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PALLADIUM- CATALYZED CASCADE REACTIONS OF 1-(3-ARYLPROP-2-YNYLOXY)-2-BROMO BENZENE DERIVATIVES WITH ORGANOBORON COMPOUNDS

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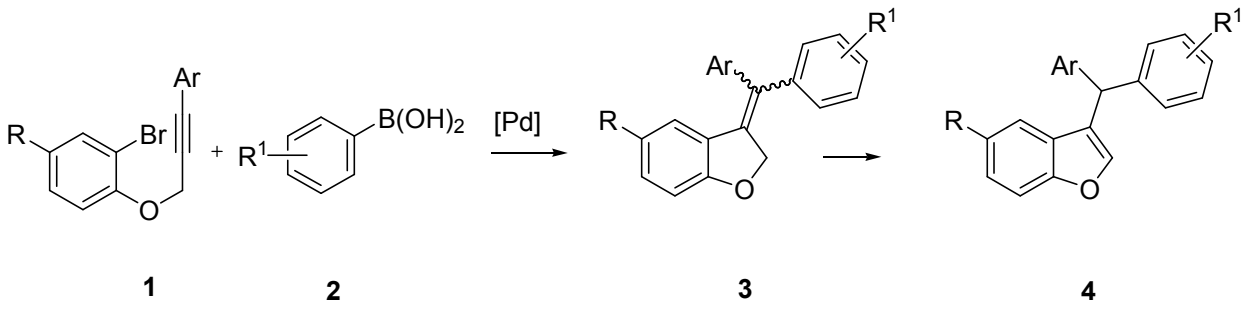
ABSTRACT. Applications of the cascade cyclocarbopalladation reaction followed by Suzuki-Miyaura coupling reactions of the ready available aryl-substituted propargylic aryl ethers with arylboronic acid and potassium trans-β-styryltrifluoroborate accomplish a new versatile entry in the synthesis of benzofurans derivatives. Notably, a new approach to the challenging synthesis of C3 functionalized 2-unsubstituted benzofurans has been developed by a cyclocarbopalladation/cross-coupling/aromatization process.

Introduction

The synthesis of highly functionalized polycyclic compounds has been greatly advanced by the development of cascade reactions catalyzed by transition metals.[1] By triggering such cascade events with well-defined functionalities in the structure of the starting material, these reactions have become a major tool for organic chemists to build up more complex molecules in a minimum number of steps. The main challenge in organic synthesis is the preparation of target products in a more efficient and economical manner, which will enable the use of more sophisticated structures in industry and academia. In this respect especially step economy is an important factor, since accessibility highly depends on the amount of steps required to reach the desired compounds.[2] The generally well understood reactivity of palladium has allowed the discovery of many intriguing novel cascade processes achieving relevant developments in this field, particularly on the generation of diverse poly- and heterocyclic scaffolds.[3] Carbometalations of alkynes constitute an unconventional way to create, often in a regio- and stereoselective manner, carbon-carbon bonds.[4] Intramolecular palladium-catalyzed versions are particularly attractive, for they afford (poly)carbo- and heterocyclic systems that can be further functionalized from the intermediate vinylpalladium.[5] In this field, a variety of palladium-catalyzed domino sequences consisting of addition of in situ generated arylpalladium complexes over a proximate carbon-carbon triple bond/cross coupling reactions giving final products *via* regio- and stereselective *5-exo-dig* and *6-exo-dig* cyclization processes have been reported.[6] Cascade cyclocarbopalladation reaction followed by Suzuki-Miyaura coupling, also, achieved the synthesis of

seven-membered dibenzoxapine derivatives with a stereodefined exocyclic double bond.[7] Moreover, 4-*exo-dig* cyclocarbopalladation reactions followed by a Suzuki-Miyaura or Sonogashira cross-coupling have been explored.[8] Our continuing interest[9] on the palladium-catalyzed reaction of alkynes with boronic acids directed towards the development of new synthetic approaches to the construction of fused heterocycles prompts us to explore the palladium-catalyzed reaction of 1-(3-arylprop-2-ynyloxy)-2-bromo benzene derivatives **1** with organoboron compounds **2** as viable route to the synthesis of C3 functionalized benzofurans (Scheme 1).

Scheme 1.



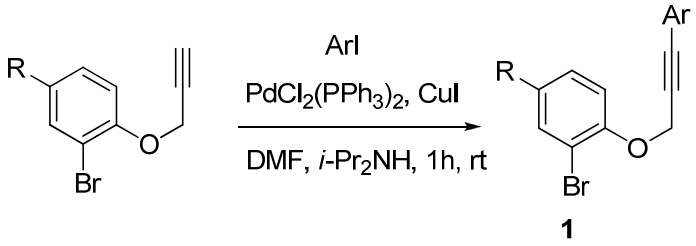
1 **2** **3** **4**

The generality, scope and limitations, as well as the product selectivity in the cascade cyclocarbopalladation reaction followed by Suzuki-Miyaura coupling or cyclocarbopalladation/cross coupling/aromatization reactions of readily available of aryl-substituted propargylic aryl ethers **1** has not been previously investigated. Applications of this key reaction can be relevant in the synthesis of new *O*-heterocycles. Usually, different types of substitution patterns in these heterocycles provide new opportunities for drug discoveries and by a fine tuning of their physical properties for applications in material science.[10] For their potential applications, development of novel synthetic strategies is in strong demand.

Results and Discussion

Ethers **1a-i** were prepared in moderate to high yields through a selective Sonogashira cross-coupling of 1-bromo-2-prop-2-ynyloxy)benzene derivatives with a range of aryl iodides (Table 1).[11] We hypothesized that the presence of the C-Br bond would be an invaluable handle for directing site selectivity and greatly expanding the breadth of potential target compounds that might be accessible by palladium-catalyzed cross-coupling reactions.[12]

Table 1. Synthesis of 1-(3-arylprop-2-ynyloxy)-2-bromo benzene derivatives **1**



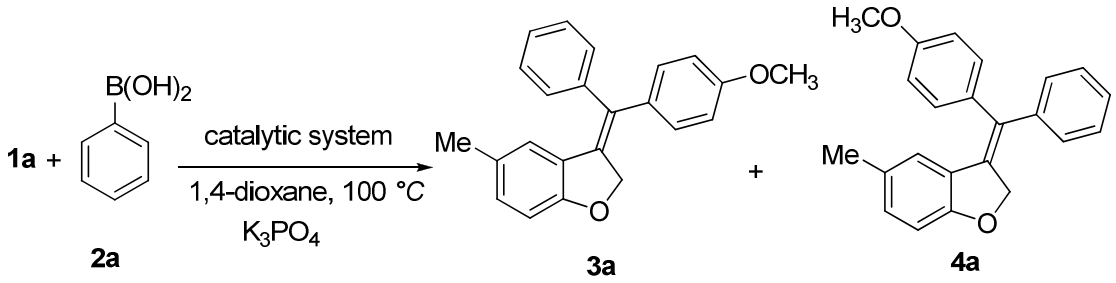
1

1	R	Ar	% yield[a,b]
1a	Me	4-MeO-C_6H_4	82
1b	Me	4-MeCO-C_6H_4	80
1c	Me	Ph	75
1d	Ph	4-MeOC_6H_4	50
1e	Ph	4-MeCOC_6H_4	67
1f	Ph	Ph	60
1g	F	4-MeOC_6H_4	55
1h	F	4-MeCOC_6H_4	80
1i	F	Ph	50

[a] Reactions were carried out on 4.44 mmol scale in DMF (3 mL)/di-isopropylamine (6 mL) at r.t., using 1.equiv. of 2-bromo-1-(prop-2-ynyloxy)benzene derivative, 0.02 equiv. of $PdCl_2(PPh_3)_2$, 0.04 equiv. of CuI and 1.3 equiv. of aryl iodide. [b] If not otherwise stated, yields refer to single run and are for pure isolated products.

Subsequent studies were directed toward searching for the best conditions for their cyclocarbopalladation/Suzuki-Miyaura couplings.[3a] Interestingly, the simple commercial available $PdCl_2(PPh_3)_2$ achieved the high stereoselective synthesis of **3a** in good yield. The choice of $PdCl_2(PPh_3)_2$ as the most suitable catalyst was shown by comparison with $Pd_2(dba)_3$/S-Phos catalytic system which was previously reported as very effective in promoting Suzuki-Miyaura cross-coupling of the less reactive heteroaryl halides (Scheme 2).[12] The formation of undesired direct coupling products was not observed.

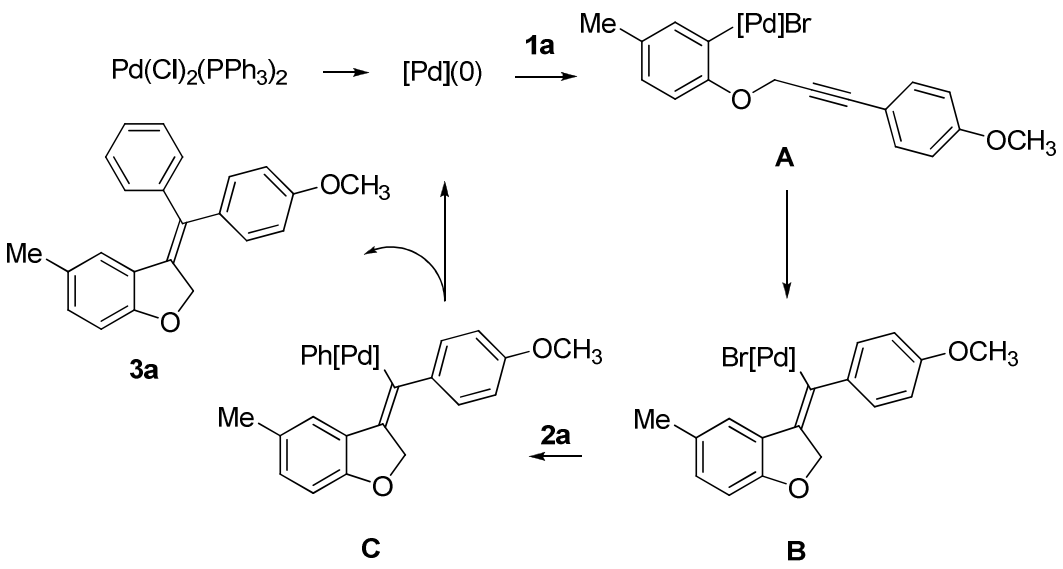
Scheme 2



Entry[a]	Catalyst (mol %)	Time (h)	Yield(%)[b,c]	**3a**/**4a** ratio
1	$Pd_2(dba)_3$/S-Phos	15	76	9/1
2	$PdCl_2(PPh_3)_2$	2	**77**	> 99/1

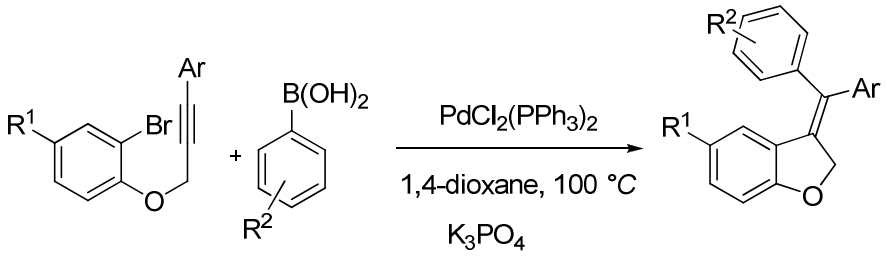
The formation of the stereoisomer **3a** would be derived by the intramolecular *syn* addition over the C-C-triple bond of the *in situ* generated arylpalladium(II) **A** which provides alkenylpalladium complex **B**. Next, transmetallation with the arylboronic acid in the presence of K_3PO_4 would lead to intermediate **C**. The reductive elimination of palladium from species **C** affords **3a** and regenerates the palladium(0) species (Scheme 3).

