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Easy Access to New Heterocyclic Systems: 1,4-Oxazine and Substituted 1,4-Oxazines

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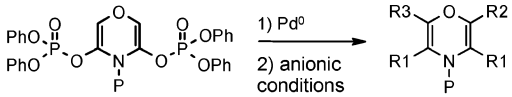

R_1, R_2, R_3, R_4 = aryl, heteroaryl, alkenyl, alkynyl, alcohol, SiR_3, SnR_3, H

In the course of our investigations on the synthesis of new nitrogen heterocyclic derivatives, we were interested in the synthesis and study of new 1,4-oxazine rings. To this aim, the desired bisvinylphosphate was prepared from *N*-Boc morpholine-3,5-dione and was then engaged in palladium-catalyzed reactions (reduction, Suzuki, and Stille cross-coupling reactions). The 1,4-oxazine and its corresponding 3,5-disubstituted derivatives were obtained in fair to good yields and were then functionalized under anionic conditions.

Introduction

Ever-growing knowledge in molecular cell biology and recent progress in biomedical research have considerably increased the number of known targets for therapeutic intervention. As a result, imperative demand for making diverse small molecule libraries available for biological screening has constituted a powerful driving force for advanced synthetic organic chemistry.[1] Identifying improved methods for heterocycle synthesis and, essentially, giving access to new heterocyclic scaffolds are of prime importance. In connection with our efforts to develop synthetic routes to nitrogen-containing heterocyclic derivatives,[2,5] and particularly six-membered ones, we intended to prepare the oxazine systems **I** or **II** (cf. Figure 1) and various substituted derivatives of this kind (compounds **III**, **IV**, and **V**). These compounds are valuable building blocks for the synthesis of more complex derivatives. Although the importance of benzo-fused 1,4-oxazines has been extensively documented, principally as a result of pharmaceutical and medicinal research,[3] to the best of our knowledge, there is one sole literature precedent for the study of the original 1,4-oxazine heterocycle.[4]

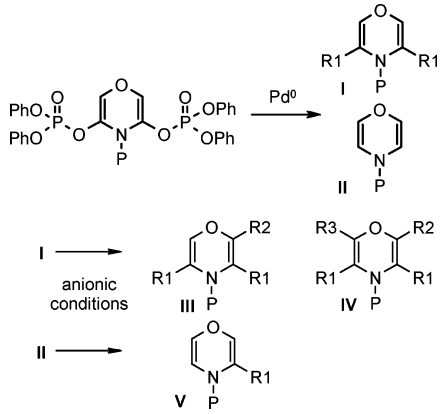

FIGURE 1. Access to 1,4-oxazine (**I**) and mono-, tri-, and tetrasubstituted derivatives (**III**, **IV**, and **V**).

As part of our interest in using readily available enol phosphates for the synthesis of new heterocyclic compounds,[5,6] we wish to report herein a full account of our investigations on 1,4-oxazine derivatives. In previous reports,[5] we have outlined the synthesis of 2,6-disubstituted 1,4-dihydropyridines from imide derivatives by way of Pd-catalyzed coupling reaction of the corresponding bisvinylphosphates. In this study, we explored the possibility of synthesizing 1,4-oxazine and its corresponding 3,5-disubstituted derivatives by the same method. We considered then functionalizing these new scaffolds under anionic conditions to get easy access to mono-, tri-, and tetrasubstituted 1,4-oxazines with diversity on the side chains.

(1) (a) For diversity-oriented synthesis, see: Tan, D. S. *Nat. Chem. Biol.* **2005**, *1*, 74. (b) Burke, M. D.; Schreiber, S. L. *Angew. Chem., Int. Ed.* **2004**, *43*, 46. (c) Schreiber, S. L. *Science* **2000**, *287*, 1964.

(2) (a) Lepifre, F.; Buon, C; Roger, P.-Y.; Bouyssou, P.; Coudert, G. *Tetrahedron Lett.* **2004**, *45*, 8257. (b) Lepifre, F.; Clavier, S.; Bouyssou, P.; Coudert, G. *Tetrahedron* **2001**, *57*, 6969. (c) Buon, C.; Chacun-Lefevre, L.; Rabot, R.; Bouyssou, P.; Coudert, G. *Tetrahedron* **2000**, *56*, 605. (d) Lepifre, F.; Buon, C.; Rabot, R.; Bouyssou, P.; Coudert, G. *Tetrahedron Lett.* **1999**, *40*, 6373.

