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Asymmetric Homoaldol Reactions with Cyclohex-2-enyl *N*,*N*-Diisopropylcarbamate: Kinetic Resolution, Elucidation of the Stereochemical Course and Applications in the Synthesis of Hexahydroisobenzofuran-4-(1*H*)-ones

Jochen Becker,[a] Roland Fröhlich,[a][‡] Kirsi Salorinne,[b][‡] and and Dieter Hoppe*[a]

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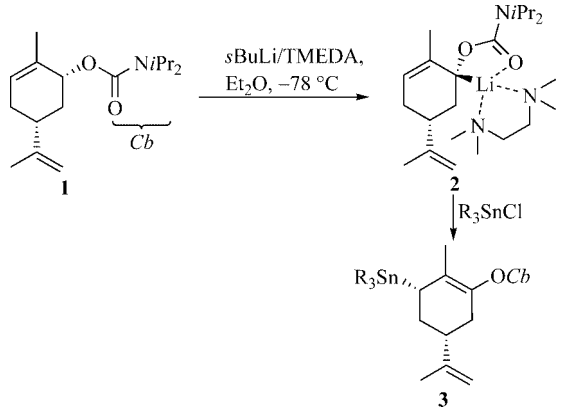
Enantio-enriched cyclohex-2-enyl *N*,*N*-diisopropylcarbamate (**5**) is stereospecifically deprotonated by *sec*-butyllithium/(–)-sparteine (**9**) to form the configurationally stable lithium complex **7**·**9**. A kinetic resolution of *rac*-**5** by *n*-butyllithium/(–)-sparteine (**9**) yielded (*R*)-**5** with up to 99 % *ee*. Electrophilic substitution with tin electrophiles proceeds in a *anti*-S_E' fashion as shown by chemical correlations. The synthesized allylstannanes **10** undergo a highly stereospecific $TiCl_4$-mediated homoaldol reaction with various aldehydes, yielding *syn*-configured homoaldol products **12**. These were transferred into *all-cis*-configured hexahydroisobenzofuran-4(1*H*)-ones **22** by BF_3·OEt_2-mediated reactions with aldehydes. The configurations of several products were determined by X-ray structure analysis.

Introduction

Enantio-enriched lithiated alk-2-enyl *N*,*N*-diisopropylcarbamates are valuable homoenolate reagents and have often been used, after lithium–titanium exchange, in highly stereoselective homoaldol reactions.[1,2] As we have recently demonstrated, alkyl-substituted cyclohex-2-enyl carbamates of type **1**, under certain structural preconditions, are smoothly deprotonated by means of alkyllithium/diamine to form persistent, configurationally stable lithium compounds **2**. These are usually attacked by tin-electrophiles in an *anti*-S_E' fashion (Scheme 1) to yield diastereomerically pure allylstannanes **3**.[3]



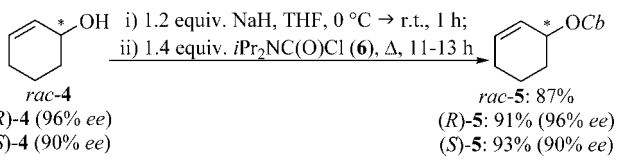
Scheme 1.

[a] Organisch-Chemisches Institut, Westfälische Wilhelms-Universität Münster,
Corrensstr. 40, 48149 Münster
Fax: +49-251-83-36531
E-mail: dhoppe@uni-muenster.de
[b] Nanoscience Center, University of Jyväskylä,
40014, Finland
[‡] X-ray crystal structure analysis.

Results and Discussion

Synthesis of Chiral Carbamates 5

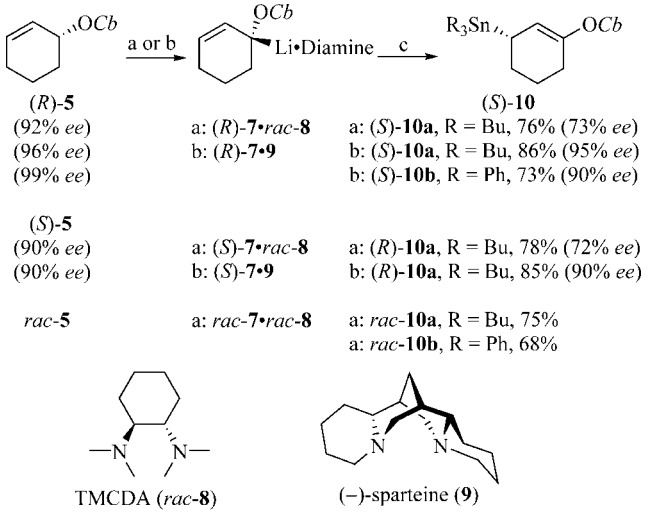
From our recent studies, carried out with racemic cyclohex-2-enyl *N*,*N*-diisopropyl carbamate (*rac*-**5**), no conclusion could be drawn about the configurational stability of lithiated intermediate *rac*-**7** that may undergo stereospecific substitution reactions as found for alkyl-substituted cyclohex-2-enyl carbamates like **1**.[3] The carbamate *rac*-**5** was prepared by the usual method,[4] from the alcohol *rac*-**4**[5] and *N*,*N*-diisopropylcarbamoyl chloride (**6**), in 87% yield (Scheme 2). In the same way, (*R*)-**5** (96% *ee*) and (*S*)-**5** (90% *ee*) were synthesized from the optically active cyclohex-2-enols (*R*)-**4**[6] and (*S*)-**4**.[7]



Scheme 2. Synthesis of optically active cyclohex-2-enyl carbamates **5**.

Deprotonation and Stannylation

Carbamates *rac*-**5**, (*R*)-**5**, and (*S*)-**5** were subjected to different deprotonation conditions and the lithiated species were trapped by Bu_3SnCl or Ph_3SnCl to afford the stannanes **10a** or **10b**, respectively (Scheme 3, Table 1). Deprotonation in presence of *N*,*N*,*N*′,*N*′-tetramethylethylenediamine (TMEDA) as chelating ligand resulted in low yields and stereoselectivities of the stannane **10a** (entries 1–3). Better yields of *rac*-**10a** (75%) were obtained when using *n*BuLi and *rac*-*trans*-1,2-bis(dimethylamino)cyclohexane (TMCDA, *rac*-**8**) (Entry 4). Starting from (*R*)-**5** (92% *ee*) or (*S*)-**5** (90% *ee*) under the same reaction conditions, (*S*)-**10a** or (*R*)-**10a** were obtained with lower enantiomeric excesses, 73% *ee* or 72% *ee*, respectively (Entries 5 and 6). After lithiation times of 30 min and 60 min, the stannane



Scheme 3. Lithiation and subsequent stannylation; reagents and conditions: (a) 1.3 equiv. *n*BuLi/*rac*-**8**, Et_2O (for R = Bu) or toluene (for R = Ph), –78 °C, 4–5 h; (b) 1.3 equiv. *s*BuLi/**9**, Et_2O (R = Bu) or toluene (R = Ph), –78 °C, 30–180 min; (c) i) 2.0 equiv. R_3SnCl, –78 °C, 1–2 h; ii) NH_4Cl/H_2O.

(*S*)-**10a** was obtained with 90% and 95% optical yield, respectively (entries 7 and 8).

The lithiated complexes **7**•*rac*-**8** have only a limited configurational stability, resulting in a slow epimerisation. After 5 h, the enantio-enrichment decreases from 96% *ee* to 73% *ee* (Entry 9). After lithiation times of 30 min and 60 min the stannane (*S*)-**10a** was obtained with 90% and 95% OY, respectively (Entries 7 and 8). Obviously, the minor enantiomer (*S*)-**5** is lithiated faster than (*R*)-**5** because of matched and mismatched interactions of the chiral substrates and the racemic ligand *rac*-**8**. Here also a kinetic resolution of the diastereomeric lithium complexes takes place during the substitution step: the *ee* decreases, if the amount of the electrophile and the substitution time are decreased (Entries 8 and 10). When *s*BuLi/(–)-sparteine (**9**) were used for deprotonation, (*R*)-**5** or (*S*)-**5** afforded stannanes (*S*)-**10a** or (*R*)-**10a** in high yields and without loss of optical purity (Entries 12–16). The complex (*R*)-**7**•**9** is configurationally stable for more than 3 h at –78 °C. As frequently observed, the rate of epimerisation of chiral organolithium compounds decreases with increasing the bulk of the complexing diamine.[8]

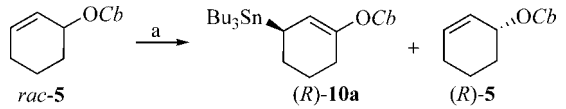
The reaction of the (–)-sparteine/lithium complex (*R*)-**7**•**9** with Ph_3SnCl yielded a semicrystalline sample of stannane (*R*)-**10b** in 73% yield and 90% *ee* (Entry 18). Unfortunately, the crystals turned out to be racemic, whereas the (*R*)-enantiomer remained as an oil. Although, no direct proof for the configuration of stannanes (*R*)-**10a** and (*R*)-**10b** was possible at this stage, the above assignments were concluded from the *anti*-S_E'-substitution of substituted cyclohex-2-enyl carbamates[3] and the stereochemical results of Lewis acid catalysed homoaldol reactions of stannanes **10** (vide infra).

We also investigated the possibility of a kinetic resolution of *rac*-**5** by use of equimolar amounts of *n*BuLi/(–)-sparteine (**9**), combined with subsequent trapping of the lithium intermediate by Bu_3SnCl (Scheme 4, Table 2).[9,10]

Table 1. Deprotonation of **5** and subsequent stannylation.

Entry	**5** (% *ee*)[a]	R–Li/Diamine (*t* [min])	Equiv. R_3SnCl (*t* [min])	**10** (% yield)[b]	% *ee*[a]	% OY[c]
1	*rac*-**5**	*n*BuLi/TMEDA (300)	2.0 Bu_3SnCl (60)	*rac*-**10a** (21)	*rac*	–
2	*rac*-**5**	*s*BuLi/TMEDA (120)	2.0 Bu_3SnCl (120)	*rac*-**10a** (36)	*rac*	–
3	(*S*)-**5** (90)	*s*BuLi/TMEDA (60)	2.0 Bu_3SnCl (60)	(*R*)-**10a** (54)	45	50
4	*rac*-**5**	*n*BuLi/*rac*-**8** (240)	2.0 Bu_3SnCl (60)	*rac*-**10a** (75)	*rac*	–
5	(*R*)-**5** (92)	*n*BuLi/ *rac*-**8** (300)	2.0 Bu_3SnCl (120)	(*S*)-**10a** (76)	73	79
6	(*S*)-**5** (90)	*n*BuLi/*rac*-**8** (240)	2.0 Bu_3SnCl (60)	(*R*)-**10a** (78)	72	80
7	(*R*)-**5** (96)	*s*BuLi/*rac*-**8** (30)	2.0 Bu_3SnCl (60)	(*S*)-**10a** (57)	86	90
8	(*R*)-**5** (96)	*s*BuLi/*rac*-**8** (60)	2.0 Bu_3SnCl (60)	(*S*)-**10a** (64)	91	95
9	(*R*)-**5** (96)	*s*BuLi/*rac*-**8** (300)	2.0 Bu_3SnCl (60)	(*S*)-**10a** (42)	73	76
10	(*R*)-**5** (96)	*s*BuLi/*rac*-**8** (60)	1.0 Bu_3SnCl (10)	(*S*)-**10a** (58)	85	89
11[d]	(*R*)-**5** (96)	*s*BuLi/*rac*-**8** (60)	2.0 Bu_3SnCl (60)	(*S*)-**10a** (72)	54	56
12	(*R*)-**5** (96)	*s*BuLi/**9** (30)	2.0 Bu_3SnCl (60)	(*S*)-**10a** (68)	95	99
13	(*R*)-**5** (99)	*s*BuLi/**9** (60)	2.0 Bu_3SnCl (60)	(*S*)-**10a** (61)	97	98
14	(*R*)-**5** (96)	*s*BuLi/**9** (180)	2.0 Bu_3SnCl (60)	(*S*)-**10a** (86)	95	99
15	(*S*)-**5** (90)	*s*BuLi/**8** (30)	2.0 Bu_3SnCl (60)	(*R*)-**10a** (85)	90	>99
16	(*S*)-**5** (90)	*s*BuLi/**9** (60)	2.0 Bu_3SnCl (60)	(*R*)-**10a** (66)	87	97
17[d]	*rac*-**5**	*n*BuLi/*rac*-**8** (360)	2.0 Ph_3SnCl (120)	*rac*-**10b** (68)	*rac*	–
18[d]	(*R*)-**5** (99)	*s*BuLi/**9** (60)	2.0 Ph_3SnCl (120)	(*S*)-**10b** (73)	90	91

[a] Enantiomeric excesses were determined by HPLC. [b] Isolated yields. [c] OY: optical yield, conservation of the original enantio-enrichment of **5**. [d] Toluene was used as solvent.



Scheme 4. Kinetic resolution of *rac*-**5**; reagents and conditions: (a) i) 1.0 equiv. *n*BuLi/**9**, –78 °C, t; ii) 1.3 equiv. or 2.0 equiv. Bu_3SnCl, 1 h.

Table 2. Results of the kinetic resolution of **5**.

Entry	solvent	*t*	(*R*)-**10a** (% *ee*)[a]	(*R*)-**5** (% *ee*)[a]
1[b,c]	toluene	2 h	11 (77)	71 (11% *op*)
2[b]	toluene	4 h	33 (66)	56 (46)
3[b]	toluene	8 h	36 (68)	53 (54)
4[b]	Et_2O	8 h	37 (66)	44 (68)
5[d]	toluene	8 h	22 (78)	69 (30)
6[d]	*n*-pentane	8 h	18 (82)	54 (23% *op*)
7[b]	toluene	21.5 h	58 (35)	28 (99)

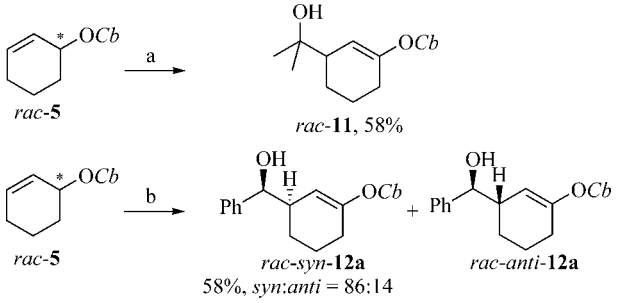
[a] Isolated yields. Enantiomeric excesses were determined by HPLC. [b] *n*BuLi was added to a solution of the carbamate *rac*-**5** and **9** at –78 °C. [c] 0.5 equiv. *n*BuLi/**9**. [d] *rac*-**5** was added to a solution of *n*BuLi/**9** at –90 °C.

