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Oxidative Kinetic Resolution of Some Naphtholic Alcohols Mediated by a Chiral Hypervalent Iodine Reagent

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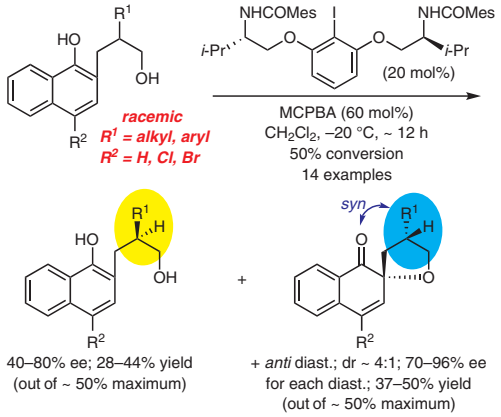


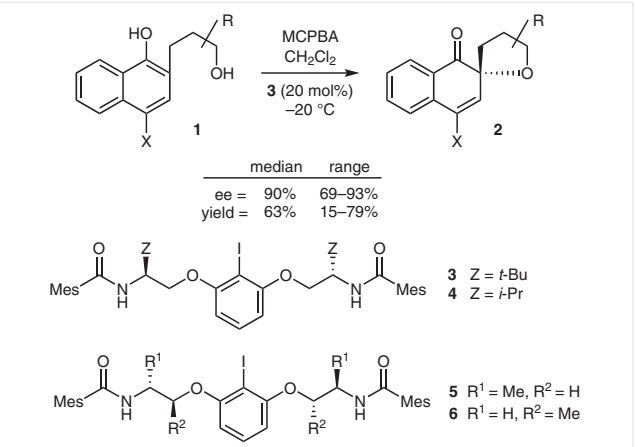
Received: 22.05.2018
Accepted after revision: 21.06.2018
Published online: 02.08.2018
DOI: 10.1055/s-0037-1610214; Art ID: ss-2018-z0334-fa

Abstract A chiral aryl iodide enables the catalytic, oxidative kinetic resolution of various 2-[(3-hydroxy-2-alkyl)propyl]naphthalen-1-ols.

Key words alcohols, asymmetric catalysis, hypervalent iodine, kinetic resolution

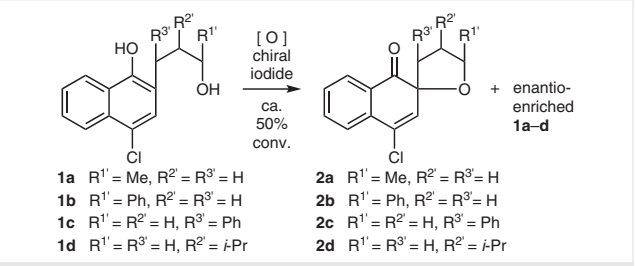
A recent contribution from these laboratories describes the catalytic, enantioselective oxidative cyclization of naphtholic alcohols **1** to spirocycles **2** (Scheme 1; R = H).[1] This process is mediated by a hypervalent[2] form of chiral aryl iodide[3] **3**, which is recognized as a structural variant of the Uyanik–Ishihara catalyst, **6**.[4] Unlike the related reaction of carboxylic acids,[4] the rate of cyclization of **1** is rather slow, typically requiring from 12 hours (X ≠ acyl) to as long as some days (X = acyl). Attempts to accelerate the reaction by introducing a *gem*-dialkyl motif on the hydroxypropyl chain (Thorpe–Ingold effect)[5] resulted in even slower rates. Evidently, in the present case, unfavorable steric interactions between substrate and catalyst override rate-enhancing effects. This observation led to the surmise that the same interactions could promote the kinetic resolution of alcohols **1**,[6] wherein R is a single alkyl group. Indeed, our publication illustrated one such example.

Examples of kinetic resolution mediated by hypervalent iodine species are known,[7] but systematic studies of the process appear to be unrecorded. This provided an incentive to further research the kinetic resolution of alcohols **1**, in that results of such investigations may well assist in the future development of more effective hypervalent iodine catalysts.



Scheme 1 Enantioselective oxidative cyclization of alcohols **1** catalyzed by aryl iodide **3**

The pursuit of the foregoing objective commenced with an exploration of the behavior of substrates (±)-**1a–d** (Scheme 2). The presence of a chlorine atom at the naphtholic 4-position ensured that no oxidation to naphthoquinones would occur upon exposure of these materials to io-



Scheme 2 Model substrates employed in the initial phase of this study

dine-based oxidants. This process consumes significant amounts of 4-unsubstituted naphthol substrates, to the detriment of overall efficiency.[1]

The action of a chiral oxidant on (±)-**1a–d** could not only promote selective cyclization of one enantiomer to **2**, providing enantioenriched residual alcohol (= kinetic resolution), but also alter the diastereoselectivity of the process. Accordingly, the oxidative cyclization of **1a–d** was first executed with an achiral iodine oxidant, so as to evaluate the innate (substrate-controlled) selectivity of the reaction. Past experience had shown that the chiral iodides in Scheme 1 perform best in CH_2Cl_2 and that the stereochemical course of the reaction was quite solvent-dependent. It thus seemed advisable to carry out the spiroetherification of **1a–d** in CH_2Cl_2. To that end, [bis(trifluoroacetoxy)iodo]benzene (PIFA) was chosen as the oxidant, because it is known to perform well in CH_2Cl_2. In all cases, the four stereoisomers of each product (two enantiomers of each diastereomer), were separable by chiral supercritical fluid chromatography (SFC). Integration of the SFC trace enabled the determination of diastereomeric ratios and, later, of enantiomeric excess values. However, the diastereomers were difficult to separate by flash column chromatography. Fortunately, their ^{1}H NMR signals were well resolved, enabling the assignment of relative configurations by NOESY-2D NMR spectrometry.[1]

Substrates bearing a group at the 1′-position **1a**,**b** reacted with poor diastereoselectivity (d.r. ≈ 1.5:1 for **1a**, 1.8:1 for **1b**). In either case, the 1′-substituent in the major diastereomer was *anti* to the naphthol-derived carbonyl group within the newly formed tetrahydrofuran ring. The major products are thus described as (±)-*anti*-**2a** and (±)-*anti*-**2b**, and the minor ones as (±)-*syn*-**2a** and (±)-*syn*-**2b**. The oxidative cyclization of **1c** returned only (±)-*anti*-**2c**.[1] In contrast to the above cases, the cyclization of **1d** returned (±)-*syn*-**2d** as the dominant product (d.r. ≈ 4:1; see Table 3). Also, yields of spiroethers **2d** were higher compared to **2a–c**. Alcohol **1d** was thus chosen as the test substrate for oxidative cyclization/kinetic resolution.[1]

The process in question was initially studied with catalysts **3–6** under the conditions optimized earlier for the asymmetric cyclization of unsubstituted alcohols **1**.[1] Reactions were run to about 50% conversion in order to assess the enantiomeric enrichment of recovered **1d** and of products. To that end, only 0.6 equivalents of MCPBA were used in each experiment (Table 1). The diastereoselectivity of the process was largely unaffected by the nature of the chiral catalyst. With regard to optical enrichment of residual **1d**, iodoarenes **3** and **6** afforded material of a moderate 54–57% ee. Much better results were obtained with **4**, which returned unreacted **1d** of 79% ee. Catalyst **4** also exhibited a higher selectivity factor (S = 10) relative to its congeners (S = 4.5–5.6). Furthermore, reactions run with **4** proceeded at a faster rate relative to **3** (13.5 vs. 20 h). Finally, reactions run with iodides **3** and **4** returned (+)-**1d**, later shown to be of *S*-configuration, while **6** afforded (*R*)-(–)-**1d** (vide infra). That catalysts **3** and **4** promote the opposite sense of induction relative to **5** is consistent with earlier findings.[1]

An opposite sense of asymmetric induction was also observed for spiroethers **2** (Table 1). It subsequently transpired that iodide **4** induced formation of *syn*-**2d** of *R*,*R*-configuration, and of *anti*-**2d** of *R*-configuration at the spirocenter and *S*-configuration at the isopropyl-bearing carbon.

Biographical Sketches

Nikita Jain (Siliguri, India, 1988), received her B.Sc. in 2010 from St. Xavier's College (India) and her M.Sc. in 2012 from IIT Kanpur (India), where she synthesized 2,2-diarylethylamines and various γ-aminobutyric acid derivatives in the group of Prof. Manas K. Ghorai. She pursued her Ph.D. (2012–2017) in the group of Prof. Marco A. Ciufolini at The University of British Columbia, Vancouver. There, she developed methodologies for enantioselective oxidative amidation and cycloetherification of naphthols using chiral hypervalent iodine reagents. She is currently working as a Research Scientist at SWITCH Materials Inc., Burnaby, Canada.

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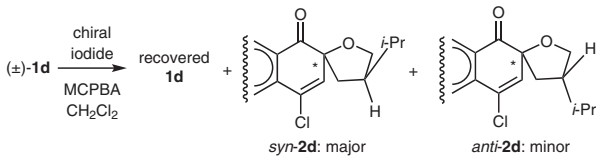
Henceforth, the configurations of cyclic products are reported so that the first one relates to the spirocenter; the second one, to the alkyl-bearing carbon.

Table 1 Enantioselective Cyclization/Kinetic Resolution of Test Alcohol **1d** Mediated by Catalysts **3–6**[a]



Iodide	3	4	5	6
Reaction time (h)	20	13.5	6.5	6
Conversion[b] (%)	52	56	53	54
d.r.[c]	80:20	83:17	83:17	77:23
Yield (%) *syn* + *anti* **2d**[d]	49	52	47	50
ee (%) *syn*-**2d**[e]	90	94	77	89
Config. *syn*-**2d**[f]	*R*,*R*	***R*,*R***	***S*,*S***	***S*,*S***
ee (%) *anti*-**2d**[e]	97	98	79	97
Config. *anti*-**2d**[f]	*R*,*S*	*R*,*S*	*S*,*R*	*S*,*R*
ee (%) recov. **1d**[e]	57	79	57	54
Config. recov. **1d**[g]	(*S*)-(+)-	(*S*)-(+)-	(*R*)-(−)-	(*R*)-(−)-
Yield (%) recov. **1d**[d]	30	35	29	30
S-factor[h]	5.6	10.0	5.3	4.5

[a] Reaction conditions: 20 mol% chiral iodide, 60 mol% MCPBA, 0.02 M solution, –20 °C.
[b] Determined by ^{1}H NMR spectroscopy using 3,5-dimethoxybenzaldehyde as the internal standard.
[c] Diastereomeric ratio: determined by integration of the chiral SFC trace of the mixture of products after column chromatography.
[d] Isolated yields after chromatography.
[e] Enantiomeric excess: determined by chiral SFC.
[f] In all cases, the first configuration is that of the spirocenter, the second one, that of the alkyl-bearing carbon.
[g] Determined by X-ray diffractometry (see text).
[h] Selectivity factor, $S = \ln[(1 - c)(1 - ee_{SM})]/\ln[(1 - c)(1 + ee_{SM})]$; ee_{SM} = ee of recovered starting material, c = conversion.

