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# Diversity-Oriented Synthesis of Chlorinated Arenes by One-Pot Cyclizations of 4-Chloro-1,3-bis(trimethylsilyloxy)buta-1,3-dienes

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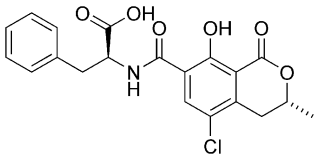
**Keywords:** Arenes / Cyclization / Organochlorine compounds / Regioselectivity / Silyl enol ethers

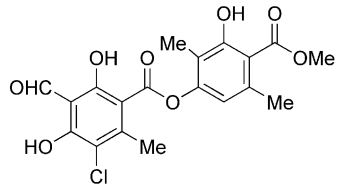
A variety of 3-chlorosalicylates were prepared by one-pot cyclizations of the first reported 4-chloro-1,3-bis(trimethylsilyloxy)buta-1,3-dienes with various 1,3-dielectrophiles. These include cyclizations with 3-silyloxy-2-en-1-ones, 3-aryl-3-silyloxy-2-en-1-ones, 1-methoxy-1-en-3-ones, 1,1-bis(methylthio)-1-en-3-ones, 3-oxo orthoesters, 1,1,3,3-tetraethoxypropanes, 1,1-diacetylcyclopropane, and 3-formylchromones.


## Introduction

Chlorinated benzene derivatives represent important core structures in medicinal chemistry and are present in a variety of natural products, including dibenzo[*b*,*e*][1,4]dioxepin-11-ones,[1] spirocycles (e.g., the clastogenic, cytotoxic and antifungal aspirochlorins, grisandions, griseofulvins and epigriseofulvin),[2] xanthones (austocystin A),[3] tetracyclins,[4] isochromanones (ochratoxin A, Scheme 1),[5] terpenes (ascofuranol, ascochlorin),[6] macrocycles (radicicol, bazzanin K),[7] dibenzo[*b*,*d*]pyran-6-one (graphislactone G),[8] oligosaccharides (flambamycin),[9] benzophenones,[10] polycycles,[11] arenes[12] and biaryls (ambigol A).[13] They have found many technical and medicinal applications and represent important synthetic building blocks. 2-Acyl-4-chlorophenols are found, for example, in the natural product chloratranorin (Scheme 2);[1] other natural products include dihydronidulin.[14] Geodin[15] and geodinhydrate methyl ester[16] show antibacterial and antifungal activity, and 7-chloro-1-*O*-methylemodin has been reported to exhibit antiviral activity.[17] 3-Chlorosalicylates and related compounds are also present in simple arenes, acetophenones (longissiminone B), benzophenones (chloroisosulochrin, pestalone) and diaryl ethers (methyl chloroasterrate),[18] falconensin B,[19] natural chromones[20] and 7-chloro-8-hydroxy-6-methoxy-3-methylisochroman-1-one.[21]



Scheme 1. Ochratoxin A.



Scheme 2. Chloratranorin.

With the development of new and efficient catalysts, chloroarenes are attracting more and more interest as substrates for transition-metal-catalysed cross-coupling reactions.[22,23] Classic syntheses of functionalized chlorophenols, based on chlorination of phenols, often suffer from low regioselectivities and yields. An alternative strategy relies on the use of suitable chlorinated substrates in cyclization reactions, although examples of this building block strategy have so far been reported only rarely. Syntheses of 4-chlorophenols based on [4+2] cycloadditions of chloro-substituted buta-1,3-dienes have been reported: Brassard and co-workers, for example, reported the synthesis of a chlorinated anthraquinone through a [4+2] cycloaddition between 2-chloro-1-methoxy-1,3-bis(trimethylsilyloxy)buta-1,3-diene and a 2-chloronaphthoquinone,[24] and 4-chlorophenol was also prepared through a [4+2] cycloaddition between a chlorinated thiophene and dimethyl acetylenedicarboxylate.[25]

1,3-Bis(trimethylsilyloxy)buta-1,3-dienes (e.g., Chan's diene[26]) represent important synthetic building blocks that have been used in formal [3+2], [3+3], [4+2] and [4+3] cyclizations and various other transformations.[27,28] We have re-

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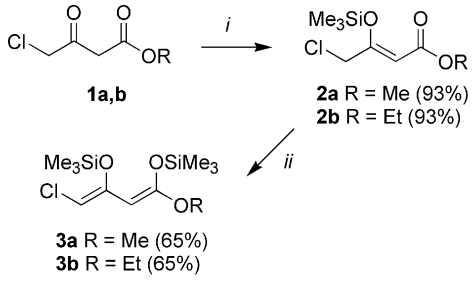
cently reported the synthesis of 4-chlorophenols by cyclization of 1,3-bis(silyloxy)buta-1,3-dienes with 2-chloro-3-silyloxy-2-en-1-ones[29] and the synthesis of chlorinated hetero- and carbacycles through cyclization reactions of 2-chloro-1,3-bis(silyloxy)buta-1,3-dienes.[30] Recently we have reported[31] the synthesis of the first 4-chloro-1,3-bis(silyloxy)-buta-1,3-dienes and their application to the synthesis of chlorinated arenes and hetarenes. Here we report full details and a significant extension of the scope. A variety of 3-chlorosalicylates were prepared through formal [3+3] cyclocondensations with various 1,3-dielectrophiles. The products are not readily available by other methods.

## Results and Discussion

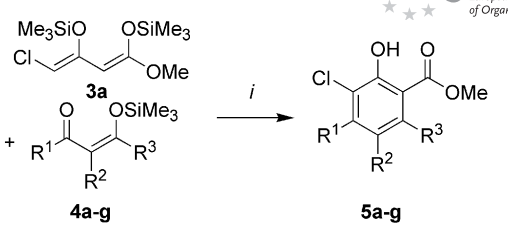
The silylation of commercially available methyl and ethyl 4-chloroacetoacetate (**1a** and **1b**) gave the 4-chloro-3-(silylox)ycrotonates **2a** and **2b** (Scheme 3). The 1-alkoxy-4-chloro-1,3-bis(silyloxy)buta-1,3-dienes **3a** and **3b** were prepared by deprotonation (LDA) of **2a** and **2b** at –78 °C and subsequent addition of chlorotrimethylsilane. Notably, the chloro group proved to be compatible with the reaction conditions. Dienes **3a** and **3b** can be stored at –20 °C under inert atmosphere for several weeks.




Scheme 3. Synthesis of **3a** and **3b**. *Conditions: i.* $Me_3SiCl$, $NEt_3$, $C_6H_6$, 20 °C, 72 h; *ii.* 1) LDA, THF, –78 °C, 1 h, 2) $Me_3SiCl$, –78 → 20 °C.

$TiCl_4$-mediated [3+3] cyclizations between diene **3a** and the 3-silyloxy-2-en-1-ones **4a**–**g**, prepared by silylation of the corresponding 1,3-diketones, afforded the 3-chlorosalicylates **5a**–**g** (Scheme 4, Table 1). During the optimization, it proved to be important to carry out the reactions in highly concentrated solutions. The employment of other Lewis acids, such as $Me_3SiOTf$, $BF_3{\cdot}OEt_2$, $Et_2AlCl$ or $Sc(OTf)_3$, proved unsuccessful (low levels of conversion or formation of complex mixtures). It has previously been reported[26] that the cycloaddition between 1-methoxy-1,3-bis(silyloxy)buta-1,3-diene and enone **4c** proceeds with excellent regioselectivity. In contrast, product **5c**, derived from diene **3a**, was isolated as an inseparable mixture of regioisomers. Derivative **5f** contains two chlorine atoms ($R^2$ = Cl).

$TiCl_4$-mediated [3+3] cyclizations between the 4-chloro-1,3-bis(silyloxy)-1,3-dienes **3a** or **3b** and the 3-aryl-3-silyloxy-2-en-1-ones **6a**–**f**, prepared by silylation of the corresponding benzoylacetones, afforded the chlorinated biaryls



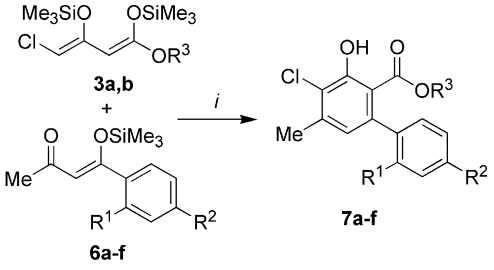

Scheme 4. Synthesis of **5a**–**g**. *Conditions: i.* $TiCl_4$, $CH_2Cl_2$, –78° to 20 °C, 20 h.

Table 1. Synthesis of 3-chlorosalicylates **5a**–**g**.

| 4,5 | $R^1$ | $R^2$ | $R^3$ | **5** (%)[a] |
|---|---|---|---|---|
| **a** | Me | Me | Me | 38 |
| **b** | Me | H | Me | 36 |
| **c** | Me | $(CH_2)_4$ | | 42[b] |
| **d** | Me | Et | Me | 44 |
| **e** | Et | H | Et | 38 |
| **f** | Me | Cl | Me | 36 |
| **g** | Me | $CO_2Et$ | Me | 30 |

[a] Yields of isolated products. [b] 1:1 mixture of regioisomers.

**7a**–**f** (Scheme 5, Table 2). During the optimization it again proved to be important to carry out the reactions in highly concentrated solutions. As in the case of the syntheses of **5a**–**g**, the use of other Lewis acids was not successful. The products containing the aryl group located *ortho* to the ester group were formed with very good regioselectivity. The formation of the regioisomers with the aryl group *para* to the ester group could not be detected by chromatography or NMR spectroscopy. However, the yields of **7a**–**f** were only moderate, which can be explained by practical problems during the chromatographic purification. The regioselectivity can be interpreted in terms of a mechanism first suggested by Chan et al.,[26] proceeding through $TiCl_4$-mediated isomerization of **6a**–**f**, conjugate addition by attack of carbon atom C-4 of the diene onto **6** and subsequent cyclization and aromatization. The structures of all products were confirmed spectroscopically. The structure of **7b** was independently confirmed by an X-ray crystal structure analysis (Figure 1).[32]




Scheme 5. Synthesis of **7a**–**f**. *Conditions: i.* $TiCl_4$, $CH_2Cl_2$, –78°→ 20 °C, 20 h.

$TiCl_4$-mediated reactions between **3a** or **3b** and the 1-methoxy-1-en-3-ones **8a**–**c** resulted in the regioselective formation of the 3-chlorosalicylates **9a**–**c** (Scheme 6, Table 3). The $R^3$ substituent in each product is located *ortho* to the

Table 2. Synthesis of 4-chlorobiphenyls **7a**–**e**.

| 6,7 | $R^1$ | $R^2$ | $R^3$ | 7 (%)[a] |
|---|---|---|---|---|
| **a** | H | H | Me | 42 |
| **b** | H | H | Et | 41 |
| **c** | H | F | Et | 48 |
| **d** | Cl | H | Et | 50 |
| **e** | Me | H | Et | 45 |
| **f** | F | H | Et | 40 |

[a] Yields of isolated products.

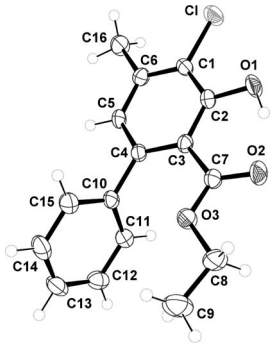
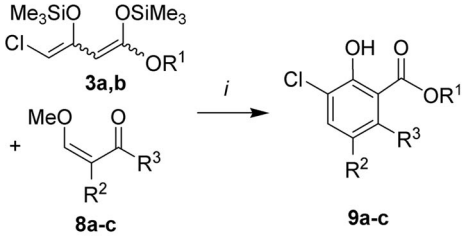



Figure 1. Ortep plot of **7b** (50% probability level).

ester group. The formation of the other regioisomer could not be detected by chromatography or NMR spectroscopy. The moderate yields can again be explained by practical problems during chromatography. The employment of $Me_3$-SiOTf resulted in low levels of conversion and the use of $BF_3{\cdot}OEt_2$, $Et_2AlCl$ or $Sc(OTf)_3$ resulted in the formation of complex mixtures. The yields could not be improved when the reactions were carried out in more dilute solutions. The regioselectivity can be explained in terms of a mechanism related to that discussed for the formation of salicylates **7a**–**f**. The structure of **9c** was independently confirmed by X-ray crystal structure analysis (Figure 2).[32]




Scheme 6. Synthesis of **9a**–**c**. *Conditions: i.* $TiCl_4$, $CH_2Cl_2$, –78 → 20 °C, 20 h, 25%.

Table 3. Synthesis of 3-chlorosalicylates **9a**–**c**.

| 8,9 | $R^1$ | $R^2$ | $R^3$ | 9 (%)[a] |
|---|---|---|---|---|
| **a** | Me | H | Me | 25 |
| **b** | Et | CN | 4-$ClC_6H_4$ | 40 |
| **c** | Et | CN | Me | 38 |

[a] Yields of isolated products.

Cyclizations between the 4-chloro-1,3-bis(trimethylsilyloxy)buta-1,3-diene **3b** and the 1,1-bis(methylthio)-1-en-3-ones **10a**–**i**, by our recently reported procedure,[33] afforded

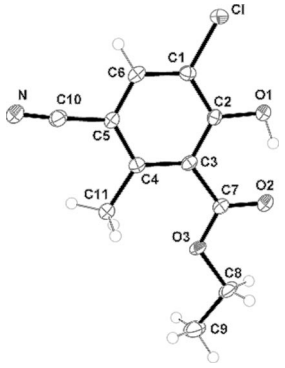
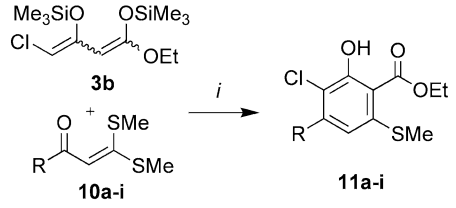



Figure 2. Ortep plot of **9c** (50% probability level).

the novel 3-chloro-6-(methylthio)salicylates **11a**–**i** in moderate to excellent yields (Scheme 7, Table 4). In each case the product containing the methylthio group located *ortho* to the ester group was formed with very good regioselectivity. The formation of other regioisomers, with the methylthio group located *para* to the ester group, again could not be detected by chromatography or NMR spectroscopy. The cyclizations proceed by attack of the terminal carbon atom of the diene on the carbonyl group and subsequent cyclization. The structure of **11a** was independently confirmed by X-ray crystal structure analysis (Figure 3).[32]




Scheme 7. Synthesis of 3-chloro-6-(methylthio)salicylates **11a**–**i**. *Conditions: i.* 1) $TiCl_4$, –78 → 20 °C, 14 h; 2) HCl (10%).

Table 4. Synthesis of 3-chloro-6-(methylthio)salicylates **11a**–**i**.

| 10,11 | R | 11 (%)[a] |
|---|---|---|
| **a** | Ph | 96 |
| **b** | 4-$MeC_6H_4$ | 89 |
| **c** | 4-$FC_6H_4$ | 83 |
| **d** | 4-$MeOC_6H_4$ | 44 |
| **e** | 4-$PhC_6H_4$ | 51 |
| **f** | 4-$EtC_6H_4$ | 59 |
| **g** | 4-$ClC_6H_4$ | 54 |
| **h** | 4-$BrC_6H_4$ | 67 |
| **i** | Me | 91 |

[a] Yields of isolated products.

Cyclizations between the 4-chloro-1,3-bis(trimethylsilyloxy)buta-1,3-diene **3b** and the 3-oxo orthoesters **12a**–**j**, by our recently reported procedure,[34] afforded the novel 3-chloro-4-methoxysalicylates **13a**–**j** in moderate to good yields (Scheme 8, Table 5). In each case the product containing the methoxy group located *para* to the ester group was regioselectively formed. The formation of the regioisomers, with the methoxy group located *ortho* to the ester group, could not be detected by chromatography or NMR

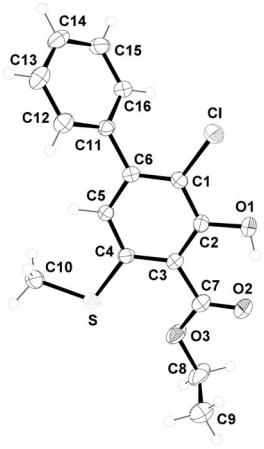
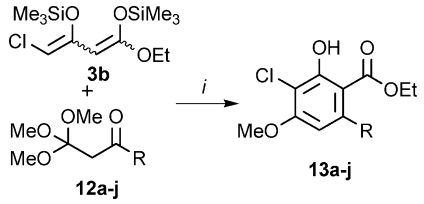



Figure 3. ORTEP plot of **11a** (50% probability level).

spectroscopy. The cyclizations proceed by attack of the terminal carbon atom of the diene onto the orthoester group and subsequent cyclization.




Scheme 8. Synthesis of 3-chloro-4-methoxysalicylates **13a**–**j**. *Conditions*: *i*. 1) $TiCl_4$, –78 → 20 °C, 14 h; 2) HCl (10%).

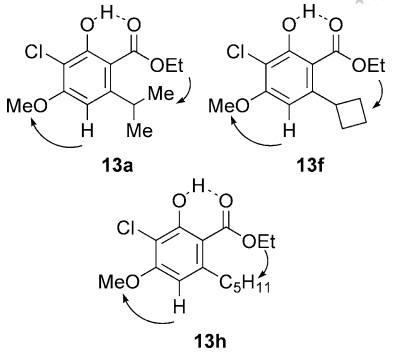
Table 5. Synthesis of 3-chloro-4-methoxysalicylates **13a**–**j**.

| **12**,**13** | R | **13** (%)[a] |
|---|---|---|
| **a** | *i*Pr | 60 |
| **b** | *n*Pr | 65 |
| **c** | Ph | 65 |
| **d** | 4-$ClC_6H_4$ | 52 |
| **e** | *c*Pr | 56 |
| **f** | *c*Bu | 61 |
| **g** | *c*Pent | 59 |
| **h** | *n*Pent | 63 |
| **i** | *c*Pent($CH_2$)$_2$ | 36 |
| **j** | *c*Hex | 47 |

[a] Yields of isolated products.

