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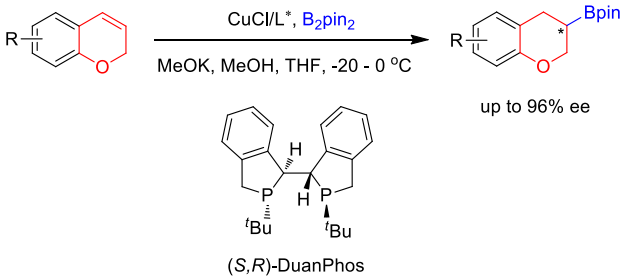


ABSTRACT: A highly regioselective asymmetric hydroboration of 2*H*-chromenes catalyzed by the complex of CuCl and diphosphine ligand (*S*,*R*)-DuanPhos has been realized under mild conditions to produce 3-boryl chromans achieving good yields and excellent enantioselectivities, up to 96% ee. This work provides an efficient approach to synthesis of chiral 3-boryl chromans and derivatives.

INTRODUCTION

The chiral chroman is a pervasive structural motif found in numerous bioactive molecules and pharmaceuticals.[1] Chiral oxygen heterocycles are widely used as therapeutically important drugs such as Equol for treating cardiovascular disease and breast cancer, Mucroquinone, Myristinin B and Chromanol 293B (Figure 1).[2, 3] Due to the significance in pharmaceutical synthesis, considerable effort has been dedicated to the enantioselective synthesis of chromans.[4]

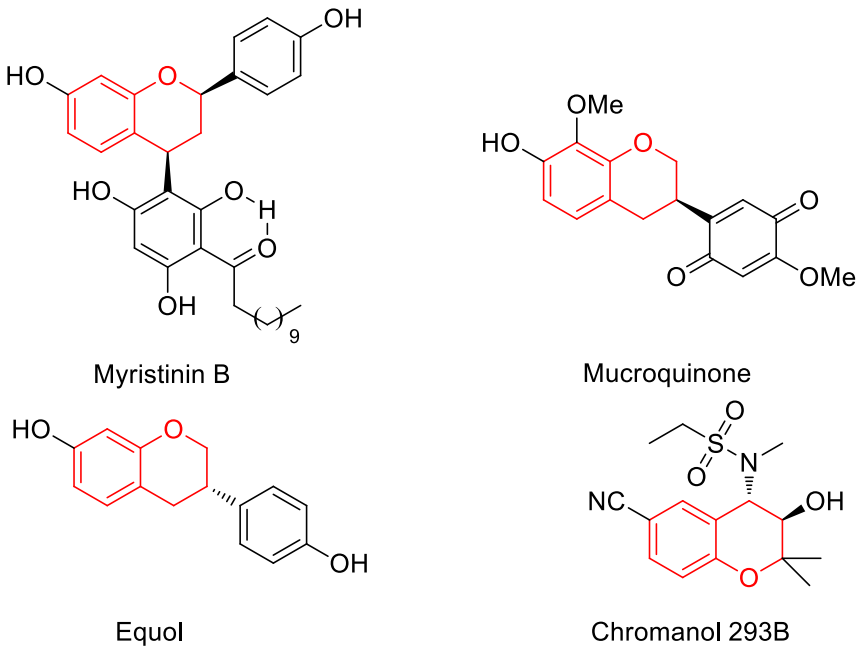
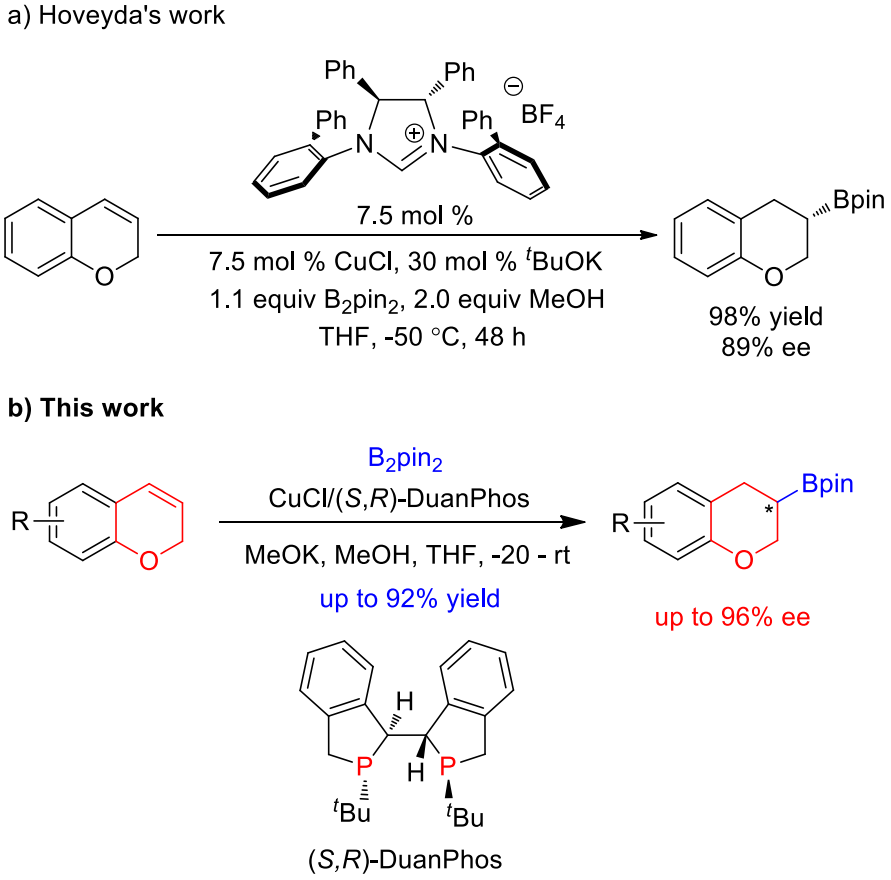


Figure 1. Selected bioactive compounds bearing chiral chroman.

In addition, chiral borylated chromans are versatile intermediates in pharmaceutical and synthetic chemistry, and can be used for construction of various important molecules via convenient transformations of C-B bond to C-O, C-N, C-C, and C-halogen bonds.[5] Therefore, to develop efficient catalysts and approaches for enantioselective synthesis of chiral borylated chromans is highly desirable. Although highly chemo- and regioselective catalytic asymmetric hydroboration of various substrates, such as olefins [6] and *N*-heterocyclic substrates including indoles, 1,2-dihydropyridines and 1,2-dihydroquinolines,[7] has emerged substantially for the synthesis of optically active boron-containing compounds and significant progress has also been achieved,[8] the catalyzed enantioselective hydroboration of 2*H*-chromenes still remains a challenge. This is possibly attributed to the high energy barrier encountered during the conjugation of the C=C double bond with phenyl ring, as well as the interaction of the oxygen atom with the borated reagent which maybe has a negative effect on the hydroboration. To the best of our knowledge, there is scarce example on the enantioselective hydroboration of 2*H*-chromenes reported.

Hoveyda's group reported the hydroboration of aryl substituted alkenes including an example of 2*H*-chromene promoted by NHC-based catalysts achieving high yield and 89% ee (Scheme 1a).[9] Thus far, the investigation on asymmetric hydroboration of 2*H*-chromenes is still in its infancy. Both the efficient catalyst and substrate scope is limited. Herein we report a highly regioselective copper catalyzed asymmetric hydroboration of 2*H*-chromenes using a chiral diphosphine ligand (*S*,*R*)-DuanPhos to afford chiral chromans with high yields and enantioselectivities, up to 96% ee (Scheme 1b).

Scheme 1. Cu-catalyzed Asymmetric Hydroboration of 2*H*-Chromenes.

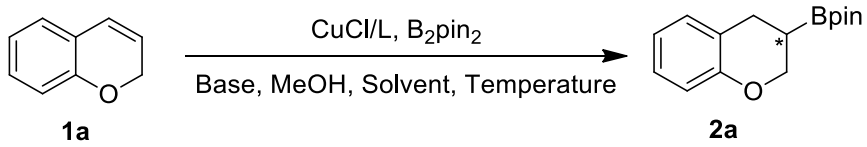


RESULTS AND DISCUSSION

We initially chose 2*H*-chromene **1a** as the model substrate to investigate the hydroboration reaction using the complex of (*S*)-Binap (**L1**) and CuCl as the catalyst. In the presence of 20 mmol % of MeOK and MeOH (2.0 equiv) the reaction of **1a** with bis(pinacolato)diboron (B_2pin_2) in THF proceeded at 0 °C for 1 h and then was allowed to warm to room temperature and remained for 4 h providing the desired product **2a** without any regio-isomer in 59% yield and 80% ee (Table 1, entry 1). Based on the promising result, the effect of the reaction temperature was further evaluated. It was revealed that the higher enantioselectivity could be achieved with comparable yield at the lower initial temperature of -20 °C (Table 1, entry 2). However, the further lower temperature, -78 °C, resulted in decreased reactivity and the lower yield was observed (Table 1, entry 3). Subsequently, some other bases, such as ^{t}BuONa, ^{t}BuOLi, and ^{t}BuOK, were also screened. But lower yields or enantioselectivities were obtained (Table 1, entries 4 – 6). In the absence of base the reaction could not proceed (Table 1, entry 7). Using MeOK as the base, the effect of solvents was also investigated. Dichloromethane or toluene could only give much lower yield (Table 1, entries 8 and 9). Despite a higher yield achieved in 1,2-dimethoxylethane, the enantioselectivity was slightly decreased (Table 1, entry 10). On the basis of the pioneering work, some diphosphine ligands (Figrue 2) were capable of promoting the hydroboration reaction of various substrates.[6-8] These ligands including (*R*)-SegPhos (**L2**), (*R*)-DM-SegPhos (**L3**), (R,S_p)-JosiPhos-1 (**L4**) and (*R*,*R*)-Me-DuPhos (**L5**), which exhibited good performance were evaluated in this transformation. However, most of them could only give poor yields or enantioselectivities (Table 1, entries 11–14). Remarkably, (*S*,*R*)-DuanPhos (**L6**) provided the desired product **2a** achieving much higher yield and excellent enantioselectivity, 87% and 94% ee,

respectively (Table 1, entry 15). Finally, the optimal reaction conditions were established as gradient temperature/CuCl/(*S*,*R*)-DuanPhos/MeOK/THF.

