Diastereoselective Manipulations of Bicyclo[*m*.1.0]alkane Derivatives. 2. Nucleophilic Additions to the Carbonyl Carbons of Bicyclo[*m*.1.0]alkan-2-ones[1]

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Received September 25, 1995[⊗]

Enantiomerically enriched bicyclo[*m*.1.0]alkan-2-ones having larger ring sizes between five and 16 members were prepared and subjected to additions of nucleophiles to the carbonyl carbon. Such additions were efficient and highly diastereoselective for all nucleophiles for bicycles with ring sizes greater than seven. Diastereoselectivity for these additions is rationalized by assuming early transition states and exposure of the same carbonyl face to the ring exterior in the vast majority of populated conformers for each bicyclic ketone.

Introduction

Common-ringed[2] systems are frequently employed as templates in stereocontrolled organic synthesis. Since the number of available conformations is limited, the reactivity of ring-bound functional groups can often be predicted with certainty. Medium and large rings can adopt a greater number of conformations. Despite an early presumption that stereocontrolled manipulation of such "floppy" rings was impossible, Still,[3] Vedejs,[4] and others[5] demonstrated that predictable manipulations of medium and large rings are possible in cases where a local conformational bias exists due to the presence of one or more stereogenic units.

While considerable work on medium and large heterocyclic rings has appeared, the synthetic potential of medium and large carbocycles is less well investigated.

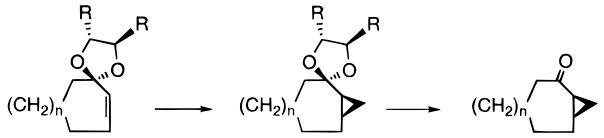

Figure 1. Synthesis of enantiomerically enriched cyclopropyl ketones **3**.

A limitation for medium and large carbocycles has been the difficulty in introducing stereogenic units. We previously developed a method for diastereoselective cyclopropanation of 2-cycloalken-1-one ketals **1** (Figure 1).[6] Thus, bicyclo[*m*.1.0]alkan-2-ones **3**, possessing cis ring fusion for $m = 3-14$ or trans ring fusion for $m = 7-14$, are available in either enantiomeric form via hydrolyses of the corresponding cyclopropane ketals **2**. We have undertaken computational and synthetic studies to advance our understanding of these carbocycles and to evaluate their suitability as synthetic intermediates for construction of complex natural products. In the preceding paper the populated conformations of the set of bicyclo[*m*.1.0]alkan-2-ones **3** were studied by computational methods.[7] In this paper the results of studies of nucleophilic additions to the carbonyls of several bicyclo[*m*.1.0]alkan-2-ones **3** are presented and discussed.

Results and Discussion

Enantiomerically enriched cyclopropyl ketals **2,** prepared as previously described,[6a,8] were hydrolyzed using aqueous HCl in methanol[1] to provide bicyclic ketones **3a**−**i**. To each of these ketones were added one or more nucleophiles as summarized in Table 1. In some cases both the major and the minor product diastereomers arising from attack of the nucleophile at opposite faces of the carbonyl were isolated and characterized. In all such instances but one (Table 1, entry 1) the product diastereomers differed in polarity (α values on analytical TLC plates ranged from 1.2 to 4.9) and were readily

[⊗] Abstract published in *Advance ACS Abstracts,* March 1, 1996.

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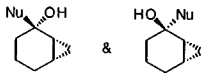
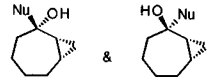
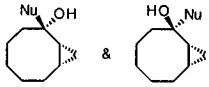
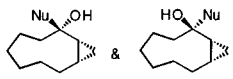
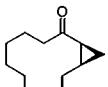
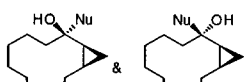
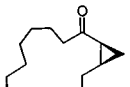
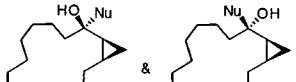
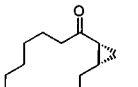
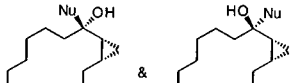
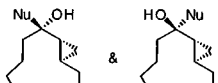
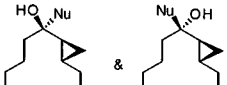
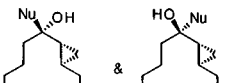
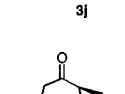
Table 1. Additions of Nucleophiles to Carbonyls of Bicyclo[*m*.1.0]alkan-2-ones 3a–k

Starting Material	Products	Entry	Nucleophile	Product, Yield, %	Diastereomer Ratio[a]	α[b]
		1	MeLi	**4**, 50[c]	1:1	1.0
3a	**4a** **4b**					
		2	LAH	**5**, 61	3:2	1.6
		3	MeLi	**6**, 88	2:5	1.4
		4	*n*-BuLi	**7**, 82	3:5	1.3
3b	**5a-7a** **5b-7b**					
		5	LAH	**9**, 99	>20:1	
		6	MeLi	**10**, 99	>20:1	
		7	*n*-BuLi	**11**, 92	>20:1	
		8	PhMgBr	**12**, 95	22:1	1.8
		9	CH_2=CHMgBr	**13**, 99	>20:1	
3c	**9a-14a** **9b-14b**	10	*n*-BuC≡CLi	**14**, 98	>20:1	
		11	MeLi	**15**, 66	>20:1	
3d	**15a** **15b**					
		12	LAH	**16**, 88	>20:1	
		13	CH_2=CHMgBr	**17**, 57	1:72	1.2
3e	**16a-17a** **16b-17b**					
		14	LAH	**18**, 96	>20:1	
		15	CH_2=CHMgBr	**19**, 77	57:1	2.3
3f	**18a-19a** **18b-19b**					
		16	MeLi	**20**, 94	>20:1	
3g	**20a** **20b**					
		17	MeLi	**21**, 99	>20:1	
3h	**21a** **21b**					
		18	LAH	**22**, 96	35:1	2.1
		19	MeLi	**23**, 87	>20:1	
		20	*n*-BuLi	**24**, 54	>20:1	
		21	PhMgBr	**25**, 97	194:1	1.9
		22	CH_2=CHMgBr	**26**, 94	43:1	1.7
3i	**22a-27a** **22b-27b**	23	*n*-BuC≡CLi	**27**, 98	50:1	1.9
		24	MeLi	**28**, 90	>20:1	
3j	**28a** **28b**					
		25	LAH	**29**, 99	36:1	1.9
		26	MeLi	**30**, 90	>20:1	
		27	*n*-BuLi	**31**, 86	61:1	1.8
		28	PhMgBr	**32**, 88	>20:1	1.7
		29	CH_2=CHMgBr	**33**, 71	>20:1	
3k	**29a-34a** **29b-34b**	30	*n*-BuC≡CLi	**34**, 91	62:1	4.9

[a] Ratio of isolated less polar to more polar diastereomers or limit of detection by 62.9 MHz ^{13}C NMR spectroscopy. [b] Ratio of R_f's on analytical tlc plates; see experimental for solvent systems. [c] Ketone **3a** and carbinols **4a** and **4b** were chromatographically inseparable.

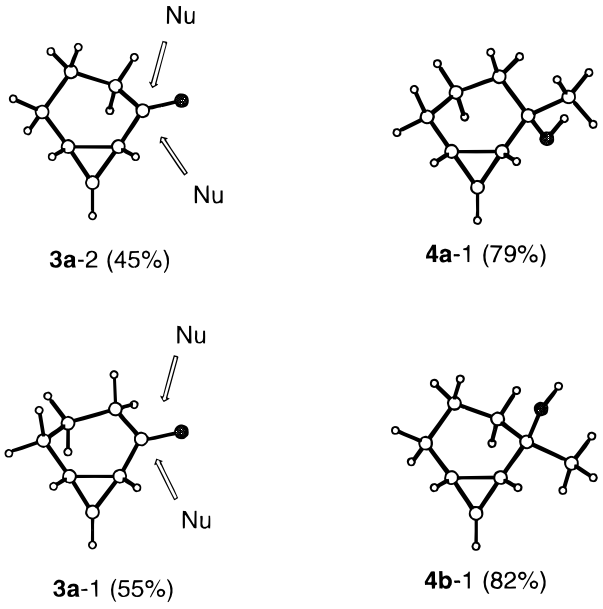


Figure 2. Nucleophilic attack on the lowest energy conformers of **3a**.

separated by column chromatography. In other cases diastereoselectivity was sufficiently high so that the minor diastereomer was not observed. In such instances the minimal diastereomer ratio is given as >20:1, the limit of detectability by ^{13}C NMR spectroscopy.[9]

Addition of methyllithium to the carbonyl carbon of (1*R*,6*S*)-bicyclo[4.1.0]heptan-2-one (**3a**) was not stereoselective, and the conversion to product was low (Table 1, entry 1). Substantial amounts of starting material were recovered, presumably because enolization was competitive with attack at carbonyl. This result, which is in keeping with the observation of others,[10] can be rationalized if early transition states are assumed[11] since both faces of the carbonyl are exposed to nucleophilic attack in both populated conformers of the starting material (see **3a**-1 and **3a**-2, Figure 2; percentage given is percent of conformer population).[7] The populated conformers of the products, **4a** and **4b**, were found using a Monte Carlo search strategy and MM2 minimization techniques.[7,12] The predominant product conformers, **4a**-1 and **4b**-1, are also depicted in Figure 2. On the basis of the small difference in the weighted average strain energies of **4a** and **4b** (Table 2), it seems likely that neither of the initially formed lithium alkoxide products corresponding to **4a** and **4b** is strongly preferred on thermodynamic grounds.

Additions to the carbonyl carbon of (1*R*,7*S*)-bicyclo-[5.1.0]octan-2-one (**3b**) were more efficient and exhibited modest diastereoselectivity (Table 1, entries 2−4). Product alcohols **5a** and **5b** were assigned structures from melting points of the known phenylurethane derivatives.[13] Cyclopropylcarbinols **6a** and **6b** were assigned structures based on chromatographic and spectroscopic comparisons with (±)-**6a** prepared from racemic 1-methyl-2-cyclohepten-1-ol (**8**) by allylic alcohol-directed Simmons−Smith cyclopropanation (Figure 3).[14] Structures for alcohols **7a** and **7b** were assigned by analogy with **6a** and **6b**.

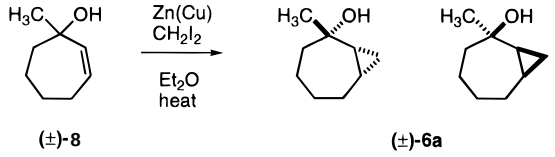


Figure 3. Synthesis of (±)-**6a**.

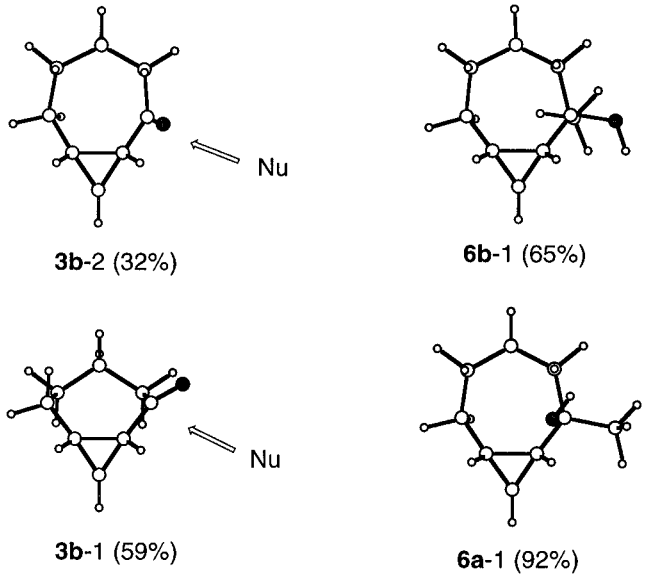


Figure 4. Nucleophilic attack on the lowest energy conformers of **3b**.