After lithiation of *rac*-**5** with 1.0 equiv. *n*BuLi/**9** for 8 h in toluene half of the starting material was consumed (Entry 3). The enantiomer (*S*)-**5** is lithiated faster than (*R*)-**5**, leading to an enantio-enrichment of the stannane (*R*)-**10a** after stereospecific *syn*-S_E' substitution of the lithiated species with Bu_3SnCl.

The difference of the free enthalpies $\Delta\Delta G^{\ddagger}$ at –78 °C of the deprotonation transition states of (*S*)-**5** and (*R*)-**5** is not sufficient to allow complete differentaion of the enantiomers by the chiral base *n*BuLi/**9**. Thus, (*R*)-**10a** was achieved with 68% *ee* (36% yield) and (*R*)-**5** with 54% *ee* (53% yield). At –90 °C in *n*-pentane or toluene the conversion is slower but more selective; up to 82% *ee* (18% yield) were achieved for the allylstannane (*R*)-**10a** (entries 5 and 6). Lithiation of *rac*-**5** for 21.5 h in toluene at –78 °C afforded the carbamate (*R*)-**5** with a synthetically useful enrichment of 99% *ee* and 28% yield (max. yield 50%, Entry 7).

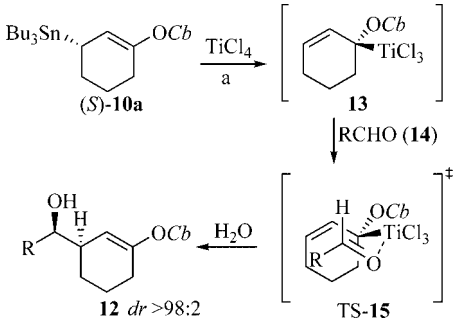
Homoaldol Reactions with 5

Addition of acetone to the solution of *rac*-**7**·TMCDA resulted in γ-addition product *rac*-**11** in 58% yield besides starting material (Scheme 5). Using benzaldehyde, *rac-syn*-**12a** was obtained in 58% yield; but, as usual for the lithium method, only moderate diastereoselectivity favoring *rac-syn*-**12a** over *rac-anti*-**12a** was observed. The configuration of *rac-syn*-**12a** was secured by comparison of the analytical data with that of the corresponding homoaldol product resulting from the Lewis acid-mediated homoaldol reaction (vide infra).



Scheme 5. Homoaldol reactions of the lithiated species; reagents and conditions: (a) i) 1.3 equiv. *n*BuLi/*rac*-**8**, Et_2O, –78 °C, 5 h; ii) 3.0 equiv. acetone, –78 °C, 2 h; (b) i) 1.3 equiv. *n*BuLi/*rac*-**8**, Et_2O, –78 °C, 4 h; ii) 3.0 equiv. PhCHO, –78 °C, 3 h.

The $TiCl_4$-mediated homoaldol reaction[9a,11] of stannanes **10a** proceeded with high yields and stereoselectivities (Scheme 6, Table 3). For this purpose, a solution of (*R*)-**10a** or (*S*)-**10a** and 1.3 equiv. of aldehyde **14** was stirred for 10–20 min at –78 °C after addition of 1.3 equiv. $TiCl_4$. After aqueous work up, *syn*-configured homoaldol products **12** were obtained with 50 to 88% yield with essentially no loss of enantiomeric purity (Table 3). The simple diastereoselectivity was excellent (>98:2) in all $TiCl_4$-mediated homoal-



Scheme 6. $TiCl_4$-mediated homoaldol reaction of allylstannane **10a**; reagents and conditions: (a) 1.3 equiv. $TiCl_4$, 1.3 equiv. RCHO (**14**), –78 °C, 10–20 min.

Table 3. Results of the homolaldol reactions.

Entry	Stannane **10a** (% *ee*)[a]	Aldehyde, R	Product **12**	Configuration	% Yield[b,c]	% *ee*	% OY[d]
1	(*S*)-**10a** (95)	**14a**, Ph	**12a**	[3*R*,3(1*S*)]	82 (88)	92[a]	97
2	(*S*)-**10a** (70)	**14b**, 2-naphthyl	**12b**	[3*R*,3(1*S*)]	72 (77)	70[a]	>99
3	(*R*)-**10a** (90)	**14c**, *p*-BrPh	*ent*-**12c**	[3*S*,3(1*R*)]	80 (82)	88[a]	98
4	(*S*)-**10a** (84)	**14d**, *p*-MeOPh	**12d**	[3*R*,3(1*S*)]	81 (74)	84[a]	>99
5	(*R*)-**10a** (87)	**14e**, 2-furyl	*ent*-**12e**	[3*S*,3(1*R*)]	50 (60)	85[a]	98
6	(*S*)-**10a** (97)	**14f**, Me	**12f**	[3*R*,3(1*R*)]	74 (86)	96[e]	99
7	(*S*)-**10a** (84)	**14g**, $CH(CH_3)_2$	**12g**	[3*R*,3(1*R*)]	72 (70)	85[e,f]	>95

[a] Enantiomeric excesses were determined by HPLC. [b] Isolated yields. Yields of the racemate strarting from *rac*-**10a** are given in brackets. [c] *dr* >98:2 For all reactions as determined from the crude product by GC (HP-5). [d] OY: Optical yield, conservation of the original enantio-enrichment of **10a**. [e] Enantiomeric excesses were determined by GC. [f] +/–5% *ee*.

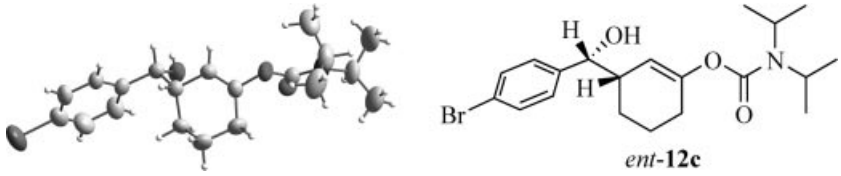
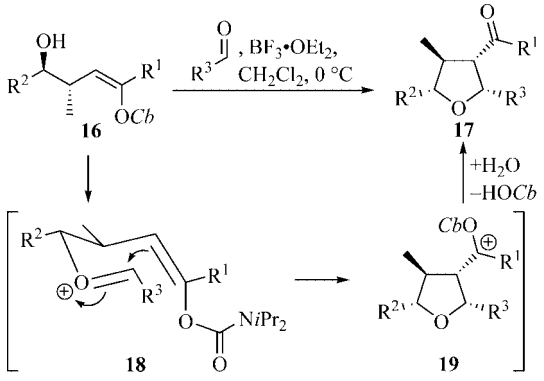


Figure 1. Solid state structure of [3*S*,3(1*R*)]-3-[1-(4-bromophenyl)-1-hydroxymethyl]cyclohex-1-enyl *N*,*N*-diisopropylcarbamate (*ent*-**12c**).[12,13]

dol reactions which were investigated here. Product *ent*-**12c**, formed from (*R*)-**10a** and *p*-bromobenzaldehyde **14c**, gave suitable crystals for an X-ray analysis with anomalous dispersion (Figure 1).[12,13]

It clearly shows the (3*S*)-configuration. Overall, Bu_3Sn was substituted by the hydroxyalkyl residue with inversion of the configuration. The stereochemical course is in accordance with an exchange of Bu_3Sn for $TiCl_3$ in an *anti*-S_E' manner and a *syn* addition of the aldehyde via a Zimmerman–Traxler transition state TS-**15**.[14] Due to the strong Lewis acidity of the trichlorotitanium complex, TS-**15** may be a tighter transition state as a result of the shorter O–Ti bond than in the Li-mediated carbonyl addition, which results in a high *syn*-selectivity of products **12**.

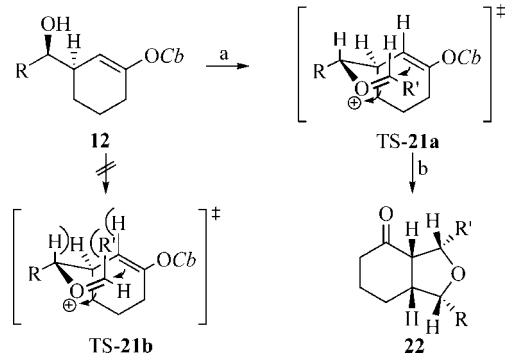


Scheme 7. Synthesis of *cis*,*trans*,*cis*-3-acyl-tetrahydrofurans **17**.

Synthesis of *all-cis*-Hexahydroisobenzofuran-4(1*H*)-ones

Several years ago, we reported that the condensation of (*Z*)-*anti*-5-hydroxy-1-alkenylcarbamates **16** with aldehydes takes place under the influence of boron trifluoride etherate to form tetrahydrofurans **17** with high stereoselectivity (Scheme 7).[15] The Mukaiyama-type cyclocondensation proceeds through an (*E*)-oxonium ion that adopts the most preferential conformation **18**. The highly ordered transition state leads to the *cis*,*trans*,*cis*-substituted cation **19**, which affords the stereohomogeneous product **17** after hydrolytic decarbamoylation.

The homoaldol products *rac*-**12a**–**g** and achiral aldehydes **18a**–**e** were subjected to the standard conditions affording, after aqueous work up, the *all-cis*-configured bicycles **22** in good yields and with excellent diastereoselectivities (Scheme 8, Table 4). The ^1H NMR coupling constants $^3J_{3a,7a}$ of the products **22a**–**g** are in the range of 7.2–9.7 Hz confirming, that the annulation of the five-membered ring occurred in a *cis*-fashion via the intermediate **21**.[16] The *syn*-configured homoaldol products lead to *all-cis*-substituted tetrahydrofurans **22**. The (*E*)-oxonium ion in TS-**21a**



Scheme 8. Synthesis of *all-cis*-hexahydroisobenzofuran-4(1*H*)-ones **22**; reagents and conditions: (a) 1.3 equiv. BF_3•OEt_2, 1.3 equiv. R′CHO (**20**), CH_2Cl_2, 0 °C → r.t., 15–330 min; (b) NH_4Cl/H_2O.

Table 4. Synthesis of annulated *all-cis*-tetrahydrofurans **22**.

Entry	**12**	R	Aldehyde, R′	**22**[b]	% Yield[a]	*dr*[c]
1	*rac*-**12b**	2-naphthyl	**20a**, *p*-BrPh	*rac*-**22a**	71	>98:2
2	*ent*-**12c** (88% *ee*)	*p*-BrPh	**20b**, $C(CH_3)_3$	*ent*-**22b** (89% *ee*)[d]	84	>98:2
3	*rac*-**12c**	*p*-BrPh	**20b**, $C(CH_3)_3$	*rac*-**22b**	73	>98:2
4	*rac*-**12d**	*p*-OCH_3Ph	**20c**, $CH(CH_3)_2$	*rac*-**22c**	67	45:55
5	**12f** (96% *ee*)	CH_3	**20d**, furyl	**22d** (96% *ee*)	68	>98:2
6	*ent*-**12f** (76% *ee*)	CH_3	**20d**, furyl	*ent*-**22d** (75% *ee*)	72	>98:2
7	*rac*-**12g**	$CH(CH_3)_2$	**20e**, vinyl	*rac*-**22e**	84	>98:2

[a] Isolated Yields. [b] Enantiomeric excesses were determined by HPLC. [c] The diastereomeric ratio was determined from the crude product by GC. [d] Recrystrallisation from *n*-pentane afforded crystals of *ent*-**22b** with >99% *ee* (HPLC).

avoids 1,3-allylic strain which results in preferential formation of products **22** with 1,3-*cis*-configuration.

The enantio-enrichments of the isobenzofurans **22** are essentially equal to those of their corresponding homoaldol products **12**. The absolute configuration of *ent*-**22b** was determined by an X-ray analysis with anomalous dispersion (Figure 2).[12,17] In general, a single diastereomer is formed, with exception of the 4-methoxyphenyl-substituted homoaldol product **12d**, which yielded a nearly 1:1 ratio of the 1,3a-*cis*- and 1,3a-*trans*-substituted hexahydroisobenzofuran-4(1*H*)-ones **22c** and *epi*-**22c**, respectively. The configuration of *epi*-**22c** was deduced from the typical coupling constant $^3J_{3a,7a}$ = 9.7 Hz,[16] as well as an nOe effect of the 3a-proton and the *o*-protons of the aromatic substituent at C-1 (Figure 3). The electron-rich aromatic substituent might cause a dehydroxylation of the homoaldol product by the Lewis acid to form the highly stabilized benzylic cation **23**. Next, the cation **23** adds unstereoselectively to the aldehyde **20c**, which leads to an epimeric configuration of the stereogenic C-1 of *epi*-**22c**. This pathway is an exception and was not observed in the other THF cyclocondensation reactions, where the configuration of the stereogenic secondary alcohol remained unchanged.