Scheme 3



Subsequently, this method was applied to the stereoselective synthesis of a variety of 2,3-dihydro-3-(diarylmethylene)benzofurans **3**. We explored the scope and the generality of the tandem palladium-catalyzed cyclocarbopalladation reaction/Suzuki-Miyaura reaction in terms of rings substitution on both substrates **1** and arylboronic acids **2.** Both electron-withdrawing and -donating groups did not have much influence on the yield of the reaction. Table 2 shows our results. By using the $PdCl_2(PPh_3)_2$ (2 mol %) in 1,4-dioxane in the presence of K_3PO_4 (3 equiv.), the tandem palladium-catalyzed cyclocarbopalladation reaction/Suzuki-Miyaura reaction of derivatives **1a-i** was quite general and proceeded smoothly at 100 °C to give exclusively the corresponding disubstituted 3-methylene-2,3-dihydrobenzofurans **3a-z** in moderate to excellent yields. The presence of the methyl, the phenyl and the F group as a substituent onto the aromatic ring attached to the oxygen moiety was compatible with the procedure. The stereochemistry of compounds **3** was unambiguously confirmed by NMR spectroscopy.[13] Boron mediated cleaving of aryl propargyl ethers was, also, not observed.[14]

Table 2. Synthesis of disubstituted 3-methylene-2,3-dihydrobenzofurans **3**



1 **2** **3**

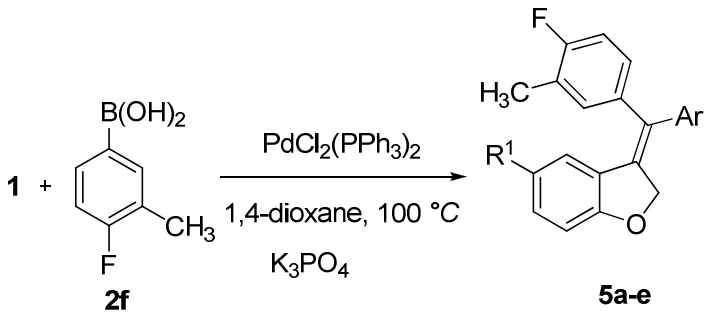
Entry[a]	R^1	Ar	R^2	Time (h)	**3** (yield %)[b]
1	Me	4-MeO-C_6H_4-	H (2a)	2	**3a** (77)
2	Me	4-MeO-C_6H_4-	4-MeO (2b)	1	**3b** (74)
3	Me	4-MeO-C_6H_4-	4-MeO_2C (2c)	1	**3c** (55)
4	Me	4-MeO-C_6H_4-	3-MeO_2C (2d)	1	**3d** (70)
5	Me	4-MeO-C_6H_4-	3-CHO (2e)	1	**3e** (45)
6	Me	4-MeCO-C_6H_4-	H	1	**3f** (83)
7	Me	4-MeCO-C_6H_4-	4-MeO	2	**3g** (88)
8	Me	4-MeCO-C_6H_4-	4-MeO_2C	2	**3h** (80)
9	Me	4-MeCO-C_6H_4-	3-MeO_2C	2	**3i** (83)
10	Me	4-MeCO-C_6H_4-	3-CHO	2	**3j** (72)
11	Me	Ph	H	2	**3k** (99)
12	Me	Ph	4-MeO	1	**3l** (82)
13	Me	Ph	3-MeO_2C	3	**3m** (52)
14	F	Ph	4-MeO_2C	1	**3n** (81)
15	F	Ph	3-MeO_2C	2	**3o** (86)
16	F	Ph	4-MeO	2	**3p** (85)
17	F	4-MeCO-C_6H_4-	4-MeO_2C	2	**3q** (82)
18	F	4-MeCO-C_6H_4-	H	2	**3r** (90)
19	F	4-MeO-C_6H_4-	4-MeO_2C	2	**3s** (76)
22	F	4-MeO-C_6H_4-	H	2	**3t** (79)
23	Ph	4-MeCO-C_6H_4-	H	3	**3u** (55)

24	Ph	4-MeCO-C_6H_4-	4-MeO_2C	2	**3v** (75)
26	Ph	Ph	H	8	**3w** (67)
27	Ph	Ph	4-MeO_2C	2	**3x** (64)
29	Ph	4-MeO-C_6H_4-	4-MeO_2C	2	**3y** (53)
30	Ph	4-MeO-C_6H_4-	H	5	**3z** (45)

[a] Reactions were carried out on 0.30 mmol scale in1,4-dioxane (2 mL) at 100 °*C*, using 1.equiv. of **1**, 0.02 equiv. of $PdCl_2(PPh_3)_2$, 3 equiv. K_3PO_4 and 1,5 equiv. of **2**. [b] If not otherwise stated, yields refer to single run and are for pure isolated products.

In absolute agreement with previous results, 4-fluoro-3-methylboronic acid **2f** was exclusively converted to the corresponding 3-((4-fluoro-3-methyl)-phenyl)-2,3-dihydrobenzofurn derivatives **5a-e** (Table 3). The inclusion of fluorine into a host of organic substrates has been shown to affect the activity of the drug in vivo and has resulted in a large number of viable drug candidates.[15] In that respect, there is a growing demand for synthetic methods for the preparation of selectively fluorinated heterocyclic compounds for use in pharmaceutical and agrochemical industry.[16]

Table 3. Synthesis of 3-((4-fluoro-3-methyl)(aryl)-2,3-dihydrobenzofurn derivatives **5**

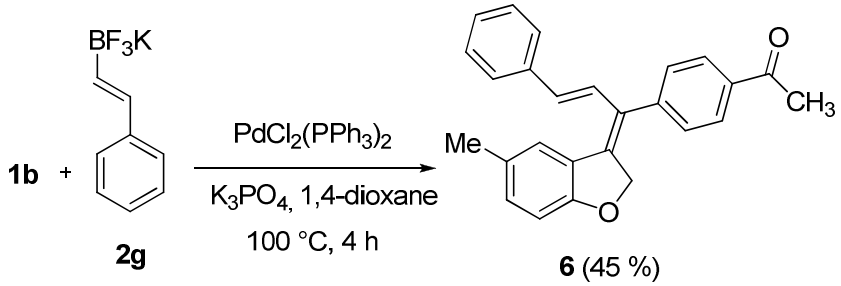


Entry	R^1	Ar	Time (h)	**5** (yield %)
1	Ph	4-MeO-C_6H_4	4	**5a** (44)
2	Ph	4MeCO-C_6H_4	4	**5b** (60)
3	Ph	Ph	2	**5c** (74)
4	F	4-MeO-C_6H_4	1	**5d** (72)
5	F	4MeCO-C_6H_4	2	**5e** (82)

[a] Reactions were carried out on 0.30 mmol scale in1,4-dioxane (2 mL) at 100 °c, using 1.equiv. of **1**, 0.02 equiv. of $PdCl_2(PPh_3)_2$, 3 equiv. K_3PO_4 and 1,5 equiv. of **2f**. [b] If not otherwise stated, yields refer to single run and are for pure isolated products.

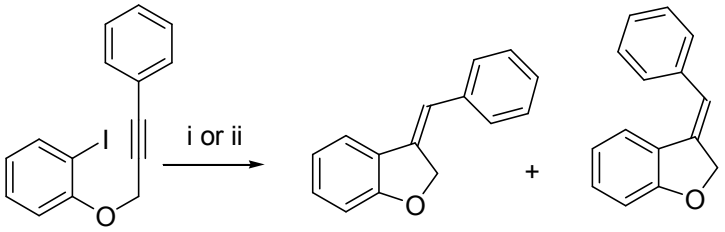
The extension of the procedure to vinyl organoboron derivatives was briefly explored. The palladium catalyzed reaction of **1b** with the potassium trans-β-styryltrifluoroborate **2g** resulted, also, highly stereoselective leading to the formation of the 1-(4-((1E,2E)-1-(5-methylbenzofuran-3(2H)-ylidene-3-phenylallyl)phenyl) ethanone **6** albeit in lower yield (Scheme 4).

Scheme 4



It is worth underlying that many examples of isomerization of the primary *syn*-adduct to the *anti*-adduct in the carbopalladation step of alkynes have been reported and the observed stereochemistry deviated from the expected Pd-mediated *syn*-insertion of triple bonds.[5,17] Moreover, the substituents on the arylpropargyl ethers have been reported to exhibit a great influence on the stereocontrol of the intramolecular carbometallation[18] and with the phenyl-substituted substrate **7** a post-carbometallation isomerization was reported to occur (Scheme 5).[19]

Scheme 5

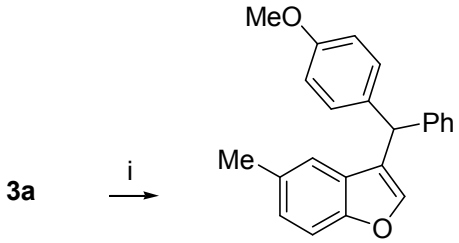


7

i = $NiBr_2Bipy$, Mn(0), DMF, rt; 54% (Z/E = 83 : 17)
ii = *n*-Buli (1 equiv), THF; 60-65% (Z/E = 10:90 at -100 °C)
(Z/E =31: 69 at - 40 °C)

The 3-methylene-2,3-dihydrobenzofurans have been reported to tend to aromatize into the corresponding 2-unsubstituted benzofurans.[19,20] Our screening for the best reaction conditions for the aromatization of compounds **3** to the corresponding C3 functionalized 2-unsubstituted benzofurans **8** showed that the process can occur under basic conditions (Table 4). While the aromatization reaction failed in 1,4-dioxane under the presence of potassium phosphate tribasic even at higher temperature (Table 4, entries 4.5), significant increase in the yield of **8a** was observed with highly polar solvents other than 1,4-dioxane, such as *N*,*N*-dimethylformamide (Table 4, entry 6). Interestingly the aromatization was also observed in the ionic liquid [bmim]BF_4 as the reaction medium (Table 4, entry 7).[21] Ionic liquids represent a class of alternative solvents which are currently receiving serious consideration because of their environmental and technological benefits.[22]

Table 4. Optimization conditions for the aromatization reaction of **3a**



8a

Entry	**Solvent**	**Acid or Base**	**Temperature °C**	**Time h**	**8a** (yield %)[a]

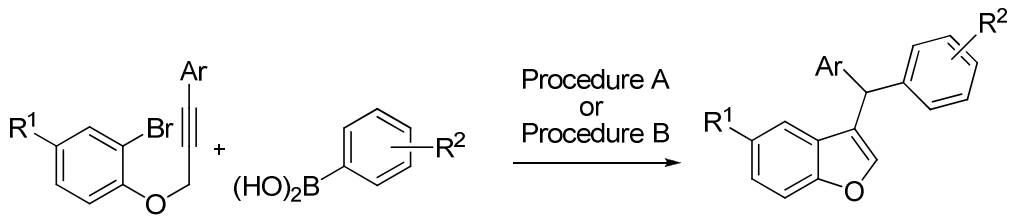
1	EtOH	HCl 2N	60	24	.
2	EtOH	HCl 2N	80	24	.
3	CH_3CN	TsOH	60	24	.
4	1,4-Dioxane	K_3PO_4	100	24	.
5	1,4-Dioxane	K_3PO_4	120	24	.
6	DMF	K_3PO_4	100	7	73
7	[bmim]BF_4	K_3PO_4	100	24	65

[a] Yields refer to single run and are for pure isolated compound **8a**.

