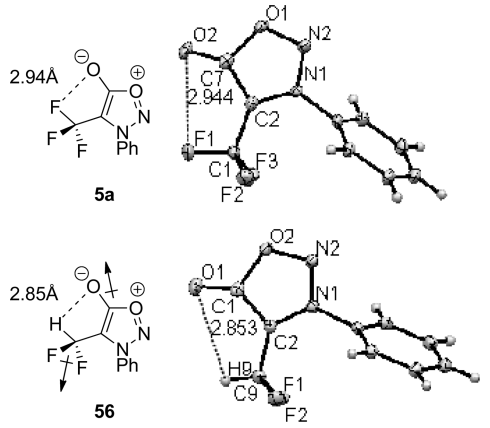


Figure 2. X-ray crystal structures of sydnones **5a** and **56**.

CONCLUSION

In conclusion, we have demonstrated that 4-trifluoromethylsydnones can be prepared by ring synthesis and ring functionalization approaches. These compounds function as valuable precursors to 5-trifluoromethylpyrazoles via highly regioselective cycloaddition reactions, although the *N*-Bn sydnone **5e** delivers an unexpected alkyne insertion reaction to provide both 5- and 3-CF_3 pyrazoles. The CF_3-pyrazole boronic esters can be further fucntionalized through established and widely utilized organoboron chemistry, demonstrated by the synthesis of key intermediates for biologically active compounds. This chemistry has been extended toward the synthesis of 4-fluoromethyl- and 4-difluoromethylsydnones. While there are inherent stability issues regarding the 4-fluoromethyl compounds, 4-difluoromethyl-*N*-phenylsydnone **56** proved to be a valuable precursor for the preparation of a range of 5-difluoromethylpyrazoles.

EXPERIMENTAL SECTION

Synthesis of Triphenylphosphine Phenylimide 1a. To a stirring solution of azidobenzene (15.86 g, 133.12 mmol) in ether (200 mL) was slowly added a solution of triphenylphosphine (34.92 g, 133.12 mmol) in ether (200 mL). The mixture was stirred for 2 h, and then the volatiles were removed in vacuo. The crude material was purified by recrystallization from ethanol to yield tetraphenylphosphine imide **1a** as a yellow solid (37.25 g, 79%): mp 134 − 135 °C (lit.[33] mp 135−136 °C); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82−7.76 (m, 6H), 7.57−7.53 (m, 3H), 7.50−7.45 (m, 6H), 7.07−7.01 (m, 2H), 6.85−6.81 (m, 2H), 6.71−6.65 (m, 1H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 151.1 (d, J = 2.5 Hz), 132.6 (d, J = 9.5 Hz), 131.7 (d, J = 2.5 Hz), 131.4 (d, J = 99.0 Hz), 128.7 (d, J = 12.0 Hz), 128.6, 123.5 (d, J = 17.5 Hz), 117.3; ^{31}P NMR (101.1 MHz, $CDCl_3$) δ 2.89; HRMS m/z $[MH]^+$ calcd for $C_{24}H_{21}NP$ 354.1412, found 354.1411.

Synthesis of Triphenylphosphine (*p*-Methoxyphenyl)imide 1b. To a stirring solution of 1-azido-4-methoxybenzene (18.40 g, 123.37 mmol) in ether (200 mL) was slowly added a solution of triphenylphosphine (32.36 g, 123.37 mmol) in ether (200 mL). The mixture was stirred for 2 h, and then the volatiles were removed in vacuo. The crude material was purified by recrystallization from ethanol to yield triphenylphosphine (*p*-methoxyphenyl)imide **1b** as a yellow solid (41.51 g, 88%): mp 116−118 °C (lit.[34] mp 117−118 °C); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82−7.78 (m, 6H), 7.54−7.50 (m, 3H), 7.47−7.42 (m, 6H), 6.83−6.81 (m, 2H), 6.68−6.66 (m, 2H), 3.70 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 152.0, 144.5 (d, J = 2.5 Hz), 132.7 (d, J = 9.5 Hz), 131.6 (d, J = 2.5 Hz), 131.5 (d, J = 99.0 Hz), 128.6 (d, J = 12.0 Hz), 123.9 (d, J = 16.5 Hz), 114.3, 55.6; ^{31}P NMR (101.1 MHz, $CDCl_3$) δ 2.49; HRMS m/z $[MH]^+$ calcd for $C_{25}H_{23}NOP$ 384.1517, found 384.1512.

Synthesis of (*Z*)-Methyl 3,3,3-Trifluoro-2-(phenylimino)-propanoate 2a.[16] To a stirring solution of methyl trifluoropyruvate (11.70 g, 75.00 mmol) in toluene (200 mL) was added solid tetraphenylphosphine imide **1a** (26.50 g, 75.00 mmol) in one portion. The mixture was stirred for 2 h before the volatiles were removed in vacuo. The crude material was suspended in petroleum ether, filtered, and washed with more petroleum ether before the volatiles were removed in vacuo. This procedure was repeated until the precipitation of triphenylphosphine oxide had ceased to yield (*Z*)-methyl 3,3,3-trifluoro-2-(phenylimino)propanoate **2a** as a yellow oil (15.95 g, 92%).

Note: Compound **2a** could alternatively be purified by flash chromatography on silica gel (eluting with 10% EtOAc in petroleum ether): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.43−7.39 (m, 2H), 7.31−7.27 (m, 1H), 7.00−6.97 (m, 2H), 3.73 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 159.9, 148.5 (q, J = 37.0 Hz), 146.4, 129.2, 127.3, 119.2, 118.2 (q, J = 278.5), 52.9; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −69.8; FTIR 2930 (w), 2856 (w), 1749 (s), 1326 (m), 1263 (s), 1190 (m), 1155 (s), 1037 (s) cm^{-1}; HRMS m/z $[MH]^+$ calcd for $C_{10}H_9F_3NO_2$ 232.0585, found 232.0591.

Synthesis of (*Z*)-Methyl 3,3,3-Trifluoro-2-(*para*-methoxyphenylimino)propanoate 2b.[35] To a stirring solution of methyl trifluoropyruvate (2.84 g, 16.02 mmol) in toluene (25 mL) was added solid triphenylphosphine (*p*-methoxyphenyl)imide **1b** (6.14 g, 18.17 mmol) in one portion. The mixture was stirred for 2 h before the volatiles were removed in vacuo. The crude material was suspended in petroleum ether, filtered, and washed with more petroleum ether before the volatiles were removed in vacuo. This procedure was repeated until the precipitation of triphenylphosphine oxide had ceased to yield (*Z*)-methyl 3,3,3-trifluoro-2-(*p*-methoxyphenylimino)-propanoate **2b** as an orange oil (3.77 g, 96%).

Note: Compound **1b** could alternatively be purified by flash chromatography on silica gel (eluting with 10% EtOAc in petroleum ether): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.03 (d, J = 9.0 Hz, 2H), 6.92 (d, J = 9.0 Hz, 2H), 3.83 (s, 3H), 3.79 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 160.9, 159.6, 146.1 (q, J = 37.0 Hz), 138.9, 122.4, 118.4 (q, J = 278.0 Hz), 114.5, 55.4, 52.9; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −69.6; FTIR 3462 (br), 2967 (w), 2845 (w), 1748 (s), 1508 (s), 1256 (s), 1162 (s), 1035 (s), 844 (m) cm^{-1}; HRMS m/z $[MH]^+$ calcd for $C_{11}H_{11}F_3NO_3$ 262.0691, found 262.0680.

Synthesis of Methyl 3,3,3-Trifluoro-2-(phenylamino)-propanoate 3a.[36] To a stirring suspension of zinc dust (8.26 g, 126.31 mmol) in AcOH (75 mL) was added (*Z*)-methyl 3,3,3-trifluoro-2-(phenylimino)propanoate **2a** (14.60 g, 63.16 mmol). The mixture was stirred at ambient temperature for 2 h, filtered, and neutralized with $NaHCO_3$. The solution was extracted with EtOAc (3 × 50 mL), washed with water (25 mL), and dried over $MgSO_4$ before the volatiles were removed to yield methyl 3,3,3-trifluoro-2-(phenylamino)propanoate **3a** as a colorless oil (11.49 g, 78%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29−7.25 (m, 2H), 6.92−6.98 (m, 1H), 6.77−6.75 (m, 2H), 4.70−4.59 (m, 2H), 3.89 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 166.8, 145.1, 129.5, 123.3 (q, J = 283.5), 120.1, 114.2, 59.6 (q, J = 31.5 Hz), 53.6; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −72.7 (d, J = 6.0 Hz); FTIR 3391 (br), 3038 (w), 2965 (w), 2853 (w), 1756 (s), 1606 (s), 1514 (s), 1441 (m), 1304 (s), 1218 (s), 1183 (s)

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cm^{-1}; HRMS m/z $[MH]^+$ calcd for $C_{10}H_{11}F_3NO_2$ 234.0742, found 234.0744.

Synthesis of Methyl 3,3,3-Trifluoro-2-(*p*-methoxyphenylamino)propanoate 3b. To a stirring suspension of zinc dust (1.82 g, 27.81 mmol) in AcOH (15 mL) was added (Z)-methyl 3,3,3-trifluoro-2-(*p*-methoxyphenylimino)propanoate **2b** (3.63 g, 13.91 mmol). The mixture was stirred at ambient temperature for 2 h, filtered, and neutralized with $NaHCO_3$. The solution was extracted with EtOAc (3 × 25 mL), washed with water (25 mL), and dried over $MgSO_4$ before the volatiles were removed in vacuo to yield methyl 3,3,3-trifluoro-2-(*p*-methoxyphenylamino)propanoate **3b** as a yellow oil (2.45 g, 67%): ^1H NMR (400 MHz, $CDCl_3$) δ 6.83 (d, J = 9.0 Hz, 2H), 6.73 (d, J = 9.0 Hz, 2H), 4.57−4.50 (quint, J = 7.0 Hz, 1H), 4.39 (d, J = 7.5 Hz, 1H), 3.85 (s, 3H), 3.77 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 167.1, 154.0, 139.0, 123.4 (q, J = 283.0), 116.2, 115.0, 61.0 (q, J = 31.0 Hz), 55.6, 53.5; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −72.7 (d, J = 6.5 Hz); FTIR 3374 (br), 2955 (w), 3836 (w), 1758 (s), 1519 (s), 1245 (s), 1126 (s), 1032 (m), 823 (m) cm^{-1}; HRMS m/z $[MH]^+$ calcd for $C_{11}H_{13}F_3NO_3$ 264.0848, found 264.0853.

Synthesis of 3,3,3-Trifluoro-2-(phenylamino)propanoic Acid 4a. To a stirring solution of methyl 3,3,3-trifluoro-2-(phenylamino)-propanoate **3a** (3.33 g, 14.28 mmol) in EtOAc (60 mL), shielded from light, was added lithium iodide (9.56 g, 71.40 mmol). The reaction was heated at reflux for 4 h and then cooled before water (25 mL) was added and the mixture was acidified with 1 M $HCl_{(aq)}$ to ∼pH 3. The solution was extracted with EtOAc (3 × 25 mL), washed with water (25 mL), and dried over $MgSO_4$ before the volatiles were removed in vacuo to yield 3,3,3-trifluoro-2-(phenylamino)propanoic acid **4a** as a brown solid (2.72 g, 85%): mp 101−103 °C; ^1H NMR (400 MHz, $CDCl_3$) δ 7.29−7.25 (m, 2H), 6.92−6.90 (m, 1H), 6.77−6.75 (m, 2H), 4.70 (q, J = 7.0 Hz, 1H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 170.6, 144.7, 129.6, 123.1 (q, J = 283.5 Hz), 120.5, 114.3, 59.6 (q, J = 32.0 Hz); ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −72.4 (d, J = 7.0 Hz); FTIR 2994 (w), 1624 (m), 1520 (m), 1260 (s), 1181 (s), 1145 (s), 1031 (m), 778 (m), 658 (m) cm^{-1}HRMS m/z $[MH]^+$ calcd for $C_9H_9F_3NO_2$ 220.0585, found 220.0587.