Table 1. Cu-Catalyzed Asymmetric Hydroboration of 1a, Optimizing Reaction Conditions.[a]



1a **2a**

entry	ligand	base	solvent	yield (%)[b]	ee (%)[c]
1[d]	**L1**	MeOK	THF	59	80
2	**L1**	MeOK	THF	57	86
3[e]	**L1**	MeOK	THF	50	80
4	**L1**	^{t}BuONa	THF	60	81
5	**L1**	^{t}BuOK	THF	50	80
6	**L1**	^{t}BuOLi	THF	40	80
7	**L1**	-	THF	-	-
8	**L1**	MeOK	DCM	40	9
9	**L1**	MeOK	toluene	50	82
10	**L1**	MeOK	DME	67	82
11	**L2**	MeOK	THF	32	60
12	**L3**	MeOK	THF	32	83
13	**L4**	MeOK	THF	47	45
14	**L5**	MeOK	THF	45	73
15	**L6**	MeOK	THF	87	94

[a] Reaction conditions: CuCl (0.025 mmol), ligand (0.025 mmol), **1a** (0.5 mmol), B_2pin_2 (0.6 mmol), base (0.1 mmol), solvent (1.5 mL), MeOH (1.0 mmol), -20 °C for 1 h, 0 °C for 1 h, rt for 4 h. [b] Isolated yield. [c] Determined by chiral HPLC or SFC analysis of the corresponding derived alcohol. [d] 0 °C for 1 h, rt for 4 h. [e] -78 °C for 1 h, -20 °C for 1 h, 0 °C for 1 h, rt for 4 h.

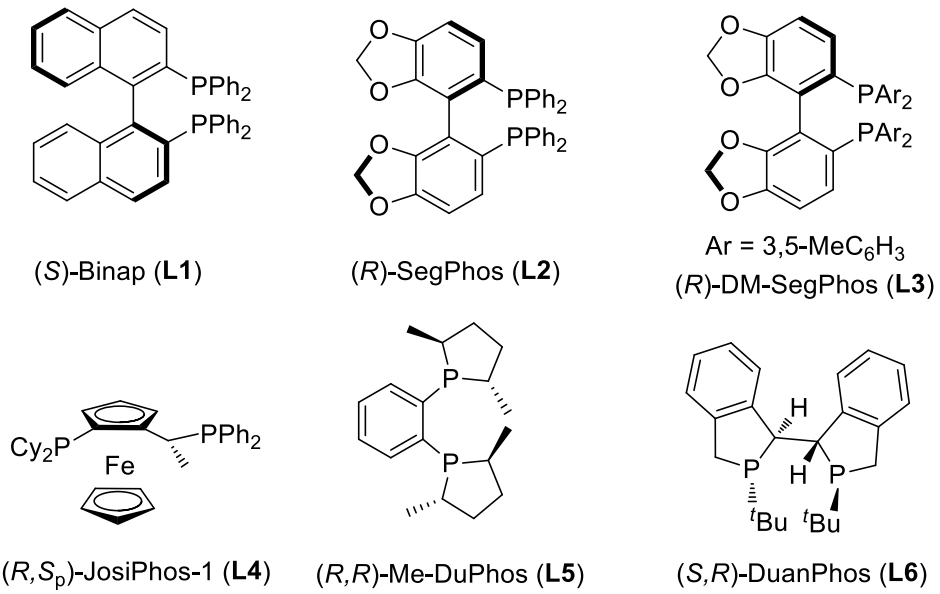
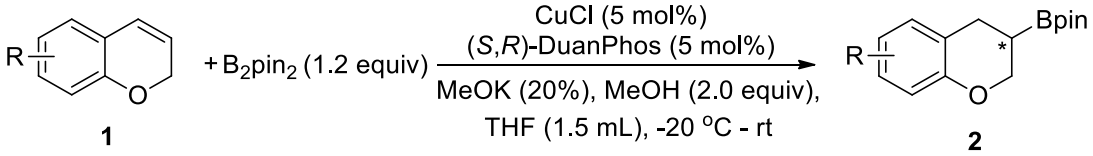


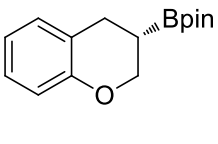
Figure 2. Structures of the bidentate phosphine ligands screened.

With the optimal reaction conditions in hand, a variety of 2*H*-chromenes with various substituents were prepared and applied to this Cu-catalyzed asymmetric hydroboration. As shown in Scheme 2, most of the boronated products could be afforded with excellent enantioselectivities (up to 96% ee) in high yields (up to 92%) by the asymmetric hydroboration of the corresponding substrates without any regio-isomers observed. It was revealed that the electronic property of the substituents on the phenyl ring had a significant influence on the enantioselectivity in this transformation. For example, the 8-Cl or 6-Br substituted substrates **1b** and **1c** bearing an electron-withdrawing group could only provide moderate enantioselectivities, 62% and 64% ee, respectively. On the contrary, the substrates **1d** – **1j** with an electron-donating substituent, such as

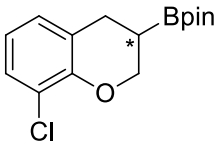
methyl, methoxyl, isopropyl and ^{t}Butyl, could be hydroborated to produce the corresponding **2d** – **2j** in good yields and higher enantioselectivities of up to 94% ee regardless of the position of the substituents on the phenyl ring. Inspired by these optimistic results, we attempted to evaluate larger sterically hindered substrates with multi substituents in this hydroboration. Notably, the disubstituted substrates **1k** – **1m** could be efficiently converted to the desired products **2k** – **2m** achieving good yields and high enantioselectivities. Especially, the product **2m** was obtained with the highest enantioselectivity, 96% ee. Even if the 5, 7, 8-trimethyl substituted substrate **1n**, it could also be converted to the product **2n** with 90% ee value albeit with a lower yield, which was perhaps attributed to the much bulkier sterically hindrance. In addition, the hydroboration of the substrates **1o** – **1q** proceeded smoothly with comparable yields, but slightly decreased enantioselectivities were observed. The larger conjugated system probably had a similarly negative effect on the enantioselectivity like the electron-withdrawing substituent on the phenyl ring.

Scheme 2. Substrate Scope.[a, b]

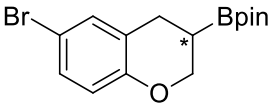




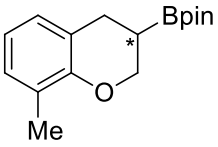
2a
87% yield, 94% ee (+)



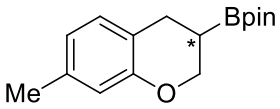
2b
81% yield, 62% ee (+)



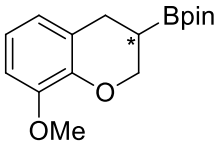
2c
65% yield, 64% ee (-)



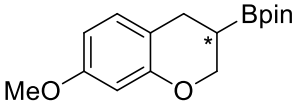
2d
85% yield, 94% ee (+)



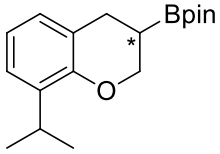
2e
82% yield, 92% ee (+)



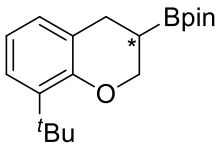
2f
87% yield, 90% ee (+)



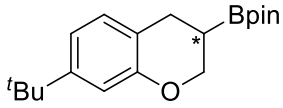
2g
70% yield, 89% ee (+)



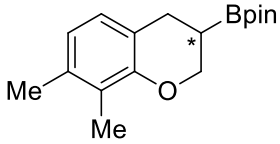
2h
92% yield, 92% ee (+)



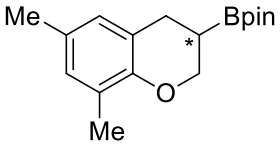
2i
87% yield, 92% ee (+)



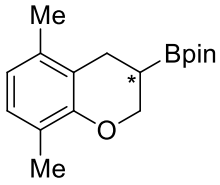
2j
55% yield, 92% ee (+)



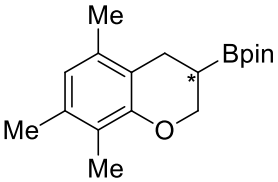
2k
82% yield, 94% ee (+)



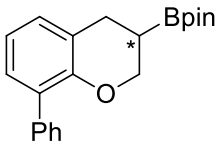
2l
80% yield, 92% ee (+)



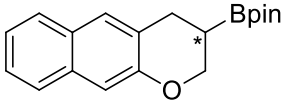
2m
85% yield, 96% ee (+)



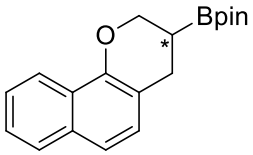
2n
51% yield, 90% ee (+)



2o
85% yield, 86% ee (+)



2p
70% yield, 76% ee (-)