Having successfully established the suitable conditions for the aromatization of derivative **3a,** we examined the versatility of the preparation of the target C3 funtionalized-2-unsubstituted benzofurans **8a** through a one pot procedure. We explored the one-pot cyclocarbopalladation/cross coupling/aromatization reactions of **1** as a suitable tool for the synthesis of C3 functionalized 2-unsubstituted benzofurans. Procedures for the synthesis of these derivatives remained scarcely described in the literature and the development of simple and general methods for their preparation is a subject of great interest.[23] Subsequently, we found that **8a** (Table 5, entry 1) could be conveniently prepared through a process in which, after extraction and evaporation of the of the mixture resulting from the reaction of **1a** with **2a** carried out for 7 h in 1,4-dioxane at 100°C in the presence of K_3PO_4 and $Pd(Cl_2)(PPh_3)_2$, DMF was added to the crude which was heated at 100 °C for further 2 h. Using this procedure (procedure A), **8a** was isolated in a slightly higher overall yield (65%) than that obtained via the stepwise protocol (56%). To simplify further the synthetic protocol by avoiding the work-up step, we attempted to optimize reaction conditions for a domino process by using the same substrates as a model system. The screening of solvents and temperature reaction showed that best results were

observed in dimethyl sulfoxide at 100 °C (Table 5, entry 2) (Procedure B). No improvements were observed with our model system even with prolonged reaction times or increasing the temperature (Table 5, entry 3). The two different procedures A and B were extended to include other substrates. While the procedure A appeared of general application, the procedure B was find to give satisfactory results in some cases (Table 5, entries 2,4, 8) but to be ineffective in others (Table 6, entries 6,10). Very likely, under the presence of the palladium catalyst, the in situ generation of a palladium(II) π-allyl complex[20a] from **3** should cause the formation of side products determining the ineffectiveness of the aromatization process.

Table 5. Synthesis of 2-unsubstituted benzofurans **8**



1 **2** **8**

Entry	R^1	Ar	R^2	Procedure	time	**8** (yield %)[a]
1	Me	4-MeO-C_6H_4	H	A	9	**8a** (65)
2	Me	4-MeO-C_6H_4	H	B	9	**8a** (51)
3	Me	4-MeO-C_6H_4	H	B[b]	24	**8a** (48)
3	Me	C_6H_5	H	A	6	**8b** (73)
4	Me	C_6H_5	H	B	3	**8b** (51)

5	Me	4-MeCO-C_6H_4	H	A	3	**8c** (72)
6	Me	4-MeCO-C_6H_4	H	B	2	**8c** (-)
7	Me	4-MeO-C_6H_4	3-MeOCO-C_6H_4	A	4.5	**8d** (55)
8	Me	4-MeO-C_6H_4	3-MeOCO-C_6H_4	B	2.5	**8d** (30)
9	F	4-MeO-C_6H_4	H	A	6	**8e** (90)
10	F	4-MeO-C_6H_4	H	B	5	**8e** (-)

[a] Yields refer to single run and are for pure isolated compounds **8**. [b] Reaction temperature = 120 °*C*.

Conclusions

The generality, scope and limitations, as well as the product selectivity in the palladium-catalyzed tandem carbocyclization/Suzuki coupling of the ready available 1-(3-arylprop-2-ynyloxy)-2-bromo benzene derivatives has been investigated. The reactions take place in the presence of $PdCl_2(PPh_3)_2$ and potassium phosphate in 1,4-dioxane as the solvent at 100 °C. Various 1-(3-arylprop-2-ynyloxy)-2-bromo benzene derivatives underwent the palladium-catalyzed cascade reaction with several arylboronic acids to afford highly stereoselectively the corresponding 2,3-dihydro-3-(diarylmethylene)-benzofurans in moderate to excellent yields. The stereochemistry of these products derives from the exclusive Pd-mediated *syn*-insertion of triple bond. The application of the procedure to the potassium trans-β-styryltrifluoroborate has been, also, shown. An efficient method for the synthesis of the scarcely described C3 functionalized 2-unsubstituted benzofurans has been developed providing a versatile tool for further expansion of their utility such as the random screening in the search for drug candidates.

Experimental Section

General Methods. ^{1}H and ^{13}C NMR spectra were recorded at 400 and 100.6 MHz, respectively. IR spectra were recorded in KBr pellets or neat in NaCl on a FT-IR spectrometer. Only the most significant IR absorptions are given. Melting points were determined on a microscopes apparatus and were uncorrected. High resolution mass spectra were recorded on Q-TOF. Unless otherwise stated, all starting materials, catalysts, and solvents were commercially available and were used as purchased. Reaction products were purified by flash chromatography on silica gel by elution with *n*-hexane/EtOAc mixtures.

General Experimental Procedure for the Synthesis of 2-bromo-*O*-aryl-prop-2-ynyl)phenols (1): Synthesis of -2-bromo-1-(3-(4-methoxyphenyl)prop-2-ynyloxy)-4-methylbenzene (1a). A solution of 2-bromo-4-methyl-1-(prop-2-ynyloxy)benzene (1 g, 4.44 mmol, 1 equiv.), $PdCl_2(PPh_3)_2$ (0.062 g, 0.09 mmol, 0.02 equiv.) and CuI (0.034 g, 0.18 mmol, 0.04 equiv.) in DMF (3 mL) /di-isopropylamine (6 mL) was treated with 4-iodoanisole (1.350 g, 5.77 mmol, 1.3 equiv.). The resulting solution was stirred at room temperature for 1 h until determined to be complete by TLC. The crude reaction mixture was poured into NH_4Cl/H_2O and extracted with ether. The combined organic extracts were washed with $NaCl/H_2O$, dried over Na_2SO_4 and finally concentrated under reduced pressure. The product was subjected to flash column chromatography (SiO_2 100 g), eluting with *n*-hexane/ethyl acetate 85:15 v/v to afford the product **1a** (1.205 g, 3.64 mmol, 82%): yellow solid; Mp: 56-57 °C; HRMS (ESI) m/z Calcd for $C_{17}H_{16}BrO_2$ $[M+H]^+$ 331.0328; found: 331.0342; IR (KBr): 2240, 1604, 1257, 1029, 831 (cm^{-1}); ^{1}H NMR ($CDCl_3$): δ 7.39-7.38 (m, 3H), 7.09-7.06 (m, 2H), 6.84 (d, *J*= 8.0 Hz, 2H), 4.97 (s, 2H), 3.83 (s, 3H), 2.31 (s, 3H); ^{13}C NMR ($CDCl_3$): δ 159.9, 152.2, 133.9, 133.3, 132.5, 128.8, 114.6, 114.3, 113.9, 112.3, 87.6, 82.3, 58.1, 55.3, 20.2; Anal Calcd for $C_{17}H_{15}BrO_2$, C, 61.65; H, 4.56; Br, 24.13 found C, 61.58; H, 4.57; Br, 24.19.

1-(4-(3-(2-bromo-4-methylphenoxy)prop-1-ynyl)phenyl)ethanone (1b): (1.218 g, 80%); yellow solid;. Mp: 60-61 °C; HRMS (ESI) m/z Calcd for $C_{18}H_{15}BrO_2Na$ $[M+Na]^+$: 365.0153; found: 365.0144;

IR (KBr): 2954, 2372, 1670, 1261, 1022, 796 (cm^{-1}); ^{1}H- NMR ($CDCl_3$): δ 7.90 (d, *J*= 8.4 Hz, 2H), 7.51 (d, *J*= 8.4 Hz, 2H), 7.41 (s, 1H), 7.11-7.03 (m, 2H), 4.99 (s, 2H), 2.60 (s, 3H), 2.30 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 197.2, 152.1, 136.7, 133.9, 132.9, 131.9, 128.8, 128.2, 127.0, 114.7, 112.4, 86.9, 86.7, 58.0, 26.6, 20.2; Anal Calcd for $C_{18}H_{15}BrO_2$, C, 62.99; H, 4.41; Br, 23.28 found C, 62.90; H, 4.42; Br, 23.22.

2-bromo-4-methyl-1-(3-phenylprop-2-ynyloxy)benzene) (1c): (1.002 g, 75%); white oil; HRMS (ESI) m/z Calcd for $C_{16}H_{13}BrONa$ $[M+Na]^+$: 323.0047; found: 323.0037; IR (KBr): 3033, 2921, 1600, 1442, 1230, 916, 730 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 7.46-7.44 (m, 3H), 7.41-7.28 (m, 3H), 7.12-7.07 (m, 2H), 4.99 (s, 2H), 2.31 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 152.2, 133.9, 132.6, 131.8, 128.8, 128.7, 128.3, 122.3, 114.8, 112.4, 87.6, 83.6, 58.1, 20,2; Anal Calcd for $C_{16}H_{13}BrO$, C, 63.81; H, 4.35; Br, 26.53 found C, 63.75; H, 4.36; Br, 26.45.

3-bromo-4-(3-(4-methoxyphenyl)prop-2-ynyloxy)biphenyl (1d): (0.870 g, 50%); white solid; Mp: 116-117 °C; HRMS (ESI) m/z Calcd for $C_{22}H_{17}BrO_2Na$ $[M+Na]^+$: 415.0310; found: 415.0329; IR (KBr): 2240, 1604, 1278, 1029, 831, 754 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 7.83 (s, 1H), 7.57-7.24 (m, 9H), 6.85 (d, *J*= 8.4 Hz, 2H), 5.05 (s, 2H), 3.83 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 160.0, 153.7, 136.0, 133.4, 132.0, 128.9, 127.3, 126.9, 126.8, 113.9, 87.9, 82.0, 58.0, 55.3. Anal Calcd for $C_{22}H_{17}BrO_2$, C, 67.19; H, 4.36; Br, 20.32 found C, 67.10; H, 4.37; Br, 20.25.

1-(4-(3-(3-bromobiphenyl-4-yloxy)prop-1-ynyl)phenyl)ethanone (1e): (1.205 g; 67%); yellow solid; Mp: 125-126 °C; HRMS (ESI) m/z Calcd for $C_{23}H_{17}BrO_2Na$ $[M+Na]^+$: 427.0310; found: 427.0311; IR (KBr): 2902, 2358, 1679, 1598, 1261, 838, 769 (cm^{-1}); ^{1}H- NMR ($CDCl_3$): δ 7.92 (d, *J*= 8.4 Hz, 2H), 7.84 (s, 1H), 7.57-7.53 (m, 5H), 7.47-7.43 (m, 2H), 7.38-7.36 (m, 1H), 7.22 (d, *J*= 8.4 Hz, 1H), 5.08 (s, 2H), 2.61 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 197.2, 153.6, 139.3, 136.7, 136.3, 132.2, 131.9, 128.9, 128.7, 128.2, 127.4, 126.9, 126.8, 114.5, 112.9, 87.0, 86.6, 57.8, 26.6; Anal Calcd for $C_{23}H_{17}BrO_2$, C, 68.16; H, 4.23; Br, 19.72 found C, 68.10; H, 4.24; Br, 19.65.

