# The Preparation of 2,3,5-Tri- and 2,3-Disubstituted Furans by Regioselective Palladium(0)-Catalyzed Coupling Reactions: Application to the Syntheses of Rosefuran and the $F_5$ Furan Fatty Acid

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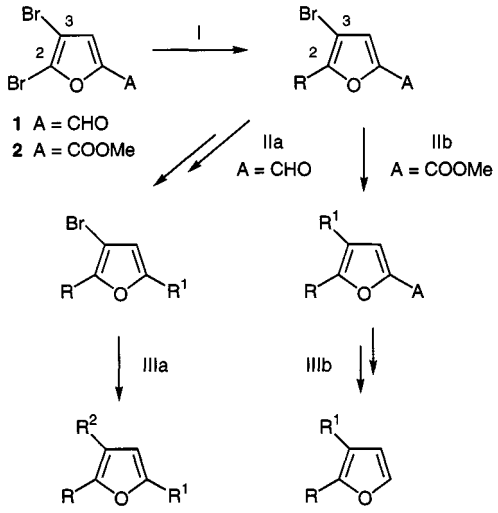
The 5-acceptor-substituted 2,3-dibromofurans **1** and **2** underwent a regioselective $Pd^0$-catalyzed coupling reaction at the C-2 carbon atom. With alkynes the corresponding 2-alkynylfurans **4** and **5** were accessible (49–97% yield). Alkyl-, aryl-, and alkenylzinc reagents gave the 2-substituted furans **8** starting from compound **2** (66–84% yield). The 2-allylfurans **8e** and **8f** were obtained by a regioselective Stille coupling in 79% and 73% yield. The latter reaction was also applied to the parent 2,3-dibromofuran (**27**) and yielded the substitution product **28** (60% yield). Subsequent $Pd^0$-catalyzed reactions to introduce a methyl group in 3-position by a methyldebromination were successfully conducted for 2-alkynyl-3-bromofurans with MeZnCl and $PdCl_2(PPh_3)_2$ as the catalyst in THF (reflux) to yield compounds **13**–**16** and **24** (67–76%) and with $SnMe_4$ and $PdCl_2[P(o\text{-Tol})_3]_2$ as the catalyst in DMA (90 °C) for the 2-allyl-3-bromofuran **8e** to yield **18** (70%). The more facile reaction of the 2-alkynylfurans relative to those of furans bearing an $sp^3$-carbon atom at C-2 appears to be due to steric reasons. Studies on the 2-alkyl-3-bromofuran **20** supported this notion. With the regioselective coupling methodology the terpene rosefuran (**22**) was prepared in four steps starting from furan **2** (35% yield overall). The $F_5$ furan fatty acid (**26**) was synthesized from furan **1** in five steps (29% yield overall).

Multiply substituted furans[1] have recently attracted increasing attention as synthetic target compounds[2] due to their widespread occurence in nature and due to the wide range of biological activities they cover. Some prominent examples of naturally occurring tri- or tetrasubstituted furans include the abundant furan fatty acids,[3] the sphinganine-derived calicogorgins[4] and the cytotoxic, diterpenoid furanocembranes,[5] pseudopteranes,[6] and gersolanes.[7] In addition, many other terpenes are known to contain a multiply substituted furan ring, e.g. the monoterpenes rosefuran[8] and α-clausenan,[9] the sesquiterpenes agassizin and furodysin,[10] and the diterpene mikanifuran.[11]

Our synthetic approach to 2,3-di- and 2,3,5-trisubstituted furans is depicted in Scheme 1. We speculated that the readily available 5-acceptor-substituted 2,3-dibromofurans **1**[12] and **2**[12] (A = acceptor) can be selectively substituted at the 2-position by $Pd^0$-catalyzed cross-coupling reactions[13] (step I). In subsequent operations the transformation of the formyl group (A = CHO) to a carbon side chain with conventional olefination methods (step IIa) and the substitution of the bromine at C-3 in a second $Pd^0$-catalyzed coupling reaction (step IIIa) was projected to yield 2,3,5-trisubstituted furans. Alternatively, a furan with the more robust methoxycarbonyl substituent at the 5-position (A = COOMe) appeared to be suited for a second $Pd^0$-catalyzed coupling at C-3 (step IIb) immediately after the first substitution. Straightforward saponification and decarboxylation was expected to yield 2,3-disubstituted furans.




Scheme 1. General strategy for preparation of 2,3,5-tri- and 2,3-disubstituted furans from the 2,3-dibromofurans **1** and **2**

The notion of a selective coupling in 5-acceptor-substituted 2,3-dibromofurans (step I, Scheme 1) was based on the assumption that the oxidative addition of $Pd^0$ was the regioselectivity-determining step of the reaction. The known propensity of these furans to undergo nucleophilic substitution reactions with high preference at C-2[14] and the analogy between the nucleophilic aromatic substitution and the oxidative addition of $Pd^0$ into aryl−halogen bonds which has been frequently stressed[15] made a preferential attack at C-2 likely. In general, even on the parent 2,3-dibromofuran, reactions that require an electrophilic carbon atom are known to occur at C-2.[1,16,17] When we started our work,[18] regioselective $Pd^0$-catalyzed coupling reactions

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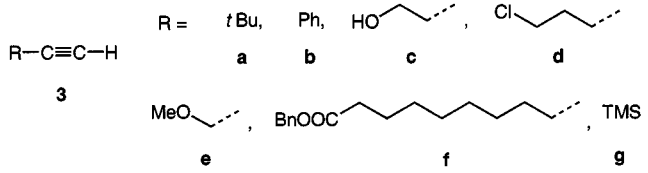
had, to the best of our knowledge, not been reported. However, there was a precedence for regioselective cross-coupling reactions on other polyhalogenated five-membered heterocycles, e.g. on thiophenes,[19] thiazoles,[20] and imidazoles,[21] to name some relevant examples. Other strategies for the synthesis of multiply substituted furans based on regioselective reactions are known and have been recently reviewed.[22] In this account we report on our results for the reactions depicted in Scheme 1 and discussed above.

## 1. Regioselective $Pd^0$-Catalyzed Coupling with Alkynes

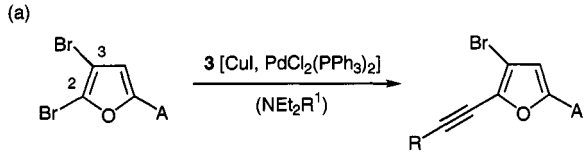
In a first set of experiments we turned towards the cross coupling of alkynes with the dibromofurans **1** and **2** according to the Sonogashira protocol.[23] The reaction is known to tolerate a plethora of functional groups, which was considered to be beneficial both for the choice of alkyne substrates and for the somewhat sensitive formyl group in furan **1**. Most of the alkynes **3** employed were commercially available. The benzyl ester **3f** was prepared from the corresponding undecynoic acid via the acid chloride [1. $(COCl)_2$ in $CH_2Cl_2$; 2. BnOH, $NEt_3$, DMAP (cat.) in $CH_2Cl_2$; 95%].




In general, the coupling reaction with furan **1** proceeded smoothly to yield a single substitution product on employing 2 equivalents of alkyne in the presence of CuI (0.2 equiv.) and $PdCl_2(PPh_3)_2$ (0.1 equiv.) [Equation (a), Table 1]. The choice of amine base, namely, diethylamine vs. triethylamine, as solvent proved to have a minor influence on the reaction course as exemplified by comparison of Entries 1 and 2, and 9 and 10, for which only small differences were observed. Although most reactions were close to completion upon stirring overnight it is advisable to extend the reaction time until no starting material is left in order to facilitate the separation of the product. Methyl propargyl ether (**3e**) did not react well with diethylamine as base. With triethylamine the yields were higher, but they did not fully match those obtained with the other alkynes.

The $^{13}$C-NMR signals for the C-2 carbon atoms of the substitution products **4** and **5** exhibit significant chemical shift differences ($\Delta\delta \approx 10$ ppm) from the signals for the starting materials **1** and **2**, whereas the other furan carbon atoms resonate at similar frequencies ($\Delta\delta \approx \pm 3$ ppm). Based on APT (attached proton test) experiments and on previously reported chemical shift data[1][24] the peaks at $\delta = 131.3$ in **1** and at $\delta = 128.3$ in **2** were assigned to the C-2 carbon atom. They are significantly deshielded upon substitution and their signals are found at $\delta = 139.8-141.3$ in **4** and at $\delta = 138.5-139.8$ in **5**. The fact that the signals for the C-3 carbon atoms are not affected by the substitution indirectly proves the regioselectivity. Direct chemical proof was obtained by hydrodebromination and concomitant carbonyl reduction of compound **4a** with $LiAlH_4$, which gave the alcohol **7** in low yield. Independent synthesis of this material starting from 5-bromofurfural (**6**)[12] as depicted in Equation (b)[25] and its comparison with the product obtained from furan **4a** suppported the regiochemical assignment. In addition, the product **4f** was converted into a natural product, the constitution of which is known (vide infra).

(a)



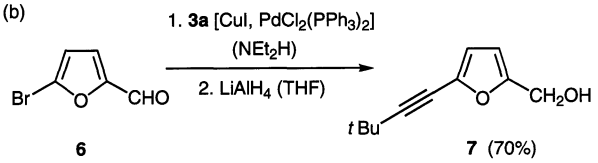

1 A = CHO 4
2 A = COOMe 5

Table 1. Regioselective Cu- (10 mol-% CuI) and Pd-catalyzed [5 mol-% $PdCl_2(PPh_3)_2$] coupling of alkynes **3** (2 equiv.) with the dibromofurans **1** and **2** in $NEt_2R^1$ as solvent at room temperature according to Equation (a)

| Entry | Furan | Alkyne | $R^1$ | Time[a] [h] | Product | Yield[b] (%) |
|---|---|---|---|---|---|---|
| 1 | **1** | **3a** | Et | 24 | **4a** | 84 |
| 2 | **1** | **3a** | H | 24 | **4a** | 83 |
| 3 | **2** | **3a** | Et | 24 | **5a** | 95 |
| 4 | **1** | **3b** | H | 72 | **4b** | 81 |
| 5 | **2** | **3b** | H | 48 | **5b** | 80 |
| 6 | **1** | **3c** | H | 96 | **4c** | 68 |
| 7 | **2** | **3c** | Et | 72 | **5c** | 73 |
| 8 | **1** | **3d** | Et | 48 | **4d** | 71 |
| 9 | **2** | **3d** | H | 48 | **5d** | 85 |
| 10 | **2** | **3d** | Et | 96 | **5d** | 97 |
| 11 | **1** | **3e** | Et | 96 | **4e** | 68 |
| 12 | **2** | **3e** | Et | 168 | **5e** | 49 |
| 13 | **1** | **3f** | H | 96 | **4f** | 61 |
| 14 | **2** | **3g** | Et | 24 | **5g** | 80 |

[a] Time required for complete conversion. — [b] Yield of isolated product.

(b)




## 2. Regioselective $Pd^0$-Catalyzed Coupling with Organometallic Compounds

Although the 2-alkynyl-substituted furans **4** and **5** are versatile precursors to 2,3,5-trisubstituted furans, we were also interested in the coupling of other organometallic reagents in order to extend the scope of the regioselective coupling reaction. The ester **2** was chosen as the substrate for these experiments. Coupling reactions with organozinc reagents[26] proceeded smoothly in THF at room temperature and gave the substitution products **8** in good yields

[Equation (c), Table 2]. The zinc reagent was generated from the corresponding lithium or magnesium reagent by transmetalation with $ZnCl_2$ (1.5−2 equiv.) in THF. If an excess of the organozinc reagent was used, a reduction (hydrodebromination) at C-3 was observed after longer reaction times or at elevated temperatures. The reduction could not be suppressed if organozinc reagents possessing a β-hydrogen atom were employed in the reaction. With *n*-butylzinc chloride, for example, the reaction proceeded under a variety of conditions to a mixture of the desired 3-bromofuran and its debrominated analogue. The 2-vinylfuran **8d** was unstable and decomposed rapidly upon standing even at −30°C.

(c)

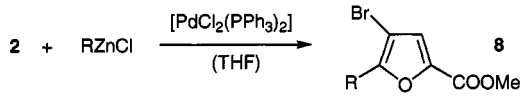


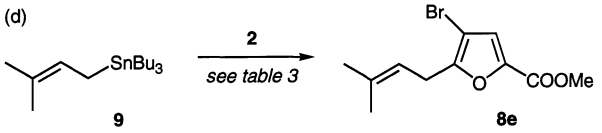

Table 2. Regioselective Pd-catalyzed [5 mol-% $PdCl_2(PPh_3)_2$] coupling of organozinc reagents with the dibromofuran **2** in THF as solvent at room temperature according to Equation (c)

| Entry | R | Equiv. | Time[a] [h] | Product | Yield[b] (%) |
|---|---|---|---|---|---|
| 1 | Ph | 2.0 | 24 | **8a** | 66 |
| 2 | 2-Furyl | 2.0 | 16 | **8b** | 76 |
| 3 | Me | 1.2 | 24 | **8c** | 84 |
| 4 | Vinyl | 2.0 | 96 | **8d**[c] | 74 |

[a] Time required for complete conversion. − [b] Yield of isolated product. − [c] The compound was unstable and decomposed rapidly upon standing.

