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A Facile One-Pot Synthesis of New Poly Functionalized Pyrrolotriazoles via a Regioselective Multicomponent Cyclisation and Suzuki–Miyaura Coupling Reactions

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Abstract: The first access to *N-1*, *N-4* disubstituted pyrrolo[2,3-*d*][1,2,3]triazoles is reported. The series were generated using a "one-pot" MCR, leading to a single regioisomer of the attempted heteroaromatic skeleton in good yields. Next, the functionalization of *C-5* and *C-6* positions was investigated. (Het)aryl groups were introduced at the *C-5* and *C-6* positions of the pyrrolo[2,3-*d*][1,2,3]triazoles using regioselective electrophilic brominations followed by Suzuki–Miyaura cross coupling reactions. Palladium-catalyzed cross-coupling conditions were optimized and a representative library of various boronic acids was employed to establish the scope and limitations of the method.

Keywords: pyrrolo[2,3-*d*][1,2,3]triazoles; multicomponent cyclisation; Suzuki–Miyaura reaction

Citation: Garnier, S.; Brugemann, K.; Zak, A.; Vercouillie, J.; Potier-Cartereau, M.; Marchivie, M.; Routier, S.; Buron, F. A Facile One-Pot Synthesis of New Poly Functionalized Pyrrolotriazoles via a Regioselective Multicomponent Cyclisation and Suzuki–Miyaura Coupling Reactions. *Catalysts* **2022**, *12*, 828. https://doi.org/10.3390/catal12080828

Academic Editor: Hiroto Yoshida

Received: 7 July 2022
Accepted: 21 July 2022
Published: 27 July 2022

1. Introduction

Pyrrole and triazole derivatives are powerful moieties to elaborate drugs which are used in various areas of medicine as anticancer, antitubercular, and analgesic agents [1–17]. For these reasons, their introduction in medicinal chemistry programs has grown, in particular in the context of molecular diversity and innovative chemical space research [18,19]. These two small heterocycles have been fused in bicyclic systems [20–24], providing original building blocks for medicinal chemists [25,26]. Nevertheless, the literature reports only one example of these two cycles combined together in a [5:5] fused ring which was designed by Cirrincione et al. to access benzylated pyrrolo[2,3-*d*][1,2,3]triazoles of type **B** [27]. To date no method is available to introduce the chosen substituents in *N-1*, *N-4*, *C-5*, and *C-6* positions. This lack of references and methods induces a gap in the exploration of the chemical space and prompted us to search for novel and efficient strategies from a unique versatile platform towards highly diversified structures in a minimum number of steps.

The reported synthetic pathway leading to the targeted bicycle started from an appropriate polysubstituted pyrrole **A** to generate, after formation of the triazole moiety, the pyrrolo[2,3-*d*][1,2,3]triazole derivatives **B** (Figure 1). Despite the apparent efficiency of this step, molecular diversity cannot be easily managed under this method due to the limitations in terms of regioselective cyclisation and access or commercial availability of pyrrole derivatives.

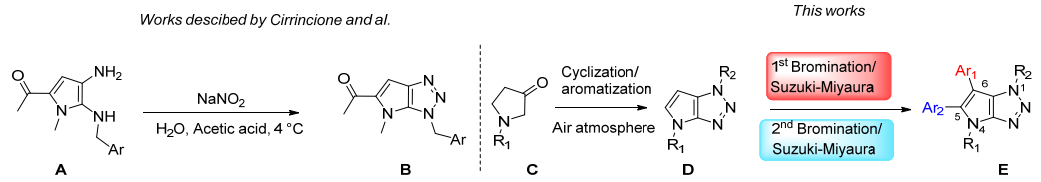


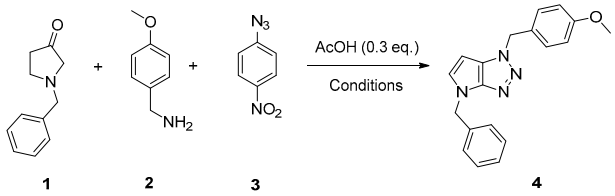
Figure 1. Access to pyrrolo[2,3-*d*][1,2,3]triazoles.

In order to introduce a wide range of functional groups, a solution consists in building a library of pyrrolo[2,3-*d*][1,2,3]triazole platforms **D** from commercially available 3-pyrrholidinone **C** patterns and then elaborating its selective functionalization using arylation procedures. With this aim in view, our expertise in heterocyclic synthesis prompted us to envision the use of regioselective halogenation/Suzuki–Miyaura sequences from a versatile platform **D** that seems to be particularly powerful to tackle this challenge [28–33]. We report herein an unprecedented synthesis of tetra-substituted-pyrrolo[2,3-*d*][1,2,3]triazoles **E**, and the optimization of the experimental conditions. Lastly, the scope of both cross-coupling reactions on these two selected positions (Figure 1) is given.

2. Results and Discussion

First at all, we focused our attention on the access of pyrrolo[2,3-*d*][1,2,3]triazole **4**, which can be prepared by using a single cascade step developed by Dehaen et al. from commercially available enolizable 3-pyrrolidinone **1** and *p*-methoxybenzylamine **2** in presence of 4-nitrophenylazide **3** and acetic acid as catalyst in air atmosphere (Table 1) [34]. The condensation of 3-pyrrolidinone with a primary amine under thermal conditions at 100 °C during 12 h generated the corresponding enamine, which, after a [3+2]cycloaddition reaction and aromatization with 4-nitroaniline as leaving group, gave only the regioisomer **4** in 30% of yield (the only degradation was observed with an inert atmosphere). The use of a sealed tube allowed us to reach a temperature of 140 °C and to slightly increase the yield of **4** to 40%. Under microwave activation, the reaction was achieved in only 1 h with a yield of 41%. To improve the efficiency of the reaction, the modulation of a few critical parameters was investigated. Replacing the solvent with THF induced a slight decrease in yield (33% versus 41% with toluene). Modulation of the numbers of equivalents of **2** and **3** was performed and the combination of 3.0 equivalents of **2** and 5.0 equivalents of azide derivative furnished **4** in a good yield of 75%. These conditions therefore appeared optimal for designing a representative library of compounds **D**.

Table 1. Optimization of conditions for the formation of **4**.

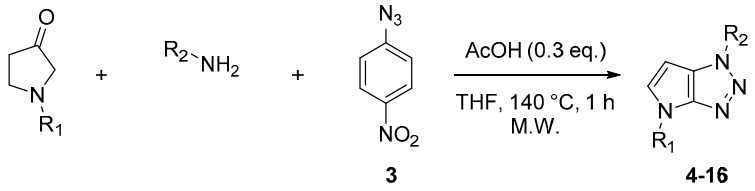


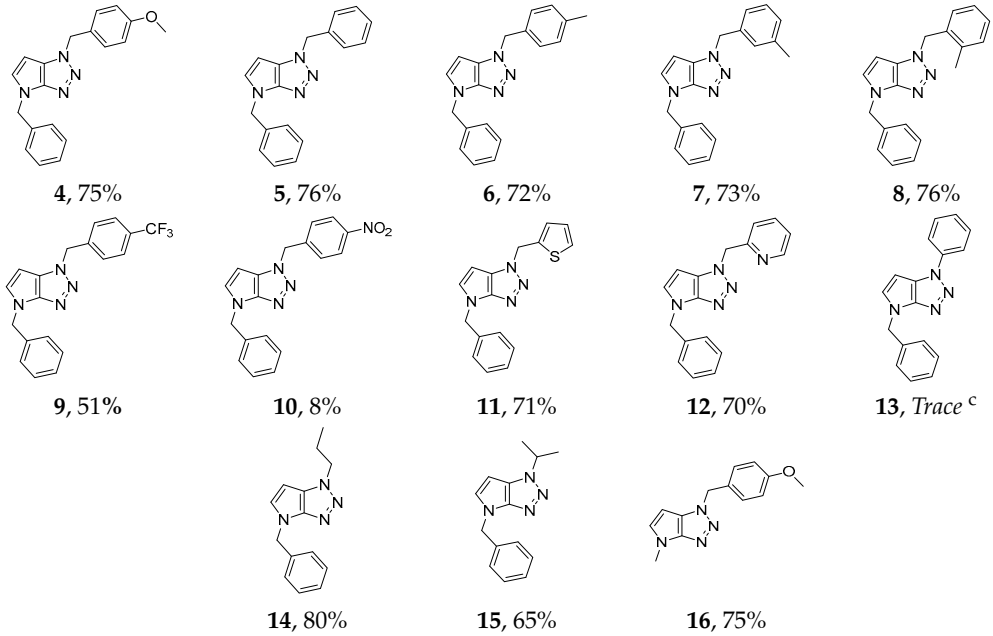
Entry	$PMBNH_2$ (eq.)	Azide 3 (eq.)	T (°C)	Time (h)	Solvent	4 [c] (%)
1	1.5	1.0	100 [a]	12	Toluene	30
2	1.5	1.0	140 [a]	12	Toluene	40
3	1.5	1.0	140 [b]	1	Toluene	41
4	1.5	1.0	140 [b]	1	THF	33
5	1.5	2.0	140 [b]	1	Toluene	48
6	3.0	2.0	140 [b]	1	Toluene	61
7	4.0	2.0	140 [b]	1	Toluene	56
8	3.0	3.0	140 [b]	1	Toluene	64
9	3.0	5.0	140 [b]	1	Toluene	75
10	3.0	6.0	140 [b]	1	Toluene	71

[a] Classical thermal condition. [b] Microwave irradiation. [c] Yields are calculated after isolation of the product.

The scope and potential limitations of the MCR step were then investigated by the modulation of the 3-pyrrolidinones and benzylamines (Table 2). First, whatever the modification of the nature of the substrates, the regioselectivity of the cyclization remained identical and only pyrrolo[2,3-*d*][1,2,3]triazole isomers were generated. The use of benzylamine or 4-methylbenzylamine was well tolerated and furnished the derivatives **5** and **6** in good yields. In contrast, the presence of electron-withdrawing substituents such as trifluoromethyl or nitro groups decreased the annelation efficiency, and compounds **9** and **10** were isolated in 51% and 8% yields, respectively.

Table 2. Scope of the MCR reaction: synthesis of **4**–**16** [a,b].





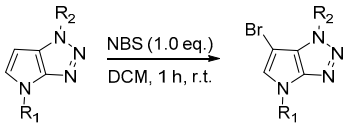
[a] General reaction conditions: 1.0 eq. of 3-pyrrolidinone derivative, 3.0 eq. of amine and 5.0 eq. of azide. [b] Yields are calculated after isolation of the products. [c] Detected by LCMS.

Next, we investigated the influence of steric hindrance using a position switch of a methyl group on the phenyl ring. Whatever the position, the assay exhibited the same behaviour and each regioisomer was isolated with a 70% higher efficiency. Finally, the aromatic switch for heterocycles was studied with 2-(aminomethyl)-thiophene or -pyridine and once again, the efficiency of the reaction was preserved, and compounds **11** and **12** were isolated in 71% and 72% yields, respectively. The only identified limit concerned the use of aniline as amine source for compound **13**, which totally inhibited the reaction due to its less nucleophile character compared to the benzyl amine derivative. Finally, the use of alkylamines restored the efficiency of the reaction, especially for the primary amine which exhibited a better reactivity than a secondary amine (**14**, 80% versus **15**, 65%).

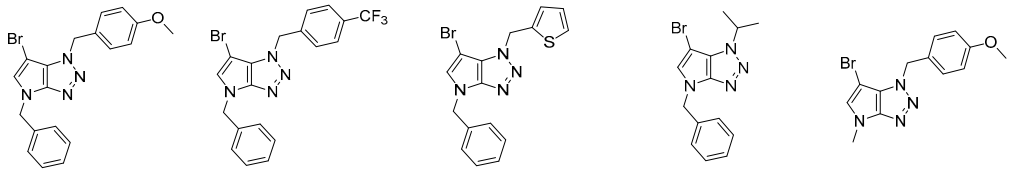
Selective halogenation in *C-6* position with *N*-Bromosuccinimide in DCM at r.t. was performed on the complete library of derivatives of type **D**. The scope of the reaction was studied with a representative panel of previously synthesized pyrrolo[2,3-*d*][1,2,3]triazoles to afford derivatives **17**–**21** (Table 3) with efficiency as bromo derivatives were mainly isolated in satisfying yields, except in the case of **15** for which the mono brominated

compound **20** was obtained in a 70% yield but accompanied with a separable amount of dibrominated product as side product (20%).

Table 3. *C-6* bromination of pyrrolo[2,3-*d*][1,2,3]triazoles: synthesis of **17–21** [a].



4,9,11, 15, 16 **17-21**

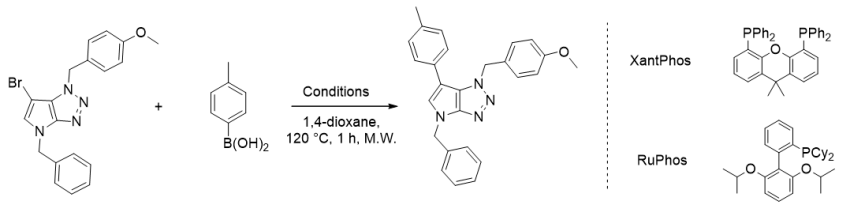


17, 93% **18**, 87% **19**, 90% **20**, 70% **21**, 90%

[a] Yields are calculated after isolation of the product.

With these compounds in hand, we then achieved the bromine displacement by Suzuki–Miyaura cross coupling to explore its reactivity, and also to access *C-6* substituted pyrrolo[2,3-*d*][1,2,3]triazoles. This objective prompted us to find a general and efficient catalytic system by optimizing the main reaction parameters (Table 4). First, we used **17** as starting material, Pd $(PPh_3)_4$ as the catalyst source, Na_2CO_3 as base, and 1,4-dioxane as a solvent under microwave irradiation for 1 h. With these conditions, the desired product **22** was isolated in a low but encouraging 19% yield (Table 4, entry 1). When the base was switched for K_2CO_3 or Cs_2CO_3, the reactivity was improved and the desired compound **22** was obtained in a 61% yield. The best result was reached with K_3PO_4 [35] with a good 74% yield for **22**. Next, we investigated the influence of the catalyst system. We increased the catalytic load to 5% but no improvement was observed. In the following experiment, we tried to catalyze the reaction with a bidentate palladium complex, which was formed by using a mixture of Pd $(OAc)_2$ (3.0 mol%) and Xantphos (6.0 mol%). While this modification induced a dramatic decrease in yield, the reactivity was boosted with the well-known Buchwald-RuPhos ligand, and product **22** was isolated in a good yield of 80% (Table 4, entry 7). Finally, a fine adjustment of the quantities of boronic acid to 1.5 equivalents gave the optimized conditions with the best 90% yield.

Table 4. Optimization of Suzuki–Miyaura cross-coupling.



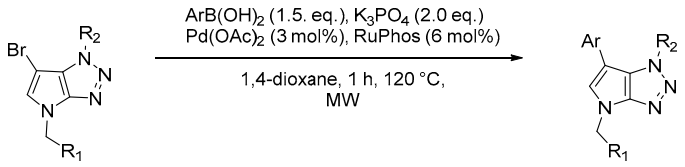
17 **22**

Entry	Boronic Acid (eq.)	Catalyst (mol%)	Ligand (mol%)	Base (eq.)	22, Yield [a] (%)
1	1,2	$Pd(PPh_3)_4$ (3.0)	-	Na_2CO_3 (2.0)	19
2	1,2	$Pd(PPh_3)_4$ (3.0)	-	K_2CO_3 (2.0)	61
3	1,2	$Pd(PPh_3)_4$ (3.0)	-	Cs_2CO_3 (2.0)	61
4	1,2	$Pd(PPh_3)_4$ (3.0)	-	K_3PO_4 (2.0)	74
5	1,2	$Pd(PPh_3)_4$ (5.0)	-	K_3PO_4 (2.0)	74
6	1,2	$Pd(OAc)_2$ (3.0)	XantPhos (6.0)	K_3PO_4 (2.0)	41
7	1,2	$Pd(OAc)_2$ (3.0)	RuPhos (6.0)	K_3PO_4 (2.0)	80
8	1,5	$Pd(OAc)_2$ (3.0)	RuPhos (6.0)	K_3PO_4 (2.0)	90

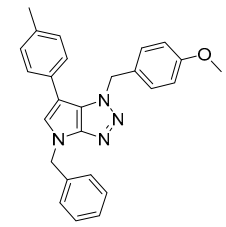
[a] Yields are calculated after isolation of the product.

Next, the scope and potential limitations of the Pd-coupling step were investigated by modulation of the boron derivatives (Table 5). The use of simple phenyl boronic acid was well tolerated and furnished the derivative **23** in good yield. In contrast, the presence of electron-withdrawing or electron-donating substituents modulated the efficiency of the reaction.

