Intramolecular Ene Reactions. Stereo- and Enantioselective Synthesis of Spirolactams through Thermolysis of Enamino Carboxamides

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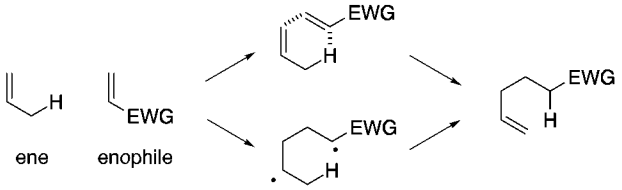
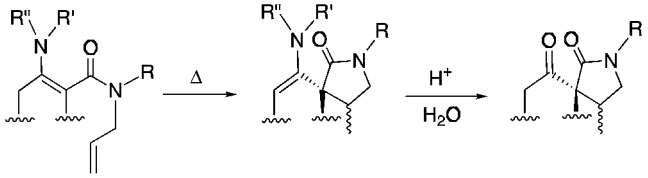
A new and facile access to spirolactams based on the thermal rearrangement of tertiary and secondary enamino carboxamides has been developed. The enamine group of an enamino carboxamide, in which no electron-withdrawing group is present in the enophile, can be involved in the ene reaction and the enamino carboxamide can be transformed into enamino or imino spirolactams. In the case of secondary carboxamido enamines, the diastereoselectivity is higher than 98%. If chiral nonracemic analogs are utilized, 50−54% enantiomeric excesses can be achieved in the final products.

The ene reaction occurs between an alkene having an allylic hydrogen (an "ene") and a compound containing an electron-deficient double bond (an "enophile") to form a σ-bond with migration of the ene double bond and a 1,5-hydrogen shift. From a mechanistic point of view the ene reaction can be concerted,[1] or can proceed stepwise, involving a diradical intermediate.[2] Ene reactions can be Lewis acid catalyzed, and in these cases the reactions occur under mild conditions through either a concerted or a stepwise zwitterionic mechanism.[3] Asymmetric catalytic ene reactions using the modified binaphthol-derived aluminum reagent[4] as well as binaphthol-derived titanium catalysts[5] have also been reported.



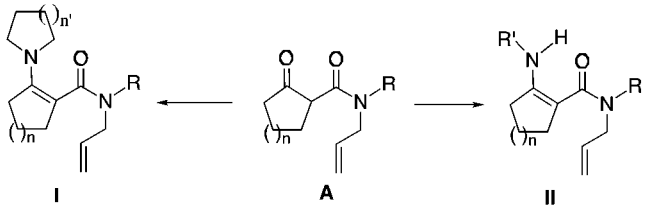
Ene reactions can be divided into "carba-ene" reactions, in which the enophile is an alkene substituted with electron-withdrawing groups, and "hetero-ene" reactions, in which hetero-enophiles including carbonyl and thiocarbonyl compounds, imines, nitro compounds, azo compounds, and dioxygen are employed.[1] In contrast, there appear to be very few hetero-ene reactions involving hetero-ene components with the exception of the Conia reaction[6] in which a thermal cyclization of an olefinic ketone through an intramolecular ene reaction of the corresponding enol occurs generally at very high temperature. More recently, hetero-ene reactions of *N*-sulfinyl-*p*-toluenesulfonamides,[7] hydrazones,[8] and thiols[9] with electron-rich olefins have been reported.

We report herein a thermal reaction involving *N*-unsaturated alkyl β-carboxamido enamines in which the enamine is the hetero-ene component, with the aim of obtaining substituted spirolactams under relatively mild thermal conditions (80−150 °C).[10]



Results and Discussion

Tertiary and secondary β-carboxamido enamines of type **I** and **II** have been prepared in quantitative yields from the corresponding β-keto amides of type **A**.[11]



[⊗] Abstract published in *Advance ACS Abstracts,* September 1, 1997.

(1) (a) Carruthers, W. In *Cycloaddition Reactions in Organic Synthesis*; Pergamon Press: Oxford, 1990; p 241. (b) Snider, B. B. Ene Reactions With Alkenes as Enophiles and Oppolzer, W. Metallo-ene Reactions in Comprehensive Organic Synthesis; Trost, B. M., Fleming, I., Eds.; Pergamon Press: Oxford, 1991; Vol. 5, Chapters 1.1 and 1.2.

