DOI 10.1515/hc-2014-0004 — Heterocycl. Commun. 2014; 20(2): 129–132

Naredla Anitha, K. Venugopal Reddy* and Y. Jayaprakash Rao

Synthesis of novel 7-(heteryl/aryl)chromones via Suzuki coupling reaction

Abstract: A series of new 7-heteroaryl and arylchromones **6a–l** were synthesized in moderate to good yields by the Suzuki reaction of the triflate (pseudo halide) **5** and a variety of heteroaryl and aryl boronic acids. The resulting products may be used as precursors for synthesis of potentially relevant compounds. The structures of all synthesized compounds were established based on IR, ^{1}H NMR, ^{13}C NMR, and DIPMS.

Keywords: heteroaryl/arylboronic acids; heteroaryl/arylchromones; pseudo halides; Suzuki coupling.

***Corresponding author: K. Venugopal Reddy,** Department of Chemistry, Osmania University, Hyderabad 500007, Andhra Pradesh, India, e-mail: kvgr1951@gmail.com
Naredla Anitha: Product Delivery Team, Integrated Product Development, Innovation plaza, Dr. Reddy's Laboratories Ltd., Baachupalli, Hyderabad 500072, Andhra Pradesh, India
Y. Jayaprakash Rao: Department of Chemistry, University College of Science Saifabad, Osmania University, Hyderabad 5000007, Andhra Pradesh, India

Introduction

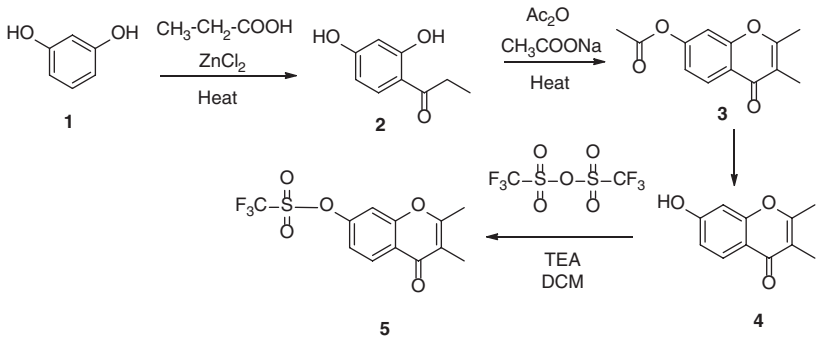
Chromones (4*H*-1-benzopyran-4-ones) are naturally occurring oxygen-containing heterocyclic compounds, which perform important biological functions in nature [1] and are a recognized pharmacophore of a large number of bioactive molecules of either natural or synthetic origin. Their derivatives are antibacterial, anticancer, antioxidant, estrogenic agents [2–4], and have been considered as privileged structures in drug development [5]. The Suzuki coupling reaction is the palladium catalyzed C-C bond formation reaction of organoboran compounds with organic halides or pseudo halides [6]. The Suzuki reaction has recently gained much prominence because it is suitable for large-scale synthesis including the industrial synthesis of pharmaceuticals and fine chemicals [7–9]. The key advantages of Suzuki coupling are mild reaction conditions and commercial availability of a wide variety of heterocyclic and arylboronic acids that are safer than other organometallic reagents [10–14]. The Suzuki coupling process tolerates many functional groups present in substrates [15], and it proceeds well in the presence of water. In addition, the inorganic byproduct of the reaction is non-toxic and easily removed from the mixture. This report presents synthesis of 7-heteryl/aryl-2,3-dimethylchromones starting from 7-hydroxy-2,3-dimethylchromones using the Suzuki coupling reaction. To the best of our knowledge, there are no reports in the literature on C-C bond formation at C-7 position of chromones.