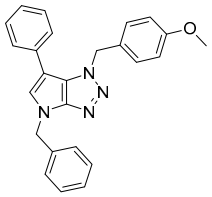
Table 5. Scope of the Suzuki–Miyaura reaction in *C-6* position: synthesis of **22–34** [a].



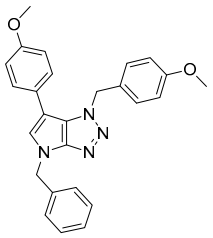
17-21 **22-34**



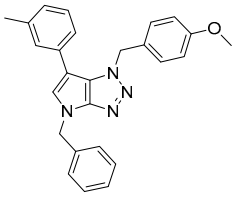
22, 90%



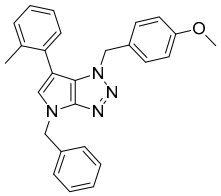
23, 92%



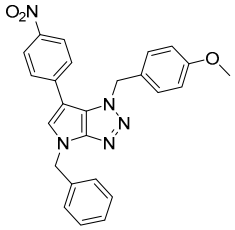
24, 48%



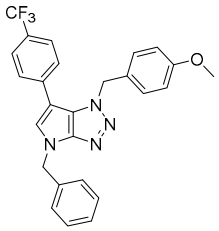
25, 73%



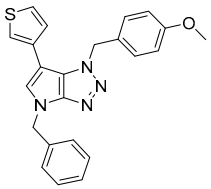
26, 33%



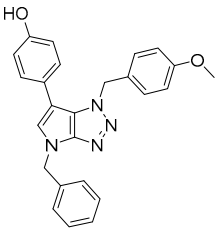
27, 42% [b]



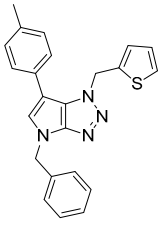
28, 57%



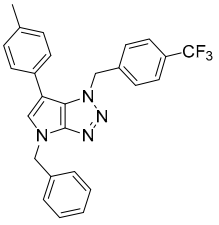
29, 60%



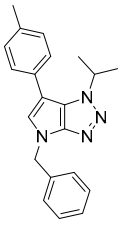
30, 29%



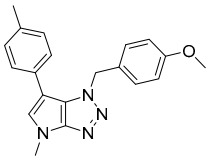
31, 91%



32, 83%



33, 82%

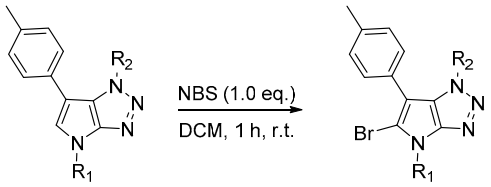


34, 65%

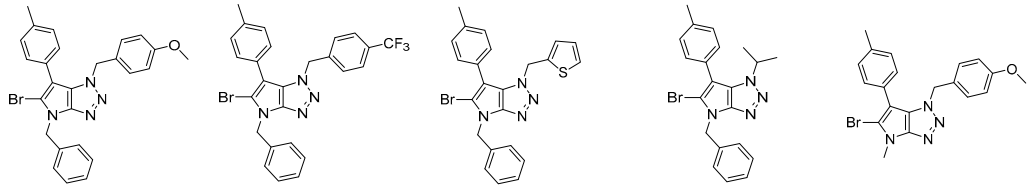
[a] Yields are calculated after isolation of the products. [b] LCMS estimated amount before purification.

In the last stage of this study, we investigated the reactivity of the *C-5* position. Bromination was performed using the same conditions as those previously used for the *C-6* position, and compounds **35–39** were isolated in excellent yields (Table 6). The scope and generality of the Suzuki–Miyaura coupling step were then examined (Table 7).

Table 6. *C-5* bromination of pyrrolo[2,3-*d*][1,2,3]triazoles: synthesis of **35–39** [a].



22, 31-34 **35-39**



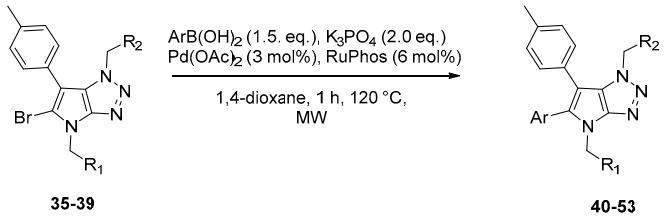
35, 86% **36**, 80% **37**, 90% **38**, 90% **39**, 95%

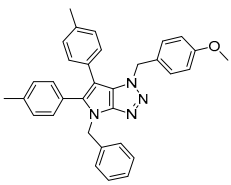
[a] Yields are calculated after isolation of the products.

We used conditions involving K_3PO_4, Pd $(OAc)_2$ and RuPhos as the catalyst systems under microwave irradiation which have proved to be useful in the *C-6* position. The arylation was successfully achieved with *para*-tolylboronic acid to afford **40** in a good 75% yield (Table 7). In the last stage of this study, we varied the nature of the boron derivative. In fact, whatever the substituent on the phenyl boronic acid (i.e., electron-donating or withdrawing), or the steric hindrance induced by an *ortho* substitution, the C-C bond was efficiently generated, and products were isolated in good to excellent yields (Table 7, products **40–53**). The only identified limit concerned the use of the poorly soluble nitrophenylboronic and 4-hydroxyphenyl boronic acids, which slightly altered the yield of the corresponding reactions. This last constraint was easily circumvented by the use of an easily removable protective group such as THP, as **48** was obtained in a near-quantitative manner. The use of heteroarylboronic acid such as thiophene derivative was well tolerated, and compound **49** was isolated in a 55% yield. Finally, the influence of the substituents in *N-1* or *N-4* positions was investigated, and again no alteration was observed as compounds **50–53** were isolated in very good yields.

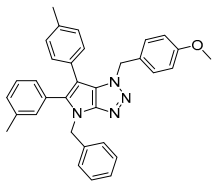
41 crystalizes in the monoclinic $P2_1/c$ space group with one molecule in the asymmetric unit and consequently 4 molecules in the unit cell (Figure 2, see Table 1 in ESI for crystallographic data). The molecular volume is high (443 $Å^3$) as the benzyl and phenyl moieties are not coplanar with the central pyrrolo–triazole ring. The two phenyls on position 5 and 6 are respectively tilted from 38.76 (4)° and 71.48 (6)° from the mean plane of the central pyrrolo–triazole ring, and benzyl groups on position 1 and 4 are almost perpendicular to the pyrrolo–triazole mean plane (86.06 (4)° and 83.60 (5)°, respectively). The phenyl ring holding a methyl in the meta position is disordered onto two positions corresponding to a rotation of 180° around the C–C bond linked to central double ring. The methyl moieties are then distributed either above (60%) or below (40%) the central ring. The cohesion of the network is essentially ensured by weak Van Der Waals interactions without any π-π staking despite the numerous aromatic rings as supported by Hirshfeld surface analysis (Figure 3).

Table 7. Scope of the Suzuki–Miyaura reaction in *C-5* position: synthesis of **40**–**53** [a].

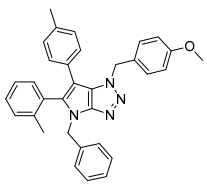




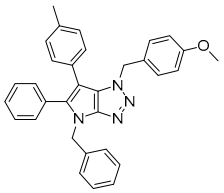
40, 75%



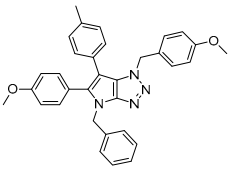
41, 97%



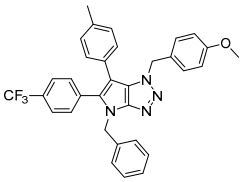
42, 88%



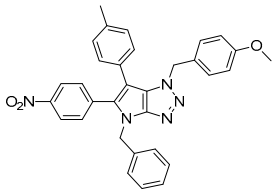
43, 76%



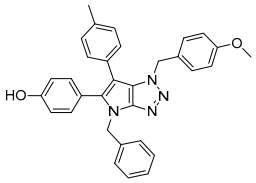
44, 83%



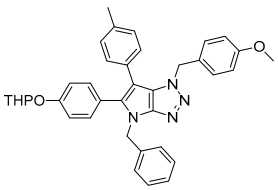
45, 88%



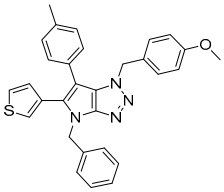
46, 48%



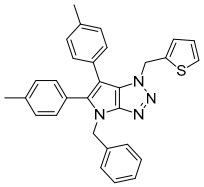
47, 49% (97% [b] from **48**)



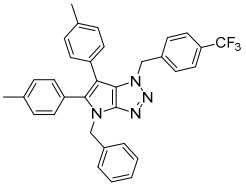
48, 96%



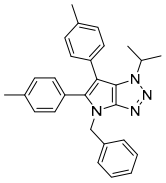
49, 55%



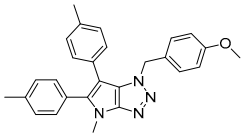
50, 96%



51, 70%



52, 78%



53, 95%

[a] Yields are calculated after the isolation of the products following purification. [b] Also obtained via deprotection of **48** in HCl 4 M in 1,4-dioxane, 20 h at r.t.

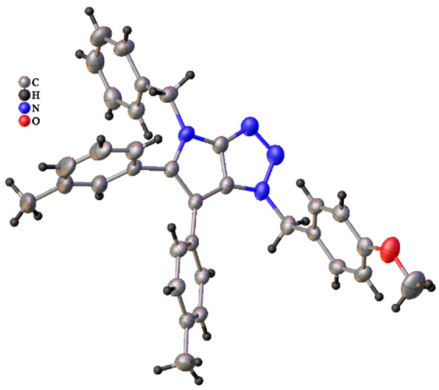


Figure 2. View of the asymmetric unit of **41** at 293 K with thermal ellipsoids drawn at the 30% probability level. The disordered phenyl ring on position 6 is represented with only one position for clarity (methyl moieties below the central ring).

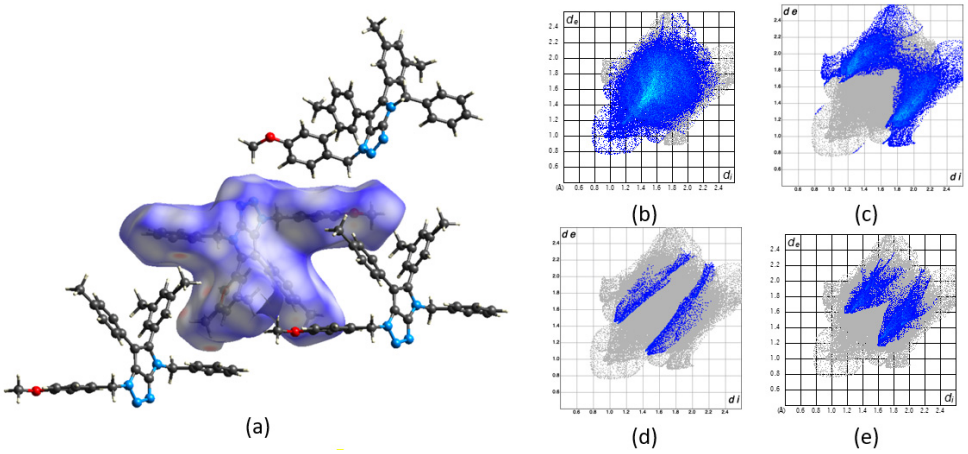


Figure 3. Hirshfeld surface analysis [36] of **41**, showing (**a**) the principal intermolecular contacts (red zone on the surface) with some main interacting molecules and fingerprints [37] of (**b**) H–H contacts, (**c**) C–H contacts (**d**) O–H contacts and (**e**) N–H contacts.

3. Conclusions

In summary, the quick access to original *N-1, N-4* disubstituted pyrrolo[2,3-*d*][1,2,3] triazoles has been described herein using a one-pot MCR leading to a single regioisomer of the attempted heteroaromatic skeleton in good yields. The functionalization of *C-5* and *C-6* positions was also investigated. First, a regioselective halogenation was performed in the *C-6* position followed by Suzuki–Miyaura coupling reaction to introduce (Het)aryl moiety with success. Next, the same sequence was also realized with the last free *C-5* functionalizable position, with the same efficiency. The scope of the Suzuki–Miyaura reactions for each position was studied and showed an excellent compatibility with a wide range of boronic acids. This work allows access to a novel class of tetra substituted pyrrolo[2,3-*d*][1,2,3]triazoles which will undoubtedly have a major impact on the further synthesis of new bioactive compounds that contain the rare pyrrolo[2,3-*d*][1,2,3]triazole scaffold as the central skeleton. Efforts to achieve these objectives, and particularly to study the reactivity of the triazolic nitrogen atoms involved in the bicyclic system, are currently in progress.

4. Materials and Methods

4.1. General Information

^{1}H NMR and ^{13}C NMR spectra were recorded on a Bruker DPX 400 Mhz instrument using $CDCl_3$ and DMSO-d_6. The chemical shifts are reported in parts per million (δ scale), and all coupling constant (J) values are reported in hertz. The following abbreviations were used for the multiplicities: s (singlet), d (doublet), t (triplet), q (quartet), p (pentuplet), m (multiplet), sext (sextuplet), and dd (doublet of doublets). All compounds were characterized by ^{1}H NMR, and ^{13}C NMR which are consistent with those reported in the literature (Supplementary Materials). Melting points are uncorrected. IR absorption spectra were obtained on a PerkinElmer PARAGON 1000 PC, and the values are reported in inverse centimeters. HRMS spectra were acquired in positive mode with an ESI source on a Q-TOF mass by the "Fédération de Recherche" ICOA/CBM (FR2708) platform and NMR data were generated on the Salsa platform. Monitoring of the reactions was performed using silica gel TLC plates (silica Merck 60 F 254). Spots were visualized by UV light (254 nm and 356 nm). Column chromatography was performed using silica gel 60 (0.063–0.200 mm, Merck). Microwave irradiation was carried out in sealed vessels placed in a Biotage Initiator or Biotage Initiator+ system (400 W maximum power). The temperatures were measured externally by IR. Pressure was measured by a non-invasive sensor integrated into the cavity lid. All reagents were purchased from commercial suppliers and were used without further purification.

*4.2. General Procedure (***A***) for* **4**–**16**

In a microwave vial already filled with anhydrous Toluene (0.25 M) and molecular sieves (3 Å), were successively added pyrrolidinone (1.0 eq.), amine (3.0 eq.), 1-Azido-4-nitrobenzene (5.0 eq.), and acetic acid (0.3 eq.). The vial was finally capped and stirred 1 h at 140 °C under microwave irradiation. The resulting mixture was reduced in a vacuum and filtered on charcoal. The crude product was purified by flash silica gel column chromatography using DCM, then PE/EtOAc mixtures to obtain the desired compound.

4.2.1. 4-Benzyl-1-(4-methoxybenzyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**4**)

The reaction was carried out as described in general procedure **A** using 4-methoxybenz ylamine (206 mg, 1.5 mmol, 3.0 eq.), 1-benzyl-3-pyrrolidinone (88.0 mg, 0.5 mmol, 1.0 eq.), 1-azido-4-nitrobenzene (410.2 mg, 2.5 mmol, 5.0 eq.), acetic acid (9.0 mg, 0.15 mmol, 0.3 eq.), and 50 mg of molecular sieves (3 Å) in anhydrous Toluene (0.25 M). The crude mixture was purified by flash chromatography on silica gel using first DCM and then (PE/EtOAc: 80/20) to afford **4** as a white solid (119.0 mg, 75%). R_f = 0.27 (PE/EtOAc: 70/30). Mp 89–91 °C. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.32–7.26 (m, 7H), 6.88 (d, *J* = 8.7 Hz, 2H), 6.78 (d, *J* = 3.1 Hz, 1H), 5.55 (d, *J* = 3.1 Hz, 1H), 5.52 (s, 2H), 5.23 (s, 2H), 3.80 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$): δ 159.8 (C_q), 150.9 (C_q), 137.0 (C_q), 130.3 (CH_{Ar}), 130.1 (2 × CH_{Ar}), 128.9 (2 × CH_{Ar}), 128.1 (CH_{Ar}), 127.9 (C_q), 127.9 (2 × CH_{Ar}), 127.0 (C_q), 114.3 (2 × CH_{Ar}), 88.6 (CH_{Ar}), 55.4 (CH_3), 53.3 (CH_2), 50.6 (CH_2). IR (ATR diamond, cm^{-1}) ν: 3101, 3038, 2928, 2836, 1611, 1431, 1302, 1184, 1084, 751, 637. HRMS (EI^+) *m/z* calcd for $C_{18}H_{19}N_4O$ $[M+H]^+$: 319.1553, found: 319.1555.