Table 2. Populated Conformers of 2-Methylbicyclo[*m*.1.0]alkan-2-ols

bicyclic alcohol	number of conformers within 20 kJ of global minimum	number of conformers within 5 kJ of global minimum	strain energy of global minimum, kJ/mol	weighted strain energy, kJ/mol
4a	4	2	73.1	73.8
4b	3	2	72.5	73.2
6a	7	1	88.1	88.7
6b	6	2	96.0	97.0
10a	4	2	102.6	102.9
10b	5	3	116.6	117.2
23a	69	8	106.7	109.0
23b	68	6	111.3	114.2
30a	857	22	103.2	108.6
30b	1032	18	108.4	113.8

The obtention of mixtures of diastereomers for additions to **3b** was consistent with its conformational ensemble, as each face of the carbonyl is exposed to attack in one or more of the populated conformers (e.g., Figure 4).[7] However, the variation of the preferred face for attack (hydride at the *Re* face of the carbonyl, methyllithium and butyllithium at the *Si* face) underscores the

(9) This is the signal-to-noise limit of detection. For previous use of ^{13}C NMR in determination of diastereomer ratios, see: Hiemstra, H.; Wynberg, H. *Tetrahedron Lett.* **1977**, *18*, 2183−2186.

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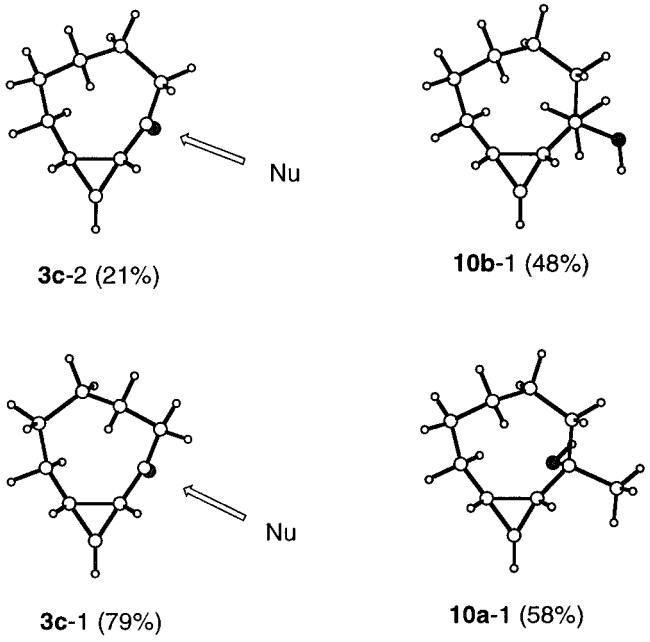


Figure 5. Nucleophilic attack on the lowest energy conformers of **3c**.

need to evaluate competing transition states for this ketone, in accord with the Curtin−Hammett principle.

A Monte Carlo search for the populated conformers of product alcohols **6a** and **6b** revealed that the former is less strained by approximately 8 kJ/mol (Table 2). As the latter was the principal product, addition of methyllithium to **3b** must have occurred under kinetic control, as expected.[11]

Previously, Winstein showed that reduction of racemic bicyclo[6.1.0]nonan-2-one ((±)-**3c**) using lithium aluminum hydride was highly diastereoselective.[15] We observed a similar result for $LiAlH_4$ reduction of (1*R*,8*S*)-**3c**, and in addition subjected this ketone to attack by a wide variety of carbanionic nucleophiles (Table 1, entries 5−10). In all experiments with **3c**, product yields were high and the observed diastereoselectivities were >20:1. In the case of phenylmagnesium bromide (entry 8), run on a 220 mg scale, both product diastereomers could be isolated and characterized, with the less polar product **12a** predominant. The principal diastereomeric products were tentatively assigned structures **9a**−**14a** in keeping with the previous assignment of structure to (±)-**9a**.[15]

The observed diastereoselectivities can be rationalized from the predominance of two conformers for **3c** in which the *Re* face of the carbonyl is exposed to attack by nucleophiles approaching from the periphery of the ring (Figure 5).[7] The *Si* face of the carbonyl is shielded by the transannular carbon and hydrogen atoms. Conformational equilibria do not change this situation, and so for nucleophilic additions to **3c** involving early transition states, the structures of the major products may be predicted from the common local conformation of the cyclopropyl ketone functional group array.

A Monte Carlo search for the populated conformers of the product alcohols derived from addition of methyllithium to **3c** revealed that the major product **10a** is less strained than **10b** by approximately 14 kJ/mol (Table 2 and Figure 5). In this case, the major product diastereomer produced under kinetic control is also the thermodynamically favored product.

(15) Poulter, C. D.; Friedrich, E. C.; Winstein, S. *J. Am. Chem. Soc.* **1970**, *92*, 4274−4281.

Less material was available for study of the larger cis-fused bicyclic ketones **3d**−**g**, so fewer experiments were performed, but similar results were obtained. Treatment of (1*R*,9*S*)-bicyclo[7.1.0]decan-2-one (**3d**) with methyllithium (Table 1, entry 11) produced exclusively cyclopropylcarbinol diastereomer **15a** in 66% yield. This diastereoselectivity is comparable to that reported by Winstein for $LiAlH_4$ reduction of racemic **3d**.[16] Reductions of (1*S*,12*R*)-bicyclo[10.1.0]tridecan-2-one (**3e**) and (1*S*,15*R*)-bicyclo[13.1.0]hexadecan-2-one (**3f**) using $LiAlH_4$ (entries 12 and 14) were highly diastereoselective and efficient. Additions of vinylmagnesium bromide to these ketones (entries 13 and 15) were highly diastereoselective, but less efficient, presumably due to competing enolization. However, treatment of (1*R*,16*S*)-bicyclo-[14.1.0]heptadecan-2-one (**3g**) with methyllithium (entry 16) gave a single diastereomer in excellent yield.

The tentative structural assignment for **15a** is in keeping with Winstein's observation[16] and is supported, and the observed diastereoselectivity rationalized, by computational studies which suggest that the *Re* face of the carbonyl of **3d** is exposed to the ring exterior in all populated conformers.[7] Similar conformationally controlled exposures of one carbonyl face to nucleophilic attack from the ring periphery are predicted from computational modeling for ketones **3e**, **3f**, and **3g**, and tentative structural assignments for products **16a**−**20a** were made accordingly.

Our study of the larger trans-fused bicyclic ketones included additions of methyllithium to (1*R*,11*R*)-bicyclo-[9.1.0]dodecan-2-one (**3h**, Table 1, entry 17), (1*S*,12*S*)-bicyclo[10.1.0]tridecan-2-one (**3i**, entry 19), (1*R*,13*R*)-bicyclo[11.1.0]tetradecan-2-one (**3j**, entry 24), and (1*S*,15*S*)-bicyclo[13.1.0]hexadecan-2-one (**3k**, entry 26). In each case, generation of the tertiary cyclopropylcarbinol was highly stereocontrolled and efficient. Similar results were observed for $LiAlH_4$ reductions of **3i** and **3k** (entries 18 and 25). Ketones **3i** and **3k** were also subjected to attack by a variety of other carbanionic nucleophiles (entries 20−23 and 27−30). In all cases the chemical yields were high and the observed diastereoselectivities were >20:1. These results were again rationalized by consideration of the populated conformers of the cyclopropyl ketones **3h**−**k**. In each case local conformational anchoring results in exposure of one face of the carbonyl to the ring exterior.[7]

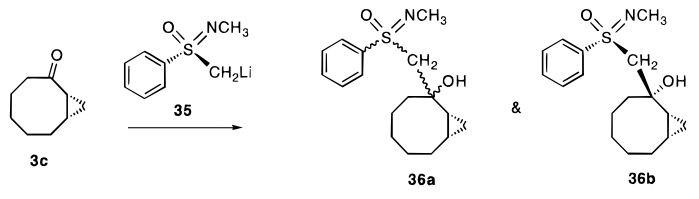
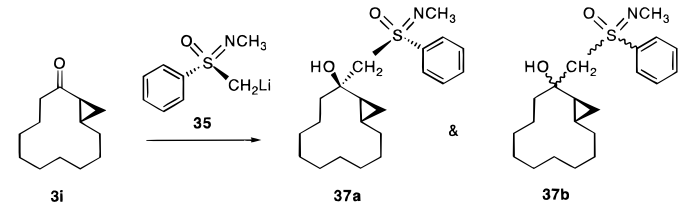
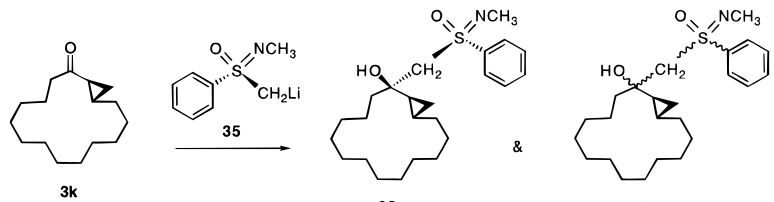
A Monte Carlo search for the populated conformers of the products **23** and **30**, derived from addition of methyllithium to ketones **3i** and **3k**, respectively, revealed that **23a** and **30a** are less strained than **23b** and **30b** (Table 2 and Figures 6 and 7). Assuming these differences in strain energy are reflected in the stabilities of the corresponding initially formed lithium alkoxides, the thermodynamically preferred diastereomers **23a** and **30a** were produced in these kinetically controlled reactions. The major products from ketones **3h**−**k** were tentatively assigned structures **21a**−**34a**.

In order to establish the facial selectivity for nucleophilic attack, ketones **3c**, **3i**, and **3k** were allowed to react with an excess of lithiosulfoximine (*S*)-**35** (Table 3).[17] Given that the sulfoximine employed possessed an ee of approximately 85%, four product diastereomers were possible for each ketone. For **3c**, a 1:10 mixture of chro-

(16) Poulter, C. D.; Freidrich, E. C.; Winstein, S. *J. Am. Chem. Soc.* **1970**, *92*, 4282−4288.

(17) (a) Johnson, C. R.; Zeller, J. R. *Tetrahedron* **1984**, *40*, 1225−1233. (b) Shiner, C. S.; Berks, A. H. *J. Org. Chem.* **1988**, *53*, 5542−5545.

Table 3. Additions of Lithiosulfoximine 35 to Carbonyls of Bicyclo[*m*.1.0]alkan-2-ones 3c, 3i, and 3k

Reaction[a]	Product Yield, %	Diastereomer Ratio[b]	α^c
	97	1:10	1.4
	98	32:1	1.7
	99	314:1	1.4

[a] The sulfoximine used was ca. 85% ee. [b] Ratio of isolated less polar and more polar diastereomers, a:b. [c] Ratio of R*f*'s run in 10% EtOAc/hexanes.

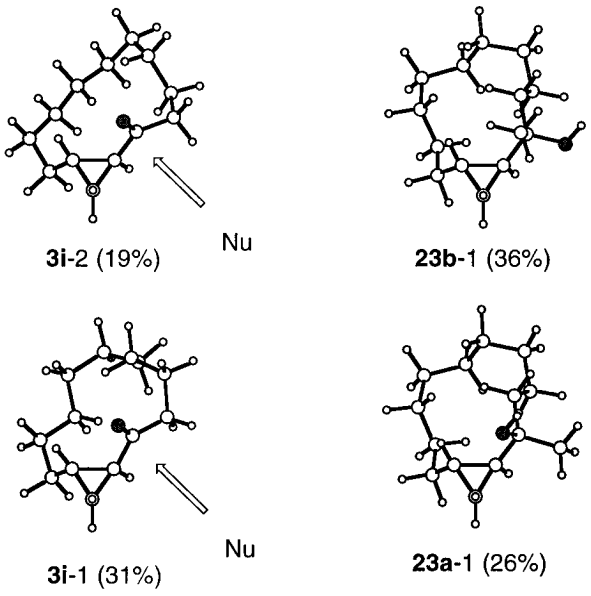


Figure 6. Nucleophilic attack on the lowest energy conformers of **3i**.