3-bromo-4-(3-phenylprop-2-ynyloxy)biphenyl (1f): (0.970 g, 60%); yellow solid. Mp: 70-71 °C; HRMS (ESI) m/z Calcd for $C_{21}H_{15}BrONa$ $[M+Na]^+$: 385.0204; found: 385.0215; IR (KBr): 1484, 1278, 754 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 7.84 (s, 1H), 7.57-7.43 (m, 6H), 7.38-7.25 (m, 6H), 5.07 (s, 2H); ^{13}C-NMR ($CDCl_3$): δ 153.7, 139.4, 136.1, 132.1, 131.8, 128.9, 128.8, 128.3, 127.3, 126.9, 126.8, 122.1, 114.6, 112.9, 87.0, 83.3, 57.9. Anal Calcd for $C_{21}H_{15}BrO$, C, 69.44; H, 4.16; Br, 22.00 found C, 69.53; H, 4.17; Br, 22.05.

2-bromo-4-fluoro-1-(3-(4-methoxyphenyl)prop-2-ynyloxy)benzene (1g): (0.818 g, 55%); yellow solid; Mp: 79-80 °C; HRMS (ESI) m/z Calcd for $C_{16}H_{12}BrFO_2Na$ $[M+Na]^+$: 356.9902; found: 356.9918; IR (KBr): 2967, 2235, 1604, 1509, 1261, 836, 734, 603 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 7.39-7.33 (m, 3H), 7.16-7.13 (m, 1H), 7.06-6.98 (m, 1H), 6.87-6.84 (m, 2H), 4.97 (s, 2H), 3.83 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 160.0, 157.2 (d, $J_{C\text{-}F}$ = 243.0 Hz), 150.9, 133.3, 121.1, 120.4 (d, $J_{C\text{-}F}$ = 25.6 Hz), 115.5 (d, $J_{C\text{-}F}$ = 8.5 Hz), 114.6 (d, $J_{C\text{-}F}$ = 22.5 Hz), 114.0 (d, $J_{C\text{-}F}$ = 11.3 Hz), 112.8 (d, $J_{C\text{-}F}$ = 10.0 Hz), 87.9, 81.8, 58.7, 55.3; Anal Calcd for $C_{16}H_{12}BrFO_2$, C, 57.34; H, 3.61; Br, 23.84 found C, 57.26; H, 3.62; Br, 23.79.

1-(4-(3-(2-bromo-4-fluorophenoxy)prop-1-ynyl)phenyl)ethanone (1h): (1.233 g; 80%); yellow solid; Mp: 73-74 °C; HRMS (ESI) m/z Calcd for $C_{17}H_{12}BrFO_2Na$ $[M+Na]^+$: 368.9902; found: 368.9900; IR (KBr): 1687, 1600, 1488, 1403, 1292, 732 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 7.91 (d, *J*=8.0 Hz, 2H), 7.51 (d, *J*=8.4 Hz, 2H), 7.36-7.38 (m, 1H), 7.14-7.02 (m, 2H), 5.00 (s, 2H), 2.61 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 197.2, 157.3 (d, $J_{C\text{-}F}$ = 243.0 Hz), 150.8, 136.8, 131.9, 128.2, 126.8, 120.6 (d, $J_{C\text{-}F}$ = 25.6 Hz), 115.7 (d, $J_{C\text{-}F}$ = 8.5 Hz), 114.7 (d, $J_{C\text{-}F}$ = 22.5 Hz), 113.1 (d, $J_{C\text{-}F}$ = 8.7 Hz), 87.1, 86.4, 58.5, 26.6; Anal Calcd for $C_{17}H_{12}BrFO_2$, C, 58.81; H, 3.48; Br, 23.02 found C, 58.73; H, 3.49; Br, 23.07.

2-bromo-4-fluoro-1-(3-phenylprop-2-ynyloxy)benzene (1i): (0.678 g, 50%); white oil; HRMS (ESI) m/z Calcd for $C_{15}H_{10}BrFONa$ $[M+Na]^+$: 326.9797; found: 326.9810; IR (KBr): 2240, 1450, 1384, 873 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 7.45-7.43 (m, 2H), 7.53-7.51 (m, 1H), 7.36-7.32 (m, 4H), 7.12-7.15 (m, 1H), 7.06-7.02 (m, 1H), 4.99 (s, 2H); ^{13}C-NMR ($CDCl_3$): δ 157.2 (d, $J_{C\text{-}F}$ = 243.0 Hz), 150.9, 131.8,

128.8, 128.3, 122.0, 120.5 (d, J_{C-F} = 25.6 Hz), 115.6 (d, J_{C-F} = 8.5 Hz), 114.6 (d, J_{C-F} = 22.5 Hz), 113.0 (d, J_{C-F} = 9.6 Hz), 87.9, 83.2, 58.6; Anal Calcd for $C_{15}H_{10}BrFO$, C, 59.04; H, 3.30; Br, 26.19 found C, 59.12; H, 3.31; Br, 26.26.

General Procedure for the Palladium-catalyzed cross-coupling of 2-bromo-*O*-aryl-prop-2-ynyl)phenols with arylboronic acids: Synthesis of (Z)-3-((4-methoxyphenyl)(phenyl)methylene)-5-methyl-2,3-dihydrobenzofuran (3a). A solution of 2-bromo-1-(3-(4-methoxyphenyl)prop-2-ynyloxy)-4-methylbenzene (**1a**) (0.1 g, 0.30 mmol, 1 equiv.), $PdCl_2(PPh_3)_2$ (0.004 g, 0.006 mmol, 0.02 equiv.) and K_3PO_4 (0.191 g, 0.90 mmol, 3 equiv.) in 1,4-dioxane (2 mL) was treated with phenylboronic acid (**2a**) (0.055 g, 0.45 mmol, 1.5 equiv.). The resulting solution was stirred at 100 °C for 2 h until determined to be complete by TLC. The crude reaction mixture was extracted with ether/H_2O. The combined organic extracts were washed with NaCl/H_2O, dried over Na_2SO_4 and finally concentrated under reduced pressure. The crude was subjected to flash column chromatography (SiO_2 50 g), eluting with *n*-hexane/ethyl acetate 90:10 v/v to afford the product **3a** (0.076 g, 0.23 mmol, 77 %): yellow solid; Mp: 100-101 °C; HRMS (ESI) m/z Calcd for $C_{23}H_{21}O_2$ $[M+H]^+$ 329.1536; found: 329.1550; IR (KBr): 1606, 1251, 1155, 754 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 7.45-7.39 (m, 3H), 7.31-7.28 (m, 2H), 7.13 (d, *J*= 8.4 Hz, 2H), 6.91-6.88 (m, 3H), 6.73 (d, *J*= 8.4 Hz, 2H), 6.06 (s, 1H), 5.30 (s, 2H), 3.83 (s, 3H), 2.03 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 162.3, 159.1, 142.6, 134.0, 133.7, 132.1, 130.8, 130.5, 129.2, 128.5, 128.2, 127.2, 125.9, 124.7, 114.3, 109.9, 75.7, 55.4, 21.0; Anal Calcd for $C_{23}H_{20}O_2$, C, 84.12; H, 6.14 found C, 84.20; H, 6.15.

3-(bis(4-methoxyphenyl)methylene)-5-methyl-2,3-dihydrobenzofuran (3b): (0.080 g; 74%); yellow solid; Mp: 149-150 °C; HRMS (ESI) m/z Calcd for $C_{24}H_{23}O_3$ $[M+H]^+$: 359.1642; found: 359.1637; IR (KBr): 1604, 1508, 1240, 833 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 7.22 (d, *J*= 8.0 Hz, 2H), 7.12 (d, *J*=8.4 Hz, 2H), 6.98-6.88 (m, 5H), 6.74 (d, *J*= 8.0 Hz, 1H), 6.26 (s, 1H), 5.28 (s, 2H), 3.89 (s, 3H), 3.84 (s, 3H), 2.08 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 162.0, 159.0, 158.6, 135.0, 133.9, 132.9, 131.8, 130.8, 130.1, 129.5,

129.1, 126.1, 124.6, 114.2, 113.7, 109.7, 75.8, 55.4, 55.3, 20.9; Anal Calcd for $C_{24}H_{22}O_3$, C, 80.42; H, 6.19 found C, 80.50; H, 6.20.

(Z)-methyl 4-((4-methoxyphenyl)(5-methylbenzofuran-3(*2H*)-ylidene)methyl)benzoate (3c): (0.064 g, 55%); white solid; Mp: 167-168 °C; HRMS (ESI) m/z Calcd for $C_{25}H_{23}O_4$ $[M+H]^+$: 387.1591; found: 387.1580; IR (KBr): 1718, 1604, 1276, 823 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 8.10 (d, *J*= 8.4 Hz, 2H), 7.41 (d, *J*= 8.0 Hz, 2H), 7.10 (d, *J*= 8.4 Hz, 2H), 6.99-6.88 (m, 3H), 6.75 (d, *J*= 8.4 Hz, 1H), 6.19 (s, 1H), 5.28 (s, 2H), 3.98 (s, 3H), 3.84 (s, 3H), 2.05 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 166.9, 162.4, 158.8, 146.5, 134.1, 134.0, 130.8, 130.7, 130.2, 129.8, 129.5, 129.4, 129.1, 125.3, 124.4, 113.9, 109.9, 75.8, 55.3, 52.2, 20.9; Anal Calcd for $C_{25}H_{22}O_4$, C, 77.70; H, 5.74 found C, 77.62; H, 5.75.

(E)-Methyl 3-((4-methoxyphenyl)(5-methylbenzofuran-3(*2H*)-ylidene)methyl)benzoate (3d): (0.081 g, 70%); yellow solid; Mp: 162-163 °C; HRMS (ESI) m/z Calcd for $C_{25}H_{23}O_4$ $[M+H]^+$: 387.1591; found: 387.1579; IR (KBr): 1718, 1604, 1508, 1276, 823, 744 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 8.11 (d, *J*= 7.2 Hz, 1H), 8.00 (s, 1H), 7.57-7.51 (m, 2H), 7.12 (d, *J*= 8.4 Hz, 2H), 6.93-6.89 (m, 3H), 6.76 (d, *J*= 8.0 Hz, 1H), 6.06 (s, 1H), 5.31 (s, 2H), 3.93 (s, 3H), 3.84 (s, 3H), 2.03 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 166.9, 162.2, 158.8, 141.9, 134.4, 134.1, 134.0, 130.9, 130.8, 130.7, 130.5, 129.5, 129.3, 129.0, 128.7, 125.5, 124.4, 113.9, 109.9, 75.7, 55.3, 52.1, 20.9; Anal Calcd for $C_{25}H_{22}O_4$, C, 77.70; H, 5.74 found C, 77.62; H, 5.75.

(E)-3-((4-Methoxyphenyl)(5-methylbenzofuran-3(*2H*)-ylidene)methyl)benzaldehyde (3e): (0.048 g, 45%); yellow solid; Mp: 125-126 °C; HRMS (ESI) m/z Calcd for $C_{24}H_{21}O_3$ $[M+H]^+$: 357.1485; found: 357.1484; IR (KBr): 1698, 1508, 1251, 1008, 835, 690 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 10.04 (s, 1H), 6.94 (d, *J*= 6.8 Hz, 1H), 7.83 (s, 1H), 7.80-7.50 (m, 2H), 7.24 (d, *J*= 8.8 Hz, 2H), 7.00-6.76 (m, 4H), 6.32 (d, *J*= 8.0 Hz, 1H), 6.05 (s, 1H), 5.31 (s, 2H), 3.84 (s, 3H), 2.09 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 192.1, 162.3, 158.9, 142.6, 137.2, 136.0, 134.4, 133.9, 131.5, 130.7, 130.3, 129.6, 129.5, 129.3, 128.3, 125.3, 124.2, 114.5, 114.0, 110.1, 75.7, 55.3, 20.9; Anal Calcd for $C_{24}H_{20}O_3$, C, 80.88; H, 5.66 found C, 80.80; H, 5.67.

