

Article

Regioselective Synthesis of New Family of 2-Substituted 1,2,3-Triazoles and Study of Their Fluorescent Properties

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Abstract: Modification of 5-aryl-4-trifluoroacetyltriazoles at the NH-moiety was investigated. Screening of the alkylation conditions revealed that using Na_2CO_3 as a base and DMF as a solvent of 2-substituted triazoles can be preferentially prepared in up to 86% yield. In the best cases, the amount of minor 1-alkyl isomer was less than 6%. $\text{S}_{\text{N}}\text{Ar}$ reaction of the 5-aryl-4-trifluoroacetyltriazoles with aryl halides having electron-withdrawing groups led to regiospecific formation of 2-aryltriazoles isolated in good-to-high yields. Chan–Lam reaction of the 5-aryl-4-trifluoroacetyltriazoles with boronic acids afforded 2-aryltriazoles as single isomers in up to 89% yield. The subsequent reaction of the prepared 2-aryltriazoles with primary and secondary amines gave a set of amides of 4-(2,5-diaryltriazolyl)carboxylic acid. The fluorescent properties of the prepared 2-substituted derivatives of triazoles were investigated to demonstrate their utility as new efficient luminophores having more than 60% quantum yields.

Keywords: 1,2,3-triazole; alkylation; arylation; fluorine; CF_3CO -group



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1. Introduction

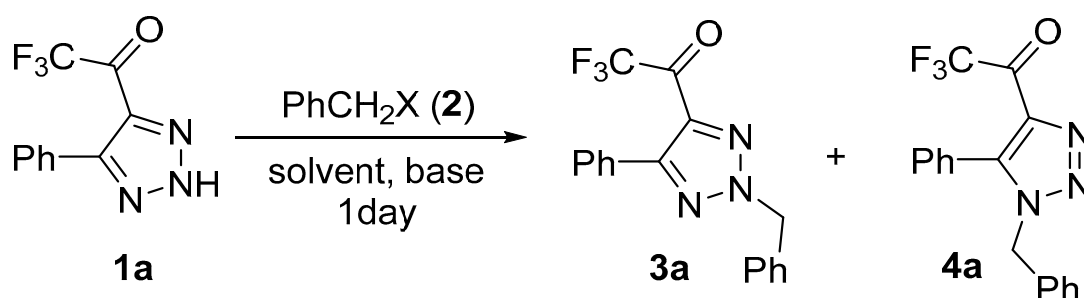
Nowadays, chemistry of fluorinated compounds is one of the most rapidly growing areas of modern organic chemistry [1–4]. Fluorinated compounds are widely used as construction materials, components of liquid crystalline compositions, agrochemicals and pharmaceuticals [5–10]. By some estimations, about 20% of currently used drugs [11–19] contain at least one fluorine atom [20]. In 2022, approximately 21% (four out of nineteen) of “small-molecule drugs” approved by the FDA are fluorinated compounds [21]. On the other hand, about 59% of all small-molecule drugs have a nitrogen heterocyclic motif [22]. Last year revealed that four out of every five small-molecule drugs approved by the FDA in 2022 (16 out of 19) are representatives of that class [21]. It is no doubt that elaboration of novel pathways to fluorinated nitrogen heterocycles is of great demand [23–30].

The most reliable strategy towards fluorinated compounds is a building block strategy, which uses the assembling of simple fluorinated molecules into more complex structures. Last year, our group was tightly engaged with the elaboration and investigation of novel fluorinated building blocks to prepare various trifluoromethylated heterocycles. Thus, we have proposed convenient syntheses of α - CF_3 - β -aryl enamines [31], α,β -diaryl- CF_3 -enones [32] and CF_3 -ynones [33], which appeared to be versatile CF_3 -building blocks for the synthesis of various fluorinated compounds [34,35]. Recently, we have found that reaction of CF_3 -ynones with sodium azide can be used for directed synthesis of either 5- CF_3 -isoxazoles or previously unknown 4-trifluoroacetyltriazoles [36]. The prepared triazoles are a new class of triazolyl compounds. In this article, we have investigated the reactivity and regioselectivity of 4-trifluoroacetyltriazoles in alkylation and arylation as well as the fluorescent properties of the prepared derivatives.

2. Results

As a starting point, we studied alkylation of the model triazole **1a** in DMF by using benzyl chloride and bromide with Na_2CO_3 as a base. We found that both reagents af-

forded benzylated triazoles **3a** and **4a** in high total yield. Moreover, the reaction proceeds regioselectively to form the 2-isomeric triazole **3a** preferentially (Scheme 1).



base	3a+4a	solvent	3a+4a
X=Cl, Na ₂ CO ₃	DMF 81%, 81:19	X=Br, Na ₂ CO ₃	81%, 81:19
X=Br, Na ₂ CO ₃	DMF 84%, 83:17	MeCN	58%, 81:19
K ₂ CO ₃	DMF 84%, 83:17	acetone	57%, 80:20
Li ₂ CO ₃	DMF 72%, 82:18	THF	56%, 80:20
Cs ₂ CO ₃	DMF 44%, 72:28	DMSO	82%, 75:25
DBU	DMF 32%, 75:25	ethylene carbonate,	70%, 68:32
NaH	DMF traces	N-methylpyrrolidinone	71%, 82:18
		EtOH	62%, 70:30
		H ₂ O	58%, 60:40
		DMF-H ₂ O (5:1)	64%, 80:20

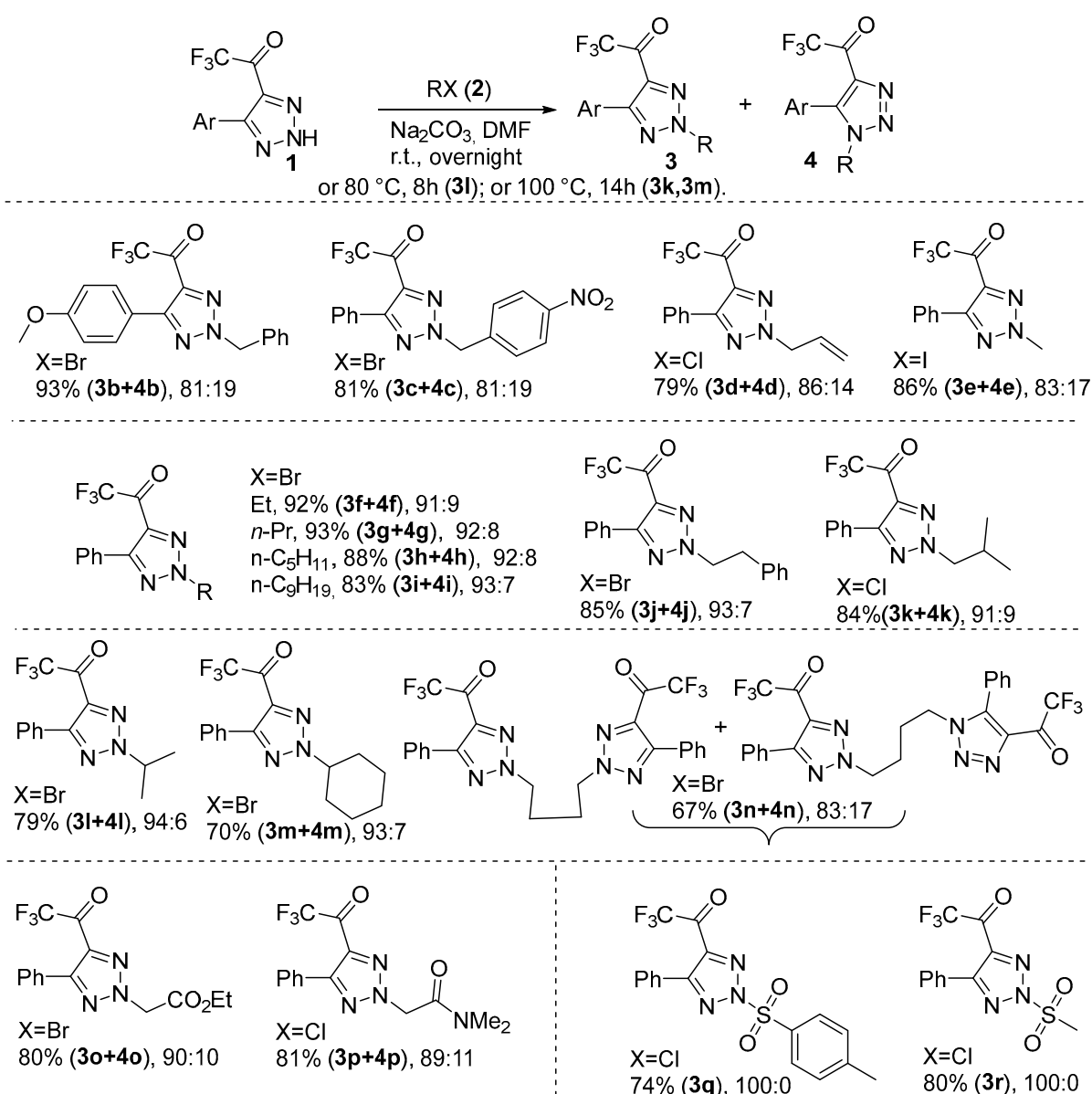
Scheme 1. Screening of the reaction conditions for alkylation of triazole **1a** with benzyl bromide and chloride.

Next, we tested several bases in the reaction. We found that application of Li₂CO₃, Na₂CO₃ and K₂CO₃ provided similar selectivity and yields. Use of Cs₂CO₃ and DBU gave triazoles less selectively and in significantly lower yield. In the case of NaH, alkylated triazoles **3a** and **4a** were not obtained at all, while the starting material was completely consumed (Scheme 1). Recently, we have demonstrated that the trifluoroacetyl group can be transformed into carboxylic or amide function by heating in basic conditions [37]. We believed that a similar transformation of the trifluoroacetyl group takes place in the case of Cs₂CO₃, DBU and NaH, leading to formation of a complex reaction mixture. Moreover, Na₂CO₃ showed the best results in terms of yield and selectivity and has been chosen as a base for further investigations. Using Na₂CO₃, we investigated the influence of the solvent on the reaction. It was found that the reaction can proceed in both protic and aprotic solvents to give *N*-alkylated triazoles in good-to-high yields. The highest yields (84%) and selectivity (only 17% of minor isomer) were observed in polar aprotic solvents (DMF, DMSO). Reaction in polar protic solvents (EtOH, H₂O) was less selective and produced 30–40% of the isomer **4a**. It should be noted that in all investigated solvents, the yields of triazoles did not drop lower than 57%. Taking into account the obtained results, we chose DMF as a solvent and Na₂CO₃ as a base for all subsequent transformations (Scheme 1).

Having in hand the suitable conditions, we performed reactions with a number of alkyl halides **2**. It was found that the product distribution is dependent on the activity of the alkylating agent. Thus, the reactions of triazoles **1a,b** with benzyl bromide as well as the reaction of triazole **1a** with 4-nitrobenzyl bromide led to a mixture of isomers **3** and **4** in 81:19 ratio. The reaction of allyl chloride, which compared to benzyl bromide by activity, afforded an 83:17 mixture of isomers. The reaction of MeI (most reactive among non-functionalized alkyl halides) with **1a** led to a mixture of **3e** and **4e** in an 83:17 ratio. The reaction with less reactive aliphatic alkyl bromides proceeds more selectively to give only

a 6–9% admixture of minor regioisomer. It should be noted that the reaction outcome is not sensitive to bulkiness of the reagents to give similar results for primary, secondary and cyclic alkyl bromides. However, heating is needed in the case of most bulky *iso*-propyl-, *cyclo*-hexyl bromides and *iso*-butyl chloride. A lower selectivity was observed in the case of the reaction with 1,4-dibromobutane; such a ratio of regioisomers can be explained by statistical factor.

Another type of the alkylating agents investigated were derivatives of 2-haloacetic acid. The alkylation of triazole **1a** with ethyl bromoacetate and 2-chloro-*N,N*-dimethylacetamide gave a mixture of isomeric triazoles in almost the same ratio (90:10 and 89:11, correspondingly). Eventually, sulfonylation of **1a** by *M*sCl and *T*sCl led to 2-substituted triazoles exclusively (Scheme 2).



Scheme 2. Alkylation and sulfonylation of triazoles **1**.

Elucidation of the structure of regioisomers **3** and **4** was carried out by comparison with the literature data. Previously, we have found that 2 + 3 cycloaddition reaction of CF₃-ynones with alkyl and aryl azides led mostly to 1-substituted triazoles with admixture of 3-substituted triazoles [38]. Careful comparison of CH₂ signals in ¹H NMR of triazoles **3** and **4** with those of 1-substituted and 3-substituted isomers showed that CH₂ signals

of minor isomers **4a** and **4o** are in good agreement with CH₂ signals of 1-alkyl triazole (Figure 1). CH₂-signals of major isomers of **3a** and **3o** are downfield shifted and differ from the CH₂ signals of 3-alkyl isomers. Hence, major isomers **3a** and **3o** are 2-substituted derivatives. It should be noted that substitution at the position 2 in NH-triazoles **1** is favored by both steric and electronic factors. Indeed, positions N-1 and N-3 of triazoles **1** are hindered by the bulky aryl substituent at C-5 and trifluoroacetyl group at C-4 atom of the triazole ring. As a result, the 2-isomer is a major one. In addition, the nucleophilicity of N-3 is diminished by the high electronegativity of the trifluoroacetyl group, which is why 3-N-isomers are not formed at all. It should be noted that major isomer **3** can be easily separated from isomer **4** by column chromatography on silica gel.