It has been reported that the cross coupling of allylzinc reagents is sluggish[26b] and the Stille coupling[27] with the corresponding allylstannanes consequently appeared to be the method of choice to install allyl groups at the 2-position of multiply substituted furans. The readily available 3-methylbut-2-enylstannane **9**[28][29] was selected for preliminary studies as its reaction product was considered to be a suitable precursor for the synthesis of rosefuran (vide infra). For the cross-coupling of stannane **9** and furan **2** some experimentation was neccessary to find the optimum conditions which guaranteed a complete and clean reaction [Equation (d), Table 3]. A slight excess of stannane **9** (1.5 equiv.) was used in all runs. In toluene and THF as solvent the coupling proceeded slowly (Entries 2 and 3) or side reactions such as hydrodebromination and decomposition of the starting material took over (Entry 1). DMF proved to be superior in terms of reaction efficiency and conversion (Entries 4−8). Still, the reaction was somewhat sluggish at a reaction temperature of 100°C with 0.05 equivalents of the catalyst (Entries 4−6). Raising the amount of catalyst to 0.1 equivalents (10 mol-%) was a remedy for this problem which allowed us to run the reaction at a slightly lower temperature (Entry 8). Finally, it turned out that *N*,*N*-dimethylacetamide (DMA) gave more reproducible results than DMF as the solvent. In the run specified by Entry 9 the desired furan **8e** was isolated in 79% yield.

(d)




With DMA as solvent it was also possible to prolong the reaction times significantly without product decomposition. This fact allowed the lowering of both the catalyst and the stannane quantity to some extent. A 70% yield of furan **8e** was obtained with 5 mol-% of $Pd(PPh_3)_4$ as catalyst and 1.2 equivalents of stannane **9** in DMA at 90°C (72 h). Other allylstannanes reacted similarly under the reaction conditions optimized for **9**, as exemplified by the clean conversion of allyltributylstannane (**10**) into furan **8f** [Equation (e)] in 73% yield.

The substitution products **8** exhibit similar characteristics in their $^{13}C$-NMR spectra to the alkynyl-substituted derivatives **4** and **5**. The deshielding of the C-2 carbon atom in compounds **8** relative to the starting material **2** is even more pronounced and a shift difference Δδ of more than 30 ppm to lower field was observed. The C-4 and C-5 carbon atom remained unaffected whereas the C-3 carbon atom was slightly shielded (Δδ = −5 ppm).

To summarize sections 1 and 2 briefly, the regioselective coupling of various carbon fragments to the 2,3-dibrominated furans **1** and **2** was achieved. For the coupling of an alkynyl group the Sonogashira conditions proved highly suitable, and allyl fragments were successfully attached to the C-2 atom of furan **2** with the Stille reaction. Alkenyl, aryl, and methyl groups could be regioselectively coupled by using the corresponding zinc reagents.

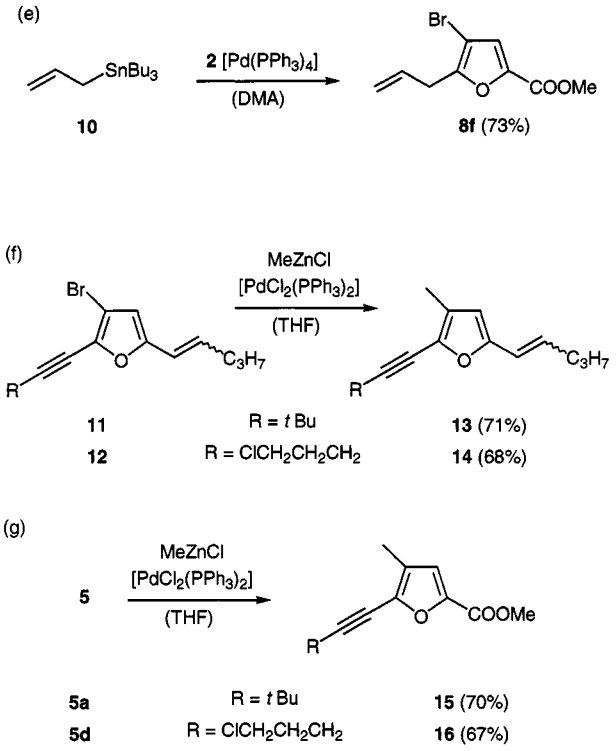
## 3. $Pd^0$-Catalyzed Cross Coupling at Carbon Atom C-3

It was crucial for the success of our strategy (Scheme 1) that a substituent could not only be introduced at the C-2 but also at the C-3 position of the furan nucleus by $Pd^0$ catalysis. Most naturally occurring furans bear a methyl group at this site and we consequently concentrated our efforts on the coupling of a methylmetal reagent with the 3-bromofurans obtained by the regioselective reactions described above. The first experiments were conducted with the 2-alkynyl-substituted furans **4** derived from furfural **1**. After Wittig olefination to the corresponding alkenes the methyldebromination could be smoothly achieved with an excess of methylzinc chloride (3 equiv.) and $PdCl_2(PPh_3)_2$ as the catalyst in refluxing THF. Two examples starting from the 3-bromofurans **11** and **12** are depicted in Equation (f). The coupling products **13** and **14** were obtained in yields of 71% and 68%, respectively. This reaction paved the way to the synthesis of 2,3,5-trisubstituted furans starting from compound **1** and an application is described in section 4.

Table 3. Attempted coupling reactions of stannane **9** (1.5 equiv.) with the dibromofuran **2** at varying conditions according to Equation (d)

| Entry | Catalyst | Equiv. | Solvent | Temperature [°C] | Time[a] [h] | Ratio **8e**/**2**[b] |
|---|---|---|---|---|---|---|
| 1 | $Pd(PPh_3)_4$ | 0.1 | toluene | reflux | 16 | 90:10[c] |
| 2 | $Pd(PPh_3)_4$ | 0.05[d] | toluene | reflux | 6 | < 5:95 |
| 3 | $Pd(PPh_3)_4$ | 0.1 | THF | reflux | 22 | < 5:95 |
| 4 | $PdCl_2(PPh_3)_2$ | 0.05 | DMF | 100 | 15 | 85:15 |
| 5 | $PdCl_2(PPh_3)_2$ | 0.05[d] | DMF | 100 | 15 | 90:10 |
| 6 | $Pd(PPh_3)_4$ | 0.05 | DMF | 100 | 24 | 92:8 |
| 7 | $Pd(PPh_3)_4$ | 0.1[e] | DMF | 90 | 22 | > 95:5 |
| 8 | $Pd(PPh_3)_4$ | 0.1 | DMF | 90 | 18 | > 95:5 |
| 9 | $Pd(PPh_3)_4$ | 0.1 | DMA | 90 | 18 | > 95:5 |

[a] Time during which the mixture was kept at the indicated temperature. – [b] The ratio was determined by GLC. – [c] Large amounts of unidentified side products were observed by GLC and $^1$H NMR. – [d] $PPh_3$ (0.1 equiv.) was added – [e] 1.2 equiv. of stannane **9** was used.




In an analogous fashion the 3-bromofurancarboxylates **5a** and **5d** were converted into the 3-methylfurancarboxylates **15** and **16** [Equation (g)].

Disappointingly, the coupling of the 3-bromofurans **8** derived from furanoic ester **2** proceeded by far less readily. The reaction was sluggish and extensive hydrodebromination at the C-3 position was found to occur. The factors influencing the ratio of starting material, hydrodebrominated product and methylated product were studied more closely on furan **8e** which was considered to be a precursor for rosefuran. In Table 4 the dependence of this ratio (**8e**/**17**/**18**) on the catalyst chosen [Equation (h)] is given. Although care is neccessary in evaluating these results, in particular if one considers the importance of catalyst preparation and solvent purity, the superiority of $PdCl_2[P(o\text{-}Tol)_3]_2$ becomes quite obvious (Entries 8–11).

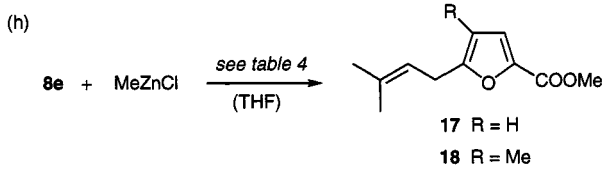



Table 4. Attempted coupling reactions of MeZnCl (3 equiv.) and the bromofuran **8e** in the presence of various catalysts (5 mol-%) according to Equation (g) in THF at reflux

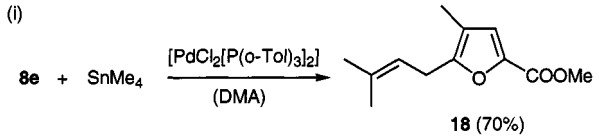
| Entry | Catalyst | Time[a] [h] | Ratio **8e**/**17**/**18**[b] |
|---|---|---|---|
| 1 | $NiCl_2(PPh_3)_2$ | 20 | 100:0:0 |
| 2 | $NiCl_2$(dppp) | 72 | 95:5:0 |
| 3 | $PdCl_2(PPh_3)_2$ | 24 | 24:38:38 |
| 4 | $PdCl_2(PPh_3)_2$[c] | 24 | 30:23:47 |
| 5 | $PdCl_2$(dppe) | 15 | 88:9:3 |
| 6 | $Pd(PPh_3)_4$ | 18 | 67:8:25 |
| 7 | $Pd(OAc)_2$/dppf | 20 | 33:29:38 |
| 8 | $Pd(OAc)_2/P(o\text{-}Tol)_3$ | 20 | 27:12:61 |
| 9 | $PdCl_2[P(o\text{-}Tol)_3]_2$ | 18 | 19:17:64 |
| 10 | $PdCl_2[P(o\text{-}Tol)_3]_2$[d] | 42 | 20:13:67 |
| 11 | $PdCl_2[P(o\text{-}Tol)_3]_2$[e] | 18 | 16:16:68 |
| 12 | $PdCl_2[P(o\text{-}Tol)_3]_2$[f] | 18 | 7:24:69 |

[a] Time for which the mixture was kept at reflux in THF. – [b] The ratio was determined by GLC. – [c] 10 mol-% of the catalyst was used. – [d] A 1:1 ratio of THF/DMF (v/v) was used as the solvent. – [e] A 1:1 ratio of THF/DMA (v/v) was used as the solvent. – [f] A 1:1 ratio of THF/DMF (v/v) was used as the solvent. The zinc reagent was added at 50°C.

It was unfortunate that the three compounds **8e**, **17**, and **18** obtained in these reaction could not be separated by chromatography due to their almost identical polarity. Even in the best run (Entry 10) the products were isolated as a mixture (61% yield) which contained **8e**, **17**, and **18** in a ratio of roughly 1:1:5 as determined by $^1$H-NMR spectroscopy.

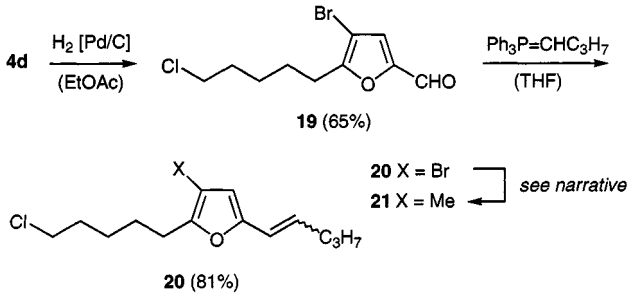
Apparently, the oxidative addition into the bromine–carbon bond of **8e** can be fairly well achieved with $PdCl_2[P(o\text{-}Tol)_3]_2$ as the catalyst. This high reactivity has been attributed to the formation of monoligated "$PdP(o\text{-}Tol)_3$" at el-

evated temperature.[30] In attempts to speed up the transmetalation and the reductive elimination we turned towards the Stille reaction. In DMA as the donor solvent the formation of $R_3SnBr$ should be highly favored[27b] and this fact might lead to an enhanced velocity of the transmetalation. Moreover, DMA allows for a higher reaction temperature, which enabled us to study the influence of temperature on the reaction course. To our delight we found that the reaction of 3-bromofuran **8e** to form the desired compound **18** proceeded cleanly and without the formation of hydrodebrominated product **17** if an excess of tetramethylstannane (2 equiv.) was employed as the reagent in DMA at 90°C in the presence of $PdCl_2[P(o\text{-Tol})_3]_2$ as the catalyst (5 mol-%). The reaction is depicted in Equation (i).




A comparison of the results we recorded in the coupling of 2-alkynyl-substituted 3-bromofurans such as **5**, **11**, and **12** (vide supra) with the observations made on the attempted coupling reactions with furan **8e** suggests that the $sp^3$-carbon atom in 2-position of **8e** not only slows down the oxidative addition but also facilitates hydrodebromination, possibly by retarding the transmetalation and/or reductive elimination step. In order to study this phenomenon further and possibly to generalize it we prepared the 3-bromofuran **20** from alkyne **4d** (Scheme 2). Hydrogenation of the alkyne yielded the 2-alkyl-substituted intermediate **19**, which was converted into compound **20** by a Wittig reaction. The alkynyl analogue **12** of furan **20** was earlier shown [cf. Equation (f)] to undergo a facile methyldebromination with MeZnCl in the presence of $PdCl_2(PPh_3)_2$. In contrast, under the same reaction conditions furan **20** gave a mixture of starting material **20**, hydrodebrominated product, and the desired methyldebrominated product **21** in a 39:21:40 ratio (GLC). This result parallels our earlier observations in the attempted coupling of methyl 3-bromo-2-(3-methylbut-2-enyl)furan-5-carboxylate (**8e**), which are given in Table 4. It supports the notion of a sterically encumbered situation retarding attempted coupling reactions at the C-3 atom of 2-alkyl-3-bromofurans. The conversion of bromide **20** into the 3-methylfuran **21** proceeded without hydrodebromination with $SnMe_4$ as the reagent and $PdCl_2[P(o\text{-Tol})_3]_2$ as the catalyst.

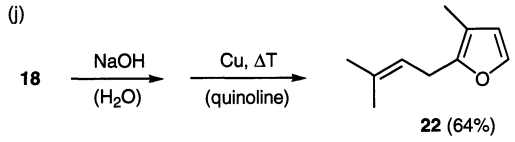
The two cross-coupling protocols for methyldebromination at the C-3 carbon atom of 3-bromofurans with either $MeZnCl/PdCl_2(PPh_3)_2$ in THF (for 2-alkynyl-substituted furans) or $SnMe_4/PdCl_2(Po\text{-Tol}_3)_2$ in DMA (for 2-alkyl-substituted furans) complete the organometallic part of the general synthetic strategy outlined in Scheme 1. It remained to show that an application to the synthesis of target molecules is possible.