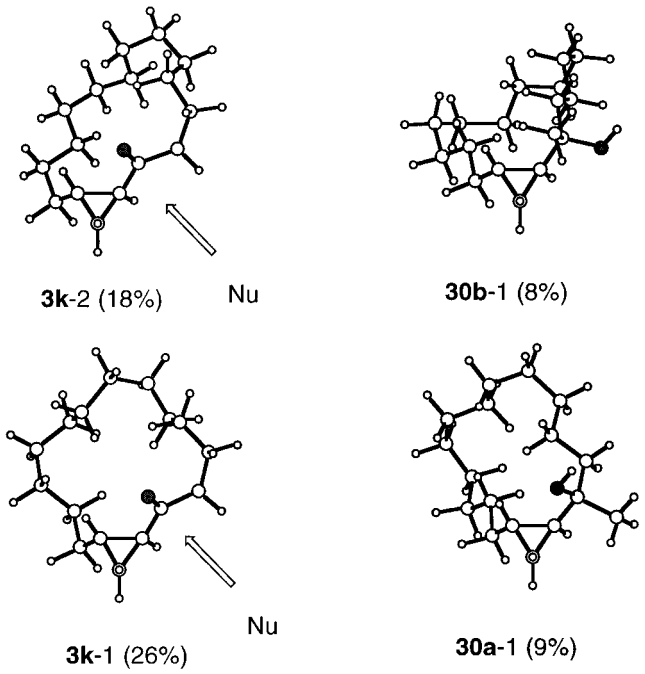


Figure 7. Nucleophilic attack on the lowest energy conformers of **3k**.

matographically separable products **36a** and **36b** was obtained (Table 3, entry 1). Single-crystal X-ray analysis confirmed that the major diastereomer **36b** possessed the structure shown. Notably, the conformation of **36b** observed in the crystal closely resembles conformer **10a**-4. The structure for the minor diastereomer **36a** was not established. For ketones **3i** and **3k**, a kinetic preference was observed for reaction with the predominant *S* enantiomer of lithiosulfoximine **35** since the product ratios observed were 32:1 and 314:1, respectively (Table 3, entries 2 and 3). The structure of product **38a** depicted in Table 3 was established by single-crystal X-ray analysis. The conformation of **38a** observed in the crystal closely resembles conformer **30a**-1 (Figure 7). Crystals of product **37a** suitable for X-ray analysis have not yet been obtained, so the structure depicted in Table 3 is tentatively assigned. Structures of the minor adducts **37b** and **38b** were not established.

Conclusion

It has been demonstrated that when enantiomerically enriched bicyclo[*m*.1.0]alkan-2-ones where $m \geq 6$ are subjected to nucleophilic attack under kinetic control, adduct alcohols are produced in high yields and with high degrees of diastereoselectivity. Diastereoselectivity is predictable if one assumes early transition states which

reflect the local conformational anchoring of the stereogenic cyclopropyl carbonyl functional group array. Such conformational anchoring may facilitate diastereoselection in other carbonyl-functionalizing reactions. Studies to explore such possibilities are currently underway.

Experimental Section

All reactions were performed in flame-dried glassware under argon. Reaction mixtures were stirred magnetically. Hygroscopic liquids and solutions of reactive intermediates were transferred via syringe. Reaction product solutions were concentrated using a rotary evaporator at 30−40 mmHg. Diethyl ether and tetrahydrofuran were distilled from sodium/benzophenone ketyl. Dichloromethane was distilled from CaH_2. Analytical thin-layer chromatography was performed on Merck precoated plates (0.25 mm, silica gel 60, F-254). Visualization of spots was effected by treatment of the plate with a 2.5% solution of anisaldehyde in ethanol containing 6% H_2SO_4 and 2% acetic acid followed by charring on a hot plate. Flash chromatography was performed on Merck silica gel 60 (230−400 mesh). Standard gravity-driven column chromatography was performed on Merck silica gel 60 (70−230 mesh). Optical rotations were measured at 589 nm. Unless noted, all NMR spectra were recorded in $CDCl_3$ solution. Proton and ^{13}C magnetic resonance spectra were recorded at 250.1 and 62.9 MHz, respectively, using tetramethylsilane (0 ppm) and the center line of the chloroform-*d* triplet (77.0 ppm) as internal standards. Unless otherwise indicated, all of the major product diastereomers were judged to be greater than 95% pure on the basis of ^1H and ^{13}C NMR analysis. Where observed, minor product diastereomers were often characterized at less than 95% purity due to the small amounts of available material. High-resolution mass spectra were recorded at the Nebraska Center for Mass Spectrometry, Lincoln, NE. Elemental analyses were performed by Desert Analytics, Tucson, AZ.

Enantiomerically enriched cyclopropyl ketals **2** were prepared as previously described.[6,8] These ketals were hydrolyzed to ketones **3** with HCl in methanol as previously described.[1] Spectral data are given below.

(1*R*,6*S*)-Bicyclo[4.1.0]heptan-2-one (3a): ref 8.

(1*R*,7*S*)-Bicyclo[5.1.0]octan-2-one (3b): ref 8.

(1*R*,8*S*)-Bicyclo[6.1.0]nonan-2-one (3c): R_f 0.30 (10% EtOAc/hexanes); $[\alpha]^{24}_D$ +87.6° (*c* 1.03, $CHCl_3$); IR (neat) cm^{-1} 2999, 2928, 2855, 1692; ^1H NMR δ 0.58−0.82 (2, m), 1.09 (1, dd, J = 10.0, 5.0 Hz), 1.19−2.31 (10, m), 2.65 (1, ddd, J = 12.2, 5.0, 4.2 Hz); ^{13}C NMR δ 8.8, 21.6, 26.2, 26.9, 27.0, 27.2, 29.6, 45.6, 211.8.

(1*S*,12*R*)-Bicyclo[10.1.0]tridecan-2-one (3e): R_f 0.46 (10% EtOAc/hexanes); mp 56−60 °C; $[\alpha]^{26}_D$ +6.7° (*c* 0.46, $CHCl_3$); IR (neat) cm^{-1} 2994, 2963, 2924, 2857, 1682; ^1H NMR δ 0.86−0.97 (1, m), 1.00−1.75 (17, m), 2.01 (1, m), 2.07 (1, td, J = 7.3, 5.7 Hz), 2.43 (1, ddd, J = 17.2, 5.7, 3.5 Hz), 2.99 (1, ddd, J = 17.2, 11.3, 2.8 Hz); ^{13}C NMR δ 12.7, 22.1, 23.1, 23.4, 23.9, 24.0, 25.3, 26.6, 26.6, 27.1, 29.2, 42.0, 209.0.

(1*S*,15*R*)-Bicyclo[13.1.0]hexadecan-2-one (3f): R_f 0.47 (10% EtOAc/hexanes); $[\alpha]^{26}_D$ +62.9° (*c* 0.41, $CHCl_3$); IR (neat) cm^{-1} 2995, 2924, 2854, 1696; ^1H NMR δ 0.91−1.00 (1, m), 1.03−1.12 (1, m), 1.12−1.53 (21, m), 1.54−1.71 (1, m), 1.76−1.93 (1, m), 1.99 (1, td, J = 8.2, 5.2 Hz), 2.55 (1, dt, J = 17.9, 5.6 Hz), 2.76 (1, ddd, J = 17.9, 8.2, 6.1 Hz); ^{13}C NMR δ 14.7, 21.7, 25.2, 25.7, 25.9, 26.0, 26.0, 26.2, 26.8, 26.9, 27.1, 27.2, 28.2, 29.2, 43.8, 209.2

Anal. Calcd for $C_{16}H_{28}O$: C, 81.29; H, 11.94. Found: C, 81.23; H, 11.87.

(1*S*,16*R*)-Bicyclo[14.1.0]heptadecan-2-one (3g): R_f 0.36 (5% EtOAc/hexanes); ^1H NMR δ 0.88−0.97 (1, m), 1.07−1.86 (27, m), 2.02 (1, td, J = 7.9, 5.6 Hz), 2.49 (1, ddd, J = 17.4, 8.4, 5.1 Hz), 2.71 (1, ddd, J = 17.4, 8.4, 6.8 Hz); ^{13}C NMR δ 13.6, 22.0, 25.6, 25.6, 25.9, 26.0, 26.3, 26.5, 26.6, 26.7, 27.3, 27.4, 28.0, 29.6, 43.9, 209.0.

(1*R*,11*R*)-Bicyclo[9.1.0]dodecan-2-one (3h): R_f 0.28 (10% EtOAc/hexanes); ^1H NMR δ 0.73−0.96 (3, m), 1.08−2.06 (15, m), 2.28 (1, ddd, J = 13.5, 8.7, 4.3 Hz), 2.81 (1, ddd, J = 13.8, 8.7, 4.0 Hz); ^{13}C NMR δ 18.0, 22.3, 23.7, 24.0, 24.4, 25.4, 27.8, 29.6, 29.7, 30.7, 42.7, 213.0.

(1*S*,12*S*)-Bicyclo[10.1.0]tridecan-2-one (3i): R_f 0.34 (10% EtOAc/hexanes); mp 35−38 °C; $[\alpha]^{25}_D$ −36.1° (*c* 3.16, $CHCl_3$); IR (neat) cm^{-1} 2996, 2925, 2857, 1688; ^1H NMR δ 0.70−0.88 (2, m), 1.23−1.79 (15, m), 1.80−2.08 (3, m), 2.25 (1, ddd, J = 13.1, 10.9, 3.2 Hz), 2.83 (1, ddd, J = 13.1, 7.6, 3.2 Hz); ^{13}C NMR δ 18.5, 23.5, 23.9, 25.3, 26.2, 26.5, 27.0, 27.4, 27.7, 27.8, 32.4, 44.6, 212.1.

Anal. Calcd for $C_{13}H_{22}O$: C, 80.36; H, 11.41. Found: C, 80.26; H, 11.36.

(1*R*,13*R*)-Bicyclo[11.1.0]tetradecan-2-one (3j): R_f 0.37 (10% EtOAc/hexanes); ^1H NMR δ 0.68−0.84 (2, m), 1.12−1.55 (16, m), 1.57−1.92 (3, m), 1.93−2.07 (1, m), 2.30 (1, ddd, J = 14.6, 8.3, 4.4 Hz), 2.80 (1, ddd, J = 14.6, 8.7, 4.4 Hz); ^{13}C NMR δ 17.8, 23.8, 25.2, 26.1, 26.5, 26.6, 26.8, 27.0, 27.5, 28.0, 29.3, 32.3, 42.2, 211.7.

(1*S*,15*S*)-Bicyclo[13.1.0]hexadecan-2-one (3k): ref 18.

Nucleophilic Additions. Preparations of compounds **22**, **32**, **34**, and **36** are illustrative of the general methodology employed.

(1*S*,2*R*,12*S*)-Bicyclo[10.1.0]tridecan-2-ol (22a) and (1*S*,2*S*,12*S*)-Bicyclo[10.1.0]tridecan-2-ol (22b). To a well-stirred suspension of lithium aluminum hydride (29 mg, 0.77 mmol) in diethyl ether (2 mL) at −78 °C was added a solution of **3i** (75 mg, 0.38 mmol) in ether (2 mL) via cannula. The cannula was rinsed three times with ether (1 mL). The reaction mixture was allowed to warm to room temperature over 3 h and then cooled to 0 °C, and the reaction was quenched by successive additions of water (30 μL), 4 N NaOH (30 μL), and water (90 μL). After stirring for 30 min at room temperature, the white precipitate was removed by filtration. Volatiles were removed *in vacuo* to give a white solid which was purified by column chromatography on silica gel 60 (70−230 mesh) eluted with 8% EtOAc/hexanes. The yield of the less polar diastereomer **22a**, R_f 0.19 (10% EtOAc/hexanes), obtained as a white crystalline solid, mp 77−78 °C, was 70 mg (0.36 mmol, 93%). The yield of the more polar diastereomer **22b**, R_f 0.09, also obtained as a white crystalline solid, mp 72−74 °C, was 2 mg (0.010 mmol, 3%).