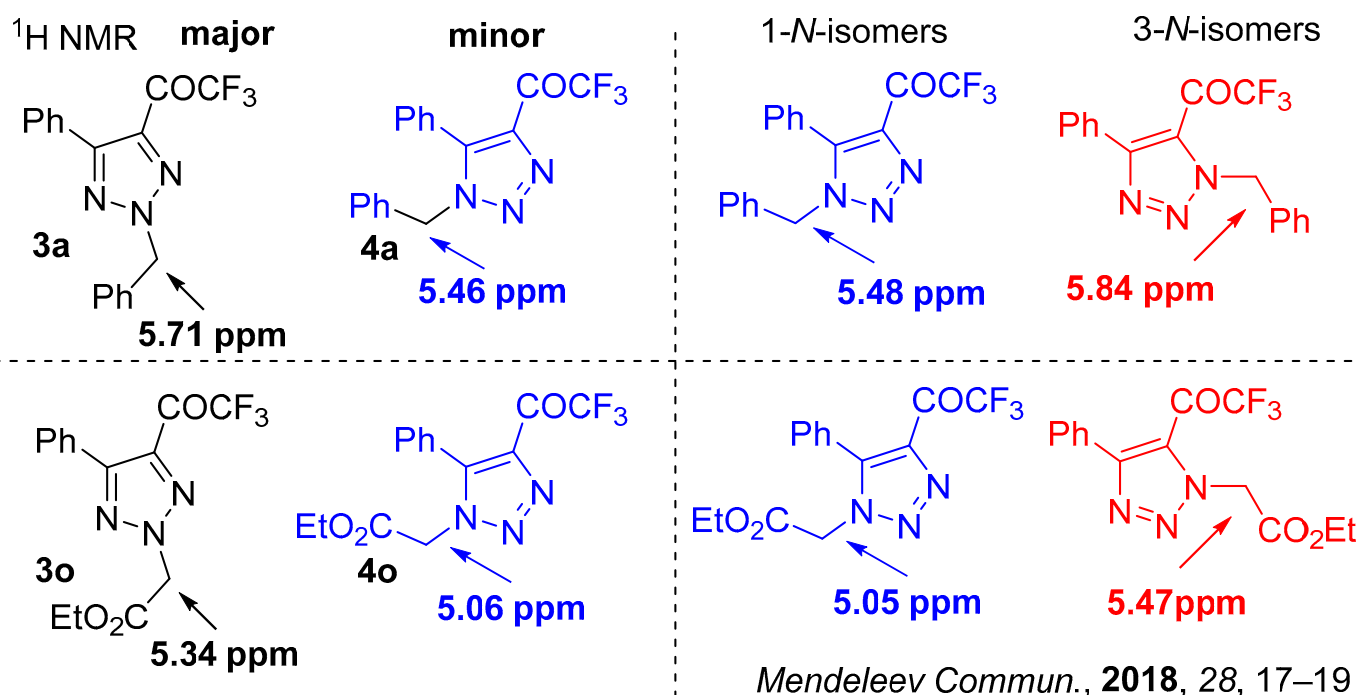
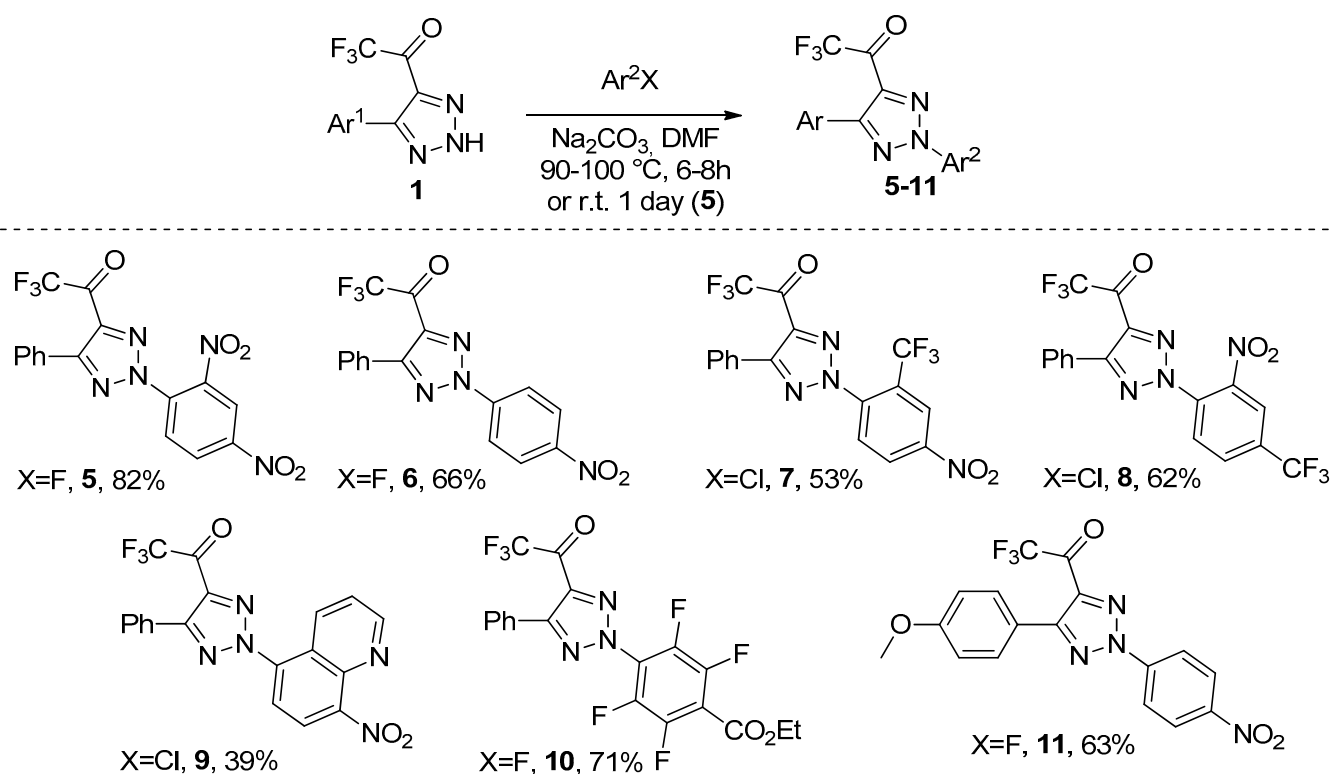
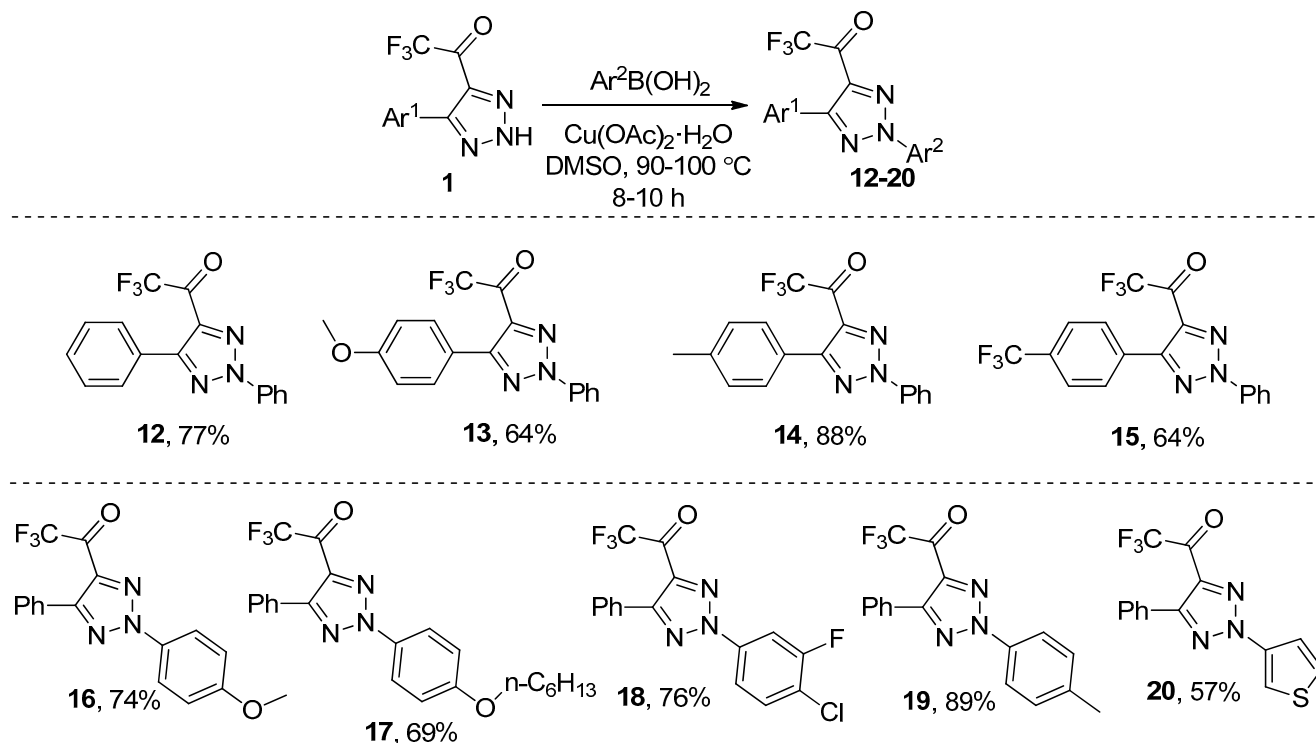


Figure 1. Elucidation of the structure of regioisomers **3** and **4**.

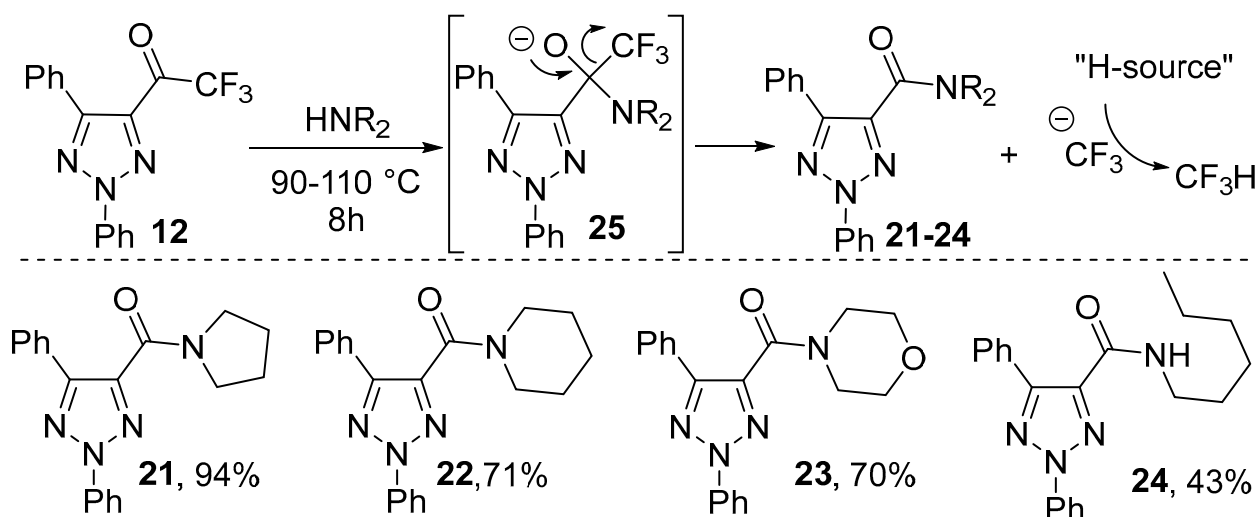
Next, we switched our attention to the reaction of triazoles **1a** with aryl halides activated by electron-withdrawing substituents. In contrast to the S_N2 reaction with alkyl halides **2**, the S_NAr reaction with aryl halides proceeds at elevated temperatures (90–100 °C). Only the reaction with highly reactive 1-fluoro-2,4-dinitrobenzene can be performed at room temperature. The arylation is regioselective to afford only 2-aryl substituted products **5–12**, which is a favorable feature of the arylation. Using this approach, we prepared a set of 2-N arylated triazoles having CF₃, NO₂ and CO₂Et groups in up to 86% yield. In addition, triazole **9** bearing a quinoline moiety was also prepared in moderate yield (Scheme 3).

In spite of the high utility of the S_NAr reaction, obvious restriction of this method is necessary in order to have an activating EWG group in the structure of the aryl halide. Therefore, we also investigated an alternative type of arylation of triazoles **1** in conditions of the Chan–Lam reaction. Carried out in open air (no balloons with oxygen and etc.) reactions of triazoles **1** with boronic acids in DMSO at heating under catalysis with copper (II) acetate afforded 2-N-aryl derivatives **12–20** in 100% regioselectively in up to 89% yields (Scheme 4). It should be noted that no additives of any ligands were needed for successful transformation of triazoles **1**.

Scheme 3. Arylation of triazoles **1** with various aryl halides **5-11**.Scheme 4. Cham-Lam arylation of triazoles **1**.

Recently, we found that N-unsubstituted 4-trifluoroacetyl triazoles react with secondary amines at elevated temperatures to produce corresponding amides as a result of formal substitution of CHF_3 [37]. The prepared 2-arylated triazoles can be used for the similar transformation as well. We performed the reaction of 2-phenyl substituted triazole

12 with some secondary and primary amines at heating. As a result, a set of amides **21–24** was obtained in good-to-high yields to provide a broad diversity of the synthesized triazole derivatives. Thus, we succeeded in preparing derivatives of pyrrolidine, piperidine, morpholine and *n*-hexylamine (Scheme 5). Taking into account the literature data [37], we proposed a possible mechanism of the reaction. First, the addition of amine to the carbonyl group of **12** led to intermediate **25**. Next, **25** eliminates the trifluoromethyl anion to afford amides **21–24**; protonation of CF_3^- gives CF_3H .



Scheme 5. Reactions of triazole **12** with secondary amines.

The 1,2,3-triazole scaffold has been intensively investigated in recent decades, boosted by the discovery of CuAAC–RuAAC reactions (metal-catalyzed alkyne–azide cycloaddition) [39,40]. Many 1,2,3-triazoles have useful practical properties and have found applications as agrochemicals, pigments, metal chelators, photostabilizers and corrosion inhibitors [41]. Many 1,2,3-triazoles are physiologically active compounds and have pharmaceutical and therapeutic applications [42–44]. Ion(s) detection capabilities of 1,2,3-triazole ligands using absorption and fluorescence spectroscopy were also reported [45–48]. Of special interest are 2-Aryl-substituted 1,2,3-triazoles, since these compounds are highly efficient UV/blue-light-emitting fluorophores [49,50]. Therefore, we investigated some photophysical properties of the prepared 2-substituted triazoles. Electronic absorption spectra ($c = 10^{-5}$ M) and fluorescence spectra data were recorded in methanol solutions ($c = 10^{-6}$ M) at room temperature. The quantum yields of fluorescence (φ) were determined by a comparative method using 2-aminopyridine as the standard. The absorption band of compounds **3** bearing alkyl group in the position 2 of triazole has one pronounced peak; however, tosyl-substituted triazole **3q** has several adsorption bands. The adsorption maxima of **3a,d,e,p,r** are in the range of 224–234 nm (Figure 2a). All these derivatives demonstrated light emission in the range 297–303 nm and quantum yields below 10% (Table 1, Figure 2b).

Table 1. Photophysical data of compounds **3**.

Compd.	$\lambda_{\text{max}}^{\text{abs}}, \text{nm}/\tilde{\nu}_{\text{max}}^{\text{abs}}, \text{cm}^{-1}$	$\epsilon, \text{L}\cdot\text{mol}^{-1}\cdot\text{cm}^{-1}$	$\lambda_{\text{max}}^{\text{fl}}, \text{nm}/\tilde{\nu}_{\text{max}}^{\text{fl}}, \text{cm}^{-1}$	φ^a	$\Delta\nu_{\text{ST}}, \text{cm}^{-1}$
3a	234/42,730	15,140	298/33,550	0.09	9180
3d	232/43,100	10,900	297/33,670	0.07	9430
3e	232/43,100	12,200	297/33,670	0.07	9430
3p	231/43,290	13,090	298/33,550	0.07	9740
3q	224/44,640	18,750	303/33,000	0.03	11,640
3r	230/43,470	11,700	299/33,440	0.03	10,030

^a Quantum yield φ relative to 2-aminopyridine in 0.1 M H_2SO_4 ($\varphi = 0.6$).