Results and discussion

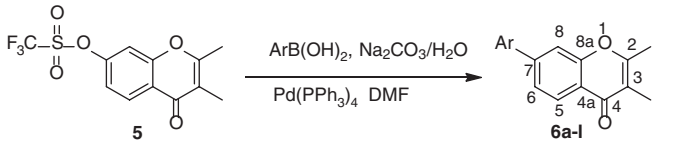
The aim of the present work was to develop a simple and efficient procedure for the preparation of new chromone derivatives bearing substituted heteroaryl and aryl moieties by Suzuki cross coupling reactions. Aryl triflates are good leaving groups that are more reactive than aryl chlorides, bromides, and more stable to moisture and air. The key intermediate chromenyl triflate **5** was prepared by a conventional method, which involves treatment of the corresponding 7-hydroxy-2,3-dimethylchromone **4** with triflic anhydride in the presence of base triethylamine [16, 17]. Compound **4** [18, 19] was prepared from resorcinol according to a procedure in the literature (Scheme 1). The structure of chromenyl triflate **5** was established by spectral analysis. The reaction of the substrate **5** with boronic acids and esters in the presence of $Pd(PPh_3)_4$, sodium carbonate in *N,N*-dimethylformamide under mild conditions afforded the corresponding heteroaryl and arylchromones **6a–l** in moderate to good yields (Scheme 2). Because aryl triflates are sensitive to strong bases, sodium carbonate was used to carry out the Suzuki reaction. The structures of compounds **6a–l** were confirmed by spectral analysis.

Conclusions

A simple and efficient method of synthesis of heteryl- and aryl-substituted chromones **6a–l** using the Suzuki cross coupling reaction was described.



Scheme 1 Synthesis of 2,3-dimethyl-4-oxo-4*H*-chromen-7-yl trifluoromethanesulfonate (**5**).



6a: Ar = 5-methyl-2-furyl
6b: Ar = 2,3-diflurophenyl
6c: Ar = 3-flurophenyl
6d: Ar = 3,4-dimethylphenyl
6e: Ar = 2-thienyl
6f: Ar = 4-chloro-3-pyridyl
6g: Ar = 2-methoxyphenyl
6h: Ar = 4-fluoro-3-methoxyphenyl
6i: Ar = 3-cyanophenyl
6j: Ar = 2-trifluromethylphenyl
6k: Ar = 3-chloro-4-methylphenyl
6l: Ar = 3-chloro-4-flurophenyl

Scheme 2 Synthesis of 7-(aryl/heteryl)-substituted chromones **6a–l**.

Experimental

Chromenyl triflate **5** [16, 17] and 7-hydroxy-2,3-dimethylchromone **4** [18, 19] were prepared by the reported procedures. Melting points were obtained on a Polmon instrument, model MP 96, and were uncorrected. IR spectra were recorded in KBr pellets on a Fourier transform Perkin-Elmer model 337 instrument. ^{1}H NMR (400 MHz) and ^{13}C NMR (100.6 MHz) spectra were recorded in $CDCl_3$ solution on a Bruker 400 spectrometer using TMS as an internal standard. Mass spectral data were obtained with an Agilent-6310 ion trap mass spectrometer.

General procedure for synthesis of 7-(aryl and heteroaryl)-2,3-dimethyl-4-chromones 6a–l

A mixture of chromenyl triflate **5** (0.8 mmol), a boronic acid (1.2 mmol), and aqueous Na_2CO_3 (1 mL, 2 M) in DMF was purged with nitrogen with stirring for 30 min, and then treated with 4 mol% of tetrakis(triphenylphosphine)palladium(0). The reaction mixture was stirred at 60°C for 3–4 h. After completion of the reaction, the mixture was cooled to room temperature, diluted with water (50 mL), and extracted with diethyl ether (3 × 30 mL). The extract was dried over Na_2SO_4 and concentrated under reduced pressure to give crude compounds **6a–l**, which were purified by column chromatography on silica gel.