The structures were established by NOESY experiments (Scheme 9). The structure of **13a** was independently confirmed by X-ray crystal structure analysis (Figure 4).[32]

Chan et al. were the first to report $TiCl_4$-mediated cyclizations between 1,3-bis(silyloxy)buta-1,3-dienes and 1,1,3,3-tetramethoxypropane (**14a**),[26] whereas we have reported[35] $TiCl_4$-mediated cyclizations between 1,3-bis(silyloxy)buta-1,3-dienes and the 1,1,3,3-tetraethoxypropanes **14b**–**e**, which are available in three steps by a known protocol.[36] $TiCl_4$-mediated cyclizations between the chlorinated diene **3a** and **14a**–**e** afforded the 3-chlorosalicylates **15a**–**e** (Scheme 10, Table 6). During the optimization of the reactions, the stoichiometry proved to be important (Table 7).




Scheme 9. Diagnostic NOESY interactions in products **13a**, **13f** and **13h**.

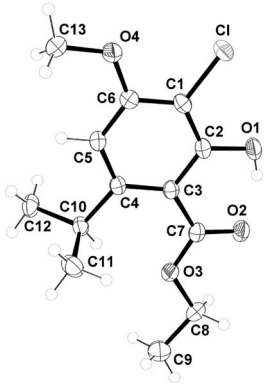
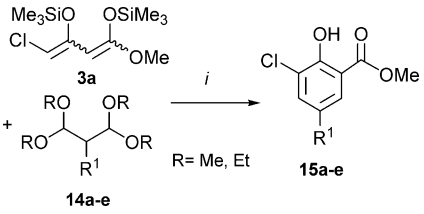



Figure 4. Ortep plot of **13a** (50% probability level).

The cyclization between **3a** and **14a** in the presence of catalytic amounts of $Me_3SiOTf$ (0.1 equiv.), by a protocol recently developed by us,[37] gave **15a**, but in very low yield.




Scheme 10. Synthesis of 3-chlorosalicylates **15a**–**e**. *Conditions*: *i*. $TiCl_4$, $CH_2Cl_2$, –78 → 20 °C.

Table 6. Synthesis of 3-chlorosalicylates **15a**–**e**.

| **14**,**15** | R | $R^1$ | **15** (%)[a] |
|---|---|---|---|
| **a** | Me | H | 26 |
| **b** | Et | Me | 35 |
| **c** | Et | *i*Pr | 36 |
| **d** | Et | *n*Pent | 52 |
| **e** | Et | *n*Hept | 30 |

[a] Yields of isolated products.

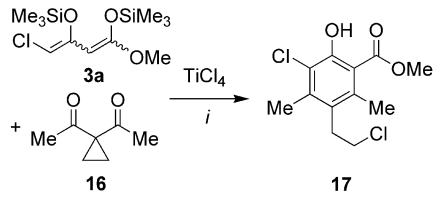
The $TiCl_4$-mediated reaction between the 4-chloro-1,3-bis(silyloxy)-1,3-diene **3a** and 1,1-diacetylcyclopropane (**16**), by our recently reported protocol,[38] afforded the 3-chlorosalicylate **17** in 30% yield (Scheme 11). The formation of the product can be explained in terms of a domino "[3+3] cyclization/homo-Michael" reaction.

Table 7. Optimization of the yield of **15a**.

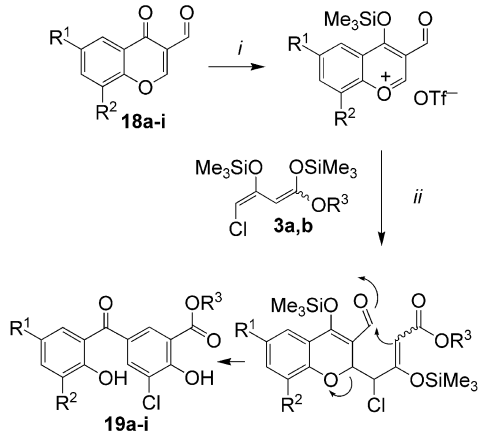
| Entry | Stoichiometry **3a**/**14a**/$Me_3SiOTf$/$TiCl_4$ | $CH_2Cl_2$ [mL mmol$^{-1}$] | **15a** (%)[a] |
|---|---|---|---|
| 1 | 1.0:1.1:0.1:0 | 10 | 19 |
| 2 | 1.0:1.1:0:1.0 | 10 | 25 |
| 3 | 2.0:1.0:0:2.0 | 2 | 26 |

[a] Yields of isolated product.




Scheme 11. Synthesis of **17**; *i*. $TiCl_4$, $CH_2Cl_2$, –78 → 20 °C, 20 h; 30%.

The $Me_3SiOTf$-catalysed reactions between the 1,3-bis-(silyloxy)-1,3-dienes **3a** or **3b** and the 3-formylchromones **18a**–**i** afforded the chlorinated 2,4′-dihydroxybenzophenones **19a**–**i** (Scheme 12, Table 8). The products are formed by domino "Michael/retro-Michael/Mukaiyama/aldol" reactions.[39] The employment of the Lewis acid $TiCl_4$, as under the conditions reported for the synthesis of **5a**–**g**, resulted in the formation of complex mixtures. The structures of all products were confirmed spectroscopically.




Scheme 12. Synthesis of **19a**–**i**. Reagents and conditions: *i*) **18a**–**i**, $Me_3SiOTf$ (0.3 equiv.), 20 °C, 10 min; *ii*) 1) **3a** or **3b** (1.3 equiv.), $CH_2Cl_2$, 0→20 °C, 12 h; 2) HCl (10%).

Table 8. Synthesis of chlorinated benzophenones **19a**–**i**.

| **18**,**19** | $R^1$ | $R^2$ | $R^3$ | **19** (%)[a] |
|---|---|---|---|---|
| **a** | H | H | Et | 42 |
| **b** | Me | H | Et | 40 |
| **c** | Et | H | Et | 40 |
| **d** | *i*Pr | H | Et | 44 |
| **e** | $NO_2$ | H | Et | 40 |
| **f** | F | H | Et | 34 |
| **g** | Cl | H | Me | 33 |
| **h** | Br | H | Et | 42 |
| **i** | Br | Br | Et | 75 |

[a] Yields of isolated products.

## Conclusions

A variety of highly substituted 3-chlorosalicylates were regioselectively prepared through one-pot cyclizations between 4-chloro-1,3-bis(trimethylsilyloxy)buta-1,3-dienes and various 1,3-dielectrophiles. The products are not readily available by other methods.

## Experimental Section

**General Comments:** All solvents were dried by standard methods and all reactions were carried out under argon. For $^1H$ and $^{13}C$ NMR spectra the deuterated solvents indicated were used. Mass spectrometric data (MS) were obtained by electron ionization (EI, 70 eV), chemical ionization (CI, isobutane) or electrospray ionization (ESI). For preparative scale chromatography silica gel 60 (0.063–0.200 mm, 70–230 mesh) was used.

**General Procedure for the Synthesis of 2a and 2b:** A solution of methyl or ethyl 4-chloroacetoacetate (**1a** or **1b**, 1.0 equiv.) and triethylamine (1.3 equiv.) in benzene (2 mL per 1 mmol of **1**) was stirred at 20 °C for 30 min. Chlorotrimethylsilane (1.5 equiv.) was added and the solution was stirred at 20 °C for 3 d. The solvent was removed in vacuo, and *n*-hexane (50 mL) was added to the residue. The mixture was filtered under argon and the filtrate was concentrated in vacuo. *n*-Hexane (50 mL) was again added to the residue, the mixture was filtered, and the filtrate was concentrated in vacuo. Because of the unstable natures of **2a** and **2b**, only NMR spectra could be obtained.

**Methyl 4-Chloro-3-(trimethylsilyloxy)but-2-enoate (2a):** Compound **2a** was isolated as a light brown oil (8.925 g, 93%) from methyl 4-chloroacetoacetate (**1a**, 5.1 mL, 43.0 mmol), triethylamine (7.7 mL, 55.9 mmol) and chlorotrimethylsilane (8.1 mL, 64.5 mmol) in benzene (86 mL). $^1H$ NMR (250 MHz, $CDCl_3$): $\delta$ = 0.20 (s, 9 H, $CH_3$), 3.59 (s, 3 H, $OCH_3$), 4.48 (s, 2 H, $CH_2$), 5.09 (s, 1 H, CH) ppm. $^{13}C$ NMR (63 MHz, $CDCl_3$): $\delta$ = 0.002 ($CH_3$), 41.1 ($CH_2$), 51.2 ($OCH_3$), 101.2 (CH), 147.5 (*C*$OOCH_3$), 166.9 [*C*$OSi(CH_3)_3$] ppm.

**Methyl 4-Chloro-3-(trimethylsilyloxy)but-2-enoate (2b):** Compound **2b** was isolated as a light brown oil (9.711 g, 95%) from ethyl 4-chloroacetoacetate (**1b**, 5.6 mL, 43.0 mmol), triethylamine (7.7 mL, 55.9 mmol) and chlorotrimethylsilane (8.1 mL, 64.5 mmol) in benzene (86 mL). $^1H$ NMR (250 MHz, $CDCl_3$): $\delta$ = 0.30 (s, 9 H, $CH_3$), 1.27 (t, $^3J$ = 7.1 Hz 3 H, $OCH_2CH_3$), 4.15 (q, $^3J$ = 7.1 Hz, 2 H, $OCH_2CH_3$), 4.58 (s, 2 H, $CH_2$), 5.18 (s, 1 H, CH) ppm.

**General Procedure for the Synthesis of 3a and 3b:** A THF solution of LDA was prepared from diisopropylamine (1.3 equiv.), *n*BuLi (1.3 equiv.) and THF (1.5 mL per 1 mmol of *n*BuLi), and **2a** or **2b** (1.0 equiv.) was added at –78 °C. After the system had been stirred for 1 h at –78 °C chlorotrimethylsilane (1.5 equiv.) was added at –78 °C. The solution was allowed to warm to ambient temperature over 20 h with stirring. The solvent was removed in vacuo and *n*-hexane (50 mL) was added to the residue. The mixture was filtered under argon and the filtrate was concentrated in vacuo. *n*-Hexane (50 mL) was again added to the residue, the mixture was filtered, and the filtrate was concentrated in vacuo. Because of the unstable natures of **3a** and **3b**, only NMR spectra could be obtained.

**4-Chloro-1-methoxy-1,3-bis-(trimethylsilyloxy)buta-1,3-diene (3a):** Compound **3a** was isolated as a light brown oil (1.910 g, 65%) from diisopropylamine (1.8 mL, 13.0 mmol), *n*BuLi (5.1 mL, 13.0 mmol), THF (15 mL), **2a** (2.227 g, 10.0 mmol) and chlorotrimethylsilane (1.9 mL, 15.0 mmol). $^1H$ NMR (250 MHz, $CDCl_3$): $\delta$

= 0.23 (s, 9 H, $CH_3$), 0.24 (s, 9 H, $CH_3$), 3.55 (s, 3 H, $OCH_3$), 5.40 (s, 1 H, CH), 5.61 (s, 1 H, CH) ppm. $^{13}$C NMR (63 MHz, $CDCl_3$): $\delta$ = 1.9 ($CH_3$), 55.1 ($OCH_3$), 75.8, 97.2 (CH), 147.4, 158.4 [*C*O-Si($CH_3$)$_3$] ppm.

**4-Chloro-1-ethoxy-1,3-bis-(trimethylsilyloxy)buta-1,3-diene (3b):** Compound **3b** was isolated as a brown oil (10.309 g, 97%) from diisopropylamine (6.3 mL, 45.0 mmol), *n*BuLi (17.6 mL, 45.0 mmol), THF (53 mL), **2b** (8.150 g, 34.4 mmol) and chlorotrimethylsilane (6.5 mL, 51.0 mmol). $^1$H NMR (250 MHz, $CDCl_3$): $\delta$ = 0.14 (s, 9 H, $CH_3$), 0.17 (s, 9 H, $CH_3$), 1.22 (t, $^3J$ = 7.1 Hz, 3 H, $OCH_2CH_3$), 3.61–3.78 (m, 2 H, $OCH_2CH_3$), 4.50 (s, 1 H, CH), 5.52 (s, 1 H, CH) ppm.

**General Procedure for the Synthesis of 3-Chlorosalicylates 5a–g:** $TiCl_4$ (1.0 equiv.) was added at –78 °C to an enone (**4a**–**g**, 1.0 equiv.) and diene **3a** (1.0 equiv.) in dichloromethane (2.5 mL per 1 mmol of **4**). The solution was allowed to warm slowly to 20 °C with stirring. Hydrochloric acid (10%) was added to the solution and the organic and the aqueous layers were separated. The latter was extracted with dichloromethane. The combined organic layers were dried (sodium sulfate) and filtered and the filtrate was concentrated in vacuo. The residue was purified by chromatography (silica gel, heptanes/EtOAc 20:1).

**Methyl 3-Chloro-2-hydroxy-4,5,6-trimethylbenzoate (5a):** Compound **5a** was isolated as a yellow oil (0.129 g, 38%) from **3a** (0.442 g, 1.5 mmol), **4a** (0.279 g, 1.5 mmol) and $TiCl_4$ (0.16 mL, 1.5 mmol) in $CH_2Cl_2$ (3 mL). $^1$H NMR (300 MHz, $CDCl_3$): $\delta$ = 2.17 (s, 3 H, $CH_3$), 2.38 (s, 6 H, $CH_3$), 3.95 (s, 3 H, $OCH_3$), 10.58 (s, 1 H, OH) ppm. $^{13}$C NMR (75 MHz, $CDCl_3$): $\delta$ = 16.4, 18.0, 18.9 ($CH_3$), 52.3 ($OCH_3$), 113.0, 119.9, 128.0, 135.8, 140.7 (C), 153.9 (COH), 171.5 (*C*O$OCH_3$) ppm. IR (ATR): $\tilde{\nu}$ = 2957 (w), 2922 (w), 2851 (w), 1732 (m), 1660 (m), 1593 (w), 1496 (w), 1439 (m), 1333 (m), 1314 (m), 1257 (s), 1232 (s), 1198 (s), 1160 (s), 1077 (s), 1010 (s) cm$^{-1}$. MS (GC-MS, 70 eV): *m*/*z* (%) = 230 [M]$^+$ ([$^{37}$Cl], 8), 228 [M]$^+$ ([$^{35}$Cl], 24), 198 (35), 197 (28), 196 (100). HRMS (EI): calcd. for $C_{11}H_{13}ClO_3$ [M]$^+$ ([$^{35}$Cl]): 228.05477; found 228.054628.

**Methyl 3-Chloro-2-hydroxy-4,6-dimethylbenzoate (5b):** Compound **5b** was isolated as a yellow solid (0.077 g, 36%) from **3a** (0.295 g, 1.0 mmol), **4b** (0.172 g, 1.0 mmol) and $TiCl_4$ (0.11 mL, 1.0 mmol) in $CH_2Cl_2$ (2 mL); m.p. 89–91 °C. $^1$H NMR (300 MHz, $CDCl_3$): $\delta$ = 2.35 (s, 3 H, $CH_3$), 2.47 (s, 3 H, $CH_3$), 3.96 (s, 3 H, $OCH_3$), 6.62 (s, 1 H, CH), 11.99 (s, 1 H, OH) ppm. $^{13}$C NMR (75 MHz, $CDCl_3$): $\delta$ = 20.5, 23.6 ($CH_3$), 52.3 ($OCH_3$), 110.8 (C), 119.9 (CH), 124.6, 138.7, 142.9 (C), 158.3 (COH), 172.0 (*C*O$OCH_3$) ppm. IR (KBr): $\tilde{\nu}$ = 2976 (w), 2955 (m), 2937 (w), 2854 (w), 1662 (s), 1608 (m), 1556 (w), 1452 (s), 1430 (s), 1394 (s), 1366 (s), 1294 (s), 1266 (s), 1219 (s), 1117 (w), 1075 (w), 1008 (s) cm$^{-1}$. MS (GC-MS, 70 eV): *m*/*z* (%) = 216 [M]$^+$ ([$^{37}$Cl], 9), 214 [M]$^+$ ([$^{35}$Cl], 25), 184 (34), 183 (21), 182 (100). HRMS (EI): calcd. for $C_{10}H_{11}ClO_3$ [M]$^+$ ([$^{35}$Cl]): 214.03912; found 214.039137. Elemental analysis calcd. (%) for $C_{10}H_{11}ClO_3$ (214.65): C 55.96, H 5.17; found C 55.81, H 5.27.

**Methyl 4-Chloro-3-hydroxy-1-methyl-4a,5,6,7,8,8a-hexahydronaphthalene-2-carboxylate (5c, Together with Methyl 3-Chloro-2-hydroxy-4-methyl-5,6,7,8-tetrahydronaphthalene-1-carboxylate):** Compound **5c** was isolated as a yellow solid (0.160 g, 42%) from **3a** (0.442 g, 1.5 mmol) in $CH_2Cl_2$ (3 mL), **4c** (0.319 g, 1.5 mmol) and $TiCl_4$ (0.16 mL, 1.5 mmol); m.p. 50–52 °C. $^1$H NMR (300 MHz, $CDCl_3$): $\delta$ = 1.64–1.80 (m, 8 H, $CH_2$), 2.33 (s, 3 H, $CH_3$), 2.34 (s, 3 H, $CH_3$), 2.54–2.62 (m, 4 H, $CH_2$), 2.78–2.82 (m, 2 H, $CH_2$), 2.91–2.95 (m, 2 H, $CH_2$), 3.95 (s, 3 H, $OCH_3$), 3.96 (s, 3 H, $OCH_3$), 10.52 (s, 1 H, OH), 11.19 (s, 1 H, OH) ppm. $^{13}$C NMR (75 MHz, $CDCl_3$): $\delta$ = 16.9, 17.7 ($CH_3$), 22.1, 22.5, 22.8, 22.9, 27.5, 28.2, 28.8, 29.9 ($CH_2$), 52.3, 52.4 ($OCH_3$), 111.8, 113.1, 119.6, 120.4, 128.3, 129.1, 136.5, 137.3, 141.4, 141.7 (C), 153.4, 155.0 (COH), 171.6, 171.9 (*C*O$OCH_3$) ppm. IR (ATR): $\tilde{\nu}$ = 3014 (w), 2928 (w), 2861 (w), 1652 (m), 1590 (w), 1558 (w), 1427 (m), 1406 (m), 1356 (m), 1315 (m) 1279 (m), 1223 (s), 1195 (m), 1165 (m), 1091 (m), 1079 (m), 1029 (m) cm$^{-1}$. MS (GC-MS, 70 eV): *m*/*z* (%) = 256 [M]$^+$ ([$^{37}$Cl], 7), 254 [M]$^+$ ([$^{35}$Cl], 20), 224 (35), 223 (23), 222 (100). HRMS (EI): calcd. for $C_{13}H_{15}ClO_3$ [M]$^+$ ([$^{35}$Cl]): 254.07042; found 254.070276.