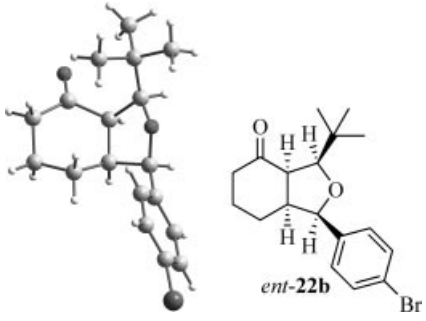


Figure 2. Solid state structure of (1*R*,3*S*,3a*R*,7a*S*)-1-(4-bromophenyl)-3-*tert*-butyl-hexahydroisobenzofuran-4(1*H*)-one (*ent*-**22b**).[12,17]

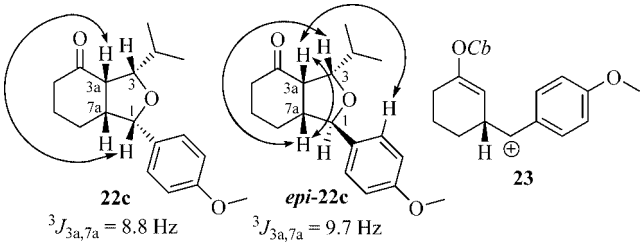
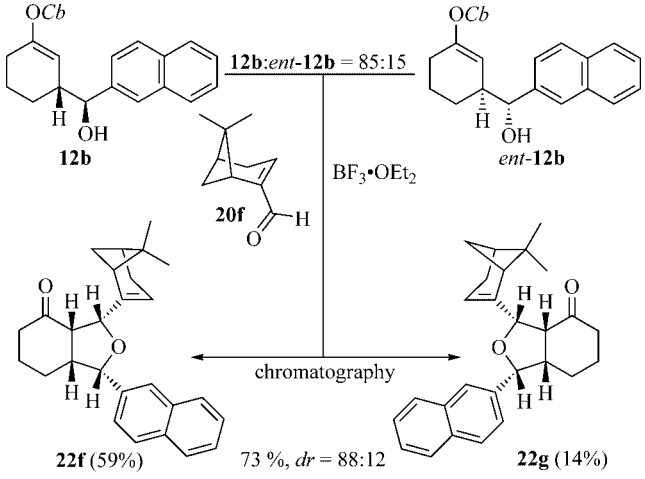


Figure 3. nOe experiments with **22c** and *epi*-**22c**.

When optically active homoaldol product **12b** (70% *ee*, *er* = 85:15) was allowed to react with enantiopure (–)-myrtenal (**20f**), two separable diastereomers **22f** and **22g** (ratio 88:12, determined by GC of the crude product) were isolated (Scheme 9). Both compounds afforded suitable crystals for an X-ray crystal structure analysis (Figure 4), which shows that they have the opposite configuration at the stereogenic 1, 3, 3a, and 7a carbon atoms.[12,18,19] The major diastereomer **22f** was formed from the (3*R*)-enantiomer **12b**, whereas **22g** was formed from the (3*S*)-configured carbamate *ent*-**12b**.



Scheme 9. Reaction of the enantio-enriched homoaldol product **12b** with (–)-myrtenal (**20f**).

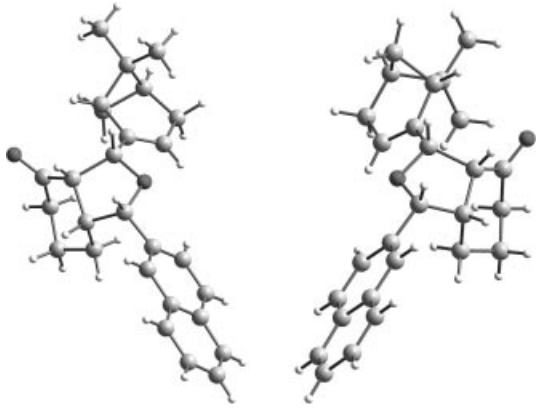
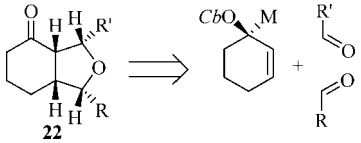


Figure 4. Solid-state structures: [1*S*,3*R*,3(1*R*,5*R*),3a*S*,7a*R*]- and [1*R*,3*S*,3(1*R*,5*R*),3a*R*,7a*S*]-3-(6,6-dimethylbicyclo[3.1.1]hept-2-en-2-yl)-1-(naphthalen-2-yl)-hexahydroisobenzofuran-4(1*H*)-one (**22f**, left)[12,18] and (**22g**, right).[12,19]

Conclusions

The homoaldol reaction of metallated cyclohex-2-enyl *N*,*N*-diisopropylcarbamate **10** with aldehydes leads to diastereomerically pure 3-(1-hydroxyalkyl)cyclohex-1-enyl carbamates of type **12**. Starting from enantio-enriched metallocarbamates, optically active addition products are formed. These undergo smooth condensation with aldehydes to form the hexahydroisobenzofuran-4(1*H*)ones **22**, (Scheme 10) providing a facile, flexible, and stereoselective



Scheme 10.

access to an important class of compounds. In the subsequent paper we report on the enantioselective synthesis of higher substituted hexahydroisobenzofuran-4(1*H*)-ones.[20]

Experimental Section

General Remarks: All solvents were dried and purified prior to use: toluene and Et_2O were distilled from sodium benzophenone ketyl, THF was distilled from potassium benzophenone ketyl and CH_2Cl_2 was distilled from powdered CaH_2. *N*,*N*,*N*′,*N*′-Tetramethylethylenediamine (TMEDA) was distilled from powdered CaH_2 and stored under Ar in the dark. *rac*-*trans*-1,2-Bis(dimethylamino)cyclohexane (TMCDA, *rac*-**8**)[21] was stored under Ar at 4 °C. (–)-Sparteine (**9**) was kept under Ar in a refrigerator after the original bottles had been opened. Solutions of *sec*-butyllithium (ca. 1.3 M in cyclohexane/hexane, 92:8) were filtered through a pad of Celite under Ar in order to remove any precipitate and were stored in a freezer (–30 °C); only a slight yellow hue is acceptable. The content of *s*BuLi was determined by titration.[22] *n*-Butyllithium (1.6 M in hexanes) and all other commercially available reagents were used as received. All reactions were performed under Ar in flame dried glassware sealed with a rubber septum. Flash column chromatography (FCC) was performed on Merck 60 silica gel (40–60 μm, 230–400 mesh ASTM), and monitored by thin-layer chromatography (TLC) on Merck 60 F_{254} TLC plates. NMR: Bruker ARX 300 or ARX 400 (routine 2D spectra) and Varian Unity Plus 600 (2D spectra). ^1H shifts are related to $SiMe_4$ (δ_H = 0.00 ppm) or to the residual content of $CHCl_3$ (δ_H = 7.24 ppm) and ^{13}C shifts to $CDCl_3$ (δ_C = 77.0 ppm). Peak multiplicities in ^1H NMR spectra are abbreviated as s (singlet), d (doublet), t (triplet), sept (septet), oct (octet), m (multiplet), and br (broad). Diastereotopic methylene protons with different chemical shifts are abbreviated as H_A and H_B. IR: Nicolet 5DCX, Bruker IFS 28 or Varian 3100 Excalibur Series with Specac Golden Gate Single Reflection ATR. MS: Bruker MicroTof (ESI). Optical rotation: Perkin–Elmer 341. Melting point: Stuart Scientific SMP3. Melting points are not corrected. Elemental analysis: Elementar-Analysensysteme Vario EL III. GC: Agilent 6890; 30 m × 0.32 mm HP-5; 1.5 mL/min H_2; start at 50 °C, 10 °C/min, end 300 °C, 15 min at 300 °C. HPLC: Waters 600E Multisolvent Delivery System and 996 PDA detector or Knauer Smartline UV detector 2600, Pump 1000 and Manager 5000 or Agilent Technologies 1200 Series (Bin Pump, ALS, TCC, DAD).

Carbamoylation of Cyclohex-2-enol. General Procedure A (GP A): Sodium hydride (60% in mineral oil, 480 mg, 12 mmol, 1.2 equiv.) was suspended in THF (20 mL) at 0 °C. A solution of cyclohex-2-enol (**4**, 981 mg, 10 mmol) in THF (1 mL) was added to the stirred suspension by syringe and stirring was continued for 1 h at room temperature. *N*,*N*-Diisopropylcarbamoyl chloride[23] (**6**, 2.29 g, 14 mmol, 1.4 equiv.) was added over a period of 5 min and the reaction mixture was heated to reflux (90 °C) for 11–13 h. After complete consumption of the starting material (TLC) the solution was cooled to room temperature and treated with aq. 2 M HCl solution (25 mL). The aqueous layer was extracted with *tert*-butyl methyl ether (TBME, 3 × 20 mL). The combined organic layers were washed with satd. aq. $NaHCO_3$ solution (25 mL), dried with $MgSO_4$, and concentrated in vacuo. FCC on silica gel (Et_2O/PE = 1:9) yielded pure cyclohex-2-enyl *N*,*N*-diisopropylcarbamate (**5**).

***rac*-Cyclohex-2-enyl *N*,*N*-Diisopropylcarbamate (*rac*-5):** According to GP A NaH (4.80 g, 120 mmol, 1.2 equiv.), racemic cyclohex-2-enol[5] (*rac*-**4**, 9.82 g, 100 mmol) and **6** (22.90 g, 140 mmol, 1.4 equiv.) were refluxed in THF (210 mL) for 11 h. Purification by FCC (Et_2O/PE = 1:9) yielded 19.53 g (87 mmol, 87%) *rac*-**5** as a colourless liquid. t_R = 11.34 min (HP-5). R_F = 0.32 (Et_2O/PE = 1:9). ^1H NMR (300 MHz, $CDCl_3$): δ = 1.19, 1.22 (2s, 12 H, *i*Pr $(CH_3)_2$), 1.57–2.16 (m, 6 H, 4-H, 5-H, 6-H), 3.91 (br. s, 2 H, *i*Pr CH), 5.22 (m, 1 H, 1-H), 5.78 (m, 1 H, 2-H), 5.88 (m, 1 H, 3-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 19.1 (CH_2, C-5), 21.1 (CH_3, *i*Pr $(CH_3)_2$), 24.9 (CH_2, C-6), 28.8 (CH_2, C-4), 45.7 (CH, *i*Pr CH), 67.9 (CH, C-1), 126.9 (CH, C-2), 131.4 (CH, C-3), 155.5 (C_q, C=O) ppm. IR (film): $\tilde{\nu}$ = 2968 (s), 2935 (m), 2871 (s) [$\nu(C_{aliph}–H)$], 1682 (s) [ν(N–C=O)] cm^{-1}. MS (ESI): *m*/*z* = 248.1600 $[M + Na]^+$. $C_{13}H_{23}NO_2$ (225.33): calcd. C 69.29, H 10.29, N 6.22; found C 69.16, H 10.63, N 6.12.

(*R*)-Cyclohex-2-enyl *N*,*N*-Diisopropylcarbamate ((*R*)-5): According to GP A NaH (1.09 g, 27.2 mmol, 1.2 equiv.), (*R*)-cyclohex-2-enol[6] ((*R*)-**4**, 96% *ee*, 2.23 g, 22.7 mmol) and **6** (5.21 g, 32 mmol, 1.4 equiv.) were refluxed in THF (68 mL) for 13 h. Purification by FCC (Et_2O/PE = 1:9) yielded 4.63 g (20.6 mmol, 91%) (*R*)-**5** as a colourless liquid. $[\alpha]_D^{20}$ = +147.3 (*c* = 1.07, $CHCl_3$) at 96% *ee*; HPLC Chiralcel OD-H (4.6 × 250 mm), λ = 200 nm, *i*PrOH/*n*-hexane = 1:2000, 0.5 mL/min, 24.57 min ((*R*)-**5**), 28.17 min ((*S*)-**5**).

(*S*)-Cyclohex-2-enyl *N*,*N*-Diisopropylcarbamate ((*S*)-5): According to GP A NaH (302 mg, 7.56 mmol, 1.2 equiv.), (*S*)-cyclohex-2-enol[7] ((*S*)-**4**, 90% *ee*, 600 mg, 6.3 mmol) and **6** (1.45 g, 140 mmol, 1.4 equiv.) were refluxed in THF (18 mL) for 13 h. Purification by FCC (Et_2O/PE = 1:9) yielded 1.317 g (5.85 mmol, 93%) (*S*)-**5** as a colourless liquid. $[\alpha]_D^{20}$ = –135.4 (*c* = 1.03, $CHCl_3$) at 90% *ee*; HPLC Chiralcel OD-H.

Deprotonation of Cyclohex-2-enyl Carbamate 5 and Stannylation. General Procedure B (GP B): A solution of cyclohex-2-enyl carbamate **5** (225 mg, 1.0 mmol), TMEDA (151 mg, 1.3 equiv.) [or TMCDA *rac*-**8** (221 mg, 1.3 equiv.) or (–)-sparteine (**9**, 305 mg, 1.3 equiv.)] in Et_2O (5 mL) was cooled to –78 °C. 1.23 M *s*BuLi solution (1.04 mL, 1.3 equiv.) [or 1.6 M *n*BuLi solution (0.81 mL, 1.3 equiv.)] were added dropwise and the solution was stirred for 30 min–6 h. Bu_3SnCl (650 mg, 2.0 equiv.) was then added dropwise by syringe and stirring at –78 °C was continued for 1–2 h. The reaction was quenched at –78 °C with satd. aq. NH_4Cl solution (2 mL) and the mixture was warmed to room temperature. The layers were separated and the aqueous layer was extracted with TBME (3 × 10 mL). The combined organic layers were dried with $MgSO_4$, filtered and the solvent was removed in vacuo. FCC on silica gel (Et_2O/PE = 1:19) yielded the pure stannane **10**.