Synthesis of 3,3,3-Trifluoro-2-(*p*-methoxyphenylamino)-propanoic Acid 4b. To a stirring solution of methyl 3,3,3-trifluoro-2-(*p*-methoxyphenylamino)propanoate **3b** (8.02 g, 30.47 mmol) in EtOAc (100 mL), shielded from light, was added lithium iodide (16.31 g, 121.88 mmol). The reaction was heated at reflux for 4 h and then cooled before water (25 mL) was added and the mixture was acidified with 1 M $HCl_{(aq)}$ to ∼pH 3. The solution was extracted with EtOAc (3 × 25 mL), washed with water (25 mL), and dried over $MgSO_4$ before the volatiles were removed in vacuo to yield 3,3,3-trifluoro-2-(*p*-methoxyphenylamino)propanoic acid **4b** as a brown solid (5.76 g, 76%): mp 120−123 °C; ^1H NMR (400 MHz, $CDCl_3$) δ 6.84 (d, J = 9.0 Hz, 2H), 6.74 (d, J = 9.0 Hz, 2H), 6.52 (br, 1H), 4.56 (q, J = 7.0 Hz, 1H), 3.78 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 170.2, 154.2, 138.6, 122.5 (q, J = 283.5 Hz), 116.4, 115.1, 61.0 (q, J = 31.5 Hz), 55.7; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −72.5 (d, J = 7.0 Hz); HRMS m/z $[MH]^+$ calcd for $C_{10}H_{10}F_3NO_3$ 249.1865, found 249.1869.

Synthesis of 4-Trifluoromethyl-*N*-phenylsydnone 5a. To a stirring solution of 3,3,3-trifluoro-2-(phenylamino)propanoic acid **4a** (3.20 g, 14.60 mmol) in dimethyoxyethane (15 mL) was added isoamyl nitrite (2.16 mL, 16.06 mmol). The reaction was stirred for 5 h and then concentrated in vacuo to yield an oil that was triturated with petroleum ether, filtered, and dried in vacuo to be used without further purification. (CAUTION: this nitrosamine intermediate is a suspected carcinogen). To a stirring suspension of the solid in DCM (15 mL) was added trifluoroacetic anhydride (4.06 mL, 29.20 mmol) at 0 °C. The reaction was warmed to ambient temperature and stirred for 1 h, and then approximately 10 mL of water was added and the mixture was neutralized with $NaHCO_3$. The organic layer was extracted with DCM (3 × 25 mL) and dried over $MgSO_4$ before the volatiles were removed in vacuo. The crude material was purified by recrystallization from ethanol to yield 4-trifluoromethyl-*N*-phenylsydnone **5a** as a tan solid (2.31 g, 69%).

Note: Compound **5a** could alternatively be purified by flash chromatography on silica gel (eluting with 20% EtOAc in petroleum ether): mp 112−114 °C; ^1H NMR (400 MHz, $CDCl_3$) δ 7.78 (t, J = 7.5 Hz, 1H), 7.69 (t, J = 7.5 Hz, 2H), 7.62 (d, J = 7.5 Hz, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 163.2, 133.5, 133.3, 130.2, 124.6, 119.3 (q, J = 268.0 Hz), 98.1 (q, J = 41.0 Hz); ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −56.3; FTIR 1791 (s), 1479 (m), 1330 (m), 1215 (m), 1120 (s), 1024 (m) cm^{-1}; HRMS m/z $[MH]^+$ calcd for $C_9H_6F_3N_2O_2$ 231.0381, found 231.0389.

Synthesis of 4-Trifluoromethyl-*N*-(*p*-methoxyphenyl)-sydnone 5b. To a stirring solution of 3,3,3-trifluoro-2-(*p*-methoxyphenylamino)propanoic acid **4b** (4.75 g, 19.08 mmol) in dimethyoxyethane (20 mL) was added isoamyl nitrite (2.81 mL, 20.99 mmol). The reaction was stirred for 3 h and then concentrated in vacuo to yield an oil that was triturated with petroleum ether, filtered, and dried in vacuo to be used without further purification. (CAUTION: this nitrosamine intermediate is a suspected carcinogen.) To a stirring suspension of the solid in DCM (20 mL) was added trifluoroacetic anhydride (5.30 mL, 38.16 mmol) at 0 °C. The reaction was warmed to ambient temperature and stirred for 1 h, then approximately 10 mL of water was added and the mixture was neutralized with $NaHCO_3$. The organic layer was extracted with DCM (3 × 25 mL) and dried over $MgSO_4$ before the volatiles were removed in vacuo. The crude material was purified by recrystallization from ethanol to yield 4-trifluoromethyl-*N*-(*p*-methoxyphenyl)sydnone **5b** as a tan solid (2.78 g, 56%).

Note: Compound **5b** could alternatively be purified by flash chromatography on silica gel (eluting with 20% EtOAc in petroleum ether): mp 65−66 °C; ^1H NMR (400 MHz, $CDCl_3$) δ 7.54 (d, J = 9.0 Hz, 2H), 7.12 (d, J = 9.0 Hz, 2H), 3.94 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 163.2, 163.1, 125.9, 119.5 (q, J = 264.0 Hz), 115.5, 115.2, 98.0 (q, J = 43.0 Hz), 55.9; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −56.4; FTIR 2948 (w), 1790 (s), 1512 (m), 1476 (m), 1205 (m), 1124 (s), 1018 (s), 979 (m), 837 (m) cm^{-1}; HRMS m/z $[MH]^+$ calcd for $C_{10}H_8F_3N_2O_3$ 261.0487, found 261.0481.

General Procedure 1: Trifluoromethylation of Iodosydnones (See Scheme 4). To a stirring suspension of the iodosydnone (1 equiv) and CuI (1 equiv) in DMF (0.2 M) was added methyl fluorosulfonyldifluoroacetate (5 equiv) under a nitrogen atmosphere, and the mixture was heated at 80 °C for the designated time. The reaction was filtered, brine was added to the filtrate, and the solution was extracted with EtOAc. The organic fractions were subsequently washed with brine and dried over $MgSO_4$ before the volatiles were removed in vacuo. The crude material was purified by flash chromatography on silica gel (eluting with 20% EtOAc in petroleum ether, unless otherwise stated) to yield the title sydnones.

4-Trifluoromethyl-*N*-phenylsydnone 5a. Following general procedure 1 using 4-iodo-*N*-phenylsydnone **7a** (1.44 g, 5.00 mmol), CuI (920 mg, 5.00 mmol), and methyl fluorosulfonyldifluoroacetate (4.80 g, 25.00 mmol) in DMF (25 mL), stirring for 20 h, 4-trifluoromethyl-*N*-phenylsydnone **5a** was isolated as a tan solid (906 mg, 79%).

4-Trifluoromethyl-*N*-(*p*-methoxyphenyl)sydnone 5b. Following general procedure 1 using 4-iodo-*N*-(*para*-methoxyphenyl)-sydnone **7b** (1.59 g, 5.0 mmol), CuI (952 mg, 5.0 mmol), and methyl fluorosulfonyldifluoroacetate (4.80 g, 25.00 mmol) in DMF (25 mL), stirring for 20 h, 4-trifluoromethyl-*N*-(*p*-methoxyphenyl)-sydnone **5b** was isolated as a tan solid (1.04 g, 80%).

4-Trifluoromethyl-*N*-(*p*-nitrophenyl)sydnone 5c. Following general procedure 1 using 4-iodo-*N*-(*p*-nitrophenyl)sydnone **7c** (1.33 g, 4.00 mmol), CuI (762 mg, 4.00 mmol), and methyl fluorosulfonyldifluoroacetate (3.84 g, 20 mmol) in DMF (20 mL), stirring for 40 h, 4-trifluoromethyl-*N*-(*p*-nitrophenyl)sydnone **5c** was isolated as a yellow solid (605 mg, 55%): mp 110−111 °C; ^1H NMR (400 MHz, $CDCl_3$) δ 8.58 (d, J = 9.0 Hz, 1H), 7.92 (d, J = 9.0 Hz, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 162.5, 150.5, 137.7, 126.4, 125.7, 120.5 (q, J = 268.0 Hz), 98.4 (q, J = 43.0 Hz); ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −56.0; FTIR 3125 (w), 1780 (s), 1531 (s), 1349 (s), 1210 (s), 1119 (s), 1028 (s), 851 (s), 764 (m) cm^{-1}; HRMS m/z $[EI]^+$ calcd for $C_9H_4F_3N_3O_4$ 275.0154, found 275.0165.

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4-Trifluoromethyl-*N*-methylsydnone 5d. Following general procedure 1 using 4-iodo-*N*-methylsydnone **7d** (1.13 g, 5.00 mmol), CuI (952 mg, 5.00 mmol), and methyl fluorosulfonyldifluoroacetate (4.80 g, 25.00 mmol) in DMF (25 mL), stirring for 20 h, 4-trifluoromethyl-*N*-methylsydnone **5d** was isolated as a colorless oil (605 mg, 72%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.23 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 163.2, 119.7 (q, J = 267.5 Hz), 96.9 (q, J = 44.0 Hz), 40.2; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −58.3; FTIR 3051 (w), 1774 (s), 1516 (m), 1353 (m), 1196 (s), 1126 (s), 1004 (s), 743 (m), 600 (m) cm^{-1}; HRMS m/z [EI] $^+$ calcd for $C_4H_4F_3N_2O_2$ 169.0225, found 169.0228.

4-Trifluoromethyl-*N*-benzylsydnone 5e. Following general procedure 1 using 4-iodo-*N*-benzylsydnone **7e** (1.51 g, 5.00 mmol), CuI (952 mg, 5.00 mmol), and methyl fluorosulfonyldifluoroacetate (4.80 g, 25.00 mmol) in DMF (25 mL), stirring for 20 h, 4-trifluoromethyl-*N*-benzylsydnone **5e** was isolated as a yellow solid (580 mg, 48%): mp 50−51 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.46−7.44 (m, 3H), 7.39−7.38 (m, 2H), 5.61 (s, 2H, CH_2); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 163.4, 130.3, 129.4, 129.3, 128.5, 119.6 (q, J = 267.5 Hz), 96.2 (q, J = 43.5 Hz), 58.1; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −57.2; FTIR 2919 (w), 1768 (s), 1513 (m), 1383 (m), 1173 (m), 1114 (s), 1021 (s), 729 (m), 695 (s) cm^{-1}; HRMS m/z [EI]$^+$ calcd for $C_{10}H_7F_3N_2O_2$ 244.0460, found 244.0459.

General Procedure 2: Cycloaddition Reactions of 4-Trifluoromethylsydnones and Alkynes (See Table 1). A solution of a 4-trifluoromethylsydnone (1 equiv) and an alkyne (2 equiv) in *o*-DCB (0.5 M) in a sealed microwave vessel was heated at 180 °C for the designated length of time. After cooling, the crude materials were purified by flash chromatography on silica gel (eluting with 5% EtOAc in petroleum ether, unless otherwise stated) to yield the title pyrazoles.

Synthesis of 1,3-Diphenyl-5-trifluoromethyl-1*H*-pyrazole 8a. Following general procedure 2 using 4-trifluoromethyl-*N*-phenylsydnone **5a** (115 mg, 0.5 mmol) and ethynylbenzene (102 mg, 1.0 mmol), heating for 24 h, 1,3-diphenyl-5-trifluoromethyl-1*H*-pyrazole **8a** was isolated as a colorless solid (125 mg, 87%): mp 50−53 °C (lit.[9] mp 50−52 °C); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92−7.90 (m, 2H), 7.62−7.39 (m, 8H), 7.16 (s, 1H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 151.7, 139.2, 134.0 (q, J = 39.0 Hz), 131.8, 129.3, 129.2, 128.8, 128.7, 125.9, 125.8, 119.8 (q, J = 269.0 Hz), 106.1 (br); ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −57.6; FTIR 3073 (w), 1600 (w), 1505 (m), 1447 (m), 1288 (m), 1237 (s), 1167 (s), 989 (m), 770 (s), 693 (s) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{16}H_{12}F_3N_2$ 289.0953, found 289.0943.