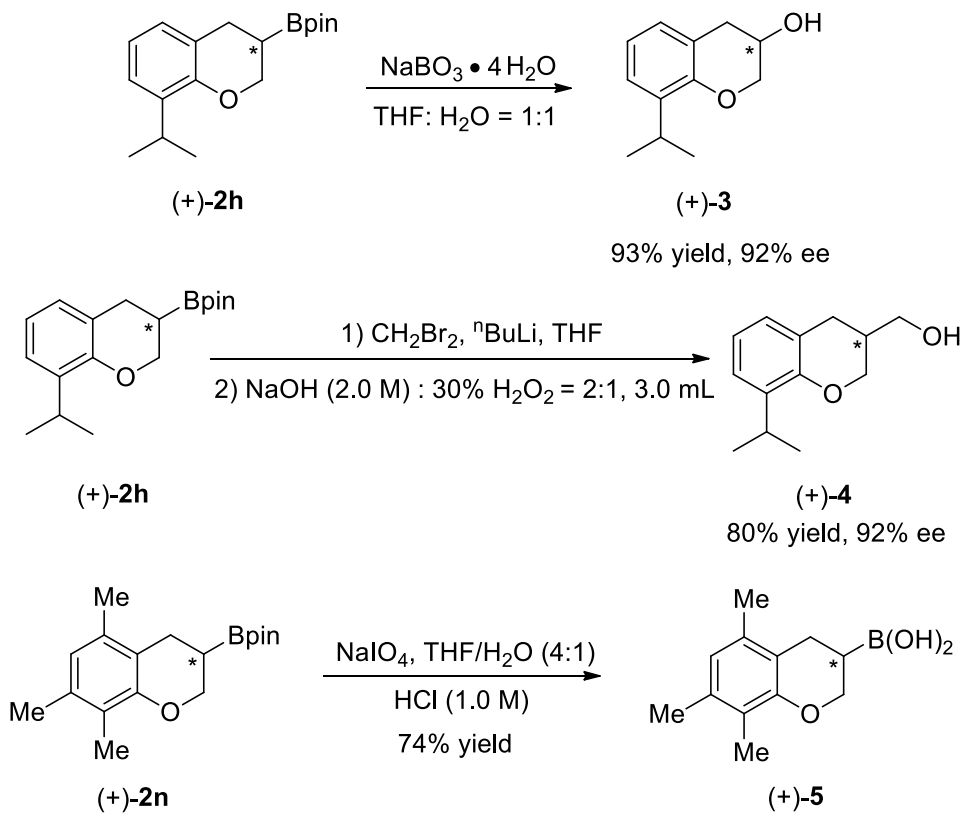


2q
83% yield, 86% ee (+)

[a] Unless otherwise mentioned, all reactions were carried out with CuCl (0.025 mmol), (*S*,*R*)-DuanPhos (0.025 mmol), **1** (0.5 mmol), B_2pin_2 (0.6 mmol), MeOK (0.1 mmol), THF (1.5 mL), MeOH (1.0 mmol), -20 °C for 1 h, 0 °C for 1 h, rt for 4 h. [b] Enantiomeric excess values were determined by chiral HPLC or SFC analysis of the corresponding derived alcohols.

The resulting products **2** are versatile synthetic intermediates that can be easily converted to numerous other useful derivatives (Scheme 3). For example, by construction of C-O bond the product **2h** could be converted into the chiral 8-isopropylchroman-3-ol **3** in 93% yield without any loss of enantioselectivity.[7a, 10] The product **2h** could also be used for the synthesis of primary alcohol **4** by construction of C−C bond in 80% yield with maintained enantioselectivity, 92% ee.[11] Besides, the chiral boronate **2n** could also be successfully transformed into the corresponding boronic acid **5** in the presence of $NaIO_4$ and HCl (aq).[12]

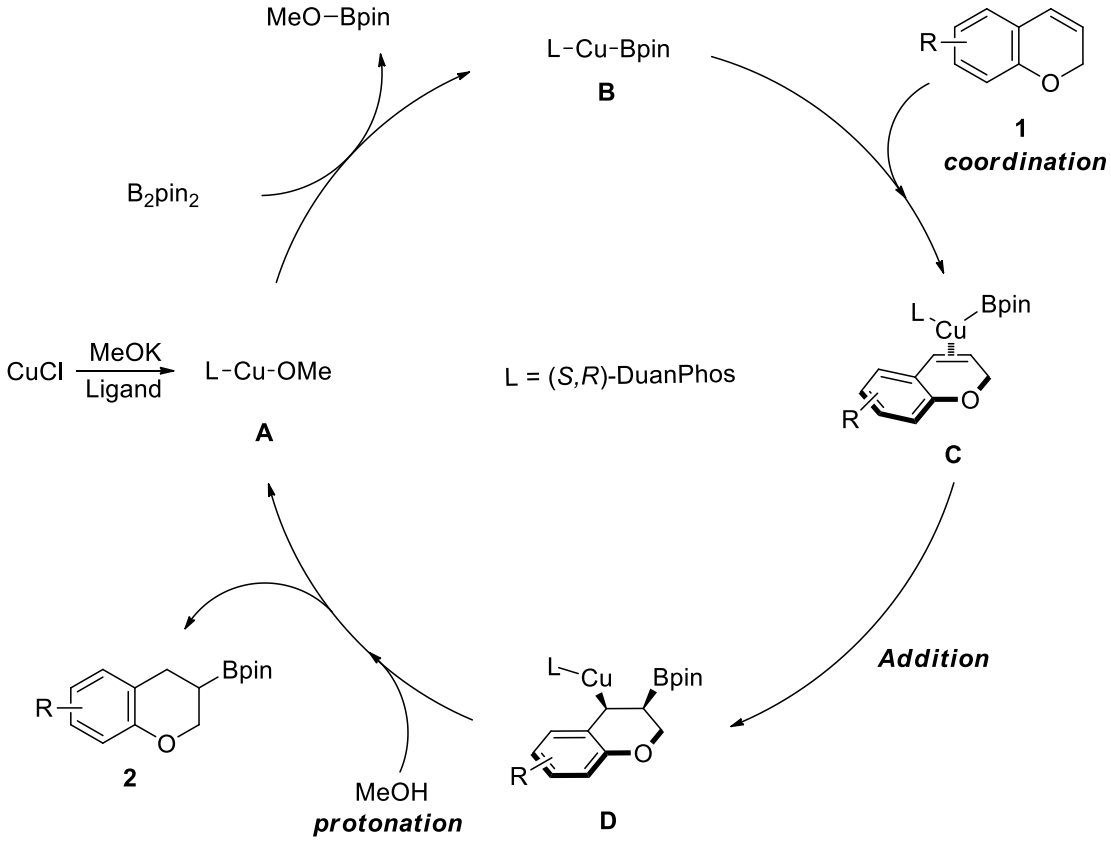
Scheme 3. Representative Transformations of Products 2.



According to previous reports,[8] a possible catalytic cycle for the asymmetric hydroboration of chromenes was proposed as illustrated in Scheme 4. In the presence of CuCl, the diphosphine ligand (*S*, *R*)-DuanPhos, and MeOK, a diphosphine ligated Cu-OMe complex **A** was initially formed. The borylcopper species **B** was then generated by reaction with B_2pin_2. Subsequently, the

coordination of the species **B** with the double bonds and addition to substrate **1** provided the intermediate **D**, which could be protonated by Methanol to yield the borylated product **2** and regenerate the copper methoxide **A**.

Scheme 4. Proposed Catalytic Cycle for the Hydroboration.



CONCLUSIONS

In summary, an efficient asymmetric hydroboration of 2*H*-chromenes catalyzed by the complex of CuCl and chiral diphosphine ligand (*S*,*R*)-DuanPhos to afford chiral chromans with high yields and enantioselectivities, up to 96% ee, has been realized. This strategy provides a straightforward approach to important chiral 3-boryl chromans, which can be readily converted to various useful compounds including chiral alcohols.

EXPERIMENTAL SECTION

General Information: All of the air- or moisture-sensitive reactions and manipulations were performed using standard Schlenk techniques and in a nitrogen-filled glovebox. DME, THF, dioxane and toluene were distilled from sodium benzophenone ketyl. CH_2Cl_2 was distilled from calcium hydride. Anhydrous MeOH was distilled from magnesium.^{1}H NMR and $^{13}C\{^1H\}$NMR spectra were recorded on Bruker AV (400 MHz) spectrometers and JEOL JNM-ECX600P and JNM-ECS600 (600 MHz) spectrometers (CDC_{13} was the solvent used for the NMR analysis, with tetramethylsilane (TMS) as the internal standard). Chemical shifts were reported upfield to TMS (0.00 ppm) for ^{1}H NMR. Data is represented as follows: chemical shift, integration, multiplicity (s = singlet, d = doublet, dd = double of doublets, t = triplet, q = quartet, m = multiplet), and coupling constants (*J*) in Hertz (Hz). Optical rotation was determined using an automatic polarimeter (Rudolph research Analytical). HPLC analysis was conducted on Agilent 1260 series instrument. SFC analysis was conducted on Agilent 1260 series instrument. HRMS was carried out on a Waters LCT Premier XE mass spectrometer with APCI or ESI.