The observation that a decrease in the steric demand of the alkyl group in **3** versus **4** (*t*-Bu vs *i*-Pr) resulted in better catalytic performance induced us to evaluate the methyl analogue, **5**.[8] However, this catalyst proved to be inferior: the ee's of recovered **1d** and of cyclic products, as well as the selectivity factor (S = 5.3), were markedly lower compared to **4**. Overall, the latter iodide seemed to be optimal for kinetic resolution.

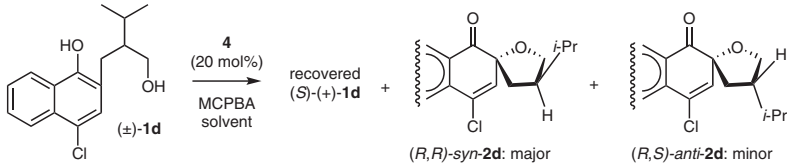
Just as observed earlier for the reaction **1** → **2**,[1] kinetic resolutions orchestrated by iodoarene **4** occurred best in a 0.02 M solution in CH_2Cl_2 at –20 °C (Table 2). Changes in temperature or concentration had no major effect on efficiency, except for a slight lowering of the S-factor. However, the nature of the solvent was critical. Among the alternative solvents that were tested, only $CHCl_3$ proved to be moderately competent. Yet, reactions run in this medium returned scalemic **1d** of lower ee relative to CH_2Cl_2. On the other hand, the spiroether products still exhibited an excellent enantiomeric enrichment. Polar solvents, either neat or admixed with CH_2Cl_2, were damaging. Thus, substantial loss of asymmetric induction was observed when the reaction was run in a mixture of CH_2Cl_2 and nitromethane, while no enantioselectivity at all ensued upon operation in neat trifluoroethanol (TFE).[9] Nonpolar solvents such as toluene were also unsatisfactory. Finally, reactions run in a mixture of CH_2Cl_2 and methyl *tert*-butyl ether were found to be extremely slow, resulting in hardly any conversion after 6 hours. Perhaps unsurprisingly, the best conditions for effective cycloetherification/kinetic resolution were the same as those employed earlier for the enantioselective cyclization of **1**.

The absolute configurations of unreacted **1d** and of *syn*- and *anti*-**2d** thus produced were determined as reported by us earlier.[1]

Alcohol (+)-**1d** of 79% ee, retrieved from a reaction run with **4**, was subjected to a second round of oxidative cyclization mediated by the same catalyst (Scheme 3). This reaction was halted at 43% conversion, whereupon residual (+)-**1d** was found to be of 96% ee. This highly enantioenriched material was converted into the crystalline bis-*p*-bromobenzoate ester (−)-**7**, which proved to be of *S*-configuration upon X-ray crystallographic analysis. This means that (*S*)-(+)-**1d** is the slow reacting alcohol enantiomer when (±)-**1d** cyclizes in the presence of iodide **4** (or **3**), and (*R*)-(−)-**1d** is the fast reacting one. Consequently, the absolute configuration of the carbon atom bearing the *i*-Pr group in major diastereomer *syn*-**2d** (94% ee, Table 1) must be *R*. But the relative configuration of *syn*-**2d** requires that the spirocenter of the molecule also be of *R*-configuration. Therefore, *syn*-**2d** obtained with catalysts **3** and **4** must be of *R*,*R* configuration.

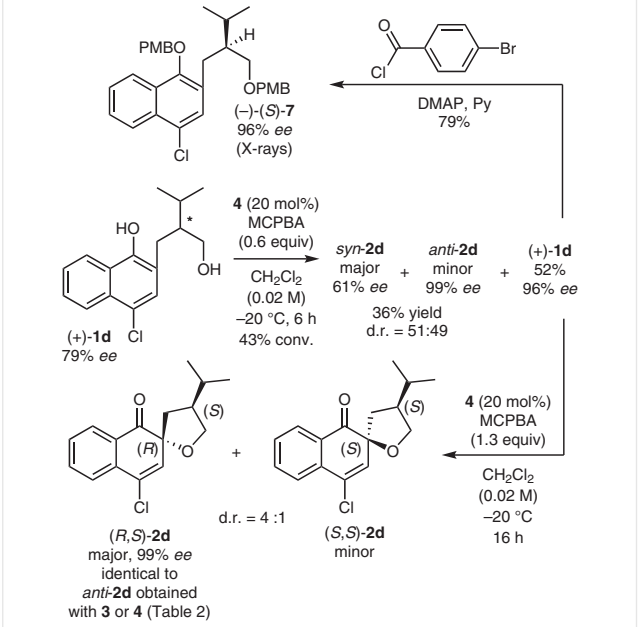
Furthermore, (*S*)-(+)-**1d** of 96% ee was again subjected to cyclization in the presence of **4**, thereby yielding a 1:4 mixture of *syn*-**2d** (minor in this case) and *anti*-**2d** (major). The 4:1 mixture of *syn*-**2d** (major) and *anti*-**2d** (minor) produced in the reaction of Table 2, and the 1:4 one of *syn*-**2d** (minor) and *anti*-**2d** (major) obtained as per Scheme 4, were independently subjected to NOESY 2D NMR study, which nicely confirmed the relative configuration of each product. Furthermore, *anti*-**2d** arising as the major product from the cyclization of (*S*)-(+)-**1d** of 96% ee was identical (chiral SFC; NMR) to the major enantiomer of *anti*-**2d** obtained earlier from the reactions in Table 2. Therefore, the absolute configuration of the carbon atom bearing the *i*-Pr group in *anti*-**2d** produced with catalysts **3** and **4** is *S*. But the relative configuration of the molecule requires that the spirocenter be of *R*-configuration. The absolute configuration of *anti*-**2d** must then be *R*,*S*. Chiral iodides **3** and **4** thus operate preferentially on the *R*-enantiomer of **1d** and pro-

Table 2 Effect of Solvent on the Performance of Catalyst **4** with Test Substrate **1d**[a]



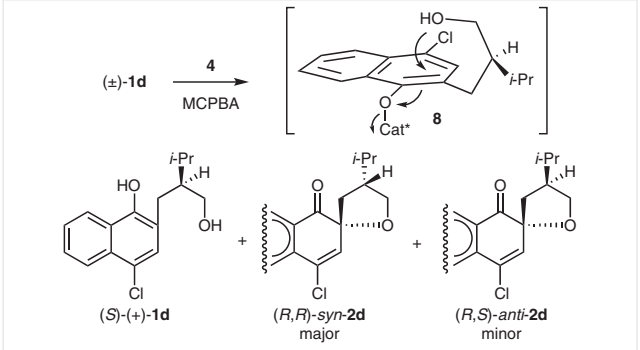
Solvent:	CH_2Cl_2[b]	CH_2Cl_2[c]	CH_2Cl_2[d]	1:3 CH_2Cl_2/ $MeNO_2$	4:3 CH_2Cl_2/ MTBE[e]	$CHCl_3$	Toluene	TFE[f]
Reaction time (h)	13.3	7.3	9.7	18.5	6	16.5	14.3	13.5
Conversion[g] (%)	56	58	60	50	<5	51	53	59
d.r.[h]	83:17	84:16	80:20	82:18	–	82:18	88:12	75:25
Yield (%) *syn* + *anti* **2d**[i]	52	53	52	44	–	50	34	48
ee (%) (*R*,*R*)-*syn*-**2d**[j]	94	89	90	80	–	94	90	32
ee (%) (*R*,*S*)-*anti*-**2d**[j]	98	92	97	79	–	98	71	<5
ee (%) recov. (*S*)-**1d**[j]	79	80	78	48	–	62	45	<5
Yield (%) recov. (*S*)-**1d**[i]	35	36	35	30	–	35	38	<5
S-factor[k]	10.0	8.9	7.2	4.5	–	7.3	3.5	–

[a] Reaction conditions: 0.6 equiv MCPBA, 0.02 M solution.
[b] Reaction performed at –20 °C.
[c] Reaction performed at 0 °C.
[d] Reaction performed at –20 °C at a concentration of 0.05 M.
[e] MTBE: methyl *tert*-butyl ether.
[f] TFE: 2,2,2-trifluoroethanol.
[g] Determined by ^{1}H NMR spectroscopy using 3,5-dimethoxybenzaldehyde as the internal standard, (c = 100% yield of starting material).
[h] Determined by integration of the chiral SFC trace of the mixture of products after column chromatography.
[i] Isolated yields after column chromatography.
[j] Determined by chiral SFC.
[k] Selectivity factor, $S = \ln[(1 - c)(1 - ee_{SM})]/\ln[(1 - c)(1 + ee_{SM})]$; ee_{SM} = *ee* of recovered starting material, c = conversion.



Scheme 3 Determination of the absolute configurations of enantioenriched spirocycle (*R*,*S*)-*anti*-**2d** (minor product obtained upon cyclization of **1d** in the presence of **4**) and of recovered alcohol **1d**

mote the formation of spirocenters of *R*-configuration (Scheme 4). This is consistent with the sense of induction observed earlier with substrates **1** (R = H).[1]



Scheme 4 Preferred stereochemical course of the oxidative cyclization/kinetic resolution of alcohol **1d** with catalyst **4**

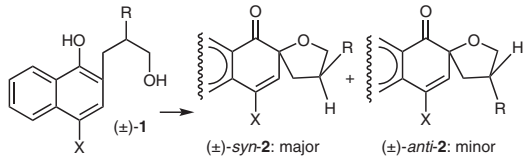
In contrast, the kinetic resolution of compounds **1a–c** mediated by catalyst **4** was inefficient: recovered alcohols were of uniformly low (<10%) ee.[1] Moreover, (±)-**1a**,**b** afforded highly enantioenriched spirocyclic products (configurations not determined), but with low diastereoselectivity,

while (±)-**1c** provided (+)-**2c** as a single diastereomer of only 34% ee. Therefore, no further work was done with 1′- or 3′-substituted materials.