(Z)-1-(4-((5-methylbenzofuran-3(*2H*)-ylidene)(phenyl)methyl)phenyl)ethanone (3f): (0.085 g, 83%); yellow solid; Mp: 175-176 °C; HRMS (ESI) m/z Calcd for $C_{24}H_{21}O_2$ $[M+H]^+$: 341.1536; found: 341.1528; IR (KBr): 1673, 1600, 1481, 1268, 987, 719 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 7.95 (d, *J*= 8.0 Hz, 1H), 7.48-7.46 (m, 3H), 7.33-7.21 (m, 4H), 6.96 (d, *J*= 6.0 Hz, 1H), 6.77 (d, *J*= 8.0 Hz, 1H), 6.10 (s, 1H), 5.31 (s, 2H), 2.61 (s, 3H), 2.06 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 197.4, 162.5, 146.7, 140.7, 136.2, 135.6, 131.2, 131.1, 129.6, 129.4, 129.2, 128.6, 128.3, 127.9, 125.3, 125.1, 110.0, 75.4, 26.6, 20.9; Anal Calcd for $C_{24}H_{20}O_2$, C, 84.68; H, 5.92 found C, 84.60; H, 5.91.

(E)-1-(4-((4-Methoxyphenyl)(5-methylbenzofuran-3(*2H*)-ylidene)methyl)phenyl)ethanone (3g): (0.097 g, 88%); brown solid; Mp: 150-151 °C; HRMS (ESI) m/z Calcd for $C_{25}H_{23}O_3$ $[M+H]^+$: 371.1642; found: 371.1631; IR (KBr): 1677, 1509, 1243, 815 (cm^{-1}); ^{1}H NMR ($CDCl_3$): δ 7.94 (d, *J*= 8.0 Hz, 2H), 7.29 (d, *J*= 7.6 Hz, 2H), 7.22 (d, *J*= 8.0 Hz, 2H), 7.00-6.95 (m, 3H), 6.76 (d, *J*= 8.0 Hz, 1H), 6.29 (s, 1H), 5.27 (s, 2H), 3.89 (s, 3H), 2.62 (s, 3H), 2.09 (s, 3H); ^{13}C NMR ($CDCl_3$): δ 197.5, 162.5, 159.4, 147.2, 135.9, 135.5, 132.9, 131.1, 130.8, 130.0, 129.4, 128.6, 128.4, 125.5, 124.9, 114.5, 110.0, 75.5, 55.4, 26.6, 21.0; Anal Calcd for $C_{25}H_{22}O_3$, C, 81.06; H, 5.99 found C, 81.14; H, 5.98.

(E)-Methyl-4-((4-acetylphenyl)(5-methylbenzofuran-3(*2H*)-ylidene)methyl)benzoate (3h): (0.096 g, 80%); yellow solid; Mp: 156-157 °C; HRMS (ESI) m/z Calcd for $C_{26}H_{23}O_4$ $[M+H]^+$: 399.1591; found: 399.1587; IR (KBr): 1722, 1681, 727 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 8.13 (d, *J*= 8.0 Hz, 2H), 7.94 (d, *J*= 8.4 Hz, 2H), 7.41 (d, *J*= 8.0 Hz, 2H), 7.26 (d, *J*= 8.0 Hz, 2H), 6.97 (d, *J*= 7.6 Hz, 1H), 6.77 (d, *J*= 8.0 Hz, 1H), 6.21 (s, 1H), 5.28 (s, 2H), 3.99 (s, 3H), 2.61 (s, 3H), 2.05 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 197.3, 166.8, 162.8, 146.2, 145.5, 136.9, 135.9, 131.7, 130.4, 129.8, 129.7, 129.5, 128.7, 128.4, 128.3, 124.74, 124.69, 110.3, 75.5, 52.2, 26.5, 20.9. Anal Calcd for $C_{26}H_{22}O_4$, C, 78.37; H, 5.57 found C, 78.45; H, 5.58.

(E)-methyl-3-((4-acetylphenyl)(5-methylbenzofuran-3(*2H*)-ylidene)methyl)benzoate (3i): (0.099 g, 83%); yellow solid; Mp: 150-151 °C; HRMS (ESI) m/z Calcd for $C_{26}H_{23}O_4$ $[M+H]^+$: 399.1591; found: 399.1578; IR (KBr): 1720, 1685, 725, 619 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 8.13 (s, 1H), 7.99-7.94 (m, 3H),

7.55 (d, *J*= 8.0 Hz, 2H), 7.29 (d, *J*= 7.6 Hz, 2H), 6.95 (d, *J*= 8.0 Hz, 1H), 6.76 (d, *J*= 8.0 Hz, 1H), 6.06 (s, 1H), 5.29 (s, 2H), 3.99 (s, 3H), 2.60 (s, 3H), 2.02 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 197.4, 166.8, 162.7, 146.2, 141.0, 137.0, 135.7, 134.4, 131.5, 131.2, 130.8, 129.8, 129.5, 129.2, 129.0, 124.9, 124.8, 110.2, 75.4, 52.2, 26.5, 20.9; Anal Calcd for $C_{26}H_{22}O_4$, C, 78.37; H, 5.57 found C, 78.46; H, 5.58.

(E)-3-((4-acetylphenyl)(5-methylbenzofuran-3(*2H*)-ylidene)methyl)benzaldehyde (3j): (0.080 g, 72%); yellow solid; Mp: 128-130 °C. HRMS (ESI) m/z Calcd for $C_{25}H_{20}O_3Na$ $[M+Na]^+$: 391.1305; found: 391.1302; IR (KBr): 2358, 1677,1481, 1265, 811 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 10.01 (s, 1H), 7.97-7.95 (m, 3H), 7.84 (d, *J*= 13.6 Hz, 1H), 7.64 (s, 1H), 7.28 (d, *J*= 7.6 Hz, 2H), 6.96 (d, *J*= 8.0 Hz, 1H), 6.77 (d, *J*= 8.0 Hz, 1H), 6.06 (s, 1H), 5.29 (s, 2H), 2.62 (s, 3H), 2.01 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 197.5, 192.1, 162.7, 146.1, 141.7, 137.3, 137.2, 136.0, 135.8, 131.8, 131.3, 129.9, 129.6, 129.3, 129.0, 128.8, 128.4, 124.8, 124.6, 110.4, 75.5, 26.6, 20.9; Anal Calcd for $C_{25}H_{20}O_3$, C, 81.50; H, 5.47 found C, 81.59; H, 5.48.

3-(Diphenylmethylene)-5-methyl-2,3-dihydrobenzofuran (3k): (0.089 g, 99%); yellow wax; HRMS (ESI) m/z Calcd for $C_{22}H_{19}O$ $[M+H]^+$: 299.1436; found: 299.1441; IR (KBr): 1590,1481, 1220, 813 (cm^{-1}); ^{1}H- NMR ($CDCl_3$): δ 7.52-7.13 (m, 10H), 6.98 (d, *J*= 8.0 Hz, 1H), 6.82 (d, *J*= 8.0 Hz, 1H), 6.19 (s, 1H), 5.36 (s, 2H), 2.11 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 162.3, 142.1, 141.4, 134.4, 132.4, 131.9, 130.6, 129.0, 128.8, 128.5, 128.2, 127.6, 127.2, 126.7, 124.9, 109.9, 75.7, 20.9; Anal Calcd for $C_{22}H_{18}O$, C, 88.56; H, 6.08 found C, 88.64; H, 6.07.

(E)-3-((4-Methoxyphenyl)(phenyl)methylene)-5-methyl-2,3-dihydrobenzofuran (3l): (0.081 g, 82%); yellow solid; Mp: 103-104 °C; HRMS (ESI) m/z Calcd for $C_{23}H_{21}O_2$ $[M+H]^+$: 329.1542; found: 329.1545; IR (KBr): 1606, 1482, 1288, 981 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 7.44-7.42 (m, 3H), 7.32-7.29 (m, 2H), 7.14 (d, *J*= 8.8 Hz, 2H), 6.90-6.87 (m, 3H), 6.74 (d, *J*= 8.4 Hz, 2H), 6.06 (s, 1H), 5.31 (s, 2H), 3.84 (s, 3H), 2.04 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 162.3, 159.1, 142.6, 134.0, 133.7, 132.1, 130.8, 130.5, 129.2, 128.5, 128.2, 127.2, 125.9, 124.7, 114.3, 109.9, 75.7, 55.4, 21.0; Anal Calcd for $C_{23}H_{20}O_2$, C, 84.12; H, 6.14 found C, 84.21; H, 6.15.

(E)-**Methyl 3-((5-methylbenzofuran-3(*2H*)-ylidene)(phenyl)methyl)benzoate (3m)**: (0.056 g, 52%); yellow solid; Mp: 132-133 °C; HRMS (ESI) m/z Calcd for $C_{24}H_{20}O_3Na$ $[M+Na]^+$: 379.1310; found: 379.1326; IR (KBr): 1722, 1482, 1284, 983 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 8.12 (d, *J*= 6.0 Hz, 1H), 8.03 (s, 1H), 7.59-7.52 (m, 7H), 6.94 (d, *J*= 8.0 Hz, 1H), 6.77 (d, *J*=8.4 Hz, 1H), 6.09 (s, 1H), 5.30 (s, 2H), 3.93 (s, 3H), 2.04 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 166.9, 162.4, 141.7, 141.6, 135.2, 134.3, 131.0, 130.9, 130.8, 129.4, 129.0, 128.8, 128.6, 128.2, 127.4, 125.2, 124.6, 110.0, 75.6, 52.2, 20.9; Anal Calcd for $C_{24}H_{20}O_3$, C, 80.88; H, 5.66 found C, 80.80; H, 5.67.

(E)-Methyl 4-((5-fluorobenzofuran-3(*2H*)-ylidene)(phenyl)methyl)benzoate (3n): (0.088 g, 81%); yellow solid; Mp: 116-117 °C; HRMS (ESI) m/z Calcd for $C_{23}H_{17}FO_3Na$ $[M+Na]^+$: 383.1059; found: 383.1052; IR (KBr): 1714, 1477, 1272, 817 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 7.95 (d, *J*= 8.4 Hz, 2H), 7.48-7.46 (m, 3H), 7.32-7.28 (m, 4H), 6.84-6.76 (m, 2H), 5.97-5.95 (m, 1H), 5.34 (s, 2H), 2.62 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 166.7, 160.4, 156.9 (d, $J_{C\text{-}F}$ = 235.0 Hz), 145.4, 141.0, 134.3 (d, $J_{C\text{-}F}$ = 3.5 Hz), 132.7, 130.5, 129.6, 129.5, 128.7, 128.1, 127.8, 126.2 (d, $J_{C\text{-}F}$ = 9.3 Hz), 116.8 (d, $J_{C\text{-}F}$ = 25.0 Hz), 110.7 (d, $J_{C\text{-}F}$ = 12.5 Hz), 110.6 (d, $J_{C\text{-}F}$ = 22.5 Hz), 76.2, 52.2; Anal Calcd for $C_{23}H_{17}FO_3$, C, 76.65; H, 4.75 found C, 76.73; H, 4.76.