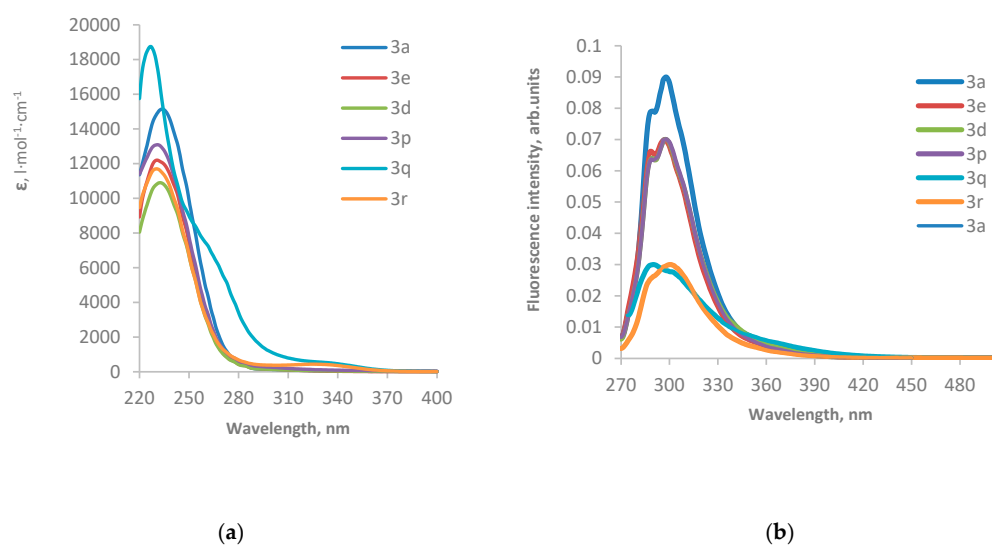


Figure 2. (a) Absorption and (b) emission spectra of solutions of compounds **3** in methanol.

Much more interesting photophysical properties are observed for 2-aryl substituted triazoles **6–24**. Among these types of triazoles, we found highly efficient fluorophores demonstrating emission in the range 335–368 nm and quantum yields up to 65% in methanol solution. However, it was found that the nature of the substituent in the 2-aryl group of triazoles **6** influences dramatically the emission properties (Table 2). For example, compounds **6–8,11** do not fluoresce at all. Complete quenching of fluorescence in these cases can be explained by the presence of the EWG group at the aryl fragment attached to the position 2 of the triazole. In contrast, high quantum yields are observed when the aryl group at the position 2 is electron-rich. The absorption spectra of compounds **6,7,10,11,13,20** have two bands, which is especially pronounced for compounds **7,10**. The introduction of an electron-withdrawing group into the 2-aryl substituent leads to a bathochromic shift of the absorption band. It is most pronounced for compounds **6** and **7** (Figure 3a). The exception is **10**, for which a slight hypsochromic shift is observed. At the same time, despite the low quantum yield, **10** has the largest Stokes shift among the compounds of this series (Figure 3b). Most probably, this is due to the influence of its fluorinated fragment. The introduction of substituents into the *para*-position of 5-aryltriazole does not affect significantly the position of the absorption band, causing only a slight bathochromic shift for **13** (Figure 4a). The quantum yields of **12–20** compounds turned out to be the best among the N-2-aryl-1,2,3-triazoles studied by us and are in the range of 0.23–0.65 (Figure 4b). The highest value for compound **15**, for compounds **14, 16–20**, is about 0.60.

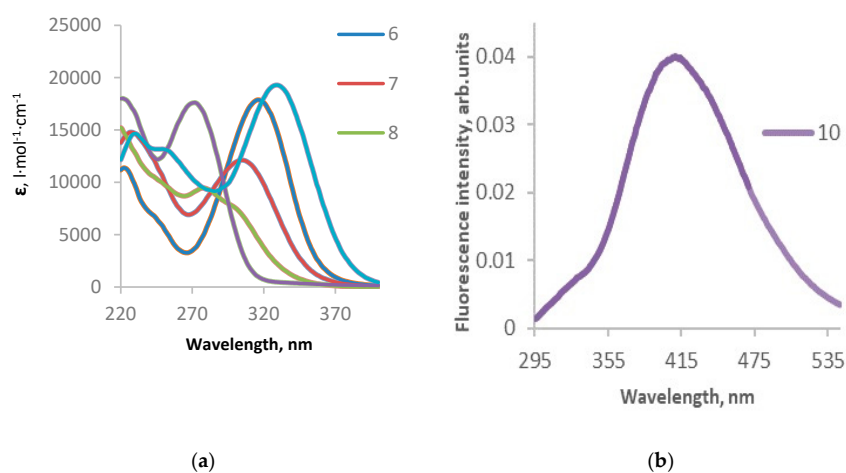


Figure 3. (a) Absorption and (b) emission spectra of solutions of compounds **6–8,10,11** in methanol.

Table 2. Photophysical data of compounds 6–8, 10–20.

Compd.	$\lambda_{\max}^{\text{abs}}$, nm/ $\tilde{\nu}_{\max}^{\text{abs}}$, cm^{-1} ^a	ϵ , $\text{L}\cdot\text{mol}^{-1}\cdot\text{cm}^{-1}$	$\lambda_{\max}^{\text{fl}}$, nm/ $\tilde{\nu}_{\max}^{\text{fl}}$, cm^{-1}	ϕ ^b	$\Delta\nu_{\text{ST}}$, cm^{-1}
6	222/45,040	11,370		—	
	316/31,640	17,880			
7	227/44,050	14,800		—	
	305/32,780	12,120			
8	278/35,970	15,240		—	
10	221/45,240	18,020			
	271/36,900	17,600	408/24,500	0.04	12,400
11	230/43,480	14,650		—	
	329/30,390	19,290			
12	276/36,230	17,420	335/29,850	0.52	6380
	241/41,490	13,560			
13	283/35,330	19,660	364/27,470	0.41	7860
	279/35,840	20,630	339/29,490	0.60	6350
15	276/36,230	20,120	342/29,240	0.65	6990
16	287/34,840	16,580	366/27,320	0.59	7520
17	289/34,600	21,450	368/27,180	0.60	7420
18	291/34,360	22,860	338/29,580	0.57	4780
19	279/35,840	22,370	345/28,980	0.60	6860
20	226/44,240	14,620			
	278/35,970	19,300	347/28,810	0.23	7160

^a For compounds with two absorption bands, the positions of both bands are given, ^b quantum yield ϕ relative to 2-aminopyridine in 0.1 M H_2SO_4 ($\phi = 0.6$).

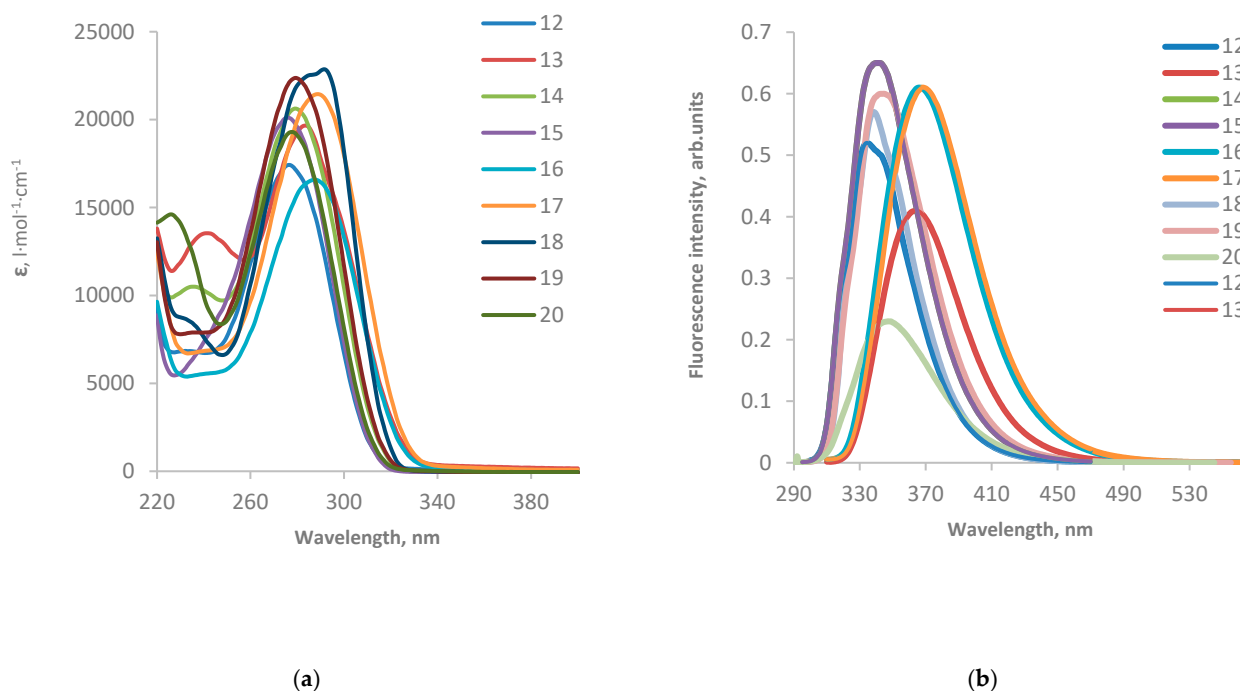


Figure 4. (a) Absorption and (b) emission spectra of solutions of compounds 12–20 in methanol.

The spectral characteristics of amides 21–24 are presented in Table 3. The maximum of the absorption band is in the range of 286–290 nm. These types of triazoles demonstrate emission in the region of 340–345 nm and quantum yields up to 26%. In spite of structural similarity, the influence of amine is very pronounced. For example, compound 21 has a rather high extinction coefficient of $29,740 \text{ L}\cdot\text{mol}^{-1}\cdot\text{cm}^{-1}$, and compound 24 has the highest quantum yield of 26% among the amides obtained (Figure 5).

Table 3. Photophysical data of compounds 21–24.

Compd.	$\lambda_{\max}^{\text{abs}}$, nm/ $\tilde{\nu}_{\max}^{\text{abs}}$, cm^{-1}	ϵ , $\text{L}\cdot\text{mol}^{-1}\cdot\text{cm}^{-1}$	$\lambda_{\max}^{\text{fl}}$, nm/ $\tilde{\nu}_{\max}^{\text{fl}}$, cm^{-1}	φ^{a}	$\Delta\nu_{\text{ST}}$, cm^{-1}
21	290/34,480	29,740	342/29,240	0.03	5240
22	290/34,480	20,310	342/29,240	0.04	5240
23	289/34,600	21,450	340/29,410	0.02	5190
24	286/34,960	19,420	345/28,980	0.26	5980

^a Quantum yield φ relative to 2-aminopyridine in 0.1 M H_2SO_4 ($\varphi = 0.6$).

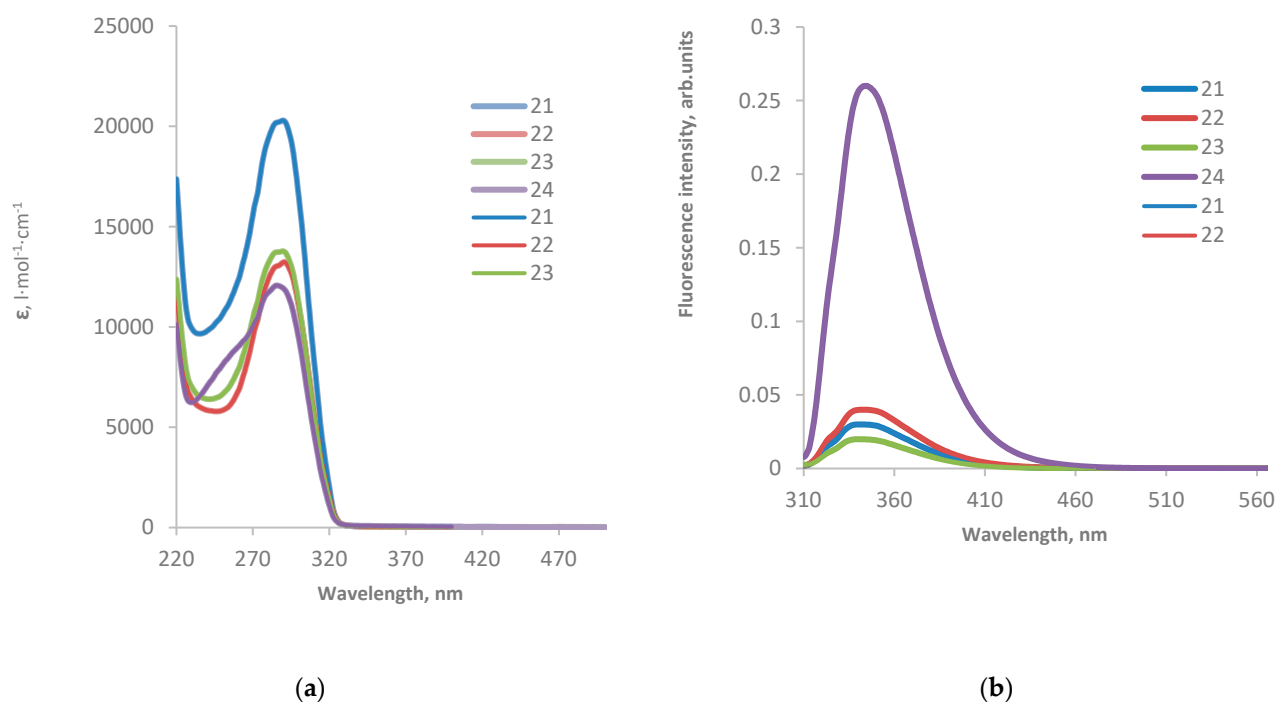


Figure 5. (a) Absorption and (b) emission spectra of solutions of compounds 21–24 in methanol.

Thus, the absorption and emission range of all studied compounds is in the ultraviolet region, and 12–19 compounds have sufficiently high quantum yields.

3. Materials and Methods

In general, ^1H , ^{13}C and ^{19}F NMR spectra were recorded on Bruker AVANCE 400 MHz spectrometer in CD_3CN and CDCl_3 at 400.1, 100.6 and 376.5 MHz, respectively. Chemical shifts (δ) in ppm are reported with the use of the residual CHD_2CN and chloroform signals (1.94, 7.25 for ^1H and 1.30, 77.0 for ^{13}C) as internal reference. The ^{19}F chemical shifts were referenced to C_6F_6 (−162.9 ppm). The coupling constants (J) are given in Hertz (Hz). HRMS spectra were measured on the MicroTof Bruker Daltonics instrument. TLC analysis was performed on “Macherey-Nagel ALUGRAM Xtra SIL G/UV₂₅₄” plates. Column chromatography was performed on silica gel “Macherey-Nagel 0.063–0.2 nm (Silica 60)”. All reagents were of reagent grade and were used as such or were distilled prior to use. Triazoles 1 were prepared as reported previously [43]. Melting points were determined on the Electrothermal 9100 apparatus (Electrothermal, Stone, Staffordshire, UK). Electronic absorption spectra were recorded on Genesys 50 (Thermo Scientific) in cuvettes with an optical path length of 1 cm at room temperature using methanol as a solvent. Emission spectra were recorded with a Hitachi F2700 spectrofluorometer (Hitachi, Tokyo, Japan) in 1 cm quartz cuvettes. The relative fluorescence quantum yields (φ) were measured using 2-aminopyridine 0.1 M H_2SO_4 ($\varphi = 0.60$) as a standard. [51]

Screening of the optimal conditions for modification of triazoles 1 by alkylating reagents. A 4 mL vial with a screw cap was charged with triazole 1a (0.060 g, 0.25 mmol),

solvent (0.5 mL), base (0.38 mmol, 1.5 equiv.) and corresponding alkylating reagent (0.275 mmol, 1.1 equiv., 0.035 g (BnCl) or 0.047 g (BnBr)). The reaction mixture was stirred at room temperature overnight. The yields and ratio of **3a** and **4a** were determined by ^{19}F NMR using PhCF_3 as an internal standard.