(*S*)-3-(Tributylstannyl)cyclohex-1-enyl *N*,*N*-Diisopropylcarbamate ((*S*)-10a): Representative procedure: According to GP B (*R*)-cyclohex-2-enyl carbamate (*R*)-**5** (96% *ee*, 113 mg, 0.5 mmol) and (–)-sparteine (**9**, 152 mg, 0.65 mmol, 1.3 equiv.) were dissolved in Et_2O (2.5 mL). The solution was cooled to –78 °C and 1.23 M *s*BuLi solution (0.52 mL, 0.65 mmol, 1.3 equiv.) was added dropwise over a period of 5 min. The solution was stirred for additional 3 h. Bu_3SnCl (325 mg, 1.0 mmol, 2.0 equiv.) was then added and stirring was continued for 1 h. The reaction was quenched with satd. aq. NH_4Cl solution (1 mL) and worked up according to GP B. FCC on silica gel (Et_2O/PE = 1:19) yielded 222 mg (0.43 mmol, 86%) (*S*)-**10a** (95% *ee*) as a colourless liquid. *rac*-**10a** was obtained from *rac*-**5** (225 mg, 1.0 mmol), after lithiation with TMCDA *rac*-**8** (221 mg, 1.3 mmol, 1.3 equiv.) and 1.6 M *n*BuLi solution (0.81 mL, 1.3 mmol, 1.3 equiv.), by stannylation with Bu_3SnCl (650 mg, 2.0 mmol, 2.0 equiv.) as a colourless liquid; yield 384 mg (0.75 mmol, 75%). t_R = 20.24 min (HP-5). R_F = 0.33 (Et_2O/PE = 1:9). ^1H NMR (400 MHz, $CDCl_3$): δ = 0.89 (t, $^3J_{1',4'}$ = 7.3 Hz, 9 H, 4′-H), 0.90 (m, 6 H, 1′-H), 1.22, 1.23 (2 br. s, 12 H, *i*Pr $(CH_3)_2$), 1.32 (dt, $^3J_{1',4'}$ = 7.3 Hz, $^3J_{2',3'}$ = 7.2 Hz, 6 H, 3′-H), 1.48 (m, 6 H, 2′-H), 1.62–1.82 (m, 3 H, 4-H_A/5-H), 1.98 (m, 1 H, 4-

H_B), 2.08 (m, 1 H, 6-H_A), 2.21 (m, 1 H, 3-H), 2.33 (m, 1 H, 6-H_B), 3.81, 4.00 (2 br. s, 2 H, *i*Pr CH), 5.44 (m, 1 H, 2-H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 9.1 ($^1J_{1',Sn}$ = 295.4 Hz, C-1′, CH_2), 13.6 (CH_2, C-4′), 21.1 (CH_3, *i*Pr $(CH_3)_2$), 23.2 (CH, C-3), 23.5 (CH_2, C-5), 26.2 (CH_2, C-6), 27.3 (CH_2, C-4), 27.5 (CH_2, C-2′), 29.2 (CH_2, C-3′), 46.2 (CH, *i*Pr CH), 117.6 (CH, C-2), 144.3 (C_q, C-1), 154.3 (C_q, C=O) ppm. IR (ATR): $\tilde{\nu}$ = 2957 (m), 2926 (s), 2873 (w) 2852 (w) (ν(C_{aliph}–H), 1707 (s) [ν(N–C=O)] cm^{-1}. MS (ESI): *m*/*z* = 538.2684 $[M + Na]^+$. $C_{25}H_{49}NO_2Sn$ (514.37): calcd. C 58.38, H 9.60, N 2.72 found C 58.28, H 9.92, N 2.59. $[\alpha]_D^{20}$ = –55.9 (*c* = 1.00, $CHCl_3$) at 95% *ee* HPLC Chira Grom 1 (2 × 250 mm), λ = 210 nm, *i*PrOH/*n*-hexane = 1:2000, 0.3 mL/min, 6.55 min ((*S*)-**10a**), 15.13 min ((*R*)-**10a**).

Kinetic Resolution of *rac*-Cyclohex-2-enyl *N*,*N*-Diisopropylcarbamate (*rac*-5): Representative procedure I (Table 2, Entry 7): *rac*-cyclohex-2-enyl carbamate *rac*-**5** (4.50 g, 20.0 mmol) and (–)-sparteine (**9**, 4.68 g, 20.0 mmol, 1.0 equiv.) were dissolved in toluene (50 mL) in a Schlenk tube, equipped with a rubber septum, and the solution was cooled to –78 °C. 1.6 M *n*BuLi solution (12.5 mL, 20.0 mmol) was added dropwise over a period of 20 min. The tube was sealed with a glass stopper and the solution was stirred for 21 h 30 min at –78 °C. Bu_3SnCl (8.4 g, 26.0 mmol, 1.3 equiv.) was added over a period of 10 min and the solution was stirred for additional 50 min. The reaction was quenched with satd. aq. NH_4Cl solution (20 mL) and worked up according to GP B. FCC on silica gel (Et_2O/PE = 1:19, then 1:10) yielded 5.935 g (11.53 mmol, 58%) (*R*)-**10a** with 35% *ee* (HPLC) and 1.278 g (5.67 mmol, 28%) (*R*)-**5** with 99% *ee* (HPLC). (*R*)-**10a**: $[\alpha]_D^{20}$ = +24.3 (*c* = 1.11, $CHCl_3$) at 35% *ee*; (*R*)-**5**: $[\alpha]_D^{20}$ = +150.3 (*c* = 1.00, $CHCl_3$) at 99% *ee*.

Representative procedure II (Table 2, Entry 6): To a solution of (–)-sparteine (**9**, 468 mg, 2.0 mmol, 1.0 equiv.) in *n*-pentane (10 mL) at –90 °C was added 1.6 M *n*BuLi solution (1.25 mL, 2.0 mmol). *rac*-Cyclohex-2-enyl carbamate *rac*-**5** (450 mg, 2.0 mmol) was added dropwise over a period of 20 min and the solution was stirred for 8 h at –90 °C. Bu_3SnCl (1.3 g, 4.0 mmol, 2.0 equiv.) was added over a period of 10 min and the solution was stirred for additional 60 min and worked up as described in Representative procedure I. Yield 185 mg (0.36 mmol, 18%) (*R*)-**10a** with 82% *ee* (HPLC) and 242 mg (1.08 mmol, 54%) (*R*)-**5** with 23% *op*. (*R*)-**10a**: $[\alpha]_D^{20}$ = +53.0 (*c* = 1.00, $CHCl_3$) at 82% *ee*; (*R*)-**5**: $[\alpha]_D^{20}$ = +34.4 (*c* = 0.99, $CHCl_3$) (23% *op*).

(*S*)-3-(Triphenylstannyl)cyclohex-1-enyl *N*,*N*-Diisopropylcarbamate ((*S*)-10b): According to GP B, (*R*)-cyclohex-2-enyl carbamate (*R*)-**5** (99% *ee*, 113 mg, 0.5 mmol) and (–)-sparteine (**9**, 152 mg, 0.65 mmol, 1.3 equiv.) were dissolved in toluene (3 mL). To the cooled solution (–78 °C) 1.23 M *s*BuLi solution (0.52 mL, 0.65 mmol, 1.3 equiv.) was added dropwise over a period of 5 min. The solution was stirred for additional 1 h. Ph_3SnCl (385 mg, 1.0 mmol, 2.0 equiv.), dissolved in toluene (5 mL), was added and stirring was continued for 1 h. The reaction was quenched with satd. aq. NH_4Cl solution (3 mL). Work up according to GP B and FCC on silica gel (Et_2O/PE = 1:6) yielded 210 mg (0.37 mmol, 73%) (*S*)-**10b** with 90% *ee* as a colourless oil. The racemate crystallized from a solution of the product in *n*-pentane, whereas the enantio-enriched product remained as an oil.[24] *rac*-**10b** was obtained from *rac*-**5** (113 mg, 0.5 mmol) after lithiation with TMCDA (*rac*-**8**, 111 mg, 0.65 mmol, 1.3 equiv.) and 1.6 M *n*BuLi solution (0.41 mL, 0.65 mmol, 1.3 equiv.) by stannylation with Ph_3SnCl (385 mg, 1.0 mmol, 2.0 equiv.), yield 193 mg (0.24 mmol, 67%). M.p. 100 °C (PE for *rac*-**10b**). t_R = 25.36 min (HP-5). R_F = 0.37 (Et_2O/PE = 1:9). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.22, 1.24 (2 br. s, 12 H, *i*Pr $(CH_3)_2$), 1.77 (m, 2 H, 5-H), 1.99–2.19 (m, 3 H, 6-H/4-H_A), 2.35 (m, 1 H, 4-H_B), 2.96 (m, $^2J_{3,Sn}$ = 80.7 Hz, 1 H, 3-H), 3.77, 4.05 (2 br. s, 2 H, *i*Pr CH), 5.69 (m, 1 H, 2-H), 7.37 (m, 4 H, *m*-PhCH, *p*-PhCH), 7.52–7.64 (m, 1 H, *o*-PhCH) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 21.1 (CH_3, *i*Pr $(CH_3)_2$), 23.3 (CH_2, C-5), 26.0 (CH_2, C-6), 26.4 (CH, C-3), 27.2 (CH_2, C-4), 46.1(CH, *i*Pr CH), 116.2 (CH, $^2J_{2,Sn}$ = 41.7 Hz, C-2), 128.5 (CH, $^3J_{m\text{-}Ph,Sn}$ = 47.9 Hz, *m*-Ph), 128.8 (CH, $^4J_{p\text{-}Ph,Sn}$ = 10.9 Hz, *p*-Ph), 137.3 (CH, $^2J_{o\text{-}Ph,Sn}$ = 33.9 Hz, *o*-Ph), 138.7 (C_q, $^1J_{i\text{-}C\text{-}Ph,Sn}$ = 464.8 Hz, 444.0 Hz, *i*-C-Ph), 146.1 (C_q, C-1), 146.1 (C_q, C=O) ppm. (IR (film): $\tilde{\nu}$ = 3063 (m), 3048 (m), 3042 (m) [ν(C_{arom}–H)], 2992 (m), 2969 (m), 2943 (m), 2928 (m) [ν(C_{aliph}–H)], 1707 (s) [ν(N–C=O)] cm^{-1}. MS (ESI): *m*/*z* = 598.1743 $[M + Na]^+$. $C_{31}H_{37}NO_2Sn$ (574.34): calcd. C 64.83, H 6.49, N 2.44; found C 64.71, H 6.54, N 2.50. $[\alpha]_D^{20}$ = –34.1 (*c* = 1.05, $CHCl_3$) at 90% *ee*; HPLC Chira Grom 1 (2 × 250 mm), λ = 210 nm, *i*PrOH/*n*-hexane = 1:500, 0.3 mL/min, 5.00 min ((*R*)-**10b**), 7.22 min ((*S*)-**10b**).

***rac*-3-(1-Hydroxy-1-methylethyl)cyclohex-1-enyl *N*,*N*-Diisopropylcarbamate (*rac*-11):** *rac*-Cyclohex-2-enyl carbamate *rac*-**5** (225 mg, 1.0 mmol) was lithiated according to GP B with TMCDA *rac*-**8** (226 mg, 1.30 mmol, 1.3 equiv.) and 1.6 M *n*BuLi solution (0.81 mL, 1.3 mmol, 1.3 equiv.) in Et_2O (5 mL) at –78 °C. The solution was stirred for additional 5 h. Acetone (174 mg, 3.0 mmol, 3.0 equiv.) was added and stirring was continued for 1 h. The reaction was quenched with satd. aq. NH_4Cl solution (4 mL). Work up according to GP B and FCC on silica gel (Et_2O/PE = 1:2) yielded 165 mg (0.58 mmol, 58%) *rac*-**11** as a colourless oil. t_R = 14.52 min (HP-5). R_F = 0.30 (Et_2O/PE = 1:1). ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.19 (s, 3 H, 2′-CH_3), 1.22, 1.25 (br. s, 2′-CH_3, *i*Pr $(CH_3)_2$, 15 H, br. s), 1.58–1.91 (m, 4 H, 4-H/5-H), 2.06, 2.14 (2 m, 2 H, 6-H), 2.33 (m, 1 H, 3-H), 3.91 (br. s, 2 H, *i*Pr CH), 5.44 (s, 1 H, 2-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 20.9 (CH_3, *i*Pr $(CH_3)_2$), 22.2 (CH_3, C-2′), 23.8 (CH_3, C-2′), 26.2, 27.3, 28.1 (CH_2, C-4/C-5/C-6), 46.2 (CH, *i*Pr CH), 46.4 (CH, C-3), 72.7 (C_q, C-OH), 113.9 (CH, C-2), 150.5 (C_q, C-1), 153.8 (C_q, C=O) ppm. IR (film): $\tilde{\nu}$ = 2970 (s), 2936 (m), 2866 (s) [ν(C_{aliph}–H)], 1690 (s) [ν(N–C=O)] cm^{-1}. MS (ESI): *m*/*z* = 306.2049 $[M + Na]^+$. $C_{16}H_{29}NO_3$ (283.41): calcd. C 67.81, H 10.31, N 4.94; found C 67.57, H 10.43, N 4.71.