4.2.2. 1,4-Dibenzyl-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**5**)

The reaction was carried out as described in general procedure **A** using benzylamine (161 mg, 1.5 mmol, 3.0 eq.), 1-benzyl-3-pyrrolidinone (88 mg, 0.5 mmol, 1.0 eq.), 1-azido-4-nitrobenzene (410.2 mg, 2.5 mmol, 5.0 eq.), acetic acid (9 mg, 0.15 mmol, 0.3 eq.), and 50 mg molecular sieves (3 Å) in anhydrous toluene (0.25 M). The crude mixture was purified by flash chromatography on silica gel using first DCM and then (PE/EtOAc: 80/20) to afford **5** as a yellow solid (110 mg, 76%). R_f = 0.25 (PE/EtOAc: 80/20). Mp 107–109 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.38–7.22 (m, 10H), 6.79 (d, *J* = 3.2 Hz, 1H), 5.59 (s, 2H), 5.57 (d, *J* = 3.2 Hz, 1H), 5.24 (s, 2H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 150.9 (C_q), 137.0 (C_q), 134.9 (C_q), 130.4 (CH_{Ar}), 129.0 (2 × CH_{Ar}), 128.9 (2 × CH_{Ar}), 128.5 (CH_{Ar}), 128.5 (2 × CH_{Ar}), 128.1 (CH_{Ar}), 128.0 (C_q), 127.8 (2 × CH_{Ar}), 88.5 (CH_{Ar}), 53.7 (CH_2), 50.6 (CH_2). IR (ATR diamond, cm^{-1}) ν: 3085, 3032, 2971, 1520, 1313, 1169, 1075, 938, 727, 694. HRMS (EI^+) *m/z* calcd for $C_{18}H_{17}N_4$ $[M+H]^+$: 289.1448, found: 289.1450.

4.2.3. 4-Benzyl-1-(4-methylbenzyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**6**)

The reaction was carried out as described in general procedure **A** using 4-methylbenzy lamine (182 mg, 1.5 mmol, 3.0 eq.) as amine, 1-benzyl-3-pyrrolidinone (88 mg, 0.5 mmol, 1.0 eq.) as pyrrolidinone, 1-azido-4-nitrobenzene (410.2 mg, 2.5 mmol, 5.0 eq.), acetic acid (9 mg, 0.15 mmol, 0.3 eq.), and 50 mg molecular sieves (3 Å) in anhydrous toluene (0.25 M). The crude mixture was purified by flash chromatography on silica gel using first DCM and then (PE/EtOAc: 80/20) to afford **6** as a white solid (103 mg, 72%). R_f = 0.21 (PE/EtOAc: 80/20). Mp 70–72 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.32–7.20 (m, 7H), 7.15 (m, 2H), 6.78 (d, *J* = 3.2 Hz, 1H), 5.57 (d, *J* = 3.2 Hz, 1H), 5.53 (s, 2H), 5.22 (s, 2H), 2.32 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 150.8 (C_q), 138.3 (C_q), 137.0 (C_q), 131.9 (C_q), 130.3 (CH_{Ar}), 129.6 (2 × CH_{Ar}), 128.9 (2 × CH_{Ar}), 128.5 (2 × CH_{Ar}), 128.0 (CH_{Ar}), 127.9 (C_q), 127.8 (2 × CH_{Ar}), 88.5 (CH_{Ar}), 53.5 (CH_2), 50.6 (CH_2), 21.3 (CH_3). IR (ATR diamond, cm^{-1}) ν: 3098, 3030, 2934, 2838, 1612, 1494, 1351, 1111, 1082, 972, 818, 773. HRMS (EI^+) *m/z* calcd for $C_{19}H_{19}N_4$ $[M+H]^+$: 303.1604, found: 303.1608.

4.2.4. 4-Benzyl-1-(3-methylbenzyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**7**)

The reaction was carried out as described in general procedure **A** using 3-methylbenzy lamine (182 mg, 1.5 mmol, 3.0 eq.) as amine, 1-benzyl-3-pyrrolidinone (88 mg, 0.5 mmol, 1.0 eq.) as pyrrolidinone, 1-azido-4-nitrobenzene (410.2 mg, 2.5 mmol, 5.0 eq.), acetic acid (9 mg, 0.15 mmol, 0.3 eq.), and 50 mg molecular sieves (3 Å) in anhydrous toluene (0.25 M). The crude mixture was purified by flash chromatography on silica gel using first DCM and then (PE/EtOAc: 80/20) to afford **7** as a white solid (105 mg, 73%). R_f = 0.21 (PE/EtOAc: 80/20). Mp 58–60 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.32–7.21 (m, 6H), 7.13 (m, 3H), 6.79 (d, *J* = 3.2 Hz, 1H), 5.59 (d, *J* = 3.2 Hz, 1H), 5.55 (s, 2H), 5.24 (s, 2H), 2.33 (s, 3H, H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 150.9 (C_q), 138.7 (C_q), 137.0 (C_q), 134.8 (C_q), 130.4 (CH_{Ar}), 129.3 (CH_{Ar}), 129.2 (CH_{Ar}), 128.9 (2 × CH_{Ar}), 128.8 (CH_{Ar}), 128.1 (CH_{Ar}), 128.0 (C_q), 127.8 (2 × CH_{Ar}), 125.6 (CH_{Ar}), 88.5 (CH_{Ar}), 53.7 (CH_2), 50.6 (CH_2), 21.5 (CH_3). IR (ATR diamond, cm^{-1}) ν: 3028, 2927, 1518, 1366, 1201, 1099, 938, 770, 691. HRMS (EI^+) *m/z* calcd for $C_{19}H_{19}N_4$ $[M+H]^+$: 303.1604, found: 303.1609.

4.2.5. 4-Benzyl-1-(2-methylbenzyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**8**)

The reaction was carried out as described in general procedure **A** using 4-methylbenzy lamine (182 mg, 1.5 mmol, 3.0 eq.) as amine, 1-benzyl-3-pyrrolidinone (88 mg, 0.5 mmol, 1.0 eq.) as pyrrolidinone, 1-azido-4-nitrobenzene (410.2 mg, 2.5 mmol, 5.0 eq.), acetic acid (9 mg, 0.15 mmol, 0.3 eq.), and 50 mg molecular sieves (3 Å) in anhydrous toluene (0.25 M). The crude mixture was purified by flash chromatography on silica gel using first DCM and then (PE/EtOAc: 80/20) to afford **8** as a white solid (107 mg, 76%). R_f = 0.21 (PE/EtOAc: 80/20). Mp 73–75 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.36–7.19 (m, 9H), 6.75 (d, *J* = 3.2 Hz, 1H), 5.60 (s, 2H), 5.35 (d, *J* = 3.2 Hz, 1H), 5.23 (s, 2H), 2.38 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 150.7 (C_q), 137.5 (C_q), 137.0 (C_q), 132.7 (C_q), 130.9 (CH_{Ar}), 130.3 (CH_{Ar}), 129.9 (CH_{Ar}), 129.0 (CH_{Ar}), 128.9 (2 × CH_{Ar}), 128.0 (CH_{Ar}), 128.0 (C_q), 127.8 (2 × CH_{Ar}), 126.4 (CH_{Ar}), 88.5 (CH_{Ar}), 52.0 (CH_2), 50.6 (CH_2), 19.2 (CH_3). IR (ATR diamond, cm^{-1}) ν: 3029, 2922, 1519, 1453, 1343, 1175, 1074, 924, 734, 696. HRMS (EI^+) *m/z* calcd for $C_{19}H_{19}N_4$ $[M+H]^+$: 303.1604, found: 303.1605.

4.2.6. 4-Benzyl-1-(4-(trifluoromethyl)benzyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**9**)

The reaction was carried out as described in general procedure **A** using 4-(trifluoromethyl)benzylamine (263 mg, 1.5 mmol, 3.0 eq.) as amine, 1-benzyl-3-pyrrolidinone (88 mg, 0.5 mmol, 1.0 eq.) as pyrrolidinone, 1-azido-4-nitrobenzene (410.2 mg, 2.5 mmol, 5.0 eq.), acetic acid (9 mg, 0.15 mmol, 0.3 eq.), and 50 mg molecular sieves (3 Å) in anhydrous toluene (0.25 M). The crude mixture was purified by flash chromatography on silica gel using first DCM and then (PE/EtOAc: 80/20) to afford **9** as a beige solid (91 mg, 51%). R_f = 0.13 (PE/EtOAc: 80/20). Mp 105–107 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.61 (d, *J* = 8.0 Hz, 2H), 7.41 (d, *J* = 8.0 Hz, 2H), 7.37–7.24 (m, 5H), 6.85 (d, *J* = 3.2 Hz, 1H), 5.68–5.63 (m, 3H), 5.26 (s, 2H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 150.9 (C_q), 139.1 (C_q), 136.8 (C_q), 131.32–130.24 (m, C_q and CH_{Ar}), 129.0 (2 × CH_{Ar}), 128.5 (2 × CH_{Ar}), 128.2 (CH_{Ar}), 127.9 (C_q), 127.9 (2 × CH_{Ar}), 126.00 (q, *J* = 3.7 Hz, 2 × CH_{Ar}), 124.03 (d, *J* = 272.2 Hz, C_q), 88.1 (CH_{Ar}), 53.0 (CH_2), 50.7 (CH_2). ^{19}F NMR (376 MHz, Chloroform-*d*): δ −62.7. IR (ATR diamond, cm^{-1}) ν: 2169, 1990, 1521, 1327, 1157, 1066, 1018, 819, 744, 715. HRMS (EI^+) *m/z* calcd for $C_{19}H_{16}F_3N_4$ $[M+H]^+$: 357.1322, found: 357.1323.

4.2.7. 4-Benzyl-1-(4-nitrobenzyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**10**)

The reaction was carried out as described in general procedure **A** using 4-nitrobenzyla mine hydrochloride (283 mg, 1.5 mmol, 3.0 eq.) as amine, 1-benzyl-3-pyrrolidinone (88 mg, 0.5 mmol, 1.0 eq.) as pyrrolidinone, 1-azido-4-nitrobenzene (410.2 mg, 2.5 mmol, 5.0 eq.), acetic acid (9 mg, 0.15 mmol, 0.3 eq.), and 50 mg molecular sieves (3 Å) in anhydrous toluene (0.25 M). The crude mixture was purified by flash chromatography on silica gel using first DCM and then (PE/EtOAc: 80/20) to afford **10** as a white solid (13 mg, 8%). R_f = 0.13 (PE/EtOAc: 80/20). Mp 123–125 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 8.21 (d,

J = 8.5 Hz, 2H), 7.44 (d, *J* = 8.5 Hz, 2H), 7.35–7.28 (m, 5H), 6.88 (d, *J* = 3.2 Hz, 1H), 5.74–5.67 (m, 3H), 5.27 (s, 2H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 150.9 (C_q), 148.1 (C_q), 142.3 (C_q), 136.7 (C_q), 131.1 (CH_{Ar}), 130.1 (C_q), 129.0 (2 × CH_{Ar}), 128.8 (2 × CH_{Ar}), 128.2 (CH_{Ar}), 127.9 (2 × CH_{Ar}), 124.3 (2 × CH_{Ar}), 87.9 (CH_{Ar}), 52.7 (CH_2), 50.8 (CH_2). IR (ATR diamond, cm^{-1}) ν: 3062, 2937, 2850, 1518, 1341, 1241, 1105, 932, 873, 783, 696, 619. HRMS (EI^+) *m/z* calcd for $C_{19}H_{16}N_5O_2$ $[M+H]^+$: 334.1299, found: 334.1297.

4.2.8. 4-Benzyl-1-(thiophen-2-ylmethyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**11**)

The reaction was carried out as described in general procedure **A** using 2-thiophèneme thylbenzylamine (170 mg, 1.5 mmol, 3.0 eq.) as amine, 1-benzyl-3-pyrrolidinone (88 mg, 0.5 mmol, 1.0 eq.) as pyrrolidinone, 1-azido-4-nitrobenzene (410.2 mg, 2.5 mmol, 5.0 eq.), acetic acid (9 mg, 0.15 mmol, 0.3 eq.), and 50 mg molecular sieves (3 Å) in anhydrous toluene (0.25 M). The crude mixture was purified by flash chromatography on silica gel using first DCM and then (PE/EtOAc: 80/20) to afford **11** as a brown solid (105 mg, 71%). R_f = 0.22 (PE/EtOAc: 80/20). Mp 65–67 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.31 (m, 6H), 7.16 (m, 1H), 7.02 (m, 1H), 6.85 (d, *J* = 3.2 Hz, 1H), 5.80 (s, 2H), 5.71 (d, *J* = 3.2 Hz, 1H), 5.27 (s, 2H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 150.8 (C_q), 136.9 (C_q), 136.7 (C_q), 130.5 (CH_{Ar}), 128.9 (2 × CH_{Ar}), 128.2 (CH_{Ar}), 128.1 (CH_{Ar}), 127.8 (2 × CH_{Ar}), 127.7 (C_q), 127.2 (CH_{Ar}), 126.7 (CH_{Ar}), 88.5 (CH_{Ar}), 50.6 (CH_2), 48.0 (CH_2). IR (ATR diamond, cm^{-1}) ν: 3101, 2918, 1600, 1520, 1360, 1273, 1172, 1029, 853, 751, 694. HRMS (EI+) *m/z* calcd for $C_{16}H_{15}N_4S$ $[M+H]^+$: 295.1012, found: 295.1013.

4.2.9. 4-Benzyl-1-(pyridin-2-ylmethyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**12**)

The reaction was carried out as described in general procedure **A** using pyridin-2-ylmethanamine (162 mg, 1.5 mmol, 3.0 eq.) as amine, 1-benzyl-3-pyrrolidinone (88 mg, 0.5 mmol, 1.0 eq.) as pyrrolidinone, 1-Azido-4-nitrobenzene (410.2 mg, 2.5 mmol, 5.0 eq.), acetic acid (9 mg, 0.15 mmol, 0.3 eq.), and 50 mg molecular sieves (3 Å) in anhydrous toluene (0.25 M). The crude mixture was purified by flash chromatography on silica gel using first DCM and then (PE/EtOAc: 80/20) to afford **12** as a yellow solid (101 mg, 70%). R_f = 0.22 (PE/EtOAc: 50/50). Mp 79–81 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 8.59 (dd, *J* = 5.0, 1.8 Hz, 1H), 7.61 (td, *J* = 7.7, 1.8 Hz, 1H), 7.34–7.25 (m, 5H), 7.21 (dd, *J* = 7.7, 5.0 Hz, 1H), 7.09 (d, *J* = 7.7 Hz, 1H), 6.85 (d, *J* = 3.2 Hz, 1H), 5.80 (d, *J* = 3.2 Hz, 1H), 5.74 (s, 2H), 5.25 (s, 2H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 155.2 (C_q), 150.8 (C_q), 149.5 (CH_{Ar}), 137.2 (CH_{Ar}), 136.8 (C_q), 130.6 (CH_{Ar}), 128.8 (2 × CH_{Ar}), 128.3 (C_q), 128.0 (CH_{Ar}), 127.8 (2 × CH_{Ar}), 123.1 (CH_{Ar}), 122.2 (CH_{Ar}), 88.5 (CH_{Ar}), 55.1 (CH_2), 50.6 (CH_2). IR (ATR diamond, cm^{-1}) ν: 3091, 3032, 2956, 2933, 2359, 1612, 1514, 1300, 1171, 1027, 832, 759. HRMS (EI^+) *m/z* calcd for $C_{17}H_{16}N_5$ $[M+H]^+$: 290.1400, found: 290.1405.

4.2.10. 4-Benzyl-1-propyl-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**14**)

The reaction was carried out as described in general procedure **A** using propylamine (89 mg, 1.5 mmol, 3.0 eq.) as amine, 1-benzyl-3-pyrrolidinone (88 mg, 0.5 mmol, 1.0 eq.) as pyrrolidinone, 1-azido-4-nitrobenzene (410.2 mg, 2.5 mmol, 5.0 eq.), acetic acid (9 mg, 0.15 mmol, 0.3 eq.), and 50 mg molecular sieves (3 Å) in anhydrous toluene (0.25 M). The crude mixture was purified by flash chromatography on silica gel using first DCM and then (PE/EtOAc: 80/20) to afford **14** as an orange oil (96 mg, 80%). R_f = 0.15 (PE/EtOAc: 80/20). ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.39–7.21 (m, 5H), 6.88 (d, *J* = 3.2 Hz, 1H), 5.96 (d, *J* = 3.2 Hz, 1H), 5.26 (s, 2H), 4.39 (t, *J* = 7.4 Hz, 2H), 1.99 (h, *J* = 7.4 Hz, 2H), 0.98 (t, *J* = 7.4 Hz, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 150.8 (C_q), 137.1 (C_q), 130.3 (CH_{Ar}), 128.9 (2 × CH_{Ar}), 128.0 (C_q and CH_{Ar}), 127.8 (2 × CH_{Ar}), 88.1 (CH_{Ar}), 51.4 (CH_2), 50.6 (CH_2), 23.0 (CH_2), 11.5 (CH_3). IR (ATR diamond, cm^{-1}) ν: 3031, 2956, 2933, 2875, 1733, 1519, 1355, 1268, 1144, 1026, 900, 731, 696. HRMS (EI^+) *m/z* calcd for $C_{14}H_{17}N_4$ $[M+H]^+$: 241.1448, found: 241.1448.