The encouraging results obtained with **1d** warranted further investigation of analogous 2′-substituted substrates. Indeed, the resolution of primary alcohols bearing a stereogenic center at the β-position (such as **1d**) is challenging.[10] Kinetic resolution mediated by **4** offered an interesting and novel opportunity.

The compounds thus examined are alcohols **1e**–**p**,[8] which, as before, were first subjected to oxidative cyclization with PIFA in CH_2Cl_2 (Table 3). This consistently resulted in preferential (3–4:1) formation of *syn*-**2e**–**p**.

Table 3 Diastereoselectivity in the Oxidative Cyclization of 2′-Monosubstituted Alcohols **1** Mediated by PIFA[a]

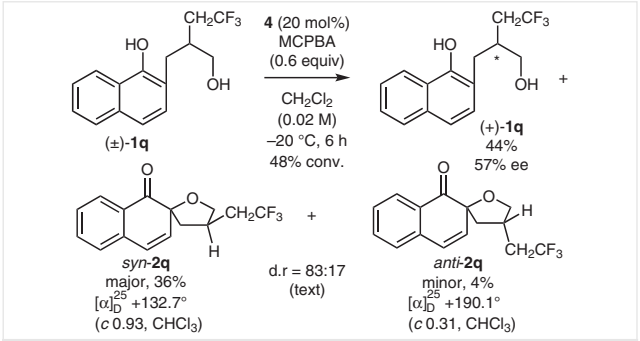


Entry	X	R	dr	Yield (%)[b]
d	Cl	*i*-Pr	77:23[c]	49
e	Cl	Me	68:32[d]	45
f	Cl	CH_2CF_3	74:26[c]	46
g	Cl	Bn	69:31[c]	48
h	Cl	*c*-C_6H_{11}	75:25[c]	50
i	Cl	Ph	68:32[c]	39
j	Br	Me	68:32[d]	48
k	Br	Bn	73:27[c]	33
l	Br	*i*-Pr	78:22[c]	44
m	Br	*c*-C_6H_{11}	79:21[c]	43
n	H	Me	68:32[d]	18
o	H	*i*-Pr	77:23[c]	28
p	H	*c*-C_6H_{11}	77:23[c]	20

[a] Reaction conditions: PIFA, CH_2Cl_2.
[b] Isolated yields (non-optimized) after silica gel column chromatography.
[c] Determined by integration of chiral SFC trace.
[d] Determined by integration of the ^{1}H NMR spectrum of the crude reaction mixture.

Diastereomeric ratios were once again measured by integration of ^{1}H NMR spectra of product mixtures or of chromatograms obtained by chiral SFC, and the relative configuration of *syn*- and *anti*-**2e**–**p** was determined by 2D NOESY NMR.[8] Notice how substrates incorporating halogen at the naphtholic 4-position cyclized in generally higher yields relative to their unsubstituted analogues **1n**–**p**, a significant fraction which was lost to naphthoquinone formation.

Kinetic resolution of **1e**–**p** in the presence of **4** yielded the results summarized in Table 4. In all cases, recovered starting alcohol was dextrorotatory. The highest enantiomeric enrichments of unreacted (+)-**1** were observed in the 4-Cl series (ee >70%), as were the best selectivity factors, S. An especially high S-value of 19 was attained with **1f**. Substrates with R = Me consistently returned (+)-**1** of less than 50% ee. Contrary to what was observed earlier with **1d**, catalyst **4** generally enhanced the diastereoselectivity of the reaction of **1e**–**p** in favor of the *syn*-isomer. The most notable effect in that sense was recorded with **1f**, for which the *syn*-selectivity increased from 74:26 with PIFA (Table 3) to 91:9 with **4**. Spiroethers obtained from 4-H and 4-Cl substrates were of generally good to excellent ee, except for *anti*-**2i**, while those resulting from 4-Br alcohols tended to be of slightly lower ee. As seen in Table 4, in some cases chiral SFC failed to separate the enantiomers of the spirocycles. This was especially distressing in the context of **1q** (Scheme 5), because, unlike other cyclic products, diastereomers *syn*-**2q** and *anti*-**2q** were readily separable by flash column chromatography and exhibited large positive rotations (> +100; Scheme 5). The failure of chiral SFC to separate their enantiomers prevented a straightforward determination of their ee.

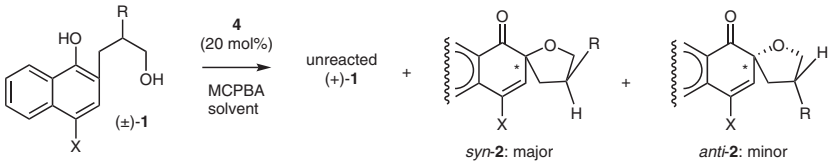


Scheme 5 Behavior of alcohol **1q**

In summary, chiral iodide **4** appears to be a competent catalyst for the kinetic resolution of alcohols **1d**–**p**, affording improved selectivity factors relative to structurally related catalysts. This work illustrates a new application of chiral hypervalent iodine species as mediators of the kinetic resolution of primary alcohols bearing a stereogenic center at the β-position.

Most commercial reagents and solvents were used as received, but CH_2Cl_2 was freshly distilled from CaH_2 under argon. All reactions were performed under argon in flame- or oven-dried flasks equipped with Teflon stirring bars and fitted with rubber septa for the introduction of materials via syringe. Reactions were monitored by TLC using silica gel 60 F_{254} precoated plates. Spots were visualized by UV or with $KMnO_4$ or vanillin stains. Flash chromatography utilized Silicycle® 230–400 mesh silica gel. Unless otherwise stated, ^{1}H (300 MHz) and ^{13}C (75 MHz) NMR spectra were recorded from $CDCl_3$ solutions at r.t. Chemical shifts are reported in parts per million (ppm) on the δ scale and coupling constants, *J*, in hertz (Hz). Standard abbreviations are used to indicate multiplicities. IR spectra (cm^{-1}) were recorded from

Table 4 Kinetic Resolution of Alcohols **1** Mediated by Catalyst **4**[a]



Entry	X	R	Conv.[b] (%)	Yield (%) recov. **1**[c,d]	ee (%) recov. **1**[e]	d.r.[e] *syn*/*anti*	Yield (%) **2**[c] (*syn* + *anti*)	ee (%)*syn*-**2**[e]	ee (%) *anti*-**2**[e]	S-factor[f]
e	Cl	Me	44	40	47	79:21[g]	42	–[h]	–[h]	6.2
f	Cl	CH_2CF_3	47	37	71	91:9	45	94	79	19.0
g	Cl	Bn	50	40	72	87:13	47	94	91	13.0
h	Cl	*c*-C_6H_{11}	58	38	76	80:20	53	92	95	7.6
i	Cl	Ph	42	40	51	86:14	37	93	59	9.5
j	Br	Me	59	35	49	81:19[g]	45	–[h]	–[h]	3.2
k	Br	Bn	52	42	71	88:12	45	86	82	10.0
l	Br	*i*-Pr	57	35	67	86:14	51	73	87	5.9
m	Br	*c*-C_6H_{11}	60	28	65	83:17	53	72	86	4.7
n	H	Me	55	40	48	86:14[g]	50	–[h]	–[h]	3.6
o	H	*i*-Pr	60	35	62	82:18	48	96	–[h]	4.3
p	H	*c*-C_6H_{11}	57	33	41	81:19	45	94	–[h]	2.7
q	H	CH_2CF_3	48	44	57	83:17	36 + 4	–[h]	–[h]	7.4

[a] Reaction conditions: 0.6 equiv MCPBA, 0.02 M solution, 13 h.
[b] Determined by ^{1}H NMR spectroscopy using 3,5-dimethoxybenzaldehyde as the internal standard, (c = 100% yield of starting material).
[c] Isolated yields after column chromatography.
[d] The maximum theoretical yield of recovered **1e**–**q** is 50%.
[e] Determined by chiral SFC.
[f] Selectivity factor, $S = \ln[(1 - c)(1 - ee_{SM})]/\ln[(1 - c)(1 + ee_{SM})]$; ee_{SM} = ee of recovered starting material, c = conversion.
[g] Determined by integration of the ^{1}H NMR spectrum of the crude reaction mixture.
[h] The enantiomers were inseparable by chiral SFC under all conditions tried.

films (PerkinElmer Universal ATR Sampling Accessories). Low and high-resolution mass spectra (*m*/*z*) were obtained in the electron impact (EI) or electrospray (ESI; MeOH solutions) mode, as specified. Optical rotations were measured at the Na_D line (589 nm) with a PerkinElmer 241 polarimeter. Enantiomeric excesses reported in this experimental section were determined using a Thar SFC station (Model 840) equipped with chiral columns OD-H (0.46 cm × 25 cm 5 µm), AD-H (0.46 cm × 25 cm 5 µm), AS-H (0.46 cm × 25 cm 5 µm), OJ-H (0.46 cm × 25 cm 5 µm) and Lux 3u Cellulose 2 (50 × 4.60 mm). The operating pressure was 120 bar and the column temperature was 33–34 °C. The intensities of the signals of each enantiomer in enantioenriched products were corrected on the basis the ratios of the signal intensities observed for the racemates. More detailed experimental protocols are provided as Supporting Information.[8]

Diastereoselective Cyclization of Alcohols 1 with PIFA in CH_2Cl_2; General Procedure

A solution of an alcohol **1** (0.36 mmol, 1.0 equiv) in CH_2Cl_2 (12.0 mL) was slowly added at r.t. over a period of 2 min to a solution of PIFA (170 mg, 0.4 mmol, 1.1 equiv) in CH_2Cl_2 (8.0 mL). The final concentration of substrate was then nominally 0.02 M. The solution was stirred for 1 to 2 h, whereupon TLC showed that the reaction was complete. The mixture was evaporated to dryness and the residue was purified by flash column chromatography to afford spiroethers **2**.