2,3-Dimethyl-7-(5-methyl-2-furyl)-4*H*-4-chromone (6a) Yield 60%; white solid; mp 123°C; IR: 1633.0 cm^{-1} (C=O); ^{1}H NMR: δ 8.14 (d, *J* = 8.3 Hz, H-5), 7.60 (m, H-6, H-8), 6.71 (d, *J* = 3.0 Hz, H-3′), 6.10 (d, *J* = 3.0 Hz, H-4′), 2.40 (s, CH_3-2), 2.39 (s, CH_3-5′), 2.05 (s, CH_3-3); ^{13}C NMR: δ 177.6 (C=O), 166.9 (C-2′), 161.8 (C-2), 156.4 (C-8a), 156.2 (C-5′), 142.4 (C-7), 128.4 (C-4′), 124.8 (C-3′), 124.4 (C-4a), 123.5 (C-5), 121.4 (C-6), 116.7 (C-3), 115.1 (C-8), 20.2 (5′-CH_3), 18.7 (2-CH_3), 10.2 (3-CH_3). HR-ESI-MS. Calcd for $C_{16}H_{14}O_3^+$: m/z 254.0943, found: m/z 254.0938.

7-(2,3-Diflurophenyl)-2,3-dimethyl-4*H*-4-chromone (6b) Yield 70%; mp 136°C; IR: 1638.0 cm^{-1} (C=O); ^{1}H NMR: δ 8.28 (d, *J* = 8.0 Hz, H-5), 7.61 (d, *J* = 1.2 Hz, H-8), 7.54 (dd, *J* = 8.0 Hz, *J* = 1.2 Hz, H-6), 7.29–7.20 (m, H-3′, H-4′, H-5′), 2.46 (s, CH_3-2), 2.11 (s, CH_3-3); ^{13}C NMR: δ 177.4 (C=O), 162.2 (C-2), 155.6 (C-8a), 148.2 (C-2′), 142.7 (C-3′), 143.6 (C-5), 136.7 (C-7), 129.6 (C-1′), 127.3 (C-6′), 126.7 (C-5′), 123.3 (C-4a), 121.7 (C-4′), 117.3 (C-6), 117.1 (C-3), 115.4 (C-8), 18.6 (2-CH_3), 10.1 (3-CH_3). HR-ESI-MS: Calcd for $C_{17}H_{12}F_2O_2^+$: m/z 286.0805, found: m/z 286.0801.

7-(3-Fluorophenyl)-2,3-dimethyl-4*H*-4-chromone (6c) Yield 58%; mp 107°C; IR: 1630.0 cm^{-1} (C=O); ^{1}H NMR: δ 8.25 (d, *J* = 8.0 Hz, H-5), 7.60 (d, *J* = 1.2 Hz, H-8), 7.56–7.49 (m, H-6, H-2′), 7.43–7.37 (m, H-5′), 7.28–7.23 (m, H-4′, H-6′), 2.45 (s, CH_3-2), 2.10 (s, CH_3-3); ^{13}C NMR: δ 176.1 (C=O), 161.5 (C-2), 155.5 (C-8a), 148.2 (C-3′), 142.7 (C-1′), 144.8 (C-5), 134.9 (C-7), 129.6 (C-2′), 127.3 (C-6′), 126.7 (C-5′), 123.4 (C-4a), 122.6 (C-4′), 118.1 (C-6), 117.4 (C-3), 115.6 (C-8), 18.6 (2-CH_3), 10.1 (3-CH_3). HR-ESI-MS. Calcd for $C_{17}H_{12}FO_2^+$: m/z 268.0900, found: m/z 268.0903.