**Methyl 3-Chloro-5-ethyl-2-hydroxy-4,6-dimethylbenzoate (5d):** Compound **5d** was isolated as a yellow solid (0.161 g, 44%) from **3a** (0.442 g, 1.5 mmol), **4d** (0.301 g, 1.5 mmol) and $TiCl_4$ (0.16 mL, 1.5 mmol) in $CH_2Cl_2$ (3 mL); m.p. 49–51 °C. $^1$H NMR (300 MHz, $CDCl_3$): $\delta$ = 1.06 (t, $^3J$ = 7.5 Hz, 3 H, $CH_3$), 2.41 (s, 6 H, $CH_3$), 2.65 (q, $^3J$ = 7.5 Hz, 2 H, $CH_2$), 3.95 (s, 3 H, $OCH_3$), 10.58 (s, 1 H, OH) ppm. $^{13}$C NMR (75 MHz, $CDCl_3$): $\delta$ = 13.6, 17.3, 18.0 ($CH_3$), 23.2 ($CH_2$), 52.4 ($OCH_3$), 113.4, 120.3, 133.9, 135.4, 140.4 (C), 153.9 (COH), 171.6 (*C*O$OCH_3$) ppm. IR (KBr): $\tilde{\nu}$ = 3422 (br., w), 3016 (w), 2972 (m), 2956 (w), 2937 (w), 2875 (w), 1656 (s), 1592 (w), 1552 (w), 1496 (w), 1442 (s), 1406 (w), 1377 (w), 1352 (s), 1321 (m), 1310 (m), 1255 (s), 1226 (s), 1195 (m), 1165 (w), 1081 (m), 1049 (w) cm$^{-1}$. MS (GC-MS, 70 eV): *m*/*z* (%) = 244 [M]$^+$ ([$^{37}$Cl], 9), 242 [M]$^+$ ([$^{35}$Cl], 26), 212 (35), 210 (100), 197 (29), 195 (88). $C_{12}H_{15}ClO_3$ (242.70): calcd. C 59.39, H 6.23; found C 59.09, H 6.40.

**Methyl 3-Chloro-4,6-diethyl-2-hydroxybenzoate (5e):** Compound **5e** was isolated as a yellow oil (0.139 g, 38%) from **3a** (0.442 g, 1.5 mmol), **4e** (0.301 g, 1.5 mmol) and $TiCl_4$ (0.16 mL, 1.5 mmol) in $CH_2Cl_2$ (3 mL). $^1$H NMR (300 MHz, $CDCl_3$): $\delta$ = 1.17 (t, $^3J$ = 7.4 Hz, 3 H, $CH_3$), 1.22 (t, $^3J$ = 7.4 Hz, 3 H, $CH_3$), 2.74 (q, $^3J$ = 7.4 Hz, 2 H, $CH_2$), 2.88 (q, $^3J$ = 7.4 Hz, 2 H, $CH_2$), 3.97 (s, 3 H, $OCH_3$), 6.65 (s, 1 H, CH), 11.81 (s, 1 H, OH) ppm. $^{13}$C NMR (75 MHz, $CDCl_3$): $\delta$ = 13.5, 16.0 ($CH_3$), 27.3, 29.4 ($CH_2$), 52.4 ($OCH_3$), 110.5, 119.5 (C), 121.9 (CH), 145.2, 148.4 (C), 158.1 (COH), 171.8 (*C*O$OCH_3$) ppm. IR (ATR): $\tilde{\nu}$ = 2968 (w), 2935 (w), 2874 (w), 1734 (w), 1658 (s), 1606 (w), 1547 (w), 1435 (m), 1398 (m), 1359 (m), 1310 (m), 1291 (m), 1254 (s), 1202 (s), 1116 (w), 1094 (w), 1068 (m), 1032 (w), 1017 (w) cm$^{-1}$. MS (GC/MS, 70 eV): *m*/*z* (%) = 244 [M]$^+$ ([$^{37}$Cl], 6), 242 [M]$^+$ ([$^{35}$Cl], 17), 212 (33), 210 (100). HRMS (EI): calcd. for $C_{12}H_{15}ClO_3$ [M]$^+$ ([$^{35}$Cl]): 242.07042; found 242.070864.

**Methyl 3,5-Dichloro-2-hydroxy-4,6-dimethylbenzoate (5f):** Compound **5f** was isolated as a colourless solid (0.133 g, 36%) from **3a** (0.442 g, 1.5 mmol), **4f** (0.310 g, 1.5 mmol) and $TiCl_4$ (0.16 mL, 1.5 mmol) in $CH_2Cl_2$ (3 mL); m.p. 67–69 °C. $^1$H NMR (300 MHz, $CDCl_3$): $\delta$ = 2.54 (s, 3 H, $CH_3$), 2.57 (s, 3 H, $CH_3$), 3.98 (s, 3 H, $OCH_3$), 11.16 (s, 1 H, OH) ppm. $^{13}$C NMR (75 MHz, $CDCl_3$): $\delta$ = 19.4, 19.9 ($CH_3$), 52.8 ($OCH_3$), 112.9, 121.0, 127.1, 136.0, 141.0 (C), 155.4 (COH), 171.1 (*C*O$OCH_3$) ppm. IR (KBr): $\tilde{\nu}$ = 2957 (w), 2930 (w), 1704 (s), 1665 (s), 1591 (w), 1439 (s), 1379 (s), 1358 (m), 1283 (s), 1228 (s), 1130 (w), 1070 (w), 1010 (m) cm$^{-1}$. MS (EI, 70 eV): *m*/*z* (%) = 250 [M]$^+$ ([$^{37}$Cl], 15), 248 [M]$^+$ ([$^{35}$Cl], 23), 218 (66), 216 (100). HRMS (EI): calcd. for $C_{10}H_{10}Cl_2O_3$ [M]$^+$ ([$^{35}$Cl]): 248.00015; found 247.999925.

**1-Ethyl 3-Methyl 5-Chloro-4-hydroxy-2,6-dimethylisophthalate (5g):** Compound **5g** was isolated as a light red, viscous oil (0.180 g, 30%) from **4g** (0.150 g, 2.0 mmol), **3a** (0.600 g, 2.26 mmol) and $TiCl_4$ (0.240 mL, 2.2 mmol). $^1$H NMR (250 MHz, $CDCl_3$): $\delta$ = 1.31 (t, $^3J$ = 7.4 Hz, 3 H, $OCH_2CH_3$), 1.36 (t, $^3J$ = 7.6 Hz, 3 H, $OCH_2CH_3$), 2.29 (s, 3 H, $CH_3$), 2.39 (s, 3 H, $CH_3$), 4.31 (q, $^3J$ = 7.6 Hz, 2 H, $OCH_2CH_3$), 4.38 (q, $^3J$ = 7.6 Hz, 2 H, $OCH_2CH_3$), 11.84 (s, 1 H, OH) ppm. $^{13}$C NMR (75 MHz, $CDCl_3$): $\delta$ = 14.0, 14.1 ($OCH_2CH_3$), 18.1, 20.8 ($CH_3$), 61.5, 62.3 ($OCH_2CH_3$), 111.7,

116.9, 129.1, 135.1, 139.0 (C), 158.2 (COH), 169.1, 171.0 (CO) ppm. GC-MS (EI, 70 eV): *m/z* (%) = 300 $[M]^+$ (23), 254 (100), 226 (7), 208 (34), 197 (4), 182 (4), 153 (4), 125 (4), 89 (7). HRMS (EI): calcd. for $C_{14}H_{17}ClO_5$: 300.07590; found 300.07615.

**General Procedure for the Synthesis of Chlorinated Biaryls 7a–f:** $TiCl_4$ (1.0 equiv.) was added dropwise at –78 °C under argon to a $CH_2Cl_2$ solution of a 3-silyloxy-2-en-1-one (**6a**–**f**, 1.0 equiv.) and a 4-chloro-1,3-bis(silyl enol ether) (**3a** or **3b**, 1.0 equiv.). The solution was stirred for 30 min at –78 °C and was then allowed to warm to 20 °C over 18 h. An aqueous solution of HCl (10%) was added to the reaction mixture. The organic layer was separated and the aqueous layer was repeatedly extracted with $CH_2Cl_2$. The combined organic extracts were dried ($Na_2SO_4$) and filtered. The filtrate was concentrated in vacuo and the residue was purified by chromatography (silica gel, *n*-heptane/EtOAc) to gave a biaryl (**7a**–**f**).

**Methyl 4-Chloro-3-hydroxy-5-methylbiphenyl-2-carboxylate (7a):** Compound **7a** was isolated as a white solid (119 mg, 42%) from **6a** (234 mg, 1 mmol), 1,3-bis(silyl enol ether) **3a** (324 mg, 1.1 mmol) and $TiCl_4$ (208 mg, 0.12 mL, 0.58 mmol); m.p. 94–96 °C. $^1$H NMR (250 MHz, $CDCl_3$): $\delta$ = 2.43 (s, 3 H, $CH_3$), 3.49 (s, 3 H, $OCH_3$), 6.75 (s, 1 H, ArH), 7.18–7.21 (m, 2 H, ArH), 7.31–7.37 (m, 3 H, ArH), 11.32 (s, 1 H, OH) ppm. $^{13}$C NMR (62.9 MHz, $CDCl_3$): $\delta$ = 20.7 ($CH_3$), 51.9 ($OCH_3$), 110.8, 121.4 (C), 124.2, 127.0 (CH), 127.4, 128.0 (2 C, CH), 142.0, 142.38, 142.47, 157.0 (C), 171.1 (C=O) ppm. IR (neat): $\tilde{\nu}$ = 3369 (w), 2951 (w), 2918 (w), 1664 (s), 1596 (w), 1435 (s), 1347 (m), 1050 (m), 771 (s) $cm^{-1}$. MS (GC = 70 eV): *m/z* (%) = 278 $[M]^+$ ($[^{37}Cl]$, 7), 276 $[M]^+$ (20), 244 (100), 216 (9), 181 (9), 152 (24). HRMS (EI): calcd. for $C_{15}H_{13}ClO_3$ $[M]^+$ ($[^{35}Cl]$): 276.05477; found 276.054965.

**Ethyl 4-Chloro-3-hydroxy-5-methylbiphenyl-2-carboxylate (7b):** Compound **7b** was isolated as a crystalline solid (112 mg, 41%) from **6b** (234 mg, 1 mmol), 1,3-bis(silyl enol ether) **3b** (330 mg, 1.1 mmol) and $TiCl_4$ (208 mg, 0.12 mL, 0.58 mmol); m.p. 94–96 °C. $^1$H NMR (300 MHz, $CDCl_3$): $\delta$ = 0.74 (t, $J$ = 7.4 Hz, 3 H, $CH_3$), 2.42 (s, 3 H, $CH_3$), 3.95 (q, $J$ = 7.4 Hz, 2 H, $OCH_2$), 6.71 (s, 1 H, ArH), 7.17–7.20 (m, 2 H, ArH), 7.31–7.36 (m, 3 H, ArH), 11.53 (s, 1 H, OH) ppm. $^{13}$C NMR (62.9 MHz, $CDCl_3$): $\delta$ = 12.9 ($CH_3$), 20.7 ($CH_3$), 61.3 ($OCH_2$), 110.8, 121.4 (C), 124.1, 126.8 (CH), 127.6, 128.0 (2 C, CH), 142.32, 142.36, 142.5, 157.2 (C), 170.7 (C=O) ppm. IR (neat): $\tilde{\nu}$ = 3063 (s), 2988 (m), 2921 (m), 2881 (w), 1651 (m), 1599 (m), 1440 (m), 1375 (s), 1266 (s), 1216 (s) $cm^{-1}$. MS (GC = 70 eV): *m/z* (%) = 292 $[M]^+$ ($[^{37}Cl]$, 7), 290 $[M]^+$ ($[^{37}Cl]$, 18), 244 (100), 216 (7), 181 (9), 152 (21). HRMS (EI): calcd. for $C_{16}H_{15}ClO_3$ $[M]^+$ ($[^{35}Cl]$): 290.07042; found 290.070573.

**Ethyl 4-Chloro-4′-fluoro-3-hydroxy-5-methyl[1,1′-biphenyl]-2-carboxylate (7c):** Compound **7c** was isolated as a crystalline solid (59 mg, 48%) from **6c** (101 mg, 0.4 mmol), 1,3-bis(silyl enol ether) **3b** (135 mg, 0.44 mmol) and $TiCl_4$ (0.05 mL, 0.44 mmol); m.p. 140–142 °C. $^1$H NMR (250 MHz, $CDCl_3$): $\delta$ = 0.75 (t, $J$ = 7.1 Hz, 3 H, $CH_3$), 2.35 (s, 3 H, $CH_3$), 3.94 (q, $J$ = 7.0 Hz, 2 H, $OCH_2$), 6.60 (s, 1 H, ArH), 6.94–7.01 (m, 2 H, ArH), 7.06–7.12 (m, 2 H, ArH), 11.53 (s, 1 H, OH) ppm. $^{13}$C NMR (62.9 MHz, $CDCl_3$): $\delta$ = 13.06 ($CH_3$), 20.6 ($CH_3$), 61.4 ($OCH_2$), 110.7 (C), 114.2, 114.6 (CH), 121.7 (C), 124.2, 129.6, 129.7 (CH), 138.3, 141.3, 142.4, 157.4, 160.1 (C), 170.5 (C=O) ppm. IR (neat): $\tilde{\nu}$ = 3076 (w), 2917 (s), 2837 (m), 1656 (m), 1602 (s), 1504 (m), 1453 (m), 1375 (s), 1221 (m), 1155 (s), 777 (m) $cm^{-1}$. MS (GC = 70 eV): *m/z* (%) = 310 $[M]^+$ ($[^{37}Cl]$, 6), 308 $[M]^+$ (19), 262 (100), 234 (9), 199 (9), 170 (22). HRMS (EI): calcd. for $C_{16}H_{14}ClFO_3$ $[M]^+$ ($[^{35}Cl]$): 308.06100; found 308.060716.

**Ethyl 2′,4-Dichloro-3-hydroxy-5-methyl[1,1′-biphenyl]-2-carboxylate (7d):** Compound **7d** was isolated as a crystalline solid (85 mg, 49%) from **6d** (140 mg, 0.53 mmol), 1,3-bis(silyl enol ether) **3b** (179 mg, 0.58 mmol) and $TiCl_4$ (0.06 mL, 0.58 mmol); m.p. 85–88 °C. $^1$H NMR (250 MHz, $CDCl_3$): $\delta$ = 0.69 (t, $J$ = 7.4 Hz, 3 H, $CH_3$), 2.35 (s, 3 H, $CH_3$), 3.92 (q, $J$ = 7.4 Hz, 2 H, $OCH_2$), 6.54 (s, 1 H, ArH), 7.07–7.11 (m, 1 H, ArH), 7.18–7.20 (m, 2 H, ArH), 7.21–7.32 (m, 1 H, ArH), 11.90 (s, 1 H, OH) ppm. $^{13}$C NMR (62.9 MHz, $CDCl_3$): $\delta$ = 12.8 ($CH_3$), 20.7 ($CH_3$), 61.5 ($OCH_2$), 110.8, 112.2 (C), 123.8, 126.2,128.3, 128.6, 129.6 (CH), 132.3, 139.1, 141.3, 142.9, 157.7 (C), 170.3 (C=O) ppm. IR (neat): $\tilde{\nu}$ = 3305 (br), 2986 (m), 2855 (w), 1731 (w), 1651 (s), 1435 (w), 1374 (s), 1214 (s), 1011 (m), 753 (s) $cm^{-1}$. MS (GC = 70 eV): *m/z* (%) = 326 $[M]^+$ ($[^{37}Cl]$, 2), 324 $[M]^+$ (4), 289 (98), 280 (65), 278 (100), 261 (67). HRMS (EI): calcd. for $C_{16}H_{14}Cl_2O_3$ $[M]^+$ ($[^{35}Cl]$): 324.03145; found 324.030996.

**Ethyl 4-Chloro-3-hydroxy-2′,5-dimethyl[1,1′-biphenyl]-2-carboxylate (7e):** Compound **7e** was isolated as a crystalline solid (120 mg, 40%) from **6e** (248 mg, 1 mmol), 1,3-bis(silyl enol ether) **3b** (339 mg, 1.1 mmol) and $TiCl_4$ (0.12 mL, 1.1 mmol); m.p. 77–79 °C. $^1$H NMR (250 MHz, $CDCl_3$): $\delta$ = 0.69 (t, $J$ = 7.4 Hz, 3 H, $CH_3$), 1.95 (s, 3 H, $CH_3$), 2.34 (s, 3 H, $CH_3$), 3.87 (q, $J$ = 7.4 Hz, 2 H, $OCH_2$), 6.53 (s, 1 H, ArH), 6.90–6.94 (m, 1 H, ArH), 7.07–7.10 (m, 2 H, ArH), 7.15–7.21 (m, 1 H, ArH), 11.85 (s, 1 H, OH) ppm. $^{13}$C NMR (62.9 MHz, $CDCl_3$): $\delta$ = 12.8 ($CH_3$), 19.9 ($CH_3$), 20.7 ($CH_3$), 61.3 ($OCH_2$), 110.7, 121.3 (C), 123.7, 125.0, 127.0, 128.4, 129.1 (CH), 134.9, 141.9, 142.2, 142.8, 157.7 (C), 170.7 (C=O) ppm. IR (neat): $\tilde{\nu}$ = 2985 (w), 2922 (m), 2853 (w), 1650 (s), 1600 (m), 1373 (s), 1294 (s), 1213 (m), 727 (s) $cm^{-1}$. MS (GC = 70 eV): *m/z* (%) = 306 $[M]^+$ ($[^{37}Cl]$, 4), 304 $[M]^+$ (13), 260 (35), 258 (100), 195 (21), 165 (24). HRMS (EI): calcd. for $C_{17}H_{17}ClO_3$ $[M]^+$ ($[^{35}Cl]$): 304.08607; found 304.0086736.