(±)-4′-Chloro-4-isopropyl-4,5-dihydro-1′*H*,3*H*-spiro[furan-2,2′-naphthalen]-1′-one (2d)

Eluent: 1:19 EtOAc/hexanes; yield: 24 mg (49%) from 50 mg of (±)-**1d**; colorless oil; 3:1 mixture of *syn*- and *anti*-**2d**.

IR (film): 1693 cm^{-1}.

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 8.04–7.99 (m, 1 H), 7.72–7.64 (m, 2 H), 7.48–7.43 (m, 1 H), 6.42 (s, 0.75 H), 6.37 (s, 0.25 H), 4.42 (app t, *J* = 7.5 Hz, 0.25 H), 4.26 (app t, *J* = 7.5 Hz, 0.75 H), 3.86 (app t, *J* = 9.0 Hz, 0.75 H), 3.76 (app t, *J* = 7.5 Hz, 0.25 H), 2.43–1.99 (m, 3 H), 1.70–1.49 (m, 1 H), 0.95–0.88 (m, 6 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 199.6, 135.1 (2 C), 135.0, 134.9, 133.8, 133.7, 129.4, 129.3, 129.2, 129.0, 128.9 (2 C), 127.7, 125.6, 125.5, 86.3, 84.6, 48.4, 45.3, 43.4, 40.9, 32.1, 31.5, 22.1, 22.0, 21.9, 21.7.

HRMS: *m*/*z* [M – H]$^-$ calcd for $C_{16}H_{16}ClO_2$: 275.0844; found: 275.0816.

(±)-4′-Chloro-4-methyl-4,5-dihydro-1′*H*,3*H*-spiro[furan-2,2′-naphthalen]-1′-one (2e)

Eluent: 1:19 EtOAc/hexanes; yield: 9 mg (45%) from 20 mg of (±)-**1e**; colorless oil; 7:3 mixture of *syn*- and *anti*-**2e**.

IR (film): 1692 cm^{-1}.

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 8.04–7.99 (m, 1 H), 7.72–7.64 (m, 2 H), 7.48–7.43 (m, 1 H), 6.40 (s, 0.7 H), 6.39 (s, 0.3 H), 4.38 (app t, *J* = 7.6 Hz, 0.3 H), 4.23 (app t, *J* = 7.6 Hz, 0.7 H), 3.74 (app t, *J* = 9.9 Hz, 0.7 H), 3.65 (app t, *J* = 8.1 Hz, 0.3 H), 2.80–2.61 (m, 0.3 H), 2.59–2.45 (m, 0.7 H), 2.37 (dd, *J* = 12.9, 7.0 Hz, 0.3 H), 2.19 (dd, *J* = 12.5, 7.5 Hz, 0.7 H), 1.99 (dd, *J* = 11.5, 10.7 Hz, 0.7 H), 1.66–1.61 (m, 0.3 H), 1.13 (d, *J* = 6.5, 2.3 H), 1.09 (d, *J* = 6.7 Hz, 0.7 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 199.5, 135.1 (2 C), 135.0, 134.9, 133.9, 133.6, 129.4, 129.3, 129.2, 129.1, 128.9, 127.7, 125.6, 125.5, 85.8, 84.5, 77.1, 77.0, 46.0, 44.1, 35.2, 32.8, 16.8, 15.6.

HRMS: *m*/*z* calcd [M + Na]$^+$ for $C_{14}H_{13}ClO_2Na$: 271.0502; found: 271.0509.

(±)-4′-Chloro-4-(2,2,2-trifluoroethyl)-4,5-dihydro-1′*H*,3*H*-spiro[furan-2,2′-naphthalen]-1′-one (2f)

Eluent: 1:19 EtOAc/hexanes; yield: 23 mg (46%) as a mixture of diastereomers from 50 mg of (±)-**1f**; light yellow oil; 3:1 mixture of *syn*- and *anti*-**2f**.

IR (film): 1692 cm^{-1}.

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 8.03 (app d, *J* = 7.6 Hz, 1 H), 7.74–7.67 (m, 2 H), 7.50–7.45 (m, 1 H), 6.36 (s, 0.75 H), 6.33 (s, 0.25 H), 4.49 (app t, *J* = 8.0 Hz, 0.25 H), 4.31 (app t, *J* = 7.8 Hz, 0.75 H), 3.88 (app t, *J* = 9.1 Hz, 0.75 H), 3.77 (app t, *J* = 8.4 Hz, 0.25 H), 3.07–2.96 (m, 0.25 H), 2.84–2.67 (m, 0.75 H), 2.50–2.22 (m, 3 H), 2.15 (dd, *J* = 12.8, 9.6 Hz, 0.75 H), 1.73 (dd, *J* = 12.9, 10.6 Hz, 0.25 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 198.9, 198.6, 135.3, 135.2, 134.9, 132.6, 132.2, 130.4, 130.1, 129.7, 129.6, 128.8, 127.8, 126.5 (q, *J* = 277.0 Hz), 125.8, 125.7, 85.0, 83.2, 74.5, 74.3, 42.8, 41.7, 35.9 (q, *J* = 28.9 Hz), 34.3 (q, *J* = 3.1 Hz).

HRMS: *m*/*z* [M + Na]$^+$ calcd for $C_{15}H_{12}ClF_3O_2Na$: 339.0376; found: 339.0374.

(±)-4-Benzyl-4′-chloro-4,5-dihydro-1′*H*,3*H*-spiro[furan-2,2′-naphthalen]-1′-one (2g)

Eluent: 1:19 to 1:9 EtOAc/hexanes; yield: 24 mg (48%) as a mixture of diastereomers from 50 mg of (±)-**1g**; light yellow oil; 7:3 mixture of *syn*- and *anti*-**2g**.

IR (film): 1691 cm^{-1}.

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 8.05 (d, *J* = 9.0 Hz, 0.7 H), 7.97 (d, *J* = 6.0 Hz, 0.3 H), 7.71–7.64 (m, 2 H), 7.49–7.43 (m, 1 H), 7.32–7.16 (m, 5 H), 6.40 (s, 0.3 H), 6.37 (s, 0.7 H), 4.38 (app t, *J* = 9.0 Hz, 0.3 H), 4.22 (app t, *J* = 6.0 Hz, 0.7 H), 3.94 (app t, *J* = 9.0 Hz, 0.7 H), 3.83 (app t, *J* = 7.5 Hz, 0.3 H), 3.00–2.66 (m, 3 H), 2.29 (dd, *J* = 12.0, 6.0 Hz, 0.3 H), 2.12 (app d, *J* = 6.0 Hz, 1.4 H), 1.75 (dd, *J* = 15.0, 10.5 Hz, 0.3 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 199.4, 140.3, 140.0, 135.1, 135.0, 134.9, 133.6, 133.3, 129.5, 129.4, 129.2 (2 C), 129.1, 128.7 (3 C), 128.6, 127.7, 126.5, 125.6 (2 C), 85.6, 84.3, 75.5, 75.3, 44.0, 42.6, 42.0, 40.0, 38.8, 38.0.

HRMS: *m*/*z* [M + Na]$^+$ calcd for $C_{20}H_{17}ClO_2Na$: 347.0815; found: 347.0818.

(±)-4′-Chloro-4-cyclohexyl-4,5-dihydro-1′*H*,3*H*-spiro[furan-2,2′-naphthalen]-1′-one (2h)

Eluent: 1:19 EtOAc/hexanes; yield: 15 mg (50%) as a mixture of diastereomers from 30 mg of (±)-**1h**; colorless oil; 3:1 mixture of *syn*- and *anti*-**2h**.

IR (film): 1692 cm^{-1}.

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 8.04–7.99 (m, 1 H), 7.72–7.64 (m, 2 H), 7.48–7.42 (m, 1 H), 6.40 (s, 0.75 H), 6.36 (s, 0.25 H), 4.42 (app t, *J* = 7.8 Hz, 0.25 H), 4.27 (app t, *J* = 7.5 Hz, 0.75 H), 3.86 (app t, *J* = 8.3 Hz, 0.75 H), 3.77 (app t, *J* = 8.5 Hz, 0.25 H), 2.46–1.99 (m, 3 H), 1.75–1.61 (m, 5 H), 1.37–1.13 (m, 4 H), 1.68–0.92 (m, 2 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 199.7, 199.6, 135.1 (2 C), 135.0, 134.9, 133.9, 133.7, 129.4, 129.3, 129.2, 129.0 (2 C), 128.8, 127.7, 125.6, 125.5, 86.2, 84.4, 74.9, 74.8, 47.0, 44.0, 43.0, 41.8, 41.2, 40.6, 32.7, 32.6, 32.4, 32.1, 26.4, 26.2 (2 C).

HRMS: *m*/*z* [M + Na]$^+$ calcd for $C_{19}H_{21}ClO_2Na$: 339.1128; found: 339.1128.

(±)-4′-Chloro-4-phenyl-4,5-dihydro-1′H,3*H*-spiro[furan-2,2′-naphthalen]-1′-one (2i)

Eluent: 1:19 EtOAc/hexanes; yield: 20 mg (39%) as a mixture of diastereomers from 50 mg of (±)-**1i**; light yellow oil; ca. 7:3 mixture of *syn*- and *anti*-**2i**.

IR (film): 1690 cm^{-1}.

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 8.09–8.04 (m, 1 H), 7.76–7.67 (m, 2 H), 7.51–7.46 (m, 1 H), 7.37–7.32 (m, 4 H), 7.29–7.24 (m, 1 H), 6.51 (s, 0.7 H), 6.47 (s, 0.3 H), 4.66 (app t, *J* = 8.0 Hz, 0.3 H), 4.45 (app t, *J* = 7.9 Hz, 0.7 H), 4.22 (dd, *J* = 10.8, 8.5 Hz, 0.7 H), 4.10 (app t, *J* = 8.6 Hz, 0.3 H), 3.98–3.86 (m, 0.3 H), 3.71–3.59 (m, 0.7 H), 2.66–2.43 (m, 1.7 H), 2.16 (dd, *J* = 12.9, 10.6 Hz, 0.3 H,).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 199.2, 139.9, 138.7, 135.1 (2 C), 135.0, 133.2, 132.9, 129.9, 129.6, 129.5, 129.0, 128.9, 127.8 (2 C), 127.5, 127.4, 127.2, 125.8, 125.7, 85.8, 83.9, 76.4, 76.3, 46.1, 45.6, 43.6, 43.5.