4.2.11. 4-Benzyl-1-isopropyl-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**15**)

The reaction was carried out as described in general procedure **A** using isopropylamine (89 mg, 1.5 mmol, 3.0 eq.) as amine, 1-benzyl-3-pyrrolidinone (88 mg, 0.5 mmol, 1.0 eq.) as pyrrolidinone, 1-azido-4-nitrobenzene (410.2 mg, 2.5 mmol, 5.0 eq.), acetic acid (9 mg, 0.15 mmol, 0.3 eq.), and 50 mg molecular sieves (3 Å) in anhydrous toluene (0.25 M). The crude mixture was purified by flash chromatography on silica gel using first DCM and then (PE/EtOAc: 80/20) to afford **15** as a brown oil (78 mg, 65%). R_f = 0.26 (PE/EtOAc: 80/20). ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.40–7.25 (m, 5H), 6.90 (d, *J* = 3.2 Hz, 1H), 6.00 (d, *J* = 3.2 Hz, 1H), 5.27 (s, 2H), 4.95 (hept, *J* = 6.8 Hz, 1H), 1.64 (d, *J* = 6.8 Hz, 6H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 150.8 (C_q), 137.0 (C_q), 129.9 (CH_{Ar}), 128.8 (2 × CH_{Ar}), 128.0 (CH_{Ar}), 127.8 (2 × CH_{Ar}), 126.2 (C_q), 88.7 (CH_{Ar}), 52.5 (CH), 50.5 (CH_2), 22.3 (2 × CH_3). IR (ATR diamond, cm^{-1}) ν: 3030, 2977, 2931, 1518, 1488, 1388, 1242, 1077, 1028, 727, 697. HRMS (EI+) *m/z* calcd for $C_{14}H_{17}N_4$ $[M+H]^+$: 241.1448, found: 241.1452.

4.2.12. 1-(4-Methoxybenzyl)-4-methyl-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**16**)

The reaction was carried out as described in general procedure **A** using 4-methoxybenz ylamine (206 mg, 1.5 mmol, 3.0 eq.) as amine, 1-methyl-3-pyrrolidinone (50 mg, 0.5 mmol, 1.0 eq.) as pyrrolidinone, 1-Azido-4-nitrobenzene (410.2 mg, 2.5 mmol, 5.0 eq.), acetic acid (9 mg, 0.15 mmol, 0.3 eq.), and 50 mg molecular sieves (3 Å) in anhydrous toluene (0.25 M). The crude mixture was purified by flash chromatography on silica gel using first DCM and then (PE/EtOAc: 80/20) to afford **16** as a yellow oil (58 mg, 48%). R_f = 0.17 (PE/EtOAc: 70/30). ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.26 (d, *J* = 8.6 Hz, 2H), 6.88 (d, *J* = 8.6 Hz, 2H), 6.76 (d, *J* = 3.1 Hz, 1H), 5.54 (d, *J* = 3.1 Hz, 1H), 5.52 (s, 2H), 3.79 (s, 3H), 3.77 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 159.7 (C_q), 151.0 (C_q), 131.3 (CH_{Ar}), 129.8 (2 × CH_{Ar}), 127.6 (C_q), 127.0 (C_q), 114.2 (2 × CH_{Ar}), 87.7 (CH_{Ar}), 55.3 (CH_3), 53.1 (CH_2), 33.0 (CH_3). IR (ATR diamond, cm^{-1}) ν: 2162, 2002, 1612, 1512, 1303, 1222, 1174, 1028, 819, 740, 702. HRMS (EI+) *m/z* calcd for $C_{13}H_{15}N_4O$ $[M+H]^+$: 243.1240, found: 243.1245.

*4.3. General Procedure (***B***) for the Bromination of C-6 Position of 1,4-dihydropyrrolo[2,3-d][1,2,3]triazole Derivatives* **17**–**21**

To a solution of corresponding 1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole derivative (1.0 eq.) in DCM (0.05 M) was added N-bromosuccinimide (1.0 eq.) and the mixture was stirred 1 h at room temperature. The resulting mixture was quenched using water and phases were separated. The aqueous phase was extracted with DCM and combined organic phases were washed with brine and dried over $MgSO_4$. After being concentrated under vacuum conditions, the residue was purified by flash chromatography on silica gel affording the desired 6-bromo-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole derivative.

4.3.1. 4-Benzyl-6-bromo-1-(4-Methoxybenzyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**17**)

The reaction was carried out as described in general procedure **B** using 4-benzyl-1-(4-methoxybenzyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **4** (67 mg, 0.21 mmol, 1.0 eq.), and NBS (39 mg, 0.21 mmol, 1.0 eq.) in DCM (0.05 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (80/20) to afford **17** as a beige solid (78 mg, 93%). R_f = 0.55 (PE/EtOAc: 70/30). Mp 88–90 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.38–7.27 (m, 7H), 6.85 (d, *J* = 8.7 Hz, 2H), 6.82 (s, 1H), 5.57 (s, 2H), 5.20 (s, 2H), 3.78 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 159.8 (C_q), 150.3 (C_q), 136.2 (C_q), 129.7 (2 × CH_{Ar}), 129.4 (CH_{Ar}), 129.1 (2 × CH_{Ar}), 128.4 (CH_{Ar}), 128.1 (2 × CH_{Ar}), 127.8 (C_q), 126.1 (C_q), 114.3 (2 × CH_{Ar}), 74.7 (C_q), 55.4 (O-CH_3), 52.5 (CH_2), 51.0 (CH_2). IR (ATR diamond, cm^{-1}) ν: 3098, 2934, 2858, 1612, 1463, 1280, 1027, 928, 759, 636. HRMS (EI+) *m/z* calcd for $C_{19}H_{18}BrN_4O$ $[M+H]^+$: 397.0659, found: 397.0655.

4.3.2. 4-Benzyl-6-bromo-1-(4-(trifluoromethyl)benzyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3] triazole (**18**)

The reaction was carried out as described in general procedure **B** using 4-benzyl-1-(4-(trifluoromethyl)benzyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **9** (241 mg, 0.68 mmol, 1.0 eq.), and NBS (130 mg, 0.68 mmol, 1.0 eq.) in DCM (0.05 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (80/20) to afford **18** as a yellow solid (257 mg, 87%). R_f = 0.70 (PE/EtOAc: 70/30). Mp 93–95 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.60 (d, *J* = 8.0 Hz, 2H), 7.48 (d, *J* = 8.0 Hz, 2H), 7.41–7.28 (m, 5H), 6.86 (s, 1H), 5.69 (s, 2H), 5.22 (s, 2H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 150.2 (C_q), 139.5 (C_q), 136.0 (C_q), 130.8 (d, *J* = 32.5 Hz, C_q), 129.7 (CH_{Ar}), 129. (2 × CH_{Ar}), 128.5 (CH_{Ar}), 128.4 (2 × CH_{Ar}), 128.1 (2 × CH_{Ar}), 126.2 (C_q), 126.0 (q, *J* = 3.8 Hz, 2 × CH_{Ar}), 124.0 (d, *J* = 272.2 Hz, C_q), 74.5 (C_q), 52.3 (CH_2), 51.0 (CH_2). ^{19}F NMR (376 MHz, Chloroform-*d*): δ −62.7. IR (ATR diamond, cm^{-1}) ν: 1323, 1155, 1111, 1066, 789, 776, 726, 698. HRMS (EI+) *m/z* calcd for $C_{19}H_{15}BrF_3N_4$ $[M+H]^+$: 435.0427, found: 435.0423.

4.3.3. 4-Benzyl-6-bromo-1-(thiophen-2-ylmethyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**19**)

The reaction was carried out as described in general procedure **B** using 4-benzyl-1-(thiophen-2-ylmethyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **11** (62 mg, 0.21 mmol, 1.0 eq.), and NBS (39 mg, 0.21 mmol, 1.0 eq.) in DCM (0.05 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (80/20) to afford **19** as a yellow pale solid (68 mg, 90%). R_f = 0.27 (PE/EtOAc: 80/20). Mp: 96–96 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.38–7.22 (m, 6H), 7.20–7.13 (m, 1H), 6.98–6.93 (m, 1H), 6.84 (s, 1H), 5.81 (s, 2H), 5.20 (s, 2H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 150.1 (C_q), 137.6 (C_q), 136.2 (C_q), 129.6 (CH_{Ar}), 129.1 (2 × CH_{Ar}), 128.5 (CH_{Ar}), 128.1 (2 × CH_{Ar}), 127.9 (CH_{Ar}), 127.2 (CH_{Ar}), 126.7 (CH_{Ar}), 126.0 (C_q), 74.8 (C_q), 51.0 (CH_2), 47.5 (CH_2). IR (ATR diamond, cm^{-1}) ν: 3107, 2164, 2015, 1516, 1334, 1180, 1070, 929, 748, 669. HRMS (EI+) *m/z* calcd for $C_{16}H_{14}BrN_4S$ $[M+H]^+$: 373.0117, found: 373.0114.

4.3.4. 4-Benzyl-6-bromo-1-isopropyl-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**20**)

The reaction was carried out as described in general procedure **B** using 4-benzyl-1-isopropyl-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **15** (50 mg, 0.21 mmol, 1.0 eq.), and NBS (39 mg, 0.21 mmol, 1.0 eq.) in DCM (0.05 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (80/20) to afford **20** as an orange oil (48 mg, 70%). R_f = 0.38 (PE/EtOAc: 80/20). ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.35–7.25 (m, 5H), 6.87 (s, 1H), 5.20 (s, 2H), 5.04 (hept, *J* = 6.8 Hz, 1H), 1.67 (d, *J* = 6.8 Hz, 6H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 150.3 (C_q), 136.2 (C_q), 129.0 (CH_{Ar}), 128.9 (2 × CH_{Ar}), 128.0 (CH_{Ar}), 127.9 (2 × CH_{Ar}), 124.9 (C_q), 74.6 (C_q), 52.9 (CH), 50.7 (CH_2), 22.8 (2 × CH_3). IR (ATR diamond, cm^{-1}) ν: 2978, 1512, 1454, 1344, 1178, 1145, 1126, 1062, 923, 729. HRMS (EI+) *m/z* calcd for $C_{14}H_{16}BrN_4$ $[M+H]^+$: 319.0553, found: 319.0554.

4.3.5. 6-bromo-1-(4-methoxybenzyl)-4-methyl-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**21**)

The reaction was carried out as described in general procedure **B** using 1-(4-meth oxybenzyl)-4-methyl-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **16** (51 mg, 0.21 mmol, 1.0 eq.), and NBS (39 mg, 0.21 mmol, 1.0 eq.) in DCM (0.05 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (80/20) to afford **21** as a white solid (61 mg, 90%). R_f = 0.30 (PE/EtOAc: 70/30). Mp 123–125 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.33 (d, *J* = 8.6 Hz, 2H), 6.85 (d, *J* = 8.6 Hz, 2H), 6.82 (s, 1H), 5.57 (s, 2H), 3.77 (s, 3H), 3.76 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 159.7 (C_q), 150.5 (C_q), 130.5 (CH_{Ar}), 129.6 (2 × CH_{Ar}), 127.9 (C_q), 126.0 (C_q), 114.3 (2 × CH_{Ar}), 73.8 (C_q), 55.4 (CH_3), 52.5 (CH_2), 33.4 (CH_3). IR (ATR diamond, cm^{-1}) ν: 2980, 2160, 1610, 1514, 1300, 1251, 1078, 1028, 948, 819, 750. HRMS (EI+) *m/z* calcd for $C_{13}H_{14}BrN_4O$ $[M+H]^+$: 321.0346, found: 321.0340.

*4.4. General Procedure (***C***): Suzuki–Miyaura Cross-Coupling in C-6 Position of 6-bromo-1,4-dihydropyrrolo[2,3-d][1,2,3]triazole Derivative* **22**–**33**

A solution of corresponding 6-bromo-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole derivative (1.0 eq.), potassium phosphate tribasic (2.0 eq.), and corresponding aryl boronic acid (1.5 eq.) in dry 1,4-dioxane (0.15 M) was degassed by argon bubbling for 15 min. Pd $(OAc)_2$ (0.03 eq.) and RuPhos (0.06 eq.) were added and the mixture was heated at 120 °C for 1 h under microwave irradiation. The reaction mixture was filtered through a pad of celite, and the filtrate was reduced to dryness under vacuum. The residue was taken up in DCM, washed with water and dried over $MgSO_4$. After being concentrated under vacuum conditions, the residue was purified by flash chromatography on silica gel affording the desired *6-Arylated* 1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole derivative.

4.4.1. 4-Benzyl-1-(4-methoxybenzyl)-6-(p-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**22**)

The reaction was carried out as described in general procedure **C** using 4-benzyl-6-bromo-1-(4-methoxybenzyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **17** (70 mg, 0.18 mmol, 1.0 eq.), *p*-tolyl boronic acid (37 mg, 0.27 mmol, 1.5 eq.), potassium phosphate tribasic (76 mg, 0.36 mmol, 2.0 eq.), Pd $(OAc)_2$ (1.21 mg, 0.0054 mmol, 0.03 eq.), and RuPhos (5 mg, 0.011 mmol, 0.06 eq.) in dry 1,4-dioxane (0.15 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (70/30) to afford **22** as a white solid (66 mg, 90%). R_f = 0.25 (PE/EtOAc: 70/30). Mp 91–93 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.37 (m, 4H), 7.34–7.29 (m, 1H), 7.21 (d, *J* = 8.1 Hz, 2H), 7.15 (d, *J* = 8.1 Hz, 2H), 7.06 (d, *J* = 8.7 Hz, 2H), 6.97 (s, 1H), 6.75 (d, *J* = 8.7 Hz, 2H), 5.67 (s, 2H), 5.31 (s, 2H), 3.76 (s, 3H), 2.38 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 159.4 (C_q), 151.4 (C_q), 136.8 (C_q), 136.2 (C_q), 130.4 (C_q), 129.5 (2 × CH_{Ar}), 129.0 (2 × CH_{Ar}), 128.8 (2 × CH_{Ar}), 128.2 (C_q), 128.2 (CH_{Ar}), 128.0 (2 × CH_{Ar}), 127.4 (2 × CH_{Ar}), 127.4 (CH_{Ar}), 125.8 (C_q), 114.1 (2 × CH_{Ar}), 107.2 (C_q), 55.4 (CH_3), 53.1 (CH_2), 50.7 (CH_2), 21.2 (CH_3). IR (ATR diamond, cm^{-1}) ν: 2930, 2835, 1611, 1535, 1245, 1174, 1071, 945, 733, 597. HRMS (EI+) *m/z* calcd for $C_{26}H_{25}N_4O$ $[M+H]^+$: 409.2023, found: 409.2021.

4.4.2. 4-Benzyl-1-(4-methoxybenzyl)-6-phenyl-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**23**)

The reaction was carried out as described in general procedure **C** using 4-benzyl-6-bromo-1-(4-methoxybenzyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **17** (70 mg, 0.18 mmol, 1.0 eq.), phenyl boronic acid (33 mg, 0.27 mmol, 1.5 eq.), potassium phosphate tribasic (76 mg, 0.36 mmol, 2.0 eq.), $Pd(OAc)_2$ (1.21 mg, 0.0054 mmol, 0.03 eq.), and RuPhos (5 mg, 0.011 mmol, 0.06 eq.) in dry 1,4-dioxane (0.15 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (70/30) to afford **23** as a white solid (65 mg, 92%). R_f = 0.47 (PE/EtOAc: 70/30). Mp 127–129 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.36–7.20 (m, 10H), 7.01 (d, *J* = 8.3 Hz, 2H), 6.96 (s, 1H), 6.74 (d, *J* = 8.3 Hz, 2H), 5.65 (s, 2H), 5.29 (s, 2H), 3.73 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 159.4 (C_q), 151.5 (C_q), 136.7 (C_q), 133.4 (C_q), 129.0 (2 × CH_{Ar}), 128.9 (2 × CH_{Ar}), 128.8 (2 × CH_{Ar}), 128.2 (CH_{Ar}), 128.2 (C_q), 128.1 (2 × CH_{Ar}), 127.5 (3 × CH_{Ar}), 126.6 (CH_{Ar}), 125.7 (C_q), 114.2 (2 × CH_{Ar}), 107.3 (C_q), 55.4 (CH_3), 53.1 (CH_2), 50.7 (CH_2). IR (ATR diamond, cm^{-1}) ν: 2162, 2009, 1512, 1348, 1300, 1251, 1026, 908, 792, 669, 582. HRMS (EI+) *m/z* calcd for $C_{25}H_{23}N_4O$ $[M+H]^+$: 395.1866, found: 395.1865.