Spectral data for 22a: $[\alpha]^{24}_D$ −113.4° (*c* 3.25, $CHCl_3$); IR (neat) cm^{-1} 3321 (br), 2997, 2918, 2844; ^1H NMR δ 0.08−0.19 (1, m), 0.63−0.87 (4, m), 1.18−1.75 (17, m), 1.91−2.08 (1, m), 3.92−4.00 (1, m); ^{13}C NMR δ 9.2, 11.0, 21.0, 21.5, 22.4, 23.4, 23.9, 27, 27.6, 27.8, 32.5, 36.3, 68.0; HRMS calcd for $C_{13}H_{24}O$ 196.1827, found 196.1823.

Spectral data for 22b: ^1H NMR δ 0.22−0.30 (1, m), 0.35−0.44 (1, m), 0.58−0.84 (3, m), 1.20−1.88 (17, m), 1.95−2.09 (1, m), 2.84−2.94 (1, m); ^{13}C NMR δ 16.9, 21.0, 23.4, 24.1, 24.8, 25.1, 27.3 , 27.6, 28.0, 32.7, 35.6, 77.2.

(1*S*,2*R*,15*S*)-2-Phenylbicyclo[13.1.0]hexadecan-2-ol (32a) and (1*S*,2*S*,15*S*)-2-Phenylbicyclo[13.1.0]hexadecan-2-ol (32b). To a well-stirred solution of phenylmagnesium bromide (0.27 mL of a 3 M solution, 0.81 mmol) in ether (2 mL) at −78 °C was added a solution of **3k** (64 mg, 0.27 mmol) in ether (2 mL) via an addition funnel. The funnel was rinsed twice with ether (0.5 mL). The reaction mixture was allowed to warm to 0 °C over 30 min, and the reaction was quenched by dropwise addition of a saturated aqueous NH_4Cl solution (5 mL). The mixture was diluted with water (5 mL) and extracted three times with ether (15 mL). The ether extracts were dried ($MgSO_4$), filtered, and concentrated *in vacuo* to give a colorless oil which was purified by column chromatography on silica gel 60 (70−230 mesh) eluted with 5% ether/hexanes. The yield of the less polar diastereomer **32a**, an oil homogeneous by TLC, R_f 0.35 (10% EtOAc/hexanes), was 74 mg (0.24 mmol, 88%). Diastereomer **32b** (approximately 2−3 mg) was obtained as an oil, R_f 0.21, contaminated by residue from the commercial phenylmagnesium bromide solution.

Spectral data for 32a: $[\alpha]^{25}_D$ +0.88° (*c* 2.51, $CHCl_3$); IR (neat) cm^{-1} 3470 (br), 3057, 2995, 2925, 2852, 1598; ^1H NMR δ 0.18−0.27 (1, m), 0.48−0.58 (1, m), 0.73−0.89 (1, m), 0.95−1.62 (23, m), 1.75−2.04 (3, m), 7.18−7.37 (3, m), 7.47−7.53 (2, m); ^{13}C NMR δ 8.1, 14.6, 22.6, 25.7, 26.2, 26.3, 26.4, 27.1, 27.2,

(18) Nelson, K. A.; Mash, E. A. *J. Org. Chem.* **1986**, *51*, 2721−2724.

27.4, 27.8, 29.2, 33.8, 43.9, 73.9, 125.4, 126.5, 128.0, 147.4; HRMS calcd for $C_{22}H_{34}O$ 314.2610, found 314.2611.

Spectral data for 32b: ^{1}H NMR δ −0.06−0.02 (1, m), 0.09−0.17 (1, m), 0.36−0.50 (1, m), 0.55−0.90 (2, m), 0.99−1.08 (1, m), 1.15−2.16 (24, m), 6.80−6.98 (3, m), 7.20−7.36 (2, m).

(1*S*,2*R*,15*S*)-2-(1-Hexynyl)bicyclo[13.1.0]hexadecan-2-ol (34a) and (1*S*,2*S*,15*S*)-2-(1-Hexynyl)bicyclo[13.1.0]-hexadecan-2-ol (34b). To a well-stirred solution of 1-hexyne (54 mg, 0.66 mmol) in ether (2 mL) at 0 °C was added a solution of *n*-butyllithium in hexanes (0.5 mL of a 1.3 M solution, 0.64 mmol). After 10 min the mixture was cooled to −78 °C and a solution of **3k** (51 mg, 0.21 mmol) in ether (2 mL) was added via cannula. The cannula was rinsed twice with ether (1 mL). The reaction mixture was allowed to warm to 0 °C over 3 h, and the reaction was quenched by dropwise addition of a saturated aqueous NH_4Cl solution (5 mL). The mixture was diluted with water (5 mL) and extracted three times with ether (15 mL). The ether extracts were dried ($MgSO_4$), filtered, and concentrated *in vacuo* to give a pale yellow oil which was purified by column chromatography on silica gel 60 eluted first with 5% and then with 10% ether/hexanes. The yield of the less polar diastereomer **34a**, obtained as an oil homogeneous by TLC, R_f 0.34 (10% EtOAc/hexanes), was 62 mg (0.19 mmol, 90%). The yield of the more polar diastereomer **34b**, also obtained as an oil homogeneous by TLC, R_f 0.07, was 1.0 mg (0.003 mmol, 1%).

Spectral data for 34a: $[\alpha]^{25}_D$ −4.9° (*c* 3.08, $CHCl_3$); IR (neat) cm^{-1} 3616, 3466 (br), 3066, 2996, 2927, 2853, 2233; ^{1}H NMR δ 0.20−0.30 (1, m), 0.58−0.75 (2, m), 0.81−0.97 (5, m), 1.12−1.85 (28, m), 2.21 (2, t, J = 6.9 Hz); ^{13}C NMR δ 7.9, 13.6, 14.2, 18.3, 21.9, 23.1, 25.7, 26.2, 26.3, 26.4, 27.1, 27.3, 28.6, 29.2, 30.9, 33.5, 43.3, 68.2, 83.6, 84.0; HRMS calcd for $C_{22}H_{38}O$ 318.2923, found 318.2919.

Spectral data for 34b: IR (neat) cm^{-1} 3441 (br), 2925, 2853, 2230; ^{1}H NMR δ 0.20−0.30 (1, m), 0.75−1.02 (7, m), 1.20−1.90 (28, m), 2.15−2.28 (2, m).

(1*R*,2*S*,8*S*,*SS*)-2-[(*N*-Methyl-*S*-phenylsulfoximidoyl)-methyl]bicyclo[6.1.0]nonan-2-ol (36b). To a well-stirred solution of (*S*)-*N*,*S*-dimethyl-*S*-phenylsulfoximine [382 mg, 2.3 mmol, ∼85% ee, $[\alpha]^{25}_D$ +116° (*c* 4.0, MeOH), lit.[17b] $[\alpha]^{25}_D$ −135.9° (*c* 4.60, MeOH) for the *R* enantiomer] in THF (4 mL) at 0 °C was added a solution of *n*-BuLi in hexanes (1.6 mL of a 1.2 M solution, 1.92 mmol). The solution was cooled to −78 °C, and a solution of **3c** (103 mg, 0.75 mmol) in THF (2 mL) was added via cannula. The cannula was rinsed with THF (2 × 1 mL). After 2 h, the mixture was poured into a saturated aqueous NH_4Cl solution (15 mL) and extracted with ether (2 × 25 mL). The ether was dried ($MgSO_4$), filtered, and concentrated *in vacuo* to give a yellow oil which was purified by column chromatography on silica gel 60 (70−230 mesh) eluted with 12% EtOAc/hexanes. The yield of the less polar diastereomer **36a**, R_f 0.11 (10% EtOAc/hexanes), obtained as a white crystalline solid, mp 108−111 °C, was 21 mg (0.07 mmol, 9%). The yield of the more polar diastereomer **36b**, R_f 0.08, also obtained as a white crystalline solid, mp 111.5−113.5 °C, was 203 mg (0.66 mmol, 88%).

Spectral data for 36a: $[\alpha]^{24}_D$ +3.1° (*c* 1.0, $CHCl_3$); IR (neat) cm^{-1} 3238 (br), 3021, 2990, 2923, 2860, 1475, 743, 690; ^{1}H NMR δ 0.35−0.70 (4, m), 1.36−1.92 (9, m), 2.60 (3, s), 2.70−2.81 (1, m), 3.02 (1, d, J = 13.8 Hz), 3.50 (1, d, J = 13.8 Hz), 6.39 (1, s), 7.54−7.68 (3, m), 7.85−7.93 (2, m); ^{13}C NMR δ 4.6, 17.4, 21.7, 24.6, 25.5, 25.9, 28.8, 29.1, 40.9, 66.3, 74.7, 128.9, 129.5, 133.0, 139.2.

Spectral data for 36b: $[\alpha]^{24}_D$ +32.6° (*c* 7.3, $CHCl_3$); IR (neat) cm^{-1} 3240 (br), 3061, 2919, 2801, 742, 689; ^{1}H NMR δ 0.57−0.90 (4, m), 1.36−1.65 (6, m), 1.70−1.97 (4, m), 2.61 (3, s), 3.11 (1, d, J = 13.7 Hz), 3.29 (1, d, J = 13.7 Hz), 6.69 (1, s), 7.52−7.66 (3, m), 7.84−7.91 (2, m); ^{13}C NMR δ 7.9, 16.7, 20.0, 22.9, 23.7, 26.1, 28.5, 28.6, 44.8, 67.7, 73.9, 128.8, 129.4, 132.9, 139.5; HRMS calcd for $C_9H_{14}O$ (M − $C_8H_{11}NOS$) 138.1045, found 138.1043, calcd for $C_8H_{11}NOS$ 169.0562, found 169.0559.

The structure of **36b** was established by single-crystal X-ray analysis.[20]

(1*R*,2*S*,6*S*)-2-Methylbicyclo[4.1.0]heptan-2-ol (4a) and (1*R*,2*R*,6*S*)-2-Methylbicyclo[4.1.0]heptan-2-ol (4b). From ketone **3a** (510 mg, 4.6 mmol) and methyllithium in ether (6.4 mL of a 1.4 M solution, 9.0 mmol) at −78 °C was obtained an inseparable mixture consisting of recovered **3a** and diastereomeric alcohols **4a** and **4b**, R_f 0.17 (30% ethyl ether/hexanes). The latter were obtained in approximately 50% yield and in a 1:1 ratio as determined by NMR spectroscopy.

Spectral data for the mixture of 4a and 4b: ^{1}H NMR δ −0.18 (1, q, J = 4.8 Hz), 0.30 (1, q, J = 5.1 Hz), 0.50−0.73 (2, m), 0.85−1.83 (24, m); ^{13}C NMR δ 7.8, 10.0, 10.8, 12.6, 17.6, 18.8, 22.4, 22.6, 23.1, 30.3, 30.9, 34.5, 36.6, 68.7.