**Ethyl 4-Chloro-2′-fluoro-3-hydroxy-5-methyl[1,1′-biphenyl]-2-carboxylate (7f):** Compound **7f** was isolated as a crystalline solid (390 mg, 45%) from **6f** (720 mg, 2.85 mmol), 1,3-bis(silyl enol ether) **3b** (970 mg, 3.14 mmol) and $TiCl_4$ (0.34 mL, 3.14 mmol); m.p. 76–79 °C. $^1$H NMR (250 MHz, $CDCl_3$): $\delta$ = 0.75 (t, $J$ = 6.5 Hz, 3 H, $CH_3$), 2.34 (s, 3 H, $CH_3$), 3.96 (q, $J$ = 7.0 Hz, 2 H, $OCH_2$), 6.60 (s, 1 H, ArH), 6.91–6.98 (m, 1 H, ArH), 7.06–7.11 (m, 2 H, ArH), 7.22 (m, 1 H, ArH), 11.53 (s, 1 H, OH) ppm. $^{13}$C NMR (62.9 MHz, $CDCl_3$): $\delta$ = 13.0 ($CH_3$), 20.7 ($CH_3$), 61.5 ($OCH_2$), 111.0 (C), 114.4, 114.8 (CH), 122.3 (C), 123.7, 124.4, 129.0 (CH), 135.4, 142.9, 142.4, 157.7, 161.0 (C), 170.5 (C=O) ppm. IR (neat): $\tilde{\nu}$ = 3040 (w), 2979 (m), 1657 (m), 1604 (m), 1495 (m), 1440 (m), 1374 (s), 1260 (s), 1215 (s), 759 (s) $cm^{-1}$. MS (GC = 70 eV): *m/z* (%) = 310 $[M]^+$ ($[^{37}Cl]$, 8), 308 $[M]^+$ (24), 262 (100), 234 (12), 199 (11), 170 (24). HRMS (EI): calcd. for $C_{16}H_{14}ClFO_3$ $[M]^+$ ($[^{35}Cl]$): 308.06100; found 308.060555.

**General Procedure for the Synthesis of 3-Chlorosalicylates 9a–c:** $TiCl_4$ (1.0 equiv.) was added at –78 °C to a 1-methoxy-1-en-3-one (**8a**–**c**, 1.0 equiv.) and a diene (**3a** or **3b**, 1.0 equiv.) in dichloromethane (2.5 mL per 1 mmol of **8**). The solution was allowed to warm slowly to 20 °C with stirring. Hydrochloric acid (10%) was added to the solution and the organic and the aqueous layers were separated. The latter was extracted with dichloromethane. The combined organic layers were dried (sodium sulfate) and filtered, and the filtrate was concentrated in vacuo. The residue was purified by chromatography (silica gel, heptanes/EtOAc 20:1).

**Methyl 3-Chloro-2-hydroxy-6-methylbenzoate (9a):** Compound **9a** was isolated as an orange oil (0.050 g, 25%) from **3a** (0.295 g, 1.0 mmol) in $CH_2Cl_2$ (2 mL), **8a** (0.100 g, 1.0 mmol) and $TiCl_4$ (0.11 mL, 1.0 mmol). $^1$H NMR (300 MHz, $CDCl_3$): $\delta$ = 2.50 (s, 3 H, $CH_3$), 3.98 (s, 3 H, $OCH_3$), 6.66 (dd, $^2J$ = 0.8, $^3J$ = 8.2 Hz, 1 H, CH), 7.36 (d, $J$ = 8.2 Hz, 1 H, CH), 11.83 (d, $^4J$ = 0.5 Hz, 1 H,

OH) ppm. $^{13}$C NMR (75 MHz, $CDCl_3$): $\delta$ = 23.7 ($CH_3$), 52.5 ($OCH_3$), 113.5, 120.0 (C), 122.8, 134.2 (CH), 140.0 (C), 158.1 (COH), 171.9 (*C*$OOCH_3$) ppm. IR (KBr): $\tilde{\nu}$ = 3018 (w), 2957 (m), 2928 (m), 2852 (w), 1665 (s), 1601 (m), 1567 (w), 1453 (s), 1417 (s), 1350 (s), 1299 (s), 1256 (s), 1205 (s), 1156 (m), 1122 (w) cm$^{-1}$. MS (GC/MS, 70 eV): *m*/*z* (%) = 202 [M]$^+$ ([$^{37}$Cl], 9), 200 [M]$^+$ ([$^{35}$Cl], 28), 170 (34), 169 (23), 168 (100). HRMS (EI): calcd. for $C_9H_9ClO_3$ [M]$^+$ ([$^{35}$Cl]): 200.02347; found 200.023426.

**Ethyl 3-Chloro-6-(4-chlorophenyl)-5-cyano-2-hydroxybenzoate (9b):** Compound **9b** was isolated as a yellow solid (0.134 g, 40%) from **3b** (0.400 g, 1.3 mmol) in $CH_2Cl_2$ (2 mL), **8b** (0.235 g, 1.0 mmol) and $TiCl_4$ (0.11 mL, 1.0 mmol); m.p. 116–118 °C. $^1$H NMR ($CDCl_3$, 300 MHz): $\delta$ = 0.80 (t, $^3J$ = 7.2 Hz, 3 H, $OCH_2CH_3$), 4.03 (q, $^3J$ = 7.2 Hz, 2 H, $OCH_2CH_3$), 7.15–7.17, 7.41–7.44 (m, 4 H, CH), 7.83 (s, 1 H, CH), 12.16 (s, 1 H, OH) ppm. $^{13}$C NMR ($CDCl_3$, 75 MHz): $\delta$ = 12.9 ($OCH_2CH_3$) 62.7 ($OCH_2CH_3$), 105.9, 114.3 (C), 123.4 (C≡N), 128.5, 129.5 (CH), 134.8, 136.5 (C), 136.9, 146.3, (CH), 160.9 (COH), 169.3 (C=O) ppm. IR (ATR): $\tilde{\nu}$ = 3074 (w), 2995 (w), 2977 (w), 2935 (w), 2227 (s), 1731 (w), 1658 (s), 1651 (s), 1598 (w), 1574 (w), 1556 (w), 1495 (s), 1471 (w), 1442 (m), 1397 (s), 1373 (s), 1326 (w), 1306 (w), 1245 (w), 1220 (m), 1195 (m), 1114 (w), 1091 (s), 1013 (s) cm$^{-1}$. MS (EI, 70 eV): *m*/*z* (%) = 339 [M]$^+$ ([$^{37}$Cl] [$^{37}$Cl], 3), 337 [M]$^+$ ([$^{37}$Cl] [$^{35}$Cl], [$^{35}$Cl] [$^{37}$Cl], 16), 335 [M]$^+$ ([$^{35}$Cl] [$^{35}$Cl], 25), 293 (13), 292 (13), 291 (68), 290 (20), 289 (100), 198 (22). HRMS (EI): calcd. for $C_{16}H_{11}O_3NCl_2$ ([M]$^+$, $^{35}$Cl) 335.01105; found 335.011032.

**Ethyl 3-Chloro-5-cyano-2-hydroxy-6-methylbenzoate (9c):** Compound **9c** was isolated as a yellow crystalline solid (0.092 g, 38%) from **3b** (0.400 g, 1.3 mmol) in $CH_2Cl_2$ (2 mL), **8c** (0.139 g, 1.0 mmol) and $TiCl_4$ (0.11 mL, 1.0 mmol); m.p. 111–113 °C. $^1$H NMR ($CDCl_3$, 300 MHz): $\delta$ = 1.46 (t, $^3J$ = 7.2 Hz, 3 H, $OCH_2CH_3$), 2.76 (s, 3 H, $CH_3$), 4.51 (q, $^3J$ = 7.0 Hz, 2 H, $OCH_2CH_3$), 7.73 (s, 1 H, CH), 12.43 (s, 1 H, OH) ppm. $^{13}$C NMR ($CDCl_3$, 75 MHz): $\delta$ = 14.0 ($OCH_2CH_3$) 21.6 ($CH_3$), 62.3 ($OCH_2CH_3$), 106.0, 114.6, 117.2 (C), 121.5 (C≡N), 137.1 (CH), 144.6 (C), 161.6 (COH), 170.4 (C=O) ppm. IR (ATR): $\tilde{\nu}$ = 3060 (m), 2984 (w), 2941 (w), 2742 (w), 2560 (w), 2226 (s), 1861 (w), 1731 (w), 1652 (s), 1591 (w), 1562 (m), 1474 (w), 1434 (s), 1398 (m), 1374 (s), 1336 (w), 1313 (w), 1301 (w), 1232 (s), 1205 (m), 1182 (w), 1112 (w), 1098 (w), 1060 (w), 1033 (w), 1003 (s) cm$^{-1}$. MS (EI, 70 eV): *m*/*z* (%) = 241 [M]$^+$ ([$^{37}$Cl], 6), 239 [M]$^+$ ([$^{35}$Cl], 17), 195 (31), 194 (21), 193 (100). HRMS (EI): calcd. for $C_{11}H_{10}O_3NCl$ ([M]$^+$, $^{35}$Cl) 239.03437; found 239.034019.

**General Procedure for the Synthesis of 3-Chloro-6-(methylthio)salicylates 11a–i:** $TiCl_4$ (1.0 equiv.) was added at –78 °C to a 1,1-bis-(methylthio)-1-en-3-one **10** (1.0 equiv.) and the 4-chloro-1,3-bis-(trimethylsilyloxy)buta-1,3-diene **3b** (1.3 equiv.) in dichloromethane (2.5 mL per 1 mmol of **10**). The solution was allowed to warm slowly to 20 °C with stirring. Hydrochloric acid (10%) was added to the solution and the organic and the aqueous layers were separated. The latter was extracted with dichloromethane. The combined organic layers were dried (sodium sulfate) and filtered, and the filtrate was concentrated in vacuo. The residue was purified by chromatography (silica gel, heptanes/EtOAc 10:1).

**Ethyl 3-Chloro-2-hydroxy-6-(methylthio)-4-phenylbenzoate (11a):** Compound **11a** was isolated as a yellow crystalline solid (0.308 g, 96%) from **3b** (0.400 g, 1.3 mmol) in $CH_2Cl_2$ (2 mL), **10a** (0.224 g, 1.0 mmol) and $TiCl_4$ (0.11 mL, 1.0 mmol); m.p. 76–77 °C. $^1$H NMR ($CDCl_3$, 250 MHz): $\delta$ = 1.50 (t, $^3J$ = 7.1 Hz, 3 H, $OCH_2CH_3$), 2.40 (s, 3 H, $SCH_3$), 4.53 (q, $^3J$ = 7.1 Hz, 2 H, $OCH_2CH_3$), 6.63 (s, 1 H, CH), 7.44 (s, 5 H, CH), 12.29 (s, 1 H, OH) ppm. $^{13}$C NMR ($CDCl_3$, 63 MHz): $\delta$ = 14.2 ($OCH_2CH_3$), 16.4 ($SCH_3$), 62.7 ($CH_2CH_3$), 110.1 (C), 116.9 (CH), 117.1 (C), 128.2, 128.3, 129.0 (CH), 138.7, 142.1, 145.8 (C), 159.3 (COH), 170.4 (C=O) ppm. IR (ATR): $\tilde{\nu}$ = 3057 (w), 2980 (w), 2918 (w), 1653 (s), 1587 (m), 1529 (m), 1495 (m), 1473 (w), 1443 (m), 1373 (s), 1342 (m), 1309 (m), 1278 (s), 1242 (s), 1187 (s), 1145 (s), 1111 (w), 1055 (m), 1011 (s) cm$^{-1}$. MS (EI, 70 eV): *m*/*z* (%) = 324 [M]$^+$ ([$^{37}$Cl], 13), 322 [M]$^+$ ([$^{35}$Cl], 32), 278 (39), 277 (23), 276 (100), 233 (15). HRMS (EI): calcd. for $C_{16}H_{15}O_3ClS$ ([M]$^+$, $^{35}$Cl) 322.04249; found 322.042502.

**Ethyl 3-Chloro-2-hydroxy-4-(4-methylphenyl)-6-(methylthio)benzoate (11b):** Compound **11b** was isolated as a yellow solid (0.211 g, 89%) from **3b** (0.400 g, 1.3 mmol) in $CH_2Cl_2$ (2 mL), **10b** (0.283 g, 1.0 mmol) and $TiCl_4$ (0.11 mL, 1.0 mmol); m.p. 103–105 °C. $^1$H NMR ($CDCl_3$, 250 MHz): $\delta$ = 1.50 (t, $^3J$ = 7.1 Hz, 3 H, $OCH_2CH_3$), 2.39 (s, 3 H, $CH_3$), 2.41 (s, 3 H, $SCH_3$), 4.53 (q, $^3J$ = 7.1 Hz, 2 H, $OCH_2CH_3$), 6.62 (s, 1 H, CH), 7.28–7.36 (m, 4 H, CH), 12.29 (s, 1 H, OH) ppm. $^{13}$C NMR ($CDCl_3$, 63 MHz): $\delta$ = 14.2 ($OCH_2CH_3$), 16.4 ($SCH_3$), 21.3 ($CH_3$), 62.7 ($OCH_2CH_3$), 109.9, 116.9 (C), 117.1, 128.2, 128.3. 129.0 (CH), 135.8, 138.3, 142.0, 145.8 (C), 159.3 (COH), 170.4 (C=O) ppm. IR (ATR): $\tilde{\nu}$ = 3296 (w), 2992 (w), 2967 (w), 2916 (w), 2866 (w), 1648 (s), 1609 (w), 1584 (m), 1546 (w), 1473 (m), 1447 (m), 1407 (w), 1395 (m), 1372 (s), 1341 (m), 1307 (m), 1279 (s), 1241 (s), 1202 (w), 1188 (m), 1147 (m), 1106 (m), 1040 (w), 1008 (s) cm$^{-1}$. MS (EI, 70 eV): *m*/*z* (%) = 338 [M]$^+$ ([$^{37}$Cl], 13), 336 [M]$^+$ ([$^{35}$Cl], 32), 292 (39), 291 (23), 290 (100), 247 (12). HRMS (EI): calcd. for $C_{17}H_{17}O_3ClS$ ([M]$^+$, $^{35}$Cl) 336.057884; found 336.05814. Elemental analysis calcd. (%) for $C_{17}H_{17}ClO_3S$ (336.83): C 60.62, H 5.09, S 9.52; found C 60.69, H 5.43, S 9.62.

**Ethyl 3-Chloro-4-(4-fluorophenyl)-2-hydroxy-6-(methylthio)benzoate (11c):** Compound **11c** was isolated as a yellow solid (0.201 g, 83%) from **3b** (0.400 g, 1.3 mmol) in $CH_2Cl_2$ (2 mL), **10c** (0.242 g, 1.0 mmol) and $TiCl_4$ (0.11 mL, 1.0 mmol); m.p. 94–96 °C. $^1$H NMR ($CDCl_3$, 300 MHz): $\delta$ = 1.44 (t, $^3J$ = 7.2 Hz, 3 H, $OCH_2CH_3$), 2.34 (s, 3 H, $SCH_3$), 4.47 (q, $^3J$ = 7.2 Hz, 2 H, $OCH_2CH_3$), 6.54 (s, 1 H, CH), 7.05–7.11, 7.33–7.38 (m, 4 H, CH), 12.24 (s, 1 H, OH) ppm. $^{13}$C NMR ($CDCl_3$, 75 MHz): $\delta$ = 14.2 ($OCH_2CH_3$), 16.5 ($SCH_3$), 62.8 ($CH_2CH_3$), 110.2 (C), 115.1, 115.4, 117.0, 130.8, 130.9 (CH), 134.7 (d, $J_{C,F}$ = 3.3 Hz, 1 C), 142.3, 144.7 (C), 159.4 (COH), 161.1, 164.4 (C), 170.3 (C=O) ppm. $^{19}$F NMR ($CDCl_3$, 235 MHz): $\delta$ = –113.13 (CF) ppm. IR (ATR): $\tilde{\nu}$ = 3075 (w), 3042 (w), 2993 (w), 2916 (w), 2656 (w), 2622 (w), 1892 (w), 1645 (s), 1589 (s), 1531 (m), 1505 (s), 1481 (w), 1449 (m), 1412 (m), 1397 (m), 1372 (s), 1340 (m), 1307 (w), 1298 (w), 1278 (s), 1246 (m), 1228 (w), 1215 (w), 1196 (w), 1160 (w), 1151 (m), 1110 (w), 1101 (m), 1012 (s) cm$^{-1}$. MS (EI, 70 eV): *m*/*z* (%) = 342 [M]$^+$ ([$^{37}$Cl], 12), 340 [M]$^+$ ([$^{35}$Cl], 31), 296 (39), 295 (22), 294 (100), 251 (16). HRMS (EI): calcd. for $C_{16}H_{14}O_3ClFS$ ([M]$^+$, $^{35}$Cl) 340.032595; found 340.03307.