Scheme 2. Preparation of furan **20** from the 2-alkynylfuran **4d** and attempted coupling reactions

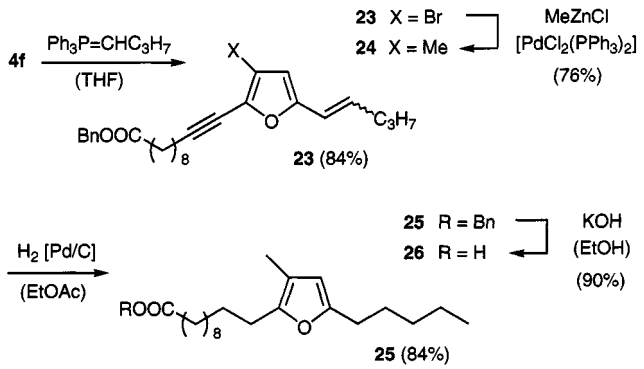
## 4. Synthetic Applications

The monoterpene rosefuran (**22**) [Equation (j)] was selected as an example for a 2,3-disubstituted furan, which should be accessible by the route depicted in Scheme 1 along steps I, IIb, and IIIb. Indeed, the direct precursor **18** for rosefuran was prepared from methyl 2,3-dibromfuran-5-carboxylate (**2**) in two successive Stille reactions as described in sections 2 and 3. The total yield amounted to 55%. The decarboxylation was achieved by conventional saponification and decarboxylation to yield rosefuran in a short and efficient way. An alternative approach will be discussed in section 5.




As an example for a 2,3,5-trisubstituted furan we had selected a furan fatty acid, namely the so-called $F_5$ acid (26) that had been previously prepared by Schlenk et al. from methyl 3-methylfuran-2-carboxylate in 5 steps (3% yield)[31] and by Marson et al. from cyclodecanone in 6 steps (13% yield).[2b] We started the synthesis (Scheme 3) from the above-mentioned ester **4f** which was converted by a Wittig reaction into compound **23** and by a subsequent $Pd^0$-catalyzed coupling to the furan **24**. The transformation to the free acid can be achieved by treatment with hydrogen at high pressure effecting both the hydrogenation of the multiple bonds and the hydrogenolysis of the benzyl ester.[18a] A two-step procedure, first conducting the rapidly occurring hydrogenation at atmosperic pressure and then saponifying the ester **25**, proved to be more efficient and it gave the desired acid **26** in 76% yield.

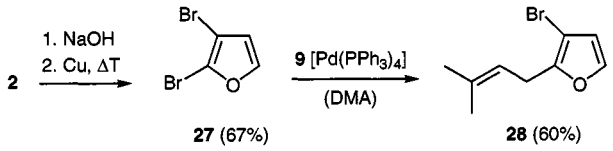
Overall, the reaction sequence starting from the bulk material 2,3-dibromofurfural (**1**) proceeded in five steps with a total yield of 29%. The substitution pattern at the 2- and the 5-position can be varied over a broad range which should facilitate the synthesis of additional target compounds by this strategy.




Scheme 3. The synthesis of the $F_5$ furan fatty acid (**26**) starting from the product **4f** of the regioselective cross coupling at C-2

## 5. Reasons for the Pronounced Regioselectivity

In the introduction we alluded to the fact that the oxidative addition of $Pd^0$ in the 2-position of compounds **1** and **2** is a facile process which eventually determines the regioselectivity of the reaction. Although the experimental data obtained so far undermine this hypothesis, it remained unclear why the oxidative addition into the carbon−bromine bond is so facile at the 2-position. This phenomenon could be either due to the inherent higher electrophilicity of C-2 over C-3 or it could be induced by the acceptor substituent at C-5, which is expected to withdraw electron density from the 2- and 4-position by its −M effect, or it could be due to the sum of both. In order to clarify this question we studied the Stille reaction of 2,3-dibromofuran (**27**), which was prepared from the ester **2** by saponification and decarboxylation[16b] (Scheme 4). This substrate exhibited the same selectivity observed for the acceptor-substituted analogue **2** [cf. Equation (d)], and it yielded exclusively the 3-bromofuran **28**.




Scheme 4. Preparation[16b] and regioselective Stille reaction of 2,3-dibromofuran (**27**)

No side reactions at C-3 were observed but the yield was lower than the one obtained with compound **2**. Apparently, the acceptor substituent is not neccessary for the regioselectivity control but it does have a beneficial influence on the stability of the furan nucleus. Indeed, it was previously observed that acceptor-substituted furans are less labile than alkyl-substituted furans under oxidative and acidic conditions,[1] a fact which is in accord with our observations. For the synthesis of 2,3-disubstituted furans as outlined in Scheme 1, a possible alternative route is obvious, i.e., the successive introduction of substituents in the 2- and 3-position of 2,3-dibromofuran (**27**) by $Pd^0$-catalyzed coupling reactions. If one considers that 2,3-dibromofuran is prepared from ester **2** this is, in effect, an interchange of steps conducting the decarboxylation *prior* to the cross coupling. We have not looked into this route more closely as it did not appear to be advantageous for the reasons mentioned above.

## 6. Summary and Conclusion

5-Acceptor-substituted 2,3-dibromofurans **1** and **2** undergo a regioselective $Pd^0$-catalyzed cross-coupling reaction at the C-2 carbon atom with a variety of reagents. The observed regioselectivity is most likely due to the electron deficiency at this position, which renders an oxidative addition of $Pd^0$ in the C−Br bond facile. The Stille reaction of furan **2** and the parent 2,3-dibromofuran (**27**) with stannane **9** proceeded equally well. Apparently, the acceptor substituent at C-5 is not required for an activiation of the 2-position. A $Pd^0$-catalyzed coupling at the more electron-rich C-3 carbon atom is by far more difficult to achieve. Two methods were devised which facilitate a methyldebromination at this site. The first method is applicable to 2-alkynyl-3-bromofurans and employs MeZnCl and $PdCl_2(PPh_3)_2$ as the catalyst. The desired reaction proceeds smoothly in refluxing THF. The second method was developed for 2-alkyl-3-bromofurans, the $Pd^0$-catalyzed cross coupling of which is hampered by two factors. First, the oxidative addition is retarded and the reaction rate is consequently much lower than in the case of the 2-alkynyl-3-bromofurans. Second, a hydrodebromination at C-3 is observed as a side reaction, which point towards an ineffective transmetalation or reductive elimination. These problems are overcome by using $SnMe_4$ and the catalyst $PdCl_2[P(o\text{-}Tol)_3]_2$ in DMA as the solvent (90°C). With these reagents clean cross-coupling reactions have been achieved at the C-3 position. Ready access to 2,3-dibsubstituted and 2,3,5-trisubstituted furans is possible by combining the regioselective cross coupling at C-2 and the subsequent methyldebromination at C-3. The two natural products rosefuran (**22**) and $F_5$ fatty acid (**26**) were prepared in short synthetic sequences following this strategy.

## Experimental Section

**General:** All reactions involving water-sensitive compounds were carried out in flame-dried glassware with magnetic stirring under argon. THF was distilled from K/Na immediately prior to use. Common solvents [*tert*-butyl methyl ether (TBME), pentane (P), diethyl ether, ethyl acetate, and methanol] were distilled prior to use. Furans **1**,[12] **2**,[12] **6**,[12] **27**,[16b] and stannane **9**[29] were prepared according to reported procedures. *N*,*N*-dimethylformamide (DMF; Fluka puriss. abs.), *N*,*N*-dimethylacetamide (DMA; Fluka puriss. abs.) and all other reagents were used as received. − Melting points (uncorrected): Reichert hot-stage. − IR: Bruker IFS 88 FT-IR or Nicolet 510 M FT-IR. − MS: Varian CH7 (EI) or Finnigan MAT 95S (HRMS). − GLC: Hewlett−Packard HP 6890 series GC system, column HP-1 (cross-linked methylsiloxane, 30 m). − $^1H$ and $^{13}C$ NMR: Bruker ARX-200 and Bruker AC-300. Chemical shifts are reported relative to tetramethylsilane as internal reference. $CDCl_3$ was used as solvent unless stated otherwise. The multiplicities of the $^{13}C$-NMR signals were determined by attached pro-

ton test (APT) experiments. − Elementary analysis: Varian Elementar vario EL. − TLC: Merck glass sheets 0.25 mm silica gel 60-$F_{254}$). A PE/TBME mixture was used as the eluent; detection by UV or by coloration with cerium(IV) ammonium molybdate (CAM). − Flash chromatography:[32] Merck silica gel 60 (230−400 mesh) (ca. 50 g for 1 g of material to be seperated), eluent given in parentheses.

**Benzyl 10-Undecynoate (3f):** To 5 mmol of 10-undecynoic acid (910 mg), dissolved in 30 mL of $CH_2Cl_2$, a catalytic amount of DMF was added and the mixture was cooled to 0°C. A solution of 10 mmol of oxalyl chloride (1.27 g, 0.88 mL) in 20 mL of $CH_2Cl_2$ was added dropwise. After complete transformation (2 h), the solvent was removed in vacuo. The crude product was dissolved in 20 mL of $CH_2Cl_2$ and the solution was added slowly to a mixture of 5.5 mmol of benzyl alcohol (595 mg), 0.25 mmol of 4-(dimethylamino)pyridine (31 mg) and 5 mmol of $NEt_3$ (1.01 g, 0.70 mL) in 20 mL of $CH_2Cl_2$. After stirring for 2 h at room temperature, the solvent was removed in vacuo and the residue was purified by flash chromatography (P/TBME = 90:10). A total of 1.30 g (95%) of compound **3f** was obtained as a colorless liquid. − $R_f$ = 0.62 (P/TBME = 75:25). − IR (film): $\tilde{\nu}$ = 3299 $cm^{-1}$ (m, C≡C−H), 3035 (w, $C_{Ar}$−H), 2935 (s, C−H), 2858 (m, C−H), 2119 (w, C≡C), 1737 (s, C=O). − $^1$H NMR (200 MHz): δ = 1.10−1.65 (m, 12 H), 1.86 (t, *J* = 2.5 Hz, 1 H), 2.10 (dt, *J* = 7.2 Hz, *J* = 2.5 Hz, 2 H), 2.27 (t, *J* = 7.2 Hz, 2 H), 5.04 (s, 2 H), 7.22−7.32 (m, 5 H). − $^{13}$C NMR (50 MHz): δ = 18.3 (t), 24.9 (t), 28.4 (t), 28.6 (t) 28.8 (t) 29.0 (t), 29.1 (t), 34.2 (t), 66.0 (t), 68.1 (d), 84.7 (s), 128.1 (d), 128.1 (d), 128.5 (d), 136.1 (s), 173.6 (s). − MS (70 eV); *m/z* (%): 272 (0.2) [$M^+$], 108 (31), 91 (100) [$C_7H_7^+$]. − $C_{18}H_{24}O_2$ (272.387): calcd. C 79.37, H 8.88; found C 79.13, H 8.78.

**3-Bromo-2-(3,3-dimethylbut-1-ynyl)furan-5-carbaldehyde (4a). − Typical Procedure A:** To a stirred solution of 10 mmol of furan **1**[12] (2.54 g), 1 mmol of CuI (190 mg), and 0.5 mmol of $PdCl_2(PPh_3)_2$ (350 mg) in 50 mL of the amine at room temperature was slowly added 20 mmol of alkyne **3a** (1.64 g). After the period of time indicated in Table 1 (24 h), the amine was removed by distillation. The solid was filtered off and washed with P/TBME = 50:50. Further purification was carried out by flash chromatography (P/TBME = 98:2). A total of 2.14 g (84%) of furan **4a** was obtained as an orange solid. − $R_f$ = 0.60 (P/TBME = 75:25). − M.p. 60−64°C. − IR (KBr): $\tilde{\nu}$ = 2917 $cm^{-1}$ (m, C−H), 2220 (m, C≡C), 1680 (s, C=O), 1040 (w, C−Br). − $^1$H NMR (300 MHz): δ = 1.35 (s, 9 H), 7.22 (s, 1 H), 9.54 (s, 1 H). − $^{13}$C NMR (75 MHz): δ = 28.5 (s), 30.2 (q), 67.5 (s), 106.2 (s), 110.6 (s), 122.8 (d), 141.3 (s), 150.9 (s), 176.7 (d). − MS (70 eV); *m/z* (%): 256 (59) [$M^+$ ($^{81}$Br)], 254 (61) [$M^+$ ($^{79}$Br)], 241 (73) [(M − $CH_3$)$^+$ ($^{81}$Br)], 227 (93) [(M − CHO)$^+$ ($^{81}$Br)], 225 (100) [(M − CHO)$^+$ ($^{79}$Br)], 175 (12) [(M − Br)$^+$], 118 (57), 103 (67), 77 (68), 63 (34), 41 (24). − $C_{11}H_{11}BrO_2$ (255.108): calcd. C 51.79, H 4.35; found C 52.20, H 4.64.