[3*RS*,3(1*SR*)]- and [3*RS*,3(1*RS*)]-3-[(1-Hydroxyphenyl)methyl]cyclohex-1-enyl *N*,*N*-Diisopropylcarbamate (*rac*-*syn*-12a and *rac*-*anti*-12a): *rac*-Cyclohex-2-enyl carbamate *rac*-**5** (450 mg, 2.00 mmol) was lithiated according to GP B with TMCDA *rac*-**8** (452 mg, 2.60 mmol, 1.3 equiv.) and 1.6 M *n*BuLi solution (0.81 mL, 2.60 mmol, 1.3 equiv.) in Et_2O (5 mL) at –78 °C for 4 h. Benzaldehyde (**14a**, 636 mg, 6.0 mmol, 3.0 equiv.) was then added and stirring was continued for 3 h. The reaction was quenched with satd. aq. NH_4Cl solution (8 mL). Work up according to GP B and FCC on silica gel (Et_2O/PE = 1:1) yielded 386 mg (1.17 mmol, 58%) of an inseparable mixture of *rac*-*syn*-**12a**/*rac*-*anti*-**12a** = 86:14 as a colourless solid. *rac*-*syn*-**12a**: see above. *rac*-*anti*-**12a**: M.p. 93–95 °C (Et_2O/PE for *rac*-*syn*-**12a**/*rac*-*anti*-**12a** = 86:14). t_R = 18.81 min (HP-5). R_F = 0.33 (Et_2O/PE = 1:1). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.21 (br. s, 12 H, *i*Pr $(CH_3)_2$), 1.42–1.66 (m, 2 H, 4-H), 1.88 (m, 1 H, 5-H_A), 2.08–2.21 (m, 2 H, 6-H), 2.33 (m, 1 H, 3-H), 2.65 (m, 1 H, 5-H_B), 3.80, 3.96 (2 br. s, 2 H, *i*Pr CH), 4.47 (d, $^3J_{3,CH\text{-}O}$ = 6.9 Hz, 1 H, CH-O), 5.52 (s, 1 H, 2-H), 7.26 (m, 1 H, *p*-PhCH), 7.34 (m, 4 H, *o*-/*m*-PhCH) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 20.6 (CH_3, *i*Pr $(CH_3)_2$), 21.6, 25.7, 27.4 (CH_2, C-4/C-5/C-6), 42.6 (CH, C-3), 46.2 (CH, *i*Pr CH), 76.8 (C_q, C-OH), 113.5 (CH, C-2), 126.3, 127.2, 128.1 (CH, *o*-/*m*-/*p*-Ph), 143.6 (C_q, *i*-C-Ph), 150.6 (C_q, C-1), 153.8 (C_q, C=O) ppm. IR (KBr): $\tilde{\nu}$ = 3426 (s) [ν(O–H)], 2971 (m), 2938 (m), 2873 (s) [ν(C_{aliph}–H)], 1683 (s) [ν(N–C=O)] cm^{-1}. MS (ESI): *m*/*z* = 354.2044 $[M + Na]^+$. $C_{20}H_{29}NO_3$ (331.45, mixture

of diastereomers): calcd. C 72.47, H 8.82, N 4.23; found C 72.47, H 8.86, N 4.13.

Synthesis of *syn*-Homoaldol Products 12. General Procedure C (GP C): To a stirred solution of 3-(tributylstannyl)cyclohex-1-enyl *N*,*N*-diisopropylcarbamate (**10a**, 514 mg, 1.0 mmol) and the aldehyde **14** (1.3 equiv.) in CH_2Cl_2 (4 mL) at –78 °C, $TiCl_4$ (247 mg, 1.3 equiv.)[25] was added dropwise by syringe. After complete consumption of **10a** (TLC) satd. aq. NH_4Cl solution (2 mL) was added and the reaction mixture was warmed to room temperature. CH_2Cl_2 (5 mL) was added, the aqueous layer was extracted with TBME (3 × 10 mL) and dried with $MgSO_4$. After removal of the solvent in vacuo, the residue was purified by flash column chromatography[26] on silica gel (Et_2O/PE mixtures) to yield the homoaldol products **12**.

[3*R*,3(1*S*)]-3-(1-Hydroxyphenylmethyl)cyclohex-1-enyl *N*,*N*-Diisopropylcarbamate (12a): According to GP C (*S*)-**10a** (95% *ee*, 138 mg, 0.27 mmol), benzaldehyde (**14a**, 37 mg, 0.35 mmol, 1.3 equiv.), and $TiCl_4$ (67 mg, 0.35 mmol, 1.3 equiv.) were stirred in CH_2Cl_2 (2 mL) for 15 min at –78 °C. Purification by FCC (Et_2O/PE = 1:1) yielded 73 mg (0.22 mmol, 82%) **12a** as a colourless solid. *rac*-**12a** was obtained from *rac*-**10a** (514 mg, 1.0 mmol), $TiCl_4$ (209 mg, 1.1 mmol, 1.1 equiv.), and **14a** (117 mg, 1.1 mmol, 1.1 equiv.) as a colourless solid; yield 293 mg (0.88 mmol, 88%). M.p. 100 °C (Et_2O/PE for *rac*-**12a**), m.p. 87 °C (Et_2O/PE for **12a** at 92% *ee*). t_R = 18.52 min (HP-5). R_F = 0.33 (Et_2O/PE = 1:1). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.19, 1.22 (2 br. s, 12 H, *i*Pr (CH_3)$_2$), 1.53–1.66 (m, 2 H, 4-H), 1.86 (m, 1 H, 5-H_A), 2.08–2.21 (m, 2 H, 6-H), 2.53 (dd, $^3J_{3,CH–O}$ = 5.9 Hz, J = 2.7 Hz, 1 H, 3-H), 2.67 (m, 1 H, 5-H_B), 3.80, 3.96 (2 br. s, 2 H, *i*Pr CH), 4.61 (d, $^3J_{3,CH–O}$ = 5.9 Hz, 1 H, CH-O), 5.10 (s, 1 H, 2-H), 7.26 (m, 1 H, *p*-PhCH), 7.34 (m, 4 H, *o*-/*m*-PhCH) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 21.1 (CH_3, *i*Pr (CH_3)$_2$), 21.4, 23.1, 27.6 (CH_2, C-4/C-5/C-6), 42.8 (CH, C-3), 46.4 (CH, *i*Pr CH), 77.5 (CH, C-OH), 114.8 (CH, C-2), 126.6, 127.4, 128.3 (CH, *o*-/*m*-/*p*-Ph), 142.9 (C_q, *i*-C-Ph), 151.2 (C_q, C-1), 153.9 (C_q, C=O) ppm. IR (ATR): $\tilde{\nu}$ = 3426 (s) [ν(O–H)], 2971 (m), 2938 (m), 2873 (s) [ν(C_{aliph}–H)], 1683 (s) [ν(N–C=O)] cm^{-1}. MS (ESI): *m*/*z* = 354.2041 [M + Na]$^+$. $C_{20}H_{29}NO_3$ (331.45): calcd. C 72.47, H 8.82, N 4.23; found C 72.37, H 8.79, N 4.12. $[\alpha]_D^{20}$ = –20.5 (c = 1.01, $CHCl_3$) at 92% *ee*; HPLC Chira Grom 2 (2 × 250 mm), λ = 210 nm, *i*PrOH/*n*-hexane = 1:80, 0.3 mL/min, 9.21 min (*ent*-**12a**), 13.63 min (**12a**).

[3*R*,3(1*S*)]-3-[1-Hydroxy-1-(naphthalen-2-yl)methyl]cyclohex-1-enyl *N*,*N*-Diisopropylcarbamate (12b): According to GP C (*S*)-**10a** (70% *ee*, 257 mg, 0.5 mmol), 2-naphthaldehyde (**14b**, 101 mg, 0.65 mmol, 1.3 equiv.), and $TiCl_4$ (123 mg, 0.65 mmol, 1.3 equiv.) were stirred in CH_2Cl_2 (2 mL) for 15 min at –78 °C. Purification by FCC (Et_2O/PE = 3:2) yielded 136 mg (0.36 mmol, 72%) **12b** as a colourless solid. *rac*-**12b** was obtained from *rac*-**12a** (514 mg, 1.0 mmol), $TiCl_4$ (209 mg, 1.1 mmol, 1.1 equiv.), and **14b** (172 mg, 1.1 mmol, 1.1 equiv.) as a colourless solid; yield 295 mg (0.77 mmol, 77%). M.p. 145 °C (Et_2O/PE for *rac*-**12b**), m.p. 131–132 °C (Et_2O/PE for **12b** at 70% *ee*). t_R = 22.56 min (HP-5). R_F = 0.37 (Et_2O/PE = 3:2). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.17, 1.19 (2 br. s, 12 H, *i*Pr (CH_3)$_2$), 1.54–1.68 (m, 3 H, 4-H/5-H_A), 1.85 (m, 1 H, 5-H_B), 2.08 (br. d, $^2J_{6\text{-}HA,6\text{-}HB}$ = 16.7 Hz, 1 H, 6-H_A), 2.19 (br. d, $^2J_{6\text{-}HA,6\text{-}HB}$ = 16.7 Hz, 1 H, 6-H_B), 2.77 (m, 1 H, 3-H), 2.98 (br. s, 1 H, OH), 3.77, 3.92 (2 br. s, 2 H, *i*Pr CH), 4.76 (d, $^3J_{3,CH–O}$ = 6.3 Hz, 1 H, CH-O), 5.13 (s, 1 H, 2-H), 7.46 (m, 3 H, Ar-H), 7.80 (m, 4 H, Ar-H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 20.7 (CH_3, *i*Pr (CH_3)$_2$), 21.4 (CH_2, C-5), 23.1 (CH_2, C-4), 27.6 (CH_2, C-6), 42.6 (CH, C-3), 46.3 (CH, *i*Pr CH), 77.5 (CH, C-OH), 114.8 (CH, C-2), 124.8, 125.4, 125.6, 126.0, 127.7, 127.9, 128.1 (CH, *C*-Ar), 133.0, 133.3 (C_q, C-Ar), 140.4 (C_q, *i*-C-Ar), 151.1 (C_q, C-1): 153.8 (C_q, C=O) ppm. IR (ATR): $\tilde{\nu}$ = 3421 (m) [ν(O–H)], 3053 (w) [ν(C_{arom}–H)], 2973 (m), 2949 (m), 2869 (w) [ν(C_{aliph}–H)], 1669 (s) [ν(N–C=O)] cm^{-1}. MS (ESI): *m*/*z* = 404.2193 [M + Na]$^+$. $C_{24}H_{31}NO_3$ (381.51): calcd. C 75.56, H 8.19, N 3.67; found C 75.51, H 8.09, N 3.54. $[\alpha]_D^{20}$ = –23.8 (c = 1.01, $CHCl_3$) at 70% *ee*; HPLC Chira Grom 2 (2 × 250 mm), λ = 227 nm, *i*PrOH: *n*-hexane = 1:80, 0.3 mL/min, 22.15 min (**12b**), 24.93 min (*ent*-**12b**).

[3*S*,3(1*R*)]-3-(1-(4-Bromophenyl)-1-hydroxymethyl)cyclohex-1-enyl *N*,*N*-Diisopropylcarbamate (*ent*-12c): According to GP C (*R*)-**10a** (90% *ee*, 195 mg, 0.38 mmol), 4-bromobenzaldehyde (**14c**, 91 mg, 0.49 mmol, 1.3 equiv.), and $TiCl_4$ (93 mg, 0.49 mmol, 1.3 equiv.) were stirred in CH_2Cl_2 (2 mL) for 15 min at –78 °C. Purification by FCC (Et_2O/PE = 2:1) yielded 124 mg (0.30 mmol, 80%) *ent*-**12c** as a colourless solid. *rac*-**12c** was obtained from *rac*-**10a** (1.058 g, 2.0 mmol), $TiCl_4$ (543 mg, 2.6 mmol, 1.3 equiv.), and **14c** (461 mg, 2.6 mmol, 1.3 equiv.) as a colourless solid; yield 674 mg (0.82 mmol, 82%). M.p. 95 °C (Et_2O/PE for *rac*-**12c**), m.p. 102–104 °C (Et_2O/PE for *ent*-**12c** at 88% *ee*). t_R = 20.04 min (HP-5), R_F = 0.32 (Et_2O/PE = 3:2). ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.20, 1.23 (2 br. s, 12 H, *i*Pr (CH_3)$_2$), 1.43–1.66 (m, 3 H, 4-H/5-H_A), 1.85 (m, 1 H, 5-H_B), 2.04–2.23 (m, 2 H, 6-H), 2.53 (br. s, 1 H, OH), 2.63 (m, 1 H, 3-H), 3.89 (br. s, 2 H, *i*Pr CH), 4.59 (d, $^3J_{3,CH–O}$ = 5.9 Hz, 1 H, CH-O), 5.10 (s, 1 H, 2-H), 7.24 (d, J = 8.6 Hz, 2 H, Ar-H), 7.45 (d, J = 8.6 Hz, 2 H, Ar-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 20.9 (CH_3, *i*Pr (CH_3)$_2$), 21.2 (CH_2, C-5), 22.6 (CH_2, C-4), 27.5 (CH_2, C-6), 42.6 (CH, C-3), 46.2 (CH, *i*Pr CH), 76.1 (CH, C-OH), 114.4 (CH, C-2), 120.9 (C_q, C-Ar), 128.2, 131.2 (CH, C-Ar), 141.8 (C_q, *i*-C-Ar), 151.3 (C_q, C-1), 153.7 (C_q, C=O) ppm. IR (ATR): $\tilde{\nu}$ = 3450 (s) [ν(O–H)], 2969 (m), 2935 (m), 2870 (w) [ν(C_{aliph}–H)], 1688 (s) [ν(N–C=O)] cm^{-1}. MS (ESI): *m*/*z* = 432.1146 [M + Na]$^+$. $C_{20}H_{28}BrNO_3$ (410.35): calcd. C 58.54, H 6.88, N 3.41; found C 58.43, H 6.92, N 3.39. $[\alpha]_D^{20}$ = +23.7 (c = 1.12, $CHCl_3$) at 88% *ee*; HPLC Chira Grom 2 (2 × 250 mm), λ = 223 nm, *i*PrOH: *n*-hexane = 1:100, 0.3 mL/min, 14.73 min (*ent*-**12c**), 18.10 min (**12c**).