Procedure for the preparation of substrate 1a: Chroman-4-one (0.74 g, 5.00 mmol, 1 equiv) was suspended in methanol (50 mL) and treated with an excess of $NaBH_4$ (0.28 g, 7.50 mmol, 1.5 equiv) at 0 ºC. The resulting mixture was stirred for 30 minutes at room temperature, then concentrated in vacuo. The residue was partitioned between CH_2Cl_2 and H_2O. The organic layer was separated, and the aqueous layer was extracted with CH_2Cl_2. The organic layers was then combined, washed with H_2O, dried over anhydrous Na_2SO_4, filtered and concentrated to yield the desired compound.[13]

p-Toluenesulfonic acid (3.00 mg, 0.02 mmol) and hydroquinone (5.0 mg, 0.05 mmol) were added to a solution of chroman-4-ol (0.75 g, 5.00 mmol) in toluene (20 mL). The reaction mixture was heated under reflux using a Dean–Stark trap (2 h), washed with water, dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (petroleum ether).[14]

Procedure for the preparation of substrates 1b-1e, 1j and 1l： Equimolar quantities of chloropropionic acid (5.43g, 50.00 mmol, 1 equiv) and appropriate phenol (50 mmol) were placed in a conical flask, to which aqueous solution of NaOH (11.52 g, 0.12 mol in 25 mL water) was slowly added with constant stirring and then heating to 75 – 80 ºC, reacting for 12 h. After the reaction, with sufficient cooling and acidified by adding con. HCl, extracted with ethyl acetate, followed by saturated brine. It was dried over anhydrous Na_2SO_4 and then solvent was removed. The crude product was purified by silica gel chromatography (petroleum ether: EtOAc = 5:1).[15]

3-Phenoxypropanoic acids were placed in a conical flask, to which sulfoxide chloride (5 mL) was quickly added with constant stirring. The reaction mixture was heated under reflux for 2 h, then concentrated in vacuo and CH_2Cl_2 was added to the mixture. The anhydrous aluminum chloride (2.67g, 20.00 mmol, 2 equiv) was added in batches at 0 ºC and the reaction stirred for 1 h at 0 ºC, then the reaction mixture was allowed to warm to rt. The reaction was quenched with H_2O slowly at 0 ºC, extracted with CH_2Cl_2, followed by saturated brine. It was dried over anhydrous Na_2SO_4 and then solvent was removed. The crude product was purified by silica gel chromatography (petroleum ether: EtOAc = 7:1).

Procedure for the preparation of substrates 1f-1i, 1k and 1m-1q: To a solution of phenols (50.00 mmol) in acetone (200 mL) was added K_2CO_3 (27.64 g, 0.2 mol) and

3-bromoprop-1-yne (7.14 g, 60.00 mmol). The resulting mixture was stirred at reflux temperature during overnight and the reaction stopped by filtration and evaporation under vacuum. The crude product was extracted with CH_2Cl_2, followed by saturated brine. It was dried over anhydrous Na_2SO_4 and then solvent was removed. The crude product was purified by silica gel chromatography (PE/EA = 5:1).[16]

A mixture of (prop-2-yn-1-yloxy) benzene (10.00 mmol) and N, N-diethylaniline (1.6 mL) was refluxed for 8-12 h. After cooling to room temperature, the reaction mixture was diluted with ethyl acetate. The resulting mixture was washed with hydrochloric acid (2M), water and brine, and then dried over anhydrous Na_2SO_4. The solvent was evaporated and the crude product was purified by silica gel chromatography using petroleum ether/EtOAc as an eluent (PE/EA = 150:1–100:1) to give the corresponding compounds.[16]

2*H*-chromene (1a): Colorless oil; 0.50 g, yield: 75%; ^{1}H NMR (600 MHz, $CDCl_3$): δ (ppm) 6.67 (t, *J* = 6.2 Hz, 1H), 6.56 (d, *J* = 6.0 Hz, 1H), 6.50 – 6.47 (m, 1H), 6.41 (d, *J* = 6.3 Hz, 1H), 6.13 (dd, *J* = 7.8, 0.9 Hz, 1H), 5.63 – 5.59 (m, 1H), 4.85 (dt, *J* = 2.6, 1.2 Hz, 2H); ^{13}C{^{1}H}NMR (100 MHz, $CDCl_3$): δ (ppm) 143.3, 123.4, 121.3, 119.7, 118.0, 117.6, 117.1, 112.6, 72.5. The analytical data are consistent with the literature.[17]

8-chloro-2*H*-chromene (1b): Colorless oil; 0.58 g, yield: 70%; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 7.13 (dd, *J* = 7.9, 1.7 Hz, 1H), 6.82 (dd, *J* = 7.5, 1.7 Hz, 1H), 6.78 – 6.73 (m, 1H), 6.37 (dt, *J* = 9.9, 1.9 Hz, 1H), 5.77 (dt, *J* = 9.9, 3.5 Hz, 1H), 4.92 (dd, *J* = 3.5, 1.9 Hz, 2H); ^{13}C{^{1}H}NMR (100 MHz, $CDCl_3$): δ (ppm) 149.8, 129.8, 125.1, 124.1, 123.7, 122.6, 121.6, 120.8, 66.4. The analytical data are consistent with the literature.[18]

6-bromo-2*H*-chromene (1c): Colorless oil; 0.92 g, yield: 87%; ^{1}H NMR (400 MHz, $CDCl_3$): δ

(ppm) 7.16 (dd, *J* = 8.5, 2.4 Hz, 1H), 7.05 (d, *J* = 2.4 Hz, 1H), 6.63 (d, *J* = 8.5 Hz, 1H), 6.33 (dt, *J* = 9.9, 1.9 Hz, 1H), 5.79 (dt, *J* = 9.9, 3.5 Hz, 1H), 4.81 (dd, *J* = 3.5, 1.9 Hz, 2H); $^{13}C\{^{1}H\}$NMR (100 MHz, $CDCl_3$): δ (ppm) 153.0, 131.9, 129.1, 124.2, 123.6, 123.4, 117.5, 113.3, 65.7. The analytical data are consistent with the literature.[18]

8-methyl-2*H*-chromene (1d): Colorless oil; 0.62 g, yield: 85%; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 6.87 (d, *J* = 7.2 Hz, 1H), 6.75 – 6.60 (m, 2H), 6.31 (dt, *J* = 9.8, 1.7 Hz, 1H), 5.66 (dt, *J* = 9.8, 3.5 Hz, 1H), 4.74 (dd, *J* = 3.5, 1.8 Hz, 2H), 2.07 (s, 3H); $^{13}C\{^{1}H\}$NMR (100 MHz, $CDCl_3$): δ(ppm) 152.0, 130.7, 125.0, 124.9, 124.3, 121.9, 121.6, 120.6, 65.4. The analytical data are consistent with the literature.[18]

7-methyl-2*H*-chromene (1e): Colorless oil; 0.44 g, yield: 60%; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 6.84 (d, *J* = 7.6 Hz, 1H), 6.67 (d, *J* = 7.7 Hz, 1H), 6.60 (s, 1H), 6.39 (d, *J* = 9.8 Hz, 1H), 5.70 (dt, *J* = 9.7, 3.6 Hz, 1H), 4.84 – 4.74 (m, 2H), 2.28 (s, 3H); $^{13}C\{^{1}H\}$NMR (100 MHz, $CDCl_3$): δ (ppm) 143.3, 131.6, 121.1, 119.7, 117.7, 116.7, 115.9, 113.1, 72.5, 37.2. The analytical data are consistent with the literature.[19]

8-methoxy-2*H*-chromene (1f): Colorless oil; 1.12 g, yield: 69%; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 6.88 – 6.68 (m, 2H), 6.59 (dd, *J* = 7.1, 1.4 Hz, 1H), 6.39 (d, *J* = 9.8 Hz, 1H), 5.76 (dt, *J* = 9.7, 3.5 Hz, 1H), 4.86 (dd, *J* = 3.4, 1.8 Hz, 2H), 3.84 (s, 3H); $^{13}C\{^{1}H\}$NMR (100 MHz, $CDCl_3$): δ (ppm) 147.6, 142.7, 124.5, 123.0, 122.0, 120.8, 118.9, 112.0, 65.7, 55.9. The analytical data are consistent with the literature.[18]

7-methoxy-2*H*-chromene (1g): Colorless oil; 0.86 g, yield: 53%; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 6.95 (t, *J* = 8.2 Hz, 1H), 6.67 (d, *J* = 9.9 Hz, 1H), 6.41 – 6.20 (m, 2H), 5.63 (dt, *J* = 9.7, 3.5 Hz, 1H), 4.66 (d, *J* = 1.6 Hz, 2H), 3.72 (s, 3H); $^{13}C\{^{1}H\}$NMR (100 MHz, $CDCl_3$): δ (ppm) 155.2,

154.9, 129.0, 119.8, 119.4, 111.8, 108.8, 103.6, 65.0, 55.6. The analytical data are consistent with the literature.[19]

8-isopropyl-2*H*-chromene (1h): Red oil; 1.24 g, yield: 71%; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 7.03 (dd, *J* = 7.1, 2.1 Hz, 1H), 6.83 – 6.75 (m, 2H), 6.39 (dt, *J* = 9.8, 1.7 Hz, 1H), 5.73 (dt, *J* = 9.7, 3.6 Hz, 1H), 4.75 (dd, *J* = 3.6, 1.7 Hz, 2H), 3.27 – 3.12 (m, 1H), 1.19 (s, 1H), 1.18 (s, 6H); ^{13}C{^{1}H}NMR (100MHz,$CDCl_3$): δ(ppm) 151.1, 135.8, 126.1, 125.3, 124.2, 122.3, 121.8, 121.0, 65.3, 26.7, 22.6. TOF-HRMS calcd for $C_{12}H_{15}O$ [M+H$^+$]:175.1017, found 175.1013.