HRMS: *m*/*z* [M + Na]$^+$ calcd for $C_{19}H_{15}ClO_2Na$: 333.0658; found: 333.0659.

(±)-4′-Bromo-4-methyl-4,5-dihydro-1′*H*,3*H*-spiro[furan-2,2′-naphthalen]-1′-one (2j)

Eluent: 1:19 EtOAc/hexanes; yield: 24 mg (48%) as a mixture of diastereomers from 50 mg of (±)-**1j**; light yellow oil; ca. 7:3 mixture of *syn*- and *anti*-**2j**.

IR (film): 1691 cm^{-1}.

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 8.02–7.96 (m, 1 H), 7.70–7.63 (m, 2 H), 7.46–7.41 (m, 1 H), 6.67–6.66 (m, 1 H), 4.38 (app t, *J* = 7.6 Hz, 0.3 H), 4.24 (app t, *J* = 7.6 Hz, 0.7 H), 3.75 (dd, *J* = 9.9, 8.4 Hz, 0.7 H), 3.64 (app t, *J* = 8.1 Hz, 0.3 H), 2.78–2.66 (m, 0.3 H), 2.61–2.45 (m, 0.7 H), 2.37 (dd, *J* = 12.9, 7.0 Hz, 0.3 H), 2.20 (dd, *J* = 12.5, 7.5 Hz, 0.7 H), 1.97 (dd, *J* = 12.3, 10.6 Hz, 0.7 H), 1.66–1.62 (m, 0.3 H), 1.13–1.07 (m, 3 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 199.6, 138.4, 138.1, 135.8, 135.7, 135.0 (2 C), 129.5, 129.4, 129.3, 129.0, 128.3, 128.2, 127.6, 119.8, 119.5, 86.7, 85.4, 77.0, 46.0, 43.9, 35.2, 32.7, 16.7, 15.6.

HRMS: *m*/*z* [M + Na]$^+$ calcd for $C_{14}H_{13}{}^{79}BrO_2Na$: 314.9997; found: 314.9993.

(±)-4-Benzyl-4′-bromo-4,5-dihydro-1′*H*,3*H*-spiro[furan-2,2′-naphthalen]-1′-one (2k)

Eluent: 1:19 EtOAc/hexanes; yield: 16.7 mg (33%) as a mixture of diastereomers from 50 mg of (±)-**1k**; light yellow oil.; 3:1 mixture of *syn*- and *anti*-**2k**.

IR (film): 1691 cm^{-1}.

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 8.02 (d, *J* = 7.7 Hz, 0.75 H), 7.95 (d, *J* = 7.7 Hz, 0.25 H), 7.67–7.66 (m, 2 H), 7.47–7.41 (m, 1 H), 7.31–7.16 (m, 5 H), 6.66–6.64 (m, 1 H), 4.38 (app t, *J* = 7.7 Hz, 0.25 H), 4.22 (dd, *J* =

8.1, 6.4 Hz, 0.75 H), 3.94 (app t, *J* = 8.6 Hz, 0.75 H), 3.82 (app t, *J* = 8.1 Hz, 0.25 H), 2.99–2.63 (m, 3 H), 2.29 (dd, *J* = 13.0, 7.0 Hz, 0.25 H), 2.13–2.10 (m, 1.75 H), 3.50 (dd, *J* = 13.1, 9.8 Hz, 0.25 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 199.4, 140.2, 140.0, 138.1, 137.8, 135.7, 135.1, 135.0, 129.5, 129.4, 129.2, 128.7 (2 C), 128.6, 128.3, 128.2, 127.6, 126.5, 120.0, 86.6, 85.3, 75.6, 75.3, 43.9, 42.6, 41.8, 39.9, 38.8, 38.0.

HRMS: *m*/*z* [M + Na]$^+$ calcd for $C_{20}H_{17}{}^{79}BrO_2Na$: 391.0310; found: 391.0301.

(±)-4′-Bromo-4-isopropyl-4,5-dihydro-1′*H*,3*H*-spiro[furan-2,2′-naphthalen]-1′-one (2l)

Eluent: 1:19 EtOAc/hexanes; yield: 22 mg (44%) as a mixture of diastereomers from 50 mg of (±)-**1l**; light yellow oil; 4:1 mixture of *syn*- and *anti*-**2l**.

IR (film): 1692 cm^{-1}.

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 8.02–7.97 (m, 1 H), 7.70–7.63 (m, 2 H), 7.46–7.41 (m, 1 H), 6.68 (s, 0.8 H), 6.64 (s, 0.2 H), 4.42 (app t, *J* = 7.8 Hz, 0.2 H), 4.26 (app t, *J* = 7.6 Hz, 0.8 H), 3.86 (app t, *J* = 9.5 Hz, 0.8 H), 3.76 (app t, *J* = 8.5 Hz, 0.2 H), 2.39–1.97 (m, 3 H), 1.70–1.60 (m, 1 H), 0.95–0.88 (m, 6 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 199.6, 138.3, 138.2, 135.8, 135.7, 135.0 (2 C), 129.5, 129.3 (2 C), 128.3, 128.2, 127.6, 119.8, 87.2, 85.5, 75.1, 74.9, 48.4, 45.3, 43.3, 40.6, 32.9, 31.6, 22.0, 21.9 (2 C), 21.7.

HRMS: *m*/*z* [M + Na]$^+$ calcd for $C_{16}H_{17}{}^{79}BrO_2Na$: 343.0310; found: 343.0315.

(±)-4′-Bromo-4-cyclohexyl-4,5-dihydro-1′*H*,3*H*-spiro[furan-2,2′-naphthalen]-1′-one (2m)

Eluent: 1:19 EtOAc/hexanes; yield: 21 mg (43%) as a mixture of diastereomers from 50 mg of (±)-**1m**; light yellow oil; ca. 4:1 mixture of *syn*- and *anti*-**2m**.

IR (film): 1692 cm^{-1}.

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 8.01–7.96 (m, 1 H), 7.70–7.63 (m, 2 H), 7.46–7.40 (m, 1 H), 6.67 (s, 0.8 H), 6.63 (s, 0.2 H), 4.42 (app t, *J* = 7.7 Hz, 0.2 H), 4.27 (app t, *J* = 7.7 Hz, 0.8 H), 3.86 (app t, *J* = 9.5 Hz, 0.8 H), 3.77 (app t, *J* = 8.7 Hz, 0.2 H), 2.44–1.97 (m, 3 H), 1.74–1.59 (m, 5 H), 1.37–1.13 (m, 4 H), 1.08-0.92 (m, 2 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 199.7, 138.4, 138.2, 135.8, 135.7, 135.0, 134.9, 129.4, 129.3 (2 C), 129.0, 128.3, 128.2, 127.6, 119.7, 119.3, 87.1, 85.3, 74.9, 74.8, 47.0, 43.9, 43.0, 41.8, 41.2, 40.3, 32.7, 32.5, 32.3, 32.1, 26.4, 26.2.

HRMS: *m*/*z* [M + H]$^+$ calcd for $C_{19}H_{22}{}^{79}BrO_2$: 361.0803; found: 361.0800.

(±)-4-Methyl-4,5-dihydro-1′*H*,3*H*-spiro[furan-2,2′-naphthalen]-1′-one (2n)

Eluent: 1:19 to 1:9 EtOAc/hexanes; yield: 6 mg (18%) as a mixture of diastereomers from 30 mg of (±)-**1n**; colorless oil; 7:3 mixture of *syn*- and *anti*-**2n**.

IR (film): 1685 cm^{-1}.

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 8.00–7.95 (m, 1 H), 7.55 (app td, *J* = 7.5, 1.2 Hz, 1 H), 7.34 (app t, *J* = 7.2 Hz, 1 H), 7.19 (app d, *J* = 7.6 Hz, 1 H), 6.50–6.46 (m, 1 H), 6.24–6.18 (m, 1 H), 4.41 (app t, *J* = 7.6 Hz, 0.30 H), 4.24 (app t, *J* = 7.6 Hz, 0.7 H), 3.79 (dd, *J* = 10.1, 8.2 Hz, 0.7 H), 3.65 (app t, *J* = 8.1 Hz, 0.3 H), 2.84–2.68 (m, 0.3 H), 2.63–2.45 (m, 0.7 H), 2.35 (dd, *J* = 12.8, 7.0 Hz, 0.3 H), 2.13 (dd, *J* = 12.4, 7.6 Hz, 0.7 H), 1.97 (dd, *J* = 12.3, 10.4 Hz, 0.7 H), 1.60–1.52 (m, 0.3 H), 1.13–1.07 (m, 3 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 201.8, 137.5 (2 C), 137.2, 136.9, 134.8, 134.7, 129.2, 129.1, 128.2, 128.1, 127.4 (2 C), 127.3, 125.6, 125.2, 85.4, 83.9, 77.0, 46.4, 44.1, 35.3, 32.6, 16.9, 15.7.

HRMS: *m*/*z* [M + H]$^+$ calcd for $C_{14}H_{15}O_2$: 215.1072; found: 215.1067.

(±)-4-Isopropyl-4,5-dihydro-1′*H*,3*H*-spiro[furan-2,2′-naphthalen]-1′-one (2o)

Eluent: 1:19 to 1:9 EtOAc/hexanes; yield: 8 mg (28%) as a mixture of diastereomers from 30 mg of (±)-**1o**; colorless oil; 3:1 mixture of *syn*- and *anti*-**2o**.

IR (film): 1711 cm^{-1}.