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(3) (a) Snider, B. B. *Acc. Chem. Res.* **1980**, *13*, 426−432. (b) Snider, B. B.; Ron, E. *J. Am. Chem. Soc.* **1985**, *107*, 8160−8164.

(4) (a) Maruoka, K.; Hoshino, Y.; Shirasaka, T.; Yamamoto, H. *Tetrahedron Lett.* **1988**, *29*, 3967−3970. (b) Whitesell, J. K. *Acc. Chem. Res.* **1985**, *18*, 280−284. (c) Whitesell, J. K.; Bhattacharya, A.; Buchanan, C. C.; Chen, H. H.; Deyo, D.; James, D.; Liu, C.-L.; Minton, M. A. *Tetrahedron* **1986**, *42*, 2993−3001.

(5) (a) Mikami, K.; Terada, M.; Nakai, T. *J. Am. Chem. Soc.* **1989**, *111*, 1940−1941. (b) Mikami, K.; Terada, M.; Nakai, T. *Chem. Express* **1989**, *4*, 589−592. (c) Mikami, K.; Terada, M.; Nakai, T. *J. Am. Chem. Soc.* **1990**, *112*, 3949−3954.

(6) (a) Brocard, J.; Moinet, G.; Conia, J. M. *Bull. Soc. Chim. Fr.* **1972**, 1711−1717. (b) Mandville, G.; Leyendecker, F.; Conia, J. M. *Bull. Soc. Chim. Fr.* **1973**, 963−971. (c) Leyendecker, K.; Drouin, J.; Conia, J. M. *Tetrahedron Lett.* **1974**, 2931−2934. (d) Conia, J. M.; Le Perchec, P. *Synthesis* **1975**, 1−19. (e) Bortolussi, M.; Bloch, R.; Conia, J. M. *Bull. Soc. Chim. Fr.* **1975**, 2727−2730. (f) Conia, J. M.; Lange, G. L. *J. Org. Chem.* **1978**, *43*, 564−567.

(7) Marson, C. M.; Giles, P. R. *J. Org. Chem.* **1995**, *60*, 8067−8073.

(8) (a) Arnold, R. T.; Showell, J. S. *J. Am. Chem. Soc.* **1957**, *79*, 419−422. (b) Koerner Von Gustorf, E. H. *Tetrahedron Lett.* **1968**, 4693−4694. (c) Chan, B. L.; Taylor, D. R. *J. Chem. Soc., Perkin Trans. 1* **1977**, 1463−1468. (d) Laporterie, A.; Dubac, J.; Manuel, G.; Deleris, G. *Tetrahedron* **1978**, 2669−2673.

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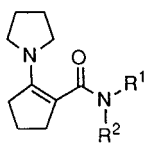
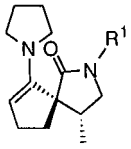
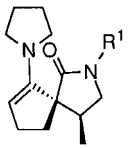
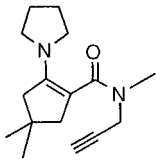
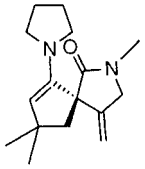
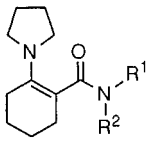
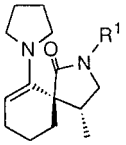
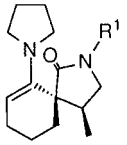
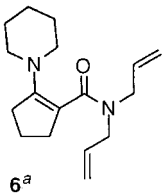
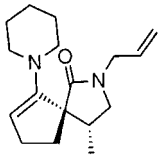
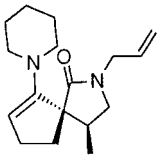
Table 1. Thermocyclization of Tertiary β-Carboxamido Enamines

Starting Material	Products		Global Yield % (a/b)[b]
 **1**[a] $R^1 = R^2$ = allyl	 **14a** R^1 = allyl	 **14b** R^1 = allyl	85 (80/20)
2[a] R^1 = Me, R^2 = allyl	**15a** R^1 = Me	**15b** R^1 = Me	76 (86/14)
 **3**[c]	 **16**		95
 **4**[a] $R^1 = R^2$ = allyl	 **17a** R^1 = allyl	 **17b** R^1 = allyl	92 (87/13)
5[a] R^1 = Me, R^2 = allyl	**18a** R^1 = Me	**18b** R^1 = Me	85 (90/10)
 **6**[a]	 **19a**	 **19b**	65 (78/22)

[a] Heated neat at 150 °C for 5 h, [b] Determined by ^{1}H NMR, [c] Heated neat at 80 °C for 1 h.