4.4.3. 4-Benzyl-1-(4-methoxybenzyl)-6-(4-methoxyphenyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**24**)

The reaction was carried out as described in general procedure **C** using 4-benzyl-6-bromo-1-(4-methoxybenzyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **17** (70 mg, 0.18 mmol, 1.0 eq.), *p*-methoxyphenyl boronic acid (41 mg, 0.27 mmol, 1.5 eq.), potassium phosphate tribasic (76 mg, 0.36 mmol, 2.0 eq.), Pd $(OAc)_2$ (1.21 mg, 0.0054 mmol, 0.03 eq.), and RuPhos (5 mg, 0.011 mmol, 0.06 eq.) in dry 1,4-dioxane (0.15 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (70/30) to afford **24** as a beige solid (37 mg, 48%). R_f = 0.37 (PE/EtOAc: 70/30). Mp 87–89 °C. ^{1}H NMR

(400 MHz, Chloroform-*d*): δ 7.38–7.27 (m, 5H), 7.20 (d, *J* = 8.7 Hz, 2H), 7.02 (d, *J* = 8.7 Hz, 2H), 6.89 (s, 1H), 6.86 (d, *J* = 8.7 Hz, 2H), 6.75 (d, *J* = 8.7 Hz, 2H), 5.62 (s, 2H), 5.28 (s, 2H), 3.82 (s, 3H), 3.74 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 159.4 (C_q), 158.6 (C_q), 151.4 (C_q), 136.9 (C_q), 129.0 (2 × CH_{Ar}), 128.8 (2 × CH_{Ar}), 128.8 (2 × CH_{Ar}), 128.2 (C_q), 128.1 (CH_{Ar}), 128.0 (2 × CH_{Ar}), 127.1 (CH_{Ar}), 125.9 (C_q), 125.8 (C_q), 114.3 (2 × CH_{Ar}), 114.1 (2 × CH_{Ar}), 106.8 (C_q), 55.5 (CH_3), 55.3 (CH_3), 53.0 (CH_2), 50.6 (CH_2). IR (ATR diamond, cm^{-1}) ν: 2924, 2167, 2029, 1514, 1300, 1176, 1028, 948, 835, 785, 736, 675, 592. HRMS (EI+) *m/z* calcd for $C_{26}H_{25}N_4O_2$ $[M+H]^+$: 425.1972, found: 425.1967.

4.4.4. 4-Benzyl-1-(4-methoxybenzyl)-6-(m-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**25**)

The reaction was carried out as described in general procedure **C** using 4-benzyl-6-bromo-1-(4-Methoxybenzyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **22** (70 mg, 0.18 mmol, 1.0 eq.), *m*-tolyl boronic acid (37 mg, 0.27 mmol, 1.5 eq.), potassium phosphate tribasic (76 mg, 0.36 mmol, 2.0 eq.), Pd $(OAc)_2$ (1.21 mg, 0.0054 mmol, 0.03 eq.), and RuPhos (5 mg, 0.011 mmol, 0.06 eq.) in dry 1,4-dioxane (0.15 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (70/30) to afford **25** as a yellow oil (54 mg, 73%). R_f = 0.25 (PE/EtOAc: 70/30). ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.37–7.27 (m, 5H), 7.24–7.18 (m, 1H), 7.13–7.08 (m, 2H), 7.07–7.01 (m, 3H), 6.97 (s, 1H), 6.79–6.74 (d, *J* = 8.7 Hz, 2H), 5.66 (s, 2H), 5.30 (s, 2H), 3.74 (s, 3H), 2.31 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 159.4 (C_q), 151.5 (C_q), 138.4 (C_q), 136.8 (C_q), 133.2 (C_q), 129.0 (2 × CH_{Ar}), 128.7 (CH_{Ar}), 128.7 (2 × CH_{Ar}), 128.2 (C_q), 128.2 (CH_{Ar}), 128.1 (CH_{Ar}), 128.0 (2 × CH_{Ar}), 127.5 (CH_{Ar}), 127.3 (CH_{Ar}), 125.7 (C_q), 124.5 (CH_{Ar}), 114.2 (2 × CH_{Ar}), 107.4 (C_q), 55.4 (CH_3), 53.1 (CH_2), 50.7 (CH_2), 21.5 (CH_3). IR (ATR diamond, cm^{-1}) ν: 3034, 2920, 1608,1531, 1506, 1350, 1246, 1029, 914, 779. HRMS (EI+) *m/z* calcd for $C_{26}H_{25}N_4O$ $[M+H]^+$: 409.2023, found: 409.2020.

4.4.5. 4-Benzyl-1-(4-methoxybenzyl)-6-(o-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**26**)

The reaction was carried out as described in general procedure **C** using 4-benzyl-6-bromo-1-(4-Methoxybenzyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **17** (70 mg, 0.18 mmol, 1.0 eq.), *o*-tolyl boronic acid (37 mg, 0.27 mmol, 1.5 eq.), potassium phosphate tribasic (76 mg, 0.36 mmol, 2.0 eq.), Pd $(OAc)_2$ (1.21 mg, 0.0054 mmol, 0.03 eq.), and RuPhos (5 mg, 0.011 mmol, 0.06 eq.) in dry 1,4-dioxane (0.15 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (70/30) to afford **26** as a yellow oil (24 mg, 33%). R_f = 0.25 (PE/EtOAc: 70/30). ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.35–7.28 (m, 5H), 7.25–7.20 (m, 2H), 7.18–7.12 (m, 1H), 7.10–7.06 (m, 1H), 6.77 (d, *J* = 8.7 Hz, 2H), 6.75 (s, 1H), 6.61 (d, *J* = 8.7 Hz, 2H), 5.36 (s, 2H), 5.28 (s, 2H), 3.72 (s, 3H), 2.10 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 159.4 (C_q), 149.0 (C_q), 137.1 (C_q), 137.0 (C_q), 132.6 (C_q), 131.1 (CH_{Ar}), 130.2 (CH_{Ar}), 129.4 (2 × CH_{Ar}), 129.0 (2 × CH_{Ar}), 128.6 (CH_{Ar}), 128.1 (CH_{Ar}), 127.9 (2 × CH_{Ar}), 127.8 (C_q), 127.6 (CH_{Ar}), 126.9 (C_q), 125.7 (CH_{Ar}), 113.9 (2 × CH_{Ar}), 105.0 (C_q), 55.4 (CH_3), 52.9 (CH_2), 50.7 (CH_2), 20.6 (CH_3). IR (ATR diamond, cm^{-1}) ν: 2924, 1610, 1454, 1348, 1246, 1157, 1029, 796, 768. HRMS (EI+) *m/z* calcd for $C_{26}H_{25}N_4O$ $[M+H]^+$: 409.2023, found: 409.2019.

4.4.6. 4-Benzyl-1-(4-methoxybenzyl)-6-(4-(trifluoromethyl)phenyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**28**)

The reaction was carried out as described in general procedure **C** using 4-benzyl-6-bromo-1-(4-methoxybenzyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **17** (70 mg, 0.18 mmol, 1.0 eq.), 4-(trifluoromethyl)phenyl boronic acid (51 mg, 0.27 mmol, 1.5 eq.), potassium phosphate tribasic (76 mg, 0.36 mmol, 2.0 eq.), Pd $(OAc)_2$ (1.21 mg, 0.0054 mmol, 0.03 eq.), and RuPhos (5 mg, 0.011 mmol, 0.06 eq.) in dry 1,4-dioxane (0.15 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (70/30) to afford **28** as a yellow solid (47 mg, 57%). R_f = 0.42 (PE/EtOAc: 70/30). Mp 111–113 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.53 (d, *J* = 8.1 Hz, 2H), 7.40–7.29 (m, 7H), 7.04 (s, 1H), 7.00 (d, *J* = 8.7 Hz, 2H), 6.76 (d, *J* = 8.7 Hz, 2H), 5.67 (s, 2H), 5.31 (s, 2H),

3.73 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 159.5 (C_q), 151.7 (C_q), 137.1 (C_q), 136.4 (C_q), 129.1 (2 × CH_{Ar}), 128.5 (2 × CH_{Ar}), 128.4 (CH_{Ar}), 128.2 (C_q), 128.1 (2 × CH_{Ar}), 128.0 (CH_{Ar}), 127.8 (C_q), 127.3 (2 × CH_{Ar}), 125.8 (q, *J* = 3.8 Hz, 2 × CH_{Ar}), 125.4 (C_q), 121.7 (d, *J* = 272.0 Hz, C_q), 114.3 (2 × CH_{Ar}), 106.1 (C_q), 55.4 (CH_3), 53.4 (CH_2), 50.9 (CH_2). ^{19}F NMR (376 MHz, Chloroform-*d*): δ −62.31. IR (ATR diamond, cm^{-1}) ν: 2931, 2179, 1980, 1612, 1514, 1325, 1251, 1101, 1016, 925, 839, 694. HRMS (EI+) *m/z* calcd for $C_{26}H_{22}F_3N_4O$ $[M+H]^+$: 463.1740, found: 463.1741.

4.4.7. 4-Benzyl-1-(4-methoxybenzyl)-6-(thiophen-3-yl)1,4-dihydropyrrolo[2,3-*d*][1,2,3] triazole (**29**)

The reaction was carried out as described in general procedure **C** using 4-benzyl-6-bromo-1-(4-methoxybenzyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **17** (50 mg, 0.126 mmol, 1.0 eq.), 3-thienyl boronic acid (25 mg, 0.189 mmol, 1.5 eq.), potassium phosphate tribasic (54 mg, 0.253 mmol, 2.0 eq.), Pd $(OAc)_2$ (0.9 mg, 0.004 mmol, 0.03 eq.), and RuPhos (3.5 mg, 0.008 mmol, 0.06 eq.) in dry 1,4-dioxane (0.15 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (70/30) to afford **29** as a yellow oil (30 mg, 60%). R_f = 0.33 (PE/EtOAc: 70/30). ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.40–7.30 (m, 6H), 7.04 (m, 4H), 6.99 (s, 1H), 6.80 (d, *J* = 8.2 Hz, 2H), 5.68 (s, 2H), 5.30 (s, 2H), 3.76 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 159.4 (C_q), 151.2 (C_q), 136.7 (C_q), 133.6 (C_q), 129.0 (2 × CH_{Ar}), 128.6 (2 × CH_{Ar}), 128.2 (CH_{Ar}), 128.1 (C_q), 128.0 (2 × CH_{Ar}), 127.7 (CH_{Ar}), 127.5 (CH_{Ar}), 126.2 (C_q), 125.7 (C_q), 119.9 (CH_{Ar}), 114.2 (2 × CH_{Ar}), 102.0 (C_q), 55.3 (CH_3), 52.9 (CH_2), 50.7 (CH_2). IR (ATR diamond, cm^{-1}) ν: 2926, 2837, 1961, 1610, 1512, 1340, 1246, 1149, 1029, 848, 794, 648. HRMS (EI+) *m/z* calcd for $C_{23}H_{20}N_4OS$ $[M+H]^+$: 401.1431, found: 401.1433.

4.4.8. 4-(4-Benzyl-1-(4-methoxybenzyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazol-6-yl)phenol (**30**)

The reaction was carried out as described in general procedure **C** using 4-benzyl-6-bromo-1-(4-Methoxybenzyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **17** (70 mg, 0.18 mmol, 1.0 eq.), *p*-hydroxyphenyl boronic acid (37 mg, 0.27 mmol, 1.5 eq.), potassium phosphate tribasic (76 mg, 0.36 mmol, 2.0 eq.), Pd $(OAc)_2$ (1.21 mg, 0.0054 mmol, 0.03 eq.), and RuPhos (5 mg, 0.011 mmol, 0.06 eq.) in dry 1,4-dioxane (0.15 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (70/30) to afford **30** as an orange solid (21 mg, 29%). R_f = 0.20 (PE/EtOAc: 70/30). Mp 175–177 °C. ^{1}H NMR (400 MHz, Acetone-d_6) δ 8.31 (bs, 1H), 7.42 (d, *J* = 7.0 Hz, 2H), 7.38–7.25 (m, 6H), 7.02 (d, *J* = 8.6 Hz, 2H), 6.85 (d, *J* = 8.5 Hz, 2H), 6.77 (d, *J* = 8.6 Hz, 2H), 5.68 (s, 2H), 5.32 (s, 2H), 3.71 (s, 3H). ^{13}C NMR (101 MHz, Acetone-d_6): δ 160.3 (C_q), 157.0 (C_q), 152.1 (C_q), 138.7 (C_q), 129.7 (C_q), 129.5 (4 × CH_{Ar}), 129.4 (2 × CH_{Ar}), 128.7 (2 × CH_{Ar}), 128.6 (CH_{Ar}), 128.1 (CH_{Ar}), 126.3 (C_q), 125.7 (C_q), 116.5 (2 × CH_{Ar}), 114.7 (2 × CH_{Ar}), 107.6 (C_q), 55.5 (CH_3), 53.4 (CH_2), 51.0 (CH_2). IR (ATR diamond, cm^{-1}) ν: 2952, 2924, 1612, 1512, 1249, 1175, 1029, 839, 779, 657. HRMS (EI+) *m/z* calcd for $C_{25}H_{23}N_4O_2$ $[M+H]^+$: 411.1816, found: 411.1814.

4.4.9. 4-Benzyl-1-(thiophen-2-ylmethyl)-6-(p-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**31**)

The reaction was carried out as described in general procedure **C** using 4-benzyl-6-bromo-1-(thiophen-2-ylmethyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **19** (203 mg, 0.54 mmol, 1.0 eq.), *p*-tolyl boronic acid (111 mg, 0.82 mmol, 1.5 eq.), potassium phosphate tribasic (236 mg, 1.09 mmol, 2.0 eq.), Pd $(OAc)_2$ (3.7 mg, 0.02 mmol, 0.03 eq.), and RuPhos (16 mg, 0.03 mmol, 0.06 eq.) in dry 1,4-dioxane (0.15 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (80/20) to afford **31** as a yellow oil (191 mg, 91%). R_f = 0.18 (PE/EtOAc: 80/20). ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.35–7.25 (m, 7H), 7.20–7.15 (m, 3H), 6.96 (s, 1H), 6.86–6.82 (m, 1H), 6.81–6.78 (m, 1H), 5.86 (s, 2H), 5.29 (s, 2H), 2.37 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 151.4 (C_q), 138.3 (C_q), 136.8 (C_q), 136.4 (C_q), 130.4 (C_q), 129.7 (2 × CH_{Ar}), 129.0 (2 × CH_{Ar}), 128.2 (CH_{Ar}), 128.0 (2 × CH_{Ar}), 127.5 (CH_{Ar}), 127.4 (2 × CH_{Ar}), 127.0 (CH_{Ar}), 126.9 (CH_{Ar}), 126.2 (CH_{Ar}), 125.5 (C_q), 107.2 (C_q), 50.7 (CH_2), 48.5 (CH_2), 21.3 (CH_3). IR (ATR diamond, cm^{-1}) ν: 2927,

2156, 1535, 1514, 1435, 1344, 1232, 1180, 929, 852, 792, 748, 619, 578. HRMS (EI+) *m/z* calcd for $C_{23}H_{21}N_4S$ $[M+H]^+$: 385.1481, found: 385.1483.

4.4.10. 4-Benzyl-6-(*p*-tolyl)-1-(4-(trifluoromethyl)benzyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3] triazole (**32**)

The reaction was carried out as described in general procedure **C** using 4-benzyl-6-bromo-1-(4-(trifluoromethyl)benzyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **18** (100 mg, 0.23 mmol, 1.0 eq.), *p*-tolyl boronic acid (48 mg, 0.34 mmol, 1.5 eq.), potassium phosphate tribasic (98 mg, 0.46 mmol, 2.0 eq.), Pd $(OAc)_2$ (1.6 mg, 0.007 mmol, 0.03 eq.), and RuPhos (6.5 mg, 0.014 mmol, 0.06 eq.) in dry 1,4-dioxane (0.15 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (80/20) to afford **32** as a white solid (85 mg, 83%). R_f = 0.36 (PE/EtOAc: 80/20). Mp 143–145 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.48 (d, *J* = 8.0 Hz, 2H), 7.38–7.28 (m, 5H), 7.18 (d, *J* = 8.0 Hz, 2H), 7.15–7.07 (m, 4H), 6.96 (s, 1H), 5.74 (s, 2H), 5.29 (s, 2H), 2.34 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 151.4 (C_q), 140.0 (C_q), 136.6 (C_q), 136.5 (C_q), 130.36 (d, *J* = 32.6 Hz, C_q), 130.1 (C_q), 129.6 (2 × CH_{Ar}), 129.0 (2 × CH_{Ar}), 128.3 (CH_{Ar}), 128.1 (2 × CH_{Ar}), 127.8 (2 × CH_{Ar}), 127.7 (CH_{Ar}), 127.3 (2 × CH_{Ar}), 125.9 (C_q), 125.8 (q, *J* = 3.8 Hz, 2 × CH_{Ar}), 124.0 (d, *J* = 272.2 Hz, C_q), 107.1 (C_q), 53.0 (CH_2), 50.8 (CH_2), 21.2 (CH_3). ^{19}F NMR (376 MHz, Chloroform-*d*): δ −62.7. IR (ATR diamond, cm^{-1}) ν: 2916, 2848, 2160, 1512, 1325, 1159, 1112, 1066, 1016, 933, 823, 702, 628. HRMS (EI+) *m/z* calcd for $C_{26}H_{21}F_3N_4$ $[M+H]^+$: 447.1791, found: 447.1793.