[3*R*,3(1*S*)]-3-[1-Hydroxy-1-(4-methoxyphenyl)methyl]cyclohex-1-enyl *N*,*N*-Diisopropylcarbamate (12d): According to GP C (*S*)-**10a** (84% *ee*, 1.058 g, 2.00 mmol), 4-methoxybenzaldehyde (**14d**, 354 mg, 2.60 mmol, 1.3 equiv.), and $TiCl_4$ (543 mg, 2.60 mmol, 1.3 equiv.) were stirred in CH_2Cl_2 (8 mL) for 10 min at –78 °C. Purification by FCC (Et_2O/PE = 3:1) yielded 585 mg (1.62 mmol, 81%) **12d** as a colourless solid. *rac*-**12d** was obtained from *rac*-**10a** (1.058 g, 2.0 mmol), $TiCl_4$ (543 mg, 2.6 mmol, 1.3 equiv.), and **14d** (354 mg, 2.6 mmol, 1.3 equiv.) as a colourless solid; yield 536 mg (1.48 mmol, 74%). M.p. 95 °C (Et_2O/PE for *rac*-**12d**), m.p. 100–102 °C (Et_2O/PE for **12d** at 84% *ee*). t_R = 20.75 min (HP-5). R_F = 0.29 (Et_2O/PE = 2:1). ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.21, 1.22 (2 br. s, 12 H, *i*Pr (CH_3)$_2$), 1.51 (m, 1 H, 4-H_A), 1.57–1.67 (m, 2 H, 5-H), 1.86 (m, 1 H, 4-H_B), 2.05–2.25 (m, 3 H, 6-H/OH), 2.67 (m, 1 H, 3-H), 3.81 (br. s and s, 4 H, *i*Pr CH, Ar-OCH_3), 3.97 (br. s, 1 H, *i*Pr CH), 4.60 (d, $^3J_{3,CH–O}$ = 6.0 Hz, 1 H, CH-O), 5.12 (s, 1 H, 2-H), 6.79 (d, J = 8.4 Hz, 1 H, Ar-H), 6.93 (d, J = 8.4 Hz, 2 H, Ar-H), 7.23 (d, J = 8.4 Hz, 1 H, Ar-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 20.8 (CH_3, *i*Pr (CH_3)$_2$), 21.3 (CH_2, C-5), 22.9 (CH_2, C-4), 27.5 (CH_2, C-6), 42.6 (CH, C-3), 46.2 (CH, *i*Pr CH), 55.2 (CH_3, O-CH_3), 76.7 (CH, C-OH), 111.8, 113.0 (CH, C-Ar), 114.7 (CH, C-2), 118.8, 129.1 (CH, C-Ar), 144.4 (C_q, *i*-C-Ar), 151.0 (C_q, C-1), 153.7 (C_q, C=O), 159.6 (C_q, C-Ar) ppm. IR (ATR): $\tilde{\nu}$ = 3431 (m) [ν(O–H)], 2962 (m), 2937 (m), 2929 (m), 2857 (m), [ν(C_{aliph}–H)], 1692 (s) [ν(N–C=O)] cm^{-1}. MS (ESI): *m*/*z* = 384.2140 [M + Na]$^+$. $C_{21}H_{31}NO_4$ (361.48): calcd. C 69.78, H 8.64, N 3.87; found C 69.45, H 8.60, N 3.73. $[\alpha]_D^{20}$ = –15.0 (c = 1.02, $CHCl_3$) at 84% *ee*;

HPLC Chira Grom 2 (2×250 mm), λ = 226 nm, *i*PrOH/*n*-hexane = 1:80, 0.3 mL/min, 16.94 min (*ent*-**12d**), 23.35 min (**12d**).

[3*S*,3(1*R*)]-3-[1-(Furan-2-yl)-1-hydroxymethyl]cyclohex-1-enyl *N*,*N*-Diisopropylcarbamate (*ent*-12e): According to GP C (*R*)-**10a** (87% *ee*, 676 mg, 1.30 mmol), furan-2-carbaldehyde (**14e**, 162 mg, 1.69 mmol, 1.3 equiv.), and $TiCl_4$ (320 mg, 1.69 mmol, 1.3 equiv.) were stirred in CH_2Cl_2 (5 mL) for 15 min at –78 °C. Purification by FCC (Et_2O/PE = 2:1) yielded 207 mg (0.65 mmol, 50%) *ent*-**12e** as a colourless liquid. *rac*-**12e** was obtained from *rac*-**10a** (1.058 g, 2.0 mmol), $TiCl_4$ (543 mg, 2.6 mmol, 1.3 equiv.), and **14e** (250 mg, 2.6 mmol, 1.3 equiv.) as a colourless liquid; yield 388 mg (1.21 mmol, 60%). t_R = 16.95 min (HP-5), R_F = 0.18 (Et_2O/PE = 3:2). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.17, 1.19 (2 br. s, 12 H, *i*Pr $(CH_3)_2$), 1.44 (m, 1 H, 4-H_A), 1.62 (m, 1 H, 5-H_A), 1.73–1.86 (m, 2 H, 4-H_B/5-H_B), 2.07–2.20 (m, 2 H, 6-H), 2.63 (m, 1 H, 3-H), 3.77, 3.95 (2 br. s, 2 H, *i*Pr CH), 4.55 (d, $^3J_{3,CH-O}$ = 7.1 Hz, 1 H, CH-O), 5.07 (s, 1 H, 2-H), 6.27 (d, *J* = 3.3 Hz, 1 H, Ar-H), 6.30 (dd, *J* = 3.3 Hz, *J* = 1.8 Hz, 1 H, Ar-H), 7.33 (dd, *J* = 1.8 Hz, *J* = 0.9 Hz, 2 H, Ar-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 20.9 (CH_3, *i*Pr $(CH_3)_2$), 21.2 (CH_2, C-5), 23.6 (CH_2, C-4), 27.4 (CH_2, C-6), 40.3 (CH, C-3), 46.1 (CH, *i*Pr CH), 71.0 (CH, C-OH), 106.8, 110.1 (CH, C-Ar), 113.8 (CH, C-2), 141.6 (Cq, *i*-C-Ar), 150.8 (C_q, C-1), 153.7 (C_q, C=O), 155.4 (C_q, C-Ar) ppm. IR (film): $\tilde{\nu}$ = 3422 (w) [ν(O–H)], 2969 (m), 2934 (m), 2871 (w) [ν(C_{aliph}–H)], 1695 (s) [ν(N–C=O)] cm^{-1}. MS (ESI): *m*/*z* = 344.1835 [M + Na]$^+$. $C_{18}H_{27}NO_4$ (321.41): calcd. C 67.26, H 8.47, N 4.36; found C 67.33, H 8.77, N 4.14. $[\alpha]_D^{20}$ = +1.9 (*c* = 1.02, $CHCl_3$) at 85% *ee*; HPLC Chira Grom 2 (2×250 mm), λ = 210 nm, *i*PrOH/*n*-hexane = 1:80, 0.3 mL/min, 9.71 min (*ent*-**12e**), 11.51 min (**12e**).

[3*R*,3(1*R*)]-3-(1-Hydroxyethyl)cyclohex-1-enyl *N*,*N*-Diisopropylcarbamate (12f): According to GP C (*S*)-**10a** (97% *ee*, 571 mg, 1.11 mmol), acetaldehyde (**14f**, 64 mg, 1.44 mmol, 1.3 equiv.), and $TiCl_4$ (275 mg, 1.44 mmol, 1.3 equiv.) were stirred in CH_2Cl_2 (5 mL) for 15 min at –78 °C. Purification by FCC (Et_2O/PE = 3:2) yielded 221 mg (0.82 mmol, 74%) **12f** as a colourless oil. *rac*-**12f** was obtained from *rac*-**10a** (1.058 g, 2.0 mmol), $TiCl_4$ (543 mg, 2.6 mmol, 1.3 equiv.), and **14f** (114 mg, 2.6 mmol, 1.3 equiv.) as a colourless oil; yield 465 mg (1.73 mmol, 86%). t_R = 14.01 min (HP-5). R_F = 0.34 (Et_2O/PE = 3:2). ^{1}H NMR (400 MHz, $CDCl_3$): δ = 1.20 (d, $^3J_{2',CH-O}$ = 6.2 Hz, 3 H, 2′-H), 1.23, 1.24 (2 br. s, 12 H, *i*Pr $(CH_3)_2$), 1.48 (m, 1 H, 4-H_A), 1.66 (m, 1 H, 5-H_A), 1.74 (m, 1 H, 4-H_B), 1.88 (m, 1 H, 5-H_B), 2.07–2.24 (m, 3 H, 6-H/OH), 2.32 (m, 1 H, 3-H), 3.76 (dq, $^3J_{2',CH-O}$ = 6.2 Hz, $^3J_{3,CH-O}$ = 1.3 Hz, 1 H, CH-O), 3.81, 4.01 (2 br. s, 2 H, *i*Pr CH), 5.27 (s, 1 H, 2-H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 20.0 (CH_3, C-2′), 20.9 (CH_3, *i*Pr $(CH_3)_2$), 21.4 (CH_2, C-5), 22.7 (CH_2, C-4), 27.5 (CH_2, C-6), 42.3 (CH, C-3), 46.1 (CH, *i*Pr CH), 70.3 (CH, C–OH), 114.7 (CH, C-2), 150.6 (C_q, C-1), 153.8 (C_q, C=O) ppm. IR (film): $\tilde{\nu}$ = 3450 (w) [ν(O–H)], 2970 (m), 2934 (m), 2870 (w) [ν(C_{aliph}–H)], 1695 (s) [ν(N–C=O)] cm^{-1}. MS (ESI): *m*/*z* = 292.1869 [M + Na]$^+$. $C_{15}H_{27}NO_3$ (269.38): calcd. C 66.88, H 10.10, N 5.20; found C 66.78, H 10.34, N 5.14. $[\alpha]_D^{20}$ = –6.5 (*c* = 1.03, $CHCl_3$) at 96% *ee*. GC DEX β-120, 125 °C isotherm, 461 min (**12f**), 481 min (*ent*-**12f**).

[3*R*,3(1*R*)]-3-(1-Hydroxy-2-methylpropyl)cyclohex-1-enyl *N*,*N*-Diisopropylcarbamate (12g): According to GP C (*S*)-**10a** (84% *ee*, 529 mg, 1.00 mmol), isobutyraldehyde (**14g**, 93 mg, 1.30 mmol, 1.3 equiv.), and $TiCl_4$ (247 mg, 1.30 mmol, 1.3 equiv.) were stirred in CH_2Cl_2 (4 mL) for 15 min at –78 °C. Purification by FCC (Et_2O/PE = 3:2) yielded 213 mg (0.72 mmol, 72%) **12g** as a colourless oil. *rac*-**12g** was obtained from *rac*-**10a** (1.058 g, 2.0 mmol), $TiCl_4$ (543 mg, 2.6 mmol, 1.3 equiv.), and **14g** (187 mg, 2.6 mmol, 1.3 equiv.) as a colourless solid; yield 417 mg (1.40 mmol, 70%). M.p. 61 °C (Et_2O for *rac*-**12g**). t_R = 15.17 min (HP-5). R_F = 0.30 (Et_2O/PE = 1:1). ^{1}H NMR (300 MHz, $CDCl_3$): δ = 0.87, 0.94 (d, 3′-H, $^3J_{2'-H,3'-H}$ = 6.8 Hz, 6 H, d), 1.18, 1.21 (2 br. s, 12 H, *i*Pr $(CH_3)_2$), 1.49–1.65 (m, 3 H, 4-H/5-H_A), 1.76 (oct, $^3J_{2',3'}$ = 6.8 Hz, $^3J_{2',CH-O}$ = 6.8 Hz, 1 H, 2′-H), 1.87 (m, 1 H, 5-H_B), 1.93 (br. s, 1 H, OH), 2.10 (m, 2 H, 6-H), 2.47 (m, 1 H, 3-H), 3.16 (dd, $^3J_{2',CH-O}$ = 6.8 Hz, $^3J_{3,CH-O}$ = 5.1 Hz, 1 H, CH-O), 3.87 (br. s, 2 H, *i*Pr CH), 5.15 (s, 1 H, 2-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 17.9, 19.4 (CH_3, C-3′), 21.0 (CH_3, *i*Pr $(CH_3)_2$), 21.4 (CH_2, C-5), 21.7 (CH_2, C-4), 27.5 (CH_2, C-6), 30.0 (CH, C-2′), 38.1 (CH, C-3), 46.2 (CH, *i*Pr CH), 79.2 (CH, C-OH), 115.4 (CH, C-2), 150.9 (C_q, C-1), 153.8 (C_q, C=O) ppm. IR (film): $\tilde{\nu}$ = 3468 (w) [ν(O–H)], 2965 (m), 2935 (m), 2872 (w) [ν(C_{aliph}–H)], 1693 (s) [ν(N–C=O)] cm^{-1}. MS (ESI): *m*/*z* = 320.2193 [M + Na]$^+$. $C_{17}H_{31}NO_3$ (297.43): calcd. C 68.65, H 10.51, N 4.71; found C 68.36, H 10.34, N 4.62. $[\alpha]_D^{20}$ = –10.7 (*c* = 1.09, $CHCl_3$) at 85 (+/–5)% *ee*. GC DEX β-120, 120 °C isotherm, 1090 min (**12g**), 1109 min (*ent*-**12g**).

Synthesis of Hexahydroisobenzofuran-4(1*H*)-ones 22. General Procedure D (GP D): To a stirred solution of the homoaldol product **12** (0.5 mmol) and aldehyde **20** (0.65 mmol, 1.3 equiv.) in CH_2Cl_2 (2 mL) at 0 °C, $BF_3{\cdot}OEt_2$ (92 mg, 0.65 mmol, 1.3 equiv.) was added through a syringe within 1 min. The solution was warmed to room temperature and stirring was continued until complete consumption of the starting material (TLC). The reaction was quenched with satd. aq. NaCl solution (3 mL), diluted with CH_2Cl_2 (5 mL) and the aqueous layer was extracted with TBME (3×10 mL). The combined organic layers were washed with satd. $NaHCO_3$ solution (5 mL), dried with $MgSO_4$ and concentrated in vacuo. The crude product was purified by FCC on silica gel (Et_2O/PE mixtures).