**Ethyl 3-Chloro-2-hydroxy-4-(4-methoxyphenyl)-6-(methylthio)benzoate (11d):** Compound **11d** was isolated as a yellow solid (0.156 g, 44%) from **3b** (0.400 g, 1.3 mmol) in $CH_2Cl_2$ (2 mL), **10d** (0.254 g, 1.0 mmol) and $TiCl_4$ (0.11 mL, 1.0 mmol); m.p. 97–98 °C. $^1$H NMR ($CDCl_3$, 300 MHz): $\delta$ = 1.49 (t, $^3J$ = 7.1 Hz, 3 H, $OCH_2CH_3$), 2.40 (s, 3 H, $SCH_3$), 3.86 (s, 3 H, $OCH_3$), 4.53 (q, $^3J$ = 7.1 Hz, 2 H, $OCH_2CH_3$), 6.62 (s, 1 H, CH), 6.96–7.00, 7.39–7.41 (m, 4 H, CH), 12.29 (s, 1 H, OH) ppm. $^{13}$C NMR ($CDCl_3$, 75 MHz): $\delta$ = 14.2 ($OCH_2CH_3$), 16.4 ($SCH_3$), 55.3 ($OCH_3$), 62.7 ($CH_2CH_3$), 109.8 (C), 113.6 (CH), 113.9 (C), 117.1, 128.3, 130.4 (CH), 131.0 (C), 131.2 (CH), 142.0, 145.4 (C), 159.4 (COH), 159.7 (C), 170.4 (C=O) ppm. IR (ATR): $\tilde{\nu}$ = 3076 (w), 3039 (w), 2999 (w), 2982 (w), 2938 (w), 2921 (w), 2842 (w), 2050 (w), 2023 (w),

1873 (w), 1731 (w), 1694 (w), 1646 (s), 1591 (s), 1508 (s), 1484 (w), 1463 (w), 1454 (w), 1440 (w), 1416 (w), 1401 (w), 1385 (w), 1369 (s), 1347 (m), 1306 (m), 1286 (s), 1244 (s), 1201 (w), 1180 (m), 1151 (w), 1124 (w), 1104 (m), 1054 (w), 1026 (w), 1015 (w) $cm^{-1}$. MS (EI, 70 eV): *m*/*z* (%) = 354 $[M]^+$ ($[^{37}Cl]$, 27), 352 $[M]^+$ ($[^{35}Cl]$, 74), 318 (17), 309 (17), 308 (80), 307 (53), 306 (100). HRMS (EI): calcd. for $C_{17}H_{17}O_4ClS$ ($[M]^+$, $^{35}Cl$) 352.05306; found 352.052915. Elemental analysis calcd. (%) for $C_{17}H_{17}ClO_4S$ (352.05): C 57.87, H 4.86, S 9.09; found C 58.17, H 5.10, S 9.36.

**Ethyl 4-Biphenylyl-3-chloro-2-hydroxy-6-(methylthio)benzoate (11e):** Compound **11e** was isolated as a yellow solid (0.203 g, 51%) from **3b** (0.400 g, 1.3 mmol) in $CH_2Cl_2$ (2 mL), **10e** (0.300 g, 1.0 mmol) and $TiCl_4$ (0.11 mL, 1.0 mmol); m.p. 155–157 °C. $^1H$ NMR ($CDCl_3$, 300 MHz): $\delta$ = 1.51 (t, $^3J$ = 7.0 Hz, 3 H, $OCH_2CH_3$), 2.42 (s, 3 H, $SCH_3$), 4.54 (q, $^3J$ = 7.0 Hz, 2 H, $OCH_2CH_3$), 6.68 (s, 1 H, CH), 7.34–7.40, 7.44–7.49, 7.52–7.55, 7.63–7.77 (m, 9 H, CH), 12.32 (s, 1 H, OH) ppm. $^{13}C$ NMR ($CDCl_3$, 75 MHz): $\delta$ = 14.2 ($OCH_2CH_3$), 16.5 ($SCH_3$), 62.8 ($CH_2CH_3$), 110.1, 116.9 (C), 117.1, 126.9, 127.1, 127.6, 128.8, 129.5 (CH), 137.6, 140.5, 141.3, 142.2, 145.4 (C), 159.4 (COH), 170.4 (C=O) ppm. IR (ATR): $\tilde{\nu}$ = 3031 (w), 2981 (w), 2961 (w), 2920 (w), 2853 (w), 1731 (w), 1705 (w), 1650 (s), 1583 (m), 1557 (w), 1516 (m), 1488 (s), 1471 (w), 1452 (w), 1434 (w), 1398 (m), 1373 (s), 1341 (m), 1306 (m), 1275 (m), 1245 (m), 1197 (w), 1181 (m), 1149 (m), 1108 (w), 1006 (s) $cm^{-1}$. MS (EI, 70 eV): *m*/*z* (%) = 400 $[M]^+$ ($[^{37}Cl]$, 27), 398 $[M]^+$ ($[^{35}Cl]$, 77), 355 (17), 354 (80), 353 (50), 352 (100), 309 (13). HRMS (EI): calcd. for $C_{22}H_{19}O_3ClS$ ($[M]^+$, $^{35}Cl$) 398.07379; found 398.072845. Elemental analysis calcd. (%) for $C_{22}H_{19}O_3ClS$ (398.90): C 66.24, H 4.80; found C 65.87, H 5.16.

**Ethyl 3-Chloro-4-(4-ethylphenyl)-2-hydroxy-6-(methylthio)benzoate (11f):** Compound **11f** was isolated as a yellow solid (0.132 g, 53%) from **3b** (0.400 g, 1.3 mmol) in $CH_2Cl_2$ (2 mL), **10f** (0.252 g, 1.0 mmol) and $TiCl_4$ (0.11 mL, 1.0 mmol); m.p. 94–96 °C. $^1H$ NMR ($CDCl_3$, 300 MHz): $\delta$ = 1.29 (t, $^3J$ = 7.6 Hz, 3 H, $CH_2CH_3$), 1.50 (t, $^3J$ = 7.2 Hz, 3 H, $OCH_2CH_3$), 2.39 (s, 3 H, $SCH_3$), 2.67–2.75 (m, 2 H, $CH_2CH_3$), 4.53 (q, $^3J$ = 7.2 Hz, 2 H, $OCH_2CH_3$), 6.63 (s, 1 H, CH), 7.27–7.30, 7.36–7.39 (m, 4 H, CH), 12.29 (s, 1 H, OH) ppm. $^{13}C$ NMR ($CDCl_3$, 75 MHz): $\delta$ = 14.2 ($OCH_2CH_3$) 15.4 ($CH_2CH_3$), 16.5 ($SCH_3$), 28.6 ($CH_2CH_3$), 62.7 ($OCH_2CH_3$), 109.9 (C), 117.2 (CH), 126.5 (C), 127.7, 129.0 (CH), 136.1, 142.0, 144.6, 145.8 (C), 159.3 (COH), 170.4 (C=O) ppm. IR (ATR): $\tilde{\nu}$ = 3049 (w), 2997 (w), 2960 (w), 2926 (w), 2874 (w), 1902 (w), 1645 (s), 1609 (w), 1587 (w), 1565 (w), 1526 (w), 1509 (s), 1469 (w), 1437 (w), 1421 (m), 1396 (m), 1371 (s), 1342 (m), 1311 (m), 1284 (s), 1246 (s), 1187 (s), 1152 (m), 1123 (w), 1096 (m), 1052 (m), 1016 (s) $cm^{-1}$. MS (EI, 70 eV): *m*/*z* (%) = 352 $[M]^+$ ($[^{37}Cl]$, 21), 350 $[M]^+$ ($[^{35}Cl]$, 65), 307 (13), 306 (74), 305 (39), 304 (100), 276 (11), 261 (16), 44 (20). HRMS (EI): calcd. for $C_{18}H_{19}O_3ClS$ ($[M]^+$, $^{35}Cl$) 350.07379; found 350.073428.

**Ethyl 3-Chloro-4-(4-chlorophenyl)-2-hydroxy-6-(methylthio)benzoate (11g):** Compound **11g** was isolated as a yellow solid (0.139 g, 54%) from **3b** (0.400 g, 1.3 mmol) in $CH_2Cl_2$ (2 mL), **10g** (0.258 g, 1.0 mmol) and $TiCl_4$ (0.11 mL, 1.0 mmol); m.p. 150–153 °C. $^1H$ NMR ($CDCl_3$, 300 MHz): $\delta$ = 1.50 (t, $^3J$ = 7.2 Hz, 3 H, $OCH_2CH_3$), 2.39 (s, 3 H, $SCH_3$), 4.53 (q, $^3J$ = 7.2 Hz, 2 H, $OCH_2CH_3$), 6.58 (s, 1 H, CH), 7.36–7.44 (m, 4 H, CH), 12.29 (s, 1 H, OH) ppm. $^{13}C$ NMR ($CDCl_3$, 75 MHz): $\delta$ = 14.2 ($OCH_2CH_3$), 16.4 ($SCH_3$), 62.8 ($OCH_2CH_3$), 110.3 (C), 116.8, 128.5, 130.4 (CH), 134.5, 137.5, 142.4, 144.5 (C), 159.4 (COH), 170.3 (C=O) ppm. IR (ATR): $\tilde{\nu}$ = 2995 (w), 2924 (w), 2850 (w), 1900 (w), 1699 (w), 1640 (s), 1613 (w), 1591 (m), 1564 (w), 1557 (w), 1524 (w), 1488 (s), 1437 (w), 1417(w), 1398 (m), 1372 (s), 1342 (m), 1310 (m), 1281 (m), 1247 (m), 1201 (w), 1188 (w), 1152 (m), 1126 (w), 1086 (m), 1048 (m), 1012 (s) $cm^{-1}$. MS (EI, 70 eV): *m*/*z* (%) = 360 $[M]^+$ ($[^{37}Cl]$ $[^{37}Cl]$, 5), 358 $[M]^+$ ($[^{37}Cl]$ $[^{35}Cl]$,$[^{35}Cl]$ $[^{37}Cl]$, 22), 356 $[M]^+$ ($[^{35}Cl]$ $[^{35}Cl]$, 30), 314 (16), 313 (15), 312 (72), 311 (22), 310 (100), 267 (15). HRMS (EI): calcd. for $C_{16}H_{14}O_3Cl_2S$ ($[M]^+$, $^{35}Cl$) 356.00352; found 356.002785. Elemental analysis calcd. (%) for $C_{16}H_{14}O_3Cl_2S$ (357.25): C 53.79, H 3.95; found C 53.14, H 4.13.

**Ethyl 4-(4-Bromophenyl)-3-chloro-2-hydroxy-6-(methylthio)benzoate (11h):** Compound **11h** was isolated as a yellow solid (0.202 g, 67%) from **3b** (0.400 g, 1.3 mmol) in $CH_2Cl_2$ (2 mL), **10h** (0.302 g, 1.0 mmol) and $TiCl_4$ (0.11 mL, 1.0 mmol); m.p. 159–161 °C. $^1H$ NMR ($CDCl_3$, 300 MHz): $\delta$ = 1.50 (t, $^3J$ = 7.2 Hz, 3 H, $OCH_2CH_3$), 2.39 (s, 3 H, $SCH_3$), 4.53 (q, $^3J$ = 7.0 Hz, 2 H, $OCH_2CH_3$), 6.60 (s, 1 H, CH), 7.29–7.33, 7.56–7.60 (m, 4 H, CH), 12.29 (s, 1 H, OH) ppm. $^{13}C$ NMR ($CDCl_3$, 75 MHz): $\delta$ = 14.2 ($OCH_2CH_3$), 16.4 ($SCH_3$), 62.8 ($OCH_2CH_3$), 110.3 (C), 116.7, 122.7, 127.8, 130.3, 130.7 (CH), 131.4, 132.0, 137.5, 142.4, 144.5 (C), 159.4 (COH), 170.3 (C=O) ppm. IR (ATR): $\tilde{\nu}$ = 2990 (w), 2923 (w), 2863 (w), 1731 (w), 1704 (w), 1646 (s), 1587 (s), 1520 (w), 1486 (s), 1435 (w), 1417 (w), 1397 (s), 1370 (s), 1341 (m), 1309 (m), 1281 (m), 1247 (m), 1201 (w), 1187 (w), 1150 (m), 1126 (w), 1098 (m), 1068 (w), 1047 (m), 1008 (s) $cm^{-1}$. MS (EI, 70 eV): *m*/*z* (%) = 404 $[M]^+$ ($[^{37}Cl]$ $[^{81}Br]$, 14), 402 $[M]^+$ ($[^{37}Cl]$ $[^{79}Br]$, $[^{35}Cl]$ $[^{81}Br]$, 59), 400 $[M]^+$ ($[^{35}Cl]$ $[^{79}Br]$, 40), 358 (54), 357 (34), 356 (100), 255 (25), 354 (91), 313 (18) 311 (14). HRMS (EI): calcd. for $C_{16}H_{14}O_3BrClS$ ($[M]^+$, $^{35}Cl$, $^{79}Br$) 399.95301; found 399.953090. Elemental analysis calcd. (%) for $C_{16}H_{14}O_3ClBrS$ (401.70): C 47.84, H 3.51; found C 47.54, H 3.57.

**Ethyl 3-Chloro-2-hydroxy-4-methyl-6-(methylthio)benzoate (11i):** Compound **11i** was isolated as a yellow solid (0.148 g, 91%) from **3b** (0.400 g, 1.3 mmol) in $CH_2Cl_2$ (2 mL), **10i** (0.162 g, 1.0 mmol) and $TiCl_4$ (0.11 mL, 1.0 mmol); m.p. 78–80 °C. $^1H$ NMR ($CDCl_3$, 300 MHz): $\delta$ = 1.46 (t, $^3J$ = 7.2 Hz, 3 H, $OCH_2CH_3$), 2.40 (s, 3 H, $CH_3$), 2.41 (s, 3 H, $SCH_3$), 4.47 (q, $^3J$ = 7.2 Hz, 2 H, $OCH_2CH_3$), 6.54 (s, 1 H, CH), 12.17 (s, 1 H, OH) ppm. $^{13}C$ NMR ($CDCl_3$, 75 MHz): $\delta$ = 14.2 ($OCH_2CH_3$) 16.4 ($SCH_3$), 21.1 ($CH_3$), 62.5 ($OCH_2CH_3$), 109.1 (C), 116.7 (CH), 118.3, 141.6, 142.7 (C), 158.9 (COH), 170.4 (C=O) ppm. IR (ATR): $\tilde{\nu}$ = 2984 (w), 2960 (w), 2919 (w), 2859 (w), 1731 (w), 1709 (w), 1650 (s), 1591 (s), 1537 (w), 1463 (w), 1443 (w), 1426 (w), 1395 (m), 1371 (s), 1341 (m), 1314 (m), 1286 (m), 1241 (s), 1190 (s), 1131 (w), 1105 (w), 1055 (m), 1017 (m) $cm^{-1}$. MS (EI, 70 eV): *m*/*z* (%) = 262 $[M]^+$ ($[^{37}Cl]$, 11), 260 $[M]^+$ ($[^{35}Cl]$, 29), 216 (40), 215 (18), 214 (100), 171 (19). HRMS (EI): calcd. for $C_{11}H_{13}O_3ClS$ ($[M]^+$, $^{35}Cl$) 260.02684; found 260.026278.

**General Procedure for the Synthesis of 3-Chloro-4-methoxysalicylates 13a–j:** $TiCl_4$ (1.0 equiv.) was added at –78 °C to a 3-oxo orthoester **12** (1.0 equiv.) and diene **3b** (1.3 equiv.) in dichloromethane (2.5 mL per 1 mmol of **12**). The solution was allowed to warm slowly to 20 °C with stirring. Hydrochloric acid (10%) was added to the solution and the organic and the aqueous layers were separated. The latter was extracted with dichloromethane. The combined organic layers were dried (sodium sulfate) and filtered and the filtrate was concentrated in vacuo. The residue was purified by chromatography (silica gel, heptanes/EtOAc, 10:1).

**Ethyl 3-Chloro-2-hydroxy-6-isopropyl-4-methoxybenzoate (13a):** Compound **13a** was isolated as a yellow crystalline solid (0.163 g, 60%) from **3b** (0.400 g, 1.3 mmol) in $CH_2Cl_2$ (2 mL), **12a** (0.190 g, 1.0 mmol) and $TiCl_4$ (0.11 mL, 1.0 mmol); m.p. 84–86 °C. $^1H$ NMR ($CDCl_3$, 300 MHz): $\delta$ = 1.23 [d, $^3J$ = 6.6 Hz, 6 H, $CH(CH_3)_2$], 1.42 (t, $^3J$ = 7.2 Hz, 3 H, $OCH_2CH_3$), 3.79–3.88 [m, 1 H, $CH(CH_3)_2$], 3.95 (s, 3 H, $OCH_3$), 4.43 (q, $^3J$ = 7.2 Hz, 2 H, $OCH_2CH_3$), 6.51 (s, 1 H, CH), 11.74 (s, 1 H, OH) ppm. $^{13}C$ NMR

($CDCl_3$, 63 MHz): $\delta$ = 14.0 ($OCH_2CH_3$), 24.1 ($CH_3$), 30.7 [$CH(CH_3)_2$], 56.0 ($OCH_3$), 61.9 ($OCH_2CH_3$), 101.1 (CH), 106.8, 107.2, 151.8 (C), 158.7 (COMe), 159.0 (COH), 171.1 (C=O) ppm. IR (ATR): $\tilde{\nu}$ = 3003 (w), 2981 (w), 2943 (w), 2911 (w), 2861 (w), 2714 (w), 2628 (w), 1650 (s), 1582 (w), 1556 (w), 1489 (w), 1471 (w), 1461 (w), 1441 (w), 1398 (s), 1379 (m), 1362 (w), 1346 (w), 1306 (w), 1296 (w), 1285 (w), 1265 (s), 1217 (s), 1186 (m), 1140 (s), 1103 (s), 1076 (s), 1018 (s) $cm^{-1}$. MS (EI, 70 eV): *m*/*z* (%) = 274 $[M]^+$ ($[^{37}Cl]$, 6), 272 $[M]^+$ ($[^{35}Cl]$, 18), 228 (36), 227 (27), 226 (100), 225 (14), 211 (17), 183 (11). HRMS (EI): calcd. for $C_{13}H_{17}O_4Cl$ ($[M]^+$, $^{35}Cl$) 272.08099; found 272.080737.

**Ethyl 3-Chloro-2-hydroxy-4-methoxy-6-propylbenzoate (13b):** Compound **13b** was isolated as a yellow crystalline solid (0.178 g, 65%) from **3b** (0.400 g, 1.3 mmol) in $CH_2Cl_2$ (2 mL), **12b** (0.190 g, 1.0 mmol) and $TiCl_4$ (0.11 mL, 1.0 mmol); m.p. 74–76 °C. $^1H$ NMR ($CDCl_3$, 250 MHz): $\delta$ = 0.97 (t, $^3J$ = 7.3 Hz, 3 H, $CH_3$), 1.42 (t, $^3J$ = 7.3 Hz, 3 H, $OCH_2CH_3$), 1.54–1.66 (m, 2 H, $CH_2$), 2.84–2.91 (m, 2 H, $CH_2$), 3.93 (s, 3 H, $OCH_3$), 4.42 (q, $^3J$ = 7.3 Hz, 2 H, $OCH_2CH_3$), 6.33 (s, 1 H, CH), 12.26 (s, 1 H, OH) ppm. $^{13}C$ NMR ($CDCl_3$, 75 MHz): $\delta$ = 14.0 ($CH_3$), 14.1 ($OCH_2CH_3$), 25.2, 39.3 ($CH_2$), 56.2 ($OCH_3$), 61.8 ($OCH_2CH_3$), 106.1 (CH), 107.5, 117.7, 146.0 (C), 158.8 (COMe), 160.0 (COH), 171.3 (C=O) ppm. IR (ATR): $\tilde{\nu}$ = 3271 (w), 2979 (w), 2962 (w), 2930 (w), 2872 (w), 2669 (w), 1726 (w), 1651 (s), 1599 (w), 1557 (w), 1494 (w), 1468 (m), 1439 (w), 1398 (m), 1373 (m), 1304 (m), 1263 (m), 1223 (w), 1208 (w), 1190 (w), 1135 (w), 1108 (w), 1095 (w), 1080 (w), 1013 (m) $cm^{-1}$. MS (EI, 70 eV): *m*/*z* (%) = 274 $[M]^+$ ($[^{37}Cl]$, 6), 272 $[M]^+$ ($[^{35}Cl]$, 17), 228 (35), 227 (19), 226 (100), 169 (14). HRMS (EI): calcd. for $C_{13}H_{17}O_4Cl$ ($[M]^+$, $^{35}Cl$) 272.080644; found 272.08099.