(E)-methyl 3-((5-fluorobenzofuran-3(*2H*)-ylidene)(phenyl)methyl)benzoate (3o): (0.093 g, 86%); white solid; Mp: 117-118 °C; HRMS (ESI) m/z Calcd for $C_{23}H_{17}FO_3Na$ $[M+Na]^+$: 383.1059; found: 383.1070; IR (KBr): 1718, 1432, 1259, 754 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 8.11-8.00 (m, 2H), 7.53-7.19 (m, 7H), 6.81-6.77 (m, 2H), 5.92 (d, *J*= 8.4 Hz, 1H), 5.32 (s, 2H), 3.91 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 166.7, 160.3, 156.9 (d, $J_{C\text{-}F}$ = 237.3 Hz), 141.0 (d, $J_{C\text{-}F}$ = 15.1 Hz), 134.4, 134.0, 132.7, 131.8, 131.3, 130.5, 129.4, 129.1, 128.7, 128.1, 127.7, 126.4 (d, $J_{C\text{-}F}$ = 9.1 Hz), 116.7 (d, $J_{C\text{-}F}$ = 25.6 Hz), 110.7 (d, $J_{C\text{-}F}$ = 11.8 Hz), 110.6 (d, $J_{C\text{-}F}$ = 23.3 Hz), 76.1, 52.2; Anal Calcd for $C_{23}H_{17}FO_3$, C, 76.65; H, 4.75 found C, 76.72; H, 4.76.

(E)-5-Fluoro-3-((4-methoxyphenyl)(phenyl)methylene)-2,3-dihydrobenzofuran (3p): (0.084 g, 85%); yellow wax; HRMS (ESI) m/z Calcd for $C_{22}H_{17}FO_2Na$ $[M+Na]^+$: 355.1110; found: 355.1098; IR

(KBr): 1604, 1475, 1247, 779 (cm^{-1}); ^{1}H- NMR ($CDCl_3$): δ 7.48-7.44 (m, 3H), 7.32-7.30 (m, 2H), 7.15 (d, *J*= 8.4 Hz, 2H), 6.92-6.90 (m, 2H), 6.80-6.76 (m, 2H), 5.94 (d, *J*= 7.6 Hz, 1H), 5.38 (s, 2H), 3.85 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 159.9, 158.9, 156.9 (d, J_{C-F} = 235.9 Hz), 140.9, 134.9, 133.7, 132.4, 129.4, 129.3, 129.2, 127.9, 127.1 (d, J_{C-F} = 10.3 Hz), 115.9 (d, J_{C-F} = 25.1 Hz), 113.9 (d, J_{C-F} = 10.3 Hz), 110.8 (d, J_{C-F} = 26.3 Hz), 110.2 (d, J_{C-F} = 8.7 Hz), 76.3, 55.3; Anal Calcd for $C_{22}H_{17}FO_2$, C, 79.50; H, 5.16 found C, 79.59; H, 5.15.

(E)-Methyl 4-((4-acetylphenyl)(5-fluorobenzofuran-3(*3H*)-ylidene)methyl)benzoate (3q): (0.099 g; 82%); brown solid; Mp: 135-137 °C; HRMS (ESI) m/z Calcd for $C_{25}H_{19}FO_4Na$ $[M+Na]^+$: 425.1165; found: 425.1151; IR (KBr): 1729, 1479, 1274, 813 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 8.14 (d, *J*= 8.0 Hz, 2H), 7.94 (d, *J*= 7.6 Hz, 2H), 7.38 (d, *J*= 8.0 Hz, 2H), 7.26 (d, *J*= 8.0 Hz, 2H), 6.86-6.76 (m, 2H), 6.01 (d, *J*= 8.8 Hz, 1H), 5.31 (s, 2H), 3.94 (s, 3H), 2.61 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 197.4, 166.7, 160.6, 156.9 (d, J_{C-F} = 237.7 Hz), 145.6, 144.7, 136.1 (d, J_{C-F}= 3.0 Hz), 131.4, 130.6, 129.4, 129.6, 129.1, 128.8, 128.3, 125.8 (d, J_{C-F} = 10.0 Hz), 117.5 (d, J_{C-F}= 25.4 Hz), 110.9 (d, J_{C-F} = 10.0 Hz), 110.8 (d, J_{C-F} = 26.4 Hz), 76.0, 52.3, 26.6; Anal Calcd for $C_{25}H_{19}FO_4$, C, 74.62; H, 4.76 found C, 74.70; H, 4.75.

(Z)-1-(4-((5-Fluorobenzofuran-3(*2H*)-ylidene)(phenyl)methyl)phenyl)ethanone (3r): (0.093 g, 90%); yellow solid; Mp: 153-155 °C; HRMS (ESI) m/z Calcd for $C_{23}H_{17}FO_2Na$ $[M+Na]^+$: 367.1110; found: 367.1098; IR (KBr): 1681, 1484, 1267, 715 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 7.95 (d, *J*= 8.4 Hz, 2H), 7.48-7.46 (m, 3H), 7.32-7.29 (m, 4H), 6.84-6.77 (m, 2H), 5.95 (dd, J_1= 9.6 Hz, J_2= 2.4 Hz, 1H), 5.34 (s, 2H), 2.62 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 197.3, 160.4, 156.9 (d, J_{C-F} = 236.4 Hz), 146.2, 140.0, 135.9, 135.3 (d, J_{C-F} = 3.6 Hz), 132.7, 129.4, 129.3, 128.6, 128.3, 128.2, 126.5 (d, J_{C-F} = 9.1 Hz), 116.9 (d, J_{C-F} = 25.0 Hz), 111.0 (d, J_{C-F} = 26.1 Hz), 110.6 (d, J_{C-F} = 8.5 Hz), 76.0, 26.6; Anal Calcd for $C_{23}H_{17}FO_2$, C, 80.22; H, 4.98 found C, 80.31; H, 4.99.

(Z)-Methyl 4-((5-fluorobenzofuran-3(*2H*)-ylidene)(4-methoxyphenyl)methyl)benzoate (3s): (0.090 g, 76%); yellow solid; Mp: 129-130 °C; HRMS (ESI) m/z Calcd for $C_{24}H_{20}FO_4$ $[M+H]^+$ 391.1340; found: 391.1343; IR (KBr): 1710, 1604, 1247, 823 (cm^{-1}); ^{1}H NMR ($CDCl_3$): δ 8.12 (d, *J*= 8.0 Hz, 2H),

7.68 (d, *J*= 8.0 Hz, 2H), 6.89 (d, *J*= 8.4 Hz, 2H), 6.90-6.74 (m, 4H), 5.99 (dd, J_1= 9.6 Hz, J_2= 2.4 Hz, 1H), 5.33 (s, 2H), 3.93 (s, 3H), 3.83 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 166.8, 160.2, 159.0, 156.9 (d, J_{C-F} = 235.9 Hz), 145.7, 133.2 (d, J_{C-F} = 2.5 Hz), 132.5, 130.4, 130.2, 129.6, 129.4, 127.2, 126.5 (d, J_{C-F} = 9.0 Hz), 116.4 (d, J_{C-F} = 25.0 Hz), 114.0, 110.6 (d, J_{C-F} = 15.0 Hz), 110.5 (d, J_{C-F} = 20.1 Hz), 76.3, 55.3, 52.2; Anal Calcd for $C_{24}H_{19}FO_4$, C, 73.84; H, 4.91 found C, 73.90; H, 4.90.

(Z)-5-fluoro-3-((4-methoxyphenyl)(phenyl)methylene)-2,3-dihydrobenzofuran (3t): (0.079 g, 79%); yellow wax; HRMS (ESI) m/z Calcd for $C_{22}H_{17}FO_2Na$ $[M+Na]^+$: 355.1110; found: 355.1108; IR (KBr): 1631, 1457, 1247, 823 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 7.40-7.22 (m, 6H), 7.02-7.00 (m, 3H), 6.83-6.78 (m, 2H), 6.20 (d, *J*= 8.4 Hz, 1H), 5.33 (s, 2H), 3.91 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 160.2, 159.3, 156.9 (d, J_{C-F} = 235.7 Hz), 142.1, 133.8, 132.9, 130.5, 128.6, 128.1, 127.5, 127.3 (d, J_{C-F} = 8.4 Hz), 116.2 (d, J_{C-F} = 24.8 Hz), 114.5, 114.0 (d, J_{C-F} = 7.9 Hz), 110.8 (d, J_{C-F} = 26.3 Hz), 110.4 (d, J_{C-F} = 8.8 Hz), 76.3, 55.3; Anal Calcd for $C_{22}H_{17}FO_2$, C, 79.50; H, 5.16 found C, 79.59; H, 5.17.

(Z)-1-(4-(Phenyl(5-phenylbenzofuran-3(*2H*)-ylidene)methyl)phenyl)ethanone (3u): (0.076 g; 55%); brown solid; Mp: 174-175 °C; HRMS (ESI) m/z Calcd for $C_{29}H_{23}O_2$ $[M+H]^+$: 403.1698; found: 403.1687; IR (KBr): 1644, 1457, 1261, 981 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 7.61-7.56 (m, 2H), 7.52-7.12 (m, 14H), 6.95 (d, *J*= 8.4 Hz, 1H), 6.54 (s, 1H), 5.41 (s, 2H), 2.63 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 197.4, 164.0, 146.3, 140.7, 135.9, 135.7, 133.4, 131.9, 130.0, 129.6, 129.44, 129.41, 129.2, 128.6, 128.3, 128.0, 126.6, 126.4, 126.1, 123.4, 110.6, 75.8, 26.6; Anal Calcd for $C_{29}H_{22}O_2$, C, 86.54; H, 5.51 found C, 86.60; H, 5.52.

(E)-Methyl 4-((4-acetylphenyl)(5-phenylbenzofuran-3(*2H*)-ylidene)methyl)benzoate (3v): (0.076 g; 55%); brown solid; Mp: 130-132 °C; HRMS (ESI) m/z Calcd for $C_{31}H_{25}O_4$ $[M+H]^+$: 461.1753; found: 461.1775; IR (KBr): 1710, 1604, 1261, 757 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 8.20-7.98 (m, 4H), 7.48-6.95 (m, 11H), 6.51 (s, 1H), 5.38 (s, 2H), 4.00 (s, 3H), 2.63 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 197.5, 166.7, 164.2, 153.3, 145.7, 145.5, 140.5, 136.7, 135.9, 133.7, 130.7, 129.9, 129.8, 128.8, 128.8, 128.3, 126.8,

126.4, 125.534, 123.2, 129.3, 110.9, 75.8, 52.3, 26.6; Anal Calcd for $C_{31}H_{24}O_4$, C, 80.85; H, 5.25 found C, 80.79; H, 5.26.

3-(Diphenylmethylene)-5-phenyl-2,3-dihydrobenzofuran (3w): (0.072 g, 67%); white solid; Mp: 160-161 °C; HRMS (ESI) m/z Calcd for $C_{27}H_{21}O$ $[M+H]^+$ 361.1587; found: 361.1582; IR (KBr): 1656, 1471, 836 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 7.53-7.26 (m, 16H), 6.94 (d, *J*= 8.4 Hz, 1H), 6.47 (s, 1H), 5.41 (s, 2H); ^{13}C-NMR ($CDCl_3$): δ 163.8, 141.8, 141.3, 140.8, 133.9, 133.3, 133.2, 129.6, 129.2, 128.8, 128.6, 128.5, 128.1, 127.7, 127.3, 126.50, 126.48, 126.4, 123.2, 110.4, 75.9; Anal Calcd for $C_{27}H_{20}O$, C, 89.97; H, 5.59 found C, 89.90; H, 5.58.