7-(3,4-Dimethylphenyl)-2,3-dimethyl-4*H*-4-chromone (6d) Yield 62%; mp 89°C; IR: 1628.0 cm^{-1} (C=O); ^{1}H NMR: δ 8.21 (d, *J* = 8.0 Hz, H-5), 7.58 (d, *J* = 1.6 Hz, H-8), 7.56 (s, H-2′), 7.43–7.38 (m, H-6′, H-5′, H-4′), 7.24 (d, *J* = 8.0 Hz, H-6), 2.43 (s, CH_3-2), 2.35 (s, CH_3-1′), 2.32 (s, CH_3-2′), 2.07 (s, CH_3-3); ^{13}C NMR: δ 177.8 (C=O), 161.8 (C-2), 156.2 (C-8a), 146.1 (C-3′), 137.3 (C-4′), 137.2 (C-7), 136.9 (C-1′), 130.3 (C-2′), 128.5 (C-5′), 126.2 (C-6′), 124.7 (C-4a), 123.5 (C-5), 121.1 (C-6), 116.9 (C-3), 115.2 (C-8),

19.9 (4′-CH_3), 19.5 (3′-CH_3), 18.6 (2-CH_3), 10.1 (3-CH_3). HR-ESI-MS. Calcd for $C_{19}H_{18}O_2^+$: m/z 278.1307, found: m/z 278.1301.

2,3-Dimethyl-7-(2-thienyl)-4*H*-4-chromone (6e) Yield 56%; mp 112°C; IR: 1635.0 cm^{-1} (C=O); ^{1}H NMR: δ 8.15 (d, *J* = 8.0 Hz, H-5), 7.58–7.55 (m, H-6, H-8), 7.43 (d, *J* = 3.0 Hz, H-3′), 7.37 (dd, *J* = 3.0 Hz, *J* = 3.6 Hz, H-4′), 7.11 (d, *J* = 3.6 Hz, H-5′), 2.40 (s, CH_3-2), 2.05 (s, CH_3-3); ^{13}C NMR: δ 177.4 (C=O), 161.9 (C-2), 156.2 (C-8a), 142.4 (C-7), 138.9 (C-2′), 128.4 (C-4′), 126.7 (C-5′), 126.5 (C-5′), 124.9 (C-3′), 124.7 (C-4a), 123.5 (C-5), 121.1 (C-6), 116.9 (C-3), 115.2 (C-8), 18.6 (2-CH_3), 10.1 (3-CH_3). HR-ESI-MS. Calcd for $C_{15}H_{12}O_2S^+$: m/z 256.0558, found: m/z 256.0547.

2,3-Dimethyl-7-(4-chloro-3-pyridyl)-4*H*-4-chromone (6f) Yield 64%; mp 145°C; IR: 1632.0 cm^{-1} (C=O); ^{1}H NMR: δ 8.66 (s, H-6′), 8.28 (d, *J* = 8.4 Hz, H-5), 7.90 (dd, *J* = 8.4 Hz, *J* = 2.8 Hz, H-4′), 7.56 (d, *J* = 1.6 Hz, H-8), 7.52 (dd, *J* = 8.4 Hz, *J* = 1.6 Hz, H-6), 7.45 (d, *J* = 8.4 Hz, H-3′), 2.44 (s, CH_3-2), 2.08 (s, CH_3-3); ^{13}C NMR: δ 177.4 (C=O), 162.2 (C-2), 156.1 (C-8a), 151.5 (C-2′) 148.1 (C-6′), 141.1 (C-5′), 137.3 (C-7), 134.0 (C-4′), 127.0 (C-6), 124.5 (C-4a), 123.2 (C-5), 122.1 (C-3′), 117.4 (C-3), 115.8 (C-8), 18.6 (2-CH_3), 10.1 (3-CH_3). HR-ESI-MS. Calcd for $C_{16}H_{12}{}^{35}ClNO_2^+$: m/z 285.0557, found: m/z 285.0548.