8-(*tert*-butyl)-2*H*-chromene (1i): Colorless oil; 1.47 g, yield: 78%; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 7.14 – 6.90 (m, 1H), 6.90 – 6.67 (m, 2H), 6.37 (d, *J* = 9.7 Hz, 1H), 5.75 (dt, *J* = 9.4, 3.5 Hz, 1H), 4.84 – 4.29 (m, 2H), 1.30 (s, 9H); ^{13}C{^{1}H}NMR (100MHz,$CDCl_3$): δ(ppm) 150.4, 132.0, 126.0, 125.2, 124.4, 122.5, 121.4, 119.0, 64.3, 34.4, 29.7. TOF-HRMS calcd for $C_{13}H_{17}O$ [M+H$^+$]:189.1271, found 189.1273.

7-(*tert*-butyl)-2*H*-chromene (1j): Colorless oil; 0.78 g, yield: 82%; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 6.89 (s, 2H), 6.82 (s, 1H), 6.40 (d, *J* = 9.7 Hz, 1H), 5.72 (dt, *J* = 9.6, 3.4 Hz, 1H), 5.03 – 4.68 (m, 2H), 1.29 (s, 9H); ^{13}C{^{1}H}NMR (100 MHz, $CDCl_3$): δ (ppm) 153.8, 153.0, 126.2, 124.4, 121.2, 119.8, 118.3, 113.0, 65.7, 34.8, 31.3. TOF-HRMS calcd for $C_{13}H_{17}O$ [M+H$^+$]:189.1271, found 189.1273.

7, 8-dimethyl-2*H*-chromene (1k): Colorless oil; 1.09 g, yield: 68%; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 6.61 (dd, *J* = 18.8, 7.6 Hz, 2H), 6.31 (d, *J* = 9.7 Hz, 1H), 5.63 (dt, *J* = 9.5, 3.5 Hz, 1H), 4.71 (d, *J* = 1.5 Hz, 2H), 2.14 (s, 3H), 2.01 (s, 3H); ^{13}C{^{1}H}NMR (100 MHz, $CDCl_3$): δ (ppm) 151.8, 138.1, 125.1, 123.7, 123.4, 122.1, 120.6, 119.9, 65.5, 20.1, 11.2. The analytical data are consistent with the literature.[20]

6, 8-dimethyl-2*H*-chromene (1l): Colorless oil; 0.48 g, yield: 59%; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 6.69 (s, 1H), 6.53 (s, 1H), 6.28 (d, *J* = 9.8 Hz, 1H), 5.65 (dt, *J* = 9.5, 3.5 Hz, 1H), 4.69 (s, 2H), 2.12 (s, 3H), 2.05 (s, 3H); ^{13}C{^{1}H}NMR (100 MHz, $CDCl_3$): δ (ppm) 150.4, 131.4, 129.9, 125.1, 124.8, 124.7, 121.9, 121.8, 65.5, 20.5, 15.5. TOF-HRMS calcd for $C_{11}H_{13}O$ [M+H$^+$]: 161.0800, found 161.0804.

5, 8-dimethyl-2*H*-chromene (1m): Colorless oil; 1.21 g, yield: 76%; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 6.90 (d, *J* = 7.6 Hz, 1H), 6.68 – 6.62 (m, 2H), 5.84 (dt, *J* = 9.9, 3.7 Hz, 1H), 4.78 (dd, *J* = 3.7, 1.7 Hz, 2H), 2.29 (s, 3H), 2.18 (s, 3H); ^{13}C{^{1}H}NMR (100 MHz, $CDCl_3$): δ (ppm) 152.4, 131.6, 130.1, 122.8, 122.4, 122.3, 121.4, 120.7, 64.8, 18.3, 15.5. The analytical data are consistent with the literature.[20]

5, 7, 8-trimethyl-2*H*-chromene (1n): Colorless oil; 1.48 g, yield: 85%; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 6.51 (d, *J* = 9.9 Hz, 1H), 6.46 (s, 1H), 5.69 (dt, *J* = 9.8, 3.7 Hz, 1H), 4.63 (dd, *J* = 3.5, 1.4 Hz, 2H), 2.14 (s, 3H), 2.10 (s,3H), 1.98 (s, 3H); ^{13}C{^{1}H}NMR (100 MHz, $CDCl_3$): δ (ppm) 151.8, 137.1, 130.3, 123.8, 122.2, 121.1, 119.9, 118.4, 64.6, 19.8, 17.7, 11.1. The analytical data are consistent with the literature.[20]

8-phenyl-2*H*-chromene (1o): Colorless oil; 1.58 g, yield: 76%; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 7.57 – 7.51 (m, 2H), 7.46 – 7.38 (m, 2H), 7.36 – 7.30 (m, 1H), 7.18 (dd, *J* = 7.1, 2.2 Hz, 1H), 7.01 – 6.90 (m, 2H), 6.49 (dt, *J* = 9.8, 1.8 Hz, 1H), 5.82 (dt, *J* = 9.8,3.6 Hz, 1H), 4.80 (dd, *J* = 3.6, 1.8 Hz, 2H); ^{13}C{^{1}H}NMR (100MHz, $CDCl_3$): δ (ppm) 150.8, 137.9, 130.5, 129.3, 128.0, 127.0, 126.0, 124.9, 122.9, 122.1, 121.2, 65.4. The analytical data are consistent with the literature.[21]

2*H*-benzo[g]chromene (1p): Colorless oil; 1.47 g, yield: 81%; ^{1}H NMR (400 MHz, $CDCl_3$): δ

(ppm) 7.93 (dd, *J* = 8.5, 0.6 Hz, 1H), 7.77 – 7.72 (m, 1H), 7.65 (d, *J* = 8.8 Hz, 1H), 7.48 (m, 1H), 7.34 (m, 1H), 7.15 – 7.10 (m, 1H), 7.07 (dd, *J* = 8.8, 0.5 Hz, 1H), 5.91 (dt, *J* = 9.9, 3.9 Hz, 1H), 4.87 (dd, *J* = 3.9, 1.7 Hz, 2H); $^{13}C\{^{1}H\}$NMR (100 MHz, $CDCl_3$): δ (ppm) 152.4, 129.9, 129.5, 128.6, 126.7, 123.7, 121.5, 121.1, 120.4, 117.8, 115.5, 65.3. The analytical data are consistent with the literature.[22]

2*H*-benzo[h]chromene (1q): Colorless oil; 1.49 g, yield: 82%; ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 8.17 – 8.10 (m, 1H), 7.76 – 7.70 (m, 1H), 7.43 (m, 2H), 7.36 (d, *J* = 8.3 Hz, 1H), 7.13 (d, *J* = 8.3 Hz, 1H), 6.54 (dt, *J* = 9.7, 1.7 Hz, 1H), 5.80 (dt, *J* = 9.7, 3.7 Hz, 1H), 5.00 (dd, *J* = 3.7, 1.8 Hz, 2H); $^{13}C\{^{1}H\}$NMR (100 MHz, $CDCl_3$): δ (ppm) 149.7, 134.5, 127.7, 126.3, 125.5, 125.4, 124.8, 124.5, 121.9, 120.6, 120.4, 117.0, 66.0. The analytical data are consistent with the literature.[17]

General procedure for the asymmetric hydroboration of substrates 1: In a N_2-filled glovebox, an oven-dried Schlenk reaction tube with magnetic stir bar was charged with (*S, R*) - DuanPhos (9.6 mg, 0.025 mmol), CuCl (2.5 mg, 0.025 mmol), MeOK (7.0 mg, 0.10 mmol) and THF (0.6 mL). The mixture was sealed with cap and allowed to stir for 15 mins. Bis(pinacolato)diboron (152 mg, 0.60 mmol) was added to the solution and THF (0.4 mL). The tube was sealed with cap and removed from glovebox. After stirring for 20 mins at -20 °C, the solution of 2*H*-chromenes (0.500 mmol) in THF (0.5 mL) and MeOH (40.6 μL, 1.00 mmol) were added by syringes dropwise. The resulting solution was stirred at -20 °C for 1 h. The solution was allowed to warm to 0 °C for 1 h, followed by stirring for 4 h at room temperature. Upon completion of the reaction, the reaction mixture was passed through a short silica gel column eluting with Et_2O. The crude mixture was purified by chromatography on silica gel to give the corresponding borylation

product as colorless oil or white solid (petroleum ether: EtOAc=100:1).

Procedure for the synthesis of 3-5: In a round bottom flask, the product **2h** (75.55 mg, 0.25 mmol) was dissolved in THF/H_2O (1:1, 4 mL). $NaBO_3$•$4H_2O$ (0.19 g, 1.25 mmol) was added at room temperature. After stirred for 2 h, the reaction mixture was extracted with EtOAc, dried over Na_2SO_4, filtered and concentrated under reduced pressure. The residue was purified by silica gel chromatography (petroleum ether: EtOAc = 5:1) to afford **3**.[10]

In an argon-filled glovebox, an oven-dried flask was charged with **2h** (60.44 mg, 0.20 mmol), dibromomethane (35 μL, 2.5 equiv) and THF (2 mL). The flask was capped, removed from the glovebox, and cooled to -78 ºC. A solution of ^{n}BuLi (200 μL, 2.5 M in hexanes, 2.5 equiv) was added dropwise. After 10 mins, the resulting mixture was allowed to warm to rt and stirred for an additional 2 h. The reaction mixture was cooled to 0 ºC, and a premixed solution of NaOH (2 M)/30% H_2O_2 (2:1, 3 mL) was added dropwise. The resulting solution was then allowed to warm to rt and stir for 3 h. After quenched with water, the mixture was extracted with ethyl acetate twice. The organic layers were combined, dried over Na_2SO_4, filtered and concentrated in vacuo. The crude material was purified by flash column chromatography (petroleum ether: EtOAc=100:1). Compound **4** was obtained as a colorless oil in 80% yield.[11]