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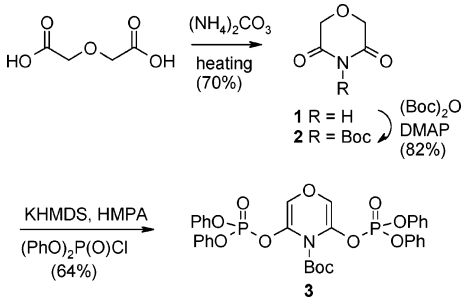
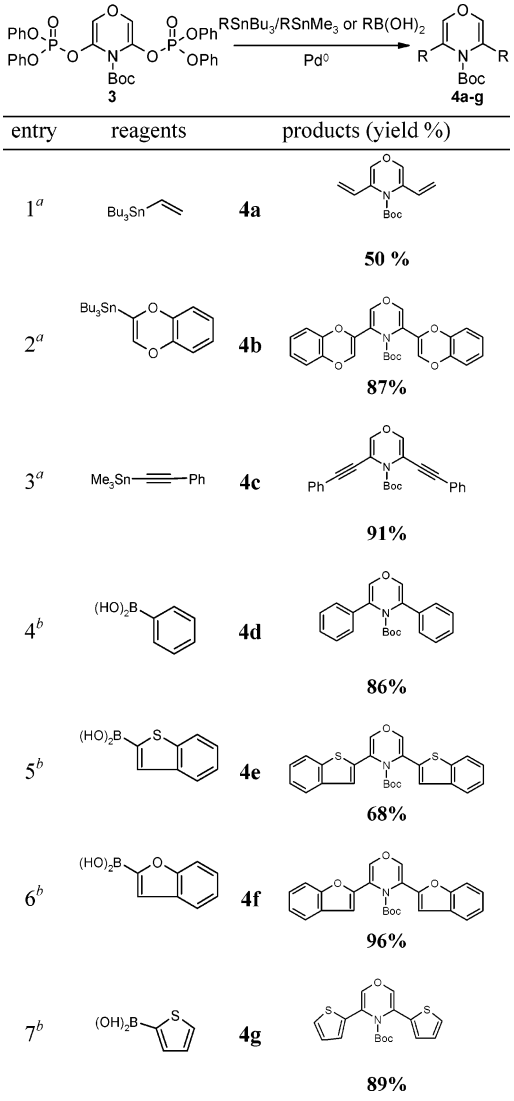
SCHEME 1. Preparation of the Bisvinylphosphate 3



Results and Discussion

On the basis of our previous results,[5] a synthesis of the desired bisvinylphosphate **3** was envisaged starting from the *N*-Boc morpholine-3,5-dione **2** (cf. Scheme 1). The latter was obtained from commercially available morpholine 3,5-dione **1**, otherwise easily prepared by fusing diglycolic acid with ammonium carbonate.[7] Treatment of the *N*-Boc derivative **2** with KHMDS (2.5 equiv) in the presence of HMPA (2.5 equiv) in THF at −78 °C provided a bispotassium enolate, which was trapped by reaction with diphenylchlorophosphate (2.2 equiv, THF, −78 °C). After workup and purification by silica gel chromatography, the required bisvinylphosphate **3** was isolated in 64% yield.[8] By using LiHMDS as a base under the same conditions, compound **3** was isolated in 55% yield. It is noteworthy that the use of LDA as a base for the formation of the bisenolate intermediate gave only very poor yields (10%), due to unreacted starting material, even in the presence of HMPA.

TABLE 1. Suzuki and Stille Coupling Reactions on Bisvinylphosphate 3



[a] Reagents and conditions: 10 mol % of $Pd(PPh_3)_4$, 5 equiv of $RSnBu_3$, 6 equiv of LiCl, THF, 2 h, reflux.[10] [b] Reagents and conditions: (i) 10 mol % of $PdCl_2(PPh_3)_2$, THF, rt, 15 min; (ii) 5 equiv of $RB(OH)_2$, 3 equiv of $Ba(OH)_2{\cdot}8H_2O$, EtOH, reflux, 1 h.