**3-Bromo-2-(phenylethynyl)furan-5-carbaldehyde (4b):** The reaction was carried out as described in typical procedure A starting from furan **1**[12] and alkyne **3b** on a 2-mmol scale. The residue was purified by flash chromatography (P/TBME = 98:2). A total of 445 mg (81%) of furan **4b** was obtained as an orange solid. − $R_f$ = 0.54 (P/TBME = 75:25). − M.p. 75−78°C. − IR (KBr): $\tilde{\nu}$ = 3094 $cm^{-1}$ (m, $C_{Ar}$−H), 3051 (m, $C_{Ar}$−H), 2204 (m, C≡C), 1684 (s, C=O), 1018 (m, C−Br). − $^1$H NMR (300 MHz): δ = 7.23 (s, 1 H), 7.30−7.40 (m, 3 H), 7.54−7.58 (m, 2 H), 9.54 (s, 1 H). − $^{13}$C NMR (75 MHz): δ = 76.9 (s), 100.4 (s), 107.4 (s), 120.9 (s), 122.8 (d), 128.6 (d), 130.0 (d), 132.0 (d), 141.0 (s), 151.6 (s), 176.8 (d). − MS (70 eV); *m/z* (%): 276 (92) [$M^+$ ($^{81}$Br)], 274 (94) [$M^+$ ($^{79}$Br)], 219 (28) [$C_{11}H_6Br^+$ ($^{81}$Br)], 217 (29) [$C_{11}H_6Br^+$ ($^{79}$Br)], 195 (7) [(M − Br)$^+$], 139 (100), 138 (99). − $C_{13}H_7BrO_2$ (275.097): calcd. C 56.76, H 2.56; found C 56.84, H 2.51.

**3-Bromo-2-(4-hydroxybut-1-ynyl)furan-5-carbaldehyde (4c):** The reaction was carried out as described in typical procedure A starting from furan **1**[12] and alkyne **3c** on a 2-mmol scale. The residue was purified by flash chromatography (P/TBME = 98:2). A total of 330 mg (68%) of furan **4c** was obtained as a red oil. − $R_f$ = 0.50 (P/TBME = 75:25). − IR (film): $\tilde{\nu}$ = 3403 $cm^{-1}$ (br, m, O−H), 2972 (w, C−H), 2886 (w, C−H), 2232 (m, C≡C), 1682 (s, C=O), 1054 (m, C−Br). − $^1$H NMR (200 MHz): δ = 1.93 (b, s, 1 H), 2.77 (t, *J* = 6.3 Hz, 2 H), 3.85 (t, *J* = 6.3 Hz, 2 H), 7.21 (s, 1 H), 9.53 (s, 1 H). − $^{13}$C NMR (50 MHz): δ = 24.1 (t), 60.4 (t), 70.2 (s), 99.4 (s), 106.8 (s), 122.7 (d), 140.7 (s), 151.0 (s), 176.8 (d). − MS (70 eV); *m/z* (%): 244 (55) [$M^+$ ($^{81}$Br)], 242 (56) [$M^+$ ($^{79}$Br)], 213 (68) [(M − $CH_3O$)$^+$ ($^{81}$Br)], 211 (70) [(M − $CH_3O$)$^+$ ($^{79}$Br)], 75 (100). − $C_9H_7BrO_3$ (243.054): calcd. C 44.47, H 2.90; found C 44.44, H 2.83.

**3-Bromo-2-(5-chloropent-1-ynyl)furan-5-carbaldehyde (4d):** The reaction was carried out as described in typical procedure A starting from furan **1**[12] and alkyne **3d** on a 2-mmol scale. The residue was purified by flash chromatography (P/TBME = 98:2) to give 391 mg (71%) of furan **4d** as an orange-brown oil. − $R_f$ = 0.50 (P/TBME = 75:25). − IR (film): $\tilde{\nu}$ = 2962 $cm^{-1}$ (w, C−H), 2230 (m, C≡C), 1682 (s, C=O), 1057 (w, C−Br). − $^1$H NMR (200 MHz): δ = 2.10 (quint, *J* = 6.5 Hz, 2 H), 2.73 (t, *J* = 6.5 Hz, 2 H), 3.72 (t, *J* = 6.5 Hz, 2 H), 7.23 (s, 1 H), 9.55 (s, 1 H). − $^{13}$C NMR (50 MHz): δ = 17.1 (t), 30.6 (t), 43.2 (t), 69.5 (s), 100.7 (s), 106.6 (s), 122.8 (d), 140.6 (s), 150.9 (s), 176.6 (d). − MS (70 eV); *m/z* (%): 278 (6) [$M^+$ ($^{81}$Br, $^{37}$Cl)], 276 (28) [$M^+$ ($^{81}$Br, $^{35}$Cl)], 274 (22) [$M^+$ ($^{79}$Br, $^{35}$Cl)], 241 (30) [(M − $^{35}$Cl)$^+$ ($^{81}$Br)], 239 (30) [(M − $^{35}$Cl)$^+$ ($^{79}$Br)], 213 (22), 211 (25), 160 (16), 131 (17), 103 (73), 75 (100). − $C_{10}H_8BrClO_2$ (275.529): calcd. C 43.59, H 2.93; found C 43.57, H 2.64.

**3-Bromo-2-(3-methoxyprop-1-ynyl)furan-5-carbaldehyde (4e):** The reaction was carried out as described in typical procedure A starting from furan **1**[12] and alkyne **3e** on a 2-mmol scale. The residue was purified by flash chromatography (P/TBME = 98:2). A total of 330 mg (68%) of furan **4e** was obtained as a yellow-brown solid. − $R_f$ = 0.48 (P/TBME = 75:25). − M.p. 38−40°C. − IR (KBr): $\tilde{\nu}$ = 2989 $cm^{-1}$ (m, C−H), 2938 (m, C−H), 2825 (m, C−H), 1687 (s, C=O), 1061 (m, C−Br). − $^1$H NMR (300 MHz): δ = 3.40 (s, 3 H), 4.33 (s, 2 H), 7.20 (s, 1 H), 9.52 (s, 1 H). − $^{13}$C NMR (75 MHz): δ = 57.9 (t), 60.0 (q), 73.9 (s), 96.6 (s), 107.8 (s), 122.2 (d), 139.8 (s), 151.5 (s), 176.8 (d). − MS (70 eV); *m/z* (%): 244 (30) [$M^+$ ($^{81}$Br)], 242 (31) [$M^+$ ($^{79}$Br)], 215 (99) [(M − CHO)$^+$ ($^{81}$Br)], 213 (100) [(M − CHO)$^+$ ($^{79}$Br)], 106 (72), 75 (100). − $C_9H_7BrO_3$ (243.054): calcd. C 44.47, H 2.90; found C 44.70, H 2.98.

**Benzyl 11-(3-Bromo-5-formylfuran-2-yl)undec-10-ynoate (4f):** The reaction was carried out as described in typical procedure A starting from furan **1**[12] and alkyne **3f** on a 2-mmol scale. The residue was purified by flash chromatography (P/TBME = 90:10). A total of 543 mg (61%) of furan **4f** was obtained as a yellow-brown oil. − $R_f$ = 0.34 (P/TBME = 75:25). − IR (film): $\tilde{\nu}$ = 3035 $cm^{-1}$ (w, $C_{Ar}$−H), 2932 (s, C−H), 2857 (m, C−H), 2231 (m, C≡C), 1737 (s, O−C=O), 1686 (s, C=O), 1059 (w, C−Br). − $^1$H NMR (200 MHz): δ = 1.15−1.65 (m, 12 H), 2.28 (t, *J* = 7.2 Hz, 2 H), 2.42 (t, *J* = 7.2 Hz, 2 H), 5.04 (s, 2 H), 7.14 (s, 1 H) 7.22−7.32 (m, 5 H), 9.46 (s, 1 H). − $^{13}$C NMR (50 MHz): δ = 19.7 (t), 24.8 (t), 27.8 (t), 28.6 (t) 28.8 (t) 28.9 (t), 29.0 (t), 34.2 (t), 66.0 (t), 68.8 (s), 103.1 (s), 106.2 (s), 122.8 (d), 128.1 (d), 128.1 (d), 128.5 (d), 136.0 (s), 141.2 (s), 150.8 (s), 173.6 (s), 176.7 (d). − MS (70 eV); *m/z* (%): 446 (2) [$M^+$ ($^{81}$Br)], 444 (2) [$M^+$ ($^{79}$Br)], 339 (4), 337 (5), 227 (7),

225 (6), 91 (100) [$C_7H_7^+$]. − $C_{23}H_{25}BrO_4$ (445.353): calcd. C 62.03, H 5.66; found C 61.97, H 5.66.

**Methyl 3-Bromo-2-(3,3-dimethylbut-1-ynyl)furan-5-carboxylate (5a):** The reaction was carried out as described in typical procedure A starting from furan **2**[12] and alkyne **3a** on a 10-mmol scale. The residue was purified by flash chromatography (P/TBME = 90:10). A total of 2.7g (95%) of furan **5a** was obtained as a white solid. − $R_f$ = 0.62 (P/TBME = 75:25). − M.p. 53−57°C. − IR (KBr): $\tilde{\nu}$ = 2970 $cm^{-1}$ (m, C−H), 2228 (m, C≡C), 1737 (s, C=O), 1037 (m, C−Br). − $^1H$ NMR (200 MHz): δ = 1.31 (s, 9 H), 3.87 (s, 3 H), 7.14 (s, 1 H). − $^{13}C$ NMR (50 MHz): δ = 28.4 (s), 30.3 (q), 52.2 (q), 67.3 (s), 105.1 (s), 109.0 (s), 121.0 (d), 139.8 (s), 143.0 (s), 157.7 (s). − MS (70 eV); *m/z* (%): 286 (43) [$M^+$ ($^{81}Br$)], 284 (45) [$M^+$ ($^{79}Br$)], 271 (100) [$(M - CH_3)^+$ ($^{81}Br$)], 269 (97) [$(M - CH_3)^+$ ($^{79}Br$)], 255 (8) [$(M - OCH_3)^+$ ($^{81}Br$)], 253 (8) [$(M - OCH_3)^+$ ($^{79}Br$)], 227 (77) [$(M - COOCH_3)^+$ ($^{81}Br$)], 225 (76) [$(M - COOCH_3)^+$ ($^{79}Br$)], 205 (16) [$(M - Br)^+$], 118 (38), 103 (38), 59 (20) [$COOCH_3^+$]. − $C_{12}H_{13}BrO_3$ (285.134): calcd. C 50.55, H 4.60; found: C 50.68, H 4.56.

**Methyl 3-Bromo-2-(phenylethynyl)furan-5-carboxylate (5b):** The reaction was carried out as described in typical procedure A starting from furan **2**[12] and alkyne **3b** on a 2-mmol scale. The residue was purified by flash chromatography (P/TBME = 98:2). A total of 488 mg (80%) of furan **5b** was obtained as a brown solid. − $R_f$ = 0.60 (P/TBME = 75:25). − M.p. 108−110°C. − IR (KBr): $\tilde{\nu}$ = 3054 $cm^{-1}$ (w, $C_{Ar}$−H), 2957 (w, C−H), 2214 (m, C≡C), 1740 (s, C=O), 1032 (m, C−Br). − $^1H$ NMR (200 MHz): δ = 3.86 (s, 3 H), 7.20 (s, 1 H), 7.30−7.40 (m, 3 H), 7.50−7.59 (m, 2 H). − $^{13}C$ NMR (50 MHz): δ = 52.3 (q), 76.8 (s), 99.0 (s), 106.4 (s), 121.1 (d), 121.1 (s), 128.5 (d), 129.6 (d), 131.8 (d), 139.4 (s), 143.9 (s) 157.6 (s). − MS (70 eV); *m/z* (%): 306 (79) [$M^+$ ($^{81}Br$)], 304 (90) [$M^+$ ($^{79}Br$)], 275 (9) [$(M - OCH_3)^+$ ($^{81}Br$)], 273 (7) [$(M - OCH_3)^+$ ($^{79}Br$)], 219 (28), 217 (26), 138 (100), 59 (12) [$COOCH_3^+$]. − $C_{14}H_9BrO_3$ (305.128): calcd. C 55.11, H 2.97; found C 54.91, H 2.88.

**Methyl 3-Bromo-2-(4-hydroxybut-1-ynyl)furan-5-carboxylate (5c):** The reaction was carried out as described in typical procedure A starting from furan **2**[12] and alkyne **3c** on a 2-mmol scale. The residue was purified by flash chromatography (P/TBME = 98:2). A total of 399 mg (73%) of furan **5c** was obtained as a brown solid. − $R_f$ = 0.12 (P/TBME = 75:25). − M.p. 98°C. − IR (KBr): $\tilde{\nu}$ = 3242 $cm^{-1}$ (br, m, O−H), 2948 (w, C−H), 2844 (w, C−H), 2232 (m, C≡C), 1732 (s, C=O), 1048 (m, C−Br). − $^1H$ NMR (200 MHz): δ = 2.62 (b, s, 1 H), 2.72 (t, *J* = 6.5 Hz, 2 H), 3.80 (m, 2 H), 3.85 (s, 3 H), 7.13 (s, 1 H). − $^{13}C$ NMR (50 MHz): δ = 23.9 (t), 52.3 (q), 60.3 (t), 69.9 (s) 98.0 (s) 105.6 (s), 120.8 (d), 139.2 (s), 143.2 (s), 157.6 (s). − MS (70 eV); *m/z* (%): 274 (30) [$M^+$ ($^{81}Br$)], 272 (41) [$M^+$ ($^{79}Br$)], 243 (51) [$(M - CH_3O)^+$ ($^{81}Br$)], 241 (45) [$(M - CH_3O)^+$ ($^{79}Br$)], 215 (3) [$(M - COOCH_3)^+$ ($^{81}Br$)], 213 (5) [$(M - COOCH_3)^+$ ($^{79}Br$)], 187 (6), 185 (26), 103 (21), 75 (100), 59 (18) [$COOCH_3^+$]. − $C_{10}H_9BrO_4$ (273.083): calcd. C 43.98, H 3.32; found C 43.93, H 3.40.