Synthesis of 1-Phenyl-3-*n*-butyl-5-trifluoromethyl-1*H*-pyrazole 9a.[10] Following general procedure 2 using 4-trifluoromethyl-*N*-phenylsydnone **5a** (115 mg, 0.5 mmol) and 1-hexyne (82 mg, 1.0 mmol), heating for 24 h, 1-phenyl-3-*n*-butyl-5-trifluoromethyl-1*H*-pyrazole **9a** was isolated as a yellow oil (105 mg, 78%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49−7.44 (m, 5H), 6.64 (s, 1H), 2.73 (t, J = 7.5 Hz, 2H), 1.76−1.68 (m, 2H), 1.50−1.41 (m, 2H), 0.98 (m, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 153.8, 139.3, 132.9 (q, J = 39.0 Hz), 129.0, 128.9, 125.6, 119.7 (q, J = 269.0 Hz), 107.7 (br), 31.5, 27.7, 22.4, 13.8; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −57.5; FTIR 3060 (w), 2968 (m), 2939 (m), 2862 (w), 1600 (m), 1505 (s), 1470 (m), 1390 (w), 1295 (m), 1186 (s), 1129 (s), 989 (m), 763 (m), 693 (m) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{14}H_{16}F_3N_2$ 269.1269, found 269.1266.

Synthesis of 1-Phenyl-3-trimethylsilyl-5-trifluoromethyl-1*H*-pyrazole 10a. Following general procedure 2 using 4-trifluoromethyl-*N*-phenylsydnone **5a** (115 mg, 0.5 mmol) and ethynyltrimethylsilane (98 mg, 1.0 mmol), heating for 24 h, 1-phenyl-3-trimethylsilyl-5-trifluoromethyl-1*H*-pyrazole **10a** was isolated as a colorless oil (106 mg, 75%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.52−7.48 (m, 5H), 6.92 (s, 1H), 0.38 (s, 9H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 153.9, 139.4, 132.9 (q, J = 39.0 Hz), 129.1, 129.0, 125.8, 120.4 (q, J = 269.0 Hz), 114.8 (br), −1.2; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −57.1; FTIR 3088 (w), 2960 (m), 1604 (m), 1504 (m), 1283 (m), 1171 (s), 975 (m), 850 (s), 761 (m), 689 (m) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{13}H_{16}F_3N_2Si$ 285.1035, found 285.1047.

Synthesis of 2-(1-Phenyl-5-trifluoromethyl-1*H*-pyrazol-3-yl)-pyridine 11a.[11] Following general procedure 2 using 4-trifluoromethyl-*N*-phenylsydnone **5a** (115 mg, 0.5 mmol) and 2-ethynylpyridine (103 mg, 1.0 mmol), heating for 24 h, 2-(1-phenyl-5-trifluoromethyl-1*H*-pyrazol-3-yl)pyridine **11a** was isolated as a yellow oil (121 mg, 84%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.68 (ddd, J = 1.0, 5.0, 7.5 Hz, 1H), 8.07 (td, J = 1.0, 8.0 Hz, 1H), 7.76 (td, J = 2.0, 7.5 Hz, 1H), 7.59−7.51 (m, 6H), 7.28 (ddd, J = 1.0, 5.0, 7.5 Hz, 1H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 152.0, 150.8, 149.6, 139.2, 136.7, 134.2 (q, J = 39.5 Hz), 129.4, 129.1, 125.8, 123.3, 120.2, 119.7 (q, J = 269.0 Hz), 107.7 (br); ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −57.7; FTIR 3076 (w), 1599 (w), 1499 (m), 1415 (m), 1282 (m), 1232 (s), 1136 (s), 994 (m), 732 (s), 694 (s) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{15}H_{11}F_3N_3$ 290.0905, found 290.0909.

Synthesis of 1-Phenyl-3-(cyclohex-1-enyl)-5-trifluoromethyl-1*H*-pyrazole 12a. Following general procedure 2 using 4-trifluoromethyl-*N*-phenylsydnone **5a** (115 mg, 0.5 mmol) and 2-ethynylcyclohexene (106 mg, 1.0 mmol), heating for 24 h, 1-phenyl-3-(cyclohex-1-enyl)-5-trifluoromethyl-1*H*-pyrazole **12a** was isolated as a yellow solid (130 mg, 89%): mp 55−57 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.53−7.46 (m, 5H), 6.86 (s, 1H), 6.45−6.43 (m, 1H), 2.53−2.50 (m, 2H), 2.27−2.22 (m, 2H), 1.83−1.77 (m, 2H), 1.74−1.68 (m, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 153.6, 139.4, 133.1 (q, J = 42.5 Hz), 129.6, 129.0 (2), 126.5, 127.0, 119.9 (q, J = 269.0 Hz), 105.0 (br), 25.8, 25.5, 22.5, 22.2; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −57.6; FTIR 3063 (w), 2939 (m), 2860 (w), 1600 (m), 1505 (s), 1450 (m), 1288 (m), 1231 (s), 1139 (s), 989 (m), 817 (w), 771 (m), 697 (m) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{16}H_{16}F_3N_2$ 293.1266, found 293.1267.

Synthesis of 1-Phenyl-3-cyclopropyl-5-trifluoromethyl-1*H*-pyrazole 13a. Following general procedure 2 using 4-trifluoromethyl-*N*-phenylsydnone **5a** (115 mg, 0.5 mmol) and ethynylcyclopropane (66 mg, 1.0 mmol), heating for 24 h, 1-phenyl-3-cyclopropyl −5-trifluoromethyl-1*H*-pyrazole **13a** was isolated as a yellow oil (111 mg, 88%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50−7.46 (m, 5H), 6.50 (s, 1H), 2.03 (tt, J = 5.0, 8.5 Hz, 1H), 1.03−0.99 (m, 2H), 0.87−0.82 (m, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 155.5, 139.3, 132.9 (q, J = 39.0 Hz), 129.0, 128.9, 125.6, 119.8 (q, J = 269.0 Hz), 105.6 (br), 8.9, 8.2; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −57.6; FTIR 3060 (w), 2936 (m), 2856 (w), 1603 (w), 1508 (m), 1288 (m), 1234 (m), 1177 (m), 1136 (s), 989 (m), 771 (m), 690 (m) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{13}H_{12}F_3N_2$ 253.0953, found 253.0957.

Synthesis of 3-(Benzyloxymethyl)-1-phenyl-5-trifluoromethyl-1*H*-pyrazole 14a. Following general procedure 2 using 4-trifluoromethyl-*N*-phenylsydnone **5a** (115 mg, 0.5 mmol) and benzyl 2-propynyl ether (146 mg, 1.0 mmol), heating for 24 h, 3-(benzyloxymethyl)-1-phenyl-5-trifluoromethyl-1*H*-pyrazole **14a** was isolated as a yellow oil (139 mg, 84%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54−7.39 (m, 10H), 6.93 (s, 1H), 4.69 (s, 2H), 4.69 (s, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 150.3, 139.1, 137.9, 133.6 (q, J = 39.0 Hz), 129.3, 129.1, 128.5, 128.0, 127.8, 125.7, 119.8 (q, J = 269.0 Hz), 108.4 (br), 72.8, 65.5; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −57.6; FTIR 3069 (w), 3034 (w), 2870 (m), 1732 (w), 1507 (s), 1299 (s), 1188 (s), 1084 (s), 992 (m), 736 (m), 701 (s) cm^{-1}; HRMS m/z [MH] $^+$ calcd for $C_{18}H_{16}F_3N_2O_2$ 333.1215, found 333.1228.

Synthesis of 1-Phenyl-3-(3-chloro)propyl-5-trifluoromethyl-1*H*-pyrazole 15a. Following general procedure 2 using 4-trifluoromethyl-*N*-phenylsydnone **5a** (115 mg, 0.5 mmol) and 5-chloro-1-pentyne (103 mg, 1.0 mmol), heating for 24 h, 1-phenyl-3-(3-chloro)propyl-5-trifluoromethyl-1*H*-pyrazole **15a** was isolated as a yellow oil (101 mg, 70%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 (m, 5H), 6.67 (s, 1H), 3.65 (t, J = 6.5 Hz, 2H), 2.91 (t, J = 7.0 Hz, 2H), 2.25−2.18 (m, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 151.8, 139.2, 133.1 (q, J = 39.5 Hz), 129.1, 129.0, 125.6, 119.8 (q, J = 269.0 Hz), 107.9 (br), 44.2, 31.9, 25.2; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −57.5; FTIR 3063 (w), 2958 (w), 2869 (w), 1600 (m), 1508 (s), 1470 (m), 1295 (m), 1183 (s), 1136 (s), 989 (m), 817 (w), 767 (m), 690 (m) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{13}H_{13}ClF_3N_2$ 289.0719, found 289.0708.

Synthesis of 1,4-Diphenyl-4-*n*-butyl-5-trifluoromethyl-1*H*-pyrazole 16a and 1,3-Diphenyl-3-*n*-butyl-5-trifluoromethyl-1*H*-pyrazole 16b. Following general procedure 2 using 4-trifluoromethyl-*N*-phenylsydnone **5a** (115 mg, 0.5 mmol) and 1-

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phenyl-1-hexyne (158 mg, 1.0 mmol), heating for 24 h, 1,4-diphenyl-4-*n*-butyl-5-trifluoromethyl-1*H*-pyrazole **16a** and 1,3-diphenyl-3-*n*-butyl-5-trifluoromethyl-1*H*-pyrazole **16b** were isolated as an inseparable mixture (48:52, **16a**/**16b**) as a yellow solid (103 mg, 62%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.68−7.66 (m, 1H), 7.58−7.42 (m, 8H), 7.39−7.37 (m, 1H), 2.78 (t, J = 7.5 Hz, 0.96H), 2.64 (t, J = 7.5 Hz, 1.04H), 1.67−1.57 (m, 2H), 1.46−1.29 (m, 2H), 0.95 (t, J = 7.5 Hz, 1.44H), 0.87 (t, J = 7.5 Hz, 1.56H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 152.5, 151.8, 140.0, 139.9, 132.6, 131.2, 130.0, 129.1, 129.0, 128.9 (2), 128.6, 128.5, 128.2, 127.8, 126.2, 126.0, 123.9, 122.7, 120.8 (q, J = 269.0 Hz), 120.4 (q, J = 269.0 Hz), 33.6, 31.3, 26.0, 23.2, 22.7, 22.5, 13.8, 13.7; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −54.3 (0.52F), −55.5 (0.48F); FTIR 3061 (w), 2961 (w), 2877 (w), 1594 (w), 1503 (m), 1319 (m), 1174 (s), 1117 (s), 979 (m), 773 (m), 692 (s), 524 (m) cm^{-1}; HRMS m/z [MH] $^+$ calcd for $C_{20}H_{20}F_3N_2$: 345.1579, found 345.1566 and 345.1570.

Synthesis of Methyl 3-Methyl-1-phenyl-5-trifluoromethyl-1*H*-pyrazole-4-carboxylate 17a and Methyl 4-Methyl-1-phenyl-5-trifluoromethyl-1*H*-pyrazole-3-carboxylate 17b. Following general procedure 2 using 4-trifluoromethyl-*N*-phenylsydnone **5a** (115 mg, 0.5 mmol) and methyl-2-butynoate (196 mg, 2.0 mmol), heating for 24 h, eluting with (10% EtOAc in petroleum ether), 3-methyl-1-phenyl-5-trifluoromethyl-1*H*-pyrazole-4-carboxylate **17a** was isolated as a yellow solid (217 mg, 76%) and methyl 4-methyl-1-phenyl-5-trifluoromethyl-1*H*-pyrazole-3-carboxylate **17b** was isolated as a yellow solid (39 mg, 14%).

17a: mp 78−79 °C (lit.[12] mp 81−83 °C); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50−7.47 (m, 3H), 7.42−7.39 (m, 2H), 3.91 (s, 3H), 2.50 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 162.6, 151.6, 139.4, 133.1 (q, J = 39.5 Hz), 129.7, 129.1, 125.8, 119.1 (q, J = 271.5 Hz), 114.1, 52.1, 13.5; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −55.8; FTIR 3048 (w), 2950 (w), 1720 (s), 1553 (m), 1317 (m), 1250 (s), 1170 (s), 1140 (s), 1098 (s), 999 (m), 959 (w), 785 (s) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{13}H_{12}F_3N_2O_2$ 285.0851, found 285.0849.