In order to obtain symmetrical 3,5-disubstituted oxazines **I**, the original bisvinylphosphate **3** was then subjected to Stille or Suzuki coupling reactions. The Stille coupling reaction was performed with tin reagents in the presence of catalytic $Pd(PPh_3)_4$ and anhydrous LiCl in refluxing THF for 2 h and afforded the desired compounds **4a**−**c** in fair to good yields. The results of these coupling reactions are presented in Table 1 (entries 1−3). One of the attractive features of our approach lies in its inherent versatility since a wide range of reactants could be used. A Pd-catalyzed Suzuki−Miyaura coupling reaction of the bisvinylphosphate **3** was also applied. By using classical conditions, such as phenylboronic acid, $PdCl_2(PPh_3)_2$ as a catalyst, aqueous Na_2CO_3 (2 M), a few drops of EtOH, in

(3) For a recent review on biologically active 1,4-benzoxazine derivatives, see the following: (a) Achari, B.; Mandal, S. B.; Dutta, P. K.; Chowdhury, C. *Synlett* **2004**, 2449 and references therein. For some recent examples, see also the following: (b) Rybczynski, P. J.; Zeck, R. E.; Dudash, J.; Combs, D. W.; Burris, T. P.; Yang, M.; Osborne, M. C.; Chen, X.; Demarest, K. T. *J. Med. Chem.* **2004**, *47*, 196. (c) Yang, W.; Wang, Y.; Ma, Z.; Golla, R.; Stouch, T.; Seethala, R.; Johnson, S.; Zhou, R.; Güngör, T.; Feyen, J. H. M.; Dickson, J. K. *Bioorg. Med. Chem. Lett.* **2004**, *14*, 2327. (d) Thomas, A.; Ross, R. A.; Saha, B.; Mahadevan, A.; Razdan, R. K.; Pertwee, R. G. *Eur. J. Pharmacol.* **2004**, *487*, 213. (e) Caliendo, G.; Perissutti, E.; Santagada, V.; Fiorino, F.; Severino, B.; Cirillo, D.; d'Emmanuele di Villa Bianca, R.; Lippolis, L.; Pinto, A.; Sorrentino, R. *Eur. J. Med. Chem.* **2004**, *39*, 815. (f) Dougherty, K. J.; Bannatyne, B. A.; Jankowska, E.; Krutki, P.; Maxwell, D. J. *J. Neurosci.* **2005**, *25*, 584. (g) Stefanic Anderluh, P.; Anderluh, M.; Ilas, J.; Mravljak, J.; Sollner Dolenc, M.; Stegnar, M.; Kikelj, D. *J. Med. Chem.* **2005**, *48*, 3110. (h) Lee, H. J.; Ban, J. Y.; Seong, Y. H. *Life Sci.* **2005**, *78*, 294. (i) Xu, D.; Chiaroni, A.; Fleury, M.-B.; Largeron, M. *J. Org. Chem.* **2006**, *71*, 6374.

(4) The sole literature precedent: Herbert, B. *Arch. Pharm.* **1982**, *315*, 684.

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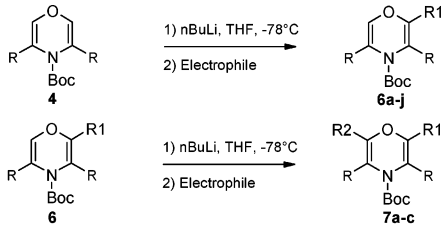
(8) The bisvinylphosphate **3** is stable for several months at 4 °C under argon atmosphere.

TABLE 2. Preparation of Tri- and Tetrasubstituted Derivatives 6a−k and 7a−c



entry	electrophiles	products (yield %)	entry	electrophiles	products (yield %)
1[a]	Bu_3SnCl	**6a** (70%)	10[a]		**6j**[14] (47%)
2[b]	TMSCl	**6b** (81%)	11[c]		**6k**[14] (44%)
3[a]		**6c**[13] (79%)	12[d]	DMF	**7a** (58%)
4[b]		**6d** (78%)	13[d]	Bu_3SnCl	**7b** (37%)
5[b]	DMF	**6e** (97%)	14[e]	DMF	**7c** (76 %)
6[b]	$CNCO_2Me$	**6f** (64%)			
7[b]		**6g** (76%)			
8[b]		**6h** (54%)			
9[b]	I_2	**6i**[14] (95%)			