4.4.11. 4-Benzyl-1-isopropyl-6-(*p*-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**33**)

The reaction was carried out as described in general procedure **C** using 4-benzyl-6-bromo-1-isopropyl-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **20** (130 mg, 0.41 mmol, 1.0 eq.), *p*-tolyl boronic acid (84 mg, 0.61 mmol, 1.5 eq.), potassium phosphate tribasic (173 mg, 0.82 mmol, 2.0 eq.), Pd $(OAc)_2$ (2.7 mg, 0.012 mmol, 0.03 eq.), and RuPhos (11.4 mg, 0.0024 mmol, 0.06 eq.) in dry 1,4-dioxane (0.15 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (80/20) to afford **33** as a yellow oil (110 mg, 82%). R_f = 0.23 (PE/EtOAc: 80/20). ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.38–7.17 (m, 9H), 6.91 (s, 1H), 5.26 (s, 2H), 4.87 (hept, *J* = 6.8 Hz, 1H), 2.37 (s, 3H), 1.60 (d, *J* = 6.8 Hz, 6H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 151.1 (C_q), 136.9 (C_q), 136.3 (C_q), 130.8 (C_q), 129.5 (2 × CH_{Ar}), 128.8 (2 × CH_{Ar}), 128.0 (CH_{Ar}), 128.0 (2 × CH_{Ar}), 127.7 (2 × CH_{Ar}), 127.2 (CH_{Ar}), 125.3 (C_q), 106.9 (C_q), 52.7 (CH), 50.6 (CH_2), 22.8 (2 × CH_3), 21.2 (CH_3). IR (ATR diamond, cm^{-1}) ν: 2981, 2920, 1573, 1535, 1512, 1452, 1348, 1174, 1157, 10101, 1028, 921, 821, 786. HRMS (EI+) *m/z* calcd for $C_{21}H_{23}N_4$ $[M+H]^+$: 331.1917, found: 331.1915.

4.4.12. 1-(4-Methoxybenzyl)-4-methyl-6-(*p*-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**34**)

The reaction was carried out as described in general procedure **C** using 6-bromo-1-(4-Methoxybenzyl)-4-methyl-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **21** (58 mg, 0.18 mmol, 1.0 eq.), *p*-tolyl boronic acid (37 mg, 0.27 mmol, 1.5 eq.), potassium phosphate tribasic (76 mg, 0.36 mmol, 2.0 eq.), Pd $(OAc)_2$ (1.21 mg, 0.0054 mmol, 0.03 eq.), and RuPhos (5 mg, 0.011 mmol, 0.06 eq.) in dry 1,4-dioxane (0.15 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (1000/0) to 70/30) to afford **34** as a white solid (39 mg, 65%). R_f = 0.11 (PE/EtOAc: 70/30). Mp 115–117 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.19 (d, *J* = 8.1 Hz, 2H), 7.14 (d, *J* = 8.1 Hz, 2H), 7.01 (d, *J* = 8.7 Hz, 2H), 6.92 (s, 1H), 6.75 (d, *J* = 8.7 Hz, 2H), 5.64 (s, 2H), 3.83 (s, 3H), 3.74 (s, 3H), 2.37 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 159.4 (C_q), 151.7 (C_q), 136.2 (C_q), 130.5 (C_q), 129.6 (2 × CH_{Ar}), 128.7 (2 × CH_{Ar}), 128.5 (CH_{Ar}), 128.3 (C_q), 127.4 (2 × CH_{Ar}), 125.6 (C_q), 114.2 (2 × CH_{Ar}), 106.6 (C_q), 55.4 (O-CH_3), 53.1 (CH_2), 33.2 (N-CH_3), 21.3 (CH_3). IR (ATR diamond, cm^{-1}) ν: 2160, 2015, 1612, 1514, 1249, 1190, 1049, 1018, 815, 754. HRMS (EI+) *m/z* calcd for $C_{20}H_{21}N_4O$ $[M+H]^+$: 333.1710, found: 333.1705.

*4.5. General Procedure (***D***) for the Bromination of C-5 Position of C-6 Arylated 1,4-dihydropyrrolo[2,3-d][1,2,3]triazole Derivatives* **35**–**39**

To a solution of corresponding 1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole derivative (1.0 eq.) in DCM (0.015 M) was added N-bromosuccinimide (1.0 eq.), and the mixture was stirred 1 h at room temperature. The resulting mixture was quenched using water and phases were separated. The aqueous phase was extracted with DCM and combined organic phases were washed with brine and dried over $MgSO_4$. After being concentrated under vacuum conditions, the residue was purified by flash chromatography on silica gel affording the desired bis 5-bromo-6-Aryl-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole derivative.

4.5.1. 4-Benzyl-5-bromo-1-(4-Methoxybenzyl)-6-(p-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**35**)

The reaction was carried out as described in general procedure **D** using 4-benzyl-1-(4-methoxybenzyl)-6-(p-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **22** (100 mg, 0.245 mmol, 1.0 eq.) and NBS (47 mg, 0.245 mmol, 1.0 eq.) in DCM (0.015 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (70/30) to afford **35** as a white solid (100 mg, 86%). R_f = 0.28 (PE/EtOAc: 70/30). Mp 127–129 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.43–7.36 (m, 2H), 7.36–7.24 (m, 3H), 7.20 (s, 4H), 6.86 (d, *J* = 8.5 Hz, 2H), 6.68 (d, *J* = 8.5 Hz, 2H), 5.45 (s, 2H), 5.40 (s, 2H), 3.73 (s, 3H), 2.41 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 159.4 (C_q), 149.2 (C_q), 137.4 (C_q), 136.6 (C_q), 129.8 (2 × CH_{Ar}), 129.3 (2 × CH_{Ar}), 129.2 (2 × CH_{Ar}), 129.0 (C_q), 128.9 (2 × CH_{Ar}), 128.1 (2 × CH_{Ar}), 128.0 (CH_{Ar}), 127.7 (C_q), 125.2 (C_q), 114.1 (2 × CH_{Ar}), 113.5 (C_q), 106.8 (C_q), 55.4 (CH_3), 52.8 (CH_2), 49.4 (CH_2), 21.4 (CH_3). IR (ATR diamond, cm^{-1}) ν: 2996, 1610, 1537, 1513, 1337, 1243, 1179, 833, 799. HRMS (EI+) *m/z* calcd for $C_{26}H_{24}BrN_4O$ $[M+H]^+$: 487.1128, found: 487.1126.

4.5.2. 4-Benzyl-5-bromo-6-(*p*-tolyl)-1-(4-(trifluoromethyl)benzyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3] triazole (**36**)

The reaction was carried out as described in general procedure **D** using 4-benzyl-6-(*p*-tolyl)-1-(4-(trifluoromethyl)benzyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **32** (85 mg, 0.19 mmol, 1.0 eq.), and NBS (36 mg, 0.19 mmol, 1.0 eq.) in DCM (0.015 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (80/20) to afford **36** as a white solid (80 mg, 80%). R_f = 0.45 (PE/EtOAc: 80/20). Mp 157–159 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.45–7.38 (m, 4H), 7.37–7.28 (m, 3H), 7.17 (d, *J* = 8.0 Hz, 2H), 7.13 (d, *J* = 8.0 Hz, 2H), 7.02 (d, *J* = 8.0 Hz, 2H), 5.57 (s, 2H), 5.42 (s, 2H), 2.40 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 149.1 (C_q), 139.4 (C_q), 137.6 (C_q), 136.4 (C_q), 130.43 (d, *J* = 32.5 Hz, C_q), 129.7 (2 × CH_{Ar}), 129.4 (2 × CH_{Ar}), 128.9 (2 × CH_{Ar}), 128.8 (C_q), 128.1 (CH_{Ar}), 128.1 (2 × CH_{Ar}), 128.0, (2 × CH_{Ar}), 125.7 (q, *J* = 3.7 Hz, 2 × CH_{Ar}), 125.4 (C_q), 124.0 (d, *J* = 271.6 Hz, C_q), 113.9 (C_q), 106.7 (C_q), 52.7 (CH_2), 49.5 (CH_2), 21.4 (CH_3). ^{19}F NMR (376 MHz, Chloroform-*d*): δ −62.7. IR (ATR diamond, cm^{-1}) ν: 2925, 2175, 1927, 1514, 1465, 1421, 1323, 1190, 933, 825, 792, 721. HRMS (EI+) *m/z* calcd for $C_{26}H_{20}BrF_3N_4$ $[M+H]^+$: 525.0896, found: 525.0894.

4.5.3. 4-Benzyl-5-bromo-1-(thiophen-2-ylmethyl)-6-(p-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**37**)

The reaction was carried out as described in general procedure **D** using 4-Benzyl-1-(thiophen-2-ylmethyl)-6-(p-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **31** (160 mg, 0.41 mmol, 1.0 eq.), and NBS (78 mg, 0.41 mmol, 1.0 eq.) in DCM (0.015 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (80/20) to afford **37** as a white solid (170 mg, 90%). R_f = 0.22 (PE/EtOAc: 90/10). Mp 128–130 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.42–7.36 (m, 2H), 7.34–7.23 (m, 7H), 7.16–7.13 (m, 1H), 6.83–6.74 (m, 1H), 6.63–6.58 (m, 1H), 5.69 (s, 2H), 5.41 (s, 2H), 2.42 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 149.1 (C_q), 137.6 (C_q), 137.5 (C_q), 136.5 (C_q), 129.7 (2 × CH_{Ar}), 129.5 (2 × CH_{Ar}), 129.0 (C_q), 128.9 (2 × CH_{Ar}), 128.1 (3 × CH_{Ar}), 127.2

(CH_{Ar}), 126.9 (CH_{Ar}), 126.4 (CH_{Ar}), 125.0 (C_q), 113.6 (C_q), 106.8 (C_q), 49.5 (CH_2), 47.9 (CH_2), 21.4 (CH_3). IR (ATR diamond, cm^{-1}) ν: 2162, 1980, 1514, 1460, 1334, 1182, 1056, 1029, 906, 831, 740, 665, 611, 590. HRMS (EI+) *m/z* calcd for $C_{23}H_{20}BrN_4S$ $[M+H]^+$: 463.0587, found: 463.0590.

4.5.4. 4-Benzyl-5-bromo-1-isopropyl-6-(*p*-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**38**)

The reaction was carried out as described in general procedure **D** using 4-Benzyl-1-isopropyl-6-(*p*-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **33** (90 mg, 0.27 mmol, 1.0 eq.), and NBS (52 mg, 0.27 mmol, 1.0 eq.) in DCM (0.015 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (80/20) to afford **38** as a white solid (100 mg, 90%). R_f = 0.51 (PE/EtOAc: 80/20). Mp 127–129 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.48–7.42 (m, 2H), 7.38–7.26 (m, 7H), 5.45 (s, 2H), 4.74 (p, *J* = 6.7 Hz, 1H), 2.44 (s, 3H), 1.50 (d, *J* = 6.7 Hz, 6H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 148.9 (C_q), 137.5 (C_q), 136.7 (C_q), 130.0 (2 × CH_{Ar}), 129.6 (C_q), 129.4 (2 × CH_{Ar}), 128.8 (2 × CH_{Ar}), 128.1 (2 × CH_{Ar}), 128.0 (CH_{Ar}), 124.7 (C_q), 113.4 (C_q), 106.6 (C_q), 52.7 (CH_3), 49.4 (CH_2), 22.6 (2 × CH_3), 21.4 (CH_3). IR (ATR diamond, cm^{-1}) ν: 3058, 2988, 1509, 1454, 1341, 1156, 1109, 1066, 788, 711. HRMS (EI+) *m/z* calcd for $C_{21}H_{22}BrN_4$ $[M+H]^+$: 409.1022, found: 409.1024.

4.5.5. 5-bromo-1-(4-Methoxybenzyl)-4-methyl-6-(*p*-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**39**)

The reaction was carried out as described in general procedure **D** using 1-(4-Methoxybe nzyl)-4-methyl-6-(*p*-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **34** (60 mg, 0.18 mmol, 1.0 eq.) and NBS (34 mg, 0.18 mmol, 1.0 eq.) in DCM (0.015 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (70/30) to afford **39** as a white solid (70 mg, 95%). R_f = 0.33 (PE/EtOAc: 70/30). Mp 153–155 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.24–7.14 (m, 4H), 6.84 (d, *J* = 8.7 Hz, 2H), 6.68 (d, *J* = 8.7 Hz, 2H), 5.45 (s, 2H), 3.83 (s, 3H), 3.73 (s, 3H), 2.42 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 159.4 (C_q), 149.5 (C_q), 137.3 (C_q), 129.7 (2 × CH_{Ar}), 129.3 (2 × CH_{Ar}), 129.1 (C_q), 129.0 (2 × CH_{Ar}), 127.8 (C_q), 124.9 (C_q), 114.2 (C_q), 114.1 (2 × CH_{Ar}), 106.3 (C_q), 55.4 (O-CH_3), 52.8 (CH_2), 32.4 (N-CH_3), 21.4 (CH_3). IR (ATR diamond, cm^{-1}) ν: 2160, 2015, 1612, 1514, 1249, 1190, 1049, 1018, 815, 764, 754. HRMS (EI+) *m/z* calcd for $C_{20}H_{20}BrN_4O$ $[M+H]^+$: 411.0815, found: 411.0813.

4.6. General Procedure (**E**)*: Suzuki–Miyaura Cross-Coupling in C-5 Position of 5-bromo-6-aryl-1,4-dihydropyrrolo[2,3-d][1,2,3]triazole Derivative* **40**–**53**

A solution of corresponding 5-bromo-6-aryl-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole derivative (1.0 eq.), potassium phosphate tribasic (2.0 eq.), and corresponding aryl boronic acid (1.5 eq.) in dry 1,4-dioxane (0.15 M) was degassed by argon bubbling for 15 min. Pd $(OAc)_2$ (0.03 eq.) and RuPhos (0.06 eq.) were added and the mixture was heated at 120 °C for 1 h under microwave irradiation. The reaction mixture was filtered through a pad of celite, and the filtrate was reduced to dryness under vacuum. The residue was taken up in DCM, washed with water and dried over $MgSO_4$. After being concentrated under vacuum conditions, the residue was purified by flash chromatography on silica gel affording the desired 5,6-arylated 1,4-dihydropyrrolo[2,3-*d*][1,2,3] triazole derivative.

4.6.1. 4-Benzyl-1-(4-methoxybenzyl)-5,6-di-*p*-tolyl-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**40**)

The reaction was carried out as described in general procedure **E** using 4-Benzyl-5-bromo-1-(4-Methoxybenzyl)-6-(p-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **35** (80 mg, 0.16 mmol, 1.0 eq.), *p*-tolyl boronic acid (34 mg, 0.25 mmol, 1.5 eq.), potassium phosphate tribasic (70 mg, 0.33 mmol, 2.0 eq.), Pd $(OAc)_2$ (1.1 mg, 0.005 mmol, 0.03 eq.), and RuPhos (4.6 mg, 0.010 mmol, 0.06 eq.) in dry 1,4-dioxane (0.15 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (70/30) to afford **40** as a white solid (61 mg, 75%). R_f = 0.23 (PE/EtOAc: 70/30). Mp 125–127 °C. ^{1}H NMR

(400 MHz, Chloroform-*d*): δ 7.25–7.17 (m, 3H), 7.13–7.03 (m, 6H), 7.00 (d, *J* = 7.8 Hz, 2H), 6.95–6.90 (m, 4H), 6.70 (d, *J* = 8.2 Hz, 2H), 5.52 (s, 2H), 5.19 (s, 2H), 3.72 (s, 3H), 2.33 (s, 3H), 2.30 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 159.3 (C_q), 140.4 (C_q), 138.4 (C_q), 137.7 (C_q), 135.9 (C_q), 131.1 (2 × CH_{Ar}), 130.3 (C_q), 129.8 (2 × CH_{Ar}), 129.2 (2 × CH_{Ar}), 129.1 (2 × CH_{Ar}), 129.0 (2 × CH_{Ar}), 128.6 (2 × CH_{Ar}), 128.3 (C_q), 128.0 (C_q), 127.6 (2 × CH_{Ar}), 127.5 (CH_{Ar}), 126.7 (C_q), 114.0 (2 × CH_{Ar}), 104.6 (C_q), 55.3 (CH_3), 52.6 (CH_2), 48.3 (CH_2), 21.5 (CH_3), 21.3 (CH_3). IR (ATR diamond, cm^{-1}) ν: 3028, 2927, 1509, 1513, 1329, 1244, 1179, 1049, 948, 924, 754. HRMS (EI+) *m/z* calcd for $C_{33}H_{31}N_4O$ $[M+H]^+$: 499.2492, found: 499.247.