**Ethyl 3-Chloro-2-hydroxy-4-methoxy-6-phenylbenzoate (13c):** Compound **13c** was isolated as a yellow oil (0.199 g, 65%) from **3b** (0.400 g, 1.3 mmol) in $CH_2Cl_2$ (2 mL), **12c** (0.244 g, 1.0 mmol) and $TiCl_4$ (0.11 mL, 1.0 mmol). $^1H$ NMR ($CDCl_3$, 300 MHz): $\delta$ = 0.73 (t, $^3J$ = 7.2 Hz, 3 H, $OCH_2CH_3$), 3.92 (s, 3 H, $OCH_3$), 3.96 (q, $^3J$ = 7.2 Hz, 2 H, $OCH_2CH_3$), 6.39 (s, 1 H, CH), 7.19–7.22, 7.33–7.36 (m, 5 H, CH), 11.87 (s, 1 H, OH) ppm. $^{13}C$ NMR ($CDCl_3$, 75 MHz): $\delta$ = 12.9 ($OCH_2CH_3$) 56.4 ($OCH_3$), 61.2 ($OCH_2CH_3$), 106.3 (CH), 106.4 (C), 127.1, 127.6, 128.0 (CH), 142.7, 144.7 (C), 158.4 (COMe), 159.0 (COH), 170.4 (C=O) ppm. IR (ATR): $\tilde{\nu}$ = 3057 (w), 2925 (w), 2853 (w), 1727 (w), 1652 (s), 1596 (s), 1554 (s), 1503 (w), 1486 (w), 1463 (w), 1444 (w), 1395 (s), 1376 (w), 1360 (w), 1321 (w), 1298 (m), 1266 (s), 1227 (s), 1185 (m), 1152 (w), 1137 (m), 1097 (s), 1072 (w), 1015 (s) $cm^{-1}$. MS (EI, 70 eV): *m*/*z* (%) = 308 $[M]^+$ ($[^{37}Cl]$, 7), 307 (3), 306 $[M]^+$ ($[^{35}Cl]$, 20), 262 (38), 261 (21), 260 (100). HRMS (EI): calcd. for $C_{16}H_{15}O_4Cl$ ($[M]^+$, $^{35}Cl$) 306.06534; found 306.065304.

**Ethyl 3-Chloro-6-(4-chlorophenyl)-2-hydroxy-4-methoxybenzoate (13d):** Compound **13d** was isolated as a yellow crystalline solid (0.178 g, 52%) from **3b** (0.400 g, 1.3 mmol) in $CH_2Cl_2$ (2 mL), **12d** (0.258 g, 1.0 mmol) and $TiCl_4$ (0.11 mL, 1.0 mmol); m.p. 126–127 °C. $^1H$ NMR ($CDCl_3$, 300 MHz): $\delta$ = 0.81 (t, $^3J$ = 7.2 Hz, 3 H, $OCH_2CH_3$), 3.92 (s, 3 H, $OCH_3$), 4.00 (q, $^3J$ = 7.0 Hz, 2 H, $OCH_2CH_3$), 6.33 (s, 1 H, CH), 7.12–7.17, 7.32–7.36 (m, 4 H, CH), 11.91 (s, 1 H, OH) ppm. $^{13}C$ NMR ($CDCl_3$, 75 MHz): $\delta$ = 13.0 ($OCH_2CH_3$), 56.4 ($OCH_3$), 61.4 ($OCH_2CH_3$), 106.2 (CH), 109.2, 117.7 (C), 127.8, 129.4 (CH), 133.2, 141.2, 142.3 (C), 158.5 (COMe), 159.2 (COH), 170.4 (C=O) ppm. IR (ATR): $\tilde{\nu}$ = 3063 (w), 3054 (w), 2979 (w), 2931 (w), 2853 (w), 1653 (s), 1596 (m), 1556 (m), 1491 (m), 1462 (m), 1442 (w), 1393 (w), 1359 (m), 1319 (w), 1304 (m), 1264 (s), 1227 (s), 1183 (m), 1151 (w), 1134 (m), 1096 (w), 1086 (w), 1015 (s) $cm^{-1}$. MS (EI, 70 eV): *m*/*z* (%) = 344 $[M]^+$ ($[^{37}Cl]$ $[^{37}Cl]$, 2), 342 $[M]^+$ ($[^{37}Cl]$ $[^{35}Cl]$, $[^{35}Cl]$ $[^{37}Cl]$, 11), 340 $[M]^+$ ($[^{35}Cl]$ $[^{35}Cl]$, 17), 298 (12), 297 (12), 296 (66), 295 (19), 294 (100). HRMS (EI): calcd. for $C_{16}H_{14}O_4Cl_2$ ($[M]^+$, $^{35}Cl$) 340.02637; found 340.026469.

**Ethyl 3-Chloro-6-cyclopropanyl-2-hydroxy-4-methoxybenzoate (13e):** Compound **13e** was isolated as a yellow solid (0.152 g, 56%) from **3b** (0.400 g, 1.3 mmol) in $CH_2Cl_2$ (2 mL), **12e** (0.188 g, 1.0 mmol) and $TiCl_4$ (0.11 mL, 1.0 mmol); m.p. 89–92 °C. $^1H$ NMR ($CDCl_3$, 300 MHz): $\delta$ = 0.63–0.69 (m, 2 H, $CH_2$), 0.91–0.98 (m, 2 H, $CH_2$), 1.41 (t, $^3J$ = 7.2 Hz, 3 H, $OCH_2CH_3$), 2.38–2.48 (m, 1 H, CH), 3.92 (s, 3 H, $OCH_3$), 4.44 (q, $^3J$ = 7.2 Hz, 2 H, $OCH_2CH_3$), 6.33 (s, 1 H, CH), 12.18 (s, 1 H, OH) ppm. $^{13}C$ NMR ($CDCl_3$, 75 MHz): $\delta$ = 8.2 ($CH_2$), 11.7 (CH), 14.1 ($OCH_2CH_3$) 56.1 ($OCH_3$), 61.8 ($OCH_2CH_3$), 103.2 (CH), 107.6, 108.1, 145.7 (C), 158.9 (COMe), 159.6 (COH), 171.5 (C=O) ppm. IR (ATR): $\tilde{\nu}$ = 3068 (w), 2985 (w), 2970 (m), 2941 (w), 2854 (w), 1743 (w), 1652 (s), 1602 (m), 1558 (m), 1468 (m), 1404 (m), 1386 (w), 1369 (m), 1296 (w), 1270 (m), 1229 (m), 1191 (m), 1158 (w), 1140 (m), 1113 (w), 1096 (m), 1055 (w), 1022 (s) $cm^{-1}$. MS (EI, 70 eV): *m*/*z* (%) = 272 $[M]^+$ ($[^{37}Cl]$, 15), 270 $[M]^+$ ($[^{35}Cl]$, 44), 244 (27), 242 (86), 226 (34), 225 (22), 224 (91), 216 (18), 215 (37), 214 (57), 213 (100), 181 (18), 161 (23), 89 (20). HRMS (EI): calcd. for $C_{13}H_{15}O_4Cl$ ($[M]^+$, $^{35}Cl$) 270.06534; found 270.065689.

**Ethyl 3-Chloro-6-cyclobutanyl-2-hydroxy-4-methoxybenzoate (13f):** Compound **13f** was isolated as a yellow solid (0.174 g, 61%) from **3b** (0.400 g, 1.3 mmol) in $CH_2Cl_2$ (2 mL), **12f** (0.202 g, 1.0 mmol) and $TiCl_4$ (0.11 mL, 1.0 mmol); m.p. 78–80 °C. $^1H$ NMR ($CDCl_3$, 300 MHz): $\delta$ = 1.44 (t, $^3J$ = 7.2 Hz, 3 H, $OCH_2CH_3$), 1.75–1.84 (m, 2 H, $CH_2$), 1.91–2.12 (m, 2 H, $CH_2$), 2.29–2.38 (m, 2 H, $CH_2$), 3.97 (s, 3 H, $OCH_3$), 4.09 (q, $^3J$ = 8.7 Hz, 1 H, CH), 4.42 (q, $^3J$ = 7.2 Hz, 2 H, $OCH_2CH_3$), 6.49 (s, 1 H, CH), 11.97 (s, 1 H, OH) ppm. $^{13}C$ NMR ($CDCl_3$, 75 MHz): $\delta$ = 14.0 ($OCH_2CH_3$) 17.9, 29.6 ($CH_2$), 40.3 (CH), 56.1 ($OCH_3$), 61.9 ($OCH_2CH_3$), 102.3 (CH), 105.8, 107.2, 148.1 (C), 158.9 (COMe), 159.4 (COH), 171.1 (C=O) ppm. IR (ATR): $\tilde{\nu}$ = 3013 (w), 2978 (w), 2947 (w), 2866 (w), 1645 (s), 1603 (m), 1574 (w), 1556 (s), 1467 (m), 1454 (m), 1399 (s), 1380 (w), 1361 (w), 1305 (w), 1292 (w), 1278 (m), 1250 (m), 1220 (w), 1207 (s), 1186 (m), 1160 (w), 1133 (m), 1107 (w), 1091 (s), 1018 (s) $cm^{-1}$. MS (EI, 70 eV): *m*/*z* (%) = 286 $[M]^+$ ($[^{37}Cl]$, 19), 284 $[M]^+$ ($[^{35}Cl]$, 52), 240 (33), 239 (18), 238 (100), 235 (39), 210 (16), 207 (18), 203 (30), 176 (13), 175 (53), 161 (15), 147 (16), 115 (15). HRMS (EI): calcd. for $C_{14}H_{17}O_4Cl$ ($[M]^+$, $^{35}Cl$) 284.08099; found 284.080896. Elemental analysis calcd. (%) for $C_{14}H_{17}ClO_4$ (284.74): C 59.05, H 6.02; found C 59.18, H 6.08.

**Ethyl 3-Chloro-6-cyclopentyl-2-hydroxy-4-methoxybenzoate (13g):** Compound **13g** was isolated as a yellow solid (0.177 g, 59%) from **3b** (0.400 g, 1.3 mmol) in $CH_2Cl_2$ (2 mL), **12g** (0.216 g, 1.0 mmol) and $TiCl_4$ (0.11 mL, 1.0 mmol); m.p. 54–55 °C. $^1H$ NMR ($CDCl_3$, 300 MHz): $\delta$ = 1.41 (t, $^3J$ = 7.2 Hz, 3 H, $OCH_2CH_3$), 1.54–1.84 (m, 6 H, $CH_2$), 1.99–2.09 (m, 2 H, $CH_2$), 3.75–3.86 (m, 1 H, CH), 3.93 (s, 3 H, $OCH_3$), 4.42 (q, $^3J$ = 7.2 Hz, 2 H, $OCH_2CH_3$), 6.52 (s, 1 H, CH), 11.68 (s, 1 H, OH) ppm. $^{13}C$ NMR ($CDCl_3$, 75 MHz): $\delta$ = 14.0 ($OCH_2CH_3$) 25.2, 34.6 ($CH_2$), 43.3 (CH), 56.0 ($OCH_3$), 61.9 ($OCH_2CH_3$), 101.6 (CH), 107.2, 107.6, 149.1 (C), 158.7 (COMe), 158.8 (COH), 171.2 (C=O) ppm. IR (ATR): $\tilde{\nu}$ = 3010 (w), 2975 (w), 2948 (m), 2868 (m), 2744 (w), 2663 (w), 1644 (s), 1603 (m), 1556 (s), 1504 (w), 1495 (w), 1471 (w), 1456 (w), 1442 (w), 1402 (s), 1383 (w), 1362 (m), 1312 (w), 1293 (s), 1264 (s), 1221 (m), 1193 (w), 1162 (w), 1137 (s), 1099 (s), 1080 (w), 1017 (s) $cm^{-1}$. MS (EI, 70 eV): *m*/*z* (%) = 300 $[M]^+$ ($[^{37}Cl]$, 5), 298 $[M]^+$ ($[^{35}Cl]$, 15), 254 (34), 253 (21), 252 (100). HRMS (EI): calcd. for $C_{15}H_{19}O_4Cl$ ($[M]^+$, $^{35}Cl$) 298.09664; found 298.096028. Elemental analysis

calcd. (%) for $C_{15}H_{19}O_4Cl$ (298.76): C 60.30, H 6.41; found C 60.45, H 6.34.

**Ethyl 3-Chloro-2-hydroxy-4-methoxy-6-pentylbenzoate (13h):** Compound **13h** was isolated as a yellow solid (0.181 g, 63%) from **3b** (0.400 g, 1.3 mmol) in $CH_2Cl_2$ (2 mL), **12h** (0.218 g, 1.0 mmol) and $TiCl_4$ (0.11 mL, 1.0 mmol); m.p. 49–50 °C. $^1$H NMR ($CDCl_3$, 300 MHz): $\delta$ = 0.90 (t, $^3J$ = 7.2 Hz, 3 H, $CH_3$), 1.31–1.37 (m, 4 H, $CH_2$), 1.42 (t, $^3J$ = 7.2 Hz, 3 H, $OCH_2CH_3$), 1.50–1.60 (m, 2 H, $CH_2$), 2.86–2.91 (m, 2 H, $CH_2$), 3.93 (s, 3 H, $OCH_3$), 4.43 (q, $^3J$ = 7.2 Hz, 2 H, $OCH_2CH_3$), 6.33 (s, 1 H, CH), 12.25 (s, 1 H, OH) ppm. $^{13}$C NMR ($CDCl_3$, 75 MHz): $\delta$ = 14.0 ($CH_3$), 14.0 ($OCH_2CH_3$), 22.6, 31.8, 32.0, 37.3 ($CH_2$), 56.2 ($OCH_3$), 61.8 ($OCH_2CH_3$), 105.9 (CH), 107.4, 108.7, 146.2 (C), 158.8 (COMe), 159.9 (COH), 171.3 (C=O) ppm. IR (ATR): $\tilde{\nu}$ = 3014 (w), 2976 (w), 2955 (w), 2931 (w), 2853 (w), 1647 (s), 1604 (s), 1559 (s), 1537 (w), 1495 (w), 1465 (m), 1442 (w), 1425 (w), 1401 (s), 1376 (m), 1300 (w), 1286 (w), 1266 (m), 1242 (w), 1222 (m), 1189 (w), 1159 (w), 1138 (m), 1121 (w), 1094 (s), 1043 (w), 1017 (s) cm$^{-1}$. MS (EI, 70 eV): *m*/*z* (%) = 302 [M]$^+$ ([$^{37}$Cl], 7), 300 [M]$^+$ ([$^{35}$Cl], 19), 285 (1), 256 (35), 255 (20), 254 (100), 198 (29), 169 (10). HRMS (EI): calcd. for $C_{15}H_{21}O_4Cl$ ([M]$^+$, $^{35}$Cl) 300.11229; found 300.111609. Elemental analysis calcd. (%) for $C_{15}H_{21}ClO_4$ (300.78): C 59.90, H 7.04; found C 60.07, H 7.13.

**Ethyl 3-Chloro-6-cyclopentylethyl-2-hydroxy-4-methoxybenzoate (13i):** Compound **13i** was isolated as a yellow solid (0.118 g, 36%) from **3b** (0.400 g, 1.3 mmol) in $CH_2Cl_2$ (2 mL), **12i** (0.244 g, 1.0 mmol) and $TiCl_4$ (0.11 mL, 1.0 mmol); m.p. 50–53 °C. $^1$H NMR ($CDCl_3$, 300 MHz): $\delta$ = 1.42 (t, $^3J$ = 7.2 Hz, 3 H, $OCH_2CH_3$), 1.49–1.64 (m, 8 H, $CH_2$), 1.76–1.81 (m, 2 H, $CH_2$), 2.89–2.94 (m, 2 H, $CH_2$), 3.73 (t, $^3J$ = 22.5 Hz, 1 H, CH), 3.93 (s, 3 H, $OCH_3$), 4.44 (q, $^3J$ = 7.2 Hz, 2 H, $OCH_2CH_3$), 6.33 (s, 1 H, CH), 12.23 (s, 1 H, OH) ppm. $^{13}$C NMR ($CDCl_3$, 75 MHz): $\delta$ = 14.2 ($OCH_2CH_3$) 25.2, 32.6, 36.5, 38.5 ($CH_2$), 40.3 (CH), 56.2 ($OCH_3$), 61.8 ($OCH_2CH_3$), 105.8 (CH), 106.2, 107.4, 146.4 (C), 158.8 ($COCH_3$), 158.9 (COH), 171.3 (C=O) ppm. IR (ATR): $\tilde{\nu}$ = 2943 (w), 2914 (w), 2866 (w), 1748 (w), 1717 (w), 1643 (s), 1602 (m), 1557 (m), 1519 (w), 1463 (w), 1443 (w), 1422 (m), 1395 (s), 1375 (s), 1355 (w), 1296 (s), 1266 (m), 1218 (s), 1190 (m), 1160 (w), 1139 (m), 1100 (s), 1018 (s) cm$^{-1}$. MS (EI, 70 eV): *m*/*z* (%) = 328 [M]$^+$ ([$^{37}$Cl], 11), 326 [M]$^+$ ([$^{35}$Cl], 31), 282 (34), 281 (22), 280 (100), 272 (15), 246 (20), 244 (62), 239 (21), 200 (27), 198 (73). HRMS (ESI-TOF/MS): calcd. for $C_{17}H_{22}O_4Cl_3$ [M – H]$^+$ ($^{35}$Cl) 325.12121; found 325.12149.