In a round bottom flask, **2n** (0.15 g, 0.5 mmol) was dissolved in a mixture solvent of THF and H_2O (4:1, 2 mL). $NaIO_4$ (0.16 g, 0.75 mmol) was then added at rt, and the suspension was stirred for 15 mins. HCl (aq, 1.0 M, 0.50 mL) was added. After the completion of the reaction, the reaction mixture was extracted with EtOAc. The combined organic layers were washed with H_2O and brine, dried over Na_2SO_4, filtered and concentrated under vacuum to give **5** as a white solid.[12]

(*S*)-2-(chroman-3-yl)-carboxylate (2a): Colorless oil; 56.7 mg, yield: 87%; 94% ee; $[\alpha]_D^{20}$ =

+29.4 (c = 0.2, EtOH); ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 7.09 – 6.99 (m, 2H), 6.78 (dd, *J* = 14.1, 8.2 Hz, 2H), 4.37 (dd, *J* = 10.9, 3.4 Hz, 1H), 4.01 (t, *J* = 11.0 Hz, 1H), 2.80 (d, *J* = 8.4 Hz, 2H), 1.70 (m, 1H), 1.24 (s, 12H); ^{13}C{^{1}H}NMR (100 MHz, $CDCl_3$): δ (ppm) 155.00, 129.5, 127.3, 123.0, 119.800, 116.7, 83.8, 67.7, 26.7, 24.7; TOF-HRMS calcd for $C_{15}H_{22}BO_3$ [M+H$^+$]: 261.1661, found 261.1659; HPLC conditions for the corresponding derived alcohol: Lux 5u Cellulose-4 (250 mm × 4.60 mm), ipa/hex = 5:95, 1.0 mL/min, 254 nm; t_A = 12.4 min (minor), t_B = 13.8 min (major). The optical rotation of the corresponding alcohol product after oxidation from **2a**: $[\alpha]_D^{20}$ = + 30.6 (c = 0.82, EtOH); The absolute configuration of **2a** was assigned by comparison with the optical rotation of the corresponding alcohol product after oxidation from **2a** reported in literature (lit. $[\alpha]_D^{20}$ = + 28.8 (c = 0.82, EtOH)).[9]

2-(8-chlorochroman-3-yl)-carboxylate (2b): Colorless oil; 59.0 mg, yield: 81%; 62% ee; $[\alpha]_D^{20}$ = +18.6 (c = 0.3, EtOH); ^{1}H NMR (400 MHz, $CDCl_3$): δ(ppm) 7.19 – 7.02 (m, 1H), 6.91 (m, 1H), 6.71 (t, *J* = 7.7 Hz, 1H), 4.66 – 4.38 (m, 1H), 4.07 (t, *J* = 11.0 Hz, 1H), 2.80 (d, *J* = 8.8 Hz, 2H), 1.88 – 1.53 (m, 1H), 1.23 (s, 12H); ^{13}C{^{1}H}NMR (100 MHz, $CDCl_3$): δ (ppm) 150.6, 127.9, 127.7, 124.6, 121.5, 119.9, 83.6, 68.1, 29.2, 26.4, 24.8; TOF-HRMS calcd for $C_{15}H_{21}BClO_3$ [M+H$^+$]: 295.1275, found 295.1270; SFC conditions for the corresponding derived alcohol: Lux 5u Cellulose-4 (250 × 4.60 mm), CO_2 : MeOH = 90:10, 3 mL/min, 210 nm; t_A = 3.7 min (minor), t_B = 4.5 min (major).

2-(6-bromochroman-3-yl)-carboxylate (2c): Colorless oil; 55.0 mg, yield: 65%; 64% ee; $[\alpha]_D^{20}$ = – 2.2 (c = 0.4, EtOH); ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 7.04 (d, *J* = 6.5 Hz, 2H), 6.55 (d, *J* = 9.4 Hz, 1H), 4.25 (dd, *J* = 11.0, 3.3 Hz, 1H), 3.90 (t, *J* = 10.8 Hz, 1H), 2.67 (d, *J* = 8.2 Hz, 2H), 1.56 (m, 1H), 1.14 (s, 12H); ^{13}C{^{1}H}NMR (100 MHz, $CDCl_3$): δ (ppm) 154.0, 132.0, 130.0, 124.9,

118.3, 112.0, 83.6, 67.7, 29.6, 26.3, 24.8; SFC conditions for the corresponding derived alcohol: Lux 5u Cellulose-4 (250 × 4.60 mm), CO_2 : MeOH = 90:10, 3 mL/min, 210 nm; t_A = 3.5 min (minor), t_B = 3.7 min (major).

2-(8-methylchroman-3-yl)-carboxylate (2d): Colorless oil; 58.0 mg, yield: 85%; 94% ee; $[\alpha]_D^{20}$ = +27.4 (c = 0.3, EtOH); ^{1}H NMR (400 MHz, $CDCl_3$): δ(ppm) 6.83 (d, *J* = 7.3 Hz, 1H), 6.77 (d, *J* = 7.4 Hz, 1H), 6.60 (t, *J* = 7.4 Hz, 1H), 4.33 (dd, *J* = 10.9, 3.4 Hz, 1H), 3.91 (t, *J* = 10.9 Hz, 1H), 2.70 (d, *J* = 8.6 Hz, 2H), 2.06 (s, 3H), 1.59 (td, *J* = 11.2, 3.3 Hz, 1H), 1.15 (s, 12H); $^{13}C\{^1H\}$NMR (100 MHz, $CDCl_3$): δ (ppm) 153.1, 128.3, 127.2, 125.9, 122.1, 119.2, 83.6, 67.8, 30.4, 26.7, 24.9, 16.3; TOF-HRMS calcd for $C_{16}H_{24}BO_3$ [M+H$^+$]: 275.1818, found 275.1816; SFC conditions for the corresponding derived alcohol: Lux 5u Cellulose-4 (250 × 4.60 mm), CO_2 : MeOH = 90:10, 3 mL/min, 210 nm; t_A = 2.9 min (minor), t_B = 3.1 min (major).

2-(7-methylchroman-3-yl)-carboxylate (2e): Colorless oil; 56.4 mg, yield 82%; 92% ee; $[\alpha]_D^{20}$ = +27.2 (c = 0.2, EtOH); ^{1}H NMR (600 MHz, $CDCl_3$): δ(ppm) 6.89 (d, *J* = 8.1 Hz, 1H), 6.71 – 6.52 (m, 2H), 4.35 (dd, *J* = 11.9, 3.9 Hz, 1H), 3.97 (t, *J* = 11.5 Hz, 1H), 2.75 (d, *J* = 9.2 Hz, 2H), 2.24 (s, 3H), 1.67 (m, 1H), 1.23 (s, 12H); $^{13}C\{^1H\}$NMR (100 MHz, $CDCl_3$): δ (ppm) 154.4, 136.9, 129.1, 120.4, 119.4, 117.0, 83.6, 68.2, 26.0, 24.8, 24.8, 21.2; TOF-HRMS calcd for $C_{16}H_{24}BO_3$ [M+H$^+$]: 275.1818, found 275.1816; SFC conditions for the corresponding derived alcohol: Lux 5u Cellulose-4 (250 × 4.60 mm), CO_2 : MeOH = 95:5, 3 mL/min, 230 nm; t_A = 2.8 min (minor), t_B = 3.1 min (major).

2-(8-methoxychroman-3-yl)-carboxylate (2f): Colorless oil; 63.2 mg, yield: 87%; 90% ee; $[\alpha]_D^{20}$ = +25.6 (c = 0.2, EtOH); ^{1}H NMR (400 MHz, $CDCl_3$): δ(ppm) 6.74 (t, *J* = 7.8 Hz, 1H), 6.66 (dd, *J* = 15.1, 7.1 Hz, 2H), 4.51 (dd, *J* = 10.6, 3.5 Hz, 1H), 4.02 (t, *J* = 11.2 Hz, 1H), 3.84 (s, 3H), 2.79 (d,

J = 8.7 Hz, 2H), 1.77 – 1.64 (m, 1H), 1.24 (s, 12H); $^{13}C\{^{1}H\}$NMR (100 MHz, $CDCl_3$): δ (ppm) 148.4, 144.4, 123.6, 121.7, 119.2, 108.9, 83.7, 68.2, 55.9, 26.5, 24.9, 24.8; TOF-HRMS calcd for $C_{16}H_{24}BO_4$ [M+H$^+$]: 291.1760, found 291.1765; SFC conditions for the corresponding derived alcohol: Lux 5u Cellulose-4 (250 × 4.60 mm), CO_2 : MeOH = 90:10, 3 mL/min, 230 nm; t_A = 5.1 min (minor), t_B = 5.6 min (major).

2-(7-methoxychroman-3-yl)-carboxylate (2g): Colorless oil; 50.8 mg, yield: 70%; 89% ee; $[\alpha]_D^{20}$ = +26.3 (c = 0.2, EtOH); ^{1}H NMR (400 MHz, $CDCl_3$): δ(ppm) 6.90 (d, *J* = 8.4 Hz, 1H), 6.40 (dd, *J* = 8.3, 2.6 Hz, 1H), 6.34 (d, *J* = 2.6 Hz, 1H), 4.35 (dd, *J* = 11.5, 3.3 Hz, 1H), 3.99 (t, *J* = 10.9 Hz, 1H), 3.73 (s, 3H), 2.73 (d, *J* = 9.5 Hz, 2H), 1.72 – 1.61 (m, 1H), 1.24(s, 12H); $^{13}C\{^{1}H\}$NMR (100 MHz, $CDCl_3$): δ (ppm) 158.7, 155.7, 129.7, 114.6, 106.9, 101.4, 83.8, 67.9, 55.5, 29.8, 25.6, 24.5; TOF-HRMS calcd for $C_{16}H_{24}BO_4$ [M+H$^+$]: 291.1760, found 291.1765; SFC conditions for the corresponding derived alcohol: Lux 5u Cellulose-4 (250 × 4.60 mm), CO_2 : MeOH = 90:10, 3 mL/min, 210 nm; t_A = 4.2 min (minor), t_B = 5.0 min (major).