(1*RS*,2*RS*,7*SR*)-Bicyclo[5.1.0]octan-2-ol ((±)-5a) and (1*RS*,2*SR*,7*SR*)-Bicyclo[5.1.0]octan-2-ol ((±)-5b). From racemic ketone **3b** (178 mg, 1.43 mmol) and lithium aluminum hydride (188 mg, 4.95 mmol) in ether at −78 °C was obtained a separable mixture consisting of less polar and more polar alcohols (±)-**5a** and (±)-**5b**, respectively. Chromatography on silica gel 60 afforded 65 mg (0.52 mmol, 36%) of (±)-**5a**, R_f 0.18 (30% ether/pentane), and 45 mg (0.36 mmol, 25%) of (±)-**5b**, R_f 0.11, as oils homgenous by TLC.

Spectral data for (±)-5a: ^{1}H NMR δ 0.35−0.62 (2, m), 0.90−2.90 (10, m), 4.13−4.29 (1, m); ^{13}C NMR δ 3.0, 14.9, 22.7, 24.9, 26.8, 28.5, 35.6, 71.2.

Spectral data for (±)-5b: ^{1}H NMR δ 0.26−0.41 (1, m), 0.68−1.05 (4, m), 1.10−1.45 (2, m), 1.58−2.0 (5, m), 2.10−2.35 (1, m), 3.35 (1, m); ^{13}C NMR δ 14.2, 14.43, 23.37, 27.86, 28.28, 31.23, 39.18, 76.48.

The phenylurethanes of (±)-**5a** and (±)-**5b** were prepared as previously described[13] and were found to melt at 73.5−75 °C (lit.[13a] mp 75.4−76 °C) and 121−122 °C (lit.[13a] mp 123−124 °C), respectively.

(1*R*,2*S*,7*S*)-2-Methylbicyclo[5.1.0]octan-2-ol (6a) and (1*R*,2*R*,7*S*)-2-Methylbicyclo[5.1.0]octan-2-ol (6b). From ketone **3b** (125 mg, 1.0 mmol) and methyllithium in ether (0.9 mL of a 1.4 M solution, 1.3 mmol) at −78 °C was obtained 124 mg (0.88 mmol, 88%) of a 2:5 mixture of product alcohols **6a** and **6b** as determined by ^{13}C NMR. Chromatography on silica gel 60 afforded 22 mg (0.16 mmol, 16%) of **6a**, R_f 0.16 (20% ether/pentane), and 88 mg (0.63 mmol, 63%) of **6b**, R_f 0.11, as oils homogeneous by TLC.

Spectral data for 6a: ^{1}H NMR δ 0.39−0.56 (2, m), 0.95−1.03 (2, m), 1.20−1.96 (12, m); ^{13}C NMR δ 4.7, 15.5, 25.0, 26.9, 27.2, 28.1, 30.4, 41.6.

Spectral data for 6b: ^{1}H NMR δ 0.34−0.53 (2, m), 0.96−2.06 (14, m); ^{13}C NMR δ 4.7, 16.2, 24.2, 25.9, 27.9, 28.1, 32.2, 40.3, 74.9.

(±)-2-Methylbicyclo[5.1.0]octan-2-ol ((±)-6a). Freshly prepared Zn−Cu couple[14] (700 mg, 11 mmol) and potassium carbonate (350 mg, 2.5 mmol) were heated to reflux in freshly distilled ether (3 mL). Diiodomethane (700 mg, 2.6 mmol) was added dropwise via syringe, and the reaction mixture was stirred for 15 min. A solution of 1-methyl-2-cyclohepten-1-ol ((±)-**8**, 72 mg, 0.57 mmol) in ether (1 mL) was added by pipet. The pipet was rinsed with ether (1 mL). After 3 h, the reaction was cooled to 0 °C and 5% potassium carbonate solution (5 mL) was added. The resulting residue was filtered and evaporated to give a pink oil which was purified on 240−400 mesh silica gel 60 eluted with ether/pentane (0−30%). The yield of (±)-**6a**, obtained as a colorless liquid, R_f 0.32 (40% ether/pentane), was 42 mg (0.30 mmol, 52%).

Spectral data for (±)-6a: IR (neat) cm^{-1} 3403 (br), 3070, 2964, 2920, 2853; ^{1}H NMR δ 0.38−0.56 (2, m), 0.92−1.02 (2, m), 1.14−1.95(12, m); ^{13}C NMR δ 4.6, 15.6, 25.0, 26.9, 27.3, 28.2, 30.4, 41.6, 73.3.

(±)-3-Hydroxy-3-methylcycloheptene ((±)-8).[19] To a solution of methyllithium (7.4 mL of a 1.0 M solution, 7.4 mmol) in ether (9 mL) at −78 °C was added a solution of 2-cycloheptenone (270 mg, 2.45 mmol) in ether (2 mL) via cannula. The cannula was rinsed twice with ether (0.5 mL). The reaction mixture was allowed to warm to 0 °C over 2 h, and the reaction was quenched by dropwise addition of a saturated aqueous NH_4Cl solution (10 mL). The mixture was diluted with water (10 mL) and extracted with ether (3 × 20 mL). The ether extracts were dried ($MgSO_4$), filtered, and concentrated to give a colorless oil which was chromatographed on silica gel 60 (70−230 mesh) eluted with 40% ether/pentane.

(19) Jefford, C. W.; Rimbault, C. G. *Tetrahedron Lett.* **1981**, *22*, 91−94.

The yield of (±)-**8**, R_f 0.12 (10% Et_2O/pentane), was 170 mg (1.35 mmol, 55%).

Spectral data for (±)-8: IR (neat) cm^{-1} 3358 (br), 3011, 2965, 2924, 2856, 1651; ^1H NMR δ 1.32 (3, d, J = 2.9 Hz), 1.50−1.90 (6, m), 2.00−2.40 (3, m), 5.64 (2, dm, J = 2.9 Hz); ^{13}C NMR δ 24.3, 27.3, 27.5, 28.6, 40.8, 74.0, 129.1, 139.7.

(1*RS*,2*SR*,7*SR*)-2-Butylbicyclo[5.1.0]octan-2-ol (7a) and (1*RS*, 2*RS*, 7*SR*)-2-Butylbicyclo[5.1.0]octan-2-ol ((±)-7b). From ketone (±)-**3b** (166 mg, 1.34 mmol) and butyllithium (2.9 mL of a 1.4 M solution in ether) at −78 °C was obtained a separable mixture consisting of less polar and more polar alcohols (±)-**7a** and (±)-**7b**, respectively. Chromatography on silica 60 afforded 77 mg (0.42 mmol, 31%) of (±)-**7a**, R_f 0.40 (15% EtOAc/hexanes), and 124 mg (0.68 mmol, 51%) of (±)-**7b**, R_f 0.30, as oils homogeneous by TLC.

Spectral data for (±)-7a: ^1H NMR δ 0.43−0.58 (2,m), 0.75−1.02 (4, m), 1.18−1.73 (15, m), 1.8−2.0 (1, m); ^{13}C NMR δ 6.10, 14.15, 15.42, 23.30, 24.77, 25.62, 25.72, 27.62, 28.75, 39.89, 43.60, 74.34.

Spectral data for (±)-7b: ^1H NMR δ 0.44−0.54 (2, m), 0.87−0.99 (3, m), 1.00−1.10 (2, m), 1.10−1.20 (1, m), 1.20−1.67 (12, m), 1.75, 1.91 (1, m), 2.00−2.15 (1, m); ^{13}C NMR δ 5.03, 15.42, 14.11, 23.39, 23.83 25.72, 26.51, 26.66, 27.77, 37.78, 45.92, 76.80.

(1*R*,2*S*,8*S*)-Bicyclo[6.1.0]nonan-2-ol (9a). From ketone **3c** (100 mg, 0.72 mmol) and lithium aluminum hydride (23 mg, 0.61 mmol) in ether at −78 °C was obtained 101 mg (0.72 mmol, 99%) of a single diastereomeric alcohol (**9a**) as an oil homogeneous by TLC, R_f 0.38 (20% EtOAc/hexanes).

Spectral data for 9a: $[\alpha]^{28}_D$ −21.7° (*c* 1.36, $CHCl_3$); IR ($CHCl_3$) cm^{-1} 3610, 3454 (br), 2994, 2915; ^1H NMR δ 0.22−0.30 (1, m), 0.50−0.70 (2, m), 0.86−0.99 (1, m), 1.15−2.00 (12, m), 4.38−4.48 (1, m); ^{13}C NMR δ 4.7, 15.7, 20.5, 20.7, 25.3, 25.3, 28.5, 36.4, 68.8.

(1*R*,2*S*,8*S*)-2-Methylbicyclo[6.1.0]nonan-2-ol (10a). From ketone **3c** (100 mg, 0.72 mmol) and methyllithium in ether (0.7 mL of a 1.4 M solution, 0.98 mmol) at −78 °C was obtained 110 mg (0.71 mmol, 99%) of a single diastereomeric alcohol (**10a**) as an oil homogeneous by TLC, R_f 0.50 (20% EtOAc/hexanes).

Spectral data for 10a: $[\alpha]^{28}_D$ −26.1° (*c* 1.22, $CHCl_3$); IR ($CHCl_3$) cm^{-1} 3603, 3480 (br), 2995, 2965, 2925, 2861; ^1H NMR δ 0.18−0.26 (1, m), 0.46−0.76 (3, m), 0.86 (1, broad s), 1.25−1.88 (13, m); ^{13}C NMR δ 4.1, 16.2, 21.2, 24.0, 24.5, 26.0, 28.6, 34.7, 44.0, 71.4.

(1*R*,2*S*,8*S*)-2-Butylbicyclo[6.1.0]nonan-2-ol (11a). From ketone **3c** (100 mg, 72 mmol) and *n*-butyllithium in ether (0.6 mL of a 1.6 M solution, 0.94 mmol) at −78 °C was obtained 131 mg (0.67 mmol, 92%) of a single diastereomeric alcohol (**11a**) as an oil homogeneous by TLC, R_f 0.58 (20% EtOAc/hexanes).

Spectral data for 11a: $[\alpha]^{28}_D$ −31.6° (*c* 1.35, $CHCl_3$); IR ($CHCl_3$) cm^{-1} 3601, 2929, 2860, 1459, 1378, 1238, 1161, 1107, 1012, 891, 853; ^1H NMR δ 0.15−0.28 (1, m), 0.45−0.71 (3, m), 0.85 (1, s), 0.91 (3, t, J = 7.0 Hz), 1.22−1.90 (16, m); ^{13}C NMR δ 4.9, 14.2, 15.4, 21.0, 23.1, 23.4, 24.4, 25.9, 26.3, 28.7, 42.7, 47.5, 73.1.

(1*R*,2*S*,8*S*)-2-Phenylbicyclo[6.1.0]nonan-2-ol (12a) and (1*R*,2*R*,8*S*)-2-Phenylbicyclo[6.1.0]nonan-2-ol (12b). From ketone **3c** (220 mg, 1.6 mmol) and phenylmagnesium bromide in ether (1.6 mL of a 3 M solution, 4.8 mmol) at −78 °C was obtained a mixture consisting of less polar and more polar diastereomeric alcohols **12a** and **12b**, respectively. After chromatographic separation, the yield of **12a**, obtained as an oil homogeneous by TLC, R_f 0.36 (10% EtOAc/hexanes), was 310 mg (1.4 mmol, 91%). The yield of **12b**, also obtained as an oil homogeneous by TLC, R_f 0.20, was 14 mg (0.066 mmol, 4%).

Spectral data for 12a: $[\alpha]^{25}_D$ −88.1° (*c* 2.38, $CHCl_3$); IR (neat) cm^{-1} 3559, 3482 (br), 3056, 2976, 2919, 2858, 1597, 732, 699; ^1H NMR δ 0.34−0.54 (2, m), 0.63−0.80 (1, m), 0.99−1.10 (1, m), 1.28 (1, s), 1.42−2.00 (9, m), 2.09 m(1, ddd, J = 13.8, 11.2, 2.9 Hz), 7.17−7.27 (1, m), 7.27−7.38 (2, m), 7.48−7.56 (2, m); ^{13}C NMR δ 4.6, 17.4, 21.2, 24.2, 25.1, 26.1, 28.6, 44.1, 74.9, 124.4, 126.4, 128.0, 151.8; HRMS calcd for $C_{15}H_{20}O$ 216.1514, found 216.1512.