**Ethyl 3-Chloro-6-cyclohexyl-2-hydroxy-4-methoxybenzoate (13j):** Compound **13j** was isolated as a yellow crystalline solid (0.147 g, 47%) from **3b** (0.400 g, 1.3 mmol) in $CH_2Cl_2$ (2 mL), **12j** (0.230 g, 1.0 mmol) and $TiCl_4$ (0.11 mL, 1.0 mmol); m.p. 80–82 °C. $^1$H NMR ($CDCl_3$, 300 MHz): $\delta$ = 1.28–1.39 (m, 4 H, $CH_2$), 1.44 (t, $^3J$ = 7.2 Hz, 3 H, $OCH_2CH_3$), 1.76–1.87 (m, 6 H, $CH_2$), 3.60 (d, $^3J$ = 72.3 Hz, 1 H, CH), 3.94 (s, 3 H, $OCH_3$), 4.43 (q, $^3J$ = 7.2 Hz, 2 H, $OCH_2CH_3$), 6.50 (s, 1 H, CH), 11.80 (s, 1 H, OH) ppm. $^{13}$C NMR ($CDCl_3$, 75 MHz): $\delta$ = 14.2 ($OCH_2CH_3$) 26.2, 27.1, 34.7 ($CH_2$), 41.5 (CH), 56.0 ($OCH_3$), 61.9 ($OCH_2CH_3$), 101.8 (CH), 106.8, 107.2, 150.7, 158.8 ($COCH_3$), 158.9 (COH), 171.3 (C=O) ppm. IR (ATR): $\tilde{\nu}$ = 2970 (w), 2927 (m), 2850 (m), 1712 (w), 1643 (s), 1602 (m), 1561 (m), 1494 (w), 1467 (w), 1443 (m), 1400 (s), 1378 (w), 1360 (w), 1330 (w), 1300 (w), 1291 (w), 1263 (s), 1218 (s), 1189 (w), 1136 (s), 1102 (s), 1076 (w), 1017 (s) cm$^{-1}$. MS (EI, 70 eV): *m*/*z* (%) = 314 [M]$^+$ ([$^{37}$Cl], 5), 312 [M]$^+$ ([$^{35}$Cl], 16), 268 (35), 267 (22), 266 (100). HRMS (ESI-TOF/MS): calcd. for $C_{16}H_{20}O_4Cl$ [M – H]$^+$ ($^{35}$Cl) 311.10556; found 311.1058. Elemental analysis calcd. (%) for $C_{16}H_{21}O_4Cl$ (312.79): C 61.44, H 6.77; found C 61.43, H 6.83.

**General Procedure for the Synthesis of 3-Chlorosalicylates 15a–e:** $TiCl_4$ (2.0 equiv.) was added at –78 °C under argon to a solution of **3a** (2.0 equiv.) and a 1,1,3,3-tetraalkoxypropane (**14a**–**e**, 1.0 equiv.) in dichloromethane (2.0 mL per 1 mmol of **14**). The solution was allowed to warm slowly to 20 °C with stirring. Hydrochloric acid (10%) was added to the solution and the organic and the aqueous layers were separated. The latter was extracted with dichloromethane. The combined organic layers were dried (sodium sulfate) and filtered and the filtrate was concentrated in vacuo. The residue was purified by chromatography (silica gel, heptanes/EtOAc 20:1).

**Methyl 3-Chloro-2-hydroxybenzoate (15a):** Compound **15a** was isolated as a yellow oil (0.054 g, 26%) from **3a** (0.590 g, 2.0 mmol), 1,1,3,3-tetramethoxypropane (**14a**, 0.164 g, 1.0 mmol) and $TiCl_4$ (0.22 mL, 2.0 mmol) in $CH_2Cl_2$ (2 mL). $^1$H NMR (300 MHz, $CDCl_3$): $\delta$ = 3.96 (s, 3 H, $OCH_3$), 6.83 (t, $^3J$ = 8.0 Hz, 1 H, CH), 7.54 (dd, $^2J$ = 1.7, $^3J$ = 6.3 Hz, 1 H, CH), 7.76 (dd, $^2J$ = 1.7, $^3J$ = 6.3 Hz, 1 H, CH), 11.33 (s, 1 H, OH) ppm. $^{13}$C NMR (75 MHz, $CDCl_3$): $\delta$ = 52.7 ($OCH_3$), 113.6 (C), 119.2 (CH), 122.2 (C), 128.4, 135.8 (CH), 157.3 (COH), 170.3 ($COOCH_3$) ppm. IR (ATR): $\tilde{\nu}$ = 3090 (w), 2955 (w), 2926 (w), 2853 (w), 1732 (w), 1675 (s), 1607 (m), 1438 (s), 1322 (s), 1282 (m), 1252 (s), 1197 (s), 1176 (s), 1151 (s), 1073 (m) cm$^{-1}$. MS (GC-MS, 70 eV): *m*/*z* (%) = 188 [M]$^+$ ([$^{37}$Cl], 11), 186 [M]$^+$ ([$^{35}$Cl], 33), 156 (34), 154 (100). HRMS (EI): calcd. for $C_8H_7ClO_3$ [M]$^+$ ([$^{35}$Cl]): 186.00782; found 186.007530.

**Methyl 3-Chloro-2-hydroxy-5-methylbenzoate (15b):** Compound **15b** was isolated as a yellow solid (0.070 g, 35%) from **3a** (0.590 g, 2.0 mmol), 1,1,3,3-tetraethoxy-2-methylpropane (**14b**, 0.234 g, 1.0 mmol) and $TiCl_4$ (0.22 mL, 2.0 mmol) in $CH_2Cl_2$ (2 mL); m.p. 104–107 °C. $^1$H NMR (250 MHz, $CDCl_3$): $\delta$ = 2.26 (s, 3 H, $CH_3$), 3.94 (s, 3 H, $OCH_3$), 7.35–7.37 (m, 1 H, CH), 7.54–7.56 (m, 1 H, CH), 11.09 (d, $^4J$ = 0.5 Hz, 1 H, OH) ppm. $^{13}$C NMR (63 MHz, $CDCl_3$): $\delta$ = 20.2 ($CH_3$), 52.6 ($OCH_3$), 113.1, 121.6 (C), 128.3 (CH), 128.8 (C), 136.5 (CH), 155.1 (COH), 170.2 ($COOCH_3$) ppm. IR (ATR): $\tilde{\nu}$ = 3092 (w), 3070 (w), 3013 (w), 2960 (w), 2922 (w), 2855 (w), 1659 (s), 1608 (m), 1469 (w), 1437 (s), 1396 (w), 1384 (w), 1329 (s), 1250 (s), 1216 (s), 1193 (s), 1175 (s), 1100 (s), 1047 (m), 1010 (m) cm$^{-1}$. MS (GC/MS, 70 eV): *m*/*z* (%) = 202 [M]$^+$ ([$^{37}$Cl], 10), 200 [M]$^+$ ([$^{35}$Cl], 30), 170 (34), 169 (19), 168 (100). $C_9H_9ClO_3$ (200.62): calcd. C 53.88, H 4.52; found C 53.87, H 4.45.

**Methyl 3-Chloro-2-hydroxy-5-isopropylbenzoate (15c):** Compound **15c** was isolated as a yellow oil (0.082 g, 36%) from **3a** (0.590 g, 2.0 mmol), 2-diethoxymethyl-1,1-diethoxy-3-methylbutane (**14c**, 0.262 g, 1.0 mmol) and $TiCl_4$ (0.22 mL, 2.0 mmol) in $CH_2Cl_2$ (2 mL). $^1$H NMR (250 MHz, $CDCl_3$): $\delta$ = 1.20 (s, 3 H, $CH_3$), 1.23 (s, 3 H, $CH_3$), 2.83 (quint, $^3J$ = 6.9 Hz, 1 H, CH), 3.96 (s, 3 H, $OCH_3$), 7.42 (d, $^4J$ = 2.2 Hz, 1 H, CH), 7.60 (dd, $J$ = 0.5, $^4J$ = 2.2 Hz, 1 H, CH), 11.13 (d, $^4J$ = 0.5 Hz, 1 H, OH) ppm. $^{13}$C NMR (75 MHz, $CDCl_3$): $\delta$ = 23.8 ($CH_3$), 33.2 (CH), 52.6 ($OCH_3$), 113.2, 121.8 (C), 125.8, 134.2 (CH), 140.0 (C), 155.3 (COH), 170.3 ($COOCH_3$) ppm. IR (ATR): $\tilde{\nu}$ = 3107 (br., w), 3006 (w), 2958 (m), 2929 (w), 2871 (w), 1676 (s), 1609 (w), 1468 (m), 1440 (s), 1384 (w), 1363 (w), 1334 (s), 1306 (m), 1278 (m), 1243 (s), 1196 (s), 1176 (s), 1150 (m), 1102 (m), 1067 (w) cm$^{-1}$. MS (GC-MS, 70 eV): *m*/*z* (%) = 230 [M]$^+$ ([$^{37}$Cl], 10), 228 [M]$^+$ ([$^{35}$Cl], 32), 198 (28), 196 (84), 183 (33), 181 (100). HRMS (EI): calcd. for $C_{11}H_{13}ClO_3$ [M]$^+$ ([$^{35}$Cl]): 228.05477; found 228.054789.

**Methyl 3-Chloro-2-hydroxy-5-pentylbenzoate (15d):** Compound **15d** was isolated as a yellow oil (0.133 g, 52%) from **3a** (0.590 g, 2.0 mmol), 2-diethoxymethyl-1,1-diethoxyheptane (**14d**, 0.290 g, 1.0 mmol) and $TiCl_4$ (0.22 mL, 2.0 mmol) in $CH_2Cl_2$ (2 mL). $^1$H NMR (250 MHz, $CDCl_3$): $\delta$ = 0.88 (t, $J$ = 6.9 Hz, 3 H, $CH_3$), 1.24–

1.32 (m, 4 H, $CH_2$), 1.51–1.63 (m, 2 H, $CH_2$), 2.48–2.54 (m, 2 H, $CH_2$), 3.96 (s, 3 H, $OCH_3$), 7.37 (d, $^4J$ = 2.2 Hz, 1 H, CH), 7.55 (d, $^4J$ = 2.2 Hz, 1 H, CH), 11.12 (d, $^4J$ = 0.5 Hz, 1 H, OH) ppm. $^{13}$C NMR (63 MHz, $CDCl_3$): $\delta$ = 14.0 ($CH_3$), 22.4, 31.0, 31.2, 34.7 ($CH_2$), 52.6 ($OCH_3$), 113.2, 121.7 (C), 127.7 (CH), 134.0 (C), 135.9 (CH), 155.2 (COH), 170.3 (*C*$OOCH_3$) ppm. IR (ATR): $\tilde{\nu}$ = 3111 (br., w), 2955 (w), 2927 (w), 2857 (w), 1676 (s), 1610 (w), 1440 (s), 1377 (w), 1325 (m), 1279 (m), 1247 (s), 1215 (m), 1196 (s), 1172 (s), 1102 (w) cm$^{-1}$. MS (GC-MS, 70 eV): *m*/*z* (%) = 258 [M]$^+$ ([$^{37}$Cl], 9), 256 [M]$^+$ ([$^{35}$Cl], 29), 226 (34), 224 (100), 169 (30), 167 (87). HRMS (EI): calcd. for $C_{13}H_{17}ClO_3$ [M]$^+$ ([$^{35}$Cl]): 256.08607; found 256.086570.

**Methyl 3-Chloro-5-heptyl-2-hydroxybenzoate (15e):** Compound **15e** was isolated as a yellow oil (0.082 g, 30%) from **3a** (0.590 g, 2.0 mmol), 2-diethoxymethyl-1,1-diethoxynonane (**14e**, 0.318 g, 1.0 mmol) and $TiCl_4$ (0.22 mL, 2.0 mmol) in $CH_2Cl_2$ (2 mL). $^1$H NMR (250 MHz, $CDCl_3$): $\delta$ = 0.87 (t, $^3J$ = 6.9 Hz, 3 H, $CH_3$), 1.24–1.28 (m, 10 H, $CH_2$), 2.51 (t, $^3J$ = 7.7 Hz, 2 H, $CH_2$), 3.96 (s, 3 H, $OCH_3$), 7.37 (d, $^4J$ = 2.2 Hz, 1 H, CH), 7.55 (d, $^4J$ = 2.2 Hz, 1 H, CH), 11.12 (d, $^4J$ = 0.5 Hz, 1 H, OH) ppm. $^{13}$C NMR (63 MHz, $CDCl_3$): $\delta$ = 14.1 ($CH_3$), 22.6, 29.0, 29.1, 31.3, 31.7, 34.7 ($CH_2$), 52.6 ($OCH_3$), 113.2, 121.7 (C), 127.7 (CH), 134.0 (C), 135.9 (CH), 155.2 (COH), 170.3 (*C*$OOCH_3$) ppm. IR (ATR): $\tilde{\nu}$ = 3114 (br., w), 2954 (w), 2924 (m), 2854 (w), 1678 (s), 1610 (w), 1587 (w), 1440 (s), 1326 (m), 1280 (m), 1252 (s), 1215 (m), 1196 (s), 1172 (s), 1102 (w), 1022 (w) cm$^{-1}$. MS (GC/MS, 70 eV): *m*/*z* (%) = 286 [M]$^+$ ([$^{37}$Cl], 9), 284 [M]$^+$ ([$^{35}$Cl], 27), 254 (34), 252 (100), 169 (27), 167 (78). HRMS (EI): calcd. for $C_{15}H_{21}ClO_3$ [M]$^+$ ([$^{35}$Cl]): 284.11737; found 284.117164.

**General Procedure for the Synthesis of 3-Chloro-5-(2-chloroethyl)-salicylate 17:** $TiCl_4$ (1.8 equiv.) was added at –78 °C under argon to a solution of 1,1-diacetylcyclopropane (**16**, 1.0 equiv.) and **3a** (1.5 equiv.) in dichloromethane (90 mL per 1 mmol of **16**). The solution was allowed to warm slowly to 20 °C with stirring. Hydrochloric acid (10%) was added to the solution and the organic and the aqueous layer were separated. The latter was extracted with dichloromethane. The combined organic layers were dried (sodium sulfate) and filtered and the filtrate was concentrated in vacuo. The residue was purified by chromatography (silica gel, heptanes/EtOAc 20:1).

**Methyl 3-Chloro-5-(2-chloroethyl)-2-hydroxy-4,6-dimethylbenzoate (17):** Compound **17** (0.081 g, 30%) was isolated as a colourless solid from **3a** (0.472 g, 1.6 mmol), **16** (0.139 g, 1.10 mmol) and $TiCl_4$ (0.22 mL, 2.0 mmol) in $CH_2Cl_2$ (100 mL); m.p. 80–82 °C. $^1$H NMR (250 MHz, $CDCl_3$): $\delta$ = 2.46 (s, 6 H, $CH_3$), 3.12–3.18 (m, 2 H, $CH_2$), 3.46–3.53 (m, 2 H, $CH_2$), 3.97 (s, 3 H, $OCH_3$), 10.69 (s, 1 H, OH) ppm. $^{13}$C NMR (63 MHz, $CDCl_3$): $\delta$ = 17.8, 18.5 ($CH_3$), 33.7, 42.0 ($CH_2$), 52.6 ($OCH_3$), 113.7, 120.9, 127.8, 136.5, 141.2 (C), 155.0 (COH), 171.3 (*C*$OOCH_3$) ppm. IR (ATR): $\tilde{\nu}$ = 3017 (w), 2980 (w), 2954 (w), 2929 (w), 2873 (w), 2851 (w), 1661 (s), 1584 (w), 1548 (w), 1439 (s), 1408 (m), 1377 (m), 1337 (s), 1311 (s), 1265 (m), 1245 (m), 1200 (s), 1161 (s), 1144 (s), 1077 (s), 1041 (m), 1011 (m) cm$^{-1}$. MS (GC-MS, 70 eV): *m*/*z* (%) = 278 [M]$^+$ ([$^{37}$Cl], 12), 276 [M]$^+$ ([$^{35}$Cl], 18), 246 (48), 244 (71), 197 (35), 195 (100). $C_{12}H_{14}Cl_2O_3$ (277.14): calcd. C 52.00, H 5.09; found C 52.09, H 4.84.

**Procedure for the Synthesis of Benzophenones 19a–i:** TMSOTf (0.3 equiv.) was added at 0 °C to a formylchromone (**18a**–**i**, 1.0 equiv.). After the system had been stirred for 5 min, dichloromethane (15 mL) and diene **3a** or **3b** (1.3 equiv.) were added. The solution was allowed to warm to ambient temperature over 12 h with stirring. Hydrochloric acid (10%) was added to the mixture and the organic and the aqueous layers were separated. The latter was extracted with dichloromethane. The combined organic layers were dried (sodium sulfate) and filtered and the filtrate was concentrated in vacuo. The residue was purified by chromatography (silica gel, heptanes/EtOAc 20:1).

**Ethyl 3-Chloro-2-hydroxy-5-(2-hydroxybenzoyl)benzoate (19a):** Compound **19a** was isolated as a colourless solid (200 mg, 42%) from **18a** (261 mg, 1.5 mmol), **3b** (602 mg, 2.0 mmol) and $Me_3SiOTf$ (0.08 mL, 0.5 mmol); m.p. 117–118 °C. $^1$H NMR (300 MHz, $CDCl_3$): $\delta$ = 1.33 (t, *J* = 7.1 Hz, 3 H, $CH_3$), 4.36 (q, *J* = 7.0, 14.2 Hz, 2 H, $OCH_2$), 6.83 (m, 1 H, ArH), 6.96 (d, *J* = 8.3 Hz, 1 H, ArH), 7.40–7.47 (m, 2 H, ArH), 7.82 (d, *J* = 2.25 Hz, 1 H, ArH), 7.68 (d, *J* = 2.3 Hz, 1 H, ArH), 8.08 (d, *J* = 2.43 Hz, 1 H, ArH), 11.60 (s, 1 H, OH), 11.80 (s, 1 H, OH) ppm. $^{13}$C NMR (62.9 MHz, $CDCl_3$): $\delta$ = 14.0 ($CH_3$), 62.6 ($OCH_2$), 113.4, 118.6 (C), 118.6, 118.9 (CH), 122.7, 129.0 (C), 130.2, 132.7, 136.2, 136.5 (CH), 160.3, 163.0 (C-OH), 169.3, 197.8 (C=O) ppm. IR (neat): $\tilde{\nu}$ = 3086 (w), 2991 (m), 2962 (w), 1720 (w), 1680 (s), 1622 (s), 1567 (m), 1444 (m), 1374 (m), 1337 (s), 1239 (s), 1014 (m) cm$^{-1}$. MS (GC = 70 eV): *m*/*z* (%): 322 [M]$^+$ ([$^{37}$Cl], 26), 320 [M]$^+$ (75), 274 (34), 181 (21), 154 (39), 121 (100). HRMS (EI) calcd. for $C_{16}H_{13}ClO_5$ [M]$^+$ ([$^{35}$Cl]): 320.04460; found 320.044647.