2-(8-isopropylchroman-3-yl)-carboxylate (2h): Colorless oil; 70.3 mg, yield: 92%; 92% ee; $[\alpha]_D^{20}$ = +28.4 (c = 0.2, EtOH); ^{1}H NMR (400 MHz, $CDCl_3$): δ(ppm) 7.01 (d, *J* = 7.5 Hz, 1H), 6.87 (d, *J* = 7.3 Hz, 1H), 6.78 (t, *J* = 7.4 Hz, 1H), 4.41 (d, *J* = 8.2 Hz, 1H), 4.02 (t, *J* = 10.7 Hz, 1H), 3.25 (dt, *J* = 13.6, 6.8 Hz, 1H), 2.82 (d, *J* = 8.3 Hz, 2H), 1.69 (dd, *J* = 15.7, 7.3 Hz, 1H), 1.24 (s, 12H), 1.19 (d, *J* = 6.9 Hz, 6H); $^{13}C\{^{1}H\}$NMR (100 MHz, $CDCl_3$): δ (ppm) 152.2, 136.4, 127.1, 123.6, 122.2, 119.5, 83.5, 67.7, 29.9, 26.6, 24.7, 22.8, 22.6. TOF-HRMS calcd for $C_{18}H_{28}BO_3$ [M+H$^+$]: 303.2131, found 303.2129; SFC conditions for the corresponding derived alcohol: Lux 5u Cellulose-4 (250 × 4.60 mm), CO_2 : MeOH = 90:10, 3 mL/min, 254 nm; t_A = 2.4 min (minor), t_B = 2.6 min (major).

2-(8-(tert-butyl)chroman-3-yl)-carboxylate (2i): Colorless oil; 68.7 mg, yield: 87%; 92% ee; $[\alpha]_D^{20}$ = +30.9 (c = 0.5, EtOH); ^{1}H NMR (400 MHz, $CDCl_3$): δ(ppm) 7.06 (d, *J* = 7.7 Hz, 1H), 6.89 (d, *J* = 7.5 Hz, 1H), 6.73 (t, *J* = 7.6 Hz, 1H), 4.40 (dd, *J* = 10.7, 3.5 Hz, 1H), 4.03 (t, *J* = 10.5 Hz, 1H), 2.83 (d, *J* = 8.4 Hz, 2H), 1.79 – 1.59 (m, 1H), 1.34 (s, 12H), 1.23 (d, *J* = 4.1 Hz, 9H); ^{13}C{^{1}H}NMR (100 MHz, $CDCl_3$): δ (ppm) 154.0, 137.7, 127.8, 124.2, 122.9, 119.2, 83.6, 67.0, 34.8, 29.8, 29.7, 27.1, 24.8; TOF-HRMS calcd for $C_{19}H_{30}BO_3$ [M+H$^+$]: 317.2284, found 317.2286; SFC conditions for the corresponding derived alcohol: Lux 5u Cellulose-3 (250 × 4.60 mm), CO_2 : MeOH = 95:5, 1.5 mL/min, 254 nm; t_A = 4.9 min (major), t_B = 5.2 min (minor).

2-(7-(tert-butyl)chroman-3-yl)-carboxylate (2j): Colorless oil; 43.5 mg, yield: 55%; 92% ee; $[\alpha]_D^{20}$ = +29.3 (c = 0.2, EtOH); ^{1}H NMR (400 MHz, $CDCl_3$): δ(ppm) 7.17 – 7.10 (m, 1H), 6.94 – 6.89 (m, 1H), 6.71 (t, *J* = 7.7 Hz, 1H), 4.55 – 4.48 (m, 1H), 4.07 (t, *J* = 11.0 Hz, 1H), 2.80 (d, *J* = 9.2 Hz, 2H), 1.75 – 1.64 (m, 1H), 1.24 (s, 12H); ^{13}C{^{1}H}NMR (100 MHz, $CDCl_3$): δ (ppm) 154.3, 150.7, 129.1, 119.6, 116.9, 113.6, 83.6, 67.9, 34.6, 31.4, 29.6, 26.2, 24.8; TOF-HRMS calcd for $C_{19}H_{30}BO_3$ [M+H$^+$]: 317.2284, found 317.2286; SFC conditions for the corresponding derived alcohol: Lux 5u Cellulose-4 (250 × 4.60 mm), CO_2 : MeOH = 95:5, 3 mL/min, 210 nm; t_A = 4.3 min (minor), t_B = 4.8 min (major).

2-(7, 8-dimethylchroman-3-yl)-carboxylate (2k): Colorless oil; 59.0 mg, yield: 82%; 94% ee; $[\alpha]_D^{20}$ = +30.3 (c = 0.4, EtOH);^{1}H NMR (400 MHz, $CDCl_3$): δ(ppm) 6.68 (d, *J* = 7.7 Hz, 1H), 6.53 (d, *J* = 7.7 Hz, 1H), 4.33 (dd, *J* = 10.9, 2.8 Hz, 1H), 3.88 (t, *J* = 11.1 Hz, 1H), 2.68 (d, *J* = 8.7 Hz, 2H), 2.12 (s, 3H), 1.99 (s, 3H), 1.56 (td, *J* = 11.0, 3.3 Hz, 1H), 1.15 (s, 12H); ^{13}C{^{1}H}NMR (100 MHz, $CDCl_3$): δ (ppm) 152.7, 135.0, 126.0, 123.9, 121.1, 119.7, 83.3, 67.9, 29.8, 26.8, 24.7, 20.1, 11.6; TOF-HRMS calcd for $C_{17}H_{26}BO_3$ [M+H$^+$]: 289.1976, found 289.1973; SFC conditions for

the corresponding derived alcohol: Lux 5u Cellulose-4 (250 × 4.60 mm), CO_2 : MeOH = 90:10, 3 mL/min, 210 nm; t_A = 3.3 min (minor), t_B = 3.5 min (major).

2-(6, 8-dimethylchroman-3-yl)-carboxylate (2l): Colorless oil; 57.6 mg, yield: 80%; 92% ee; $[\alpha]_D^{20}$ = +27.9 (c = 0.2, EtOH); ^{1}H NMR (400 MHz, $CDCl_3$): δ(ppm) 6.68 (s, 1H), 6.58 (s, 1H), 4.31 (dd, *J* = 10.9, 2.9 Hz, 1H), 3.88 (t, *J* = 11.0 Hz, 1H), 2.66 (d, *J* = 7.9 Hz, 2H), 2.11 (s, 3H), 2.04 (s, 3H), 1.62 – 1.52 (m, 1H), 1.15 (s, 12H); ^{13}C{^{1}H}NMR (100 MHz, $CDCl_3$): δ (ppm) 150.6, 128.7, 127.9, 127.1, 125.2, 121.5, 83.2, 67.5, 29.4, 26.4, 24.5, 20.1, 15.6; TOF-HRMS calcd for $C_{17}H_{26}BO_3$ [M+H$^+$]: 289.1976, found 289.1973; SFC conditions for the corresponding derived alcohol: Lux 5u Cellulose-1 (250 × 4.60 mm), CO_2 : MeOH = 95:5, 3 mL/min, 230 nm; t_A = 5.8 min (major), t_B = 6.2 min (minor).

2-(5, 8-dimethylchroman-3-yl)-carboxylate (2m): Colorless oil; 61.2 mg, yield: 85%; 96% ee; $[\alpha]_D^{20}$ = +32.1 (c = 0.3, EtOH); ^{1}H NMR (400 MHz, $CDCl_3$): δ(ppm) 6.86 (d, *J* = 7.5 Hz, 1H), 6.61 (d, *J* = 7.5 Hz, 1H), 4.41 (m, 1H), 3.94 (t, *J* = 11.0 Hz, 1H), 2.73 (m, 1H), 2.59 (dd, *J* = 16.8, 11.6 Hz, 1H), 2.19 (s, 3H), 2.15 (s, 3H), 1.70 (m, 1H), 1.27 (s, 12H); ^{13}C{^{1}H}NMR (100 MHz, $CDCl_3$): δ (ppm) 151.8, 133.4, 126.1, 122.0, 119.5, 119.1, 82.2, 65.7, 23.4, 22.9, 17.6, 14.6; TOF-HRMS calcd for $C_{17}H_{26}BO_3$ [M+H$^+$]: 289.1976, found 289.1973; SFC conditions for the corresponding derived alcohol: Lux 5u Cellulose-4 (250 × 4.60 mm), CO_2 : MeOH = 95:5, 3 mL/min, 210 nm; t_A = 5.4 min (minor), t_B = 5.7 min (major).