4.6.2. 4-Benzyl-1-(4-methoxybenzyl)-5-(m-tolyl)-6-(p-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**41**)

The reaction was carried out as described in general procedure **E** using 4-Benzyl-5-bromo-1-(4-Methoxybenzyl)-6-(p-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **35** (40 mg, 0.08 mmol, 1.0 eq.), *m*-tolyl boronic acid (17 mg, 0.12 mmol, 1.5 eq.), potassium phosphate tribasic (35 mg, 0.16 mmol, 2.0 eq.), Pd $(OAc)_2$ (0.67 mg, 0.003 mmol, 0.03 eq.), and RuPhos (2.80 mg, 0.006 mmol, 0.06 eq.) in dry 1,4-dioxane (0.15 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (70/30) to afford **41** as a white solid (40 mg, 97%). R_f = 0.35 (PE/EtOAc: 70/30). Mp 147–149 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.28–7.12 (m, 7H), 7.02 (d, *J* = 7.9 Hz, 2H), 7.00–6.92 (m, 6H), 6.74 (d, *J* = 8.6 Hz, 2H), 5.55 (s, 2H), 5.21 (s, 2H), 3.76 (s, 3H), 2.33 (s, 3H), 2.27 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 159.3 (C_q), 151.3 (C_q), 140.5 (C_q), 138.0 (C_q), 137.8 (C_q), 135.9 (C_q), 131.9 (CH_{Ar}), 130.9 (C_q), 130.3 (C_q), 129.8 (2 × CH_{Ar}), 129.3 (CH_{Ar}), 129.2 (2 × CH_{Ar}), 129.0 (2 × CH_{Ar}), 128.6 (2 × CH_{Ar}), 128.5 (CH_{Ar}), 128.3 (CH_{Ar}), 128.3 (C_q), 127.7 (2 × CH_{Ar}), 127.6 (CH_{Ar}), 126.7 (C_q), 114.0 (2 × CH_{Ar}), 104.7 (C_q), 55.4 (CH_3), 52.7 (CH_2), 48.5 (CH_2), 21.5 (CH_3), 21.3 (CH_3). IR (ATR diamond, cm^{-1}) ν: 2008, 1513, 1328, 1189, 1072, 983, 926, 783, 737, 589. HRMS (EI+) *m/z* calcd for $C_{33}H_{31}N_4O$ $[M+H]^+$: 499.2492, found: 499.2495.

4.6.3. 4-Benzyl-1-(4-methoxybenzyl)-5-(o-tolyl)-6-(p-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**42**)

The reaction was carried out as described in general procedure **E** using 4-Benzyl-5-bromo-1-(4-Methoxybenzyl)-6-(p-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **35** (40 mg, 0.08 mmol, 1.0 eq.), *o*-tolyl boronic acid (17 mg, 0.12 mmol, 1.5 eq.), potassium phosphate tribasic (35 mg, 0.16 mmol, 2.0 eq.), Pd $(OAc)_2$ (0.67 mg, 0.003 mmol, 0.03 eq.), and RuPhos (2.80 mg, 0.006 mmol, 0.06 eq.) in dry 1,4-dioxane (0.15 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (80/20) to afford **42** as a white solid (36 mg, 88%). R_f = 0.45 (PE/EtOAc: 80/20). Mp 102–104 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.31–7.24 (m, 1H), 7.23–7.08 (m, 6H), 7.03–6.92 (m, 6H), 6.88 (d, *J* = 7.8 Hz, 2H), 6.72 (d, *J* = 8.3 Hz, 2H), 5.56 (q, ABX, 2H), 5.05 (s, 2H), 3.73 (s, 3H), 2.27 (s, 3H), 1.70 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 159.3 (C_q), 151.0 (C_q), 139.1 (C_q), 138.9 (C_q), 137.3 (C_q), 135.8 (C_q), 132.1 (CH_{Ar}), 130.5 (C_q), 130.4 (C_q), 130.3 (CH_{Ar}), 129.3 (CH_{Ar}), 129.2 (2 × CH_{Ar}), 129.1 (2 × CH_{Ar}), 129.0 (2 × CH_{Ar}), 128.5 (2 × CH_{Ar}), 128.2 (C_q), 128.1 (2 × CH_{Ar}), 127.6 (CH_{Ar}), 126.4 (C_q), 125.7 (CH_{Ar}), 114.0 (2 × CH_{Ar}), 105.1 (C_q), 55.3 (CH_3), 52.7 (CH_2), 48.2 (CH_2), 21.2 (CH_3), 19.7 (CH_3). IR (ATR diamond, cm^{-1}) ν: 2162, 2046, 1992, 1517, 1436, 1253, 1186, 1031, 815, 698, 553. HRMS (EI+) *m/z* calcd for $C_{33}H_{31}N_4O$ $[M+H]^+$: 499.2492, found: 499.2491.

4.6.4. 4-(Benzyl-1-(4-Methoxybenzyl)-5-phenyl-6-(*p*-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**43**)

The reaction was carried out as described in general procedure **E** using 4-Benzyl-5-bromo-1-(4-Methoxybenzyl)-6-(p-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **35** (40 mg, 0.08 mmol, 1.0 eq.), phenyl boronic acid (15 mg, 0.12 mmol, 1.5 eq.), potassium phosphate tribasic (35 mg, 0.16 mmol, 2.0 eq.), Pd $(OAc)_2$ (0.67 mg, 0.003 mmol, 0.03 eq.), and RuPhos

(2.80 mg, 0.006 mmol, 0.06 eq.) in dry 1,4-dioxane (0.15 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (70/30) to afford **43** as a white solid (30 mg, 76%). R_f = 0.30 (PE/EtOAc: 70/30). Mp 166–168 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.36–7.28 (m, 3H), 7.27–7.17 (m, 5H), 7.13–7.07 (m, 2H), 7.03 (d, *J* = 7.8 Hz, 2H), 7.00–6.92 (m, 4H), 6.74 (d, *J* = 8.4 Hz, 2H), 5.56 (s, 2H), 5.23 (s, 2H), 3.76 (s, 3H), 2.33 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 159.3 (C_q), 151.3 (C_q), 140.2 (C_q), 137.6 (C_q), 136.0 (C_q), 131.3 (2 × CH_{Ar}), 131.0 (C_q), 130.2 (C_q), 129.8 (2 × CH_{Ar}), 129.2 (2 × CH_{Ar}), 129.0 (2 × CH_{Ar}), 128.6 (2 × CH_{Ar}), 128.5 (CH_{Ar}), 128.5 (2 × CH_{Ar}), 128.2 (C_q), 127.6 (2 × CH_{Ar}), 127.5 (CH_{Ar}), 126.7 (C_q), 114.0 (2 × CH_{Ar}), 104.9 (C_q), 55.4 (CH_3), 52.7 (CH_2), 48.4 (CH_2), 21.3 (CH_3). IR (ATR diamond, cm^{-1}) ν: 2960, 2160, 1610, 1514, 1354, 1249, 1193, 1028, 918, 771, 736. HRMS (EI+) *m/z* calcd for $C_{32}H_{29}N_4O$ $[M+H]^+$: 485.2336, found: 485.2367.

4.6.5. 4-(Benzyl-1-(4-methoxybenzyl)-5-(4-methoxyphenyl)-6-(p-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**44**)

The reaction was carried out as described in general procedure **E** using 4-Benzyl-5-bromo-1-(4-Methoxybenzyl)-6-(p-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **35** (40 mg, 0.08 mmol, 1.0 eq.), 4-methoxyphenyl boronic acid (19 mg, 0.12 mmol, 1.5 eq.), potassium phosphate tribasic (35 mg, 0.16 mmol, 2.0 eq.), Pd $(OAc)_2$ (0.67 mg, 0.003 mmol, 0.03 eq.), and RuPhos (2.80 mg, 0.006 mmol, 0.06 eq.) in dry 1,4-dioxane (0.15 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (70/30) to afford **44** as a white solid (35 mg, 83%). R_f = 0.17 (PE/EtOAc: 80/20). Mp 159–161 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.27–7.20 (m, 3H), 7.14–7.05 (m, 4H), 7.01 (d, *J* = 7.8 Hz, 2H), 6.98–6.91 (m, 4H), 6.82 (d, *J* = 8.3 Hz, 2H), 6.72 (d, *J* = 8.2 Hz, 2H), 5.52 (s, 2H), 5.19 (s, 2H), 3.80 (s, 3H), 3.73 (s, 3H), 2.31 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 159.7 (C_q), 159.3 (C_q), 151.1 (C_q), 140.2 (C_q), 137.8 (C_q), 135.8 (C_q), 132.5 (2 × CH_{Ar}), 130.4 (C_q), 129.8 (2 × CH_{Ar}), 129.2 (2 × CH_{Ar}), 129.0 (2 × CH_{Ar}), 128.6 (2 × CH_{Ar}), 128.3 (C_q), 127.6 (2 × CH_{Ar}), 127.5 (CH_{Ar}), 126.7 (C_q), 123.2 (C_q), 114.0 (2 × CH_{Ar}), 113.9 (2 × CH_{Ar}), 104.6 (C_q), 55.3 (2 × CH_3), 52.6 (CH_2), 48.3 (CH_2), 21.3 (CH_3). IR (ATR diamond, cm^{-1}) ν: 2918, 2162, 2015, 1514, 1431, 1178, 1026, 815, 777, 731, 698. HRMS (EI+) *m/z* calcd for $C_{33}H_{31}N_4O$ $[M+H]^+$: 515.2441, found: 515.2443.

4.6.6. 4-(Benzyl-1-(4-methoxybenzyl)-6-(p-tolyl)- 5-(4-(trifluoromethyl)phenyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**45**)

The reaction was carried out as described in general procedure **E** using 4-Benzyl-5-bromo-1-(4-Methoxybenzyl)-6-(p-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **35** (40 mg, 0.08 mmol, 1.0 eq.), 4-(trifluoromethyl)phenyl boronic acid (24 mg, 0.12 mmol, 1.5 eq.), potassium phosphate tribasic (35 mg, 0.16 mmol, 2.0 eq.), Pd $(OAc)_2$ (0.67 mg, 0.003 mmol, 0.03 eq.), and RuPhos (2.80 mg, 0.006 mmol, 0.06 eq.) in dry 1,4-dioxane (0.15 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (70/30) to afford **45** as a white solid (40 mg, 88%). R_f = 0.16 (PE/EtOAc: 80/20). Mp 135–137 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.53 (d, *J* = 8.0 Hz, 2H), 7.29–7.20 (m, 5H), 7.08–7.01 (m, 4H), 6.95–6.87 (m, 4H), 6.70 (d, *J* = 8.2 Hz, 2H), 5.52 (s, 2H), 5.21 (s, 2H), 3.73 (s, 3H), 2.33 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 159.4 (C_q), 151.7 (C_q), 138.4 (C_q), 137.3 (C_q), 136.6 (C_q), 134.8 (C_q), 131.5 (2 × CH_{Ar}), 130.4 (d, *J* = 32.6 Hz, C_q), 129.9 (2 × CH_{Ar}), 129.6 (C_q), 129.3 (2 × CH_{Ar}), 129.2 (2 × CH_{Ar}), 128.8 (2 × CH_{Ar}), 128.0 (C_q), 127.8 (CH_{Ar}), 127.4 (2 × CH_{Ar}), 126.6 (C_q), 125.4 (q, *J* = 3.5 Hz, C_q), 123.88 (d, *J* = 234.4 Hz, 2 × CH_{Ar}), 114.0 (2 × CH_{Ar}), 105.8 (C_q), 55.4 (CH_3), 52.7 (CH_2), 48.7 (CH_2), 21.3 (CH_3). IR (ATR diamond, cm^{-1}) ν: 2929, 2158, 1977, 1612, 1512, 1317, 1163, 1058, 817, 669. HRMS (EI+) *m/z* calcd for $C_{33}H_{28}F_3N_4O$ $[M+H]^+$: 553.2210, found: 553.2211.

4.6.7. 4-(Benzyl-1-(4-methoxybenzyl)-5-(4-nitrophenyl)-6-(p-tolyl)-1,4-dihydropyrrolo [2,3-*d*][1,2,3]triazole (**46**)

The reaction was carried out as described in general procedure **E** using 4-Benzyl-5-bromo-1-(4-Methoxybenzyl)-6-(p-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **35** (40 mg,

0.08 mmol, 1.0 eq.), 4-nitrophenyl boronic acid (21 mg, 0.12 mmol, 1.5 eq.), potassium phosphate tribasic (35 mg, 0.16 mmol, 2.0 eq.), Pd $(OAc)_2$ (0.67 mg, 0.003 mmol, 0.03 eq.), and RuPhos (2.8 mg, 0.006 mmol, 0.06 eq.) in dry 1,4-dioxane (0.15 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (70/30) to afford **46** as a white solid (21 mg, 48%). R_f = 0.19 (PE/EtOAc: 80/20). Mp 77–79 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 8.13 (d, *J* = 8.4 Hz, 2H), 7.31 (d, *J* = 8.4 Hz, 2H), 7.25–7.24 (m, 3H), 7.10–7.04 (m, 4H), 6.91 (m, 4H), 6.73 (d, *J* = 8.2 Hz, 2H), 5.54 (s, 2H), 5.28 (s, 2H), 3.76 (s, 3H), 2.36 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 159.5 (C_q), 152.2 (C_q), 147.4 (C_q), 137.8 (C_q), 137.5 (C_q), 137.1 (C_q), 137.0 (C_q), 131.9 (2 × CH_{Ar}), 130.0 (2 × CH_{Ar}), 129.5 (2 × CH_{Ar}), 129.2 (2 × CH_{Ar}), 129.2 (C_q), 128.9 (2 × CH_{Ar}), 128.0 (CH_{Ar}), 127.8 (2 × C_q), 127.2 (2 × CH_{Ar}), 126.7 (C_q), 123.7 (2 × CH_{Ar}), 114.1 (2 × CH_{Ar}), 106.7 (C_q), 55.4 (CH_3), 52.8 (CH_2), 48.9 (CH_2), 21.3 (CH_3). IR (ATR diamond, cm^{-1}) ν: 2922, 2850, 2160, 1598, 1344, 1246, 1176, 1029, 802. HRMS (EI+) *m/z* calcd for $C_{33}H_{28}N_5O_3$ $[M+H]^+$: 530.2187, found: 530.2186.

4.6.8. 4-(Benzyl-1-(4-methoxybenzyl)-6-(p-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazol-5-yl)phenol (**47**)

The reaction was carried out as described in general procedure **E** using 4-Benzyl-5-bromo-1-(4-Methoxybenzyl)-6-(p-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **35** (40 mg, 0.08 mmol, 1.0 eq.), 4-hydroxyphenyl boronic acid (17 mg, 0.12 mmol, 1.5 eq.), potassium phosphate tribasic (35 mg, 0.16 mmol, 2.0 eq.), $Pd(OAc)_2$ (0.67 mg, 0.003 mmol, 0.03 eq.), and RuPhos (2.80 mg, 0.006 mmol, 0.06 eq.) in dry 1,4-dioxane (0.15 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (70/30) to afford **47** as a white solid (20 mg, 49%). R_f = 0.08 (PE/EtOAc: 80/20). Mp 195–197 °C. ^{1}H NMR (400 MHz, Acetone-d_6): δ 8.69 (bs, 1H), 7.26–7.17 (m, 3H), 7.13–7.02 (m, 8H), 6.90 (d, *J* = 8.3 Hz, 2H), 6.83 (d, *J* = 8.2 Hz, 2H), 6.73 (d, *J* = 8.3 Hz, 2H), 5.55 (s, 2H), 5.22 (s, 2H), 3.71 (s, 3H), 2.29 (s, 3H). ^{13}C NMR (101 MHz, Acetone-d_6): δ 160.3 (C_q), 158.7 (C_q), 151.7 (C_q), 141.0 (C_q), 139.0 (C_q), 136.4 (C_q), 133.4 (2 × CH_{Ar}), 131.5 (C_q), 130.6 (2 × CH_{Ar}), 129.8 (2 × CH_{Ar}), 129.7 (2 × CH_{Ar}), 129.5 (C_q), 129. (2 × CH_{Ar}), 128.2 (CH_{Ar}), 128.1 (2 × CH_{Ar}), 127.1 (C_q), 122.8 (C_q), 116.2 (2 × CH_{Ar}), 114.6 (2 × CH_{Ar}), 105.2 (C_q), 55.5 (CH_3), 53.0 (CH_2), 48.6 (CH_2), 21.1 (CH_3). IR (ATR diamond, cm^{-1}) ν: 2177, 2031, 1971, 1612, 1454, 1064, 1026, 927, 794, 759, 723, 696. HRMS (EI+) *m/z* calculated for $C_{32}H_{29}N_4O_2$ $[M+H]^+$: 501.2285, found: 501.2285.