[a] Reagents and conditions: (i) 1.5 equiv of *n*-BuLi, THF, −78 °C, 45 min; (ii) 3 equiv of electrophile, −78 °C, 1 h. [b] Reagents and conditions: (i) 2 equiv of *n*-BuLi, THF, −78 °C, 45 min; (ii) 2 equiv of HMPA, −78 °C, 10 min; (iii) 5 equiv of electrophile, −78 °C, 3 h. [c] Reagents and conditions: (i) 1.5 equiv of *n*-BuLi, 1.2 equiv of HMPA, THF, −78 °C, 45 min; (ii) 3 equiv of electrophile, −78 °C, 1 h. [d] Reagents and conditions: (i) 3 equiv of TBDMSCl, 6 equiv of imidazole, DMF, 40 °C, 20 h (91% yield); (ii) conditions described in a. [e] Reagents and conditions: (i) 3 equiv of TBDMSCl, 6 equiv of imidazole, DMF, 50 °C, 14 h (78% yield); (ii) conditions described in a.

THF under reflux,[5] the desired disubstituted oxazine **4d** was isolated but in 45% yield only. However, using a stronger base, $Ba(OH)_2 \cdot 8H_2O$,[9] the expected bisphenyl compound **4d** could be isolated in high yield (86%). By applying these conditions in the presence of typical aryl or heteroaryl boronic acids, the corresponding 3,5-disubstituted oxazines **4d−g** were then isolated in good yields (cf. Table 1, entries 4−7).

The reductive cleavage of the vinyl phosphate group was also investigated. We had previously shown that it was possible to reduce the vinylphosphate moiety by adapting a procedure first described by Cacchi.[2b,11] Hence, treatment of bisvinylphosphate **3** with triethylammonium formate, palladium acetate, and triphenylphosphine in THF led to the core heterocyclic system **5** in 70% yield (Scheme 2). To the best of our knowledge, so far, there has been no description in the literature of 1,4-oxazine **5**. This original derivative **5** might hopefully find some useful application as a building block in organic and medicinal chemistry.

In order to take advantage of these 1,4-oxazine scaffolds, we next focused on studying their reactivity toward organometallic reagents. On the basis of our previous results in the 1,4-benzoxazine series,[2c] we investigated the functionalization of these 1,4-oxazine derivatives by means of lithium anion species derived from a hydrogen−metal interchange in the presence of

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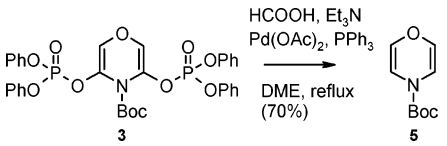
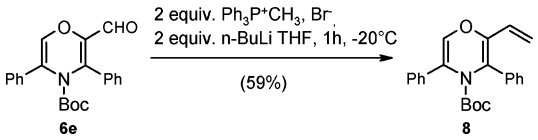
(11) Cacchi, S.; Morera, E.; Ortar, G. *Tetrahedron Lett.* **1984**, *25*, 4821.

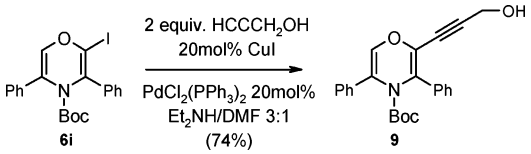
SCHEME 2. Catalyzed Palladium Reduction of Bisvinylphosphate 3



SCHEME 3. Wittig Reaction on Compound 6e



SCHEME 4. Sonogashira Reaction on Compound 6i

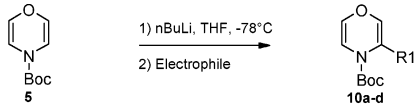


alkylithium reagents. This methodology, which offers the opportunity to easily introduce various substituents on these compounds, should be particularly useful for the development of libraries of biologically relevant 1,4-oxazine derivatives. Hence, we decided first of all to introduce various substituents at C-2 and/or C-6 on the 3,5-disubstituted 1,4-oxazines **4**. The first attempts were made on bisphenyl derivative **4d**, chosen as a model compound. The best results were obtained using *n*-BuLi as a base at −78 °C for 45 min in the presence or absence of HMPA.[12] The 2-lithio derivatives were trapped by a range of electrophiles (3−5 equiv), leading to the required trisubstituted derivatives **6a**−**i** in fair to good yields (cf. Table 2). Derivative **6e**, bearing an aldehyde function at C-2, was successfully submitted to a Wittig reaction (cf. Scheme 3), which provided the conjugated diene **8** in good yield. The latter is, for instance, a potential precursor in Diels−Alder reactions. Compounds **6a** and **6i** obtained in satisfying yield are very useful compounds in metal-catalyzed cross-coupling reactions. A Sonogashira coupling reaction[13] was also successfully realized on the iodo compound **6i** (cf. Scheme 4). Studies along this line are currently underway in our laboratory. Interestingly, the same sequence as above was effective with compounds **4f**, disubstituted by a benzofuranyl group, and **4c**, disubstituted by a phenyl ethynyl group, leading, respectively, to the trisubstituted derivatives **6j** and **6k** in moderate yields.