17b: mp 65−67 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50−7.47 (m, 3H), 7.44−7.42 (m, 2H), 3.95 (s, 3H), 2.53 (q, J = 2.0 Hz, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 162.4, 141.9, 139.2, 131.1 (q, J = 37.5 Hz), 129.9, 129.1, 126.3, 124.2, 120.1, (q, J = 270.5 Hz), 52.1, 8.9; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −55.9; FTIR 3059 (w), 2959 (w), 1719 (s), 1501 (m), 1230 (s), 1187 (s), 1118 (s), 1043 (s), 980 (m), 776 (m) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{13}H_{12}F_3N_2O_2$ 285.0851, found 285.0846.

Synthesis of 1,3,4-Triphenyl-5-trifluoromethyl-1*H*-pyrazole 18. Following general procedure 2 using 4-trifluoromethyl-*N*-phenylsydnone **5a** (115 mg, 0.5 mmol) and 1,2-diphenylethyne (178 mg, 1.0 mmol), heating for 24 h, 1,3,4-triphenyl-5-trifluoromethyl-1*H*-pyrazole **18** was isolated as an off-white solid (97 mg, 53%): mp 139−140 °C. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65−7.63 (m, 2H), 7.58−7.53 (m, 3H), 7.46−7.42 (m, 5H), 7.38−7.35 (m, 2H), 7.28−7.26 (m, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 150.4, 139.8, 131.7, 131.1, 130.4 (q, J = 36.5 Hz), 129.3, 129.1, 128.4, 128.3, 128.2, 128.0, 126.1, 122.3, 120.1 (q, J = 271.0 Hz), unable to unequivocally assign 2 × CH signals; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −54.3; FTIR 1504 (m), 1443 (m), 1224 (m), 1171 (s), 1121 (s), 976 (m), 777 (m), 689 (s), 547 (m) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{22}H_{16}F_3N_2$ 365.1266, found 365.1257.

Synthesis of 1-(*p*-Methoxyphenyl)-3-phenyl-5-trifluoromethyl-1*H*-pyrazole 19a. Following general procedure 2 using 4-trifluoromethyl-*N*-(*p*-methoxyphenyl)sydnone **5b** (130 mg, 0.5 mmol) and ethynylbenzene (102 mg, 1.0 mmol), heating for 24 h, 1-(*p*-methoxyphenyl)-3-phenyl-5-trifluoromethyl-1*H*-pyrazole **19a** was isolated as a yellow solid (135 mg, 85%): mp 89−90 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91−7.87 (d, J = 9.0 Hz, 2H), 7.51−7.39 (m, 5H), 7.11 (s, 1H), 7.06−7.01 (d, J = 9.0 Hz, 2H), 3.89 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 160.2, 151.4, 134.0 (q, J = 39.0 Hz), 132.2, 131.9, 128.8, 128.6, 127.3, 125.9, 119.9 (q, J = 269.0 Hz), 114.3, 105.6, 55.6; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −57.9; FTIR 3066 (w), 1512 (m), 1236 (m), 1166 (s), 1124 (s), 1028 (m), 986 (m), 838 (m) cm^{-1}; HRMS m/z [MH] $^+$ calcd for $C_{17}H_{14}F_3N_2O$ 319.1058, found 319.1053.

Synthesis of 1-(*p*-Methoxyphenyl)-3-*n*-butyl-5-trifluoromethyl-1*H*-pyrazole 20a. Following general procedure 2 using 4-trifluoromethyl-*N*-(*p*-methoxyphenyl)sydnone **5b** (130 mg, 0.5 mmol) and 1-hexyne (82 mg, 1.0 mmol), heating for 24 h, 1-(*p*-methoxyphenyl)-3-*n*-butyl-5-trifluoromethyl-1*H*-pyrazole **20a** was isolated as a yellow oil (106 mg, 71%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.39 (d, J = 9.0 Hz, 2H), 6.97 (d, J = 9.0 Hz, 2H), 6.59 (s, 1H), 3.86 (s, 3H), 2.71 (t, J = 7.5 Hz, 2H), 1.74−1.66 (m, 2H), 1.48−1.39 (m, 2H), 0.97 (t, J = 7.5 Hz, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 160.0, 153.4, 133.0 (q, J = 38.5 Hz), 132.3, 127.1, 180.6 (q, J = 269.0 Hz), 114.1, 107.1, 55.5, 31.6, 27.7, 22.4, 13.8; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −57.8; FTIR 2956 (m), 2931 (m), 2860 (w), 1523 (s), 1466 (m), 1250 (s), 1186 (s), 1125 (s), 990 (m), 837 (m) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{15}H_{18}F_3N_2O$ 299.1371, found 299.1375.

Synthesis of 1-(*p*-Methoxyphenyl)-3-cyclopropyl-5-trifluoromethyl-1*H*-pyrazole 21a. Following general procedure 2 using 4-trifluoromethyl-*N*-(*p*-methoxyphenyl)sydnone **5b** (130 mg, 0.5 mmol) and ethynylcyclopropane (102 mg, 1.0 mmol), heating for 24 h, 1-(*para*-methoxyphenyl)-3-cyclopropyl-5-trifluoromethyl-1*H*-pyrazole **21a** was isolated as a yellow oil (106 mg, 75%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38 (d, J = 9.0 Hz, 2H), 6.97 (d, J = 9.0 Hz, 2H), 6.45 (s, 1H), 3.87 (s, 3H), 2.01 (tt, J = 5.0, 8.5 Hz, 1H), 1.02−0.97 (m, 2H), 0.84−0.80 (m, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 160.0, 155.1, 133.1 (q, J = 38.5 Hz), 132.2, 127.2, 119.8 (q, J = 269.0 Hz), 114.1, 105.0, 55.5, 8.91, 8.16; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −57.9; FTIR 3090 (w), 3010 (w), 2840 (w), 1519 (s), 1485 (m), 1253 (s), 1177 (s), 1132 (s), 1033 (m), 986 (m), 836 (m) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{14}H_{14}F_3N_2O$ 283.1058, found 283.1057.

Synthesis of 1-(*p*-Nitrophenyl)-3-phenyl-5-trifluoromethyl-1*H*-pyrazole 22a. Following general procedure 2 using 4-trifluoromethyl-*N*-(*p*-nitrophenyl)sydnone **5c** (138 mg, 0.5 mmol) and ethynylbenzene (102 mg, 1.0 mmol), heating for 8 h, 1-(*p*-nitrophenyl)-3-phenyl-5-trifluoromethyl-1*H*-pyrazole **22a** was isolated as a yellow solid (141 mg, 85%): mp 97−99 °C (lit.[8] mp 102 °C); ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.42 (d, J = 9.0 Hz, 2H), 7.90−7.88 (m, 2H), 7.84 (d, J = 9.0 Hz, 2H), 7.51−7.42 (m, 3H), 7.23 (s, 1H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 152.9, 147.5, 144.0, 134.0 (q, J = 39.5 Hz), 131.0, 129.3, 129.0, 126.0, 125.6, 124.7, 119.6 (q, J = 269.5 Hz), 108.0 (br); ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −57.1; FTIR 3100 (w), 1596 (m), 1517 (m), 1346 (s), 1229 (s), 1124 (s), 987 (m), 853 (s), 774 (s), 690 (s) cm^{-1}; HRMS m/z [MH] $^+$ calcd for $C_{16}H_{11}F_3N_3O_2$ 334.0803, found 334.0802.

Synthesis of 1-(*p*-Nitrophenyl)-3-(3-chloro)propyl-5-trifluoromethyl-1*H*-pyrazole 23a. Following general procedure 2 using 4-trifluoromethyl-*N*-(*p*-nitrophenyl)sydnone **5c** (138 mg, 0.5 mmol) and 5-chloro-1-pentyne (103 mg, 1.0 mmol), heating for 8 h, 1-(*p*-nitrophenyl)-3-(3-chloro)propyl-5-trifluoromethyl-1*H*-pyrazole **23a** was isolated as a yellow solid (114 mg, 68%): mp 50−51 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.38 (d, J = 9.0 Hz, 2H), 7.74 (d, J = 9.0 Hz, 2H), 6.77 (s, 1H), 3.66 (t, J = 6.5 Hz, 2H), 2.93 (t, J = 7.5 Hz, 2H), 2.26−2.19 (m, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 153.4, 147.4, 143.9, 133.3 (q, J = 39.5 Hz), 125.4, 124.7, 119.6 (q, J = 269.0 Hz), 110.0 (br), 44.1, 31.6, 26.2; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −57.1; FTIR 3140 (W), 2963 (w), 2850 (w), 1601 (m), 1527 (s), 1350 (s), 1220 (m), 1125 (s), 991 (m), 857 (s), 692 (m) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{13}H_{12}ClF_3N_3O_2$ 334.0582, found 334.0570.

Synthesis of 1-Methyl-3-phenyl-5-trifluoromethyl-1*H*-pyrazole 24a.[8] Following general procedure 2 using 4-trifluoromethyl-*N*-methylsydnone **5d** (84 mg, 0.5 mmol) and ethynylbenzene (102 mg, 1.0 mmol), 1-methyl-3-phenyl-5-trifluoromethyl-1*H*-pyrazole **24a** was isolated as a yellow oil (107 mg, 95%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83−7.81 (m, 2H), 7.47−7.43 (m, 2H), 7.40−7.35 (m, 1H), 6.93 (s, 1H), 4.05 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 150.4, 133.1 (q, J = 39.0 Hz), 132.2, 128.8, 128.3, 125.6, 120.1 (q, J = 268.5 Hz), 104.5, 38.1; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −60.5; HRMS m/z [MH]$^+$ calcd for $C_{11}H_{10}F_3N_2$ 227.0796, found 227.0807.

Synthesis of 1-Methyl-3-(cyclohex-1-enyl)-5-trifluoromethyl-1*H*-pyrazole 25a. Following general procedure 2 using 4-

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trifluoromethyl-*N*-methylsydnone **5d** (84 mg, 0.5 mmol) and 2-ethynylcyclohexene (106 mg, 1.0 mmol), heating for 24 h, 1-methyl-3-(cyclohex-1-enyl)-5-trifluoromethyl-1*H*-pyrazole **25a** was isolated as a yellow oil (94 mg, 82%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.63 (s, 1H), 6.33−6.30 (m, 1H), 3.96 (s, 3H), 2.45−2.41 (m, 2H), 2.23−2.18 (m, 2H), 1.80−1.73 (m, 2H), 1.71−1.66 (m, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 152.4, 132.4 (q, J = 39.0 Hz), 129.5, 125.5, 120.2 (q, J = 268.5 Hz), 103.3 (br), 37.8, 25.8, 25.4, 22.5, 22.2; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −60.5; FTIR 3138 (w), 2925 (m), 2864 (w), 1458 (m), 1270 (s), 1188 (m), 1127 (s), 1049 (s), 813 (m), 718 (m) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{11}H_{14}F_3N_2$ 231.1109, found 231.1100.

Synthesis of 3-(Benzyloxymethyl)-1-methyl-5-trifluoromethyl-1*H*-pyrazole 26a. Following general procedure 2 using 4-trifluoromethyl-*N*-methylsydnone **5d** (84 mg, 0.5 mmol) and benzyl 2-propynyl ether (146 mg, 1.0 mmol), heating for 24 h, 3-(benzyloxymethyl)-1-methyl-5-trifluoromethyl-1*H*-pyrazole **26a** was isolated as a yellow oil (120 mg, 89%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.39−7.33 (m, 4H), 7.34−7.31 (m, 1H), 6.68 (s, 1H), 4.61 (s, 2H), 4.56 (s, 2H), 3.99 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 148.7, 137.8, 132.8 (q, J = 39.0 Hz), 128.5, 128.0, 127.8, 120.0 (q, J = 269.0 Hz), 107.0 (br), 72.6, 65.3, 38.0; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −60.5; FTIR 3029 (w), 2950 (w), 2863 (w), 1458 (m), 1270 (s), 1178 (s), 1117 (s), 1038 (s), 824 (m), 736 (m), 697 (s) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{13}H_{14}F_3N_2O$ 271.1058, found 271.1053.

Synthesis of Ethyl 1-Methyl-5-trifluoromethyl-1*H*-pyrazole-3-carboxylate 27a and Ethyl 1-Methyl-5-trifluoromethyl-1*H*-pyrazole-4-carboxylate 27b.[8] Following general procedure 2 using 4-trifluoromethyl-*N*-methylsydnone **5d** (84 mg, 0.5 mmol) and ethylpropiolate (98 mg, 1.0 mmol), eluting with 15% EtOAc in petroleum ether, ethyl 1-methyl-5-trifluoromethyl-1*H*-pyrazole-3-carboxylate **27a** and ethyl 1-methyl-5-trifluoromethyl-1*H*-pyrazole-4-carboxylate **27b** were isolated as an inseparable mixture (93:7, **27a**/**27b**) as a yellow oil (104 mg, 94%).