Reaction of triazoles (1) with alkylating reagents (general procedure). A 4 mL vial with a screw cap was charged with corresponding triazole **1** (0.5 mmol), DMF (1 mL), Na_2CO_3 (80 mg, 0.38 mmol, 1.5 equiv.) and corresponding alkylating reagent (0.55 mmol, 1.1 equiv.) The reaction mixture was stirred at room temperature overnight or heated (8 h at $80\text{ }^\circ\text{C}$ for **3l**, 14 h at $100\text{ }^\circ\text{C}$ for **3k**, 16h at $100\text{ }^\circ\text{C}$ for **3m**) and then was broken by 0.1 M HCl (20 mL). The product was extracted by CH_2Cl_2 (3×10 mL); the organic phase was washed with water (2×10 mL), brine (10 mL) and dried over Na_2SO_4 . Volatiles were evaporated in vacuo; the residue formed was purified by column chromatography on silica gel using gradient elution by hexane- CH_2Cl_2 mixture (3:1) followed by hexane- CH_2Cl_2 mixture (1:1) and CH_2Cl_2 . Evaporation of the solvents afforded corresponding pure triazole **3**. Due to low amounts of minor triazoles **4**, these compounds were not separated completely from major triazoles **3** in some cases. Mostly ^1H NMR and ^{19}F NMR were measured for **3**. Only the most characteristic signals of **3** are given in ^{13}C NMR.

1-(2-Benzyl-5-phenyl-2H-1,2,3-triazol-4-yl)-2,2,2-trifluoroethanone (3a). This was obtained from **1a** (120 mg, 0.498 mmol) and benzyl bromide (94 mg, 0.550 mmol) and purified using gradient eluting by hexane- CH_2Cl_2 (3:1) followed by hexane- CH_2Cl_2 (1:1) and CH_2Cl_2 . Total yield (**3a** + **4a**) was 139 mg (84%), ratio **3a:4a** = 83:17. For pure **3a**, it was beige oil, yield 115 mg (70%). ^1H NMR (CDCl_3 , 400.1 MHz) was δ 7.96–7.86 (m, 2H), 7.53–7.44 (m, 5H), 7.44–7.36(m, 3H), 5.71 (s, 2H). $^{13}\text{C}\{^1\text{H}\}$ NMR (CDCl_3 , 100.6 MHz) was δ 174.2 (q, $^2J_{\text{CF}} = 37.0$ Hz), 152.7, 136.4, 133.5, 130.1, 129.1, 129.0, 128.9, 128.40, 128.35, 128.2, 116.3 (q, $^1J_{\text{CF}} = 290.7$ Hz), 59.9. ^{19}F NMR (CDCl_3 , 376.5 MHz): δ -74.9 (s, 3F). HRMS (ESI-TOF) was m/z [$\text{M} + \text{H}$] $^+$. Calcd for $\text{C}_{17}\text{H}_{13}\text{F}_3\text{N}_3\text{O}^+$ was 332.1005 and found: 332.1005. IR (ν , cm^{-1}) was 1723 (C=O).

1-(1-Benzyl-5-phenyl-1H-1,2,3-triazol-4-yl)-2,2,2-trifluoroethanone (4a). This was obtained from **1a** as an admixture (83:17) in the synthesis of **3a**. For pure **4a**, see the following: Beige thick oil, yield 24 mg (14%). ^1H NMR (CDCl_3 , 400.1 MHz): δ 7.58–7.52 (m, 1H), 7.51–7.46 (m, 2H), 7.31–7.25 (m, 3H), 7.24–7.20 (m, 2H), 7.08–7.00 (m, 2H), 5.46 (s, 2H). $^{13}\text{C}\{^1\text{H}\}$ NMR (CDCl_3 , 100.6 MHz): δ 174.2 (q, $^2J_{\text{CF}} = 37.3$ Hz), 143.9, 138.1, 133.9, 130.9, 129.4, 129.0, 128.9, 128.7, 127.7, 124.4, 116.1 (q, $^1J_{\text{CF}} = 290.6$ Hz), 52.2. ^{19}F NMR (CDCl_3 , 376.5 MHz): δ -75.4 (s, 3F). NMR data are in agreement with those in the literature [38].

1-(2-Benzyl-5-(4-methoxyphenyl)-2H-1,2,3-triazol-4-yl)-2,2,2-trifluoroethanone (3b). This was obtained from **1b** (62 mg, 0.229 mmol) and benzyl bromide (43 mg, 0.251 mmol) and purified using gradient eluting by hexane- CH_2Cl_2 (3:1) followed by hexane- CH_2Cl_2 (1:1) and CH_2Cl_2 . Total yield (**3b** + **4b**) was 77 mg (93%), ratio **3b:4b** = 81:19. For pure **3b**, see the following: White solid, yield 0.0624 g (75.3%). ^1H NMR (CDCl_3 , 400.1 MHz): δ 7.89 (d, 2H, $^3J = 8.9$ Hz), 7.48–7.33 (m, 5H), 6.97 (d, 2H, $^3J = 8.9$ Hz), 5.68 (s, 2H), 3.85 (s, 3H). $^{13}\text{C}\{^1\text{H}\}$ NMR (CDCl_3 , 100.6 MHz): δ 174.3 (q, $^2J_{\text{CF}} = 37.0$ Hz), 161.0, 152.7, 136.1, 133.6, 130.6, 128.94, 128.89, 128.4, 120.6, 116.3 (q, $^1J_{\text{CF}} = 290.8$ Hz), 113.8, 59.8, 55.3. ^{19}F NMR (CDCl_3 , 376.5 MHz): δ -74.8 (s, 3F). HRMS (ESI-TOF): m/z [$\text{M} + \text{H}$] $^+$ Calcd for $\text{C}_{18}\text{H}_{15}\text{F}_3\text{N}_3\text{O}_2^+$: 362.1111; found: 362.1089.

1-(1-Benzyl-5-(4-methoxyphenyl)-1H-1,2,3-triazol-4-yl)-2,2,2-trifluoroethanone (4b). This was obtained from **1b** as an admixture (81:19) in the synthesis of **3b**: colorless oil, yield 14.6 mg (17.3%). ^1H NMR (CDCl_3 , 400.1 MHz): δ 7.33–7.27 (m, 3H), 7.17 (d, 2H, $^3J = 8.7$ Hz), 7.13–7.04 (m, 2H), 6.98 (d, 2H, $^3J = 8.7$ Hz), 5.47 (s, 2H), 3.87 (s, 3H). $^{13}\text{C}\{^1\text{H}\}$ NMR (CDCl_3 , 100.6 MHz): δ 174.2 (q, $^2J_{\text{CF}} = 37.1$ Hz), 161.5, 144.0, 137.9, 134.1, 131.1, 129.0, 128.7, 127.6, 116.0, 116.2 (q, $^1J_{\text{CF}} = 290.8$ Hz), 114.4, 55.4, 52.0. ^{19}F NMR (CDCl_3 , 376.5 MHz): δ -75.2 (s, 3F).

2,2,2-Trifluoro-1-(2-(4-nitrobenzyl)-5-phenyl-2H-1,2,3-triazol-4-yl)ethanone (3c). This was obtained from **1a** (48 mg, 0.199 mmol) and 1-(bromomethyl)-4-nitrobenzene (47 mg,

0.218 mmol) and purified using gradient eluting by hexane-CH₂Cl₂ (3:1) followed by hexane-CH₂Cl₂ (1:1) and CH₂Cl₂. Total yield (**3c** + **4c**) was 0.0609 g (81%), ratio **3c**:**4c** = 83:17. For pure **3c**, see the following: beige solid, m.p. 97–101 °C, yield 0.0493 g (65.6%). ¹H NMR (CDCl₃, 400.1 MHz): δ 8.25 (d, 2H, ³J = 8.7 Hz), 7.91–7.82 (m, 2H), 7.60 (d, 2H, ³J = 8.7 Hz), 7.49–7.43 (m, 3H), 5.81 (s, 2H). ¹³C{¹H} NMR (CDCl₃, 100.6 MHz): δ 174.1 (q, ²J_{CF} = 37.7 Hz), 153.1, 148.3, 140.1, 136.9, 130.4, 129.3, 129.1, 128.5, 127.8, 124.3, 116.1 (q, ¹J_{CF} = 290.6 Hz), 58.8. ¹⁹F NMR (CDCl₃, 376.5 MHz): δ −75.0 (s, 3F). HRMS (ESI-TOF): *m/z* [M + H]⁺ Calcd for C₁₇H₁₂F₃N₄O₃⁺: 377.0856; found: 377.0854.

2,2,2-Trifluoro-1-(1-(4-nitrobenzyl)-5-phenyl-1H-1,2,3-triazol-4-yl)ethanone (4c). This was obtained from **1a** as an admixture (81:19) in the synthesis of **3c**: pale brown viscous mass, yield 11.6 mg (15.4%). ¹H NMR (CDCl₃, 400.1 MHz): δ 5.58 (s, 2H). ¹⁹F NMR (CDCl₃, 376.5 MHz): δ −75.4 (s, 3F).

1-(2-Allyl-5-phenyl-2H-1,2,3-triazol-4-yl)-2,2,2-trifluoroethanone (3d). This was obtained from **1a** (50.2 mg, 0.208 mmol) and 3-chloroprop-1-ene (21 mg, 0.276 mmol) and purified using gradient eluting by hexane-CH₂Cl₂ (3:1) followed by hexane-CH₂Cl₂ (1:1) and CH₂Cl₂. Total yield (**3d** + **4d**) was 46 mg (79%), ratio **3d**:**4d** = 86:14. For pure **3d**, see the following: colorless oil, yield 39.6 mg (68%). ¹H NMR (CDCl₃, 400.1 MHz): δ 7.93–7.84 (m, 2H), 7.50–7.43 (m, 3H), 6.21–6.09 (m, 1H), 5.45–5.37 (m, 2H), 5.16 (dt, 2H, ³J = 6.3 Hz, ⁴J = 1.4 Hz). ¹³C{¹H} NMR (CDCl₃, 100.6 MHz): δ 174.3 (q, ²J_{CF} = 37.0 Hz), 152.6, 136.4, 130.1, 130.0, 129.1, 128.4, 128.2, 120.9, 116.2 (q, ¹J_{CF} = 290.6 Hz), 58.5. ¹⁹F NMR (CDCl₃, 376.5 MHz): δ −75.0 (s, 3F). HRMS (ESI-TOF): *m/z* [M + H]⁺ Calcd for C₁₃H₁₁F₃N₃O⁺: 282.0849; found: 282.0853.

1-(1-Allyl-5-phenyl-1H-1,2,3-triazol-4-yl)-2,2,2-trifluoroethanone (4d). This was obtained from **1a** as an admixture (86:14) in the synthesis of **3d**: colorless oil, yield 6.4 mg (11%). ¹H NMR (CDCl₃, 400.1 MHz): δ 7.58–7.50 (m, 3H), 7.40–7.36 (m, 2H), 5.95 (ddt, 1H, ²J = 16.9 Hz, ³J = 10.4 Hz, ³J = 5.7 Hz), 5.29 (d, 1H, ³J = 10.3 Hz), 5.06 (*pseudo*-dt, 1H, ²J = 17.1 Hz, ⁴J = 1.3 Hz), 4.89 (dt, ³J = 5.7 Hz, ⁴J = 1.5 Hz). ¹⁹F NMR (CDCl₃, 376.5 MHz): δ −75.3 (s, 3F).

2,2,2-Trifluoro-1-(2-methyl-5-phenyl-2H-1,2,3-triazol-4-yl)ethanone (3e). This was obtained from **1a** (51.9 mg, 0.215 mmol) and iodomethane (34 mg, 0.239 mmol) and purified using gradient eluting by hexane-CH₂Cl₂ (3:1) followed by hexane-CH₂Cl₂ (1:1) and CH₂Cl₂. Total yield (**3e** + **4e**) was 47.2 mg (86%), ratio **3e**:**4e** = 83:17. For pure **3e**, see the following: beige oil, yield 39.2 mg (71.4%). ¹H NMR (CDCl₃, 400.1 MHz): δ 7.92–7.84 (m, 2H), 7.50–7.44 (m, 3H), 4.35 (s, 3H). ¹³C{¹H} NMR (CDCl₃, 100.6 MHz): δ 174.1 (q, ²J_{CF} = 37.0 Hz), 152.6, 136.3, 130.1, 129.0, 128.4, 128.2, 116.2 (q, ¹J_{CF} = 290.5 Hz), 42.8. ¹⁹F NMR (CDCl₃, 376.5 MHz): δ −75.0 (s, 3F). HRMS (ESI-TOF): *m/z* [M + H]⁺ Calcd for C₁₁H₉F₃N₃O⁺: 256.0692; found: 256.0692.

2,2,2-Trifluoro-1-(1-methyl-5-phenyl-1H-1,2,3-triazol-4-yl)ethanone (4e). This was obtained from **1a** as an admixture (83:17) in the synthesis of **3e**: beige oil, yield 8 mg (14.6%). ¹H NMR (CDCl₃, 400.1 MHz): δ 7.63–7.51 (m, 3H), 7.44–7.34 (m, 2H), 4.01 (s, 3H). ¹³C{¹H} NMR (CDCl₃, 100.6 MHz): δ 131.0, 129.4, 129.1, 35.5. ¹⁹F NMR (CDCl₃, 376.5 MHz): δ −75.3 (s, 3F).

1-(2-Ethyl-5-phenyl-2H-1,2,3-triazol-4-yl)-2,2,2-trifluoroethanone (3f). This was obtained from **1a** (50.7 mg, 0.210 mmol) and bromoethane (25.5 mg, 0.234 mmol) and purified using gradient eluting by hexane-CH₂Cl₂ (3:1) followed by hexane-CH₂Cl₂ (1:1) and CH₂Cl₂. Total yield (**3f** + **4f**) was 0.052 g (92%), ratio **3f**:**4f** = 91:9. For pure **3f**, see the following: colorless oil, yield 47.2 mg (83.7%). ¹H NMR (CDCl₃, 400.1 MHz): δ 8.00–7.80 (m, 2H), 7.54–7.41 (m, 3H), 4.61 (q, 2H, ³J = 7.4 Hz), 1.68 (t, 3H, ³J = 7.4 Hz). ¹³C{¹H} NMR (CDCl₃, 100.6 MHz): δ 174.2 (q, ²J_{CF} = 36.7 Hz), 152.4, 136.1, 130.0, 129.0, 128.4, 116.3 (q, ¹J_{CF} = 290.7 Hz), 51.4, 14.5. ¹⁹F NMR (CDCl₃, 376.5 MHz): δ −75.0 (s, 3F). HRMS (ESI-TOF): *m/z* [M + H]⁺ Calcd for C₁₂H₁₁F₃N₃O⁺: 270.0851; found: 270.0851.

1-(1-Ethyl-5-phenyl-1H-1,2,3-triazol-4-yl)-2,2,2-trifluoroethanone (4f). This was obtained from **1a** as an admixture (91:9) in the synthesis of **3f**: colorless oil, yield 4.7 mg (8.3%). ¹H NMR (CDCl₃, 400.1 MHz): δ 7.61–7.52 (m, 3H), 7.39–7.36 (m, 2H), 4.33 (q, 2H, ³J = 7.3 Hz), 1.48 (t, 3H, ³J = 7.3 Hz). ¹⁹F NMR (CDCl₃, 376.5 MHz): δ –75.3 (s, 3F).