**Methyl 3-Bromo-2-(5-chloropent-1-ynyl)furan-5-carboxylate (5d):** The reaction was carried out as described in typical procedure A starting from furan **2**[12] and alkyne **3d** on a 10-mmol scale. The residue was purified by flash chromatography (P/TBME = 98:2). A total of 2.97 g (97%) of furan **5d** was obtained as a yellow oil. − $R_f$ = 0.55 (P/TBME = 75:25). − IR (film): $\tilde{\nu}$ = 2957 $cm^{-1}$ (m, C−H), 2845 (w, C−H), 2232 (m, C≡C), 1736 (s, C=O), 1055 (m, C−Br). − $^1H$ NMR (200 MHz): δ = 2.04 (quint, *J* = 6.5 Hz, 2 H), 2.66 (t, *J* = 6.5 Hz, 2 H), 3.66 (t, *J* = 6.5 Hz, 2 H), 3.84 (s, 3 H), 7.11 (s, 1 H). − $^{13}C$ NMR (50 MHz): δ = 17.0 (t), 30.6 (t), 43.2 (t), 52.2 (q), 69.5 (s), 99.1 (s) 105.6 (s), 120.8 (d), 139.3 (s), 143.3 (s), 157.5 (s). − MS (70 eV); *m/z* (%): 308 (16) [$M^+$ ($^{81}Br$, $^{37}Cl$)], 306 (54) [$M^+$ ($^{81}Br$, $^{35}Cl$)], 304 (63) [$M^+$ ($^{79}Br$, $^{35}Cl$)], 271 (51) [$(M - Cl)^+$ ($^{81}Br$)], 269 (51) [$(M - Cl)^+$ ($^{79}Br$)], 249 (4) [$(308 - COOCH_3)^+$], 247 (26) [$(306 - COOCH_3)^+$], 245 (21) [$(304 - COOCH_3^+$], 243 (60) [$(M - (CH_2)_2Cl)^+$ ($^{81}Br$)], 241 (60) [$(M - (CH_2)_2Cl)^+$ ($^{79}Br$)], 190 (4), 103 (66), 75 (100), 59 (48) [$COOCH_3^+$]. − $C_{11}H_{10}BrClO_3$ (305.555): calcd. C 43.24, H 3.30; found C 43.12, H 3.10.

**Methyl 3-Bromo-2-(3-methoxyprop-1-ynyl)furan-5-carboxylate (5e):** The reaction was carried out as described in typical procedure A starting from furan **2**[12] and alkyne **3e** on a 2-mmol scale. The residue was purified by flash chromatography (P/TBME = 98:2). A total of 265 mg (49%) of furan **5e** was obtained as a colorless oil. − $R_f$ = 0.45 (P/TBME = 75:25). − IR (film): $\tilde{\nu}$ = 2953 $cm^{-1}$ (m, C−H), 2895 (w, C−H), 2824 (m, C-H), 2232 (w, C≡C), 1736 (s, C=O), 1055 (m, C−Br). − $^1H$ NMR (200 MHz): δ = 3.40 (s, 3 H), 3.85 (s, 3 H), 4.33 (s, 2 H), 7.13 (s, 1 H). − $^{13}C$ NMR (50 MHz): δ = 52.3 (q), 57.8 (q), 60.0 (t), 73.9 (s), 95.4 (s) 106.9 (s), 120.8 (d), 138.5 (s), 144.0 (s), 157.5 (s). − MS (70 eV); *m/z* (%): 274 (46) [$M^+$ ($^{81}Br$)], 272 (26) [$M^+$ ($^{79}Br$)], 243 (53) [$(M - OCH_3)^+$ ($^{81}Br$)], 241 (56) [$(M - OCH_3)^+$ ($^{79}Br$)], 215 (69) [$(M - COOCH_3)^+$ ($^{81}Br$)], 213 (100) [$(M - COOCH_3)^+$ ($^{79}Br$)], 106 (62), 75 (68), 59 (36) [$COOCH_3^+$]. − $C_{10}H_9BrO_4$ (273.083): calcd. C 43.98, H 3.32; found C 43.98, H 3.16.

**Methyl 3-Bromo-2-(trimethylsilyl)ethynylfuran-5-carboxylate (5g):** The reaction was carried out as described in typical procedure A starting from furan **2**[12] and alkyne **3g** on a 2-mmol scale. The residue was purified by flash chromatography (P/TBME = 98:2). A total of 483 mg (80%) of furan **5g** was obtained as a white solid. − $R_f$ = 0.70 (P/TBME = 75:25). − M.p. 71°C. − IR (KBr): $\tilde{\nu}$ = 2959 $cm^{-1}$ (m, C−H), 2900 (m, C−H), 2161 (m, C≡C), 1729 (s, C=O), 1033 (m, C−Br). − $^1H$ NMR (200 MHz): δ = 0.25 (s, 9 H), 3.88 (s, 3 H), 7.15 (s, 1 H). − $^{13}C$ NMR (50 MHz): δ = −0.6 (q), 52.4 (q), 90.9 (s) 106.8 (s), 120.1 (s), 120.9 (d), 139.2 (s), 143.7 (s), 157.6 (s). − MS (70 eV); *m/z* (%): 302 (39) [$M^+$ ($^{81}Br$)], 300 (58) [$M^+$ ($^{79}Br$)], 287 (86) [$(M - CH_3)^+$ ($^{81}Br$)], 285 (100) [$(M - CH_3)^+$ ($^{79}Br$)], 221 (7) [$(M - Br)^+$], 147 (20), 119 (11), 89 (20), 59 (16) [$COOCH_3^+$]. − $C_{11}H_{13}BrO_3Si$ (301.209): calcd. C 43.86, H 4.35; found C 43.77, H 4.31.

**5-(3,3-Dimethylbut-1-ynyl)-2-hydroxymethylfuran (7):** The cross-coupling reaction was carried out as described in typical procedure A starting from furan **6**[12] and alkyne **3a** on a 1-mmol scale. The crude product was added to a solution of 5 mmol of $LiAlH_4$ (190 mg) in 10 mL of THF at 0°C by syringe. The mixture was stirred for 10 min at room temperature. After quenching with 5 mL of water, the product was extracted with diethyl ether (3 × 10 mL). The combined organic layers were washed with brine (10 mL), dried with $MgSO_4$, and filtered. After removal of the solvent in vacuo, the residue was purified by flash chromatography (P/TBME = 90:10). A total of 124 mg (70%) of furan **7** was obtained as a yellow solid. − $R_f$ = 0.16 (P/TBME = 75:25). − M.p. 33−36°C. − IR (KBr): $\tilde{\nu}$ = 3336 $cm^{-1}$ (br, s, O−H), 2971 (s, C−H), 2869 (m, C−H), 2225 (w, C≡C). − $^1H$ NMR (200 MHz): δ = 1.23 (s, 9 H), 2.50 (b, s, 1 H), 4.46 (s, 2 H), 6.16 (d, *J* = 3.1 Hz, 1 H), 6.32 (d, *J* = 3.1 Hz, 1 H). − $^{13}C$ NMR (75 MHz): δ = 28.2 (s), 30.7 (q), 57.4 (t), 69.9 (s), 102.7 (s), 108.8 (d), 114.5 (d), 137.5 (s), 154.3 (s). − MS (70 eV); *m/z* (%): 178 (82) [$M^+$], 163 (100) [$(M - CH_3)^+$], 147 (68) [$(M - CH_3O)^+$], 119 (18). − $C_{11}H_{14}O_2$ (178.228): calcd. C 74.13, H 7.92; found C 74.02, H 7.75.

**Methyl 3-Bromo-2-phenylfuran-5-carboxylate (8a). − Typical Procedure B:** 2 mmol of ester **2**[12] (568 mg) and 0.08 mmol of

$PdCl_2(PPh_3)_2$ (56 mg) were dissolved in 8 mL of THF at room temperature. A solution of 4 mmol of phenylzinc chloride, prepared by transmetalation of phenyllithium (4 mmol, 2.2 mL of a 1.8 M solution) with $ZnCl_2$ (6 mmol, 818 mg), in 8 mL of THF was added by syringe. The mixture was stirred at room temperature for 16 h and it was subsequently quenched with a saturated aqueous $NH_4Cl$ solution (10 mL). After extraction with ether (3 × 15 mL) the organic layers were collected, washed with brine, and dried with $MgSO_4$. After removal of the solvent, the residue was purified by flash chromatography (P/TBME = 98:2). A total of 371 mg (66%) of furan **8a** was obtained as a white solid. – $R_f$ = 0.60 (P/TBME = 75:25). – M.p. 80–84°C. – IR (KBr): $\tilde{\nu}$ = 3127 $cm^{-1}$ (m, $C_{Ar}$–H), 2952 (s, C–H), 1726 (s, C=O), 1072 (w, C–Br). – $^1H$ NMR (200 MHz): δ = 3.75 (s, 3 H), 7.10 (s, 1 H), 7.30–7.45 (m, 3 H), 7.95–8.03 (m, 2 H). – $^{13}C$ NMR (50 MHz): δ = 52.1 (q), 97.0 (s), 123.2 (d), 126.4 (d), 128.5 (s), 128.6 (d), 129.4 (d), 142.6 (s), 152.4 (s), 158.4 (s). – MS (70 eV); *m/z* (%): 282 (91) [$M^+$ ($^{81}Br$)], 280 (100) [$M^+$ ($^{79}Br$)], 251 (33) [(M – $OCH_3$)$^+$ ($^{81}Br$)], 249 (33) [(M – $OCH_3$)$^+$ ($^{79}Br$)], 224 (3) [(M – $COOCH_3$)$^+$ ($^{81}Br$)], 222 (13) [(M – $COOCH_3$)$^+$ ($^{79}Br$)], 195 (30) [(224 – CO)$^+$ ($^{81}Br$)], 193 (27), 114 (41), 77 (7) [$C_6H_5^+$], 51 (4), 28 (18). – $C_{12}H_9BrO_3$ (281.106): calcd. C 51.27, H 3.23; found C 50.94, H 3.21.

**Methyl 3-Bromo-2-(furan-2-yl)furan-5-carboxylate (8b):** The reaction was carried out as described in typical procedure B starting from furan **2**[12] on a 2-mmol scale and 4 mmol of furylzinc chloride, prepared by metalation of 4 mmol of furan (272 mg) with *n*-butyllithium (4 mmol, 2.2 mL of a 1.8 M solution) and transmetalation with $ZnCl_2$ (6 mmol, 818 mg). After workup, the residue was purified by flash chromatography (P/TBME = 98:2). A total of 411 mg (76%) of furan **8b** was obtained as a white solid. – $R_f$ = 0.60 (P/TBME = 75:25). – M.p. 82–84°C. – IR (KBr): $\tilde{\nu}$ = 3118 $cm^{-1}$ (m, $C_{Ar}$–H), 2959 (m, C–H), 1713 (s, C=O), 1022 (m, C–Br). – $^1H$ NMR (200 MHz): δ = 3.85 (s, 3 H), 6.48 (dd, *J* = 3.5 Hz, *J* = 1.7 Hz, 1 H), 7.01 (d, *J* = 3.5 Hz, 1 H), 7.19 (s, 1H), 7.50 (d, *J* = 1.7 Hz, 1 H). – $^{13}C$ NMR (50 MHz): δ = 52.2 (q), 96.0 (s), 110.9 (d), 111.8 (d), 122.5 (d), 142.6 (s), 143.4 (s), 143.7 (s), 146.0 (s), 158.2 (s). – MS (70 eV); *m/z* (%): 272 (81) [$M^+$ ($^{81}Br$)], 270 (100) [$M^+$ ($^{79}Br$)], 213 (4) [(M – $COOCH_3$)$^+$ ($^{81}Br$)], 211 (3) [(M – $COOCH_3$)$^+$ ($^{79}Br$)], 185 (26), 183 (27), 104 (11), 59 (10) . – $C_{10}H_7BrO_4$ (271.068): calcd. C 44.31, H 2.60; found C 44.43, H 2.82.

**Methyl 3-Bromo-2-methylfuran-5-carboxylate (8c):** The reaction was carried out as described in typical procedure B starting from furan **2**[12] on a 2-mmol scale and 2.4 mmol of methylzinc chloride, prepared by transmetalation of methyllithium (2.4 mmol, 1.33 mL of a 1.8 M solution) with $ZnCl_2$ (3.6 mmol, 491 mg). After workup, the residue was purified by flash chromatography (P/TBME = 98:2). A total of 368 mg (84%) of furan **8c** was obtained as a white solid. – $R_f$ = 0.70 (P/TBME = 75:25). – M.p. 58–62°C. – IR (KBr): $\tilde{\nu}$ = 2959 $cm^{-1}$ (m, C–H), 2839 (m, C–H), 1751 (s, C=O), 1040 (m, C–Br). – $^1H$ NMR (200 MHz): δ = 2.35 (s, 3 H), 3.86 (s, 3 H), 7.09 (s, 1 H). – $^{13}C$ NMR (50 MHz): δ = 12.3 (q) 52.0 (q), 98.3 (s), 121.2 (d), 142.5 (s), 154.4 (s), 158.4 (s). – MS (70 eV); *m/z* (%): 220 (55) [$M^+$ ($^{81}Br$)], 218 (52) [$M^+$ ($^{79}Br$)], 189 (57) [(M – $OCH_3$)$^+$ ($^{81}Br$)], 187 (100) [(M – $OCH_3$)$^+$ ($^{79}Br$)], 161 (5) [(M – $COOCH_3$)$^+$ ($^{81}Br$)], 159 (6) [(M – $COOCH_3$)$^+$ ($^{79}Br$)], 133 (8), 131 (12), 80 (7), 52 (22) , 51 (30), 28 (9). – $C_7H_7BrO_3$ (219.035): calcd. C 38.39, H 3.22; found C 38.23, H 3.31.