2,3-Dimethyl-7-(2-methoxyphenyl)-4*H*-4-chromone (6g) Yield 60%; mp 92°C; IR: 1634.0 cm^{-1} (C=O); ^{1}H NMR: δ 8.19 (dd, *J* = 8.2 Hz, *J* = 0.3 Hz, H-6), 7.57 (d, *J* = 0.3 Hz, H-8), 7.51 (dd, *J* = 8.1 Hz, *J* = 1.7 Hz, H-6′), 7.38 (m, H-4′, H-3′), 7.05 (m, H-5′, H-5), 3.84 (s, OCH_3), 2.43 (s, CH_3-2), 2.08 (s, CH_3-3). ^{13}C NMR: δ 177.9 (C=O), 161.9 (C-2), 156.5 (C-2′), 155.7 (C-8a), 143.6 (C-7), 130.8 (C-6′), 129.7 (C-1′), 128.9 (C-4′), 126.2 (C-5), 125.2 (C-4a), 121.1 (C-6), 121.0 (C-5′), 118.2 (C-3), 116.9 (C-8), 111.4 (C-3′), 55.6 (OCH_3), 18.6 (2-CH_3), 10.1 (3-CH_3). HR-ESI-MS. Calcd for $C_{18}H_{16}O_3^+$: m/z 280.1099, found: m/z 280.1088.

7-(4-Fluro-3-methoxyphenyl)-2,3-dimethyl-4*H*-4-chromone (6h) Yield 71%; mp 118°C; IR: 1625.0 cm^{-1} (C=O); ^{1}H NMR: δ 8.23 (d, *J* = 8.2 Hz, H-6), 7.53 (m, H-8, H-5), 7.19 (m, H-2′, H-5′, H-6′), 3.98 (s, OCH_3), 2.44 (s, CH_3-2), 2.08 (s, CH_3-3); ^{13}C NMR: δ 177.1 (C=O), 162.0 (C-2), 156.1 (C-8a), 151.6 (C-3′), 148.0 (C-4′), 145.2 (C-1′), 136.1 (C-7), 126.4 (C-5), 123.5 (C-6), 121.4 (C-6′), 120.0 (C-5′), 117.1 (C-4a), 116.4 (C-2′), 115.5 (C-3), 112.6 (C-8), 56.4 (OCH_3), 18.6 (2-CH_3), 10.1 (3-CH_3). HR-ESI-MS. Calcd for $C_{18}H_{15}FO_3^+$: m/z 298.1005, found: m/z 298.1001.

7-(3-Cyanophenyl)-2,3-dimethyl-4*H*-4-chromone (6i) Yield 76%; mp 96°C; IR: 1635.0 cm^{-1} (C=O); 2212.0 cm^{-1} (CN); ^{1}H NMR: δ 8.28 (d, *J* = 8.2 Hz, H-6), 7.93 (d, *J* = 1.4 Hz, H-8), 7.87 (dd, *J* = 7.4 Hz, *J* = 1.3 Hz, H-4′), 7.71 (dd, *J* = 7.4 Hz, *J* = 7.6 Hz, H-5′), 7.58 (m, H-5, H-2′, H-6′), 2.45 (s, CH_3-2), 2.09 (s, CH_3-3); ^{13}C NMR: δ 177.5 (C=O), 162.2 (C-2), 156.1 (C-8a), 143.4 (C-7), 140.7 (C-1′), 131.8 (C-4′), 131.6 (C-2′), 130.9 (C-6′), 129.9 (C-5′), 126.9 (C-4a), 123.3 (C-5), 122.1 (C-6), 118.1 (CN), 117.4 (C-3), 116.0 (C-8), 113.3 (C-3′), 18.6 (2-CH_3), 10.1 (3-CH_3). HR-ESI-MS. Calcd for $C_{18}H_{13}NO_2^+$: m/z 275.0946, found: m/z 275.0937.