2,2,2-Trifluoro-1-(5-phenyl-2-propyl-2H-1,2,3-triazol-4-yl)ethanone (3g). This was obtained from **1a** (53.8 mg, 0.223 mmol) and bromopropane (30.3 mg, 0.246 mmol) and purified using gradient eluting by hexane-CH₂Cl₂ (3:1) followed by hexane-CH₂Cl₂ (1:1) and CH₂Cl₂. Total yield (**3g** + **4g**) was 58.7 mg (93%), ratio **3g**:**4g** = 92:8. For pure **3g**, see the following: beige oil, yield 54 mg (85.6%). ¹H NMR (CDCl₃, 400.1 MHz): δ 7.95–7.83 (m, 2H), 7.53–7.43 (m, 3H), 4.52 (t, 2H, ³J = 7.1 Hz), 2.10 (h (sextet), 2H, ³J = 7.3 Hz), 1.02 (t, 3H, ³J = 7.4 Hz). ¹³C{¹H} NMR (CDCl₃, 100.6 MHz): δ 174.3 (q, ²J_{CF} = 37.0 Hz), 152.3, 136.1, 130.0, 129.0, 128.42, 128.41, 116.3 (q, ¹J_{CF} = 290.8 Hz), 57.8, 22.9, 10.9. ¹⁹F NMR (CDCl₃, 376.5 MHz): δ –75.0 (s, 3F). HRMS (ESI-TOF): *m/z* [M + H]⁺ Calcd for C₁₃H₁₃F₃N₃O⁺: 284.1005; found: 284.1007.

2,2,2-Trifluoro-1-(5-phenyl-1-propyl-1H-1,2,3-triazol-4-yl)ethanone (4g). this was obtained from **1a** as an admixture (92:8) in the synthesis of **3g**: yield 4.7 mg (7.4%). ¹H NMR (CDCl₃, 400.1 MHz): δ 7.60–7.52 (m, 3H), 7.36 (dd, 2H, ³J = 7.5 Hz, ⁴J = 1.6 Hz), 4.24 (t, 2H, ³J = 7.3 Hz), 1.92–1.82 (m, 2H), 0.87 (t, 3H, ³J = 7.4 Hz). ¹³C{¹H} NMR (CDCl₃, 100.6 MHz): δ 174.2 (q, ²J_{CF} = 37.1 Hz), 143.7, 137.9, 130.8, 129.3, 129.1, 128.4, 116.2 (q, ¹J_{CF} = 289.3 Hz), 50.0, 29.7, 23.3. ¹⁹F NMR (CDCl₃, 376.5 MHz): δ –75.3 (s, 3F).

2,2,2-Trifluoro-1-(2-pentyl-5-phenyl-2H-1,2,3-triazol-4-yl)ethanone (3h). This was obtained from **1a** (51.2 mg, 0.212 mmol) and bromopentane (35.6 mg, 0.236 mmol) and purified using gradient eluting by hexane-CH₂Cl₂ (3:1) followed by hexane-CH₂Cl₂ (1:1) and CH₂Cl₂. Total yield (**3h** + **4h**) was 58 mg (88 %), ratio **3h**:**4h** = 92:8. For pure **3h**, see the following: colorless oil, yield 53.4 mg (81%). ¹H NMR (CDCl₃, 400.1 MHz): δ 7.96–7.85 (m, 2H), 7.54–7.42 (m, 3H), 4.55 (t, 2H, ³J = 7.2 Hz), 2.13–2.01 (m, 2H), 1.46–1.30 (m, 4H), 0.96–0.88 (m, 3H). ¹³C{¹H} NMR (CDCl₃, 100.6 MHz): δ 174.3 (q, ²J_{CF} = 37.0 Hz), 152.3, 136.0, 130.0, 129.0, 128.4, 116.3 (q, ¹J_{CF} = 290.7 Hz), 56.2, 29.1, 28.4, 22.0, 13.8. ¹⁹F NMR (CDCl₃, 376.5 MHz): δ –75.0 (s, 3F). HRMS (ESI-TOF): *m/z* [M + H]⁺ Calcd for C₁₅H₁₇F₃N₃O⁺: 312.1318; found: 312.1322.

2,2,2-Trifluoro-1-(1-pentyl-5-phenyl-1H-1,2,3-triazol-4-yl)ethanone (4h). This was obtained from **1a** as an admixture (92:8) in the synthesis of **3h**: colorless oil, yield 4.6 mg (7%). ¹H NMR (CDCl₃, 400.1 MHz): δ 7.61–7.51 (m, 3H), 7.38–7.33 (m, 2H), 4.30–4.20 (m, 2H), 1.87–1.77 (m, 2H), 1.26–1.17 (m, 4H), 0.82 (t, 3H, ³J = 6.9 Hz). ¹³C{¹H} NMR (CDCl₃, 100.6 MHz): δ 130.8, 129.3, 129.1, 124.8, 48.5, 29.6, 28.4, 21.9, 13.7. ¹⁹F NMR (CDCl₃, 376.5 MHz): δ –75.3 (s, 3F). NMR data are in agreement with those in the literature [38].

2,2,2-Trifluoro-1-(2-nonyl-5-phenyl-2H-1,2,3-triazol-4-yl)ethanone (3i). This was obtained from **1a** (53.9 mg, 0.224 mmol) and bromononan (51.3 mg, 0.248 mmol) and purified using gradient eluting by hexane-CH₂Cl₂ (3:1) followed by hexane-CH₂Cl₂ (1:1) and CH₂Cl₂. Total yield (**3i** + **4i**) was 68.6 mg (83 %), ratio **3i**:**4i** = 93:7. For pure **3i**, see the following: colorless oil, yield 63.8 mg (77.2%). ¹H NMR (CDCl₃, 400.1 MHz): δ 7.94–7.85 (m, 2H), 7.50–7.43 (m, 3H), 4.55 (t, 2H, ³J = 7.2 Hz), 2.06 (p, 2H, ³J = 7.3 Hz), 1.44–1.21 (m, 12H), 0.91–0.83 (m, 3H). ¹³C{¹H} NMR (CDCl₃, 100.6 MHz): δ 174.3 (q, ²J_{CF} = 37.0 Hz), 152.3, 136.0, 130.0, 129.0, 128.42, 128.40, 116.3 (q, ¹J_{CF} = 290.7 Hz), 56.3, 31.8, 29.4, 29.3, 29.12, 28.9, 26.32, 22.61, 14.05. ¹⁹F NMR (CDCl₃, 376.5 MHz): δ –75.0 (s, 3F). HRMS (ESI-TOF): *m/z* [M + H]⁺ Calcd for C₁₉H₂₅F₃N₃O⁺: 368.1944; found: 368.1950.

2,2,2-Trifluoro-1-(1-nonyl-5-phenyl-1H-1,2,3-triazol-4-yl)ethanone (4i). This was obtained from **1a** as an admixture (93:7) in the synthesis of **3i**: Colorless oil, yield 4.8 mg (5.8%). ¹H NMR (CDCl₃, 400.1 MHz): δ 7.62–7.50 (m, 3H), 7.39–7.30 (m, 2H), 4.32–4.20 (m, 2H), 1.81 (p, 2H, ³J = 7.3 Hz), 1.32–1.13 (m, 12H), 0.86 (t, 3H, ³J = 7.0 Hz). ¹³C{¹H} NMR (CDCl₃, 100.6 MHz): δ 130.8, 129.3, 129.1, 124.8, 48.5, 31.7, 29.9, 29.2, 29.08, 28.7, 26.27, 22.59, 14.06. ¹⁹F NMR (CDCl₃, 376.5 MHz): δ –75.3 (s, 3F).

2,2,2-Trifluoro-1-(2-phenethyl-5-phenyl-2H-1,2,3-triazol-4-yl)ethanone (3j). This was obtained from **1a** (52.9 mg, 0.220 mmol) and (2-bromoethyl)benzene (44.8 mg, 0.242 mmol) and purified using gradient eluting by hexane-CH₂Cl₂ (3:1) followed by hexane-CH₂Cl₂ (1:1) and CH₂Cl₂. Total yield (**3j** + **4j**) was 64.8 mg (85%), ratio **3j:4j** = 93:7. For pure **3j**, see the following: colorless oil, yield 60.3 mg (79%). ¹H NMR (CDCl₃, 400.1 MHz): δ 7.92–7.84 (m, 2H), 7.51–7.45 (m, 3H), 7.34–7.19 (m, 5H), 4.84–4.76 (m, 2H), 3.43–3.36 (m, 2H). ¹³C{¹H} NMR (CDCl₃, 100.6 MHz): δ 174.2 (q, ²J_{CF} = 37.2 Hz), 152.3, 136.5, 136.1, 130.1, 129.0, 128.8, 128.7, 128.4, 128.3, 127.1, 116.2 (q, ¹J_{CF} = 290.7 Hz), 57.2, 35.6. ¹⁹F NMR (CDCl₃, 376.5 MHz): δ –75.0 (s, 3F). HRMS (ESI-TOF): *m/z* [M + H₃O]⁺ Calcd for C₁₈H₁₇F₃N₃O₂⁺: 346.1267; found: 346.1270.

2,2,2-Trifluoro-1-(1-phenethyl-5-phenyl-1H-1,2,3-triazol-4-yl)ethanone (4j). This was obtained from **1a** as an admixture (93:7) in the synthesis of **3j**: colorless oil, yield 4.5 mg (6%). ¹H NMR (CDCl₃, 400.1 MHz): δ 7.53–7.48 (m, 1H), 7.44–7.39 (m, 2H), 7.23–7.17 (m, 3H), 6.96–6.90 (m, 2H), 6.90–6.83 (m, 2H), 4.46 (t, 2H, ³J = 7.1 Hz), 3.19 (t, 2H, ³J = 7.1 Hz). ¹⁹F NMR (CDCl₃, 376.5 MHz): δ –75.4 (s, 3F). NMR data are in agreement with those in the literature [38].

2,2,2-Trifluoro-1-(2-isobutyl-5-phenyl-2H-1,2,3-triazol-4-yl)ethanone (3k). This was obtained from **1a** (48.5 mg, 0.201 mmol) and 1-chloro-2-methylpropane (27.8 mg, 0.300 mmol) by heating for 14 h at 100 °C and purified using gradient eluting by hexane-CH₂Cl₂ (3:1) followed by hexane-CH₂Cl₂ (1:1) and CH₂Cl₂. Total yield (**3k** + **4k**) was 50 mg (84%), ratio **3k:4k** = 91:9. For pure **3k**, see the following: colorless oil, yield 45.5 mg (76.2%). ¹H NMR (CDCl₃, 400.1 MHz): δ 7.95–7.82 (m, 2H), 7.53–7.42 (m, 3H), 4.37 (q, 2H, ³J = 7.3 Hz), 2.45 (hept, 1H, ³J = 6.9 Hz), 1.01 (s, 3H), 1.00 (s, 3H). ¹³C{¹H} NMR (CDCl₃, 100.6 MHz): δ 174.3 (q, ²J_{CF} = 36.7 Hz), 152.2, 136.0, 130.0, 129.0, 128.41, 128.39, 116.3 (q, ¹J_{CF} = 290.7 Hz), 63.2, 29.4, 19.7. ¹⁹F NMR (CDCl₃, 376.5 MHz): δ –75.0 (s, 3F). HRMS (ESI-TOF): *m/z* [M + H]⁺ Calcd for C₁₄H₁₅F₃N₃O⁺: 298.1163; found: 298.1163.

2,2,2-Trifluoro-1-(1-isobutyl-5-phenyl-1H-1,2,3-triazol-4-yl)ethanone (4k). This was obtained from **1a** as an admixture (91:9) in the synthesis of **3k**: colorless oil, yield 4.5 mg (7.5%). ¹H NMR (CDCl₃, 400.1 MHz): δ 7.61–7.52 (m, 3H), 7.39–7.36 (m, 2H), 4.33 (q, 2H, ³J = 7.3 Hz), 1.48 (t, 3H, ³J = 7.3 Hz). ¹⁹F NMR (CDCl₃, 376.5 MHz): δ –75.3 (s, 3F).

2,2,2-Trifluoro-1-(2-isopropyl-5-phenyl-2H-1,2,3-triazol-4-yl)ethanone (3l). This was obtained from **1a** (49.8 mg, 0.207 mmol) and 1-bromo-2-methylpropane (29 mg, 0.238 mmol) by heating for 8 h at 80 °C and purified using gradient eluting by hexane-CH₂Cl₂ (3:1) followed by hexane-CH₂Cl₂ (1:1) and CH₂Cl₂. Total yield (**3l** + **4l**) was 46 mg (79%), ratio **3l:4l** = 94:6. For pure **3l**, see the following: colorless oil, yield 43.2 mg (74.3%). ¹H NMR (CDCl₃, 400.1 MHz): δ 7.95–7.87 (m, 2H), 7.50–7.44 (m, 3H), 4.97 (hept, 1H, ³J = 6.7 Hz), 1.69 (s, 3H), 1.68 (s, 3H). ¹³C{¹H} NMR (CDCl₃, 100.6 MHz): δ 174.4 (q, ²J_{CF} = 36.9 Hz), 152.0, 135.7, 130.0, 129.0, 128.6, 128.4, 116.3 (q, ¹J_{CF} = 290.9 Hz), 59.0, 22.1. ¹⁹F NMR (CDCl₃, 376.5 MHz): δ –75.0 (s, 3F). HRMS (ESI-TOF): *m/z* [M + H]⁺ Calcd for C₁₃H₁₃F₃N₃O⁺: 284.1005; found: 284.1007.

2,2,2-Trifluoro-1-(1-isopropyl-5-phenyl-1H-1,2,3-triazol-4-yl)ethanone (4l). This was obtained from **1a** as an admixture (94:6) in the synthesis of **3l**: colorless oil, yield 2.8 mg (4.7%). ¹H NMR (CDCl₃, 400.1 MHz): δ 7.60–7.52 (m, 3H), 7.36–7.31 (m, 2H), 4.54 (hept, 1H, ³J = 6.7 Hz), 1.61 (s, 3H), 1.59 (s, 3H). ¹⁹F NMR (CDCl₃, 376.5 MHz): δ –75.3 (s, 3F).

1-(2-Cyclohexyl-5-phenyl-2H-1,2,3-triazol-4-yl)-2,2,2-trifluoroethanone (3m). This was obtained from **1a** (48 mg, 0.199 mmol) and bromocyclohexane (36 mg, 0.221 mmol) by heating for 14 h at 100 °C and purified using gradient eluting by hexane-CH₂Cl₂ (3:1) followed by hexane-CH₂Cl₂ (1:1) and CH₂Cl₂. Total yield (**3m** + **4m**) was 45.1 mg (70%), ratio **3m:4m** = 93:7. For pure **3m**, see the following: white solid, m.p. 53–54 °C, yield 41.9 mg (65.1%). ¹H NMR (CDCl₃, 400.1 MHz): δ 7.97–7.82 (m, 2H), 7.52–7.40 (m, 3H), 4.68–4.50 (m, 1H), 2.34–2.23 (m, 2H), 2.06–1.90 (m, 4H), 1.80–1.72 (m, 1H), 1.54–1.28 (m, 3H). ¹³C{¹H} NMR (CDCl₃, 100.6 MHz): δ 174.5 (q, ²J_{CF} = 36.8 Hz), 151.9, 135.7, 129.9, 129.0, 128.7, 128.4,

116.5 (q, $^1J_{CF} = 290.9$ Hz), 65.6, 32.4, 25.0, 24.8. ^{19}F NMR (CDCl₃, 376.5 MHz): δ -74.9 (s, 3F). HRMS (ESI-TOF): m/z [M + H]⁺ Calcd for C₁₆H₁₇F₃N₃O⁺: 324.1318; found: 324.1318.