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 8.00–7.95 (m, 1 H), 7.57–7.52 (m, 1 H), 7.36–7.31 (m, 1 H), 7.20–7.17 (m, 1 H), 6.50–6.46 (m, 1 H), 6.23 (d, *J* = 9.9 Hz, 0.75 H), 6.18 (d, *J* = 9.9 Hz, 0.25 H), 4.48 (app t, *J* = 7.8 Hz, 0.25 H), 4.27 (app t, *J* = 7.6 Hz, 0.75 H), 3.90 (dd, *J* = 9.8, 8.5, 0.75 H), 3.78 (app t, *J* = 8.5 Hz, 0.25 H), 2.44–1.97 (m, 3 H), 1.68–1.46 (m, 1 H), 0.94–0.88 (m, 6 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 201.8, 137.5 (2 C), 137.1, 137.0, 134.8, 134.7, 129.2, 129.1, 128.2, 128.1, 127.4 (3C), 127.3, 125.6, 125.2, 86.0, 83.9, 75.0, 74.9, 48.5, 45.2, 43.7, 40.8, 32.2, 31.6, 22.1, 22.0 (2 C), 21.7.

HRMS: *m*/*z* [M + Na]$^+$ calcd for $C_{16}H_{18}O_2Na$: 265.1204; found: 265.1213.

(±)-4-Cyclohexyl-4,5-dihydro-1′*H*,3*H*-spiro[furan-2,2′-naphthalen]-1′-one (2p)

Eluent: 1:19 to 1:9 EtOAc/hexanes; yield: 10 mg (20%) as a mixture of diastereomers from 50 mg of (±)-**1p**; colorless oil; 3:1 mixture of *syn*- and *anti*-**2p**.

IR (film): 1711 cm^{-1}.

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 8.00–7.95 (m, 1 H), 7.57–7.52 (m, 1 H), 7.36–7.31 (m, 1 H), 7.18 (app d, *J* = 7.5 Hz, 1 H), 6.50–6.45 (m, 1 H), 6.22 (d, *J* = 9.9 Hz, 0.75 H), 6.17 (d, *J* = 9.9 Hz, 0.25 H), 4.45 (app t, *J* = 7.8 Hz, 0.25 H), 4.27 (app t, *J* = 7.6 Hz, 0.75 H), 3.90 (dd, *J* = 10.2, 8.2 Hz, 0.75 H), 3.78 (app t, *J* = 8.8 Hz, 0.25 H), 2.47–2.38 (m, 0.25 H), 2.31–1.97 (m, 2.75 H), 1.75–1.59 (m, 5 H), 1.38–1.13 (m, 4 H), 1.08–0.89 (m, 2 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 201.9, 137.5 (2 C), 137.2, 137.0, 134.8, 134.7, 129.2, 129.1, 128.2, 128.1, 127.4 (3 C), 127.3, 125.5, 125.2, 85.8, 83.7, 74.9, 74.8, 47.1, 43.8, 43.3, 41.9, 41.3, 40.5, 32.7, 32.6, 32.4, 32.1, 26.5, 26.4, 26.2 (2 C).

HRMS: *m*/*z* [M + Na]$^+$ calcd for $C_{19}H_{22}O_2Na$: 305.1517; found: 305.1520.

Kinetic Resolution: (*S*)-(+)-1d; Typical Procedure

Note: The theoretical yield of enantioenriched alcohols **1** is 50%. A solution of MCPBA (53 mg of commercial, 70% pure reagent, corresponding to 37 mg of MCPBA, 215 µmol, 0.6 equiv) in CH_2Cl_2 (4 mL) was added over 5 min (syringe) to a cold (–20 °C) solution of (±)-**1d** (100 mg, 358 µmol, 1.0 equiv) and iodide **4** (50 mg, 72 µmol, 0.2 equiv) in CH_2Cl_2 (14 mL). The mixture was stirred at –20 °C and monitored for completion by TLC. After 13 h, the reaction was as quenched with sat. aq $NaHCO_3$ (10 mL) and sat. aq $Na_2S_2O_3$ (5 mL) solutions and extracted with CH_2Cl_2 (3 × 15 mL). The combined extracts were dried (Na_2SO_4) and evaporated. A ^{1}H NMR spectrum of the crude residue indicated a conversion of 56%. Flash column chromatography (eluent: 1:19 EtOAc/hexanes for the retrieval of *syn*- and *anti*-**2d**; → 3:17 EtOAc/hexanes for **1d**) afforded an 83:17 mixture of spiroethers *syn*-**2d** (major; 94% ee) and *anti*-**2d** (minor, 98% ee) (52 mg, 52% com-

bined yield) plus enantioenriched (*S*)-(+)-**1d** (35 mg, 35%, 79% ee). The diastereomeric ratio and enantiomeric excess of the purified products were then determined by supercritical fluid chromatography (SFC).

For *syn*- and *anti*-**2d**: Column: OJ-H, *i*-PrOH/liq CO_2/Et_2NH (2:98:0.1) flow rate = 1.0 mL/min; $t_{R(minor\ diast)}$ (1) = 20.21 min (major), $t_{R(major\ diast)}$ (2) = 21.71 min (major), $t_{R(major\ diast)}$ (3) = 29.42 min (minor), $t_{R(minor\ diast)}$ (4) = 31.33 min (minor).

For (*S*)-(+)-**1d**: Column (OD-H), *i*-PrOH/liq CO_2/Et_2NH (5:95:0.1), flow rate = 1.0 mL/min; t_R (1) = 45.39 min (major), t_R (2) = 55.28 min (minor). Alcohol (*S*)-(+)-**1d** (82 mg, 294 μmol) of 76% ee was subjected to a second round of the above procedure, whereupon 42 mg (51%) of material of 96% ee was obtained as a low-melting white solid; $[\alpha]_D^{24}$ +39.5 (*c* 1.86, $CHCl_3$).

IR (film): 3654, 3035 (br) cm^{-1}.

^1H NMR ($CDCl_3$, 300 MHz): δ = 8.32 (d, *J* = 9.0 Hz, 1 H), 8.15 (d, *J* = 9.0 Hz, 1 H,), 7.58–7.49 (m, 2 H), 7.30 (s, 1 H), 3.73 (dd, *J* = 9.0, 4.5 Hz, 1 H), 3.65 (dd, *J* = 9.0, 3.0 Hz, 1 H), 2.98 (dd, *J* = 15.0, 9.0 Hz, 1 H), 2.78 (dd, *J* = 15.0, 3.0 Hz, 1 H), 1.90–1.78 (m, 1 H), 1.64–1.54 (m, 1 H), 1.11 (d, *J* = 6.0 Hz, 3 H), 1.02 (d, *J* = 6.0 Hz, 3 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 149.9, 130.5, 128.9, 126.8, 126.7, 125.8, 124.1, 123.0, 122.4, 120.6, 62.9, 48.0, 29.9, 29.1, 21.2, 20.7.

HRMS: *m*/*z* [M – H]$^-$ calcd for $C_{16}H_{18}ClO_2$: 277.0995; found: 277.0994.

(+)-4-Chloro-2-(3-hydroxy-2-methylpropyl)naphthalen-1-ol [(+)-1e]

The above procedure afforded 40 mg of (+)-**1e** (40% recovery) from 100 mg of (±)-**1e**; eluent: 1:9 to 1:4 EtOAc/hexanes; off-white solid; $[\alpha]_D^{23}$ +1.7 (*c* 0.40, $CHCl_3$). SFC analysis indicates a 47% ee. Column: OD-H, *i*-PrOH/liq CO_2/Et_2NH (5:95:0.1), flow rate = 1.0 mL/min; t_R (1) = 48.32 min (major), t_R (2) = 54.15 min (minor).

IR (film): 3643–3017 (br) cm^{-1}.

^1H NMR ($CDCl_3$, 300 MHz): δ = 8.32 (d, *J* = 7.7 Hz, 1 H), 8.20 (br s, 1 H), 8.15 (d, *J* = 7.9 Hz, 1 H), 7.59–7.50 (m, 2 H), 7.30 (s, 1 H), 3.63 (dd, *J* = 10.3, 3.5 Hz, 1 H), 3.39 (dd, *J* = 9.9, 6.8 Hz, 1 H), 2.92–2.78 (m, 2 H), 2.18–2.00 (m, 2 H), 1.09 (d, *J* = 6.9 Hz, 3 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 149.8, 130.5, 129.3, 126.8, 126.7, 125.8, 124.1, 122.9, 122.4, 119.1, 65.4, 35.8, 32.5, 17.2.

HRMS: *m*/*z* [M – H]$^-$ calcd for $C_{14}H_{14}ClO_2$: 249.0682; found: 249.0682.

(+)-4-Chloro-2-[4,4,4-trifluoro-2-(hydroxymethyl)butyl]naphthalen-1-ol [(+)-1f]

The above procedure afforded 40 mg of (+)-**1f** (37% recovery) from 100 mg of (±)-**1f**; eluent: 1:9 to 1:4 EtOAc/hexanes; pale yellow solid; $[\alpha]_D^{24}$ +5.8 (*c* 0.37, $CHCl_3$). SFC analysis indicates a 71% ee. Column: OD-H, *i*-PrOH/liq CO_2/Et_2NH (5:95:0.1); flow rate = 1.0 mL/min; t_R (1) = 31.23 min (major), t_R (2) = 35.46 min (minor).

IR (film): 3687–3032 (br) cm^{-1}.

^1H NMR ($CDCl_3$, 300 MHz): δ = 8.30 (d, *J* = 8.3 Hz, 1 H), 8.17 (d, *J* = 8.3 Hz, 1 H), 7.62–7.52 (m, 2 H), 7.30 (s, 1 H), 3.65–3.64 (m, 2 H), 3.03–2.87 (m, 2 H), 2.41–2.29 (m, 3 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 150.2, 130.8, 128.6, 127.2, 127.0 (q, *J* = 277.0 Hz), 126.7, 126.2, 124.3, 123.1, 122.9, 117.7, 62.2, 35.7 (q, *J* = 28.2 Hz), 35.3 (q, *J* = 2.0 Hz), 30.8.

HRMS: *m*/*z* [M – H]$^-$ calcd for $C_{15}H_{13}ClF_3O_2$: 317.0556; found: 317.0561.

(+)-2-(2-Benzyl-3-hydroxypropyl)-4-chloronaphthalen-1-ol [(+)-1g]

The above procedure afforded 40 mg of (+)-**1g** (40% recovery) from 100 mg of (±)-**1g**; eluent: 1:4 EtOAc/hexanes; off-white solid; $[\alpha]_D^{22}$ +22.4 (*c* 0.37, $CHCl_3$). SFC analysis indicates a 72% ee. Column: AD-H, *i*-PrOH/liq CO_2/Et_2NH (7:93:0.1); flow rate = 1.0 mL/min; t_R (1) = 59.40 min (major), t_R (2) = 64.56 min (minor).