Spectroscopic data only reported for 27a: ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.12 (s, 1H), 4.40 (q, J = 7.0 Hz, 2H), 4.06 (s, 3H), 1.38 (t, J = 7.0 Hz, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 161.1, 142.6, 133.3 (q, J = 40.0 Hz), 119.4 (q, J = 269.0 Hz), 110.3, 61.4, 38.9, 14.3; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −61.0; FTIR 3147 (w), 2986 (w), 1723 (m), 1447 (m), 1270 (s), 1214 (s), 1119 (s), 1046 (s), 994 (s), 825 (m), 783 (s), 709 (m) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_8H_{10}F_3N_2O_2$ 223.0694, found 223.0686.

Synthesis of 2-Trifluoromethyl-5,6-dihydro-4*H*-pyrrolo[1,2-*b*]pyrazole 29. Following general procedure 2 using 4-trifluoromethyl-*N*-methylsydnone **5d** (84 mg, 0.5 mmol) and 5-chloro-1-pentyne (103 mg, 1.0 mmol), heating for 24 h, eluting with 30% EtOAc in petroleum ether, 2-trifluoromethyl-5,6-dihydro-4*H*-pyrrolo-[1,2-*b*]pyrazole **29** was isolated as a yellow oil (56 mg, 64%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 6.25 (s, 1H), 4.20 (t, J = 7.0 Hz, 2H), 2.94 (t, J = 7.0 Hz, 2H), 2.70−2.62 (m, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 147.0, 146.2 (q, J = 37.5 Hz), 121.2 (q, J = 268.5 Hz), 97.6 (br), 48.1, 26.1, 23.0; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −62.1; FTIR 3143 (w), 2972 (w), 2880 (w), 1484 (m), 1239 (m), 1161 (s), 1117 (s), 1086 (s), 977 (s), 802 (m), 702 (m) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_7H_8F_3N_2$ 177.0640, found 177.0645.

Synthesis of 1-Benzyl-3-phenyl-5-trifluoromethyl-1*H*-pyrazole 39a and 1-Benzyl-3- trifluoromethyl-5-phenyl-1*H*-pyrazole 39b. Following general procedure 2 using 4-trifluoromethyl-*N*-benzylsydnone **5e** (122 mg, 0.5 mmol) and ethynylbenzene (102 mg, 1.0 mmol), heating for 24 h, eluting with 5% ether in petroleum ether, 1-benzyl-3-phenyl-5-trifluoromethyl-1*H*-pyrazole **39a** was isolated as yellow oil (59 mg, 39%) and 1-benzyl-3-trifluoromethyl-5-phenyl-1*H*-pyrazole **39b** was isolated as a colorless solid (33 mg, 22%).

39a: ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85−7.83 (m, 2H), 7.47−7.43 (m, 2H), 7.40−7.32 (m, 4H), 7.30−7.28 (m, 2H), 6.97 (s, 1H), 5.50 (s, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 150.1, 135.9, 133.1 (q, J = 39.0 Hz), 132.1, 128.8, 128.7, 128.4, 128.1, 127.3, 125.7, 120.0 (q, J = 269.0 Hz), 104.9 (br), 54.9; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −59.2; FTIR 3067 (w), 3028 (w), 2930 (w). 1445 (m), 1269 (s), 1153 (s), 1128 (s), 1046 (s), 760 (m), 691 (s) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{17}H_{14}F_3N_2$ 303.1109, found 303.1108.

39b: mp 53−54 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48−7.43 (m, 3H), 7.35−7.30 (m, 5H), 7.10−7.08 (m, 2H), 6.64 (s, 1H), 5.41 (s, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 145.6, 142.1 (q, J = 38.0 Hz), 136.4, 129.4, 129.3, 129.1, 128.9, 128.8, 127.9, 126.9, 121.5 (q, J = 268.5 Hz), 104.8 (br), 53.9; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −61.9; FTIR 3075 (w), 3031 (w), 1475 (m), 1211 (m), 1128 (s), 1106 (m), 989 (s), 758 (m), 692 (s) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{17}H_{14}F_3N_2$ 303.1109, found 303.1096.

Synthesis of 1-Benzyl-3-*n*-butyl-5-trifluoromethyl-1*H*-pyrazole 40a and 1-Benzyl-3- trifluoromethyl-5-*n*-butyl-1*H*-pyrazole 40b. Following general procedure 2 using 4-trifluoromethyl-*N*-benzylsydnone **5e** (122 mg, 0.5 mmol) and 1-hexyne (82 mg, 1.0 mmol), heating for 24 h, 1-benzyl-3-*n*-butyl-5-trifluoromethyl-1*H*-pyrazole **40a** was isolated as a yellow oil (49 mg, 35%) and 1-benzyl-3-trifluoromethyl-5-*n*-butyl-1*H*-pyrazole **40b** was isolated as a yellow oil (19 mg, 13%).

40a: ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37−7.28 (m, 3H), 7.20−7.18 (m, 2H), 6.48 (s, 1H), 5.40 (s, 2H), 2.67 (t, J = 7.5 Hz, 2H), 1.70−1.62 (m, 2H), 1.46−1.47 (m, 2H), 0.97 (t, J = 7.5 Hz, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 153.0, 136.3, 132.2 (q, J = 39.0 Hz), 128.6, 127.9, 127.1, 120.2 (q, J = 269.0 Hz), 106.4 (br), 54.4, 31.7, 27.7, 22.4, 13.9; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −59.1; FTIR 3033 (w), 2956 (w), 2931 (w), 2861 (w), 1565 (w), 1453 (m), 1264 (s), 1159 (s), 1127 (s), 1036 (s), 808 (m), 693 (m) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{15}H_{18}F_3N_2$ 283.1422, found 283.1415.

40b: ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37−7.31 (m, 3H), 7.12−7.10 (m, 2H), 6.36 (s, 1H), 5.36 (s, 2H), 2.52 (t, J = 7.5 Hz, 2H), 1.59−1.51 (m, 2H), 1.39−1.31 (m, 2H), 0.89 (t, J = 7.5 Hz, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 145.1, 141.5 (q, J = 37.5 Hz), 136.0, 128.9, 128.0, 126.8, 121.6 (q, J = 269.0 Hz), 103.2, 53.8, 30.2, 25.2, 22.2, 13.7; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −61.9; FTIR 3032 (w), 2964 (w), 2930 (w), 2847 (w), 1609 (m), 1494 (m), 1214 (s), 1120 (s), 984 (m), 806 (m), 725 (m) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{15}H_{18}F_3N_2$ 283.1422, found 283.1415.

Synthesis of Dimethyl 1-Benzyl-5-trifluoromethyl-1*H*-pyrazole-3,4-dicarboxylate 45a and Dimethyl 1-Benzyl-3-trifluoromethyl-1*H*-pyrazole-4,5-dicarboxylate 45b. Following general procedure 2 using 4-trifluoromethyl-*N*-benzylsydnone **5e** (122 mg, 0.5 mmol) and DMAD (142 mg, 1.0 mmol), heating at 120 °C for 24 h, dimethyl 1-benzyl-5-trifluoromethyl-1*H*-pyrazole-3,4-dicarboxylate **45a** and dimethyl 1-benzyl-3-trifluoromethyl-1*H*-pyrazole-4,5-dicarboxylate **45b** were isolated as an inseparable mixture (96:4, **45a**/**45b**) as a yellow oil (93 mg, 54%).

Spectroscopic data only reported for 45a: ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37−7.34 (m, 3H), 7.26−7.24 (m, 2H), 5.54 (s, 2H), 3.96 (s, 3H), 3.94 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 162.6, 160.5, 140.6, 134.0, 131.0 (q, J = 40.5 Hz), 128.9, 128.7, 127.5, 119.1, 118.8 (q, J = 271.0 Hz), 56.4, 53.2, 52.8; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −58.4; FTIR 3043 (w), 2956 (w), 1729 (s), 1496 (m), 1315 (m), 1250 (s), 1176 (s), 1142 (s), 1047 (s), 965 (m), 831 (m), 731 (m) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{15}H_{14}F_3N_2O_4$ 343.0906, found 343.0922.

Synthesis of Dimethyl 1-Benzyl-5-trifluoromethyl-1*H*-pyrazole-3,4-dicarboxylate 45a and Dimethyl 1-Benzyl-3-trifluoromethyl-1*H*-pyrazole-4,5-dicarboxylate 45b. Following general procedure 2 using 4-trifluoromethyl-*N*-benzylsydnone **5e** (122 mg, 0.5 mmol) and DMAD (142 mg, 1.0 mmol), dimethyl 1-benzyl-5-trifluoromethyl-1*H*-pyrazole-3,4-dicarboxylate **45a** and dimethyl 1-benzyl-3-trifluoromethyl-1*H*-pyrazole-4,5-dicarboxylate **45b** were isolated as an inseparable mixture (63:37, **45a**/**45b**) as a yellow oil (87 mg, 51%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38−7.33 (m, 3H), 7.29−7.24 (m, 2H), 5.67 (s, 0.75H), 5.54 (s, 1.25H), 3.97 (s, 1.88H), 3.95 (s, 1.88H), 3.90 (s, 1.22H), 3.88 (s, 1.22H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 162.6, 161.6, 160.5, 158.9, 140.6, 139.7 (q, J = 39.0 Hz), 134.7, 134.4, 134.0, 131.0 (q, J = 40.0 Hz), 128.9 (2), 128.7, 128.6, 128.0, 127.5, 120.1 (q, J = 270.0 Hz), 119.1, 118.8 (q, J = 271.0 Hz), 56.4, 56.1, 53.2, 53.1, 52.8 (2), unable to unequivocally assign 1 × C signal; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −58.4 (0.63F), −61.7

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(0.37F); FTIR 3029 (w), 2968 (w), 1734 (s), 1496 (m), 1244 (s), 1187 (s), 1134 (s), 1060 (s), 964 (m), 876 (m), 719 (m) cm^{-1}; HRMS m/z $[MH]^+$ calcd for $C_{15}H_{14}F_3N_2O_4$ 343.0906, found 343.0922.

General Procedure 3: Cycloaddition Reactions of 4-Trifluoromethylsydnones and Alkynylboronates (See Table 2). A solution of a 4-trifluoromethylsydnone (0.5 mmol) and an alkynylboronate (2.0 mmol) in *o*-DCB (1 M) in a sealed microwave vessel was heated at 140 °C for the designated length of time. After cooling, the crude materials were purified by flash chromatography on silica gel (eluting with 5% EtOAc in petroleum ether, unless otherwise stated) to yield the title pyrazoles.

Synthesis of 1-Phenyl-4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-5-trifluoromethyl-1*H*-pyrazole 30a and 1-Phenyl-3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-5-trifluoromethyl-1*H*-pyrazole 30b. Following general procedure 3 using 4-trifluoromethyl-*N*-phenylsydnone **5a** (115 mg, 0.5 mmol) and 2-ethynyl-4,4,5,5-tetramethyl-1,3,2-dioaborolane (304 mg, 2.0 mmol), heating for 72 h, eluting with 40% EtOAc in petroleum ether, 1-phenyl-3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-5-trifluoromethyl-1*H*-pyrazole **30a** and 1-phenyl-3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-5-trifluoromethyl-1*H*-pyrazole **30b** were isolated as an inseparable mixture (7:93, **30a**/**30b**) as a brown solid (117 mg, 69%): mp 111−113 °C Spectroscopic data only reported for **30b**: ^1H NMR (400 MHz, $CDCl_3$) δ 7.50−7.47 (m, 5H), 7.21 (s, 1H), 1.39 (s, 12H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 139.1, 133.2 (q, J = 39.0 Hz), 129.4, 128.8, 126.1, 120.0 (q, J = 269.0 Hz), 116.0, 84.5, 24.8; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −57.5; FTIR 2988 (w), 1561 (w), 1485 (m), 1366 (m), 1290 (m), 1171 (s), 1125 (s), 995 (m), 853 (m), 777 (m), 697 (m) cm^{-1}; HRMS m/z $[MH]^+$ calcd for $C_{16}H_{19}{}^{11}BF_3N_2O_2$ 339.1492, found 339.1477.