1-(1-Cyclohexyl-5-phenyl-1H-1,2,3-triazol-4-yl)2,2,2-trifluoroethanone (4m). This was obtained from **1a** as an admixture (93:7) in the synthesis of **3m**: yield 3.2 mg (4.9%). 1H NMR (CDCl₃, 400.1 MHz): δ 7.82–7.68 (m, 2H), 7.48–7.32 (m, 3H), 5.06–4.96 (m, 1H), 2.34–2.17 (m, 2H), 2.06–1.90 (m, 4H), 1.80–1.72 (m, 1H), 1.54–1.28 (m, 3H). ^{19}F NMR (CDCl₃, 376.5 MHz): δ -75.3 (s, 3F).

1,1'-(2,2'-(Butane-1,4-diyl)bis(5-phenyl-2H-1,2,3-triazole-4,2-diyl))bis(2,2,2-trifluoroethanone) (3n). This was obtained from **1a** (74.1 mg, 0.307 mmol) and 1,4-dibromobutane (32.4 mg, 0.150 mmol) and purified using gradient eluting by hexane-CH₂Cl₂ (3:1) followed by hexane-CH₂Cl₂ (1:1) and CH₂Cl₂. Total yield (**3n** + **4n**) was 55 mg (67%), ratio **3n**:**4n** = 83:17. For pure **3n**, see the following: colorless oil, yield 45.7 mg (55.6%). 1H NMR (CDCl₃, 400.1 MHz): δ 7.95–7.76 (m, 4H), 7.53–7.40 (m, 6H), 4.72–4.60 (m, 4H), 2.27–2.13 (m, 4H). $^{13}C\{^1H\}$ NMR (CDCl₃, 100.6 MHz): δ 174.2 (q, $^2J_{CF} = 37.0$ Hz), 152.5, 136.3, 130.2, 129.0, 128.5, 128.1, 116.2 (q, $^1J_{CF} = 290.8$ Hz), 55.0, 26.1. ^{19}F NMR (CDCl₃, 376.5 MHz): δ -75.0 (s, 6F). HRMS (ESI-TOF): m/z [M + H]⁺ Calcd for C₂₄H₁₉F₆N₆O₂⁺: 537.1468; found: 537.1467.

2,2,2-Trifluoro-1-(5-phenyl-1-(4-(4-phenyl-5-(2,2,2-trifluoroacetyl)-2H-1,2,3-triazol-2-yl)butyl)-1H-1,2,3-triazol-4-yl)ethanone (4n). This was obtained from **1a** as an admixture (83:17) in the synthesis of **3n**: colorless oil, yield 9.4 mg (11.4%). 1H NMR (CDCl₃, 400.1 MHz): δ 7.89–7.83 (m, 2H), 7.55–7.44 (m, 6H), 7.32 (dd, 2H, $^3J = 7.9$ Hz, $^4J = 1.4$ Hz), 4.53 (t, 2H, $^3J = 6.6$ Hz), 4.36 (t, 2H, $^3J = 6.9$ Hz), 2.09–2.01 (m, 2H), 1.99–1.86 (m, 2H). $^{13}C\{^1H\}$ NMR (CDCl₃, 100.6 MHz): δ 174.2 (q, $^2J_{CF} = 37.5$ Hz), 174.1 (q, $^2J_{CF} = 37.7$ Hz), 152.5, 143.7, 138.0, 136.3, 131.0, 130.3, 129.19, 129.16, 129.0, 128.5, 128.3, 128.0, 116.1 (q, $^1J_{CF} = 289.8$ Hz), 116.1 (q, $^1J_{CF} = 291.0$ Hz), 54.9, 47.5, 26.5, 26.0. ^{19}F NMR (CDCl₃, 376.5 MHz): δ -75.0 (s, 3F), -75.4 (s, 3F).

Ethyl 2-(4-phenyl-5-(2,2,2-trifluoroacetyl)-2H-1,2,3-triazol-2-yl)acetate (3o). This was obtained from **1a** (52.9 mg, 0.219 mmol) and ethyl 2-bromoacetate (40.7 mg, 0.0244 mmol) and purified using gradient eluting by hexane-CH₂Cl₂ (3:1) followed by hexane-CH₂Cl₂ (1:1) and CH₂Cl₂. Total yield (**3o** + **4o**) was 57 mg (80%), ratio **3o**:**4o** = 90:10. For pure **3o**, see the following: Beige solid, m.p. 58–60 °C, yield 51.3 mg (72%). 1H NMR (CDCl₃, 400.1 MHz): δ 7.93–7.84 (m, 2H), 7.50–7.44 (m, 3H), 5.34 (s, 2H), 4.29 (q, 2H, $^3J = 7.1$ Hz), 1.30 (t, 3H, $^3J = 7.1$ Hz). $^{13}C\{^1H\}$ NMR (CDCl₃, 100.6 MHz): δ 174.2 (q, $^2J_{CF} = 37.4$ Hz), 165.3, 152.9, 137.1, 130.2, 129.1, 128.4, 127.9, 116.1 (q, $^1J_{CF} = 290.8$ Hz), 62.6, 56.5, 14.0. ^{19}F NMR (CDCl₃, 376.5 MHz): δ -75.1 (s, 3F). HRMS (ESI-TOF): m/z [M + H]⁺ Calcd for C₁₄H₁₃F₃N₃O₃⁺: 328.0904; found: 328.0908.

Ethyl 2-(5-phenyl-4-(2,2,2-trifluoroacetyl)-1H-1,2,3-triazol-1-yl)acetate (4o). This was obtained from **1a** as an admixture (90:10) in the synthesis of **3o**: colorless oil, yield 5.7 mg (8%). 1H NMR (CDCl₃, 400.1 MHz): δ 7.56–7.52 (m, 2H), 7.38–7.36 (m, 2H), 5.04 (s, 2H), 4.21 (q, 2H, $^3J = 7.1$ Hz), 1.23 (t, 3H, $^3J = 7.1$ Hz). $^{13}C\{^1H\}$ NMR (CDCl₃, 100.6 MHz): δ 131.1, 129.2, 62.7, 49.1. ^{19}F NMR (CDCl₃, 376.5 MHz): δ -75.3 (s, 3F). NMR data are in agreement with those in the literature [38].

***N,N*-Dimethyl-2-(4-phenyl-5-(2,2,2-trifluoroacetyl)-2H-1,2,3-triazol-2-yl)acetamide (3p)**. This was obtained from **1a** (47.6 mg, 0.198 mmol) and 2-chloro-*N,N*-dimethylacetamide (26.7 mg, 0.220 mmol) and purified using gradient eluting by hexane-CH₂Cl₂ (3:1) followed by hexane-CH₂Cl₂ (1:1) and CH₂Cl₂. Total yield (**3p** + **4p**) was 52 mg (81%), ratio **3p**:**4p** = 89:11. For the mixture of **3p** and **4p**, see the following: light yellow solid, m.p. 126–128 °C. For **3p**: 1H NMR (CDCl₃, 400.1 MHz): δ 7.92–7.84 (m, 2H), 7.47–7.41 (m, 3H), 5.43 (s, 2H), 3.08 (s, 3H), 3.00 (s, 3H). $^{13}C\{^1H\}$ NMR (CDCl₃, 100.6 MHz): δ 174.2 (q, $^2J_{CF} = 37.2$ Hz), 163.9, 152.8, 136.9, 130.1, 129.2, 128.3, 128.1, 116.2 (q, $^1J_{CF} = 291.0$ Hz), 56.9, 36.4, 35.9. ^{19}F NMR (CDCl₃, 376.5 MHz): δ -74.9 (s, 3F). 1H NMR (CD₃CN, 400.1 MHz): δ 7.88–7.80 (m, 2H), 7.56–7.46 (m, 3H), 5.54 (s, 2H), 3.03 (s, 3H), 3.00 (s, 3H). $^{13}C\{^1H\}$ NMR (CD₃CN, 100.6 MHz): δ 174.8 (q, $^2J_{CF} = 36.5$ Hz), 165.8, 153.2, 137.6, 131.0, 130.0, 129.4,

129.4, 117.2 (q, $^1J_{CF} = 290.2$ Hz), 58.0, 38.4, 35.9. ^{19}F NMR (CD_3CN , 376.5 MHz): δ -73.0 (s, 3F). HRMS (ESI-TOF): m/z $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{14}\text{H}_{14}\text{F}_3\text{N}_4\text{O}_2^+$: 327.1063; found: 327.1070.

***N,N*-Dimethyl-2-(5-phenyl-4-(2,2,2-trifluoroacetyl)-1*H*-1,2,3-triazol-1-yl)acetamide (4p).**

This was obtained from **1a** as an admixture (89:11) in the synthesis of **3p**: ^1H NMR (CDCl_3 , 400.1 MHz): δ 7.55–7.47 (m, 3H), 5.08 (s, 2H), 2.97 (s, 3H), 2.95 (s, 3H). $^{13}\text{C}\{^1\text{H}\}$ NMR (CDCl_3 , 100.6 MHz): δ 130.9, 129.4, 128.9, 55.3. ^{19}F NMR (CDCl_3 , 376.5 MHz): δ -75.3 (s, 3F). ^1H NMR (CD_3CN , 400.1 MHz): δ 5.21 (s, 2H). $^{13}\text{C}\{^1\text{H}\}$ NMR (CD_3CN , 100.6 MHz): δ 131.8, 130.4, 129.7, 129.4, 117.2 (q, $^1J_{CF} = 290.2$ Hz), 38.8, 36.9, 36.3. ^{19}F NMR (CD_3CN , 376.5 MHz): δ -73.2 (s, 3F).

2,2,2-Trifluoro-1-(5-phenyl-2-tosyl-2*H*-1,2,3-triazol-4-yl)ethanone (3q). This was obtained from **1a** (60 mg, 0.249 mmol) and 4-toluenesulfonyl chloride (52 mg, 0.274 mmol) and purified using gradient eluting by hexane- CH_2Cl_2 (1:1) followed by CH_2Cl_2 : white crystals, m.p. 156–160 °C, yield 73 mg (74%). ^1H NMR (CDCl_3 , 400.1 MHz): δ 8.08 (d, 2H, $^3J = 8.4$ Hz), 7.83 (dd, 2H, $^3J = 7.9$ Hz, $^4J = 1.4$ Hz) 7.52–7.39 (m, 5H), 2.46 (s, 3H). $^{13}\text{C}\{^1\text{H}\}$ NMR (CDCl_3 , 100.6 MHz): δ 174.5 (q, $^2J_{CF} = 37.9$ Hz), 153.4, 148.1, 138.6, 131.6, 130.8, 130.6, 129.6, 129.3, 128.5, 126.9, 115.8 (q, $^1J_{CF} = 290.5$ Hz), 21.9. ^{19}F NMR (CDCl_3 , 376.5 MHz): δ -75.2 (s, 3F). HRMS (ESI-TOF): m/z $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{17}\text{H}_{13}\text{F}_3\text{N}_3\text{O}_3\text{S}^+$: 396.0324; found: 396.0626. IR (ν , cm^{-1}): 1731 (C=O).

2,2,2-Trifluoro-1-(2-(methylsulfonyl)-5-phenyl-2*H*-1,2,3-triazol-4-yl)ethanone (3r). This was obtained from **1a** (58.5 mg, 0.243 mmol) and methanesulfonyl chloride (30.5 mg, 0.267 mmol) and purified using gradient eluting by hexane- CH_2Cl_2 (3:1) followed by hexane- CH_2Cl_2 (1:1) and CH_2Cl_2 : pale yellow solid, m.p. 99–100 °C, yield 62 mg (80%). ^1H NMR (CDCl_3 , 400.1 MHz): δ 7.93–7.82 (m, 2H), 7.56–7.46 (m, 3H), 3.62 (s, 3H). $^{13}\text{C}\{^1\text{H}\}$ NMR (CDCl_3 , 100.6 MHz): δ 174.4 (q, $^2J_{CF} = 38.6$ Hz), 153.6, 138.6, 131.1, 129.3, 128.7, 126.6, 115.8 (q, $^1J_{CF} = 290.4$ Hz), 41.7. ^{19}F NMR (CDCl_3 , 376.5 MHz): δ -75.2 (s, 3F). HRMS (ESI-TOF): m/z $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{11}\text{H}_9\text{F}_3\text{N}_3\text{O}_3\text{S}^+$: 320.0313; found: 320.0315.

Synthesis of 2-aryltriazoles (5–11) by the reaction of triazoles (1) with aryl halogenides (general procedure). A 4 mL vial with a screw cap was charged with corresponding triazole **1** (0.5 mmol), DMF (1 mL), Na_2CO_3 (80 mg, 0.38 mmol, 1.5 equiv.) and corresponding aryl halogenide (0.55 mmol, 1.1 equiv.). The reaction mixture was stirred at room temperature for 1 day (for **5**) or heated at 90–100 °C for 6–8 h until full consumption of the starting material (^{19}F NMR control) occurred. The reaction mixture was broken by 0.1 M HCl (20 mL). The product was extracted by CH_2Cl_2 (3×10 mL); the organic phase was washed with water (2×10 mL), brine (10 mL) and dried over Na_2SO_4 . Volatiles were evaporated in vacuo; the residue formed was purified by column chromatography on silica gel using gradient elution by hexane- CH_2Cl_2 mixture (3:1) followed by hexane- CH_2Cl_2 mixture (1:1). Evaporation of the solvents afforded corresponding pure triazole **5–11**.

1-(2-(2,4-Dinitrophenyl)-5-phenyl-2*H*-1,2,3-triazol-4-yl)-2,2,2-trifluoroethanone (5). This was obtained from **1a** (57 mg, 0.237 mmol) and 1-fluoro-2,4-dinitrobenzene (49 mg, 0.263 mmol) and purified using gradient eluting by hexane- CH_2Cl_2 (3:1) followed by hexane- CH_2Cl_2 (1:1): pale yellow powder, m.p. 132–134 °C, yield 79 mg (82%). ^1H NMR (CDCl_3 , 400.1 MHz): δ 8.67 (d, 1H, $^4J = 2.4$ Hz), 8.56 (dd, 1H, $^3J = 8.9$ Hz, $^4J = 2.4$ Hz), 8.31 (d, 1H, $^3J = 8.9$ Hz), 7.83 (dd, 2H, $^3J = 7.7$ Hz, $^4J = 1.7$ Hz), 7.49–7.40 (m, 3H). $^{13}\text{C}\{^1\text{H}\}$ NMR (CDCl_3 , 100.6 MHz): δ 173.7 (q, $^2J_{CF} = 38.2$ Hz), 153.8, 147.1, 142.8, 138.7, 134.1, 130.8, 129.0, 128.4, 127.4, 126.4, 120.7, 115.6 (q, $^1J_{CF} = 290.5$ Hz). ^{19}F NMR (CDCl_3 , 376.5 MHz): δ -75.0 (s, 3F). HRMS (ESI-TOF): m/z $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{16}\text{H}_9\text{F}_3\text{N}_5\text{O}_5^+$: 408.0550; found: 408.0549. IR (ν , cm^{-1}): 1738 (C=O); 1545, 1540, 1349, 1335 (NO_2).