7-(2-Trifluromethylphenyl)-2,3-dimethyl-4*H*-4-chromone (6j) Yield 70%; mp 128°C; IR: 1630.0 cm^{-1} (C=O); ^{1}H NMR: δ 8.21 (dd, *J* = 8.1 Hz, *J* = 0.2 Hz, H-6′), 7.78 (d, *J* = 7.8 Hz, H-5), 7.90 (dd, *J* = 8.4 Hz, *J* = 2.8 Hz, H-4′), 7.56 (d, *J* = 1.6 Hz, H-8), 7.52 (dd, *J* = 8.4 Hz, *J* = 1.6 Hz, H-6), 7.45 (d, *J* = 8.4 Hz, H-3′), 2.44 (s, CH_3-2), 2.08 (s, CH_3-3); ^{13}C NMR: δ 177.5 (C=O), 162.2 (C-2), 156.1 (C-8a), 143.4 (C-1′), 140.7 (C-7), 134.4 (C-2′), 130.6 (C-5′), 129.7 (C-6′), 127.4 (C-3′), 126.7 (C-4a), 123.3 (C-5), 122.1 (C-6), 118.1 (CF_3), 117.4 (C-3), 116.2 (C-8), 113.4 (C-3′), 18.4 (2-CH_3), 10.1 (3-CH_3). HR-ESI-MS. Calcd for $C_{18}H_{13}F_3O_2^+$: m/z 318.0869, found: m/z 318.0864.

7-(3-Chloro-4-methylphenyl)-2,3-dimethyl-4*H*-4-chromone (6k) Yield 70%; mp 136°C; IR: 1632.0 cm^{-1} (C=O); ^{1}H NMR: δ 8.22 (dd, *J* = 8.2 Hz, *J* = 1.4 Hz, H-6), 7.46 (d, *J* = 1.4 Hz, H-8), 7.40 (d, *J* = 7.8 Hz, H-5′), 7.33 (d, *J* = 7.8 Hz, H-6′), 7.46 (d, *J* = 8.2 Hz, H-5), 7.15 (s, H-2′), 2.43 (s, CH_3-2), 2.39 (s, CH_3), 2.08 (s, CH_3-3); ^{13}C NMR: δ 177.1 (C=O), 162.0 (C-2), 155.5 (C-8a), 144.2 (C-1′), 139.8 (C-7), 135.9 (C-4′), 131.9 (C-3′), 130.9 (C-2′), 130.6 (C-5′), 127.9 (C-6′), 126.1 (C-4a), 125.5 (C-5), 121.5 (C-6), 118.4 (C-3), 117.1 (C-8), 20.9 (4′-CH_3), 18.6 (2-CH_3), 10.1 (3-CH_3). HR-ESI-MS. Calcd for $C_{18}H_{15}{}^{35}ClO_2^+$: m/z 298.0761, found: m/z 298.0765.

7-(3-Chloro-4-fluoro-phenyl)-2,3-dimethyl-4H-4-chromone (6l) Yield 67%; mp 140°C; IR: 1627.0 cm^{-1} (C=O); ^{1}H NMR: δ 8.24 (dd, *J* = 8.2 Hz, *J* = 1.4 Hz, H-6), 7.68 (d, *J* = 1.4 Hz, H-8), 7.52 (m, H-2′, H-5′, H-6′), 7.25 (d, *J* = 8.2 Hz, H-5), 2.44 (s, CH_3-2), 2.08 (s, CH_3-3); ^{13}C NMR: δ 177.6 (C=O), 162.1 (C-2), 159.6 (C-8a), 157.1 (C-7), 156.1 (C-1′), 143.6 (C-5), 136.7 (C-6′), 129.6 (C-2′), 127.1 (C-3′), 126.7 (C-5′), 123.3 (C-4a), 121.7 (C-4′), 117.3 (C-6), 117.0 (C-4a), 115.6 (C-8), 18.6 (2-CH_3), 10.1 (3-CH_3). HR-ESI-MS. Calcd for $C_{17}H_{12}F^{35}ClO_2^+$: m/z 302.0510, found: m/z 302.0506.

Acknowledgments: The authors are grateful to Dr. Reddy's Laboratories Ltd. for providing facilities and analytical support.

Received December 29, 2013; accepted February 4, 2014

References

[1] Ellis, G. P. Chromenes, Chromanones and Chromones. In *The Chemistry of Heterocyclic Compounds*; Wiley: New York, 1977; Vol. 31.