(1*SR*,3*RS*,3a*SR*,7a*RS*)-3-(4-Bromophenyl)-1-(naphthalen-2-yl)hexahydroisobenzofuran-4(1*H*)-one (*rac*-22a): According to GP D *rac*-**12b** (190 mg, 0.50 mmol), 4-bromobenzaldehyde (**20a**, 120 mg, 0.65 mmol, 1.3 equiv.), and $BF_3{\cdot}OEt_2$ (92 mg, 0.65 mmol, 1.3 equiv.) were stirred for 2 h. FCC (Et_2O/PE = 2:1) yielded 150 mg (0.36 mmol, 71%) *rac*-**22a** as a colourless oil. t_R = 25.17 min (HP-5). R_F = 0.33 (Et_2O/PE = 2:1). ^{1}H NMR (300 MHz, $CDCl_3$): δ = 1.03 (m, 1 H, 5-H_A), 1.15–1.41 (m, 3 H, 6-H/7-H_A), 1.73 (m, 1 H, 7-H_B), 2.03 (br. d, $^2J_{5A,5B}$ = 15.8 Hz, 1 H, 5-H_B), 2.84 (ddt, $^3J_{1,7a}$ = $^3J_{1,7A}$ = 5.9 Hz, $^3J_{3a,7a}$ = 8.9 Hz, $^3J_{7B,7a}$ = 11.8 Hz, 1 H, 7a-H), 3.66 (dd, $^3J_{3,3a}$ = 11.4 Hz, $^3J_{3a,7a}$ = 7.4 Hz, 1 H, 3a-H), 5.31 (d, $^3J_{1,7a}$ = 4.1 Hz, 1 H, 1-H), 5.50 (d, $^3J_{3,3a}$ = 11.4 Hz, 1 H, 3-H), 7.38 (d, *J* = 8.6 Hz, 2 H, Ar-H), 7.46–7.54 (m, 2 H, Ar-H), 7.85–7.94 (m, 3 H, Ar-H), 8.02 (s, 1 H, Ar-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 22.9 (CH_3, C-6), 23.4 (CH_2, C-7), 41.5 (CH_2, C-5), 47.2 (CH, C-7a), 58.5 (CH, C-3a), 79.9 (CH, C-3), 83.6 (CH, C-1), 121.5 (C_q, C-Ar), 123.8, 124.3, 125.9, 126.3, 127.7, 127.9, 128.1, 131.4 (CH, C-Ar), 132.7, 133.2, 135.3, 138.3 (C_q, C-Ar), 210.7 (C_q, C-4) ppm. IR (film): $\tilde{\nu}$ = 3061 (w), 3053 [ν(C_{arom}–H)], 2940 (m), 2865 (m) [ν(C_{aliph}–H)], 1703 (s) [ν(C=O)] cm^{-1}. MS (ESI): *m*/*z* = 443.0609 [M + Na]$^+$. $C_{24}H_{21}BrO_2$ (421.33): calcd. C 68.42, H 5.02; found C 68.67, H 5.12.

(1*R*,3*S*,3a*R*,7a*S*)-1-(4-Bromophenyl)-3-(*tert*-butyl)hexahydroisobenzofuran-4(1*H*)-one (*ent*-22b): According to GP D *ent*-**12c** (88% *ee*, 62 mg, 0.15 mmol), pivaldehyde (**20b**, 27 mg, 0.31 mmol, 2.1 equiv.), and $BF_3{\cdot}OEt_2$ (40 mg, 0.28 mmol, 1.9 equiv.) were stirred for 90 min. FCC (Et_2O/PE = 1:2) yielded 44 mg (0.13 mmol, 84%) *ent*-**22b** as a colourless solid. *rac*-**22b** was obtained from *rac*-**12c** (205 g, 0.5 mmol), pivaldehyde (**20b**, 90 mg, 1.05 mmol, 2.1 equiv.), and $BF_3{\cdot}OEt_2$ (135 mg, 0.95 mmol, 1.9 equiv.) as a colourless solid; yield 128 mg (0.37 mmol, 73%). M.p. 87 °C (Et_2O/PE for *rac*-**22b**), m.p. 116–118 °C (Et_2O/PE for *ent*-**22b** at 89% *ee*), m.p. 122 °C (Et_2O/PE for *ent*-**22b** at >99% *ee*). t_R = 21.10 min

(HP-5). R_F = 0.53 (Et_2O/PE = 2:1). ^1H NMR (300 MHz, $CDCl_3$): δ = 0.99 (s, 9 H, $C(CH_3)_3$), 1.10–1.19 (m, 2 H, 5-H_A, 6-H_A), 1.36, 1.63 (2 m, 2 H, 6-H_B/7-H_A), 2.28 (m, 1 H, 7-H_B), 2.40 (m, 1 H, 5-H_B), 2.70 (ddt, $^3J_{1,7a}$ = $^3J_{1,7A}$ = 5.9 Hz, $^3J_{3a,7a}$ = 8.9 Hz, $^3J_{7B,7a}$ = 11.8 Hz, 1 H, 7a-H), 3.16 (dd, $^3J_{3,3a}$ = 9.8 Hz, $^3J_{3a,7a}$ = 8.9 Hz, 1 H, 3a-H), 3.78 (d, $^3J_{3,3a}$ = 9.8 Hz, 1 H, 3-H), 4.71 (d, J = 5.9 Hz, 1 H, 1-H), 7.18 (d, J = 8.4 Hz, 2 H, Ar-H), 7.41 (J = 8.4 Hz, 2 H, Ar-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 22.2 (CH_2, C-6), 23.2 (CH_2, C-7), 27.4 (CH_3, $C(CH_3)_3$), 34.3 (CH_2, C-5), 41.6 (C_q, $C(CH_3)_3$), 46.0 (CH, C-7a), 55.0 (CH, C-3a), 81.0 (CH, C-3), 90.5 (CH, C-1), 120.8 (C_q, C-Ar), 127.5, 131.2 (CH, C-Ar), 137.9 (C_q, C-Ar), 213.6 (C_q, C-4) ppm. IR (film): $\tilde{\nu}$ = 2933 (m), 2861 (m) [$\nu(C_{aliph}–H)$], 1689 (s) [$\nu(C=O)$] cm^{-1}. MS (ESI): m/z = 373.0766 $[M + Na]^+$. $C_{18}H_{23}BrO_2$ (351.28): calcd. C 61.54, H 6.60; found C 61.37, H 6.48. $[a]_D^{20}$ = +168.7 (c = 0.98, $CHCl_3$) at 89% *ee*; HPLC Chira Grom 1 (2 × 250 mm), λ = 224 nm, *i*PrOH/*n*-hexane = 1:80, 0.3 mL/min, 8.39 min (**22b**), 9.78 min (*ent*-**22b**).

(1*SR*,3*SR*,3a*SR*,7a*RS*)- and (1*RS*,3*SR*,3a*SR*,7a*RS*)-3-Isopropyl-1-(4-methoxyphenyl)hexahydroisobenzofuran-4(1*H*)-one (*rac*-22c and *epi-rac*-22c): According to GP D *rac*-**12d** (180 mg, 0.50 mmol), isobutyraldehyde (**20c**, 47 mg, 0.65 mmol, 1.3 equiv.), and $BF_3{\cdot}OEt_2$ (92 mg, 0.65 mmol, 1.3 equiv.) were stirred for 4 h. FCC (Et_2O/PE = 2:1) yielded 97 mg (0.34 mmol, 67%) of an inseparable mixture of *rac*-**22c**: *epi-rac*-**22c** = 45:55[27] as a colourless oil. t_R = 17.28 min minor diastereomer: *rac*-**22c**, t_R = 17.40 min major diastereomer: *epi-rac*-**22c** (HP-5). R_F = 0.29 (Et_2O/PE = 2:1). ^1H NMR (300 MHz, $CDCl_3$): δ (*rac*-**22c**) = 0.80, 1.03 (2 d, $^3J_{i\mathrm{Pr(Me)},i\mathrm{PrCH}}$ = 6.4 Hz, 6 H, *i*Pr (CH_3)$_2$), 1.10–1.33, 1.48–1.87, 2.05–2.44 (3 m, 8 H, 5-H/6-H/7-H/3a-H/*i*Pr CH), 2.57 (m, 1 H, 7a-H), 3.18 (br. t, $^3J_{3,3a}$ = $^3J_{3a,7a}$ = 8.8 Hz, 1 H, 3a-H), 3.18 (br. t, $^3J_{3,3a}$ = $^3J_{3a,7a}$ = 9.2 Hz, 1 H, 3a-H), 3.72 (s, 3 H, O-CH_3), 3.76 (m, 1 H, 3-H), 4.74 (d, $^3J_{1,7a}$ = 5.1 Hz, 1 H, 1-H), 6.79 (m, 2 H, Ar-H), 7.16 (m, 2 H, Ar-H) ppm. δ (*epi-rac*-**22c**) = 0.89, 0.95 (2 d, $^3J_{i\mathrm{Pr(Me)},i\mathrm{PrCH}}$ = 6.8 Hz, 6H, *i*Pr (CH_3)$_2$), 1.10–1.33, 1.48–1.87, 2.05–2.44 (3 m, 8 H, 5-H/6-H/7-H/7a-H/*i*Pr CH), 2.63 (dd, $^3J_{3,3a}$ = 5.2 Hz, $^3J_{3a,7a}$ = 9.7 Hz, 1H, 3a-H), 3.71 (s, 3-H, O-CH_3), 4.23 (dd, $^3J_{3,3a}$ = 5.2 Hz, $^3J_{3,i\mathrm{PrCH}}$ = 5.9 Hz, 1H, 3-H), 4.26 (d, $^3J_{1,7a}$ = 9.4 Hz, 1H, 1-H), 6.79 (m, 2H, Ar-H), 7.16 (m, 2 H, Ar-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ (*rac*-**22c**) = 19.7, 20.3 (CH_3, *i*Pr (CH_3)$_2$), 23.0 (CH_2, C-6), 23.3 (CH_2, C-7), 31.1 (CH_2, C-5), 42.1 (CH, *i*Pr CH), 47.2 (CH, C-7a), 54.1 (CH, C-3a), 81.7 (CH, C-3), 85.6 (CH, C-1), 113.5, 126.9 (CH, C-Ar), 130.6, 158.6 (C_q, C-Ar), 212.5 (C_q, C-4) ppm. δ (*epi-rac*-**22c**) = 18.1, 18.7 (CH_3, *i*Pr (CH_3)$_2$), 22.0 (CH_2, C-6), 23.7 (CH_2, C-7), 32.5 (CH_2, C-5), 40.7 (CH, *i*Pr CH), 49.2 (CH, C-7a), 55.2 (CH, C-3a), 82.0 (CH, C-3), 82.5 (CH, C-1), 113.7, 127.4 (CH, C-Ar), 132.6, 159.3 (C_q, C-Ar), 210.7 (C_q, C-4) ppm. IR (film): $\tilde{\nu}$ = 2956 (m), 2934 (m), 2865 (m) [$\nu(C_{aliph}–H)$], 1706 (s) [$\nu(C=O)$] cm^{-1}. MS (ESI): m/z = 311.1620 $[M + Na]^+$. $C_{18}H_{24}O_3$ (288.38, mixture of diastereomers): calcd. C 74.97, H 8.39; found C 74.78, H 8.57.

(1*S*,3*S*,3a*S*,7a*R*)-3-(Furan-2-yl)-1-methyl-hexahydroisobenzofuran-4(1*H*)-one (22d): According to GP D **12f** (96% *ee*, 86 mg, 0.32 mmol), furan-2-carbaldehyde (**20d**, 46 mg, 0.48 mmol, 1.5 equiv.), and $BF_3{\cdot}OEt_2$ (59 mg, 0.42 mmol, 1.5 equiv.) were stirred for 15 min. FCC (Et_2O/PE = 1:1) yielded 48 mg (0.22 mmol, 68%) **22d** (96% *ee*) as a colourless oil. *ent*-**22d** was obtained from *ent*-**12f** (76% *ee*, 46 mg, 0.17 mmol), furan-2-carbaldehyde (**20d**, 25 mg, 0.26 mmol, 1.5 equiv.), and $BF_3{\cdot}OEt_2$ (31 mg, 0.22 mmol, 1.3 equiv.) as a colourless oil; yield 27 mg (0.13 mmol, 72%) *ent*-**22d** (75% *ee*), colourless oil. t_R = 12.03 min (HP-5). R_F = 0.29 (Et_2O/PE = 2:1). ^1H NMR (300 MHz, $CDCl_3$): δ = 1.31 (d, $^3J_{1,1\text{-}CH3}$ = 6.3 Hz, 3 H, 1-CH_3), 1.44–1.54 (m, 2 H, 5-H_A/6-H_A), 1.63–1.74 (m, 3 H, 6-H_B/7-H_A), 1.92 (m, 1 H, 7-H_B), 2.11 (m, 1 H, 5-H_B), 2.31 (m, 1 H, 7a-H), 3.24 (dd, $^3J_{3,3a}$ = 11.0 Hz, $^3J_{3a,7a}$ = 8.3 Hz, 1 H, 3a-H), 4.00 (dq, $^3J_{1,1'\text{–}CH3}$ = 6.3 Hz, $^3J_{1,7a}$ = 10.5 Hz, 1 H, 1-H), 5.19 (d, $^3J_{3,3a}$ = 11.0 Hz, 1 H, 3-H), 6.24 (m, 2 H, Ar-H), 7.25 (m, 1 H, Ar-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 15.1 (CH_3, 1′-CH_3), 21.2 (CH_2, C-6), 23.7 (CH_2, C-7), 39.8 (CH_2, C-5), 46.1 (CH; C-7a), 57.0 (CH, C-3a), 75.6 (CH, C-3), 78.6 (CH, C-1), 108.2, 110.4, 142.2 (CH, C-Ar), 152.4 (C_q, C-Ar), 210.5 (C_q, C-4) ppm. IR (film): $\tilde{\nu}$ = 3143 (w), 3117 [$\nu(C_{arom}–H)$], 2939 (m), 2869 (m) [$\nu(C_{aliph}–H)$], 1702 (s) [$\nu(C=O)$] cm^{-1}. MS (ESI): m/z = 243.0989 $[M + Na]^+$. $C_{13}H_{16}O_3$ (220.26): calcd. C 70.89, H 7.32; found C 70.59, H 7.51. **22d**: $[a]_D^{20}$ = –169.1 (c = 1.03, $CHCl_3$) at 96% *ee*; *ent*-**22d**: $[a]_D^{20}$ = +141.0 (c = 1.06, $CHCl_3$) at 75% *ee*; HPLC Chiralcel OJ-RH (150 × 4.6 mm), λ = 230 nm, MeCN/H_2O = 38:62, 0.5 mL/min, 13.88 min (*ent*-**22d**), 14.66 min (**22b**).