**Methyl 3-Bromo-2-vinylfuran-5-carboxylate (8d):** The reaction was carried out as described in typical procedure B starting from furan **2**[12] on a 2-mmol scale and 4 mmol of vinylzinc chloride, prepared by transmetalation of vinylmagnesium chloride (4 mmol, 2.1 mL of a 1.9 M solution) with zinc chloride (6 mmol, 818 mg). After workup, the residue was purified by flash chromatography (P/TBME = 98:2). A total of 342 mg (74%) of furan **8d** was obtained as a yellow oil. The compound decomposed rapidly upon standing at 0°C and a correct elemental analysis was not obtained. – $R_f$ = 0.65 (P/TBME = 75:25). – $^1H$ NMR (200 MHz): δ = 3.85 (s, 3 H), 5.44 (dd, *J* = 1.0 Hz, *J* = 11.5 Hz, 1 H), 6.02 (dd, *J* = 1.0 Hz, *J* = 17.8 Hz, 1 H), 6.56 (dd, *J* = 11.5 Hz, *J* = 17.8 Hz, 1 H), 7.12 (s, 1 H). – $^{13}C$ NMR (75 MHz): δ = 52.0 (q), 95.6 (s), 118.4 (t), 121.6 (d), 121.6 (d), 142.9 (s), 152.7 (s), 158.2 (s). – MS (70 eV); *m/z* (%): 232 (93) [$M^+$ ($^{81}Br$)], 230 (92) [$M^+$ ($^{79}Br$)], 201 (98) [(M – $OCH_3$)$^+$ ($^{81}Br$)], 199 (100) [(M – $OCH_3$)$^+$ ($^{79}Br$)], 174 (18) [(M – $COOCH_3$)$^+$ ($^{81}Br$)], 172 (20) [(M – $COOCH_3$)$^+$ ($^{79}Br$)], 92 (19), 64 (71).

**Methyl 3-Bromo-2-(3-methylbut-2-enyl)furan-5-carboxylate (8e). – Typical Procedure C:** 2 mmol of furan **2**[12] (568 mg), 3 mmol of tri-*n*-butyl(3-methylbut-2-enyl)stannane (**9**)[29] (1.08 g) and 0.1 mmol of $Pd(PPh_3)_4$ (116 mg) were dissolved in 10 mL of DMA and the mixture was heated to 90°C for 16 h. The mixture was cooled to room temperature and subsequently quenched with a saturated aqueous $NH_4Cl$ solution (10 mL). After extraction with ether (3 × 15 mL), the organic layers were combined, washed with brine (15 mL), and dried with $MgSO_4$. The solvent was removed in vacuo and the residue was purified by flash chromatography (P/TBME = 98:2). A total of 432 mg (79%) of furan **8e** was obtained as a colorless oil. – $R_f$ = 0.80 (P/TBME = 75:25). – IR (film): $\tilde{\nu}$ = 2955 $cm^{-1}$ (m, C–H), 2928 (m, C–H), 2857 (w, C–H), 1736 (s, C=O), 1030 (m, C–Br). – $^1H$ NMR (200 MHz): δ = 1.70 (d, *J* = 1.5 Hz, 6 H), 3.39 (d, *J* = 7.0 Hz, 2 H), 3.84 (s, 3 H), 5.23 (t sept, *J* = 7.0 Hz, *J* = 1.5 Hz, 1 H), 7.08 (s, 1 H). – $^{13}C$ NMR (50 MHz): δ = 18.0 (q), 25.6 (q), 25.8 (t), 52.0 (q), 97.4 (s), 117.1 (d), 121.3 (d), 135.2 (s), 142.6 (s), 156.9 (s), 158.4 (s). – MS (70 eV); *m/z* (%): 274 (98) [$M^+$ ($^{81}Br$)], 272 (100) [$M^+$ ($^{79}Br$)], 259 (55) [(M – $CH_3$)$^+$ ($^{81}Br$)], 257 (58) [(M – $CH_3$)$^+$ ($^{79}Br$)], 243 (11) [(M – $OCH_3$)$^+$ ($^{81}Br$)], 241 (10) [(M – $OCH_3$)$^+$ ($^{79}Br$)], 215 (23) [(M – $COOCH_3$)$^+$ ($^{81}Br$)], 213 (33) [(M – $COOCH_3$)$^+$ ($^{79}Br$)], 193 (15) [(M – Br)$^+$], 178 (24), 134 (89), 119 (30), 78 (80), 59 (53) [$COOCH_3^+$], 41 (83). – $C_{11}H_{13}BrO_3$ (273.123): calcd. C 48.37, H 4.80; found C 48.00, H 4.96.

**Methyl 2-Allyl-3-bromofuran-5-carboxylate (8f):** The reaction was carried out as described in typical procedure C starting from furan **2**[12] and stannane **10** on a 2-mmol scale. After workup, the residue was purified by flash chromatography (P/TBME = 98:2). A total of 358 mg (73%) of furan **8f** was obtained as a colorless oil. – $R_f$ = 0.75 (P/TBME = 75:25). – IR (film): $\tilde{\nu}$ = 2955 $cm^{-1}$ (m, C–H), 2924 (m, C–H), 2853 (w, C–H), 1738 (s, C=O), 1024 (m, C–Br). – $^1H$ NMR (200 MHz): δ = 3.38–3.50 (m, 2 H), 3.84 (s, 3 H), 5.04–5.10 (m, 1 H), 5.12–5.17 (m, 1 H), 5.73–5.95 (m, 1 H), 7.10 (s, 1 H). – $^{13}C$ NMR (50 MHz): δ = 30.9 (t), 52.0 (q), 98.4 (s), 118.0 (t), 121.2 (d), 131.2 (d), 143.0 (s), 155.1 (s), 158.3 (s). – MS (70 eV); *m/z* (%): 246 (63) [$M^+$ ($^{81}Br$)], 244 (64) [$M^+$ ($^{79}Br$)], 215 (28) [(M – $OCH_3$)$^+$ ($^{81}Br$)], 213 (28) [(M – $OCH_3$)$^+$ ($^{79}Br$)], 187 (41) [(M – $COOCH_3$)$^+$ ($^{81}Br$)], 185 (40) [(M – $COOCH_3$)$^+$ ($^{79}Br$)], 160 (60), 158 (100), 138 (78), 106 (30), 78 (80), 51 (63), 28 (27). – $C_9H_9BrO_3$ (245.070): calcd. C 44.11, H 3.70; found C 44.46, H 3.93.

**3-Bromo-2-(3,3-dimethylbut-1-ynyl)-5-pent-1-enylfuran (11). – Typical Procedure D:** To a suspension of 2 mmol of *n*-butyltriphenylphosphonium bromide (0.80 g) in 15 mL of THF 2 mmol of *n*-butyllithium (1.36 mL of a 1.47 M solution in hexane) was slowly added at 0°C. The mixture was stirred for 10 min. A solution of 2 mmol of furan **4a** in 5 mL of THF was added by syringe over a

period of 20 min. The mixture was refluxed for 2 h and subsequently quenched with 5 mL of water. The product was extracted with ether (3 × 10 mL), the combined organic layers were washed with brine (10 mL), dried with $MgSO_4$, and filtered. After removal of the solvent in vacuo, the residue was purified by flash chromatography (P/TBME = 90:10). A total of 360 mg (61%) of furan **11** was obtained as a yellow oil. Analytical data are provided for the predominant (*Z*) isomer [(*Z*)/(*E*) ratio: 86:14]. − $R_f$ = 0.70 (P/TBME = 75:25). − IR (film): $\tilde{\nu}$ = 2971 $cm^{-1}$ (s, C−H), 2931 (m, C−H), 2873 (m, C−H), 2225 (w, C≡C), 1038 (w, C−Br). − $^1H$ NMR (200 MHz): δ = 0.88 (t, *J* = 7.4 Hz, 3 H), 1.27 (s, 9 H), 1.40 (sext, *J* = 7.4 Hz, 2 H), 2.28 (dq, *J* = 7.4 Hz, *J* = 1.8 Hz, 2 H), 5.56 (dt, *J* = 11.8 Hz, *J* = 7.4 Hz, 1 H), 6.01 (dt, *J* = 11.8 Hz, *J* = 1.8 Hz, 1 H), 6.21 (s, 1 H). − $^{13}C$ NMR (50 MHz): δ = 13.7 (q), 22.9 (t), 28.3 (s), 30.5 (q), 31.3 (t), 68.0 (s), 105.7 (s), 109.8 (s), 112.5 (d), 116.7 (d), 132.9 (s), 134.2 (d), 152.9 (s). − MS (70 eV); *m/z* (%): 296 (84) [$M^+$ ($^{81}Br$)], 294 (87) [$M^+$ ($^{79}Br$)], 281 (99) [(M − $CH_3$)$^+$ ($^{81}Br$)], 279 (100) [(M − $CH_3$)$^+$ ($^{79}Br$)], 267 (30) [(M − $C_2H_5$)$^+$ ($^{81}Br$)], 265 (100) [(M − $C_2H_5$)$^+$ ($^{79}Br$)], 239 (14) [(M − $C_4H_9$)$^+$ ($^{81}Br$)], 237 (15) [(M − $C_4H_9$)$^+$ ($^{79}Br$)], 158 (17), 55 (90), 41 (45). − $C_{15}H_{19}BrO$ (295.215): calcd. C 61.03, H 6.49; found C 61.24, H 6.49.

**3-Bromo-2-(5-chloropent-1-ynyl)-5-pent-1-enylfuran (12):** The reaction was carried out as described in typical procedure D starting from furan **4d** on a 3-mmol scale. After workup, the residue was purified by flash chromatography (P/TBME = 95:5). A total of 825 mg (87%) of furan **12** was obtained as an orange-yellow oil. Analytical data are provided for the predominant (*Z*) isomer [(*Z*)/(*E*) ratio: 81:19]. − $R_f$ = 0.80 (P/TBME = 75:25). − IR (film): $\tilde{\nu}$ = 2961 $cm^{-1}$ (s, C−H), 2228 (w, C≡C), 1055 (w, C−Br). − $^1H$ NMR (200 MHz): δ = 0.94 (t, *J* = 7.3 Hz, 3 H), 1.48 (sext, *J* = 7.3 Hz, 2 H), 2.05 (quint, *J* = 6.5 Hz, 2 H), 2.35 (dq, *J* = 7.3 Hz, *J* = 1.8 Hz, 2 H), 2.68 (t, *J* = 6.5 Hz, 2 H), 3.70 (t, *J* = 6.5 Hz, 2 H), 5.64 (dt, *J* = 11.8 Hz, *J* = 7.3 Hz, 1 H), 6.06 (dt, *J* = 11.8 Hz, *J* = 1.8 Hz, 1 H), 6.27 (s, 1 H). − $^{13}C$ NMR (50 MHz): δ = 13.6 (q), 17.2 (t), 22.5 (t), 31.0 (t), 31.6 (t), 43.5 (t), 70.5 (s), 97.2 (s), 106.3 (s), 112.5 (d), 116.4 (d), 133.3 (s), 134.5 (d), 153.2 (s). − MS (70 eV); *m/z* (%): 318 (45) [$M^+$ ($^{81}Br$, $^{37}Cl$)], 316 (100) [$M^+$ ($^{81}Br$, $^{35}Cl$)], 314 (88) [$M^+$ ($^{79}Br$, $^{35}Cl$)], 287 (99) [(M − $C_2H_5$)$^+$ ($^{81}Br$, $^{35}Cl$)], 171 (49), 55 (72), 41 (42). − $C_{14}H_{16}BrClO$ (315.633): calcd. C 53.27, H 5.11; found C 53.09, H 5.07.

**2-(3,3-Dimethylbut-1-ynyl)-3-methyl-5-pent-1-enylfuran (13):** The typical procedure B was slightly modified to the extent that the reaction mixture was kept at reflux for 18 h. The reaction was carried out on a 1-mmol scale starting from furan **11** using 3 mmol of methylzinc chloride, prepared by transmetalation of methyllithium (1.67 mL of a 1.8 M solution) with $ZnCl_2$ (4.5 mmol, 610 mg). After workup, the residue was purified by flash chromatography (P/TBME = 98:2). A total of 164 mg (71%) of furan **13** was obtained as a yellow oil. Analytical data are provided for the predominant (*Z*) isomer [(*Z*)/(*E*) ratio: 85:15]. − $R_f$ = 0.75 (P/TBME = 75:25). − IR (film): $\tilde{\nu}$ = 2969 $cm^{-1}$ (s, C−H), 2928 (m, C−H), 2870 (m, C−H), 2226 (w, C≡C). − $^1H$ NMR (200 MHz): δ = 0.95 (t, *J* = 7.5 Hz, 3 H), 1.31 (s, 9 H), 1.48 (sext, *J* = 7.5 Hz, 2 H), 2.03 (s, 3 H), 2.36 (dq, *J* = 7.5 Hz, *J* = 1.8 Hz, 2 H), 5.53 (dt, *J* = 11.8 Hz, *J* = 7.5 Hz, 1 H), 6.09 (dt, *J* = 11.8 Hz, *J* = 1.8 Hz, 1 H), 6.09 (s, 1 H). − $^{13}C$ NMR (50 MHz): δ = 10.5 (q), 13.8 (q), 22.6 (t), 28.3 (s), 30.9 (q), 31.4 (t), 69.2 (s), 105.3 (s), 111.9 (d), 117.3 (d), 125.9 (s) 132.1 (d), 133.3 (s), 152.2 (s). − MS (70 eV); *m/z* (%): 230 (100) [$M^+$], 215 (96) [(M − $CH_3$)$^+$], 201 (75) [(M − $C_2H_5$)$^+$], 173 (18) [(M − $C_4H_9$)$^+$], 28 (34). − $C_{16}H_{22}O$ (230.345): calcd. C 83.43, H 9.63; found C 83.14, H 9.70.