IR (film): 3666–3099 (br) cm^{-1}.

^1H NMR ($CDCl_3$, 300 MHz): δ = 8.32 (d, *J* = 7.7 Hz, 1 H), 8.16 (d, *J* = 7.8 Hz, 1 H), 7.60–7.50 (m, 2 H), 7.37–7.20 (m, 6 H), 3.56–3.45 (m, 2 H), 2.99–2.71 (m, 4 H), 2.27–2.14 (m, 1 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 149.9, 139.9, 130.6, 129.1, 128.9, 128.8, 126.8, 126.7, 126.6, 125.9, 124.1, 123.0, 122.5, 119.3, 62.9, 43.0, 38.5, 30.9.

HRMS: *m*/*z* [M – H]$^-$ calcd for $C_{20}H_{18}ClO_2$: 325.0995; found: 325.0988.

(+)-4-Chloro-2-(2-cyclohexyl-3-hydroxypropyl)naphthalen-1-ol [(+)-1h]

The above procedure afforded 38 mg of (+)-**1h** (38% recovery) from 100 mg of (±)-**1h**; eluent: 1:9 EtOAc/hexanes; off-white solid; $[\alpha]_D^{23}$ +43.4 (*c* 0.34, $CHCl_3$). SFC analysis indicates a 76% ee. Column: OD-H, *i*-PrOH/liq CO_2/Et_2NH (5:95:0.1); flow rate = 1.0 mL/min; t_R (1) = 73.27 min (major), t_R (2) = 90.21 min (minor).

IR (film): 3662–3004 (br) cm^{-1}.

^1H NMR ($CDCl_3$, 300 MHz): δ = 8.46 (br s, 1 H), 8.31 (d, *J* = 7.8 Hz, 1 H), 8.15 (d, *J* = 7.9 Hz, 1 H), 7.58–7.49 (m, 2 H), 7.29 (s, 1 H), 3.73–3.68 (m, 1 H), 3.60–3.57 (m, 1 H), 2.95 (dd, *J* = 14.1, 8.7 Hz, 1 H), 2.76 (dd, *J* = 14.2, 4.1 Hz, 1 H), 2.22 (br s, 1 H), 1.94–1.69 (m, 5 H), 1.59–1.46 (m, 2 H), 1.34–0.99 (m, 5 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 149.8, 130.4, 128.8, 126.8, 126.7, 125.8, 124.1, 122.9, 122.4, 120.8, 62.5, 47.0, 39.8, 31.5, 30.8, 29.1, 26.7 (2 C), 26.6.

HRMS: *m*/*z* [M – H]$^-$ calcd for $C_{19}H_{22}ClO_2$: 317.1308; found: 317.1315.

(+)-4-Chloro-2-(3-hydroxy-2-phenylpropyl)naphthalen-1-ol [(+)1i]

The above procedure afforded 40 mg of (+)-**1i** (40% recovery) from 100 mg of (±)-**1i**; eluent: 3:17 EtOAc/hexanes; colorless oil; $[\alpha]_D^{24}$ +5.2 (*c* 0.40, $CHCl_3$). SFC analysis indicates a 51% ee. Column: AS-H, *i*-PrOH/liq CO_2/Et_2NH (5:95:0.1); flow rate = 1.0 mL/min; t_R (1) = 61.37 min (minor), t_R (2) = 68.02 min (minor).

IR (film): 3650–3098 (br) cm^{-1}.

^1H NMR ($CDCl_3$, 300 MHz): δ = 8.34 (d, *J* = 7.7 Hz, 1 H), 8.18 (d, *J* = 8.0 Hz, 1 H), 8.03 (br s, 1 H), 7.62–7.52 (m, 2 H), 7.41–7.28 (m, 5 H), 7.18 (s, 1 H), 3.80 (app d, *J* = 4.4 Hz, 2 H), 3.42 (dd, *J* = 13.8, 9.3 Hz, 1 H), 3.16–3.08 (m, 1 H), 3.00 (dd, *J* = 13.8, 4.7 Hz, 1 H), 2.35 (br s, 1 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 149.7, 142.4, 130.6, 128.9 (2 C), 127.8, 127.3, 126.9, 126.7, 126.0, 124.2, 122.9, 122.8, 119.4, 64.8, 47.6, 31.7.

HRMS: *m*/*z* [M + Na]$^+$ calcd for $C_{19}H_{17}ClO_2Na$: 335.0815; found: 335.0818.

(+)-4-Bromo-2-(3-hydryoxy-2-methylpropyl)naphthalen-1-ol [(+)-1j]

The above procedure afforded 35 mg of (+)-**1j** (35% recovery) from 100 mg of (±)-**1j**; eluent: 3:17 EtOAc/hexanes; light brown solid; $[\alpha]_D^{26}$ +2.3 (*c* 0.35, $CHCl_3$). SFC analysis indicates a 49% ee. Column: OD-H, *i*-PrOH/liq CO_2/Et_2NH (5:95:0.1); flow rate = 1.0 mL/min; t_R (1) = 58.93 min (major), t_R (2) = 67.57 min (minor).

IR (film): 3638–3022 (br) cm^{-1}.

^1H NMR ($CDCl_3$, 300 MHz): δ = 8.31 (d, *J* = 7.7 Hz, 1 H), 8.11 (d, *J* = 7.9 Hz, 1 H), 7.58–7.50 (m, 3 H), 3.48 (dd, *J* = 10.3, 3.8 Hz, 1 H), 3.39 (dd, *J* = 10.3, 6.7 Hz, 1 H), 2.92–2.78 (m, 2 H), 2.15–2.06 (m, 1 H), 1.09 (d, *J* = 6.9 Hz, 3 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 150.7, 133.0, 131.8, 127.1, 126.9, 126.7, 125.9, 123.0, 119.6, 112.4, 65.5, 35.8, 32.4, 17.2.

HRMS: *m*/*z* [M – H]$^-$ calcd for $C_{14}H_{14}{}^{79}BrO_2$: 293.0177; found: 293.0182.

(+)-2-(2-Benzyl-3-hydroxypropyl)-4-bromonaphthalen-1-ol [(+)-1k]

The above procedure afforded 42 mg of (+)-**1k** (42% recovery) from 100 mg of (±)-**1k**; eluent: 1:9 to 1:4 EtOAc/hexanes; light brown solid; $[\alpha]_D^{25}$ +13.5 (*c* 0.42, $CHCl_3$). SFC analysis indicates a 71% ee. Column: AD-H, *i*-PrOH/liq CO_2/Et_2NH (6:94:0.1), flow rate = 1.0 mL/min; t_R (1) = 95.24 min (major), t_R (2) = 102.94 min (minor).

IR (film): 3662–3099 (br) cm^{-1}.

^1H NMR ($CDCl_3$, 300 MHz): δ = 8.31 (d, *J* = 8.3 Hz, 1 H), 8.10 (d, *J* = 7.8 Hz, 1 H), 7.58–7.49 (m, 2 H), 7.39–7.32 (m, 3 H), 7.28–7.22 (m, 3 H), 3.58–3.48 (m, 2 H), 2.99–2.73 (m, 4 H), 2.28–2.15 (m, 1 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 150.7, 139.9, 132.6, 131.8, 129.2, 128.8, 127.1, 126.9, 126.7, 126.6, 125.9, 123.0, 119.9, 112.6, 62.9, 43.0, 38.5, 30.9.

HRMS: *m*/*z* [M – H]$^-$ calcd for $C_{20}H_{18}{}^{79}BrO_2$: 369.0490; found: 369.0498.

(+)-4-Bromo-2-(2-(hydroxymethyl)-3-methylbutyl)naphthalen-1-ol [(+)-1l]

The above procedure afforded 35 mg of (+)-**1l** (35% recovery) from 100 mg of (±)-**1l**; eluent: 1:9 to 1:4 EtOAc/hexanes; off-white solid; $[\alpha]^{26}{}_D$ +20.6 (*c* 0.35, $CHCl_3$). SFC analysis indicates a 67% ee. Column: OD-H, *i*-PrOH/liq CO_2/Et_2NH (5:95:0.1), flow rate = 1.0 mL/min; t_R (1) = 54.37 min (major), t_R (2) = 69.16 min (minor).

IR (film): 3655–3018 (br) cm^{-1}.

^1H NMR ($CDCl_3$, 300 MHz): δ = 8.31 (d, *J* = 7.7 Hz, 1 H), 8.10 (d, *J* = 7.8 Hz, 1 H), 7.58–7.48 (m, 3 H), 3.73 (dd, *J* = 10.4, 5.5 Hz, 1 H), 3.64 (dd, *J* = 10.3, 3.7 Hz, 1 H), 2.97 (dd, *J* = 14.3, 8.6 Hz, 1 H), 2.77 (dd, *J* = 14.3, 4.5 Hz, 1 H), 1.90–1.79 (m, 1 H), 1.64–1.54 (m, 1 H), 1.11 (d, *J* = 6.7 Hz, 3 H), 1.02 (d, *J* = 6.8, 3 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 150.6, 132.5, 131.7, 127.0 (2 C), 126.7, 125.8, 123.0, 121.3, 112.5, 62.8, 48.0, 29.9, 29.1, 21.2, 20.7.

HRMS: *m*/*z* [M – H]$^-$ calcd for $C_{16}H_{18}{}^{79}BrO_2$: 321.0490; found: 321.0499.

(+)-4-Bromo-2-(2-cyclohexyl-3-hydroxypropyl)naphthalen-1-ol [(+)-1m]

The above procedure afforded 28 mg of (+)-**1m** (28% recovery) from 100 mg of (±)-**1m**; eluent: 1:9 EtOAc/hexanes; off-white solid; $[\alpha]_D^{26}$ +37.5 (*c* 0.28, $CHCl_3$). SFC analysis indicates a 65% ee. Column: OD-H, *i*-PrOH/liq CO_2/Et_2NH (10:90:0.1), flow rate = 1.0 mL/min; t_R (1) = 27.60 min (major), t_R (2) = 32.59 min (minor).