(E)-Methyl 4-(phenyl(5-phenylbenzofuran-3(*2H*)-ylidene)methyl)benzoate (3x): (0.080 g; 64%); yellow solid; Mp: 153-154 °C; HRMS (ESI) m/z Calcd for $C_{29}H_{23}O_3$ $[M+H]^+$: 419.1647; found: 419.1652; IR (KBr): 2358,1656, 1471, 863 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 8.19 (d, *J*= 8.0 Hz, 2H),7.52-7.25 (m, 13H), 6.96 (d, *J*= 8.4 Hz, 1H), 6.58 (s, 1H), 5.40 (s, 2H), 4.02 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 166.8, 164.0, 146.2, 141.1, 140.7, 134.8, 133.5, 131.9, 130.5, 129.9, 129.5, 129.3, 128.7, 128.2, 127.7, 126.7, 126.5, 125.9, 123.0, 110.7, 76.0, 52.2; Anal Calcd for $C_{29}H_{22}O_3$, C, 83.23; H, 5.30 found C, 83.30; H, 5.31.

(Z)-Methyl 4-((4-methoxyphenyl)(5-phenylbenzofuran-3(*2H*)-ylidene)methyl)benzoate (3y): (0.071 g, 53%); white solid; Mp: 163-164 °C. HRMS (ESI) m/z Calcd for $C_{30}H_{25}O_4$ $[M+H]^+$: 449.1753; found: 449.1766; IR (KBr): 1710, 1471, 1286, 771 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 8.16 (s, 2H), 7.47-6.92 (m, 13H), 6.49 (s, 1H), 5.39 (s, 2H), 3.99 (s, 3H), 3.84 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 166.9, 163.8, 159.0, 146.4, 140.7, 133.6, 133.5, 131.7, 130.5, 130.3, 129.9, 129.5, 129.4, 129.0, 128.7, 126.6, 126.5, 126.2, 122.9, 114.0, 110.6, 76.1, 55.3, 52.2; Anal Calcd for $C_{30}H_{24}O_4$, C, 80.34; H, 5.39 found C, 80.42; H, 5.40.

3-((4-methoxyphenyl)(phenyl)methylene)-5-phenyl-2,3-dihydrobenzofuran (3z): (0.053 g, 45%); yellow solid; Mp: 158-159 °C; HRMS (ESI) m/z Calcd for $C_{28}H_{22}O_2Na$ $[M+Na]^+$: 413.1517; found:

413.1498; IR (KBr): 1590, 1261, 1035, 935 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 6.52-6.94 (m, 16H), 6.53 (s, 1H), 5.44 (s, 2H), 3.86 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 163.6, 158.8, 141.5, 140.9, 134.2, 133.2, 132.9, 132.7, 129.7, 129.5, 129.2, 128.6, 128.5, 127.657, 126.8, 126.5 , 123.0, 113.9, 110.4, 76.1, 55.3. Anal Calcd for $C_{28}H_{22}O_2$, C, 86.13; H, 5.68 found C, 86.20; H, 5.69.

(E)-3-((4-Fluoro-3-methylphenyl)(4-methoxyphenyl)methylene)-5-phenyl-2,3-dihydrobenzofuran (5a): (0.056 g, 44%); yellow solid; Mp: 140-141 °C; HRMS (ESI) m/z Calcd for $C_{29}H_{24}FO_2$ $[M+H]^+$ 423.1755; found: 423.1741; IR (KBr): 1631, 1484, 1247, 981 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 7.39-7.17 (m, 11H), 6.95-6.93 (m, 3H), 6.63 (s, 1H), 5.40 (s, 2H), 3.87 (s, 3H), 2.35 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 163.6, 161.0 (d, $J_{C\text{-}F}$ = 246.2 Hz), 158.8, 140.9, 137.1, 134.2, 133.3, 132.9, 132.9, 132.72, 132.67, 132.0, 129.4, 128.7, 128.6, 126.4, 125.6 (d, $J_{C\text{-}F}$ = 17.5 Hz), 123.0, 115.7 (d, $J_{C\text{-}F}$ = 21.9 Hz), 114.7, 113.9, 110.4, 76.1, 55.3, 14.6; Anal Calcd for $C_{29}H_{23}FO_2$, C, 82.44; H, 5.49 found C, 82.50; H, 5.50.

(E)-1-(4-((4-Fluoro-3-methylphenyl)(5-phenylbenzofuran3(*2H*)ylidene)methyl)phenyl)ethanone (5b): (0.078 g, 60%); yellow solid; Mp: 175-176 °C; HRMS (ESI) m/z Calcd for $C_{30}H_{24}FO_2$ $[M+H]^+$: 435.1760; found: 435.1758; IR (KBr): 1683, 1590, 1161, 744 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 7.97 (d, *J*= 8.0 Hz, 2H), 7.43-7.13 (m, 11H), 6.93 (d, *J*= 9.6 Hz, 1H), 6.63 (s, 1H), 5.36 (s, 2H), 2.62 (s, 3H),), 2.33 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 197.4, 164.0, 161.1 (d, $J_{C\text{-}F}$ = 247.1 Hz), 146.4, 140.7, 136.2 (d, $J_{C\text{-}F}$ = 3.8 Hz), 135.9 (d, $J_{C\text{-}F}$ = 24.0 Hz), 135.8, 133.6, 132.6 (d, $J_{C\text{-}F}$ = 5.1 Hz), 130.9, 129.73, 128.65, 128.3, 126.7, 126.4, 126.1, 125.95, 125.89, 123.3, 115.9 (d, $J_{C\text{-}F}$ = 22.0 Hz), 110.7, 75.8, 26.6, 14.59, 14.55; Anal Calcd for $C_{30}H_{23}FO_2$, C, 82.93; H, 5.34 found C, 82.85; H, 5.34.

(E)-3-((4-Fluoro-3-methylphenyl)(phenyl)methylene)-5-phenyl-2,3-dihydrobenzofuran(5c): (0.087 g, 74%); white solid; Mp: 157-158 °C. HRMS (ESI) m/z Calcd for $C_{28}H_{22}FO$ $[M+H]^+$: 393.1655; found: 393.1668; IR (KBr): 1631, 1484, 1247, 981 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 7.38-7.10 (m, 15H), 6.93 (d, *J*= 8.4 Hz, 1H), 6.65 (s, 1H), 5.37 (s, 2H), 2.34 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 163.8, 160.9 (d, $J_{C\text{-}F}$ = 245.8 Hz), 141.8, 140.9, 136.8 (d, $J_{C\text{-}F}$ = 3.8 Hz), 134.1, 133.4, 132.6 (d, $J_{C\text{-}F}$ = 4.9 Hz), 132.2, 129.0, 128.71, 128.66, 128.59, 128.09, 127.4, 126.6, 126.4, 126.3, 125.7 (d, $J_{C\text{-}F}$ = 17.4 Hz), 123.08,

115.7 (d, $J_{C\text{-}F}$ = 22.1 Hz), 110.5, 76.0, 14.61 (d, $J_{C\text{-}F}$ = 3.0 Hz); Anal Calcd for $C_{28}H_{21}FO$, C, 85.69; H, 5.39 found C, 85.75; H, 5.40.

(E)-5-fluoro-3-((4-fluoro-3-methylphenyl)(4-mthoxyphenyl)methylene)-2,3dihydrobenzofuran (5d): (0.079 g, 72%); yellow solid; Mp: 146-147 °C; HRMS (ESI) m/z Calcd for $C_{23}H_{19}F_2O_2$ $[M+H]^+$: 365.1353; found: 365.1348; IR (KBr): 1594, 1477, 1251, 831 (cm^{-1}); ^1H NMR ($CDCl_3$): δ 7.14-7.09 (m, 5H), 6.92-6.76 (m, 4H), 6.04 (d, *J*=8.8 Hz, 1H), 5.34 (s, 2H), 3.85 (s, 3H), 2.32 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 160,9 (d, $J_{C\text{-}F}$ = 246.0 Hz), 159.9, 158.9, 156.9 (d, $J_{C\text{-}F}$ = 235.9 Hz), 136.5 (d, $J_{C\text{-}F}$ = 3.7 Hz), 134.1, 132.9, 132.3 (d, $J_{C\text{-}F}$ = 5.0 Hz), 129.4, 128.3 (d, $J_{C\text{-}F}$ = 7.9 Hz), 127.1, 125.8 (d, $J_{C\text{-}F}$ = 17.2 Hz), 116.0 (d, $J_{C\text{-}F}$ = 25.1 Hz), 115.7 (d, $J_{C\text{-}F}$ = 22.6 Hz), 113.9, 113.9, 110.7 (d, $J_{C\text{-}F}$ = 26.4 Hz), 110.4 (d, $J_{C\text{-}F}$ = 8.75 Hz), 76.3, 55.3, 14.6 (d, $J_{C\text{-}F}$ = 2.8 Hz); Anal Calcd for $C_{23}H_{18}F_2O_2$, C, 80.22; H, 4.98 found C, 80.30; H, 4.99.

(E)-1-(4-((4-Fluoro-3-methylphenyl)(5-fluorobenzofuran3(*3H*)ylidene)methyl)phenyl)ethanone (5e): (0.093 g, 82%); yellow wax; IR HRMS (ESI) m/z Calcd for $C_{24}H_{18}F_2O_2$ $[M+Na]^+$: 399.1173; found: 399.1192; (KBr): 1683, 1479, 1265, 821 (cm^{-1}); ^1H-NMR ($CDCl_3$): δ 7.96 (d, *J*= 8.4 Hz, 2H), 7.29 (d, *J*= 8.4 Hz, 2H), 6.95-6.79 (m, 5H), 6.07 (dd, J_1= 7.6 Hz, J_2= 2.8 Hz, 1H), 5.31 (s, 2H), 2.62 (s, 3H), 2.32 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 197.5, 161.1 (d, $J_{C\text{-}F}$ = 246.1 Hz), 156.9 (d, $J_{C\text{-}F}$ = 266.6 Hz), 146.2, 135.9, 135.6, 132.4 (d, $J_{C\text{-}F}$ = 5.3 Hz), 131.9 (d, $J_{C\text{-}F}$ = 3.9 Hz), 128.7, 128.4, 128.3, 128.2, 126.4 (d, $J_{C\text{-}F}$ = 9.3 Hz), 126.2 (d, $J_{C\text{-}F}$ = 17.6 Hz), 117.1 (d, $J_{C\text{-}F}$ = 22.1 Hz), 115.9 (d, $J_{C\text{-}F}$ = 22.6 Hz), 110.9 (d, $J_{C\text{-}F}$ = 23.8 Hz), 110.8 (d, $J_{C\text{-}F}$ = 6.3 Hz), 75.9, 26.6, 14.6 (d, $J_{C\text{-}F}$ = 3.8 Hz); Anal Calcd for $C_{24}H_{18}F_2O_2$, C, 76.58; H, 4.82 found C, 76.67; H, 4.83.