The thermolysis of neat tertiary β-carboxamido enamines **I** was achieved by heating at 150 °C for 5 h, while the acetylenic compound **3** was heated neat at 80 °C for 1 h. The results are reported in Table 1.

The enamino spirolactams arising from the thermolysis of compounds **1**−**6** were isolated in good to excellent yields (65−95%) and with good diastereoselectivity (78/22 to 90/10). When enamine **1** was heated at high temperature (230 °C), the yield increased to 95% and the diastereoselectivity remained unchanged. The thermolysis of the enamine derived from piperidine (compound **6**) gave poorer results (yield and diastereoselectivity) than the corresponding enamine derived from pyrrolidine (compound **1**). Furthermore, when the thermolyses of β-carboxamido enamines **1**, **2**, **4**, **5**, and **6** were performed in xylene heated at reflux ($c = 10^{-2}$ M), and the thermolysis of **3** was carried out in benzene heated at reflux, the corresponding enamino spirolactams were isolated in the same yield (and diastereoselectivity) as when they were thermolyzed neat. We point out that the formation of the enamino spirolactams could not be catalyzed by Lewis acids such as Me_2AlCl or Et_2AlCl.[3a]

Scheme 1. Hydrolysis of Enamines

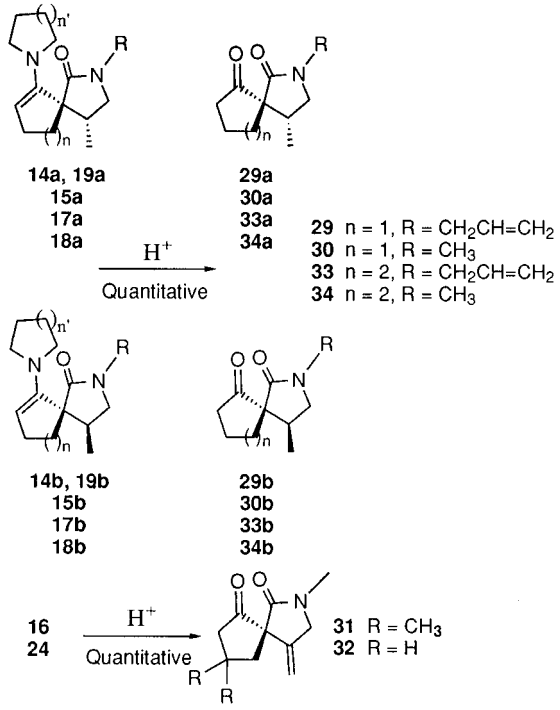


Table 2. Chemical Shifts (ppm) of the Methyl Group in Enamino Spirolactams and Their Corresponding Keto Spirolactams

enamino spirolactams	a	b	keto spirolactams	a	b
14	0.91	0.82	**29**	1.02	1.09
19	0.92	0.85			
15	0.90	0.75	**30**	1.01	1.05
17	0.97	0.67	**33**	0.99	1.09
18	0.98	0.91	**34**	0.98	1.15

Racemic and chiral nonracemic keto spirolactams **29**, **30**, and **33** were obtained by the hydrolysis of the corresponding enamino spirolactams **14**/**19**, **15**, and **17** (Table 1, Scheme 1) and imino spirolactams **22**, **23**, and **25** (*vide infra*, Table 3) and by the hydrolysis of the corresponding chiral imino spirolactams **26**, **27**, and **28** (*vide infra*, Table 4). Racemic compounds **34** were similarly obtained from compounds **18** (Scheme 1).