IR (film): 3648–3008 (br) cm^{-1}.

^1H NMR ($CDCl_3$, 300 MHz): δ = 8.31 (d, *J* = 7.7 Hz, 1 H), 8.10 (d, *J* = 7.8 Hz, 1 H), 7.57–7.49 (m, 3 H), 3.75 (dd, *J* = 10.4, 5.1 Hz, 1 H), 3.61 (dd, *J* = 10.4, 3.5 Hz, 1 H), 2.96 (dd, *J* = 14.2, 8.8 Hz, 1 H), 2.77 (dd, *J* = 14.1, 4.3 Hz, 1 H), 1.96–1.70 (m, 5 H), 1.61–1.45 (m, 2 H), 1.39–0.99 (m, 5 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 150.6, 132.5, 131.7, 127.0 (2 C), 126.7, 125.8, 123.0, 121.4, 112.5, 62.5, 47.0, 39.9, 31.6, 30.8, 29.0, 26.7 (2 C), 26.6.

HRMS: *m*/*z* [M – H]$^-$ calcd for $C_{19}H_{22}{}^{79}BrO_2$: 361.0803; found: 361.0805.

(+)-2-(3-Hydroxy-2-methylpropyl)naphthalen-1-ol [(+)-1n]

The above procedure afforded 40 mg of (+)-**1n** (40% recovery) from 100 mg of (±)-**1n**;[11] eluent: 1:9 to 3:7 EtOAc/hexanes; white solid; $[\alpha]_D^{25}$ +1.3 (*c* 0.40, $CHCl_3$). SFC analysis indicates a 48% ee. Column: OD-H, *i*-PrOH/liq CO_2/Et_2NH (10:90:0.1), flow rate = 1.0 mL/min; t_R (1) = 19.58 min (major), t_R (2) = 21.72 min (minor).

(+)-2-[2-(Hydroxymethyl)-3-methylbutyl]naphthalen-1-ol [(+)-1o]

The above procedure afforded 35 mg of (+)-**1o** (35% recovery) from 100 mg of (±)-**1o**; eluent: 1:9 to 1:4 EtOAc/hexanes; off-white solid; $[\alpha]_D^{26}$ +34.3 (*c* 0.36, $CHCl_3$). SFC analysis indicates a 62% ee. Column: OD-H, *i*-PrOH/liq CO_2/Et_2NH (10:90:0.1), flow rate = 1.0 mL/min; t_R (1) = 18.69 min (major), t_R (2) = 22.35 min (minor).

IR (film): 3650–3021 (br) cm^{-1}.

^1H NMR ($CDCl_3$, 300 MHz): δ = 8.28 (d, *J* = 7.7 Hz, 1 H), 8.21 (s, 1 H), 7.76 (d, *J* = 6.9 Hz, 1 H), 7.49–7.41 (m, 2 H), 7.36 (d, *J* = 8.3 Hz, 1 H), 7.21 (d, *J* = 8.3 Hz, 1 H), 3.74–3.61 (m, 2 H), 2.99 (dd, *J* = 14.1, 8.5 Hz, 1 H), 2.82 (dd, *J* = 14.2, 4.4 Hz, 1 H), 1.99 (br s, 1 H), 1.90–1.79 (m, 1 H), 1.65–1.52 (m, 1 H), 1.12 (d, *J* = 6.6 Hz, 3 H), 1.02 (d, *J* = 6.7 Hz, 3 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 150.4, 133.5, 129.1, 127.2, 125.5 (2 C), 125.0, 122.3, 119.9, 119.6, 62.8, 48.0, 29.7, 29.1, 21.1, 20.6.

HRMS: *m*/*z* [M – H]$^-$ calcd for $C_{16}H_{19}O_2$: 243.1385; found: 243.1385.

(+)-2-(2-Cyclohexyl-3-hydroxypropyl)naphthalen-1-ol [(+)-1p]

The above procedure afforded 33 mg of (+)-**1p** (33% recovery) from 100 mg of (±)-**1p**; eluent: 3:17 to 1:4 EtOAc/hexanes; off-white solid; $[\alpha]_D^{26}$ +40.8 (*c* 0.14, $CHCl_3$). SFC analysis indicates a 41% ee. Column: OD-H, *i*-PrOH/liq CO_2/Et_2NH (10:90:0.1), flow rate = 1.0 mL/min; t_R (1) = 24.67 min (major), t_R (2) = 30.55 min (minor).

IR (film): 3648–3004 (br) cm^{-1}.

^1H NMR ($CDCl_3$, 300 MHz): δ = 8.41 (s, 1 H), 8.31 (d, *J* = 8.7 Hz, 1 H), 7.79 (d, *J* = 8.6 Hz, 1 H), 7.50–7.43 (m, 2 H), 7.39 (d, *J* = 8.3 Hz, 1 H), 7.21 (d, *J* = 8.3 Hz, 1 H), 3.68–3.57 (m, 2 H), 2.98 (dd, *J* = 15.0, 8.4 Hz, 1 H), 2.82 (dd, *J* = 14.2, 4.5 Hz, 1 H), 2.45 (br s, 1 H), 1.97–1.71 (m, 5 H), 1.61–1.44 (m, 2 H), 1.39–0.99 (m, 5 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 150.4, 133.6, 129.2, 127.4, 125.6 (2 C), 125.1, 122.3, 120.4, 119.8, 62.6, 47.1, 39.7, 31.5, 30.8, 29.2, 26.7 (3 C).

HRMS: *m*/*z* [M + Na]$^+$ calcd for $C_{19}H_{24}O_2Na$: 307.1674; found: 307.1669.

(+)-2-[4,4,4-Trifluoro-2-(hydroxymethyl)butyl]naphthalen-1-ol [(+)-1q]

The above procedure afforded 44 mg of (+)-**1q** (44% recovery) from 100 mg of (±)-**1q**; eluent: 1:9 to 3:17 EtOAc/hexanes; light yellow oil; $[\alpha]_D^{20}$ +4.6 (*c* 0.42, $CHCl_3$). SFC analysis indicates a 57% ee. Column: OD-H, *i*-PrOH/liq CO_2/Et_2NH (10:90:0.1), flow rate = 1.0 mL/min; t_R (1) = 14.50 min (major), t_R (2) = 16.38 min (minor).

IR (film): 3710–3104 (br) cm^{-1}.

^1H NMR ($CDCl_3$, 300 MHz): δ = 8.27–8.24 (m, 1 H), 7.80–7.77 (m, 1 H), 7.52–7.45 (m, 2 H), 7.41 (d, *J* = 8.4 Hz, 1 H), 7.20 (d, *J* = 8.4 Hz, 1 H), 3.65–3.55 (m, 2 H), 3.05–2.91 (m, 2 H), 2.39–2.25 (m, 3 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 150.7, 133.9, 129.1, 127.6, 127.1 (q, *J* = 277.1 Hz), 126.1, 125.5 (2 C), 122.2, 120.4, 117.4, 62.2, 35.6 (q, *J* = 28.1 Hz), 35.5 (q, *J* = 2.0 Hz), 30.9.

HRMS: *m*/*z* [M – H]$^-$ calcd for $C_{15}H_{14}F_3O_2$: 283.0946; found: 283.0942.

Compound (+)-*syn*-2q

Yield: 36 mg (36%) from 100 mg of (±)-**1q**; white solid; mp 39–41 °C; $[\alpha]_D^{25}$ +132.7 (*c* 0.93, $CHCl_3$).

IR (film): 1685 cm^{-1}.

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 7.98 (d, *J* = 7.7 Hz, 1 H), 7.57 (app t, *J* = 7.5 Hz, 1 H), 7.36 (app t, *J* = 7.5, 1 H), 7.20 (d, *J* = 7.6 Hz, 1 H), 6.54 (d, *J* = 9.8 Hz, 1 H), 6.17 (d, *J* = 9.9 Hz, 1 H), 4.32 (app t, *J* = 7.8 Hz, 1 H), 3.93 (app t, *J* = 9.0 Hz, 1 H), 2.83–2.41 (m, 1 H), 2.37–2.07 (m, 4 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 200.9, 137.3, 135.5, 135.2, 128.8, 128.5, 127.6, 127.5, 126.4, 126.6 (q, *J* = 276.8 Hz), 82.6, 74.4, 43.1, 36.0 (q, *J* = 28.7 Hz), 34.4 (q, *J* = 2.6 Hz).

HRMS (ESI): *m*/*z* [M + Na]$^+$ calcd for $C_{15}H_{13}F_3O_2Na$: 305.0765; found: 305.0765.

Compound (+)-*anti*-2q

Yield: 4.0 mg (4%) from 100 mg of (±)-**1q**; colorless oil; $[\alpha]_D^{25}$ +190.1 (*c* 0.31, $CHCl_3$).

IR (film): 1688 cm^{-1}.

^{1}H NMR ($CDCl_3$, 300 MHz): δ = 7.97 (d, *J* = 7.7 Hz, 1 H), 7.56 (app t, *J* = 7.5 Hz, 1 H), 7.35 (app t, *J* = 7.4 Hz, 1 H), 7.19 (d, *J* = 7.5 Hz, 1 H), 6.54 (d, *J* = 9.8 Hz, 1 H), 6.14 (d, *J* = 9.8 Hz, 1 H), 4.53 (app t, *J* = 8.0 Hz, 1 H), 3.78 (app t, *J* = 8.4 Hz, 1 H), 3.10–2.97 (m, 1 H), 2.44 (dd, *J* = 13.0, 7.1 Hz, 1 H), 2.33–2.11 (m, 2 H), 1.68 (dd, *J* = 12.8, 10.6 Hz, 1 H).

^{13}C NMR ($CDCl_3$, 75 MHz): δ = 201.1, 137.3, 135.8, 135.1, 128.7, 128.4, 127.5, 126.7, 126.5 (q, *J* = 277.1 Hz), 84.6, 74.6, 41.7, 36.6 (q, *J* = 29.0 Hz), 32.1 (q, *J* = 2.3 Hz).

Funding Information

We thank NSERC for support of this research.

Supporting Information

Supporting information for this article is available online at https://doi.org/10.1055/s-0037-1610214. Preparation and kinetic resolution of alcohols **1a**–**q**; characterization data; ^{1}H and ^{13}C NMR spectra (104 pages).

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