Synthesis of 1-Methyl-4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-5-trifluoromethyl-1*H*-pyrazole 31b. Following general procedure 3 using 4-trifluoromethyl-*N*-methylsydnone **5d** (84 mg, 0.5 mmol) and 2-ethynyl-4,4,5,5-tetramethyl-1,3,2-dioaborolane (304 mg, 2.0 mmol), heating for 72 h, eluting with 40% EtOAc in petroleum ether, 1-methyl-3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-5-trifluoromethyl-1*H*-pyrazole **31b** was isolated as a brown oil (122 mg, 44%): ^1H NMR (400 MHz, $CDCl_3$) δ 7.00 (s, 1H), 4.04 (s, 3H), 1.34 (s, 12H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 132.3 (q, J = 39.0 Hz), 120.3 (q, J = 268.5 Hz), 115.0, 84.4, 38.2, 24.8; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −60.5; FTIR 2977 (m), 1554 (m), 1236 (s), 1161 (s), 1121 (s), 1050 (s), 993 (m), 856 (m), 719 (m), 635 (w) cm^{-1}; HRMS m/z $[MH]^+$ calcd for $C_{11}H_{17}{}^{11}BF_3N_2O_2$ 277.1335, found 277.1328.

Synthesis of 1-Phenyl-3-trimethylsilyl-4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-5-trifluoromethyl-1*H*-pyrazole 32a and 1-phenyl-4-trimethylsilyl-3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-5-trifluoromethyl-1*H*-pyrazole 32b. Following general procedure 3 using 4-trifluoromethyl-*N*-phenylsydnone **5a** (115 mg, 0.5 mmol) and trimethyl((4,4,5,5-tetramethyl-1,3,2-dixaborolan-2-yl)ethynyl)silane (448 mg, 2.0 mmol), heating for 48 h, 1-phenyl-3-trimethylsilyl-4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-5-trifluoromethyl-1*H*-pyrazole **32a** was isolated as a yellow solid (120 mg, 58%) and 1-phenyl-4-trimethylsilyl-3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-5-trifluoromethyl-1*H*-pyrazole **32b** was isolated as a yellow solid (13 mg, 6%).

32a: mp 115−117 °C; ^1H NMR (400 MHz, $CDCl_3$) δ 7.49−7.46 (m, 5H), 1.40 (s, 12H), 0.40 (s, 9H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 159.9, 140.3, 137.8 (q, J = 37.5 Hz), 129.7, 129.5, 126.7, 121.3 (q, J = 270.5 Hz), 84.6, 25.7, 0.0; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −54.5; FTIR 2976 (w), 1504 (w), 1338 (m), 1252 (m), 1139 (s) 1048 (m), 848 (s), 765 (m), 693 (m) cm^{-1}; HRMS m/z $[MH]^+$ calcd for $C_{19}H_{27}{}^{11}BF_3N_2O_2Si$ 411.1887, found 411.1890.

32b: mp 113−115 °C; ^1H NMR (400 MHz, $CDCl_3$) δ 7.46−7.43 (m, 5H), 1.39 (s, 12H), 0.40 (s, 9H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 139.3, 136.0 (q, J = 37.5 Hz), 128.4, 128.0, 125.6, 124.1, 120.1 (q, J = 270.5 Hz), 83.7, 24.3, 0.0; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −52.5; FTIR 2980 (w), 1499 (w), 1241 (s), 1168 (s), 1139 (s), 988 (w), 847 (m), 772 (w) cm^{-1}; HRMS m/z $[MH]^+$ calcd for $C_{19}H_{27}{}^{11}BF_3N_2O_2Si$ 411.1887, found 411.1901.

Synthesis of 1-(*p*-Nitrophenyl)-3-trimethylsilyl-4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-5-trifluoromethyl-1*H*-pyrazole 33a. Following general procedure 3 using 4-trifluoromethyl-*N*-(*p*-nitrophenyl)sydnone (136 mg, 0.5 mmol) and trimethyl-((4,4,5,5-tetramethyl-1,3,2-dixaborolan-2-yl)ethynyl)silane (448 mg, 2.0 mmol), heating for 24 h, 1-(*p*-nitrophenyl)-3-trimethylsilyl-4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-5-trifluoromethyl-1*H*-pyrazole **33a** was isolated as a yellow solid (125 mg, 55%).

Note: Compound **33a** was isolated as an inseparable mixture (9:1) with the protodeboronated pyrazole: ^1H NMR (400 MHz, $CDCl_3$) δ 8.37 (d, J = 9.0 Hz, 2H), 7.69 (d, J = 9.0 Hz, 2H), 1.40 (s, 12H), 0.40 (s, 9H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 160.6, 147.5, 144.5, 137.3 (q, J = 38.0 Hz), 126.4, 124.4, 123.1 (q, J = 271.0 Hz), 84.5, 25.0, −0.8; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −54.0; FTIR 2984 (w), 1525 (m), 1357 (m), 1256 (s), 1135 (s), 1037 (s), 982 (m), 838 (s), 755 (m) cm^{-1}; HRMS m/z $[MH]^+$ calcd for $C_{19}H_{26}{}^{11}BF_3N_3O_4Si$ 456.1738, found 456.1756.

Synthesis of 1-Phenyl-3-*n*-butyl-4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-5-trifluoromethyl-1*H*-pyrazole 34a. Following general procedure 3 using 4-trifluoromethyl-*N*-phenylsydnone **5a** (115 mg, 0.5 mmol) and 2-(hex-1-yn-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (416 mg, 2.0 mmol), heating for 72 h, 1-phenyl-3-*n*-butyl-4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-5-trifluoromethyl-1*H*-pyrazole **34a** was isolated as a yellow oil (108 mg, 55%): ^1H NMR (400 MHz, $CDCl_3$) δ 7.48−7.42 (m, 5H), 2.84−2.80 (m, 2H), 1.73−1.64 (m, 2H), 1.48−1.39 (m, 2H), 1.38 (s, 12H), 0.96 (t, J = 7.5 Hz, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 159.2, 139.5, 136.8 (q, J = 38.0 Hz), 129.0, 128.9, 126.0, 120.1 (q, J = 270.5 Hz), 84.0, 32.7, 28.1, 24.7, 22.7, 13.9; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −55.1; FTIR 2959 (m), 2923 (m), 2872 (w), 1510 (m), 1331 (m), 1239 (s), 1176 (s), 4468 (s), 1076 (s), 984 (m), 855 (m), 771 (m) cm^{-1}; HRMS m/z $[MH]^+$ calcd for $C_{20}H_{27}{}^{11}BF_3N_2O_2$ 395.2118, found 395.2120.

Synthesis of 3-trifluoromethyl-5-phenyl-1*H*-pyrazole 37 and 1-(4-Methoxy-3-nitrophenyl)-3-phenyl-5-trifluoromethyl-1*H*-pyrazole 38. To an ice-cooled stirring suspension of 1-(*p*-methoxyphenyl)-3-phenyl-5-trifluoromethyl-1*H*-pyrazole **19a** (80 mg, 0.25 mmol) in a mixture of acetonitrile and water (4:1, 6.25 mL) was added a cooled solution of CAN (1.37 g, 2.50 mmol) in water (5 mL). The reaction was warmed to ambient temperature, stirred for 22 h, and then concentrated in vacuo. Water (10 mL) was added to the residue which was then extracted with DCM (3 × 10 mL). The organic fractions were washed with saturated $NaHCO_{3(aq)}$ then dried over $MgSO_4$ before the volatiles were removed in vacuo. The crude material was purified by flash chromatography on silica gel (eluting with 15% EtOAc in petroleum ether) to isolate 3-trifluoromethyl-5-phenyl-1*H*-pyrazole as a yellow solid **37** (24 mg, 47%) and 1-(4-methoxy-3-nitrophenyl)-3-phenyl-5-trifluoromethyl-1*H*-pyrazole was isolated as a yellow solid **38** (12 mg, 13%).

37: mp 121−123 °C (lit.[37] mp 122−123 °C); ^1H NMR (400 MHz, $CDCl_3$) δ 10.54 (br, 1H), 7.60−7.58 (m, 2H), 7.49−7.43 (m, 3H), 6.74 (s, 1H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 145.1, 143.7 (q, J = 38.5 Hz), 129.5, 129.3, 127.9, 125.6, 121.1 (q, J = 267.0 Hz), 101.1; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −62.2; HRMS m/z $[MH]^+$ calcd for $C_{10}H_8F_3N_2$ 213.0640, found 213.0630.

38: ^1H NMR (400 MHz, $CDCl_3$) δ 8.15 (d, J = 2.5 Hz, 1H), 7.87−7.85 (m, 2H), 7.78 (dd, J = 2.5, 9.0 Hz, 1H), 7.49−7.42 (m, 3H), 7.24 (d, J = 9.0 Hz, 1H), 7.15 (s, 1H), 4.08 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 153.4, 152.3, 139.2, 134.1 (q, J = 39.5 Hz), 131.4, 131.3, 131.1, 129.0, 128.9, 125.9, 123.5, 119.6 (q, J = 269.5 Hz), 113.9, 106.6, 57.0; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −57.6; HRMS m/z $[MH]^+$ calcd for $C_{17}H_{13}F_3N_3O_3$ 364.0909, found 364.0908.

Synthesis of 3-Trifluoromethyl-5-phenyl-1*H*-pyrazole 37.[37] A solution of 1-benzyl-3-phenyl-5-trifluoromethyl-1*H*-pyrazole **39a** and 1-benzyl-3-trifluoromethyl-5-phenyl-1*H*-pyrazole **39b** (71:29, **39a**/**39b**; 76 mg, 0.25 mmol) in methanol (5 mL) and AcOH (5 drops) was flowed through a H-Cube continuous flow hydrogenator (1 mL min^{-1}) with a 20% $Pd(OH)_2/C$ catalyst cartridge at 80 °C using controlled H_2 mode (70 bar) as a continuous loop. Once the reaction was complete by TLC analysis, the system was washed with

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methanol (10 mL). The reaction was subsequently neutralized with $NaHCO_3$ then filtered and the volatiles were removed in vacuo. The crude material was purified by flash chromatography on silica gel (eluting with 20% EtOAc in petroleum ether) to yield 3-trifluoromethyl-5-phenyl-1*H*-pyrazole **37** as a colorless solid (40 mg, 75%).

Synthesis of 1,3-Diphenyl-5-trifluoromethyl-1*H*-pyrazole 8a.[8] A solution of 1-phenyl-3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-5-trifluoromethyl-1*H*-pyrazole **5b** (80 mg, 0.24 mmol), bromobenzene (74 mg, 0.47 mmol), CsF (108 mg, 0.71 mmol), and $PdCl_2$(dppf) (8 mg, 0.01 mmol) in a mixture of DME and water (1:1, 1 mL) in a sealed microwave vessel was heated at 140 °C for 30 min in a CEM Microwave Explorer Reactor. After cooling, the volatiles were removed in vacuo before the crude material was purified by flash chromatography on silica gel (eluting with 5% EtOAc in petroleum) to yield 1,3-diphenyl-5-trifluoromethyl-1*H*-pyrazole **8a** as a colorless solid (40 mg, 59%).

Synthesis of 1-Phenyl-5-trifluoromethyl-1*H*-pyrazol-3(2*H*)-one 35.[38] To a stirring suspension of 1-phenyl-3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-5-trifluoromethyl-1*H*-pyrazole **5b** (68 mg, 0.20 mmol) and Na_2CO_3 (21 mg, 0.2 mmol) in ethanol (8 mL) was added H_2O_2 (30% w/w) (2 mL) dropwise. After 30 min, the reaction mixture was concentrated in vacuo. The residue was dissolved in water (20 mL) and then extracted with EtOAc (3 × 10 mL), and the organic fractions were dried over $MgSO_4$ before the volatiles were removed in vacuo. The crude material was purified by flash chromatography on silica gel (eluting with 30% EtOAc in petroleum ether) to yield 1-phenyl-5-trifluoromethyl-1*H*-pyrazol-3(2*H*)-one **35** as a colorless solid (27 mg, 59%): mp 159−160 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.26 (br, 1H), 7.55−7.46 (m, 5H), 6.18 (s, 1H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 161.7, 138.0, 133.7 (q, J = 39.5 Hz), 129.4, 129.3, 125.7, 119.1 (q, J = 270.0 Hz), 95.1; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −58.3; FTIR 3065 (w), 1592 (m), 1481 (m), 1197 (s), 1120 (s), 1086 (s), 976 (m), 768 (s), 674 (s) cm^{-1}; HRMS m/z $[MH]^+$ calcd for $C_{10}H_8F_3N_2O$ 229.0589, found 229.0597.