(1*RS*,3*SR*,3a*SR*,7a*RS*)-1-Isopropyl-3-vinyl-hexahydroisobenzofuran-4(1*H*)-one (*rac*-22e): According to GP D *rac*-**12g** (74 mg, 0.25 mmol), acroleine (**20e**, 19 mg, 0.33 mmol, 1.3 equiv.), and $BF_3{\cdot}OEt_2$ (46 mg, 0.33 mmol, 1.3 equiv.) were stirred for 5 h 30 min. FCC (Et_2O/PE = 1:2) yielded 44 mg (0.21 mmol, 84%) *rac*-**22e** as a colourless oil. t_R = 10.30 min (HP-5). R_F = 0.36 (Et_2O/PE = 1:2). ^1H NMR (300 MHz, $CDCl_3$): δ = 0.88, 1.05 (2 d, $^3J_{i\mathrm{Pr(Me)},i\mathrm{PrCH}}$ = 6.6 Hz, 6 H, *i*Pr (CH_3)$_2$), 1.43 (m, 1 H, 5-H_A), 1.56 (m, 1 H, 6-H_A), 1.73 (m, 1 H, 6-H_B), 1.86 (dsept, $^3J_{i\mathrm{Pr(Me)},i\mathrm{PrCH}}$ = 6.6 Hz, $^3J_{1,i\mathrm{PrCH}}$ = 3.5 Hz, 1 H, *i*Pr CH), 1.98–2.11 (m, 2 H, 7-H), 2.31–2.43 (m, 2 H, 5-H_B/7a-H), 3.17 (dd, $^3J_{3,3a}$ = 11.5 Hz, $^3J_{3a,7a}$ = 7.1 Hz, 1 H, 3a-H), 3.30 (dd, $^3J_{1,i\mathrm{PrCH}}$ = 3.5 Hz, $^3J_{1,7a}$ = 9.8 Hz, 1 H, 1-H), 4.62 (ddt, $^3J_{1',3}$ = 5.8 Hz, $^3J_{3,3a}$ = 11.5 Hz, J = 1.3 Hz, 1 H, 3-H), 5.12 (dt, $^3J_{1',2'A}$ = 10.5 Hz, $^2J_{2'A,2'B}$ = 1.6 Hz, 1 H, 2′-H_A), 5.33 (dt, $^3J_{1',2'B}$ = 17.2 Hz, $^2J_{2'A,2'B}$ = 1.6 Hz, 1 H, 2′-H_B), 5.71 (ddd, $^3J_{1',2'A}$ = 10.5 Hz, $^3J_{1',2'B}$ = 17.2 Hz, $^3J_{1',3}$ = 5.8 Hz, 1 H, 1′-H) ppm. ^{13}C NMR (75 MHz, $CDCl_3$): δ = 19.0, 20.1 (CH_3, *i*Pr (CH_3)$_2$), 21.6 (CH_2, C-6), 23.7 (CH_2, C-7), 28.2 (CH, *i*Pr CH), 42.1 (CH_2, C-5), 44.1 (CH; C-7a), 57.3 (CH, C-3a), 79.2 (CH, C-3), 88.9 (CH, C-1), 116.5 (CH_2, C-2′), 136.6 (CH, C-1′), 211.2 (C_q, C-4) ppm. IR (film): $\tilde{\nu}$ = 2958 (m), 2943 (m), 2873 (m) [$\nu(C_{aliph}–H)$], 1704 (s) [$\nu(C=O)$] cm^{-1}. MS (ESI): m/z = 231.1346 $[M + Na]^+$. $C_{13}H_{20}O_2$ (208.30): calcd. C 74.96, H 9.68; found C 74.96, H 9.94.

[1*S*,3*R*,3(1*R*,5*R*),3a*S*,7a*R*]- and [1R,3S,3(1*R*,5*R*),3a*R*,7a*S*]-3-(6,6-Dimethylbicyclo[3.1.1]hept-2-en-2-yl)-1-(naphthalen-2-yl)-hexahydro-isobenzofuran-4(1*H*)-one (22f) and (22g): According to GP D **12b** (70% *ee*, 95 mg, 0.25 mmol), (1*R*)-(–)-myrtenal (49 mg, 0.33 mmol, 1.3 equiv.), and $BF_3{\cdot}OEt_2$ (46 mg, 0.33 mmol, 1.3 equiv.) were stirred for 1 h. FCC (Et_2O/PE = 1:2) yielded 57 mg (0.15 mmol, 59%) **22f** and 13 mg (0.04 mmol, 14%) **22g** (total yield 73%, *dr* = 88:12[27]) as colourless crystalline solids. **22f**: M.p. 205 °C (Et_2O/PE). t_R = 24.11 min (HP-5). R_F = 0.56 (Et_2O/PE = 3:2). ^1H NMR (500 MHz, $CDCl_3$): δ = 0.90 (s, 3 H, 6′-CH_3), 1.03 (d, J = 9.2 Hz, 1 H, 5-H_A), 1.11 (m, 1 H, 6-H_A), 1.28 (s, 3 H, 6′-CH_3), 1.34–1.47 (m, 2 H, 6-H_B/7-H_A), 1.89 (m, 1 H, 7-H_B), 1.97 (dt, J = 5.6 Hz, J = 1.6 Hz, 1 H, 5′-H), 2.08 (m, 1 H, 1′-H), 2.31–2.40 (m, 5 H, 4′-H, 5-H_B, 7′-H), 2.77 (m, 1 H, 7a-H), 3.41 (dd, $^3J_{3,3a}$ = 11.2 Hz, $^3J_{3,7a}$ = 7.5 Hz, 1 H, 3a-H), 4.64 (dq, $^3J_{3,3a}$ = 11.2 Hz, J = 2.2 Hz, 1 H, 3-H), 5.08 (d, $^3J_{1,7a}$ = 4.3 Hz, 1 H, 1-H), 6.08 (m, 1 H, 3′-H), 7.44–7.52 (m, 3 H, Ar-H), 7.83 (d, J = 8.5 Hz, 2 H, Ar-H), 7.88 (d, J = 7.9 Hz, 1 H, Ar-H), 7.94 (s, 1 H, Ar-H) ppm. ^{13}C NMR (500 MHz, $CDCl_3$): δ = 20.8 (CH_3, 6′-CH_3), 23.4 (CH_2, C-6), 23.9 (CH_2, C-7), 26.1 (CH_3, 6′-CH_3), 30.9 (CH_2, C-5), 31.6 (CH_2, C-7′), 38.5 (C_q, C-6′), 40.7 (CH, C-1′), 42.3 (CH_2, C-4′), 44.8 (CH, C-5′), 47.6 (CH, C-7a), 56.5 (CH, C-3a), 81.6 (CH, C-3), 82.6 (CH, C-1), 118.4 (CH, C-3′), 124.1, 124.5, 125.7, 126.1, 127.7, 127.8, 127.9 (CH, C-Ar), 132.7, 133.2, 135.7 (C_q, C-Ar), 145.7 (C_q, C-2′), 211.5 (C_q, C-4) ppm. IR: $\tilde{\nu}$ = (ATR) [= 3049 (w)

ν(C_{arom}–H)], 2990 (m), 2929 (s), 2860 (m) [ν(C_{aliph}–H)], 1694 (s) [ν(C=O)] cm^{-1}. MS (ESI): *m/z* = 409.2133 $[M + Na]^+$. $C_{27}H_{30}O_2$ (386.52): calcd. C 83.90, H 7.82; found C 83.82, H 7.82. $[\alpha]_D^{20}$ = –127.6 (*c* = 1.03, $CHCl_3$). **22g**: M.p. 150 °C (Et_2O/PE). t_R = 23.98 min (HP-5). R_F = 0.34. ^1H NMR (400 MHz, $CDCl_3$): δ = 0.94 (s, 3 H, 6′-CH_3), 1.08 (d, *J* = 8.2 Hz, 1 H, 5-H_A), 1.24 (m, 1 H, 6-H_A), 1.36 (s, 3 H, 6′-CH_3), 1.44 (m, 1 H, 6-H_B), 1.63 (m, 1 H, 7-H_A), 1.83 (m, 1 H, 7-H_B), 2.08–2.18 (m, 2 H, 1′-H, 5′-H), 2.29–2.40 (m, 5 H, 4′-H, 5-H_B, 7′-H), 2.77 (ddt, $^3J_{1,7a}$ = $^3J_{7A,7a}$ = 5.4 Hz, $^3J_{3a,7a}$ = 7.2 Hz, $^3J_{7B,7a}$ = 12.8 Hz, 1 H, 7a-H), 3.36 (dd, $^3J_{3,3a}$ = 11.2 Hz, $^3J_{3a,7a}$ = 7.2 Hz, 1 H, 3a-H), 4.85 (d, $^3J_{3,3a}$ = 11.2 Hz, 1 H, 3-H), 5.05 (d, $^3J_{1,7a}$ = 5.4 Hz, 1 H, 1-H), 5.74 (s, 1 H, 3′-H), 7.37–7.50 (m, 3 H, Ar-H), 7.80–7.83 (m, 4 H, Ar-H) ppm. ^{13}C NMR (100 MHz, $CDCl_3$): δ = 21.5 (CH_3, 6′-CH_3), 22.8 (CH_2, C-6), 23.6 (CH_2, C-7), 26.5 (CH_3, 6′-CH_3), 31.5 (CH_2, C-5), 31.7 (CH_2, C-7′), 37.9 (C_q, C-6′), 40.3 (CH, C-1′), 41.0 (CH_2, C-4′), 43.2 (CH, C-5′), 45.9 (CH, C-7a), 56.1 (CH, C-3a), 82.5 (CH, C-3), 83.9 (CH, C-1), 122.9 (CH, C-3′), 124.0, 124.4, 125.7, 126.1, 127.7, 127.8, 127.9 (CH, C-Ar), 132.7, 133.2, 135.9 (C_q, C-Ar), 144.5 (C_q, C-2′), 211.3 (C_q, C-4) ppm. IR (ATR): $\tilde{\nu}$ = 3049 (w) [ν(C_{arom}–H)], 2993 (m), 2940 (s), 2861 (m) [ν(C_{aliph}–H)], 1698 (s) [ν(C=O)] cm^{-1}. MS (ESI): *m/z* = 409.2129 $[M + Na]^+$. $C_{27}H_{30}O_2$ (386.52): calcd. C 83.90, H 7.82; found C 83.79, H 7.88. $[\alpha]_D^{20}$ = +94.8 (*c* = 0.63, $CHCl_3$).

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[13] X-ray crystal structure analysis for **12c**: formula $C_{20}H_{28}BrNO_3$, *M* = 410.34, colorless crystal 0.10 × 0.05 × 0.03 mm, *a* = 7.465(1), *b* = 10.067(1), *c* = 27.851(1) Å, *V* = 2093.0(4) $Å^3$, ρ_{calc} = 1.302 $g\,cm^{-3}$, μ = 2.810 mm^{-1}, empirical absorption correction (0.766 ≤ *T* ≤ 0.921), *Z* = 4, orthorhombic, space group $P2_12_12_1$ (No. 19), λ = 1.54178 Å, *T* = 223 K, ω and φ scans, 8000 reflections collected (±*h*, ±*k*, ±*l*), $[(\sin\theta)/\lambda]$ = 0.60 $Å^{-1}$, 3039 independent (R_{int} = 0.060) and 2225 observed reflections [$I \geq 2\sigma(I)$], 231 refined parameters, *R* = 0.056, wR_2 = 0.114, Flack parameter –0.07(4), max. residual electron density 0.32 (–0.26) e·$Å^{-3}$, hydrogen atoms calculated and refined as riding atoms.

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[18] X-ray crystal structure analysis for **22f**: formula $C_{27}H_{30}O_2$, *M* = 386.51, colorless crystal 0.40 × 0.25 × 0.10 mm, *a* = 6.907(1),

b = 8.946(1), c = 16.886(1) Å, β = 96.83(1)°, V = 1036.0(2) Å^3, ρ_{calc} = 1.239 g cm^{-3}, μ = 0.590 mm^{-1}, empirical absorption correction (0.798 ≤ T ≤ 0.943), Z = 2, monoclinic, space group $P2_1$ (No. 4), λ = 1.54178 Å, T = 223 K, ω and φ scans, 8144 reflections collected (±h, ±k, ±l), [(sinθ)/λ] = 0.60 Å^{-1}, 2652 independent (R_{int} = 0.030) and 2622 observed reflections [$I \geq 2\sigma(I)$], 264 refined parameters, R = 0.035, wR_2 = 0.093, Flack parameter 0.0(3), max. residual electron density 0.12 (–0.11) e·Å^{-3}, hydrogen atoms calculated and refined as riding atoms.

[19] X-ray crystal structure analysis for **22g**: formula $C_{27}H_{30}O_2$, M = 386.51, colorless crystal 0.20 × 0.20 × 0.15 mm, a = 6.479(1), b = 8.790(1), c = 18.784(1) Å, β = 98.24(1)°, V = 1058.7(2) Å^3, ρ_{calc} = 1.212 g cm^{-3}, μ = 0.577 mm^{-1}, empirical absorption correction (0.893 ≤ T ≤ 0.918), Z = 2, monoclinic, space group $P2_1$ (No. 4), λ = 1.54178 Å, T = 223 K, ω and φ scans, 11912 reflections collected (±h, ±k, ±l), [(sinθ)/λ] = 0.60 Å^{-1}, 3613 independent (R_{int} = 0.048) and 3226 observed reflections [$I \geq 2\sigma(I)$], 264 refined parameters, R = 0.070, wR_2 = 0.190, Flack parameter –0.4(5), max. residual electron density 0.13 (–0.15) e·Å^{-3}, hydrogen atoms calculated and refined as riding atoms.

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[24] Samples of the crystalline product had 23% *ee* (HPLC), the oily residue had 94% *ee* (HPLC).

[25] For larger scale reactions (>1 mmol) 1.1 equiv. of the aldehyde and $TiCl_4$ are sufficient for complete conversions. In small scale reactions 1.3 equiv. are recommended because of some hydrolysis of $TiCl_4$ by atmospheric moisture.

[26] In order to remove all traces of the liberated stannanes the crude products were purified two times by flash column chromatography.

[27] The diastereomeric ratio was determined from the crude products by GC (HP-5).

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