**Ethyl 3-Chloro-2-hydroxy-5-(2-hydroxy-5-methylbenzoyl)benzoate (19b):** Compound **19b** was isolated as a colourless solid (201 mg, 40%) from **18b** (282 mg, 1.5 mmol), **3b** (602 mg, 2.0 mmol) and $Me_3SiOTf$ (0.08 mL, 0.5 mmol); m.p. 142–144 °C. $^1$H NMR (250 MHz, $CDCl_3$): $\delta$ = 1.35 (t, *J* = 7.1 Hz, 3 H, $CH_3$), 2.21 (s, 3 H, $CH_3$), 4.36 (q, *J* = 7.0, 14.2 Hz, 2 H, $OCH_2$), 6.89 (d, *J* = 8.3 Hz, 1 H, ArH), 6.96 (d, *J* = 8.3 Hz, 1 H, ArH), 7.24–7.29 (m, 2 H, ArH), 7.85 (d, *J* = 2.1 Hz, 1 H, ArH), 8.10 (d, *J* = 2.1 Hz, 1 H, ArH), 11.43 (s, 1 H, OH), 11.81 (s, 1 H, OH) ppm. $^{13}$C NMR (62 MHz, $CDCl_3$): $\delta$ = 14.0 ($CH_3$), 20.5 ($CH_3$), 62.6 ($OCH_2$), 113.4, 118.0 (C), 118.4 (CH), 122.7, 128.0, 129.2 (C), 130.2, 132.3, 136.1, 137.5 (CH), 160.2, 160.9 (C–OH), 169.3, 197.7 (C=O) ppm. IR (neat): $\tilde{\nu}$ = 3065 (w), 2993 (w), 2856 (w), 1679 (s), 1627 (s), 1581 (s), 1482 (m), 1375 (m), 1338 (s), 1288 (s), 1210 (s), 786 (s) cm$^{-1}$. MS (GC = 70 eV): *m*/*z* (%): 336 [M]$^+$ ([$^{37}$Cl], 13), 334 [M]$^+$ (37), 288 (11), 181 (9), 134 (100), 77 (11). HRMS (EI): calcd. for $C_{17}H_{15}ClO_5$ [M]$^+$ ([$^{35}$Cl]): 334.06025; found 334.060293.

**Ethyl 3-Chloro-5-(5-ethyl-2-hydroxybenzoyl)-2-hydroxybenzoate (19c):** Compound **19c** was isolated as a yellow oil (0.140 g, 40%) from **18c** (0.202 g, 1.0 mmol), $Me_3SiOTf$ (0.05 mL, 0.3 mmol) and **3b** (0.402 g, 1.3 mmol) in $CH_2Cl_2$ (15 mL); m.p. 69–72 °C. $^1$H NMR ($CDCl_3$, 250 MHz): $\delta$ = 1.19 (t, $^3J$ = 7.6 Hz, 3 H, $CH_2CH_3$), 1.40 (t, $^3J$ = 7.1 Hz, 3 H, $OCH_2CH_3$), 2.57 (q, $^3J$ = 7.6 Hz, 2 H, $CH_2CH_3$), 4.46 (q, $^3J$ = 7.1 Hz, 2 H, $OCH_2CH_3$), 7.01 (dd, $^3J$ = 8.2 Hz, 1 H, CH), 7.35–7.40 (m, 2 H, CH), 7.97 (dd, $^4J$ = 2.2 Hz, 1 H, CH), 8.20 (d, $^4J$ = 2.0 Hz, 1 H, CH), 11.50 (s, 1 H, OH), 11.90 (s, 1 H, OH) ppm. $^{13}$C NMR (63 MHz, $CDCl_3$): $\delta$ = 14.1 ($CH_3$), 15.8 ($OCH_2CH_3$), 27.9 ($CH_2$), 62.6 ($OCH_2CH_3$), 113.3 (C), 118.5 (CH), 122.9 (C), 129.1, 130.4 (CH), 131.3, 134.6 (C), 136.3, 136.5 (CH), 160.4, 161.1 (COH), 169.4, 197.7 (C=O) ppm. IR (ATR): $\tilde{\nu}$ = 3271 (w), 3068 (w), 2967 (w), 2930 (w), 2871 (w), 1731 (w), 1675 (s), 1626 (s), 1600 (m), 1572 (m), 1479 (w), 1465 (w), 1454 (w), 1401 (w), 1373 (m), 1341 (w), 1324 (w), 1287 (w), 1258 (m), 1184 (m), 1146 (w), 1114 (w), 1096 (m), 1017 (s) cm$^{-1}$. MS (GC-MS, 70 eV): *m*/*z* (%) = 348 [M]$^+$ (38), 149 (42), 148 (100), 133 (38). HRMS (EI): calcd. for $C_{18}H_{17}O_5Cl$ [M]$^+$ 348.07590; found 348.07127.

**Ethyl 3-Chloro-2-hydroxy-5-(2-hydroxy-5-isopropylbenzoyl)benzoate (19d):** Compound **19d** was isolated as a white solid (0.158 g, 44%) from **18d** (0.216 g, 1.0 mmol), $Me_3SiOTf$ (0.05 mL, 0.3 mmol) and **3b** (0.402 g, 1.3 mmol) in $CH_2Cl_2$ (15 mL); m.p. 62–63 °C. $^1$H

NMR (250 MHz, [D$_6$]DMSO): $\delta$ = 3.68 (s, 3 H, $OCH_3$), 5.44 (s, 1 H, CH) ppm. $^{13}$C NMR (63 MHz, [D$_6$]DMSO): $\delta$ = 51.7 ($OCH_3$), 93.5 (CH), 111.4 (C–Cl), 144.7 (C), 154.4 (COH), 162.1, 163.1 (C=O) ppm. IR (ATR): $\tilde{\nu}$ = 2983 (w), 2943 (w), 2909 (w), 2883 (w), 1724 (s), 1643 (w), 1608 (w), 1461 (w), 1405 (w), 1369 (m), 1348 (w), 1299 (m), 1258 (s), 1176 (s), 1098 (m), 1067 (w), 1020 (s) cm$^{-1}$. MS (GC-MS, 70 eV): *m/z* (%) = 178 [M]$^+$ (2), 94 (11), 57 (100). HRMS (EI): calcd. for $C_{11}H_{13}O_3Cl$ [M]$^+$ 228.05477; found 228.054628.

**Ethyl 3-Chloro-2-hydroxy-5-(2-hydroxy-5-nitrobenzoyl)benzoate (19e):** Compound **19e** was isolated as a light yellow solid (141 mg, 40%) from **18e** (219 mg, 1.0 mmol), **3b** (401 mg, 1.3 mmol) and $Me_3SiOTf$ (0.05 mL, 0.3 mmol); m.p. 159–161 °C. $^1$H NMR (250 MHz, $CDCl_3$): $\delta$ = 1.34 (t, $J$ = 7.1 Hz, 3 H, $CH_3$), 4.36 (q, $J$ = 7.2, 14.2 Hz, 2 H, $OCH_2$), 7.12 (d, $J$ = 9.3 Hz, 1 H, ArH), 7.93 (d, $J$ = 2.62 Hz, 1 H, ArH), 8.14 (d, $J$ = 2.35 Hz, 1 H, ArH), 8.32 (dd, $J$ = 3.0, 9.3 Hz, 1 H, ArH), 8.50 (d, $J$ = 2.5 Hz, 1 H, ArH), 11.99 (s, 1 H, OH), 12.29 (s, 1 H, OH) ppm. $^{13}$C NMR (62 MHz, $CDCl_3$): $\delta$ = 14.0 ($CH_3$), 62.9 ($OCH_2$), 113.6, 117.5 (C), 119.7 (CH), 123.8, 127.4 (C), 128.7, 130.5, 131.0, 136.0 (CH), 139.5 (C), 161.3, 167.7 (C-OH), 169.1, 196.6 (C=O) ppm. IR (neat): $\tilde{\nu}$ = 2919 (m), 2850 (w), 1682 (m), 1632 (m), 1460 (m), 1336 (s) cm$^{-1}$. MS (GC = 70 eV): *m/z* (%): 367 [M]$^+$ ([$^{37}$Cl], 21), 365 [M]$^+$ (77), 329 (7), 319 (100), 283 (16), 154 (58). HRMS (EI): calcd. for $C_{16}H_{12}NClO_7$ [M]$^+$ ([$^{35}$Cl]): 365.02919; found 365.029150.

**Ethyl 3-Chloro-5-(5-fluoro-2-hydroxybenzoyl)-2-hydroxybenzoate (19f):** Compound **19f** was isolated as a yellow solid (0.116 g, 34%) from **18f** (0.192 g, 1.0 mmol), $Me_3SiOTf$ (0.05 mL, 0.3 mmol) and **3b** (0.402 g, 1.3 mmol) in $CH_2Cl_2$ (15 mL); m.p. 104–108 °C. $^1$H NMR (250 MHz, $CDCl_3$): $\delta$ = 1.42 (t, $^3J$ = 7.1 Hz, 3 H, $OCH_2CH_3$), 4.48 (q, $^3J$ = 7.1 Hz, 2 H, $OCH_2CH_3$), 7.03–7.09 (m, 1 H, CH), 7.21–7.24 (m, 1 H, CH), 7.26–7.32 (m, 1 H, CH), 7.94 (d, $^4J$ = 2.2 Hz, 1 H, CH), 8.17 (d, $^4J$ = 2.2 Hz, 1 H, CH), 11.41 (s, 1 H, OH), 11.95 (s, 1 H, OH) ppm. $^{13}$C NMR (63 MHz, $CDCl_3$): $\delta$ = 14.1 ($OCH_2CH_3$), 62.8 ($OCH_2CH_3$), 113.6 (C), 117.2, 117.6 (CH), 120.0, 120.1 (CH), 123.2 (C), 123.9, 124.3 (CH), 128.5 (C), 130.2 136.0 (CH), 159.2, 160.7 (COH), 169.3, 196.9 (C=O) ppm. $^{19}$F NMR ($CDCl_3$, 235 MHz): $\delta$ = –123.5 ($CF_3$) ppm. IR (ATR): $\tilde{\nu}$ = 3074 (w), 3001 (w), 2986 (w), 2929 (w), 1678 (m), 1638 (m), 1617 (m), 1581 (m), 1475 (s), 1412 (m), 1376 (m), 1347 (s), 1336 (s), 1317 (m), 1285 (s), 1261 (s), 1240 (m), 1210 (s), 1194 (s), 1144 (s), 1099 (s), 1016 (m) cm$^{-1}$. MS (GC-MS, 70 eV): *m/z* (%) = 340 [M]$^+$ ([$^{37}$Cl], 30), 338 [M]$^+$ ([$^{35}$Cl], 87), 292 (43), 154 (90), 139 (100). HRMS (EI): calcd. for $C_{16}H_{12}ClFO_5$ [M]$^+$ 338.03518; found 338.035409.

**Methyl 3-Chloro-5-(5-chloro-2-hydroxybenzoyl)-2-hydroxybenzoate (19g):** Compound **19g** was isolated as a yellow solid (0.112 g, 33%) from **18g** (0.209 g, 1.0 mmol), $Me_3SiOTf$ (0.05 mL, 0.3 mmol) and **3a** (0.383 g, 1.3 mmol) in $CH_2Cl_2$ (15 mL); m.p. 151–154 °C. $^1$H NMR (250 MHz, $CDCl_3$): $\delta$ = 4.02 (s, 3 H, $OCH_3$), 7.05 (dd, $^3J$ = 8.5, $^5J$ = 0.6 Hz, 1 H, CH), 7.45–7.51 (m, 2 H, CH), 7.94 (d, $^4J$ = 2.2 Hz, 1 H, CH), 8.15 (d, $^4J$ = 2.2 Hz, 1 H, CH), 11.54 (s, 1 H, OH), 11.85 (s, 1 H, OH) ppm. $^{13}$C NMR (63 MHz, $CDCl_3$): $\delta$ = 53.3 ($OCH_3$), 113.2, 119.4 (C), 120.3 (CH), 123.3, 123.7, 128.5 (C), 130.2, 131.5, 136.2, 136.4 (CH), 160.7, 161.5 (COH), 169.7, 196.8 (C=O) ppm. IR (ATR): $\tilde{\nu}$ = 3077 (w), 2959 (w), 2920 (w), 2851 (w), 1697 (m), 1629 (m), 1600 (m), 1568 (m), 1464 (m), 1436 (m), 1353 (s), 1322 (m), 1286 (m), 1258 (m), 1223 (s), 1192 (s), 1160 (s), 1104 (m) cm$^{-1}$. MS (GC-MS, 70 eV): *m/z* (%) = 342 [M]$^+$ ([$^{37}$Cl], 30), 340 [M]$^+$ ([$^{35}$Cl], 44), 308 (16), 155 (50), 154 (100). $C_{15}H_{10}Cl_2O_5$ (341.14): calcd. C 52.81, H 2.95; found C 52.66, H 3.13.

**Ethyl 5-(5-Bromo-2-hydroxybenzoyl)-3-chloro-2-hydroxybenzoate (19h):** Compound **19h** was isolated as a light yellow solid (170 mg, 42%) from **18h** (253 mg, 1.0 mmol), **3b** (401 mg, 1.3 mmol) and $Me_3SiOTf$ (0.05 mL, 0.3 mmol); m.p. 133–135 °C. $^1$H NMR (250 MHz, $CDCl_3$): $\delta$ = 1.36 (t, $J$ = 7.2 Hz, 3 H, $CH_3$), 4.37 (q, $J$ = 7.2, 14.2 Hz, 2 H, $OCH_2$), 6.90 (d, $J$ = 8.8 Hz, 1 H, ArH), 7.51–7.60 (m, 2 H, ArH), 7.8 (d, $J$ = 2.1 Hz, 1 H, ArH), 8.09 (d, $J$ = 2.1 Hz, 1 H, ArH), 11.50 (s, 1 H, OH), 11.88 (s, 1 H, OH) ppm. $^{13}$C NMR (62 MHz, $CDCl_3$): $\delta$ = 14.0 ($CH_3$), 62.7 ($OCH_2$), 110.4, 113.5, 119.8, (C), 120.7 (CH), 123.2, 128.3 (C), 130.4, 134.5, 136.0, 139.1 (CH), 160.8, 161.9 (C–OH), 169.2, 196.6 (C=O) ppm. IR (neat): $\tilde{\nu}$ = 3068 (w), 2917 (w), 1686 (s), 1625 (s), 1595 (s), 1567 (s), 1343 (s), 1164 (s), 681 (s) cm$^{-1}$. MS (GC = 70 eV): *m/z* (%): 401 [M]$^+$ ([$^{37}$Cl], 12), 399 [M]$^+$ (77), 354 (33), 200 (100), 198 (75), 154 (67). HRMS (EI): calcd. for $C_{16}H_{12}BrClO_5$ [M]$^+$ ($^{35}$Cl, $^{81}$Br): 399.95307; found 399.952332.

**Ethyl 3-Chloro-5-(3,5-dibromo-2-hydroxybenzoyl)-2-hydroxybenzoate (19i):** Compound **19i** was isolated as a yellow solid (0.360 g, 75%) from **19i** (0.332 g, 1.0 mmol), $Me_3SiOTf$ (0.05 mL, 0.3 mmol) and **3b** (0.402 g, 1.3 mmol) in $CH_2Cl_2$ (15 mL); m.p. 166–169 °C. $^1$H NMR (250 MHz, $CDCl_3$): $\delta$ = 1.43 (t, $^3J$ = 7.1 Hz, 3 H, $OCH_2CH_3$), 4.48 (q, $^3J$ = 7.1 Hz, 2 H, $OCH_2CH_3$), 7.64 (d, $^4J$ = 2.2 Hz, 1 H, CH), 7.91 (d, $^4J$ = 2.2 Hz, 1 H, CH), 7.95 (dd, $^4J$ = 2.2 Hz, 1 H, CH), 8.16 (d, $^4J$ = 2.2 Hz, 1 H, CH), 11.99 (d, $^4J$ = 0.5 Hz, 1 H, OH), 12.13 (d, $^4J$ = 0.5 Hz, 1 H, OH) ppm. $^{13}$C NMR (75 MHz, $CDCl_3$): $\delta$ = 14.1 ($OCH_2CH_3$), 62.8 ($OCH_2CH_3$), 110.4, 113.5, 120.4, 123.5, 127.7 (C), 130.6, 133.8, 136.0, 141.4 (CH), 158.4, 161.1 (COH), 169.1, 196.2 (C=O) ppm. IR (ATR): $\tilde{\nu}$ = 3070 (w), 2979 (w), 2930 (w), 2872 (w), 1723 (w), 1714 (w), 1681 (w), 1651 (w), 1651 (w), 1626 (s), 1590 (m), 1566 (m), 1552 (m), 1444 (m), 1405 (w), 1377 (s), 1339 (s), 1300 (s), 1256 (m), 1227 (s), 1174 (m), 1096 (w), 1016 (w), 1001 (w) cm$^{-1}$. MS (GC-MS, 70 eV): *m/z* (%) = 476 [M]$^+$ (23), 280 (56), 279 (53), 278 (100), 276 (47), 200 (40), 181 (60), 154 (92). HRMS (EI): calcd. for $C_{16}H_{11}O_5Br_2Cl$ [M]$^+$ 475.86563; found 475.864230.

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