Spectral data for 12b: ^1H NMR δ −0.30 to −0.21 (1, m), 0.49−0.60 (1, m), 0.85−1.02 (1, m), 1.14−1.30 (1, m), 1.35−2.45 (10, m), 7.16−7.36 (3, m), 7.42−7.49 (2, m).

(1*R*,2*R*,8*S*)-2-Ethenylbicyclo[6.1.0]nonan-2-ol (13a). From ketone **3c** (100 mg, 0.72 mmol) and vinylmagnesium bromide in ether (0.94 mL of a 1.0 M solution, 0.94 mmol) at −78 °C was obtained 120 mg (0.72 mmol, 99%) of a single diastereomeric alcohol (**13a**) as an oil homogeneous by TLC, R_f 0.55 (20% EtOAc/hexanes).

Spectral data for 13a: $[\alpha]^{28}_D$ −43.9° (*c* 1.65, $CHCl_3$); IR ($CHCl_3$) cm^{-1} 3595, 3500 (br), 3007, 2925, 2861, 1708, 1634; ^1H NMR δ 0.15−0.25 (1, m), 0.46−0.85 (3, m), 1.00 (1, s), 1.30−1.93 (10, m), 4.97 (1, d, J = 10.7 Hz), 5.19 (1, d, J = 17.3 Hz), 6.04 (1, dd, J = 17.3, 10.7 Hz); ^{13}C NMR δ 4.2, 16.5, 21.1, 23.1, 24.1, 26.0, 28.7, 42.5, 73.4, 109.7, 148.7.

(1*R*,2*S*,8*S*)-2-(1-Hexynyl)bicyclo[6.1.0]nonan-2-ol (14a). From ketone **3c** (90 mg, 0.65 mmol) and 1-lithiohexyne (approximately 0.72 mmol, prepared from 90 μL of 1-hexyne and 0.45 mL of a 1.6 M solution of n-BuLi in hexanes) in THF at −78 °C was obtained 141 mg (0.64 mmol, 98%) of a single diastereomeric alcohol (**14a**) as an oil homogeneous by TLC, R_f 0.66 (20% EtOAc/hexanes).

Spectral data for 14a: $[\alpha]^{28}_D$ −62.4° (*c* 1.23, $CHCl_3$); IR ($CHCl_3$) cm^{-1} 3595, 3003, 2929, 2861, 2222; ^1H NMR δ 0.35−0.46 (1, m), 0.55−0.68 (2, m), 0.91 (3, t, J = 6.8 Hz), 0.99−1.10 (1, m), 1.25−1.90 (14, m), 2.04−2.16 (1, m), 2.19 (2, t, J = 6.8 Hz); ^{13}C NMR δ 4.5, 13.5, 16.8, 18.2, 20.6, 21.8, 23.9, 25.3, 25.5, 28.2, 30.7, 44.3, 68.7, 81.4, 87.1.

(1*R*,2*S*,9*S*)-2-Methylbicyclo[7.1.0]decan-2-ol (15a). From ketone **3d** (30 mg, 0.2 mmol) and methyllithium in ether (0.2 mL of a 1.3 M solution, 0.26 mmol) at −78 °C was obtained 22 mg (0.13 mmol, 66%) of a single diastereomeric alcohol (**15a**) as an oil homogeneous by TLC, R_f 0.48 (1% MeOH/CH_2Cl_2).

Spectral data for 15a: $[\alpha]^{28}_D$ −28.1° (*c* 0.32, $CHCl_3$); IR ($CHCl_3$) cm^{-1} 3605, 3480 (br), 3005, 2927, 2848; ^1H NMR δ −0.05−0.03 (1, m), 0.25−0.34 (1, m), 0.42−0.73 (2, m), 0.75−1.03 (2, m), 1.18−1.36 (4, m), 1.36−1.57 (5, m), 1.60−2.15 (5, m); ^{13}C NMR δ 2.5, 14.5, 17.7, 23.5, 27.2, 28.6, 30.7, 31.3, 32.8, 41.7, 69.3.

(1*S*,2*R*,12*R*)-Bicyclo[10.1.0]tridecan-2-ol (16a). From ketone **3e** (88 mg, 0.45 mmol) and lithium aluminum hydride (35 mg, 0.92 mmol) in ether at −78 °C was obtained 78 mg (0.40 mmol, 88%) of a single diastereomeric alcohol (**16a**) as an oil homogeneous by TLC, R_f 0.21 (10% EtOAc/hexanes).

Spectral data for 16a: $[\alpha]^{25}_D$ +42.7° (*c* 3.59, $CHCl_3$); IR (neat) cm^{-1} 3387 (br), 3061, 2990, 2921, 2859; ^1H NMR δ 0.28−0.37 (1, m), 0.53−0.65 (1, m), 0.72−1.00 (2, m), 2.50−2.82 (19, m), 4.04−4.14 (1, m); ^{13}C NMR δ 6.4, 16.7, 21.9, 24.2, 24.3, 25.4, 25.7, 26.1, 26.4, 27.0, 27.1, 34.6, 69.8; HRMS calcd for $C_{13}H_{24}O$ 196.1827, found 196.1825.

(1*S*,2*S*,12*R*)-2-Ethenylbicyclo[10.1.0]tridecan-2-ol (17a) and (1*S*,2*R*,12*R*)-2-Ethenylbicyclo[10.1.0]tridecan-2-ol (17b). From ketone **3e** (67 mg, 0.34 mmol) and vinylmagnesium bromide in ether (1.3 mL of a 1 M solution, 1.3 mmol) at −78 °C was obtained a mixture consisting of less polar and more polar diastereomeric alcohols **17a** and **17b**, respectively. After chromatographic separation, the yield of **17a**, obtained as an oil homogeneous by TLC, R_f 0.52 (10% EtOAc/hexanes), was 0.6 mg (0.003 mmol, 1%). The yield of **17b**, also obtained as an oil homogeneous by TLC, R_f 0.45, was 43 mg (0.19 mmol, 56%).

Spectral data for 17a: ^1H NMR δ 0.13−0.29 (2, m), 0.35−0.46 (1, m), 0.64−0.82 (3, m), 1.10−1.92 (17, m), 4.97 (1, dd, J = 10.7, 1.1 Hz), 5.12 (1, dd, J = 17.3, 1.1 Hz), 6.00 (1, dd, J = 17.3, 10.7 Hz).

Spectral data for 17b: $[\alpha]^{25}_D$ +64.8° (*c* 1.96, $CHCl_3$); IR (neat) cm^{-1} 3601, 3492 (br), 3059, 2921, 2860, 1634; ^1H NMR δ 0.18−0.27 (1, m), 0.51−0.64 (1, m), 0.66−0.82 (1, m), 0.85−0.95 (1, m), 1.15 (1, s), 1.25−1.84 (19, m), 5.05 (1, dd, J = 10.7, 1.1 Hz), 5.18 (1, dd, J = 17.3, 1.1 Hz), 5.99 (1, dd, J = 17.3, 10.7 Hz); ^{13}C NMR δ: 5.7, 18.1, 22.9, 25.3, 25.5, 25.9, 26.2, 26.6, 27.6, 27.8, 39.2, 74.4, 111.1, 146.4; HRMS calcd for $C_{15}H_{26}O$ 222.1984, found 222.1981.

(1*S*,2*R*,15*R*)-Bicyclo[13.1.0]hexadecan-2-ol (18a). From ketone **3f** (41 mg, 0.17 mmol) and lithium aluminum hydride (16 mg, 0.42 mmol) in ether at −78 °C was obtained 39 mg

(0.16 mmol, 96%) of a single diastereomeric alcohol (**18a**) as an oil homogeneous by TLC, R_f 0.17 (10% EtOAc/hexanes).

Spectral data for 18a: $[\alpha]^{25}_D$ +3.7° (*c* 1.92, $CHCl_3$); IR (neat) cm^{-1} 3357 (br), 3063, 2991, 2927, 2855; ^1H NMR δ −0.05−0.08 (1, m), 0.63−0.88 (3, m), 1.10−1.67 (25, m), 3.35−3.48 (1, m); ^{13}C NMR δ 8.6, 15.0, 22.3, 22.6, 25.2, 25.4, 25.9, 26.2, 26.3, 26.6, 26.7, 27.0, 27.3, 36.6, 69.7; HRMS calcd for $C_{16}H_{30}O$ 238.2297, found 238.2294.

(1*S*,2*S*,15*R*)-2-Ethenylbicyclo[13.1.0]hexadecan-2-ol (19a) and (1*S*,2*R*,15*R*)-2-Ethenylbicyclo[13.1.0]hexadecan-2-ol (19b). From ketone **3f** (60 mg, 0.25 mmol) and vinylmagnesium bromide in THF (1.0 mL of a 1 M solution, 1.0 mmol) at −78 °C was obtained a mixture consisting of less polar and more polar diastereomeric alcohols **19a** and **19b**, respectively. The yield of **19a**, obtained as an oil homogeneous by TLC, R_f 0.44 (10% EtOAc/hexanes), was 51 mg (0.19 mmol, 76%). The yield of **19b**, also obtained as an oil homogeneous by TLC, R_f 0.19, was 0.9 mg (0.003 mmol, ca. 1%).

Spectral data for 19a: $[\alpha]^{25}_D$ +52.6° (*c* 2.21, $CHCl_3$); IR (neat) cm^{-1} 3603, 3488 (br), 3059, 2927, 2855, 1637; ^1H NMR δ 0.18−0.27 (1, m), 0.50−0.61 (1, m), 0.70−0.92 (2, m), 1.14 (1, s), 1.22−1.82 (24, m), 5.06 (1, dd, J = 10.6, 1.1 Hz), 5.19 (1, dd, J = 17.2, 1.1), 5.98 (1, dd, J = 17.2, 10.6); ^{13}C NMR δ 5.6, 17.5, 21.0, 24.8, 25.0, 25.2, 25.2, 25.3, 26.5, 26.9, 27.7, 29.0, 39.2, 74.1, 111.2, 145.8; HRMS calcd for $C_{18}H_{32}O$ 264.2453, found 264.2457.

Spectral data for 19b: ^1H NMR δ 0.00−0.09 (1, m), 0.19−0.28 (1, m), 0.58−0.92 (2, m), 1.15−1.70 (25, m), 5.13 (1, dd, J = 10.5, 1.3 Hz), 5.28 (1, dd, J = 17.1, 1.3 Hz), 5.70 (1, dd, J = 17.1, 10.5 Hz).

(1*R*,2*R*,16*S*)-2-Methylbicyclo[14.1.0]heptadecan-2-ol (20a). From ketone **3g** (48 mg, 0.19 mmol) and methyllithium in ether (0.18 mL of a 1.4 M solution, 0.25 mmol) at −78 °C was obtained 48 mg (0.18 mmol, 94%) of a single diastereomeric alcohol (**20a**) as an oil homogeneous by TLC, R_f 0.55 (20% EtOAc/hexanes).

Spectral data for 20a: $[\alpha]^{28}_D$ −12.2° (*c* 0.72, $CHCl_3$); IR ($CHCl_3$) cm^{-1} 3603, 2995, 2927, 2855; ^1H NMR δ 0.18−0.27 (1, m), 0.50−0.60 (1, m), 0.70−0.80 (2, m), 0.91 (1, s), 1.20−1.78 (29, m); ^{13}C NMR δ 5.4, 17.2, 22.5, 25.9, 26.3, 26.4, 26.7, 26.8, 27.1, 27.1, 27.3, 27.4, 28.1, 28.7, 29.4, 30.1, 41.8, 72.1.