Synthesis of 1-(4-(1E,2E)-1-(5-methylbenzofuran-3(*2H*)-ylidene)-3-phenylallyl)phenyl)ethanone (6). A solution of 1-(4-(3-(2-bromo-4-methylphenoxy)prop-1-ynyl)phenyl)ethanone **(1a)** (0.1 g, 0.29 mmol, 1 equiv.), $PdCl_2(PPh_3)_2$ (0.004 g, 0.006 mmol, 0.02 equiv.) and K_3PO_4 (0.184 g, 0.87 mmol, 3 equiv.) in 1,4-dioxane (2 mL) was treated with potassium trans-β-styryltrifluoroborate (0.092 g, 0.44 mmol, 1.5 equiv.). The resulting solution was stirred at 100 °C for 4 h until determined to be complete

by TLC. The crude reaction mixture was extracted with ether/H_2O. The combined organic extracts were washed with NaCl/H_2O, dried over Na_2SO_4 and finally concentrated under reduced pressure. The product was subjected to flash column chromatography (SiO_2 50 g), eluting with *n*-hexane/ethyl acetate 85:15 v/v to afford the product **6** (0.048 g, 0.13 mmol, 45 %): yellow oil; HRMS (ESI) m/z Calcd for $C_{26}H_{23}O_2$ $[M+H]^+$: 367.1690; found: 367.1690; IR (KBr): 2921, 2360, 1683, 1265, 956 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 8.07 (d, *J*= 8.0 Hz, 2H), 7.83 (d, *J*= 16.0 Hz, 1H), 7.60 (s, 1H), 7.43-7.09 (m, 7H), 7.01 (d, *J*= 8.4 Hz, 1H), 6.82 (d, *J*= 8.4 Hz, 1H), 6.14 (d, *J*= 16.0 Hz, 1H), 4.87 (s, 2H), 2.70 (s, 3H), 2.44 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 197.7, 163.5, 145.1, 137.4, 136.4, 132.5, 131.3, 130.5, 130.4, 129.5, 129.1, 128.8, 127.8, 126.8, 126.5, 126.4, 125.2, 110.4, 75.8, 26.6, 21.3. Anal Calcd for $C_{26}H_{22}O_2$, C, 85.22; H, 6.05 found C, 85.30; H, 6.06.

General Procedure for the aromatization reaction of 3-methylene-2,3-dihydrobenzofurans 3: Synthesis of 3-((4-methoxyphenyl)(phenyl)methyl)-5-methylbenzofuran (8a). A solution of 3-((4-methoxyphenyl)(phenyl)methylene)-5-methyl-2,3-dihydrobenzofuran (**3a**) (0.05 g, 0.15 mmol, 1 equiv.) in DMF (1 mL) was added K_3PO_4 (0.318 g, 0.15 mmol, 1 equiv.) . The resulting solution was stirred at 100 °C for 7 h until determined to be complete by TLC. After cooling, the reaction mixture was dried under reduced pressure and the residue was purified by flash column chromatography (SiO_2 50 g), eluting with *n*-hexane/ethyl acetate 90:10 v/v to afford the product (0.036 g, 0.11 mmol, 73 %) as a yellow solid. Mp: 115-116 °C; HRMS (ESI) m/z Calcd for $C_{23}H_{21}O_2$ $[M+H]^+$ 329.1536; found: 329.1527; IR (KBr): 1617, 1511, 1087, 1022, 796 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 7.37-7.28 (m, 6H), 7.24 (d, *J*= 6.8 Hz, 2H), 7.16 (d, *J*= 8.4 Hz, 1H), 6.97 (s, 1H), 6.94 (s, 1H), 6.86 (d, *J*= 8.8 Hz, 2H), 5.47 (s, 1H), 3.82 (s, 3H), 2.34 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 158.3, 154.3, 144.2, 142.7, 134.6, 131.8, 129.8, 128.8, 128.5, 127.7, 126.6, 125.6, 124.0, 120.4, 113.9, 110.9, 55.2, 46.8, 21.3; Anal Calcd for $C_{23}H_{20}O_2$, C, 84.12; H, 6.14 found C, 84.20; H, 6.15.

Typical Procedure A for the Synthesis of 3,5 disubstituted-benzo[*b*]furans (8): Synthesis of 3-((4-methoxyphenyl)(phenyl)methyl)-5-methylbenzofuran (8a). A solution of 2-bromo-1-(3-(4-

methoxyphenyl)prop-2-ynyloxy)-4-methylbenzene (**1a**) (0.1 g, 0.30 mmol, 1 equiv.), $PdCl_2(PPh_3)_2$ (0.004 g, 0.006 mmol, 0.02 equiv.) and K_3PO_4 (0.191 g, 0.90 mmol, 3 equiv.) in 1,4-dioxane (2 mL) was treated with phenylboronic acid **2a** (0.055 g, 0.45 mmol, 1.5 equiv.). The resulting solution was stirred at 100 °C for 2 h until determined to be complete by TLC. The crude reaction mixture was extracted with ether/H_2O. The combined organic extracts were washed with NaCl/H_2O, dried over Na_2SO_4 and finally concentrated under reduced pressure. The residue was dissolved in DMF (2 ml) and K_3PO_4 (0.631 g, 0.30 mmol, 1 equiv.) was added. The resulting solution was stirred at 100 °C for 2 h until determined to be complete by TLC. After cooling, the reaction mixture was dried under reduced pressure and the residue was purified by flash column chromatography (SiO_2 50 g), eluting with *n*-hexane/ethyl acetate 90:10 v/v to afford the product **8a** (0.064 g, 0.19 mmol, 65 %).

Typical Procedure B for the Synthesis of 3,5 disubstituted benzo[*b*]furans (8): Synthesis of 3-((4-methoxyphenyl)(phenyl)methyl)-5-methylbenzofuran (8a). A solution of 2-bromo-1-(3-(4-methoxyphenyl)prop-2-ynyloxy)-4-methylbenzene (**1a**) (0.1 g, 0.30 mmol, 1 equiv.), $PdCl_2(PPh_3)_2$ (0.004 g, 0.006 mmol, 0.02 equiv.) and K_3PO_4 (0.318 g, 1.50 mmol, 5 equiv.) in DMSO (2 mL) was treated with phenylboronic acid (**2a**) (0.055 g, 0.45 mmol, 1.5 equiv.). The resulting solution was stirred at 100 °C for 9 h until determined to be complete by TLC. The crude reaction mixture was extracted with ether/H_2O. The combined organic extracts were washed with NaCl/H_2O, dried over Na_2SO_4 and finally concentrated under reduced pressure. After cooling, the reaction mixture was dried under reduced pressure and the residue was purified by flash column chromatography (SiO_2 50 g), eluting with *n*-hexane/ethyl acetate 90:10 v/v to afford the product **8a** (0.050 g, 0.15 mmol, 51 %).

3-Benzhydryl-5-methylbenzofuran (8b): (0.065 g, 73% [procedure **A**]; 0.046 g, 51% [procedure **B**]); yellow solid; Mp: 83-84 °C; HRMS (ESI) m/z Calcd for $C_{22}H_{19}O$ $[M+H]^+$ 299.1430; found: 299.1424; IR (KBr): 1631, 1286, 1087, 698 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 7.45-7.32 (m, 11H), 7.15 (d, *J*= 8.0 Hz, 1H), 7.06 (s, 1H), 7.02 (s, 1H), 5.59 (s, 1H), 2.40 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 154.3, 144.3, 142.4,

131.9, 128.8, 128.5, 127.7, 126,7, 125.6, 123.7, 120.4, 111.0, 47.6, 21.4; Anal Calcd for $C_{22}H_{18}O$, C, 88.56; H, 6.08 found C, 88.65; H, 6.09.

1-(4-((5-Methylbenzofuran-3-yl)(phenyl)methyl)ethanone (8c): (0.074 g, 72% [procedure **A**]); yellow solid; Mp: 90-91 °C; HRMS (ESI) m/z Calcd for $C_{24}H_{21}O_2$ $[M+H]^+$: 341.1542; found: 341.1555; IR (KBr): 1644, 1272, 1087, 703 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 7.94 (d, *J*= 8.4 Hz, 2H), 7.41-6.95 (m, 9H), 7.01 (s, 1H), 6.95 (s, 1H) 6.00 (s, 1H), 2.62 (s, 3H), 2.36 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 197.8, 154.3, 147.9,144.2, 141.5, 135.8, 132.1, 129.1, 128.8, 128.7, 127.4, 127.1, 125.8, 122.9, 120.2, 111.1, 47.6, 26.6, 21.4. Anal Calcd for $C_{24}H_{20}O_2$, C, 84.68; H, 5.92 found C, 84.60; H, 5.93.

Methyl 3-((4-methoxyphenyl)(5-methylbenzofuran-3-yl)methyl)benzoate (8d): (0.064 g, 55% [procedure **A**]; 0.035 g, 30% [procedure **B**]); yellow wax; HRMS (ESI) m/z Calcd for $C_{25}H_{23}O_4$ $[M+H]^+$: 387.1596; found: 387.1614; IR (KBr): 1722, 1604, 1284, 800 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 8.00 (s, 1H), 7.96 (d, *J*= 7.2 Hz, 1H), 7.46-7.37 (m, 3H), 7.19-7.09 (m, 3H), 6.96 (s, 1H), 6.91 (s, 1H), 6.89-6.87 (m, 2H), 5.51 (s, 1H), 3.91 (s, 3H), 3.82 (s, 3H), 2.35 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 167.1, 158.5, 154.3, 144.2, 143.2, 133.8, 133.2, 131.9, 130.5, 129.9, 129.7, 128.6, 127.9, 127.5, 125.7, 123.6, 120.2, 114.0, 111.0, 55.2, 52.1, 46.7, 21.3; Anal Calcd for $C_{25}H_{22}O_4$, C, 77.70; H, 5.74 found C, 77.61; H, 5.75.

5-Fluoro-3-((4-methoxyphenyl)(phenyl)methyl)benzofuran (8e): (0.090 g, 90% [procedure **A**]); yellow oil; HRMS (ESI) m/z Calcd for $C_{22}H_{18}FO_2$ $[M+H]^+$: $C_{22}H_{18}FO_2Na$ $[M+Na]^+$: 333.1291; found: 333.1290; IR (KBr): 1610, 1469, 1249, 1099, 852 (cm^{-1}); ^{1}H-NMR ($CDCl_3$): δ 7.43-6.79 (m, 13H), 5.46 (s, 1H), 3.81 (s, 3H); ^{13}C-NMR ($CDCl_3$): δ 158.6 (d, J_{C-F} = 237.0 Hz), 158.5, 152.1, 145.7, 142.2, 134.0, 129.8, 128.4, 128.6, 128.2, 126.8, 124.7 (d, J_{C-F} = 3.8 Hz), 114.0, 112.2 (d, J_{C-F} = 26.0 Hz), 112.0, 106.3 (d, J_{C-F} = 25.0 Hz), 55.3, 46.8; Anal Calcd for $C_{22}H_{17}FO_2$, C, 79.50; H, 5.72 found C, 79.42; H, 5.73.

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Supporting Information Available: Characterization for compounds, including copies of ^{1}H and ^{13}C NMR spectra. This material is available free of charge via the World Wide Web at http://pubs.acs.org.

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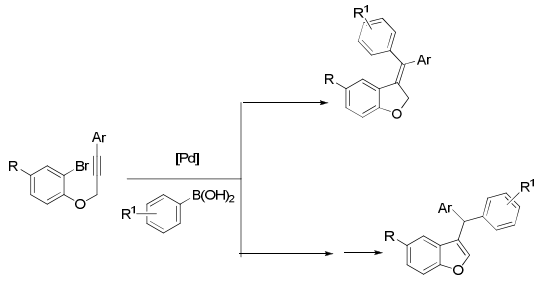
PALLADIUM-CATALYZED CASCADE REACTIONS OF 1-(3-ARYLPROP-2-YNYLOXY)-2-BROMO BENZENE DERIVATIVES WITH ORGANOBORON COMPOUNDS



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