4.6.9. 4-Benzyl-1-(4-methoxybenzyl)-5-(4-((tetrahydro-2H-pyran-2-yl)oxy)phenyl)6-(*p*-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazol-5-yl) (**48**)

The reaction was carried out as described in general procedure **E** using 4-Benzyl-5-bromo-1-(4-Methoxybenzyl)-6-(p-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **35** (40 mg, 0.08 mmol, 1.0 eq.), 4-(2-tetrahydropyranyloxy)phenylboronic acid (27 mg, 0.12 mmol, 1.5 eq.), potassium phosphate tribasic (35 mg, 0.16 mmol, 2.0 eq.), $Pd(OAc)_2$ (0.67 mg, 0.003 mmol, 0.03 eq.), and RuPhos (2.80 mg, 0.006 mmol, 0.06 eq.) in dry 1,4-dioxane (0.15 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (70/30) to afford **48** as a white solid (46 mg, 96%). R_f = 0.10 (PE/EtOAc: 80/20). Mp 167–169 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.28–7.17 (m, 3H), 7.17–7.04 (m, 4H), 7.04–6.89 (m, 8H), 6.71 (d, *J* = 8.3 Hz, 2H), 5.52 (s, 2H), 5.39 (m, 1H), 5.19 (s, 2H), 3.92 (m, 1H), 3.73 (s, 3H), 3.62 (m, 1H), 2.31 (s, 3H), 1.99 (m, 1H), 1.86 (m, 2H), 1.71–1.57 (m, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 159.3 (C_q), 157.3 (C_q), 151.0 (C_q), 140.2 (C_q), 137.7 (C_q), 135.8 (C_q), 132.4 (2 × CH_{Ar}), 130.3 (C_q), 129.8 (2 × CH_{Ar}), 129.1 (2 × CH_{Ar}), 129.0 (2 × CH_{Ar}), 128.6 (2 × CH_{Ar}), 128.3 (C_q), 127.6 (2 × CH_{Ar}), 127.5 (CH_{Ar}), 126.7 (C_q), 124.0 (C_q), 116.3 (2 × CH_{Ar}), 114.0 (2 × CH_{Ar}), 104.6 (C_q), 96.6 (CH), 62.5 (CH_2), 55.3 (CH_3), 52.6 (CH_2), 48.3 (CH_2), 30.5 (CH_2), 25.2 (CH_2), 21.3 (CH_3), 19.0 (CH_2). IR (ATR diamond, cm^{-1}) ν: 2941, 2166, 1608, 1514, 1467, 1244, 1172, 1020, 918, 817. HRMS (EI+) *m/z* calcd for $C_{37}H_{37}N_4O_3$ $[M+H]^+$: 585.2860, found: 585.2862.

4.6.10. 4-Benzyl-1-(4-methoxybenzyl)-5-(thiophen-3-yl)-6-(p-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3] triazole (**49**)

The reaction was carried out as described in general procedure **E** using 4-Benzyl-5-bromo-1-(4-Methoxybenzyl)-6-(p-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **35** (40 mg, 0.08 mmol, 1.0 eq.), 3-thienyl boronic acid (16 mg, 0.12 mmol, 1.5 eq.), potassium phosphate tribasic (35 mg, 0.16 mmol, 2.0 eq.), $Pd(OAc)_2$ (0.67 mg, 0.003 mmol, 0.03 eq.), and RuPhos (2.80 mg, 0.006 mmol, 0.06 eq.) in dry 1,4-dioxane (0.15 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (70/30) to afford **49** as a white solid (22 mg, 55%). R_f = 0.27 (PE/EtOAc: 80/20). Mp 121–123 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.28–7.20 (m, 4H), 7.13 (d, *J* = 7.2 Hz, 2H), 7.05 (m, 3H), 6.97–6.90 (m, 4H), 6.81 (d, *J* = 5.0 Hz, 1H), 6.71 (d, *J* = 8.3 Hz, 2H), 5.52 (s, 2H), 5.25 (s, 2H), 3.73 (s, 3H), 2.33 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 159.3 (C_q), 151.2 (C_q), 137.8 (C_q), 136.2 (C_q), 135.0 (C_q), 131.2 (C_q), 130.2 (C_q), 129.7 (2 × CH_{Ar}), 129.5 (CH_{Ar}), 129.1 (2 × CH_{Ar}), 129.1 (2 × CH_{Ar}), 128.7 (2 × CH_{Ar}), 128.2 (C_q), 127.6 (CH_{Ar}), 127.4 (2 × CH_{Ar}), 126.5 (CH_{Ar}), 126.5 (C_q), 125.8 (CH_{Ar}), 114.0 (2 × CH_{Ar}), 105.2 (C_q), 55.3 (CH_3), 52.7 (CH_2), 48.4 (CH_2), 21.3 (CH_3). IR (ATR diamond, cm^{-1}): δ 159.3 (C_q), 151.2 (C_q), 137.8 (C_q), 136.2 (C_q), 135.0 (C_q), 131.2 (C_q), 130.2 (C_q), 129.7 (2 × CH_{Ar}), 129.5 (CH_{Ar}), 129.1 (2 × CH_{Ar}), 129.1 (2 × CH_{Ar}), 128.7 (2 × CH_{Ar}), 128.2 (C_q), 127.6 (CH_{Ar}), 127.4 (2 × CH_{Ar}), 126.5 (CH_{Ar}), 126.5 (C_q), 125.8 (CH_{Ar}), 114.0 (2 × CH_{Ar}), 105.2 (C_q), 55.3 (CH_3), 52.7 (CH_2), 48.4 (CH_2), 21.3 (CH_3). IR (ATR diamond, cm^{-1}) ν: 2929, 2158, 1982, 1612, 1514, 1327, 1249, 1182, 1029, 788, 752, 696, 640. HRMS (EI+) *m/z* calcd for $C_{30}H_{27}N_4OS$ $[M+H]^+$: 491.1900, found: 491.1803.

4.6.11. 4-Benzyl-1-(thiophen-2-ylmethyl)-5,6-di-*p*-tolyl-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**50**)

The reaction was carried out as described in general procedure **E** using 4-Benzyl-5-bromo-1-(thiophen-2-ylmethyl)-6-(p-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **37** (100 mg, 0.22 mmol, 1.0 eq.), *p*-tolyl boronic acid (46 mg, 0.33 mmol, 1.5 eq.), potassium phosphate tribasic (94 mg, 0.44 mmol, 2.0 eq.), $Pd(OAc)_2$ (1.5 mg, 0.007 mmol, 0.03 eq.), and RuPhos (6.2 mg, 0.013 mmol, 0.06 eq.) in dry 1,4-dioxane (0.15 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (80/20) to afford **50** as a white solid (100 mg, 96%). R_f = 0.33 (PE/EtOAc: 80/20). Mp 158–160 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.25–6.99 (m, 14H), 6.83–6.78 (m, 1H), 6.66–6.63 (m, 1H), 5.76 (s, 2H), 5.19 (s, 2H), 2.35 (s, 3H), 2.32 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 151.1 (C_q), 140.6 (C_q), 138.5 (C_q), 138.3 (C_q), 137.7 (C_q), 136.0 (C_q), 131.1 (2 × CH_{Ar}), 130.4 (C_q), 129.7 (2 × CH_{Ar}), 129.3 (2 × CH_{Ar}), 129.2 (2 × CH_{Ar}), 128.6 (2 × CH_{Ar}), 127.9 (C_q), 127.6 (2 × CH_{Ar}), 127.6 (CH_{Ar}), 127.1 (CH_{Ar}), 126.9 (CH_{Ar}), 126.5 (C_q), 126.2 (CH_{Ar}), 104.7 (C_q), 48.4 (CH_2), 47.8 (CH_2), 21.5 (CH_3), 21.3 (CH_3). IR (ATR diamond, cm^{-1}) ν: 2978, 1512, 1496, 1454, 1344, 1178, 1145, 1126, 1062, 923, 729, 680. HRMS (EI+) *m/z* calcd for $C_{30}H_{27}N_4S$ $[M+H]^+$: 475.1951, found: 475.1955.

4.6.12. 4-Benzyl-5,6-di-*p*-tolyl-1-(4-(trifluoromethyl)benzyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**51**)

The reaction was carried out as described in general procedure **E** using 4-Benzyl-5-bromo-6-(*p*-tolyl)-1-(4-(trifluoromethyl)benzyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **36** (60 mg, 0.114 mmol, 1.0 eq.), *p*-tolyl boronic acid (24 mg, 0.171 mmol, 1.5 eq.), potassium phosphate tribasic (49 mg, 0.228 mmol, 2.0 eq.), $Pd(OAc)_2$ (0.8 mg, 0.003 mmol, 0.03 eq.), and RuPhos (3.2 mg, 0.007 mmol, 0.06 eq.) in dry 1,4-dioxane (0.15 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (70/30) to afford **51** as a white solid (41 mg, 70%). R_f = 0.36 (PE/EtOAc: 70/30). Mp 177–179 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.43 (d, *J* = 8.0 Hz, 2H), 7.25–7.18 (m, 3H), 7.09 (m, 8H, H-9), 6.97 (d, *J* = 7.8 Hz, 2H), 6.86 (d, *J* = 7.8 Hz, 2H), 5.63 (s, 2H), 5.21 (s, 2H), 2.34 (s, 3H), 2.29 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 151.2 (C_q), 140.8 (C_q), 140.0 (C_q), 138.6 (C_q), 137.6 (C_q), 136.1 (C_q), 131.1 (2 × CH_{Ar}), 130.1 (C_q), 129.9 (d,

J = 29.6 Hz, C_q), 129.7 (2 × CH_{Ar}), 129.3 (2 × CH_{Ar}), 129.1 (2 × CH_{Ar}), 128.7 (2 × CH_{Ar}), 128.0 (2 × CH_{Ar}), 127.8 (C_q), 127.6 (3 × CH_{Ar}), 126.9 (C_q), 125.6 (q, J = 3.7 Hz, 2 × CH_{Ar}), 124.1 (d, J = 272.1 Hz, C_q), 104.6 (C_q), 52.6 (CH_2), 48.4 (CH_2), 21.5 (CH_3), 21.2 (CH_3). ^{19}F NMR (376 MHz, Chloroform-*d*): δ −62.7. IR (ATR diamond, cm^{-1}) ν: 2196, 2025, 1514, 1323, 1122, 1066, 931, 794, 678, 586. HRMS (EI+) *m/z* calcd for $C_{33}H_{27}F_3N_4$ $[M+H]^+$: 537.2260, found: 537.2262.

4.6.13. 4-Benzyl-1-isopropyl-5,6-di-*p*-tolyl-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**52**)

The reaction was carried out as described in general procedure **E** using 4-Benzyl-5-bromo-1-isopropyl-6-(*p*-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **38** (70 mg, 0.171 mmol, 1.0 eq.), *p*-tolyl boronic acid (35 mg, 0.257 mmol, 1.5 eq.), potassium phosphate tribasic (73 mg, 0.342 mmol, 2.0 eq.), $Pd(OAc)_2$ (1.2 mg, 0.005 mmol, 0.03 eq.), and RuPhos (4.8 mg, 0.01 mmol, 0.06 eq.) in dry 1,4-dioxane (0.15 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (80/20) to afford **52** as a white solid (56 mg, 78%). R_f = 0.51 (PE/EtOAc: 80/20). Mp 137–139 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.26–7.01 (m, 13H), 5.20 (s, 2H), 4.78 (*p*, J = 6.7 Hz, 1H), 2.34 (s, 3H), 2.30 (s, 3H), 1.52 (d, J = 6.7 Hz, 6H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 150.9 (C_q), 140.3 (C_q), 138.3 (C_q), 137.8 (C_q), 136.0 (C_q), 131.2 (2 × CH_{Ar}), 130.8 (C_q), 130.0 (2 × CH_{Ar}), 129.2 (2 × CH_{Ar}), 129.1 (2 × CH_{Ar}), 128.6 (2 × CH_{Ar}), 128.1 (C_q), 127.7 (2 × CH_{Ar}), 127.5 (CH_{Ar}), 126.3 (C_q), 104.6 (C_q), 52.4 (CH), 48.4 (CH_2), 22.7 (2 × CH_3), 21.5 (CH_3), 21.3 (CH_3). IR (ATR diamond, cm^{-1}): δ 150.9 (C_q), 140.3 (C_q), 138.3 (C_q), 137.8 (C_q), 136.0 (C_q), 131.2 (2 × CH_{Ar}), 130.8 (C_q), 130.0 (2 × CH_{Ar}), 129.2 (2 × CH_{Ar}), 129.1 (2 × CH_{Ar}), 128.6 (2 × CH_{Ar}), 128.1 (C_q), 127.7 (2 × CH_{Ar}), 127.5 (CH_{Ar}), 126.3 (C_q), 104.6 (C_q), 52.4 (CH), 48.4 (CH_2), 22.7 (2 × CH_3), 21.5 (CH_3), 21.3 (CH_3). IR (ATR diamond, cm^{-1}) ν: 2980, 2160, 1514, 1350, 1199, 1165, 1103, 952, 845, 777, 669. HRMS (EI+) *m/z* calcd for $C_{28}H_{29}N_4$ $[M+H]^+$: 421.2387, found: 421.2390.

4.6.14. 1-(4-Methoxybenzyl)-4-methyl-5,6-di-*p*-tolyl-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole (**53**)

The reaction was carried out as described in general procedure **E** using 5-bomo-1-(4-Methoxybenzyl)-4-methyl-6-(*p*-tolyl)-1,4-dihydropyrrolo[2,3-*d*][1,2,3]triazole **39** (50 mg, 0.12 mmol, 1.0 eq.), *p*-tolyl boronic acid (25 mg, 0.18 mmol, 1.5 eq.), potassium phosphate tribasic (52 mg, 0.24 mmol, 2.0 eq.), $Pd(OAc)_2$ (0.8 mg, 0.004 mmol, 0.03 eq.), and RuPhos (3.3 mg, 0.007 mmol, 0.06 eq.) in dry 1,4-dioxane (0.15 M). The crude mixture was purified by flash chromatography on silica gel using (PE/EtOAc) from (100/0) to (70/30) to afford **53** as a white solid (48 mg, 95%). R_f = 0.33 (PE/EtOAc: 70/30). Mp 179–181 °C. ^{1}H NMR (400 MHz, Chloroform-*d*): δ 7.18–7.10 (m, 4H), 7.01 (d, J = 7.9 Hz, 2H), 6.96–6.88 (m, 4H), 6.71 (d, J = 8.7 Hz, 2H), 5.52 (s, 2H), 3.73 (s, 3H), 3.67 (s, 3H), 2.36 (s, 3H), 2.32 (s, 3H). ^{13}C NMR (101 MHz, Chloroform-*d*): δ 159.3 (C_q), 140.4 (C_q), 138.3 (C_q), 135.9 (C_q), 130.9 (2 × CH_{Ar}), 130.5 (C_q), 129.9 (2 × CH_{Ar}), 129.3 (2 × CH_{Ar}), 129.1 (4 × CH_{Ar}), 128.3 (C_q), 128.0 (C_q), 126.4 (C_q), 114.0 (2 × CH_{Ar}), 55.4 (CH_3), 52.6 (CH_2), 31.6 (CH_3), 21.5 (CH_3), 21.3 (CH_3). IR (ATR diamond, cm^{-1}) ν: 2922, 1610, 1512, 1390, 1247, 1176, 1033, 1020, 775, 682. HRMS (EI+) *m/z* calcd for $C_{27}H_{27}N_4O$ $[M+H]^+$: 423.2179, found: 423.2178.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/catal12080828/s1, Figures S1–S48. 1H and 13C NMR of all synthesized compounds; Tables S1 and S2 crystallographic data.

Author Contributions: Conceptualization, S.R. and F.B.; Investigation, F.B.; Methodology, S.G., K.B., A.Z. and M.M.; Supervision, J.V., M.P.-C., S.R. and F.B.; Writing—original draft, F.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: The data presented in this study are available in the article.

Acknowledgments: Authors gratefully acknowledge major financial support from the Ligue contre le Cancer du Grand Ouest (comités des Deux Sèvres, du Finistère, de l'Ile et Villaine, du Loir et Cher,

de Loire Atlantique, du Loiret, de la Vienne), the Canceropôle Grand Ouest, INCA, Région Centre Val de Loire, the SFR neuroimagerie (SFR FED 4224), which made this study possible, and also the projects CHemBio (FEDER-FSE 2014-2020-EX003677), Techsab (FEDER-FSE 2014-2020-EX011313), the RTR Motivhealth (2019-00131403) and the Labex programs SYNORG (ANR-11-LABX-0029) and IRON (ANR-11-LABX-0018-01) for their financial support of ICOA, UMR 7311, University of Orléans, CNRS. We thank the Salsa platform of ICOA for facilities in analytical chemistry.

Conflicts of Interest: The authors declare no conflict of interest.

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