As our goal was to introduce functional groups around the 1,4-oxazine ring for additional decoration, we then attempted to introduce a fourth substituent. Following the same procedure as above, tetrasubstituted compounds **7a**−**c** were isolated in moderate yields (cf. Table 2, entries 12−14). These results might be explained by a lack of reactivity of trisubstituted derivatives. However, it should be noted that in these cases the alcohol group present on compounds **6c** and **6k** should first be protected, that is, by a silyl group, in order to avoid side reactions.[14] Moreover, the preparation of tetrasubstituted derivatives, as a one-pot procedure, directly from the disubstituted compounds **6** did not increase the yields of the reaction. Similarly, nor did the use of another base such as LDA.

(12) Addition of HMPA, which stabilizes the formed anion, was in most cases useful to improve the reaction's yield.

TABLE 3. Functionalization of the 1,4-Oxazine 5[a]



entry	electrophiles	products (yield %)
1	Bu_3SnCl	**10a** (55%)
2	CNCOOMe	**10b** (82%)
3	Cyclohexanone	**10c** (64%)
4	TMSCl	**10d** (100%)

[a] Reagents and conditions: (i) 1.1 equiv of *n*-BuLi, THF, −78 °C, 5 min; (ii) 5 equiv of electrophile, −78 °C, 30 min.

Encouraged by these promising results, we turned then our attention toward the preparation of the monosubstituted derivatives **10** from the simple 1,4-oxazine ring **5** (cf. Table 3). In fact, we expected the regioselective deprotonation of this heterocyclic system at carbon C-3, in the α position to nitrogen bearing an electron-withdrawing group, rather than at carbon C-2. As a matter of fact, treatment of 1,4-oxazine **5** at −78 °C with *n*-BuLi as a base afforded the 3-lithio derivative,[15] which was quenched with various electrophiles, leading to original compounds **10a**−**d**. For instance, **10a** isolated in fair yield could then be submitted to a palladium cross-coupling reaction and thus offers an easy access to a range of 3-substituted oxazines. According to the nature of the substituents previously introduced at carbon C-3, its metalation directing potency could also be used to set the deprotonation on carbon C-2 with a view to finally obtaining 2,3-disubstituted oxazines. A lack of directing effect, on the contrary, could allow deprotonation preferentially at the C-5 carbon. Hence, introduction of new substituents at this position led in this case to unsymmetrical 3,5-disubstituted oxazines. Elaboration of these derivatives is further investigated and their properties further studied.

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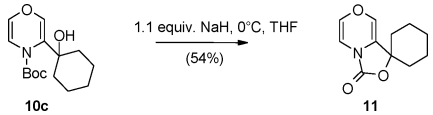
(14) In the case of compounds **6c** and **6k**, only 1.5 equiv of *n*-BuLi (instead of 2 equiv) was used in order to preclude the reaction of the base directly on the 3,4,5-trimethoxyaldehyde. The obtained corresponding alcohol is difficult to separate effectively from the desired trisubstituted compound.

(15) The regioselective functionalization of the oxazine **5** at the C-3 position was confirmed by the following reaction. The analytical data of compound **11** are depicted in the Experimental Section.



In conclusion, we have shown that the Suzuki and Stille coupling reactions realized on bisvinylphosphate, derived from *N*-Boc morpholine-3,5-dione, give an easy access to a new family of heterocyclic compounds. These oxazinic derivatives constitute ideal precursors for the elaboration of more complex molecules likely to be of interest in medicinal chemistry. Finally, our strategy allows access to various 1,4-oxazines with a high level of diversity and with different functional groups that can be used for further decoration of the scaffold. Studies are currently in progress in our laboratory with a view to exploit the potentiality furnished by this original heterocyclic system.

Experimental Section

Only representative procedures and characterizations of the products are described here. Full details can be found in the Supporting Information.