Synthesis of 3-Butyl-1,4-diphenyl-5-trifluoromethyl-1*H*-pyrazole 16a. To a stirring suspension of 3-butyl-1-phenyl-4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-5-trifluoromethyl-1*H*-pyrazole **34a** (79 mg, 0.20 mmol), $PdCl_2(PPh_3)_2$ (16 mg, 0.01 mmol), and K_3PO_4 (1.27 g, 0.60 mmol) in 1,4-dioxane (1 mL) was added bromobenzene (42 μL, 0.4 mmol) under a nitrogen atmosphere, and the mixture was heated at 85 °C for 24 h. The reaction was quenched with 1 M $HCl_{(aq)}$ and extracted with DCM (3 × 10 mL), and the organic fractions were dried over $MgSO_4$ before the volatiles were removed in vacuo. The crude material was purified by flash chromatography on silica gel (eluting with 5% EtOAc in petroleum ether) to yield 1,4-diphenyl-4-*n*-butyl-5-trifluoromethyl-1*H*-pyrazole **16a** as a yellow oil (52 mg, 76%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57−7.42 (m, 8H), 7.39−7.37 (m, 2H), 2.66−2.62 (m, 2H), 1.64−1.56 (m, 2H), 1.37−1.28 (m, 2H), 0.86 (t, J = 7.0 Hz, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 152.5, 139.8, 131.2, 130.0, 129.0 (2), 128.2, 127.8, 126.0, 125.6, 123.9, 120.2 (q, J = 270.5 Hz), 31.3, 26.0, 22.5, 13.8; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −55.3; FTIR 3075 (w), 2930 (w), 2861 (w), 1501 (m), 1166 (s), 1119 (s), 990 (m), 755 (m), 694 (s) cm^{-1}; HRMS m/z $[MH]^+$ calcd for $C_{20}H_{20}F_3N_2$ 345.1579, found 345.1589.

Synthesis of 1-Phenyl-5-trifluoromethyl-3-trimethylsilyl-1*H*-pyrazol-4-ol 36. To a stirring suspension of 1-phenyl-3-trimethylsilyl-4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)-5-trifluoromethyl-1*H*-pyrazole **32a** (82 mg, 0.20 mmol) and Na_2CO_3 (21 mg, 0.2 mmol) in ethanol (8 mL) was added H_2O_2 (30% w/w) (2 mL) dropwise. After 2 h, the reaction mixture was concentrated in vacuo. The residue was dissolved in water (20 mL) and then extracted with EtOAc (3 × 10 mL), and the organic fractions were dried over $MgSO_4$ before the volatiles were removed in vacuo. The crude material was purified by flash chromatography on silica gel (eluting with 5% EtOAc in petroleum ether) to yield 1-phenyl-5-trifluoromethyl-3-trimethylsilyl-1*H*-pyrazol-4-ol **36** as a yellow solid (48 mg, 80%): mp 114−116 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48−7.45 (m, 5H), 5.00 (br, 1H), 0.40 (s, 9H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 148.4, 142.9, 139.8, 129.0, 128.8, 125.6, 121.3 (q, J = 268.0 Hz), 116.1 (q, J = 37.0 Hz), −1.4; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −55.9; FTIR 3268 (br), 2959 (w), 1898 (w), 1560 (m), 1249 (m), 1110 (s). 976 (m), 833 (s), 768 (m), 690 (m) cm^{-1}; HRMS m/z $[MH]^+$ calcd for $C_{13}H_{16}F_3N_2OSi$ 301.0984, found 301.0972.

Synthesis of 4-(Ethoxycarbonyl)-*N*-phenylsydnone 52. To a stirring solution of the *N*-phenylsydnone **51** (4.86 g, 30 mmol) in THF (150 mL) was added *n*-BuLi in hexanes (36 mmol) dropwise under a nitrogen atmosphere at −78 °C. After 30 min, the solution was transferred *via* cannula to a stirring solution of ethyl chloroformate (14.28 mL, 150 mmol) in THF (50 mL) at −78 °C and slowly warmed to ambient temperature overnight. The reaction was subsequently quenched with 1 M $HCl_{(aq)}$ and water (100 mL) and extracted with DCM (3 × 25 mL), and the organic fractions were dried over $MgSO_4$ before the volatiles were removed in vacuo. The crude material was purified by flash chromatography on silica gel (eluting with 40% EtOAc in petroleum ether) to yield 4-(ethoxycarbonyl)-*N*-phenylsydnone **52** as a yellow solid (4.43 g, 63%): mp 105−106 °C (lit.[39] mp 100−102 °C); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.75−7.70 (m, 1H), 7.66−7.62 (m, 2H), 7.57−7.54 (m, 2H), 4.28 (q, J = 7.0 Hz, 2H), 1.28 (t, J = 7.0 Hz, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 164.5, 157.1, 134.8, 132.5, 129.5, 125.0, 99.7, 61.7, 14.1; FTIR 3064 (w), 2994 (w). 1799 (s), 1712 (s), 1447 (m), 1186 (s), 1064 (s), 760 (s), 669 (s) cm^{-1}; HRMS m/z $[MH]^+$ calcd for $C_{11}H_{11}N_2O_4$ 235.0719, found 235.0709.

Synthesis of 4-Hydroxymethyl-*N*-phenylsydnone 53. To an ice-cooled stirring suspension of $LiBH_4$ (909 mg, 41.74 mmol) in THF (40 mL) was added 4-(ethoxycarbonyl)-*N*-phenylsydnone **52** (3.26 g, 13.91 mmol) in THF (40 mL) dropwise under a nitrogen atmosphere, and the mixture was warmed to ambient temperature overnight. The reaction was subsequently quenched with saturated $NaHCO_{3(aq)}$ and then extracted with EtOAc (3 × 25 mL), and the organic fractions were dried over $MgSO_4$ before the volatiles were removed in vacuo. The crude material was purified by trituration using pentanes and ethanol (5:1) to yield 4-hydroxymethyl-*N*-phenylsydnone **53** as a yellow solid (2.27 g, 83%).

Note: Compound **53** could alternatively be purified by flash chromatography on silica gel (eluting with 80% EtOAc in petroleum ether): mp 98−100 °C (lit.[30a] mp 95−97 °C); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86−7.84 (m, 2H), 7.74−7.64 (m, 3H), 4.50 (s, 2H), 4.01 (br, 1H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 166.1, 131.0, 129.6, 127.3, 121.5, 105.3, 48.3; FTIR 3351 (br), 3060 (w), 1705 (s), 1479 (m), 1245 (m), 1011 (s), 895 (m), 770 (s), 695 (s) cm^{-1}; HRMS m/z $[MH]^+$ calcd for $C_9H_9N_2O_3$ 193.0613, found 193.0608.

Synthesis of 4-Formyl-*N*-phenylsydnone 54. To a stirring suspension of MnO_2 (4.78 g, 55.00 mmol) in DCM (100 mL) was added 4-hydroxymethyl-*N*-phenylsydnone **53** (2.11 g, 11.00 mmol) under a nitrogen atmosphere. After being stirred overnight, the reaction mixture was filtered through Celite before the volatiles were removed in vacuo to yield 4-formyl-*N*-phenylsydnone **54** as a yellow solid (1.81 g, 86%): mp 115−117 °C (lit.[30b] mp 116−118 °C); ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.59 (s, 1H), 7.79−7.74 (m, 1H), 7.70−7.63 (m, 4H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 174.7, 166.4, 133.6, 133.2, 129.9, 124.6, 105.1; FTIR 3057 (w), 1778 (s), 1644 (s), 1470 (s), 1374 (s), 1304 (m), 878 (m), 761 (s), 687 (s) cm^{-1}; HRMS m/z $[MH]^+$ calcd for $C_9H_7N_2O_3$ 191.0457, found 191.0449.

Synthesis of 4-Monofluoromethyl-*N*-phenylsydnone 55. To an ice-cooled stirring solution of 4-hydroxymethyl-*N*-phenylsydnone **53** (961 mg, 5.00 mmol) in THF (25 mL) was added deoxofluor (50% solution in THF) (2.58 mL, 6.0 mmol) dropwise under a nitrogen atmosphere. After 1 h, the reaction mixture was warmed to ambient temperature and stirred for a further 1 h. The reaction was subsequently quenched with saturated $NaHCO_{3(aq)}$ (50 mL) and extracted with DCM (3 × 10 mL), and the organic fractions were dried over $MgSO_4$ before the volatiles were removed in vacuo. The crude material was purified by flash chromatography on silica gel (eluting with 30% EtOAc in petroleum ether) to yield 4-monofluoromethyl-*N*-phenylsydnone **55** as a yellow solid (780 mg, 80%): mp 89−90 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80−7.68 (m, 5H), 5.19 (d, J = 50.0 Hz, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ

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167.6, 133.5, 133.0, 130.4, 124.3, 103.1 (d, J = 22.5 Hz), 70.2 (d, J = 170.0 Hz); ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −196.7 (t, J = 50.0 Hz); FTIR 3069 (w), 1748 (s), 1476 (m), 1269 (m), 1073 (m), 952 (s), 887 (m), 765 (s), 687 (s) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_9H_8FN_2O_2$ 195.0570, found 195.0561.

Synthesis of 4-Difluoromethyl-*N*-phenylsydnone 56. To an ice-cooled stirring solution of 4-formyl-*N*-phenylsydnone **54** (1.80 g, 9.47 mmol) in THF (20 mL), in a sealed nalgene bottle, was added deoxofluor (50% solution in THF) (20.32 mL, 94.66 mmol) dropwise under a nitrogen atmosphere. After 1 h, the reaction mixture was warmed to ambient temperature and stirred for a further 47 h. The reaction was subsequently quenched with saturated $NaHCO_{3(aq)}$ (150 mL) and extracted with DCM (3 × 25 mL), and the organic fractions were dried over $MgSO_4$ before the volatiles were removed in vacuo. The crude material was purified by flash chromatography on silica gel (eluting with 25% EtOAc in petroleum ether) to yield 4-difluoromethyl-*N*-phenylsydnone **56** as a yellow solid (1.62 g, 81%): mp 91−92 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.78−7.73 (m, 1H), δ 7.71−7.65 (m, 4H), 6.61 (t, J = 52.0 Hz, 1H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 165.9, 133.9, 133.1, 130.1, 124.4, 107.3 (t, J = 235.5 Hz), 100.7 (t, J = 27.5 Hz); ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −110.7 (d, J = 52.0 Hz); FTIR 3071 (w), 2922 (w), 1772 (s), 1478 (m), 1273 (m), 1090 (m), 1014 (s), 979 (s), 907 (m), 792 (s), 985 (s) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_9H_7F_2N_2O_2$ 213.0476, found 213.0469.

General Procedure 4: Cycloaddition Reactions of 4-Difluoromethyl-*N*-phenylsydnone and Alkynes (See Table 4). A solution of a 4-difluoromethyl-*N*-phenylsydnone **56** (106 mg, 0.5 mmol) and an alkyne (2 equiv) in *o*-DCB (1 mL) in a sealed microwave vessel was heated at 180 °C for 24 h. After cooling, the crude materials were purified by flash chromatography on silica gel (eluting with 10% EtOAc in petroleum ether unless otherwise stated) to yield the title pyrazoles.

Synthesis of 1,3-Diphenyl-5-difluoromethyl-1*H*-pyrazole 57a. Following general procedure 4 using ethynylbenzene (102 mg, 1.0 mmol), 1,3-diphenyl-5-difluoromethyl-1*H*-pyrazole **57a** was isolated as a brown oil (126 mg, 93%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94−7.92 (m, 2H), 7.63−7.60 (m, 2H), 7.58−7.54 (m, 2H), 7.52−7.46 (m, 3H), 7.42−7.38 (m, 1H), 7.10 (s, 1H), 6.70 (t, J = 53.5 Hz, 1H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 152.2, 139.0, 137.6 (t, J = 30.0 Hz), 132.3, 129.5, 128.9, 128.8, 128.5, 125.9, 125.0, 108.5 (t, J = 235.0, Hz), 104.6; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −110.0 (d, J = −53.5 Hz); FTIR 3082 (w), 1600 (m), 1489 (s), 1437 (m), 1369 (m), 1159 (m), 1074 (s), 1048 (s), 950 (m), 774 (s), 693 (s) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{16}H_{13}F_2N_2$ 271.1047, found 271.1050.