(1*R*,2*S*,11*R*)-2-Methylbicyclo[9.1.0]dodecan-2-ol (21a). From ketone **3h** (24.5 mg, 0.14 mmol) and methyllithium in ether (0.11 mL of a 1.4 M solution, 0.15 mmol) at −78 °C was obtained 28 mg (0.14 mmol, 99%) of a single diastereomeric alcohol (**21a**) as an oil.

Spectral data for 21a: IR ($CHCl_3$) cm^{-1} 3605, 3466 (br), 3003, 2925, 2851; ^1H NMR δ 0.03−0.11 (1, m), 0.42−0.58 (2, m), 0.65−0.90 (3, m), 1.22−1.77 (17, m), 2.01−2.14 (1, m); ^{13}C NMR δ 6.2, 15.0, 21.7, 22.6, 26.8, 26.9, 27.1, 28.0, 28.3, 28.7, 32.2, 40.8, 70.5.

(1*S*,2*R*,12*S*)-2-Methylbicyclo[10.1.0]tridecan-2-ol (23a). From ketone **3i** (77 mg, 0.40 mmol) and methyllithium in ether (2.0 mL of a 0.6 M solution, 1.2 mmol) at −78 °C was obtained 73 mg (0.34 mmol, 87%) of a single diastereomeric alcohol (**23a**) as a colorless solid, mp 41−45 °C, homogeneous by TLC, R_f 0.23 (10% EtOAc/hexanes).

Spectral data for 23a: $[\alpha]^{24}_D$ −89.1° (*c* 3.48, $CHCl_3$); IR (neat) cm^{-1} 3417 (br), 2995, 2925, 2848; ^1H NMR δ 0.02−0.12 (1, m), 0.58−0.85 (4, m), 0.98 (1, s), 1.20−1.67 (18, m), 1.70−1.83 (1, m), 1.92−2.06 (1, m); ^{13}C NMR δ 8.3, 12.9, 20.8, 22.5, 23.5, 24.1, 26.1, 27.3, 27.7, 28.0, 28.8, 32.7, 41.8, 70.6; HRMS calcd for $C_{14}H_{26}O$ 210.1984, found 210.1977.

(1*S*,2*R*,12*S*)-2-Butylbicyclo[10.1.0]tridecan-2-ol (24a). From ketone **3i** (71 mg, 0.37 mmol) and *n*-butyllithium in ether (0.85 mL of a 1.3 M solution, 1.1 mmol) at −78 °C was obtained 49.5 mg (0.2 mmol, 54%) of a single diastereomeric alcohol (**24a**) as an oil homogeneous by TLC, R_f 0.37 (10% EtOAc/hexanes).

Spectral data for 24a: $[\alpha]^{24}_D$ −71.0° (*c* 2.34, $CHCl_3$); IR (neat) cm^{-1} 3474 (br), 2994, 2928, 2849; ^1H NMR δ 0.04−0.16 (1, m), 0.57−1.00 (8, m), 1.18−1.75 (22, m), 1.92−2.08 (1, m); ^{13}C NMR δ 9.1, 12.0, 14.1, 20.5, 22.4, 23.3, 24.0, 25.4, 25.5, 27.2, 27.7, 28.1, 32.9, 39.5, 41.2, 72.2; HRMS calcd for $C_{17}H_{32}O$ 252.2453, found 252.2458.

(1*S*,2*R*,12*S*)-2-Phenylbicyclo[10.1.0]tridecan-2-ol (25a) and (1*S*,2*S*,12*S*)-2-Phenylbicyclo[10.1.0]tridecan-2-ol (25b). From ketone **3i** (71 mg, 0.37 mmol) and phenylmagnesium bromide in ether (0.2 mL of a 3.0 M solution, 0.66 mmol) at −78 °C was obtained a mixture consisting of less polar and more polar diastereomeric alcohols **25a** and **25b**, respectively. The yield of **25a**, obtained as an oil homogeneous by TLC, R_f 0.30 (10% EtOAc/hexanes), was 97 mg (0.37 mmol, 97%). The yield of **25b**, also obtained as an oil homogeneous by TLC, R_f 0.16, was 0.5 mg (0.002 mmol, ca. 1%).

Spectral data for 25a: $[\alpha]^{25}_D$ −38.5° (*c* 2.50, $CHCl_3$); IR (neat) cm^{-1} 3457 (br), 3057, 2996, 2925, 2847, 726, 698, 610; ^1H NMR δ 0.19−0.28 (1, m), 0.56−0.66 (1, m), 0.74−0.90 (1, m), 0.98−1.71 (17, m), 1.79 (1, td, J = 12.8, 4.1 Hz), 1.98−2.17 (2, m), 7.20−7.39 (3, m), 7.55−7.62 (2, m); ^{13}C NMR δ 9.3, 13.5, 20.8, 22.8, 23.6, 24.3, 24.7, 27.4, 27.8, 28.0, 32.8, 42.4, 74.2, 125.6, 126.9, 128.1, 147.8; HRMS calcd for $C_{19}H_{28}O$ 272.2140, found 272.2134.

Spectral data for 25b: ^1H NMR δ 0.11−0.19 (1, m), 0.68−0.92 (4, m), 1.15−1.95 (18, m), 7.20−7.37 (3, m), 7.45−7.50 (2, m).

(1*S*,2*S*,12*S*)-2-Ethenylbicyclo[10.1.0]tridecan-2-ol (26a) and (1*S*,2*S*,12*S*)-2-Ethenylbicyclo[10.1.0]tridecan-2-ol (26b). From ketone **3i** (66 mg, 0.34 mmol) and vinylmagnesium bromide in THF (1.4 mL of a 1.0 M solution, 1.4 mmol) at −78 °C was obtained a mixture consisting of less polar and more polar diastereomeric alcohols **26a** and **26b**, respectively. The yield of **26a**, obtained as an oil homogeneous by TLC, R_f 0.32 (10% EtOAc/hexanes), was 69 mg (0.31 mmol, 92%). The yield of **26b**, also obtained as an oil homogeneous by TLC, R_f 0.19, was 1.6 mg (0.01 mmol, 2%).

Spectral data for 26a: $[\alpha]^{24}_D$ −65.0° (*c* 2.45, $CHCl_3$); IR (neat) cm^{-1} 3452 (br), 3081, 2998, 2926, 2848, 1638; ^1H NMR δ 0.09−0.18 (1, m), 0.53−0.62 (1, m), 0.66−0.99 (3, m), 1.07 (1, s), 1.21−1.73 (15, m), 1.76−1.93 (1, m), 2.02 (1, ddt, J = 13.1, 9.6, 3.7 Hz), 5.06 (1, dd, J = 10.8, 1.3 Hz), 5.28 (1, dd, J = 17.4, 1.3 Hz), 6.03 (1, dd, J = 17.4, 10.8 Hz); ^{13}C NMR δ 8.8, 12.7, 20.5, 22.5, 23.5, 23.9, 24.0, 27.3, 27.8, 28.0, 32.7, 41.0, 72.7, 112.1, 145.1; HRMS calcd for $C_{15}H_{26}O$ 222.1984, found 222.1988.

Spectral data for 26b: ^1H NMR δ 0.10−0.19 (1, m), 0.67−0.92 (4, m), 1.15−1.80 (16, m), 1.93−2.08 (1, m), 2.22−2.35 (1, m), 5.03 (1, dd, J = 10.9, 1.4 Hz), 5.21 (1, dd, J = 17.4, 1.4 Hz), 5.99 (1, dd, J = 17.4, 10.9 Hz).

(1*S*,2*R*,12*S*)-2-(1-Hexynyl)bicyclo[10.1.0]tridecan-2-ol (27a) and (1*S*,2*S*,12*S*)-2-(1-Hexynyl)bicyclo[10.1.0]tridecan-2-ol (27b). From ketone **3i** (75 mg, 0.39 mmol) and 1-lithiohexyne (approximately 1.2 mmol, prepared from 178 μL of 1-hexyne and 0.90 mL of a 1.3 M solution of *n*-BuLi in hexanes) in ether at −78 °C was obtained a mixture consisting of less polar and more polar diastereomeric alcohols **27a** and **27b**, respectively. The yield of **27a**, obtained as an oil homogeneous by TLC, R_f 0.37 (10% EtOAc/hexanes), was 105 mg (0.38 mmol, 97%). The yield of **27b**, also obtained as an oil homogeneous by TLC, R_f 0.20, was 1.2 mg (0.004 mmol, 1%).

Spectral data for 27a: $[\alpha]^{25}_D$ −49.2° (*c* 4.85, $CHCl_3$); IR (neat) cm^{-1} 3456 (br), 2999, 2928, 2850, 2237; ^1H NMR δ 0.16−0.27 (1, m), 0.62−1.05 (7, m), 1.15−2.05 (22, m), 2.21 (2, t, J = 6.8 Hz); ^{13}C NMR δ 9.5, 12.7, 13.5, 18.3, 21.0, 21.9, 22.3, 23.3, 23.7, 26.5, 27.1, 27.6, 27.6, 30.8, 32.3, 41.6, 68.1, 83.3, 84.4; HRMS calcd for $C_{19}H_{32}O$ 276.2453, found 276.2452.

Spectral data for 27b: ^1H NMR δ 0.08−0.17 (1, m), 0.58−1.03 (7, m), 1.22−1.99 (22, m), 2.17 (2, t, J = 6.7 Hz).

(1*R*,2*S*,13*R*)-2-Methylbicyclo[11.1.0]tridecan-2-ol (28a). From ketone **3j** (36 mg, 0.17 mmol) and methyllithium in ether (0.16 mL of a 1.4 M solution, 0.23 mmol) at −78 °C was obtained 35 mg (0.16 mmol, 90%) of a single diastereomeric alcohol (**28a**) as an oil homogeneous by TLC, R_f 0.28 (10% EtOAc/hexanes).

Spectral data for 28a: $[\alpha]^{28}_D$ +85.2° (*c* 1.04, $CHCl_3$); IR (neat) cm^{-1} 3603, 3484 (br), 3003, 2929, 2851; ^1H NMR δ 0.00−0.09 (1, m), 0.42−0.63 (3, m), 0.80−0.93 (2, m), 1.20−1.62 (20, m), 1.67−1.80 (1, m), 1.98 (1, ddt, J = 13.9, 9.8, 3.4 Hz); ^{13}C NMR δ 6.2, 14.3, 20.8, 22.6, 22.8, 24.4, 25.5, 26.3, 26.8, 27.9, 28.3, 29.5, 34.2, 43.4, 70.4.

(1*S*,2*R*,15*S*)-Bicyclo[13.1.0]hexadecan-2-ol (29a) and (1*S*,2*S*,15*S*)-Bicyclo[13.1.0]hexadecan-2-ol (29b). From ketone **3k** (53 mg, 0.22 mmol) and lithium aluminum hydride (30 mg, 0.79 mmol) in ether at −78 °C was obtained a mixture consisting of less polar and more polar diastereomeric alcohols

29a and **29b**, respectively. The yield of **29a**, R_f 0.19 (10% EtOAc/hexanes), obtained as a white solid, mp 64−65 °C, was 51 mg (0.21 mmol, 96%). The yield of **29b**, R_f 0.10, also obtained as a white solid, was 1.4 mg (0.006 mmol, 3%).

Spectral data for 29a: $[\alpha]^{25}_D$ −69.0° (*c* 0.21, $CHCl_3$); IR (neat) cm^{-1} 3424, 3390, 3001, 2926, 2850; ^1H NMR δ 0.15−0.24 (1, m), 0.54−0.87 (4, m), 1.15−1.56 (24, m), 1.76−1.90 (1, m), 3.85−3.93 (1, m); ^{13}C NMR δ 7.7, 12.7, 23.5, 23.7, 25.9, 26.1, 26.3, 26.3, 27.1, 27.1, 29.2, 33.5, 36.9, 68.8; HRMS calcd for $C_{16}H_{30}O$ 238.2297, found 238.2296.