**2-(5-Chloropent-1-ynyl)-3-methyl-5-pent-1-enylfuran (14):** The typical procedure B was slightly modified to the extent that the reaction mixture was kept at reflux for 18 h. The reaction was carried out starting from furan **12** on a 1.5-mmol scale and 4.5 mmol of methylzinc chloride, prepared by transmetalation of methyllithium (4.5 mmol, 2.5 mL of a 1.8 M solution) with $ZnCl_2$ (6 mmol, 818 mg). After workup, the residue was purified by flash chromatography (P/TBME = 98:2). A total of 253 mg (68%) of furan **14** was obtained as a yellow oil. Analytical data are provided for the predominant (*Z*) isomer [(*Z*)/(*E*) ratio: 82:18]. − $R_f$ = 0.76 (P/TBME = 75:25). − IR (film): $\tilde{\nu}$ = 2959 $cm^{-1}$ (s, C−H), 2928 (s, C−H), 2872 (s, C−H), 2226 (w, C≡C). − $^1H$ NMR (200 MHz): δ = 0.96 (t, *J* = 7.3 Hz, 3 H), 1.48 (sext, *J* = 7.3 Hz, 2 H), 2.04 (s, 3 H), 1.97−2.13 (m, 2 H), 2.37 (dq, *J* = 7.3 Hz, *J* = 1.8 Hz, 2 H), 2.66 (t, *J* = 6.5 Hz, 2 H), 3.69 (t, *J* = 6.5 Hz, 2 H), 5.55 (dt, *J* = 11.8 Hz, *J* = 7.3 Hz, 1 H), 6.07 (dt, *J* = 11.8 Hz, *J* = 1.8 Hz, 1 H), 6.09 (s, 1 H). − $^{13}C$ NMR (50 MHz): δ = 10.5 (q), 13.8 (q), 17.2 (t), 22.6 (t), 31.3 (t), 31.4 (t), 43.6 (t), 71.7 (s), 95.1 (s), 111.9 (d), 117.1 (d), 126.3 (s), 132.4 (s), 133.0 (d), 153.0 (s). − MS (70 eV); *m/z* (%): 252 (47) [$M^+$ ($^{37}Cl$)], 250 (100) [$M^+$ ($^{35}Cl$)], 235 (19) [(M − $CH_3$)$^+$ ($^{35}Cl$)], 221 (95) [(M − $C_2H_5$)$^+$ ($^{35}Cl$)], 214 (31), 115 (68), 41 (41), 28 (79). $C_{15}H_{19}ClO$ (HRMS): calcd. 250.1124; found 250.1126.

**Methyl 2-(3,3-Dimethylbut-1-ynyl)-3-methylfuran-5-carboxylate (15):** The typical procedure B was slightly modified to the extent that the reaction mixture was kept at reflux for 18 h. The reaction was carried out starting from furan **5a** on a 1.5-mmol scale and 4.5 mmol of methylzinc chloride, prepared by transmetalation of methyllithium (4.5 mmol, 2.5 mL of a 1.8 M solution) with $ZnCl_2$ (6 mmol, 818 mg). After workup, the residue was purified by flash chromatography (P/TBME = 98:2). A total of 231 mg (70%) of furan **15** was obtained as a colorless oil. − $R_f$ = 0.60 (P/TBME = 75:25). − IR (film): $\tilde{\nu}$ = 2970 $cm^{-1}$ (s, C−H), 2930 (m, C−H), 2868 (w, C−H), 2230 (w, C≡C), 1736 (s, C=O). − $^1H$ NMR (200 MHz): δ = 1.28 (s, 9 H), 2.04 (s, 3 H), 3.83 (s, 3 H), 6.97 (s, 1 H). − $^{13}C$ NMR (50 MHz): δ = 10.3 (q), 28.2 (s), 30.6 (q), 51.9 (q), 68.3 (s), 106.8 (s), 120.4 (d), 125.6 (s), 138.5 (s), 142.5 (s), 158.6 (s). − MS (70 eV); *m/z* (%): 220 (44) [$M^+$], 205 (100) [(M − $CH_3$)$^+$], 161 (58) [(M − $COOCH_3$)$^+$], 91 (16) [$C_7H_7^+$], 41 (7). − $C_{13}H_{16}O_3$ (220.264): calcd. C 70.89, H 7.32; found C 70.49, H 7.37.

**Methyl 2-(5-Chloropent-1-ynyl)-3-methylfuran-5-carboxylate (16):** The typical procedure B was slightly modified to the extent that the reaction mixture was kept at reflux for 18 h. The reaction was carried out starting from furan **5d** on a 2-mmol scale and 6 mmol of methyl zinc chloride, prepared by transmetalation of methyl lithium (6 mmol, 3.3 mL of a 1.8 M solution) with $ZnCl_2$ (9 mmol, 1228 mg). After workup, the residue was purified by flash chromatography (P/TBME = 98:2). A total of 321 mg (67%) of furan **16** was obtained as a colorless oil. − $R_f$ = 0.50 (P/TBME = 75:25). − IR (film): $\tilde{\nu}$ = 2957 $cm^{-1}$ (m, C−H), 2928 (m, C−H), 2845 (w, C−H), 2232 (w, C≡C), 1732 (s, C=O). − $^1H$ NMR (200 MHz): δ = 2.03 (quint, *J* = 6.6 Hz, 2 H), 2.05 (s, 3 H), 2.64 (t, *J* = 6.6 Hz, 2 H), 3.66 (t, *J* = 6.6 Hz, 2 H), 3.84 (s, 3 H), 6.96 (s, 1 H). − $^{13}C$ NMR (50 MHz): δ = 10.3 (q), 17.0 (t), 30.9 (t), 43.4 (t), 51.9 (q), 70.6 (s), 96.8 (s) 120.3 (d), 126.2 (s), 138.0 (s), 142.8 (s), 158.5 (s). − MS (70 eV); *m/z* (%): 242 (35) [$M^+$ ($^{37}Cl$)], 240 (76) [$M^+$ ($^{35}Cl$)], 205 (51) [(M − Cl)$^+$], 183 (8) [(242 − $COOCH_3$)$^+$], 181 (28) [(240 − $COOCH_3$)$^+$], 177 (100) [(M − $(CH_2)_2Cl$)$^+$], 145 (28), 117 (52), 91 (31) [$C_7H_7^+$], 77 (28), 28 (26). − $C_{12}H_{13}ClO_3$ (240.683): calcd. C 59.88, H 5.44; found C 59.80, H 5.30.

**Methyl 3-Methyl-2-(3-methylbut-2-enyl)furan-5-carboxylate (18). − Typical Procedure E:** 2 mmol of furan **8e** (546 mg), 4 mmol of tetra-

methylstannane (720 mg, 0.55 mL) and 0.1 mmol of Pd(*o*-$Tol_3)_2Cl_2$ (70 mg) were dissolved in 10 mL of DMA and the mixture was heated to 90°C for 20 h. − ***CAUTION:*** Tetramethylstannane is very toxic on inhalation, in contact with skin and if swallowed! Appropriate safety protection and utmost care is required when handling this compound! − The mixture was cooled to room temperature and subsequently quenched with a saturated aqueous $NH_4Cl$ solution (10 mL). After extraction with ether (3 × 15 mL), the organic layers were combined, washed with brine (15 mL), and dried with $MgSO_4$. The solvent was removed in vacuo and the residue was purified by flash chromatography (P/TBME = 98:2). A total of 280 mg (70%) of furan **18** was obtained as a colorless oil. − $R_f$ = 0.70 (P/TBME = 75:25). − IR (film): $\tilde{\nu}$ = 2951 $cm^{-1}$ (m, C−H), 2930 (m, C−H), 2874 (w, C−H), 1732 (s, C=O). − $^1H$ NMR (200 MHz): δ = 1.69 (d, *J* = 1.5 Hz, 6 H), 1.96 (s, 3 H), 3.32 (d, *J* = 7.2 Hz, 2 H), 3.83 (s, 3 H), 5.23 (t sept, *J* = 7.2 Hz, *J* = 1.5 Hz, 1 H), 6.94 (s, 1 H). − $^{13}C$ NMR (50 MHz): δ = 9.6 (q), 17.8 (q), 25.6 (q), 25.7 (t), 51.6 (q), 116.6 (s), 118.7 (d), 121.6 (d), 133.9 (s), 141.5 (s), 155.7 (s), 159.4 (s). − MS (70 eV); *m/z* (%): 208 (87) [$M^+$], 193 (100) [$(M - CH_3)^+$], 153 (30) [$(M - C_4H_7^+$], 149 (42) [$(M - COOCH_3)^+$], 121 (14), 91 (34) [$C_7H_7^+$], 41 (29). − $C_{12}H_{16}O_3$ (208.254): calcd. C 69.21, H 7.74; found C 69.21, H 8.00.

**3-Bromo-2-(5-chloropentyl)furan-5-carbaldehyde (19). − Typical Procedure F:** 2 mmol of furan **4d** (551 mg) was dissolved in 15 mL of ethyl acetate and 0.2 mmol of the catalyst Pd/C [10% w/w] (213 mg) was added to the solution. The hydrogenolysis was carried out in a conventional hydrogenation apparatus at ambient temperature and atmospheric pressure. The progress of the reaction was indicated by the volume of consumed hydrogen and was further monitored by GLC. Upon complete transformation (150 min), the mixture was filtered and the solvent was removed in vacuo. The residue was purified by flash chromatography (P/TBME = 90:10). A total of 360 mg (65%) of furan **19** was obtained as a yellow oil. − $R_f$ = 0.58 (P/TBME = 75:25). − IR (film): $\tilde{\nu}$ = 2940 $cm^{-1}$ (m, C−H), 2864 (m, C−H), 1685 (s, C=O), 1022 (m, C−Br). − $^1H$ NMR (200 MHz): δ = 1.44−1.58 (m, 2 H), 1.65−1.86 (m, 4 H), 2.78 (t, *J* = 6.4 Hz, 2 H), 3.55 (t, *J* = 6.4 Hz, 2 H), 7.20 (s, 1 H), 9.52 (s, 1 H). − $^{13}C$ NMR (50 MHz): δ = 26.2 (t), 26.4 (t), 26.5 (t), 32.0 (t), 44.6 (t), 99.3 (s), 124.2 (d), 150.9 (s), 159.7 (s), 176.6 (d). − MS (70 eV); *m/z* (%): 282 (9) [$M^+$ ($^{81}Br$, $^{37}Cl$)], 280 (41) [$M^+$ ($^{81}Br$, $^{35}Cl$)], 278 (23) [$M^+$ ($^{79}Br$, $^{35}Cl$)], 189 (100) [$C_6H_4BrO_2^+$ ($^{81}Br$)], 109 (39), 91 (50) [$C_4H_8Cl^+$ ($^{35}Cl$)], 55 (67). − $C_{10}H_{12}BrClO_2$ (279.558): calcd. C 42.96, H 4.33; found C 43.06, H 4.33.

**3-Bromo-2-(5-chloropentyl)-5-pent-1-enylfuran (20):** The reaction was carried out as described in typical procedure D starting from furan **19** on a 1.8-mmol scale. After workup, the residue was purified by flash chromatography (P/TBME = 98:2). A total of 466 mg (81%) of furan **20** was obtained as a yellow oil. Analytical data are provided for the predominant (*Z*) isomer [(*Z*)/(*E*) ratio: 84:16]. − $R_f$ = 0.80 (P/TBME = 75:25). − IR (film): $\tilde{\nu}$ = 2957 $cm^{-1}$ (s, C−H), 2932 (s, C−H), 2868 (s, C−H), 1020 (w, C−Br). − $^1H$ NMR (200 MHz): δ = 0.94 (t, *J* = 7.3 Hz, 3 H), 1.40−1.55 (m, 4 H), 1.56−1.86 (m, 4 H), 2.33 (dq, *J* = 7.3 Hz, *J* = 1.8 Hz, 2 H), 2.64 (t, *J* = 6.5 Hz, 2 H), 3.51 (t, *J* = 6.5 Hz, 2 H), 5.53 (dt, *J* = 11.8 Hz, *J* = 7.3 Hz, 1 H), 6.05 (dt, *J* = 11.8 Hz, *J* = 1.8 Hz, 1 H), 6.19 (s, 1 H). − $^{13}C$ NMR (50 MHz): δ = 13.9 (q), 22.6 (t), 25.6 (t), 26.2 (t), 27.0 (t), 31.3 (t), 32.2 (t), 44.8 (t), 97.5 (s), 112.0 (d), 116.8 (d), 131.8 (d), 151.1 (s), 151.7 (s). − MS (70 eV); *m/z* (%): 322 (14) [$M^+$ ($^{81}Br$, $^{37}Cl$)], 320 (61) [$M^+$ ($^{81}Br$, $^{35}Cl$)], 318 (44) [$M^+$ ($^{79}Br$, $^{35}Cl$)], 291 (53) [$(M - C_2H_5)^+$ ($^{81}Br$, $^{35}Cl$)], 229 (99) [$C_{10}H_{12}BrO^+$ ($^{81}Br$)], 227 (100) [$C_{10}H_{12}BrO^+$ ($^{79}Br$)], 187 (61) [$C_7H_6BrO^+$ ($^{81}Br$)], 185 (66) [$C_7H_6BrO^+$ ($^{79}Br$)], 91 (37), 55 (49), 41 (22), 28 (31). − $C_{14}H_{20}BrClO$ (319.665): calcd. C 52.60, H 6.31; found C 52.58, H 6.20.