Synthesis of 2-(1-Phenyl-5-difluoromethyl-1*H*-pyrazol-3-yl)-pyridine 58a and 2-(1-Phenyl-5-difluoromethyl-1*H*-pyrazol-4-yl)pyridine 58b. Following general procedure 4 using 2-ethynylpyridine (103 mg, 1.0 mmol), eluting with 20% EtOAc in petroleum ether, 2-(1-phenyl-5-difluoromethyl-1*H*-pyrazol-3-yl)pyridine **58a** and 2-(1-phenyl-5-difluoromethyl-1*H*-pyrazol-4-yl)pyridine **58b** isolated as an inseparable mixture (83:17, **58a**/**58b**) as an orange oil (122 mg, 90%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.70−8.67 (m, 0.83H), 8.66−8.65 (m, 0.17H), 8.09−8.07 (m, 1H), 7.79−7.75 (m, 1H), 7.72 (t, J = 53.0 Hz, 0.17H), 7.65−7.48 (m, 5.17H), 7.44 (br, 0.83H), 7.30−7.27 (m, 0.83H), 7.25−7.22 (m, 0.17H), 6.69 (t, J = 53.5 Hz, 0.83H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 152.4, 151.1, 150.9, 149.7, 149.6, 149.5, 140.1, 138.9, 137.8 (t, J = 30.0 Hz), 136.9, 136.7, 133.0 (t, J = 24.5 Hz), 129.5, 129.3, 129.2, 129.0 (x2), 125.7, 125.1, 123.1, 122.0, 121.6, 120.3, 108.7 (t, J = 236.0 Hz), 108.4 (t, J = 236.0 Hz), 106.3; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −110.2 (d, J = 53.5 Hz, 1.67F), −111.4 (d, J = 53.0 Hz, 0.33F); FTIR 3050 (w), 1593 (m), 1500 (s), 1415 (m), 1376 (m), 1164 (m), 1075 (s), 1024 (s), 786 (s), 765 (m), 688 (s) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{15}H_{12}F_2N_3$ 272.0999, found 272.0989.

Synthesis of 1-Phenyl-3-cyclopropyl-5-difluoromethyl-1*H*-pyrazole 59a. Following general procedure 4 using ethynylcyclopropane (66 mg, 1.0 mmol), 1-phenyl-3-cyclopropyl-5-difluoromethyl-1*H*-pyrazole **59a** was isolated as a yellow oil (89 mg, 76%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50−7.49 (m, 4H), 7.45−7.42 (m, 1H), 6.59 (t, J = 53.5 Hz, 1H), 6.43 (s, 1H), 2.04 (tt, J = 5.0, 8.5 Hz, 1H), 1.03−0.98 (m, 2H), 0.86−0.82 (m, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 156.1, 139.0, 136.7 (t, J = 30.0 Hz), 129.4, 128.5, 124.8, 108.5 (t, J = 235.0 Hz), 103.8, 9.1, 8.2; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −109.8 (d, J = 53.5 Hz); FTIR 3087 (w), 2991 (w), 1502 (s), 1367 (m), 1154 (m), 1076 (s), 1023 (s), 1005 (s), 800 (m), 754 (s), 690 (s) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{13}H_{13}F_2N_2$ 235.1047, found 235.1041.

Synthesis of 1-Phenyl-3-(3-chloro)propyl-5-difluoromethyl-1*H*-pyrazole 60a. Following general procedure 4 using 5-chloro-1-pentyne (103 mg, 1.0 mmol), 1-phenyl-3-(3-chloro)propyl-5-difluoromethyl-1*H*-pyrazole **60a** was isolated as a yellow oil (79 mg, 58%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.20−7.49 (m, 4H), 7.48−7.44 (m, 1H), 6.62 (t, J = 53.5 Hz, 1H), 6.61 (s, 1H), 3.65 (t, J = 6.5 Hz, 2H), 2.91 (t, J = 7.5 Hz, 2H), 2.25−2.18 (m, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 152.4, 138.9, 136.8 (t, J = 30.0 Hz), 129.5, 128.7, 124.8, 108.5 (t, J = 235.5 Hz), 106.3, 44.3, 32.1, 25.3; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −109.8 (d, J = 53.5 Hz); FTIR 3076 (w), 2956 (w), 1504 (s), 1358 (m), 1158 (m), 1080 (s), 1023 (s), 1001 (s), 816 (m), 767 (s), 687 (s) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{13}H_{14}ClF_2N_2$ 271.0814, found 271.0809.

Synthesis of Ethyl 1-Phenyl-5-difluoromethyl-1*H*-pyrazole-3-carboxylate 61a and Ethyl 1-Phenyl-5-difluoromethyl-1*H*-pyrazole-4-carboxylate 61b.[40] Following general procedure 4 using ethyl propiolate (98 mg, 1.0 mmol), ethyl 1-phenyl-5-difluoromethyl-1*H*-pyrazole-3-carboxylate **61a** was isolated as a yellow solid (97 mg, 73%) and ethyl 1-phenyl-5-difluoromethyl-1*H*-pyrazole-4-carboxylate **61b** was isolated as a yellow oil (29 mg, 22%).

61a: mp 104−105 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54 (br, 5H), 7.28 (s, 1H), 6.63 (t, J = 53.5 Hz, 1H), 4.47 (q, J = 7.0 Hz, 2H), 1.43 (t, J = 7.0 Hz, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 161.2, 144.5, 138.3, 137.9 (t, J = 30.5 Hz), 129.8, 129.5, 125.5, 109.8, 107.9 (t, J = 236.5 Hz), 61.5, 14.4; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −110.7 (d, J = 53.5 Hz); FTIR 3080 (w), 2991 (w), 2942 (w), 1721 (s), 1448 (m), 1390 (s), 1229 (s), 1078 (s), 1039 (s), 999 (s), 755 (m), cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{13}H_{13}F_2N_2O_2$ 267.0945, found 267.0941.

61b: ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.11 (s, 1H), 7.57−7.55 (m, 2H), 7.53−7.51 (m, 3H), 7.49 (t, J = 53.0 Hz, 1H), 4.40 (q, J = 7.0 Hz, 2H), 1.42 (t, J = 7.0 Hz, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 162.3, 141.9, 139.5, 137.2 (t, J = 24.5 Hz), 129.5, 129.0, 125.7, 116.0, 107.1 (t, J = 237.5 Hz), 61.1, 14.3; ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −112.8 (d, J = 53.0 Hz); FTIR 3074 (w), 2992 (w), 2942 (w), 1705 (s), 1490 (m), 1376 (m), 1233 (s), 1190 (m), 1119 (m), 1029 (s), 975 (m), 779 (s), 689 (s) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{13}H_{13}F_2N_2O_2$ 267.0945, found 267.0935.

Synthesis of Dimethyl 5-Hydroxymethyl-1-phenyl-1*H*-pyrazole-3,4-dicarboxylate 63. A solution of 4-monofluoromethyl-*N*-phenylsydnone **55** (97 mg, 0.5 mmol) and DMAD (0.12 mL, 1.0 mmol) in *o*-DCB (1 mL) in a sealed microwave vessel was heated at 100 °C for 24 h. After cooling, the crude material was purified by flash chromatography on silica gel (eluting with 40% EtOAc in petroleum ether) to yield dimethyl 5-hydroxymethyl-1-phenyl-1*H*-pyrazole-3,4-dicarboxylate **63** as an orange solid (83 mg, 57%): mp 136−138 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60−7.57 (m, 2H), 7.51−7.48 (m, 3H), 4.76 (s, 2H), 3.97 (s, 3H), 3.85 (s, 3H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 162.8, 162.4, 144.0, 141.8, 137.8, 129.5 (2), 125.2, 115.1, 60.5, 52.7, 52.2; FTIR 3399 (br), 2942 (w), 1713 (s), 1473 (m), 1313 (m), 1218 (s), 1104 (s), 988 (m), 762 (s), 693 (s) cm^{-1}; HRMS m/z [MH]$^+$ calcd for $C_{14}H_{15}N_2O_5$ 291.0981, found 291.0974.

Synthesis of (1,3-Diphenyl-1*H*-pyrazol-5-yl)methanol 65. A solution of 4-hydroxymethyl-*N*-phenylsydnone **53** (96 mg, 0.5 mmol) and ethynylbenzene (102 mg, 1.0 mmol) in *o*-DCB (1 mL) in a sealed microwave vessel was heated at 180 °C for 24 h. After cooling, the crude material was purified by flash chromatography on silica gel (eluting with 40% EtOAc in petroleum ether) to yield (1,3-diphenyl-1*H*-pyrazol-5-yl)methanol **65** as a yellow solid (180 mg, 72%): mp 111−112 °C (lit.[41] 117−119 °C); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90−7.88 (m, 2H), 7.68−7.66 (m, 2H), 7.52−7.34 (m, 6H), 6.77 (s, 1H), 4.69 (s, 2H), 2.19 (br, 1H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 151.7, 143.5, 139.5, 132.9, 129.2, 128.7, 128.1, 127.9, 125.8, 124.5, 104.9, 55.7; FTIR 3299 (br), 3068 (w), 2879 (w), 1590 (m), 1502 (s),

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1369 (m), 1008 (m), 808 (m), 766 (s), 696 (s) cm^{-1}; HRMS *m/z* $[MH]^+$ calcd for $C_{16}H_{15}N_2O$ 251.1184, found 251.1175.

Synthesis of 5-Monofluoromethyl-1,3-diphenyl-1*H*-pyrazole 66 and (1,3-Diphenyl-1*H*-pyrazol-5-yl)methanol 65.[41] To an ice-cooled stirring solution of (1,3-diphenyl-1*H*-pyrazol-5-yl)methanol **65** (100 mg, 0.40 mmol) in THF (1 mL) was added deoxofluor(50% solution in THF) (0.10 mL, 0.48 mmol) dropwise under a nitrogen atmosphere. After 1 h, the reaction mixture was warmed to ambient temperature and stirred for a further 1 h. The reaction was subsequently quenched with saturated $NaHCO_{3(aq)}$ (5 mL) and extracted with DCM (3 × 10 mL), and the organic fractions were dried over $MgSO_4$ before the volatiles were removed in vacuo. The crude material was purified by flash chromatography on silica gel (eluting with 10% EtOAc in petroleum ether) to yield 5-monofluoromethyl-1,3-diphenyl-1*H*-pyrazole **66** as a yellow solid (32 mg, 32%) and (eluting with 30% EtOAc in petroleum ether) (1,3-diphenyl-1*H*-pyrazol-5-yl)methanol **65** as a yellow solid (41 mg, 41%).

66: mp 87−89 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.93−7.91 (m, 2H), 7.69−7.67 (m, 2H), 7.57−7.53 (m, 2H), 7.48−7.44 (m, 3H), 7.40−7.35 (m, 1H), 6.95 (d, J = 3.5 Hz, 1H), 5.38 (d, J = 49.0 Hz, 2H); ^{13}C NMR (100.6 MHz, $CDCl_3$) δ 151.9, 139.2, 138.3 (d, J = 19.5 Hz), 132.7, 129.3, 128.7, 128.3, 128.2, 125.8, 124.6, 107.6 (br), 73.8 (d, J = 166.0 Hz); ^{19}F NMR (376.5 MHz, $CDCl_3$) δ −196.9 (td, J = 3.5, 49.0 Hz); FTIR 3059 (w), 2975 (w), 1594 (m), 1500 (m), 1434 (m), 1368 (m), 1156 (m), 944 (s), 759 (s), 690 (s) cm^{-1}; HRMS *m/z* $[MH]^+$ calcd for $C_{16}H_{14}N_2F$ 253.1141, found 253.1149.

■ ASSOCIATED CONTENT

Supporting Information

^{1}H and ^{13}C NMR spectra for selected compounds. 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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