2,2,2-Trifluoro-1-(2-(4-nitrophenyl)-5-phenyl-2*H*-1,2,3-triazol-4-yl)ethanone (6). This was obtained from **1a** (60 mg, 0.249 mmol) and 1-fluoro-4-nitrobenzene (44 mg, 0.312 mmol) and purified using gradient eluting by hexane- CH_2Cl_2 (3:1) followed by hexane- CH_2Cl_2 (1:1): yellow solid, m.p. 166–168 °C, yield 59.1 mg (66%). ^1H NMR (CDCl_3 , 400.1 MHz): δ 8.47–8.37 (m, 4H), 8.04–7.91 (m, 2H), 7.58–7.49 (m, 3H). $^{13}\text{C}\{^1\text{H}\}$ NMR (CDCl_3 , 100.6 MHz):

δ 174.3 (q, $^2J_{CF} = 37.8$ Hz), 153.7, 147.7, 142.5, 138.3, 130.8, 129.2, 128.6, 127.3, 125.3, 120.2, 116.1 (q, $^1J_{CF} = 290.4$ Hz). ^{19}F NMR (CDCl_3 , 376.5 MHz): δ -60.5 (s, 3F), -75.0 (s, 3F). HRMS (ESI-TOF): m/z $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{16}\text{H}_{10}\text{F}_3\text{N}_4\text{O}_3^+$: 363.0700; found: 363.0704.

2,2,2-Trifluoro-1-(2-(4-nitro-2-(trifluoromethyl)phenyl)-5-phenyl-2H-1,2,3-triazol-4-yl)ethanone (7). This was obtained from **1a** (48.7 mg, 0.202 mmol) and 1-chloro-4-nitro-2-(trifluoromethyl)benzene (50.9 mg, 0.226 mmol) and purified using gradient eluting by hexane- CH_2Cl_2 (3:1) followed by hexane- CH_2Cl_2 (1:1): light yellow solid, m.p. 109–111 °C, yield 46 mg (53%). ^1H NMR (CDCl_3 , 400.1 MHz): δ 8.81 (d, 1H, $^4J = 2.4$ Hz), 8.62 (dd, 1H, $^3J = 8.8$ Hz, $^4J = 2.5$ Hz), 8.22 (d, 1H, $^3J = 8.8$ Hz), 8.02–7.94 (m, 2H), 7.56–7.49 (m, 3H). $^{13}\text{C}\{^1\text{H}\}$ NMR (CDCl_3 , 100.6 MHz): δ 174.3 (q, $^2J_{CF} = 38.3$ Hz), 153.7, 147.7, 140.8, 138.8, 130.9, 129.2, 128.7, 128.3, 127.9, 127.0, 126.2 (q, $^2J_{CF} = 35.1$ Hz), 124.2 (q, $^3J_{CF} = 5.3$ Hz), 121.5 (q, $^1J_{CF} = 274.4$ Hz), 116.0 (q, $^1J_{CF} = 290.4$ Hz). ^{19}F NMR (CDCl_3 , 376.5 MHz): δ -60.5 (s, 3F), -75.3 (s, 3F). HRMS (ESI-TOF): m/z $[\text{M} + \text{H}_3\text{O}]^+$ Calcd for $\text{C}_{17}\text{H}_{10}\text{F}_6\text{N}_4\text{O}_4^+$: 449.0679; found: 449.0675.

2,2,2-Trifluoro-1-(2-(2-nitro-4-(trifluoromethyl)phenyl)-5-phenyl-2H-1,2,3-triazol-4-yl)ethanone (8). This was obtained from **1a** (51 mg, 0.216 mmol) and 1-chloro-2-nitro-4-(trifluoromethyl)benzene (54 mg, 0.24 mmol) and purified using gradient eluting by hexane- CH_2Cl_2 (3:1) followed by hexane- CH_2Cl_2 (1:1): pale yellow oil, yield 57 mg (62%). ^1H NMR (CDCl_3 , 400.1 MHz): δ 8.27 (d, 1H, $^3J = 8.5$ Hz), 8.19 (*pseudo*-d, 1H, $^4J = 1.1$ Hz), 8.05 (dd, 1H, $^3J = 8.5$ Hz, $^4J = 4.1$ Hz), 7.97–7.88 (m, 2H), 7.57–7.46 (m, 3H). $^{13}\text{C}\{^1\text{H}\}$ NMR (CDCl_3 , 100.6 MHz): δ 174.1 (q, $^2J_{CF} = 38.0$ Hz), 153.9, 143.4, 138.8, 133.3, 132.7 (q, $^2J_{CF} = 35.0$ Hz), 131.0, 129.9 (q, $^3J_{CF} = 3.5$ Hz), 129.3, 128.7, 126.9, 126.1, 122.8 (q, $^3J_{CF} = 3.6$ Hz), 122.2 (q, $^1J_{CF} = 273.3$ Hz), 116.0 (q, $^1J_{CF} = 290.7$ Hz). ^{19}F NMR (CDCl_3 , 376.5 MHz): δ -64.1 (s, 3F), -75.2 (s, 3F). HRMS (ESI-TOF): m/z $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{17}\text{H}_9\text{F}_6\text{N}_4\text{O}_3^+$: 431.0573; found: 431.0576.

2,2,2-Trifluoro-1-(2-(8-nitroquinolin-5-yl)-5-phenyl-2H-1,2,3-triazol-4-yl)ethanone (9). This was obtained from **1a** (53.8 mg, 0.223 mmol) and 5-chloro-8-nitroquinoline (66 mg, 0.317 mmol) and purified using gradient eluting by hexane- CH_2Cl_2 (3:1) followed by hexane- CH_2Cl_2 (1:1): yellow powder, m.p. 114–116 °C, yield 36 mg (39%). ^1H NMR (CDCl_3 , 400.1 MHz): δ 9.09 (dd, 1H, $^3J = 4.1$ Hz, $^4J = 1.6$ Hz), 9.04 (dd, 1H, $^3J = 8.9$ Hz, $^4J = 1.6$ Hz), 8.49 (d, 1H, $^3J = 8.3$ Hz), 8.20 (d, 1H, $^3J = 8.3$ Hz), 8.03–7.95 (m, 2H), 7.76 (dd, 1H, $^3J = 8.9$ Hz, $^4J = 4.1$ Hz), 7.53–7.47 (m, 3H). $^{13}\text{C}\{^1\text{H}\}$ NMR (CDCl_3 , 100.6 MHz): δ 174.5 (q, $^2J_{CF} = 37.5$ Hz), 153.3, 152.8, 146.5, 142.5, 140.9, 138.3, 132.0, 130.4, 129.3, 128.5, 127.7, 125.5, 125.0, 123.6, 122.3, 121.2, 116.2 (q, $^1J_{CF} = 290.6$ Hz). ^{19}F NMR (CDCl_3 , 376.5 MHz): δ -75.0 (s, 3F). HRMS (ESI-TOF): m/z $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{19}\text{H}_{11}\text{F}_3\text{N}_5\text{O}_3^+$: 414.0809; found: 414.0809.

Ethyl 2,3,5,6-tetrafluoro-4-(4-phenyl-5-(2,2,2-trifluoroacetyl)-2H-1,2,3-triazol-2-yl)benzoate (10). This was obtained from **1a** (58.5 mg, 0.243 mmol) and ethyl 2,3,4,5,6-pentafluorobenzoate (64 mg, 0.267 mmol) and purified using gradient eluting by hexane- CH_2Cl_2 (3:1) followed by hexane- CH_2Cl_2 (1:1): pale yellow solid, m.p. 72–75 °C, yield 79.5 mg (71%). ^1H NMR (CDCl_3 , 400.1 MHz): δ 7.98–7.85 (m, 2H), 7.57–7.47 (m, 3H), 4.51 (q, 2H, $^3J = 7.2$ Hz), 1.43 (t, 3H, $^3J = 7.2$ Hz). $^{13}\text{C}\{^1\text{H}\}$ NMR (CDCl_3 , 100.6 MHz): δ 174.2 (q, $^2J_{CF} = 38.2$ Hz), 158.4, 153.7, 145.1 (ddt, $^2J_{CF} = 255.2$ Hz, $^3J_{CF} = 13.1$ Hz, $^4J_{CF} = 5.4$ Hz), 142.2 (ddd, $^2J_{CF} = 255.2$ Hz, $^3J_{CF} = 15.6$ Hz, $^4J_{CF} = 4.4$ Hz), 138.9, 130.8, 129.3, 128.6, 126.9, 120.9 (tt, $^3J_{CF} = 12.7$ Hz, $^4J_{CF} = 2.7$ Hz), 116.0 (q, $^1J_{CF} = 290.6$ Hz), 115.2 (t, $^3J_{CF} = 16.9$ Hz), 63.4, 14.0. ^{19}F NMR (CDCl_3 , 376.5 MHz): δ -75.2 (s, 3F), -138.13 – -138.23 (m, 2F), -145.58 – -145.74 (m, 2F). HRMS (ESI-TOF): m/z $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{19}\text{H}_{11}\text{F}_7\text{N}_3\text{O}_3^+$: 462.0683; found: 462.0681.

2,2,2-Trifluoro-1-(5-(4-methoxyphenyl)-2-(4-nitrophenyl)-2H-1,2,3-triazol-4-yl)ethanone (11). This was obtained from **1b** (52 mg, 0.192 mmol) and 1-fluoro-4-nitrobenzene (30 mg, 0.213 mmol) and purified using gradient eluting by hexane- CH_2Cl_2 (3:1) followed by hexane- CH_2Cl_2 (1:1): white solid, m.p. 55–57 °C, yield 47.7 mg (63%). ^1H NMR (CDCl_3 , 400.1 MHz): δ 8.50–8.34 (m, 4H), 7.99 (d, 2H, $^3J = 8.8$ Hz), 7.02 (d, 2H, $^3J = 8.8$ Hz), 3.88 (s, 3H). $^{13}\text{C}\{^1\text{H}\}$ NMR (CDCl_3 , 100.6 MHz): δ 174.4 (q, $^2J_{CF} = 37.4$ Hz), 161.7, 153.6, 147.7, 142.6,

138.1, 130.8, 125.3, 120.2, 119.7, 116.2 (q, $^1J_{CF} = 290.7$ Hz), 114.1, 55.4. ^{19}F NMR (CDCl_3 , 376.5 MHz): $\delta -74.8$ (s, 3F). HRMS (ESI-TOF): m/z $[\text{M} + \text{H}]^-$ Calcd for $\text{C}_{17}\text{H}_{12}\text{F}_3\text{N}_4\text{O}_4^-$: 393.0816; found: 393.0822.

Synthesis of 2-aryltriazoles (12–20) by the reaction of triazoles (1) with boronic acids (general procedure).

A 30 mL vial was charged with corresponding triazole (1) (0.25 mmol), DMSO (1.5 mL), corresponding boronic acid (0.385 mmol, 1.5 equiv.) and $\text{Cu}(\text{OAc})_2 \cdot \text{H}_2\text{O}$ (5.1 mg, 0.257 mmol, 0.1 equiv.). The reaction mixture was heated at 90–100 °C for 8–10 h at open air using a magnetic stirrer with heating. The reaction mixture was poured into 0.1 M HCl (20 mL) and extracted with CH_2Cl_2 (3×20 mL). The combined organic phase was washed with water (3×20 mL), dried over Na_2SO_4 , and then volatiles were evaporated in vacuo. The residue was purified by column chromatography on silica gel using gradient eluting by hexane- CH_2Cl_2 (3:1) followed by hexane- CH_2Cl_2 (1:1) as eluents.

1-(2,5-diPhenyl-2H-1,2,3-triazol-4-yl)-2,2,2-trifluoroethanone (12). This was obtained from triazole **1a** (400 mg, 1.660 mmol) and $\text{PhB}(\text{OH})_2$ (309 mg, 2.553 mmol): colorless crystals, m.p. 93–95 °C yield 367 mg (77%). ^1H NMR (CDCl_3 , 400.1 MHz): δ 8.28–8.18 (m, 2H), 8.03–7.95 (m, 2H), 7.59–7.46 (m, 6H). $^{13}\text{C}\{^1\text{H}\}$ NMR (CDCl_3 , 100.6 MHz): δ 174.4 (q, $^2J_{CF} = 37.5$ Hz), 152.9, 138.8, 137.1, 130.4, 129.6, 129.4, 129.2, 128.5, 128.1, 119.7, 116.3 (q, $^1J_{CF} = 290.9$ Hz). ^{19}F NMR (CDCl_3 , 376.5 MHz): $\delta -74.9$ (s, 3F). HRMS (ESI-TOF): m/z $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{16}\text{H}_{11}\text{F}_3\text{N}_3\text{O}^+$: 318.0849; found: 318.0851. IR (ν , cm^{-1}): 1716 (C=O).

2,2,2-Trifluoro-1-(5-(4-methoxyphenyl)-2-phenyl-2H-1,2,3-triazol-4-yl)-ethanone (13). This was obtained from triazole **1b** (77 mg, 0.284 mmol) and $\text{PhB}(\text{OH})_2$ (57 mg, 0.471 mmol): beige solid, m.p. 124–126 °C, yield 63 mg (64%). ^1H NMR (CDCl_3 , 400.1 MHz): δ 8.28–8.15 (m, 2H), 8.02 (d, 2H, $^3J = 9.0$ Hz), 7.58–7.51 (m, 2H), 7.49–7.43 (m, 1H), 7.02 (d, 2H, $^3J = 8.9$ Hz), 3.87 (s, 3H). $^{13}\text{C}\{^1\text{H}\}$ NMR (CDCl_3 , 100.6 MHz): δ 174.4 (q, $^2J_{CF} = 37.1$ Hz), 161.3, 152.8, 138.8, 136.8, 130.7, 129.5, 129.3, 120.4, 119.7, 116.4 (q, $^1J_{CF} = 290.9$ Hz), 55.3. ^{19}F NMR (CDCl_3 , 376.5 MHz): $\delta -74.7$ (s, 3F). HRMS (ESI-TOF): m/z $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{17}\text{H}_{13}\text{F}_3\text{N}_3\text{O}_2^+$: 348.0954; found: 348.0956.

2,2,2-Trifluoro-1-(2-phenyl-5-(*p*-tolyl)-2H-1,2,3-triazol-4-yl)-ethanone (14). This was obtained from triazole **1c** (95 mg, 0.373 mmol) and $\text{PhB}(\text{OH})_2$ (68 mg, 0.562 mmol): white solid, m.p. 124–126 °C, yield 109 mg (88%). ^1H NMR (CDCl_3 , 400.1 MHz): δ 8.22 (d, 2H, $^3J = 7.6$ Hz), 7.93 (d, 2H, $^3J = 8.2$ Hz), 7.55 (t, 2H, $^3J = 7.7$ Hz), 7.47 (t, 1H, $^3J = 7.3$ Hz), 7.32 (d, 2H, $^3J = 8.0$ Hz), 2.44 (s, 3H). $^{13}\text{C}\{^1\text{H}\}$ NMR (CDCl_3 , 100.6 MHz): δ 174.4 (q, $^2J_{CF} = 37.2$ Hz), 152.9, 140.6, 138.8, 137.0, 129.5, 129.3, 129.2, 129.1, 125.2, 119.6, 116.4 (q, $^1J_{CF} = 290.9$ Hz), 21.4. ^{19}F NMR (CDCl_3 , 376.5 MHz): $\delta -74.6$ (s, 3F). HRMS (ESI-TOF): m/z $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{17}\text{H}_{13}\text{F}_3\text{N}_3\text{O}^+$: 332.1005; found: 332.1007.