Spectral data for 29b: $[\alpha]^{25}_D$ −8.6° (*c* 0.07, $CHCl_3$); ^1H NMR δ 0.29−0.37 (1, m), 0.40−0.49 (1, m), 0.60−0.85 (3, m), 1.22−1.77 (24, m), 2.76−2.86 (1, m).

(1*S*,2*R*,15*S*)-2-Methylbicyclo[13.1.0]hexadecan-2-ol (30a). From ketone **3k** (104 mg, 0.42 mmol) and methyllithium in ether (1.0 mL of a 1.4 M solution, 1.4 mmol) at −78 °C was obtained 97 mg (0.38 mmol, 90%) of a single diastereomeric alcohol (**30a**) as an oil homogeneous by TLC, R_f 0.29 (10% EtOAc/hexanes).

Spectral data for 30a: $[\alpha]^{24}_D$ −33.7° (*c* 1.92, $CHCl_3$); IR (neat) cm^{-1} 3441 (br), 2923, 2853; ^1H NMR δ 0.05−0.15 (1, m), 0.46−0.60 (2, m), 0.62−0.94 (3, m), 1.10−1.61 (25, m), 1.65−1.81 (1, m); ^{13}C NMR δ 7.1, 14.0, 22.8, 25.7, 26.2, 26.2, 26.3, 26.7, 27.0, 27.4, 27.6, 27.8, 28.2, 29.2, 33.8, 43.7, 70.2; HRMS calcd for $C_{17}H_{32}O$ 252.2453, found 252.2450.

(1*S*,2*R*,15*S*)-2-Butylbicyclo[13.1.0]hexadecan-2-ol (31a) and (1*S*,2*S*,15*S*)-2-Butylbicyclo[13.1.0]hexadecan-2-ol (31b). From ketone **3k** (58 mg, 0.25 mmol) and *n*-butyllithium in ether (0.57 mL of a 1.3 M solution, 0.74 mmol) at −78 °C was obtained a mixture consisting of less polar and more polar diastereomeric alcohols **31a** and **31b**, respectively. The yield of **31a**, obtained as an oil homogeneous by TLC, R_f 0.38 (10% EtOAc/hexanes), was 61 mg (0.21 mmol, 85%). The yield of **31b**, also obtained as an oil homogeneous by TLC, R_f 0.21, was 1 mg (0.003 mmol, ca. 1%).

Spectral data for 31a: $[\alpha]^{24}_D$ −14.5° (*c* 0.61, $CHCl_3$); IR (neat) cm^{-1} 3477 (br), 2994, 2926, 2854; ^1H NMR δ 0.09−0.19 (1, m), 0.48−0.60 (2, m), 0.67−0.82 (3, m), 0.91 (3, t, J = 7.0 Hz), 1.13−1.62 (28, m), 1.74 (1, dd, J = 16.7, 8.3 Hz); ^{13}C NMR (C_6D_6) δ 8.1, 13.4, 14.5, 22.9, 23.9, 26.0, 26.2, 26.6, 26.6, 26.7, 27.2, 27.3, 27.4, 27.9, 28.1, 29.7, 34.3, 41.0, 42.0, 71.4; HRMS calcd for $C_{20}H_{38}O$ 294.2923, found 294.2924.

Spectral data for 31b: IR (neat) cm^{-1} 3413 (br), 2925, 2853; ^1H NMR δ 0.10−0.20 (1, m), 0.50−0.60 (1, m), 0.65−1.60 (36, m).

(1*S*,2*S*,15*S*)-2-Ethenylbicyclo[13.1.0]hexadecan-2-ol (33a). From ketone **3k** (91 mg, 0.39 mmol) and vinylmagnesium bromide in THF (1.15 mL of a 1.0 M solution, 1.15 mmol) at −78 °C was obtained 73 mg (0.28 mmol, 72%) of a single diastereomeric alcohol (**33a**) as an oil homogeneous by TLC, R_f 0.37 (10% EtOAc/hexanes).

Spectral data for 33a: $[\alpha]^{25}_D$ −10.4° (*c* 2.99, $CHCl_3$); IR (neat) cm^{-1} 3472 (br), 3080, 2995, 2925, 2853, 1638; ^1H NMR δ 0.09−0.19 (1, m), 0.38−0.48 (1, m), 0.60−0.92 (3, m), 0.98 (1, s), 1.09−1.49 (22, m), 1.54−1.65 (1, m), 1.66−1.81 (1, m), 5.01 (1, dd, J = 10.7, 1.3 Hz), 5.17 (1, dd, J = 17.4, 1.3 Hz), 5.91 (1, dd, J = 17.4, 10.7 Hz); ^{13}C NMR (C_6D_6) δ 8.0, 14.1, 22.8, 26.1, 26.6, 26.8, 26.9, 26.9, 26.9, 27.6, 27.8, 29.7, 34.2, 42.8, 72.4, 111.5, 145.1; HRMS calcd for $C_{18}H_{32}O$ 264.2453, found 264.2454.

(1*S*,2*R*,12*S*,*SS*)-2-[(*N*-Methyl-*S*-phenylsulfoximidoyl)-methyl]bicyclo[10.1.0]tridecan-2-ol (37a). From ketone **3i** (94 mg, 0.48 mmol) and lithio-(*S*)-*N*,*S*-dimethyl-*S*-phenylsulfoximine (85% ee, ca. 1.2 mmol, prepared from 241 mg of (*S*)-*N*,*S*-dimethyl-*S*-phenylsulfoximide and 1.0 mL of a 1.2 M solution of *n*-BuLi in hexanes) in THF at −78 °C was obtained a mixture consisting of less polar and more polar diastereomeric alcohols **37a** and **37b**, respectively. The yield of **37a**, R_f 0.14 (10% EtOAc/hexanes), obtained as a colorless solid, mp 83−86 °C, was 167 mg (0.46 mmol, 95%). The yield of diastereomer **37b**, R_f 0.08, also obtained as a colorless solid, mp 110−114 °C, was 5.2 mg (0.014 mmol, 3%).

Spectral data for 37a: $[\alpha]^{24}_D$ −10.8° (*c* 8.4, $CHCl_3$); IR (neat) cm^{-1} 3258 (br), 3061, 2996, 2925, 2848, 2803, 732, 689; ^1H NMR δ −0.14−0.05 (1, m), 0.43−0.65 (2, m), 0.78−0.88 (1, m), 0.89−1.04 (1, m), 1.12−1.66 (14, m), 1.82−1.98 (1, m), 1.99−2.09 (2, m), 2.52 (3, s), 3.08 (1, d, J = 13.9 Hz), 3.24 (1, d, J = 13.9 Hz), 6.47 (1, s), 7.47−7.60 (3, m), 7.79−7.85 (2, m); ^{13}C NMR δ 9.1, 12.7, 21.1, 22.2, 23.6, 24.0, 26.7, 27.2, 27.6, 27.8, 28.7, 32.4, 38.9, 62.3, 72.6, 128.8, 129.4, 132.9, 138.9; HRMS calcd for $C_{13}H_{22}O$ (M − $C_8H_{11}NOS$) 194.1671, found 194.1631, calcd for $C_8H_{11}NOS$ 169.0562, found 169.0557.

Spectral data for 37b: $[\alpha]^{24}_D$ −23.1° (*c* 0.26, $CHCl_3$); IR (neat) cm^{-1} 3245 (br), 3061, 2998, 2924, 2849, 2803, 746, 690; ^1H NMR δ 0.35−0.45 (1, m), 0.70−1.72 (19, m), 1.79−2.06 (2, m), 2.63 (3, s), 3.25 (1, d, J = 13.8 Hz), 3.36 (1, d, J = 13.8 Hz), 6.55 (1, s), 7.52−7.68 (3, m), 7.84−7.92 (2, m); ^{13}C NMR δ 12.3, 12.8, 19.7, 21.8, 23.2, 23.7, 24.0, 27.0, 27.6, 27.8, 28.7, 32.7, 41.7, 64.2, 72.6, 128.9, 129.5, 133.0, 139.3.

(1*S*,2*R*,15*S*,*SS*)-2-[(*N*-Methyl-*S*-phenylsulfoximidoyl)-methyl]bicyclo[13.1.0]hexadecan-2-ol (38a). From ketone **3k** (92 mg, 0.39 mmol) and lithio-(*S*)-*N*,*S*-dimethyl-*S*-phenylsulfoximine (85% ee, ca. 0.96 mmol, prepared from 198 mg of (*S*)-*N*,*S*-dimethyl-*S*-phenylsulfoximide and 0.80 mL of a 1.2 M solution of n-BuLi in hexanes) in THF at −78 °C was obtained a mixture consisting of less polar and more polar diastereomeric alcohols **38a** and **38b**, respectively. The yield of **38a**, R_f 0.15 (10% EtOAc/hexanes), obtained as a colorless solid, mp 97.5−99 °C, was 157 mg (0.38 mmol, 99%). The yield of **38b**, R_f 0.11, also obtained as a colorless solid, was 0.5 mg (0.001 mmol, 0.3%).

Spectral data for 38a: $[\alpha]^{24}_D$ +25.1° (*c* 7.8, $CHCl_3$); IR (neat) cm^{-1} 3262 (br), 3063, 2923, 2852, 2803, 733, 689; ^1H NMR δ 0.00−0.10 (1, m), 0.47−0.52 (1, m), 0.64−0.80 (2, m), 0.99−1.75 (22, m), 1.93 (1, ddm, J = 14.4, 9.2 Hz), 2.14−2.28 (1, m), 2.59 (3, s), 3.14 (1, d, J = 13.9 Hz), 3.27 (1, d, J = 13.9 Hz), 6.52 (1, s), 7.54−7.68 (3, m), 7.85−7.93 (2, m); ^{13}C NMR δ 7.8, 14.1, 23.4, 25.5, 25.6, 25.8, 26.2, 26.4, 27.0, 27.3, 27.4, 27.6, 28.7, 28.8, 33.4, 41.0, 62.3, 72.3, 128.8, 129.4, 132.9, 139.0; HRMS calcd for $C_{16}H_{28}O$ (M − $C_8H_{11}NOS$) 236.2140, found 236.2142, calcd for $C_8H_{11}NOS$ 169.0562, found 169.0560.

Spectral data for 38b: ^1H NMR δ 0.39−0.48 (1, m), 0.69−1.80 (27, m), 2.62 (3, s), 3.14 (1, d, J = 13.8 Hz), 3.40 (1, d, J = 13.8 Hz), 6.36−6.46 (1, m), 7.54−7.65 (3, m), 7.85−7.91 (2, m).

The structure of **38a** was established by single-crystal x-ray analysis.[20]

Acknowledgment. Partial support of this research by Research Corporation, by the Howard Hughes Medical Research Foundation, by the Elsa U. Pardee Foundation, by the E. I. DuPont de Nemours Co., and by the University of Arizona through the Materials Characterization Program, the Department of Chemistry, and the Office of the Vice President for Research is gratefully acknowledged. Technical assistance from L. J. Williams, M. Bruck, M. A. Chandler, and J. A. Baron is gratefully acknowledged.

Supporting Information Available: Mass spectral fragment lists, ^{13}C NMR spectra of new cyclopropyl ketones **3** and of the major diastereomers for compounds **4**−**38**, and ORTEP structures for **36b** and **38a** (55 pages). This material is contained in libraries on microfiche, immediately follows this article in the microfilm version of the journal, and can be ordered from the ACS; see any current masthead page for ordering information.

JO951753K

(20) The author has deposited atomic coordinates for **36b** and **38a** with the Cambridge Crystallographic Data Centre. The coordinates can be obtained, on request, from the Director, Cambridge Crystallographic Data Centre, 12 Union Road, Cambridge, CB2 1EZ, UK.