2-(5, 7, 8-trimethylchroman-3-yl)-carboxylate (2n): White solid; MP: 87-89 °C, 38.5 mg, yield: 51%; 90% ee; $[\alpha]_D^{20}$ = +28.2 (c = 0.2, EtOH); ^{1}H NMR (400 MHz, $CDCl_3$): δ(ppm) 6.60 (s, 1H), 4.47 (m, 1H), 4.01 – 3.92 (m, 1H), 2.77 (dd, *J* = 15.3, 5.6 Hz, 1H), 2.62 (dd, *J* = 16.7, 11.8 Hz, 1H), 2.25 (s, 3H), 2.22 (s, 3H), 2.13 (s, 3H), 1.77 – 1.66 (m, 1H), 1.32 (s, 12H); ^{13}C{^{1}H}NMR

(100 MHz, $CDCl_3$): δ (ppm) 153.3, 134.3, 133.9, 122.9, 121.8, 118.2, 83.6, 67.5, 25.0, 24.6, 19.7, 18.8, 11.7; TOF-HRMS calcd for $C_{18}H_{28}BO_3$ [M+H$^+$]: 303.2131, found 303.2129; SFC conditions for the corresponding derived alcohol: Lux 5u Cellulose-4 (250 × 4.60 mm), CO_2 : MeOH = 90:10, 3 mL/min, 230 nm; t_A = 3.9 min (major), t_B = 4.1 min (minor).

2-(8-phenylchroman-3-yl)-carboxylate (2o): Colorless oil; 71.4 mg, yield: 85%; 86% ee; $[\alpha]_D^{20}$ = +18.2 (c = 0.3, EtOH); ^{1}H NMR (600 MHz, $CDCl_3$): δ(ppm) 7.52 (dd, *J* = 9.4, 2.3 Hz, 2H), 7.38 (t, *J* = 7.1 Hz, 2H), 7.32 – 7.25 (m, 1H), 7.11 (dd, *J* = 7.6, 1.9 Hz, 1H), 7.02 (dd, *J* = 7.7, 1.8 Hz, 1H), 6.86 (t, *J* = 7.6 Hz, 1H), 4.38 (dd, *J* = 11.1, 4.3 Hz, 1H), 4.01 (t, *J* = 11.0 Hz, 1H), 2.88 (d, *J* = 9.2 Hz, 2H), 1.79 – 1.65 (m, 1H), 1.23 (s, 12H); ^{13}C{^{1}H}NMR (100 MHz, $CDCl_3$): δ (ppm) 151.9, 138.8, 130.0, 129.7, 129.1, 128.6, 127.9, 126.7, 123.2, 119.7, 83.6, 67.7, 29.7, 27.2, 24.8; TOF-HRMS calcd for $C_{21}H_{26}BO_3$ [M+H$^+$]: 337.1969, found 337.1973; SFC conditions for the corresponding derived alcohol: Lux 5u Cellulose-4 (250 × 4.60 mm), CO_2 : MeOH = 90:10, 3 mL/min, 254 nm; t_A = 5.4 min (minor), t_B = 5.9 min (major).

2-(3, 4-dihydro-2H-benzo[g]chromen-3-yl)-carboxylate (2p): Colorless oil; 54.3 mg, yield: 70%; 76% ee; $[\alpha]_D^{20}$ = -2.6 (c = 0.3, EtOH);^{1}H NMR (400 MHz, $CDCl_3$): δ(ppm) 7.86 (d, *J* = 8.4 Hz, 1H), 7.73 (d, *J* = 9.3 Hz, 1H), 7.58 (d, *J* = 8.9 Hz, 1H), 7.46 (m, 1H), 7.31 (m, 1H), 7.03 (d, *J* = 8.9 Hz, 1H), 4.45 (m, 1H), 4.07 (t, *J* = 10.9 Hz, 1H), 3.18 (m, 1H), 2.98 (dd, *J* = 16.7, 11.2 Hz, 1H), 1.89 – 1.78 (m, 1H), 1.28 (s, 12H); ^{13}C{^{1}H}NMR (100 MHz, $CDCl_3$): δ (ppm) 152.7, 133.4, 129.0, 128.5, 127.6, 126.3, 123.2, 122.1, 119.3, 114.5, 83.7, 67.6, 24.9, 23.0; TOF-HRMS calcd for $C_{19}H_{24}BO_3$ [M+H$^+$]: 311.1820, found 311.1817; HPLC conditions for the corresponding derived alcohol: Lux 5u Cellulose-4 (250 mm × 4.60 mm), ipa/hex = 10:90, 1.0 mL/min, 254 nm; t_A = 9.5 min (minor), t_B = 12.7 min (major).

2-(2, 3-dihydro-1H-benzo[f]chromen-2-yl)-carboxylate (2q): Colorless oil; 64.2 mg, yield: 83%; 86% ee; $[\alpha]_D^{20}$ = +18.9 (c = 0.3, EtOH); ^{1}H NMR (400 MHz, $CDCl_3$): δ(ppm) 8.15 (d, *J* = 5.4 Hz, 1H), 7.72 (d, *J* = 4.2 Hz, 1H), 7.40 (d, *J* = 4.8 Hz, 2H), 7.29 (d, *J* = 8.1 Hz, 1H), 7.13 (d, *J* = 8.4 Hz, 1H), 4.59 (d, *J* = 10.9 Hz, 1H), 4.16 (t, *J* = 12.0 Hz, 1H), 2.91 (t, *J* = 14.0 Hz, 2H), 1.81 (dd, *J* = 15.3, 12.5 Hz, 1H), 1.25 (s, 12H); ^{13}C{^{1}H}NMR (100 MHz, $CDCl_3$): δ (ppm) 149.9, 133.2, 128.0, 127.4, 125.5, 125.1, 121.5, 119.2, 116.4, 99.9, 83.7, 68.1, 29.8, 26.7, 24.8; TOF-HRMS calcd for $C_{19}H_{24}BO_3$ [M+H$^+$]: 311.1820, found 311.1817; HPLC conditions for the corresponding derived alcohol: Lux 5u Cellulose-4 (250 mm × 4.60 mm), ipa/hex =10:90, 1.0 mL/min, 254 nm; t_A = 7.1 min (minor), t_B = 7.8 min (major).

8-isopropylchroman-3-ol (3): Colorless oil; 44.7 mg, yield 93%; 92% ee; $[\alpha]_D^{20}$ = +28.4 (c = 0.2, EtOH); ^{1}H NMR (600 MHz, $CDCl_3$): δ (ppm) 7.06 (dd, *J* = 7.8, 2.2 Hz, 1H), 7.01 – 6.57 (m, 2H), 4.24 (m, 1H), 4.23 – 4.02 (m, 2H), 3.29 (dq, *J* = 14.3, 7.2 Hz, 1H), 3.11 (dd, *J* = 17.1, 5.6 Hz, 1H), 2.80 (dd, *J* = 17.1, 6.7 Hz, 1H), 2.02 (s, 1H), 1.21 (dd, *J* = 7.1, 1.7 Hz, 6H); ^{13}C{^{1}H}NMR (100 MHz, $CDCl_3$): δ (ppm) 151.0, 136.5, 127.7, 124.2, 121.0, 118.9, 69.9, 63.5, 33.9, 26.6, 22.8, 22.6; SFC conditions for the corresponding derived alcohol: Lux 5u Cellulose-4 (250 × 4.60 mm), CO_2 : MeOH = 90:10, 3 mL/min, 254 nm; t_A = 2.4 min (minor), t_B = 2.6 min (major).

(8-isopropylchroman-3-yl) methanol (4): Colorless oil; 33.0 mg, yield: 80%; 92% ee; $[\alpha]_D^{20}$ = +49.6 (c = 0.2, EtOH); ^{1}H NMR (600 MHz, $CDCl_3$): δ (ppm) 7.03 (d, *J* = 8.5 Hz, 1H), 6.89 (d, *J* = 9.4 Hz, 1H), 6.82 (t, *J* = 7.8 Hz, 1H), 4.54 – 4.21 (m, 1H), 3.99 (dd, *J* = 11.3, 8.0 Hz, 1H), 3.68 (m, 2H), 3.26 (dt, *J* = 14.3, 7.2 Hz, 1H), 2.88 (dd, *J* = 17.1, 6.6 Hz, 1H), 2.59 (dd, *J* = 16.7, 8.2 Hz,1H), 2.39 – 2.11 (m,1H), 1.19 (dd, *J* = 7.3, 2.6 Hz, 6H); ^{13}C{^{1}H}NMR (100 MHz, $CDCl_3$): δ (ppm) 152.0, 136.2, 127.5, 123.7 120.7, 120.2, 67.5, 63.7, 34.8, 27.6, 26.4, 22.8, 22.7; TOF-HRMS calcd

for $C_{13}H_{19}O_2$ [M+H$^+$]: 207.1379, found 207.1384; SFC conditions for the corresponding derived alcohol: Lux 5 μm Amylose-1 (250 × 4.60 mm), CO_2 : MeOH = 90:10, 3 mL/min, 210 nm; t_A = 2.6 min (minor), t_B = 2.9 min (major).

(5,7,8-trimethylchroman-3-yl) boronic acid (5): White solid; MP: 111-113 ^{o}C, 81.4 mg, yield: 74%; $[\alpha]_D^{20}$ = +9.4 (c = 0.4, EtOH); ^{1}H NMR (400 MHz, $CDCl_3$): δ (ppm) 6.62 (s, 1H), 4.36 – 4.17 (m, 1H), 4.16 – 3.93 (m, 2H), 2.91 (dd, *J* = 17.2, 5.8 Hz, 1H), 2.65 (dd, *J* = 17.2, 5.4 Hz, 1H), 2.20 (s, 3H), 2.14 (s, 3H), 2.10 (s, 3H); ^{13}C{^{1}H}NMR (100 MHz, $CDCl_3$): δ (ppm) 135.4, 134.2, 124.0, 121.8, 115.4, 100.1, 69.3, 63.8, 31.8, 19.8, 18.9, 11.6; TOF-HRMS calcd for $C_{12}H_{18}BO_3$ [M+H$^+$]: 220.1346, found 220.1347.

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SUPPORTING INFORMATION

NMR, HPLC and SFC spectra. This material is available free of charge via the Internet at http://pubs.acs.org.

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