[2] Harborne, J. B.; Williams, C. A. Advances in flavonoid research since 1992. *Phytochemistry* **2000**, *55*, 481–504.

[3] McClure, J. W.; Harborne, J. B.; Mabry, T. J.; Mabry, H. *The Flavonoids*; Chapman and Hall: London, 1975.

[4] Bruneton, J. *Pharmacognosy, Phytochemistry and Medicinal Plants*; English Translation by Hatton, C. K.; Lavoisier Publishing: Paris, 1995.

[5] Harton, D. A.; Bourne, G. T.; Smythe, M. L. The combinatorial synthesis of bicyclic privileged structures or privileged substructures. *Chem. Rev*. **2003**, *103*, 893–930.

[6] Miyaura, N.; Yanagi, T.; Suzuki, A. The palladium-catalyzed cross-coupling reaction of phenylboronic acid with haloarenes in the presence of bases. *Synth. Commun*. **1981**, *11*, 513–519.

[7] Suzuki, A. Organoboran compounds in new synthetic reactions. *Pure Appl. Chem*. **1985**, *57*, 1749–1758.

[8] Martin, A. R.; Yang, Y. Palladium catalyzed cross-coupling reactions of organoboronic acids with organic electrophiles. *Acta Chem. Scand*. **1993**, *47*, 221–230.

[9] Suzuki, A. Synthetic studies via the cross-coupling reaction of organoboron derivatives with organic halides. *Pure Appl. Chem*. **1991**, *63*, 419–422.
[10] Miyaura, N.; Suzuki, A. Palladium-catalyzed cross-coupling reactions of organoboron compounds. *Chem. Rev*. **1995**, *95*, 2457–2483.
[11] Sambasivarao, K.; Lahiri, K.; Kashinath, D. Recent applications of the Suzuki-Miyuara cross coupling reaction in organic synthesis. *Tetrahedron* **2002**, *58*, 9633–9695.
[12] Miyaura, N.; Libeskind, L. S., Eds. *Advances in Metal-organic Chemistry*; Jai: London, 1998; Vol. 6, pp. 187–243.
[13] Suzuki, A. New synthetic transformations via organoboron compounds. *Pure Appl. Chem*. **1994**, *66*, 213.
[14] Suzuki, A. *Inorganoboranes for Syntheses. ACS Symposium Series 783*; Ramachandran, P. V.; Brown, H. C., Eds. American Chemical Society: Washington, DC, 2001; pp. 80–93.
[15] Suzuki, A. Recent advances in the cross-coupling reactions of organoboron derivatives with organic electrophiles, 1995–1998. *J. Organomet. Chem*. **1999**, *576*, 147–168.
[16] Guo, H.; Herdtweck, E.; Bach, T. Enantioselective Lewis acid catalysis in intramolecular [2+2] photocycloaddition reactions of coumarins. *Angew. Chem. Int. Ed*. **2010**, *49*, 7782–7785.
[17] Akrawi, O. A.; Mohammed, H. H.; Patonay, T. A.; Villinger, A.; Langer, P. Synthesis of arylated xanthones by site-selective Suzuki-Miyaura reactions of the bis(triflate) of 1,3-dihydroxyxanthone. *Tetrahedron* **2012**, *68*, 6298–6304.
[18] Yu, D.; Chen, C. H.; Brossi, A.; Lee, K. H. Anti-AIDS agents. 60. Substituted 3′*R*,4′*R*-di-*O*-(–)-camphanoyl-2′,2′-dimethyldihydropyrano[2,3-*f*]chromone (DCP) analogues as potent anti-HIV agents. *J. Med. Chem*. **2004**, *47*, 4072–4082.
[19] Rao, Y. J.; Krupadanam, G. L. D. Facile synthesis of linear and angular 2-methylfurobenzopyranone. *Bull. Chem. Soc. Japan* **1994**, *67*, 1972–1975.