Preparation of the 3,5-Bis{(phenyloxy)[bisphosphoryl]oxy}-4-(*tert*-butoxycarbonyl)-[1,4]-oxazine (3). A solution of KHMDS (1.159 g, 5.81 mmol) in THF (20 mL) was cooled to −78 °C under argon. Subsequently, a solution of **2** (0.500 g, 2.32 mmol), distilled diphenyl chlorophosphate (1.373 g, 5.11 mmol), and distilled HMPA (1.041 g, 5.81 mmol) in THF (5 mL) was added dropwise over 5 min. After 15 min at −78 °C, the reaction mixture was diluted with Et_2O (50 mL). Water (50 mL) was then added, and the mixture was extracted with EtOAc. The organic phase was dried over anhydrous $MgSO_4$ and concentrated. Flash chromatography (petroleum ether/EtOAc, 7:3 + 0.1% NEt_3) afforded **3** (1.010 g, 64%) as a white solid: mp 86−87 °C; IR (KBr) 3101, 1734, 1487, 1305, 1187 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.14−7.32 (m, 20H), 6.74 (d, $^4J_{HP}$ = 3.1 Hz, 2H), 1.41 (s, 9H); ^{13}C NMR ($CDCl_3$) δ 152.8 (s), 150.4 (s), 150.3 (s), 131.9 (s), 131.8 (s), 130.5 (s), 130.4 (s), 129.9 (d), 129.7 (s), 125.8 (d), 120.2 (d), 120.1 (d), 84.3 (s), 27.9 (q). HRMS (TOF ES+) *m*/*z* $[M + Na]^+$ calcd for $C_{23}H_{31}NO_{11}{}^{23}NaP_2$: 702.1270; found 702.1329.

General Procedure (A) for Stille-Type Coupling Reactions. (*E*,*E*)-4-(*tert*-Butoxycarbonyl)-3,5-diethenyl-[1,4]-oxazine (4a). To a stirred solution of bisvinylphosphate **3** (0.150 g, 0.22 mmol) in THF (1.7 mL), tributyl(vinyl)tin (0.350 g, 1.10 mmol) and LiCl (0.056 g, 1.32 mmol) were added under argon. Then, the flask was evacuated and backfilled with argon three times. Under argon, $Pd(PPh_3)_4$ (0.026 g, 0.02 mmol) was added, and the mixture was refluxed for 2 h. After cooling, the reaction mixture was filtered through Celite and was washed with EtOAc. The organic phase was washed with brine, dried over anhydrous $MgSO_4$, and concentrated. Flash chromatography (petroleum ether/EtOAc, 95:5) afforded **4a** (0.026 g, 50%) as a colorless oil: IR (NaCl) 2964, 2370, 1700, 1260 cm^{-1}; ^1H NMR ($CDCl_3$) δ 6.66 (s, 2H), 6.23 (dd, *J* = 11.0 and 17.3 Hz, 2H), 5.34 (dd, *J* = 1.0 and 17.0 Hz, 2H), 5.10 (dd, *J* = 1.0 and 10.8 Hz, 2H), 1.44 (s, 9H). Slow decomposition of **4a** over several hours precluded satisfactory ^{13}C NMR and HRMS analysis.

General Procedure (B) for Suzuki−Miyaura-Type Coupling Reactions. 4-(*tert*-Butoxycarbonyl)-3,5-diphenyl-[1,4]-oxazine (4d). To a solution of bisvinylphosphate **3** (0.240 g, 0.35 mmol) in THF (2.5 mL) under argon was added $PdCl_2(PPh_3)_2$ (0.025 g, 0.04 mmol). The flask was evacuated and backfilled with argon three times, and the mixture was stirred for 15 min. Then, phenylboronic acid (0.215 g, 1.77 mmol), $Ba(OH)_2 \cdot 8H_2O$ (0.334 g, 1.06 mmol), H_2O (0.7 mL), and few drops of EtOH were added. The mixture was refluxed for 1 h. After cooling, the reaction mixture was filtered through Celite and was washed with EtOAc. The organic phase was washed with brine, dried over anhydrous $MgSO_4$, and concentrated. Flash chromatography (petroleum ether/EtOAc, 9:1) afforded **4d** (0.101 g, 86%) as white crystals: mp 125 °C; IR (KBr) 3088, 2977, 1718, 1653, 1306, 1122 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.25−7.48 (m, 10H), 6.76 (s, 2H), 1.09 (s, 9H); ^{13}C NMR ($CDCl_3$) δ 153.5 (s), 137.7 (s), 134.9 (s), 128.6 (d), 127.4 (d), 126.7 (s), 126.0 (s), 124.4 (d), 81.7 (s), 27.7 (q). HRMS (EI) *m*/*z* $[M]^{+\bullet}$ calcd for $C_{21}H_{21}NO_3$: 335.1521; found 335.1534.