**2-(5-Chloropentyl)-3-methyl-5-pent-1-enylfuran (21):** The reaction was carried out as described in typical procedure E starting from furan **20** on a 0.4-mmol scale. After workup, the residue was purified by flash chromatography (P/TBME = 98:2). No hydrodebrominated product was observed. The product (50 mg) was, however, contaminated with the corresponding 2-(5-bromopentyl)furan (ca. 10% according to GLC) which is presumably formed by a Finkelstein reaction and which could not be separated by chromatography. The yield was consequently not determined and a correct elemental analysis was not obtained. Analytical data are provided for the predominant (*Z*) isomer [(*Z*)/(*E*) ratio: 80:20]. − $R_f$ = 0.82 (P/TBME = 75:25). − IR (film): $\tilde{\nu}$ = 2957 $cm^{-1}$ (s, C−H), 2930 (s, C−H), 2870 (s, C−H). − $^1H$ NMR (200 MHz): δ = 0.95 (t, *J* = 7.3 Hz, 3 H), 1.36−1.86 (m, 8 H), 1.92 (s, 3 H), 2.37 (dq, *J* = 7.3 Hz, *J* = 1.8 Hz, 2 H), 2.55 (t, *J* = 7.3 Hz, 2 H), 3.51 (t, *J* = 6.6 Hz, 2 H), 5.43 (dt, *J* = 11.8 Hz, *J* = 7.3 Hz, 1 H), 6.02 (s, 1 H), 6.07 (dt, *J* = 11.8 Hz, *J* = 1.8 Hz, 1 H). − $^{13}C$ NMR (50 MHz): δ = 9.8 (q), 13.9 (q), 22.7 (t), 25.7 (t), 26.4 (t), 27.7 (t), 31.3 (t), 32.4 (t), 44.9 (t), 112.2 (d), 115.5 (s), 117.5 (d), 129.5 (d), 149.9 (s), 150.6 (s). − MS (70 eV); *m/z* (%): 256 (22) [$M^+$ ($^{37}Cl$)], 254 (57) [$M^+$ ($^{35}Cl$)], 227 (17) [$(M - C_2H_5)^+$ ($^{37}Cl$)], 225 (46) [$(M - C_2H_5)^+$ ($^{35}Cl$)], 219 (22), 213 (10) [$(M - C_3H_7)^+$ ($^{37}Cl$)], 211 (34) [$(M - C_3H_7)^+$ ($^{35}Cl$)], 163 (100), 121 (54), 107 (38), 91 (30) [$C_4H_8Cl^+$ ($^{35}Cl$)], 55 (31), 41 (21), 28 (37). − $C_{15}H_{23}ClO$ (HRMS): calcd. 254.1437; found 254.1436.

**3-Methyl-2-(3-methylbut-2-enyl)furan (Rosefuran, 22):** 1 mmol of compound **18** (208 mg) was dissolved in 5 mL of an aqueous NaOH solution [20% w/w] and the mixture was refluxed for 4 h. After acidification with 5 N HCl to pH = 1, the mixture was extracted with ethyl acetate (3 × 10 mL), washed with brine (10 mL), and dried with $MgSO_4$. The solvent was removed in vacuo and the crude product was dissolved in 6 mL of quinoline. 3 mmol of Cu powder (212 mg) was added and the mixture heated to 180°C. After complete transformation, 20 mL of diethyl ether was added and the mixture was washed with 1 N HCl (4 × 25 mL) to remove the quinoline. The organic layer was washed with brine, dried with $MgSO_4$, and the solvent was removed in vacuo. The residue was purified by flash chromatography (P/TBME = 95:5). A total of 105 mg (70%) of furan **22** was obtained as a colorless oil. − $R_f$ = 0.80 (P/TBME = 75:25). − $^1H$ NMR (200 MHz): δ = 1.70 (s, 6 H), 1.94 (s, 3 H), 3.26 (d, *J* = 7.2 Hz, 2 H), 5.24 (t sept, *J* = 7.2 Hz, *J* = 1.2 Hz, 1 H), 6.14 (d, *J* = 1.8 Hz, 1 H), 7.20 (d, *J* = 1.8 Hz, 1 H). − All other analytical data are in agreement with those given in the literature.[2e,33]

**Benzyl 11-[(3-Bromo-5-pent-1-enylfuran)-2-yl]undec-10-ynoate (23):** The reaction was carried out as described in typical procedure D starting from furan **4f** on a 2-mmol scale. After quenching and usual workup, the residue was purified by flash chromatography (P/TBME = 90:10). A total of 815 mg (84%) of furan **23** was obtained as a brown oil. Analytical data are provided for the predominant (*Z*) isomer [(*Z*)/(*E*) ratio: 82:18]. − $R_f$ = 0.60 (P/TBME = 75:25). − IR (film): $\tilde{\nu}$ = 3032 $cm^{-1}$ (w, $C_{Ar}$−H), 2932 (s, C−H), 2859 (m, C−H), 2228 (w, C≡C), 1737 (s, O−C=O), 1059 (w, C−Br). − $^1H$ NMR (200 MHz): δ = 0.93 (t, *J* = 7.2 Hz, 3 H), 1.15−1.65 (m, 16 H), 2.33 (t, *J* = 7.2 Hz, 2 H), 2.46 (t, *J* = 7.2 Hz, 2 H), 5.09 (s, 2 H), 5.62 (dt, *J* = 11.8 Hz, *J* = 7.2 Hz, 1 H), 6.06 (dt, *J* = 11.8 Hz, *J* = 1.6 Hz, 1 H), 6.26 (s, 1 H), 7.30−7.40 (m, 5 H). − $^{13}C$ NMR (50 MHz): δ = 13.8 (q), 19.7 (t), 22.4 (t), 24.9 (t), 28.1 (t), 28.6 (t) 28.8 (t) 29.0 (t), 29.1 (t), 31.3 (t), 34.3 (t), 66.0 (t), 69.5 (s), 99.4 (s), 105.7 (s), 112.5 (d), 116.5 (d), 128.1 (d), 128.1 (d),

128.5 (d), 134.2 (d), 134.8 (s), 136.0 (s), 153.0 (s), 173.7 (s). − MS (70 eV); *m/z* (%): 486 (11) [$M^+$ ($^{81}$Br)], 484 (11) [$M^+$ ($^{79}$Br)], 395 (26) [(M − $C_7H_7$)$^+$ ($^{81}$Br)], 393 (24) [(M − $C_7H_7$)$^+$ ($^{79}$Br)], 314 (6) [(393 − Br)], 91 (100) [$C_7H_7^+$], 41 (25), 28 (48). − $C_{27}H_{33}BrO_3$ (485.488): calcd. C 66.80, H 6.85; found C 66.61, H 6.93.

**Benzyl 11-[(3-Methyl-5-pent-1-enylfuran)-2-yl]undec-10-ynoate (24):** The reaction was carried out as described in typical procedure B starting from furan **23** on a 2-mmol scale and 6 mmol of methylzinc chloride, prepared by transmetalation of methyl lithium (6 mmol, 3.33 mL of a 1.8 M solution) with $ZnCl_2$ (9 mmol, 1228 mg). After workup, the residue was purified by flash chromatography (P/TBME = 98:2). A total of 655 mg (76%) of furan **24** was obtained as a brown oil. Analytical data are provided for the predominant (*Z*) isomer [(*Z*)/(*E*) ratio: 82:18]. − $R_f$ = 0.80 (P/TBME = 75:25). − IR (film): $\tilde{\nu}$ = 3067 cm$^{-1}$ (w, $C_{Ar}$−H), 2930 (s, C−H), 2857 (s, C−H), 2228 (w, C≡C), 1738 (s, O−C=O). − $^1$H NMR (200 MHz): δ = 0.94 (t, *J* = 7.4 Hz, 3 H), 1.13−1.68 (m, 16 H), 2.27−2.48 (m, 4 H), 2.09 (s, 3 H), 5.09 (s, 2 H), 5.54 (dt, *J* = 11.7 Hz, *J* = 7.4 Hz, 1 H), 6.07 (dt, *J* = 11.7 Hz, *J* = 1.8 Hz, 1 H), 6.09 (s, 1 H), 7.30−7.36 (m, 5 H). − $^{13}$C NMR (50 MHz): δ = 10.5 (q), 13.8 (q), 19.7 (t), 22.6 (t), 24.9 (t), 28.5 (t), 28.7 (t) 28.9 (t) 29.0 (t), 29.1 (t), 31.3 (t), 34.2 (t), 66.0 (t), 70.8 (s), 97.3 (s), 111.9 (d), 117.2 (d), 125.8 (s), 128.1 (d), 128.1 (d), 128.5 (d), 132.1 (d), 133.4 (s), 136.1 (s), 152.3 (s), 173.6 (s). − MS (70 eV); *m/z* (%): 420 (43) [$M^+$], 329 (27) [(M − $C_7H_7$)$^+$], 91 (100) [$C_7H_7^+$], 41 (24), 28 (40). − $C_{28}H_{36}O_3$ (420.584): calcd. C 79.96, H 8.63; found C 79.70, H 8.86.

**Benzyl 11-[(3-Methyl-5-pentylfuran)-2-yl]undecanoate (25):** The reaction was carried out as described in typical procedure F starting from furan **24** (2 mmol, 821 mg). 0.03 mmol of $Pd(OH)_2$/C [20% w/w] (120 mg) was used as catalyst. After workup, the residue was purified by flash chromatography (P/TBME = 98:2). A total of 358 mg (84%) of furan **25** was obtained as a colorless oil. − $R_f$ = 0.70 (P/TBME = 75:25). − IR (film): $\tilde{\nu}$ = 2928 cm$^{-1}$ (s, C−H), 2857 (s, C−H), 1740 (s, O−C=O). − $^1$H NMR (200 MHz): δ = 0.88 (t, *J* = 7.4 Hz, 3 H), 1.10−1.70 (m, 22 H), 1.88 (s, 3 H), 2.33 (t, *J* = 7.3 Hz, 2 H), 2.47 (t, *J* = 7.3 Hz, 2 H), 2.50 (t, *J* = 7.3 Hz, 2 H), 5.09 (s, 2 H), 5.72 (s, 1 H), 7.28−7.38 (m, 5 H). − $^{13}$C NMR (50 MHz): δ = 9.8 (q), 14.0 (q), 22.4 (t), 25.0 (t), 25.9 (t), 27.8 (t), 28.0 (t), 28.7 (t) 29.1 (t) 29.2 (t), 29.2 (t), 29.3 (t), 29.4 (t), 29.5 (t), 31.4 (t), 34.3 (t), 66.0 (t), 107.6 (d), 113.8 (s), 128.1 (d), 128.1 (d), 128.5 (d), 136.1 (s), 149.4 (s), 153.5 (s), 173.7 (s). − MS (70 eV); *m/z* (%): 426 (10) [$M^+$], 335 (18) [(M − $C_7H_7$)$^+$], 165 (100), 91 (27) [$C_7H_7^+$]. − $C_{28}H_{42}O_3$ (HRMS): calcd. 426.3134; found 426.3132.

**11-[(3-Methyl-5-pentylfuran)-2-yl)]undecanoic Acid (26):** 1 mmol of furan **25** (427 mg) and 3 mmol of KOH (176 mg) were dissolved in 9 mL of THF/MeOH/water (1:1:1) and the solution was refluxed for 2 h. After complete transformation, the mixture was extracted with diethyl ether (3 × 15 mL), washed with brine, and dried with $MgSO_4$. The solvent was removed in vacuo and the residue was purified by flash chromatography (P/TBME = 80:20). A total of 302 mg (90%) of furan **26** was obtained as a colorless oil. − $R_f$ = 0.30 (P/TBME = 75:25). − IR (film): $\tilde{\nu}$ = 2928 cm$^{-1}$ (s, C−H), 2857 (s, C−H), 1709 (s, O−C=O). − $^1$H NMR (200 MHz): δ = 0.84−0.92 (m, 3 H), 1.14−1.70 (m, 22 H), 1.87 (s, 3 H), 2.32 (t, *J* = 7.3 Hz, 2 H), 2.45 (t, *J* = 7.3 Hz, 2 H), 2.49 (t, *J* = 7.3 Hz, 2 H), 5.71 (s, 1 H). − $^{13}$C NMR (50 MHz): δ = 9.9 (q), 14.0 (q), 22.4 (t), 24.7 (t), 25.9 (t), 27.8 (t), 27.9 (t), 28.7 (t) 29.0 (t) 29.1 (t), 29.2 (t), 29.3 (t), 29.4 (t), 29.5 (t), 31.4 (t), 34.0 (t), 107.6 (d), 113.7 (s), 149.4 (s), 153.5 (s), 179.5 (s). − MS (70 eV); *m/z* (%): 336 (36) [$M^+$], 279 (20) [(M − $C_4H_9$)$^+$], 165 (100), 108 (7), 28 (30). − $C_{21}H_{36}O_3$ (336.509): calcd. C 74.95, H 10.78; found C 74.80, H 10.71.

**3-Bromo-2-(3-methylbut-2-enyl)furan (28):** The reaction was carried out as described in typical procedure C starting from 2,3-dibromofuran (**27**) and stannane **9** on a 2-mmol scale. After workup, the residue was purified by flash chromatography (P) and kugelrohr distillation (10 mbar, 80−90°C). A total of 490 mg (60%) of furan **28**[33] was obtained as a colorless oil. − $R_f$ = 0.85 (PE/TBME = 75:25). − IR (film): $\tilde{\nu}$ = 2982 cm$^{-1}$ (m, C−H), 2930 (m, C−H), 2915 (m, C−H), 1055 (s, C−Br). − $^1$H NMR (200 MHz): δ = 1.73 (d, *J* = 1.1 Hz, 6 H), 3.35 (d, *J* = 7.2 Hz, 2 H), 5.25 (t sept, *J* = 7.2 Hz, *J* = 1.1 Hz, 1 H), 6.34 (d, *J* = 2.0 Hz, 1 H), 7.26 (d, *J* = 2.0 Hz, 1 H). − $^{13}$C NMR (50 MHz): δ = 17.8 (q), 25.3 (q), 25.6 (t), 95.4 (s), 113.6 (d), 118.4 (d), 134.3 (s), 141.1 (d), 152.0 (s). − MS (70 eV); *m/z* (%): 216 (58) [$M^+$ ($^{81}$Br)], 214 (65) [$M^+$ ($^{79}$Br)], 201 (45) [(M − $CH_3$)$^+$ ($^{81}$Br)], 199 (58) [(M − $CH_3$)$^+$ ($^{79}$Br)], 161 (25) [(M − $C_4H_7$)$^+$ ($^{81}$Br)], 159 (22) [(M − $C_4H_7$)$^+$ ($^{79}$Br)], 135 (19) [(M − Br$^+$], 120 (100) [(135 − $CH_3$)$^+$], 51 (51) [$C_4H_3^+$], 41 (83) [$C_3H_5^+$].

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