2,2,2-Trifluoro-1-(2-phenyl-5-(4-(trifluoromethyl)phenyl)-2H-1,2,3-triazol-4-yl)-ethanone (15). This was obtained from triazole **1d** (54 mg, 0.175 mmol) and $\text{PhB}(\text{OH})_2$ (31 mg, 0.256 mmol): white solid, m.p. 78–80 °C, yield 43 mg (64%). ^1H NMR (CDCl_3 , 400.1 MHz): δ 8.22 (d, 2H, $^3J = 7.8$ Hz), 8.14 (d, 2H, $^3J = 8.1$ Hz), 7.77 (t, 2H, $^3J = 8.1$ Hz), 7.61–7.46 (m, 3H). $^{13}\text{C}\{^1\text{H}\}$ NMR (CDCl_3 , 100.6 MHz): δ 174.5 (q, $^2J_{CF} = 37.8$ Hz), 151.4, 138.6, 137.3, 132.1 (q, $^2J_{CF} = 32.9$ Hz), 131.6, 129.72, 129.67, 129.6, 125.5 (q, $^4J_{CF} = 3.5$ Hz), 123.8 (q, $^1J_{CF} = 272.4$ Hz), 119.8, 116.2 (q, $^1J_{CF} = 290.6$ Hz). ^{19}F NMR (CDCl_3 , 376.5 MHz): $\delta -64.1$ (s, 3F), -74.6 (s, 3F). HRMS (ESI-TOF): m/z $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{17}\text{H}_{10}\text{F}_6\text{N}_3\text{O}^+$: 386.0723; found: 386.0737.

2,2,2-Trifluoro-1-(2-(4-methoxyphenyl)-5-phenyl-2H-1,2,3-triazol-4-yl)-ethanone (16). This was obtained from triazole **1a** (45 mg, 0.187 mmol) and (4-methoxyphenyl)boronic acid (51 mg, 0.338 mmol): white solid, m.p. 79–81 °C, yield 48 mg (74%). ^1H NMR (CDCl_3 , 400.1 MHz): δ 8.13 (d, 2H, $^3J = 9.2$ Hz), 8.03–7.96 (m, 2H), 7.53–7.47 (m, 3H), 7.03 (d, 2H, $^3J = 9.2$ Hz), 3.88 (s, 3H). $^{13}\text{C}\{^1\text{H}\}$ NMR (CDCl_3 , 100.6 MHz): δ 174.3 (q, $^2J_{CF} = 37.0$ Hz), 160.4, 152.8, 136.7, 132.4, 130.3, 129.2, 128.4, 128.2, 121.2, 116.4 (q, $^1J_{CF} = 290.6$ Hz), 114.6,

55.6. ^{19}F NMR (CDCl_3 , 376.5 MHz): δ -74.8 (s, 3F). HRMS (ESI-TOF): m/z $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{17}\text{H}_{13}\text{F}_3\text{N}_3\text{O}_2^+$: 348.0954; found: 348.0957.

2,2,2-Trifluoro-1-(2-(4-(hexyloxy)phenyl)-5-phenyl-2H-1,2,3-triazol-4-yl)-ethanone (17). This was obtained from triazole **1a** (53 mg, 0.220 mmol) and (4-(hexyloxy)phenyl)boronic acid (73 mg, 0.329 mmol): white solid, m.p. 67 – 69 $^\circ\text{C}$, yield 63 mg (69%). ^1H NMR (CDCl_3 , 400.1 MHz): δ 8.15–8.06 (m, 2H), 8.05–7.93 (m, 2H), 7.54–7.45 (m, 3H), 7.06–6.96 (m, 2H), 4.02 (t, 2H, $^3J = 6.6$ Hz), 1.86–1.76 (m, 2H), 1.53–1.44 (m, 2H), 1.40–1.31 (m, 4H), 0.92 (t, 3H, $^3J = 7.0$ Hz). $^{13}\text{C}\{^1\text{H}\}$ NMR (CDCl_3 , 100.6 MHz): δ 174.3 (q, $^2J_{\text{CF}} = 37.1$ Hz), 160.0, 152.8, 136.7, 132.2, 130.2, 129.2, 128.5, 128.2, 121.2, 116.4 (q, $^1J_{\text{CF}} = 291.0$ Hz), 115.1, 68.5, 31.6, 29.1, 25.7, 22.6, 14.0. ^{19}F NMR (CDCl_3 , 376.5 MHz): δ -74.9 (s, 3F). HRMS (ESI-TOF): m/z $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{22}\text{H}_{23}\text{F}_3\text{N}_3\text{O}_2^+$: 418.1737; found: 418.1733.

1-(2-(4-Chloro-3-fluorophenyl)-5-phenyl-2H-1,2,3-triazol-4-yl)-2,2,2-trifluoroethanone (18). This was obtained from triazole **1a** (38 mg, 0.158 mmol) and (4-chloro-3-fluorophenyl)boronic acid (41 mg, 0.235 mmol): pale yellow solid, m.p. 110 – 113 $^\circ\text{C}$, yield 44.3 mg (76%). ^1H NMR (CDCl_3 , 400.1 MHz): δ 8.05 (dd, 1H, $^3J = 9.3$ Hz, $^4J = 2.4$ Hz), 8.02–7.94 (m, 3H), 7.58 (dd, 1H, $^3J = 8.7$ Hz, $^3J = 7.6$ Hz), 7.54–7.48 (m, 3H). $^{13}\text{C}\{^1\text{H}\}$ NMR (CDCl_3 , 100.6 MHz): δ 174.2 (q, $^2J_{\text{CF}} = 37.5$ Hz), 158.3 (d, $^1J_{\text{CF}} = 250.9$ Hz), 153.3, 138.0 (d, $^3J_{\text{CF}} = 9.1$ Hz), 137.6, 131.1 (d, $^2J_{\text{CF}} = 92.7$ Hz), 129.2, 128.6, 127.6, 122.3 (d, $^3J_{\text{CF}} = 17.9$ Hz), 116.2 (q, $^1J_{\text{CF}} = 291.2$ Hz), 115.8 (d, $^4J_{\text{CF}} = 3.9$ Hz), 108.6 (d, $^3J_{\text{CF}} = 26.9$ Hz). ^{19}F NMR (CDCl_3 , 376.5 MHz): δ -75.0 (s, 3F), -112.2 (t, 1F, $J = 8.4$ Hz). HRMS (ESI-TOF): m/z $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{16}\text{H}_9\text{ClF}_4\text{N}_3\text{O}^+$: 370.0365; found: 370.0366.

2,2,2-Trifluoro-1-(5-phenyl-2-(*p*-tolyl)-2H-1,2,3-triazol-4-yl)-ethanone (19). This was obtained from triazole **1a** (36 mg, 0.149 mmol) and *p*-tolylboronic acid (30 mg, 0.221 mmol): white solid, m.p. 112 – 115 $^\circ\text{C}$, yield 44 mg (89%). ^1H NMR (CDCl_3 , 400.1 MHz): δ 8.13–8.06 (m, 2H), 8.05–7.96 (m, 2H), 7.55–7.47 (m, 3H), 7.34 (d, 2H, $^3J = 8.2$ Hz), 2.44 (s, 3H). $^{13}\text{C}\{^1\text{H}\}$ NMR (CDCl_3 , 100.6 MHz): δ 174.4 (q, $^2J_{\text{CF}} = 37.4$ Hz), 152.8, 139.7, 136.9, 136.6, 130.3, 130.1, 129.2, 128.5, 128.2, 119.6, 116.3 (q, $^1J_{\text{CF}} = 290.5$ Hz), 21.2. ^{19}F NMR (CDCl_3 , 376.5 MHz): δ -74.9 (s, 3F). HRMS (ESI-TOF): m/z $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{17}\text{H}_{13}\text{F}_3\text{N}_3\text{O}^+$: 332.1005; found: 332.1007.

2,2,2-Trifluoro-1-(5-phenyl-2-(thiophen-3-yl)-2H-1,2,3-triazol-4-yl)-ethanone (20). This was obtained from **1a** (43 mg, 0.178 mmol) and thiophen-3-ylboronic acid (34 mg, 0.266 mmol): colorless solid, m.p. 98 – 100 $^\circ\text{C}$, yield 59 mg (57%). ^1H NMR (CDCl_3 , 400.1 MHz): δ 8.03–7.92 (m, 3H), 7.75 (dd, 1H, $^3J = 5.3$ Hz, $^4J = 1.4$ Hz), 7.55–7.48 (m, 3H), 7.45 (dd, 2H, $^3J = 5.3$ Hz, $^4J = 1.4$ Hz). $^{13}\text{C}\{^1\text{H}\}$ NMR (CDCl_3 , 100.6 MHz): δ 174.3 (q, $^2J_{\text{CF}} = 37.1$ Hz), 152.8, 138.1, 136.6, 130.4, 129.2, 128.5, 127.9, 127.2, 120.6, 116.3 (q, $^1J_{\text{CF}} = 290.7$ Hz), 115.6. ^{19}F NMR (CDCl_3 , 376.5 MHz): δ -74.9 (s, 3F). HRMS (ESI-TOF): m/z $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{14}\text{H}_9\text{F}_3\text{N}_3\text{OS}^+$: 324.0413; found: 324.0413.

Synthesis of amides 21–24 (general procedure). A 4 mL vial with a screw cap was charged with 1-(2,5-diphenyl-2H-1,2,3-triazol-4-yl)-2,2,2-trifluoroethanone (**12**), (50–59 mg, 0.158–0.186 mmol) and corresponding amine (190–230 mg, ~ 2.7 mmol, ~ 12 equiv.) The reaction mixture was heated for 8 h at 90 $^\circ\text{C}$ (for **21**) or at 110 $^\circ\text{C}$ (for **22–24**) using a magnetic stirrer with heating. The reaction mixture was transferred into a round-bottom 50 mL flask using CH_2Cl_2 (10–15 mL), and then volatiles were evaporated in vacuo. The residue was passed through a short silica gel pad using CH_2Cl_2 followed by CH_2Cl_2 –MeOH (100:1) as eluents. Evaporation of volatiles afforded corresponding pure amides **21–24**.

(2,5-Diphenyl-2H-1,2,3-triazol-4-yl)(pyrrolidin-1-yl)methanone (21). This was obtained from **12** (58.6 mg, 0.185 mmol) and pyrrolidine (190 mg, 2.66 mmol) by heating at 90 $^\circ\text{C}$ for 8 h: white solid, m.p. 94 – 96 $^\circ\text{C}$, yield 55 mg (94%). ^1H NMR (CDCl_3 , 400.1 MHz): δ 8.14–8.11 (m, 2H), 7.96–7.93 (m, 2H), 7.50–7.34 (m, 6H), 3.71 (t, 2H, $^3J = 6.9$ Hz), 3.46 (t, 2H, $^3J = 6.9$ Hz), 1.97–1.82 (m, 4H). $^{13}\text{C}\{^1\text{H}\}$ NMR (CDCl_3 , 100.6 MHz): δ 161.5, 146.8, 141.1, 139.3, 129.5, 129.2, 129.0, 128.6, 127.8, 127.6, 118.9, 48.3, 46.2, 25.9, 24.2. HRMS (ESI-TOF): m/z $[\text{M} + \text{H}]^+$ Calcd for $\text{C}_{19}\text{H}_{19}\text{N}_4\text{O}^+$: 319.1553; found: 319.1560.

(2,5-Diphenyl-2H-1,2,3-triazol-4-yl)(piperidin-1-yl)methanone (22). This was obtained from **12** (50 mg, 0.158 mmol) and piperidine (205 mg, 2.41 mmol) by heating at 110 °C for 8 h: beige viscous oil, yield 37.4 mg (71%). ¹H NMR (CDCl₃, 400.1 MHz): δ 8.16–8.11 (m, 2H), 7.93–7.85 (m, 2H), 7.52–7.34 (m, 6H), 3.87–3.73 (m, 2H), 3.32–3.21 (m, 2H), 1.71–1.57 (m, 4H), 1.39–1.31 (m, 2H). ¹³C{¹H} NMR (CDCl₃, 100.6 MHz): δ 162.1, 146.1, 140.6, 139.4, 129.31, 129.26, 129.1, 128.8, 127.8, 127.3, 118.9, 48.2, 43.0, 26.1, 25.4, 24.4. HRMS (ESI-TOF): *m/z* [M + H]⁺ Calcd for C₂₀H₂₁N₄O⁺: 333.1710; found: 333.1715.

(2,5-Diphenyl-2H-1,2,3-triazol-4-yl)(morpholino)methanone (23). This was obtained from **12** (50 mg, 0.158 mmol) and morpholine (220 mg, 2.53 mmol) by heating at 110 °C for 8 h: beige solid, m.p. 140–142 °C, yield 37 mg (70%). ¹H NMR (CDCl₃, 400.1 MHz): δ 8.17–8.08 (m, 2H), 7.91–7.80 (m, 2H), 7.55–7.33 (m, 6H), 3.91–3.82 (m, 2H), 3.80–3.73 (m, 2H), 3.50–3.43 (m, 2H), 3.42–3.34 (m, 2H). ¹³C{¹H} NMR (CDCl₃, 100.6 MHz): δ 162.2, 146.8, 139.6, 139.3, 129.3, 129.1, 128.9, 128.0, 127.5, 119.0, 66.58, 66.54, 47.4, 42.5. HRMS (ESI-TOF): *m/z* [M + H]⁺ Calcd for C₁₉H₁₉N₄O₂⁺: 335.1503; found: 335.1506.

N-Hexyl-2,5-diphenyl-2H-1,2,3-triazole-4-carboxamide (24). This was obtained from **12** (53 mg, 0.167 mmol) and hexan-1-amine (240 mg, 2.38 mmol) by heating at 110 °C for 8 h: white solid, m.p. 86–88 °C, yield 25 mg (43%). ¹H NMR (CDCl₃, 400.1 MHz): δ 8.20–8.06 (m, 4H), 7.54–7.37 (m, 6H), 6.98 (t, 1H, ³J = 4.7 Hz), 3.46 (dd, 2H, ³J = 13.4 Hz, ³J = 7.1 Hz), 1.67–1.60 (m, 2H), 1.44–1.28 (m, 6H), 0.91–0.87 (m, 3H). ¹³C{¹H} NMR (CDCl₃, 100.6 MHz): δ 160.4, 139.5, 139.2, 129.38, 129.35, 129.2, 128.3, 128.2, 119.1, 39.5, 31.5, 29.6, 26.7, 22.5, 14.0. HRMS (ESI-TOF): *m/z* [M + H]⁺ Calcd for C₂₁H₂₅N₄O⁺: 349.2023; found: 349.2029.

4. Conclusions

In conclusion, we investigated modification of 5-aryl-4-trifluoroacetyl-1,2,3-triazoles at NH-moiety. We found that alkylation can be performed selectively in DMF using Na₂CO₃ as a base. The reaction proceeds at room temperature to produce selectively 2-isomers in high yields as major isomers. The selectivity of the reaction reaches a 94:6 ratio of 2- and 1-isomers. Activated by electron-withdrawing groups, aryl halides react regioselectively to form 2-aryltriazoles in good-to-high yields. Similarly, the copper catalyzed reaction with boronic acids led to 2-aryltriazoles exclusively. Transformation of the latter compounds into amides of 4-(2,5-diaryltriazolyl)carboxylic acid were achieved by heating with primary and secondary amines. Fluorescent properties of prepared 2-derivatives of 1,2,3-triazoles were investigated to reveal that some of them have quantum yields of more than 60%.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/molecules28124822/s1>, Copies of all ¹H, ¹³C and ¹⁹F NMR spectra.

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Sample Availability: Samples of the compounds **3–24** are available from the authors.

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