Preparation of the 4-(*tert*-Butoxycarbonyl)-[1,4]-oxazine (5). To a solution of bisvinylphosphate **3** (3.235 g, 4.76 mmol) in DME (20 mL), under argon, were added $Pd(OAc)_2$ (0.009 g, 0.38 mmol) and PPh_3 (0.200 g, 0.76 mmol). The flask was evacuated and backfilled with argon three times, and the mixture was stirred for 5 min. Then, this solution was cannulated dropwise, under argon, into a degassed solution of formic acid (0.876 g, 19.04 mmol) and triethylamine (2.890 g, 28.56 mmol) in DME (20 mL). The mixture was refluxed for 40 min at 85 °C. After cooling, the reaction mixture was filtered through Celite and was washed with EtOAc. The organic phase was washed with brine, dried over anhydrous $MgSO_4$, and concentrated. Flash chromatography (petroleum ether) afforded **5** (0.611 g, 70%) as a colorless oil: IR (KBr) 2983, 1700, 1684, 1653 cm^{-1}; ^1H NMR ($CDCl_3$) δ 5.97 (dd, *J* = 1.6 and 4.7 Hz, 1H), 5.82 (dd, *J* = 1.9 and 5.3 Hz, 1H), 5.60 (d, *J* = 5.0 Hz, 1H), 5.47 (d, *J* = 5.0 Hz, 1H), 1.47 (s, 9H); ^{13}C NMR ($CDCl_3$) δ 148.2 (s), 130.3 (d), 128.9 (d), 109.3 (d), 108.7 (d), 81.6 (s), 28.4 (q). HRMS (EI) *m*/*z* $[M]^{+\bullet}$ calcd for $C_9H_{13}NO_3$: 183.0895; found 183.0913.

General Procedure for the Preparation of the Trisubstituted Derivatives. 4-(*tert*-Butoxycarbonyl)-3,5-diphenyl-2-trimethylsilanyl-[1,4]-oxazine (6b). A solution of 4-(*tert*-butoxycarbonyl)-3,5-diphenyl-[1,4]-oxazine **4d** (0.100 g, 0.30 mmol) in THF (7 mL) was cooled to −78 °C under argon. Subsequently, *n*-butyllithium (0.373 mL, 1.6 M in hexane, 0.60 mmol) was added dropwise, and the reaction mixture was stirred for 45 min at −78 °C. Distilled HMPA (0.107 g, 0.60 mmol) was then added. After stirring for 10 min at −78 °C, a solution of trimethylsilyl chloride (0.162 g, 1.49 mmol) in THF (1 mL), previously dried over molecular sieves (4 Å), was added dropwise. After 1 h at −78 °C, the reaction was quenched by slow addition of water. The aqueous phase was then extracted with EtOAc, and the organic phase was washed with brine. The organic phase was dried over anhydrous $MgSO_4$ and concentrated. Flash chromatography (petroleum ether/EtOAc, 95:5) afforded **6b** (0.098 g, 81%) as a colorless oil: IR (NaCl) 2979, 1760, 1695, 1600, 1451, 1149 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.16−7.39 (m, 10H), 6.74 (s, 1H), 0.99 (s, 9H), −0.10 (s, 9H); ^{13}C NMR ($CDCl_3$) δ 153.1 (s), 151.8 (s), 139.4 (d), 136.9 (s), 136.5 (s), 135.0 (s), 129.5 (d), 128.5 (d), 128.0 (d), 127.5 (s), 127.1 (d), 124.1 (d), 81.3 (s), 27.9 (q), −0.9 (q). HRMS (EI) *m*/*z* $[M]^{+\bullet}$ calcd for $C_{24}H_{29}NO_3Si$: 407.19167; found 407.1928.

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Supporting Information Available: Detailed experimental procedures, full characterization of new compounds, and ^1H and ^{13}C NMR spectra for compounds **1**−**10**. This material is available free of charge via the Internet at http://pubs.acs.org.

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