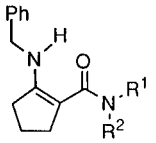
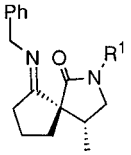
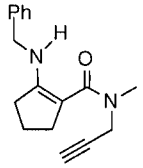
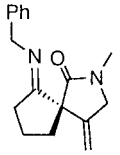
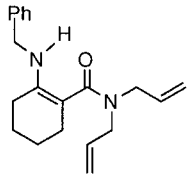
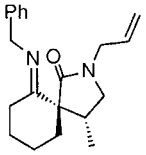
The relative and absolute configuration of keto spirolactams (−)-**29a** and (+)-**29a** was established by X-ray diffraction (*vide infra*). Thus, only the (*Z*)-isomer was obtained and by analogy the same configuration can be assigned to compounds (−)-**30a**/(+)-**30a** and (−)-**33a**/(+)-**33a**. The ^{1}H NMR spectra of the major racemic compounds **29a**, **30a**, and **33a** are identical to those of the corresponding chiral compounds; thus their relative configuration can be also established, as well as the relative configurations of the parent enamino spirolactams **14a**/**19a**, **15a**, **17a**, and imino spirolactams **22**, **23**, and **25**. By analogy, the same relative configuration can be attributed to the major isomers **18a** and **34a** (Scheme 1).

In the case of the major stereoisomers **a**, the ^{1}H NMR spectra show doublets for the methyl group at slightly lower field than the corresponding ones in the minor stereoisomers **b** (Table 2).

The mixture of compounds **17a** and **17b** has been quenched with methyl vinyl ketone in benzene to produce the Michael adduct **20** as a mixture of isomers in 53% yield. It is worth noting that enamine **20** is remarkably

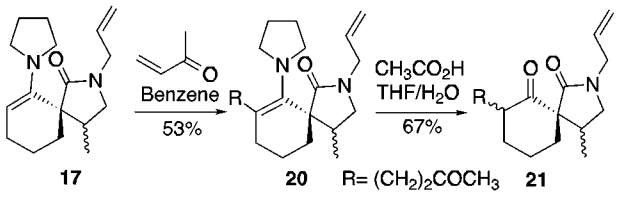
(9) Montevecchi, P. C.; Navacchia, M. L. *J. Org. Chem.* **1995**, *60*, 6455−6459.
(10) Cossy, J.; Bouzide, A. *Tetrahedron Lett.* **1992**, *33*, 2505−2508.
(11) (a) Cossy, J.; Belotti, D.; Thellend, A.; Pete, J. P. *Synthesis* **1988**, 720−723. (b) Cossy, J.; Thellend, A. *Synthesis* **1989**, 753−755.

Table 3. Thermolysis of Secondary β-Carboxamido Enamines

Starting Material[a]	Product	Global yield %
 **7** $R^1 = R^2$ = allyl	 **22** R^1 = allyl	81
8 R^1 = Me, R^2 = allyl	**23** R^1 = Me	76
 **9**	 **24**	77
 **10**	 **25**	95

[a] Heated neat at 150 °C for 5 h

stable to silica gel purification. Its hydrolysis was carried out by using aqueous acetic acid in THF heated at reflux.



When secondary β-carboxamido enamines **7**−**10** were thermolyzed at 150 °C (neat) for 5 h, the corresponding imino spirolactams were obtained in good to excellent yields (76−95%) and with total diastereoselectivity. Only the (*Z*)-stereoisomer (*vide supra*) was obtained (Table 3).

Because the thermolysis of β-carboxamido enamines afforded only one diastereoisomer, we took advantage of this stereoselectivity to achieve the synthesis of nonracemic imino spirolactams by using a nonracemic amino moiety.

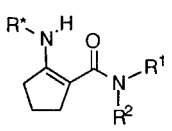
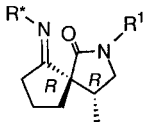
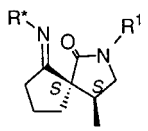
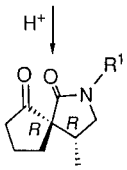
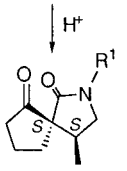
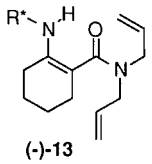
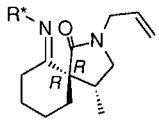
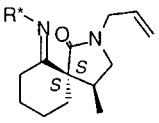
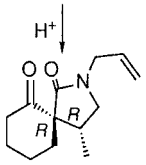
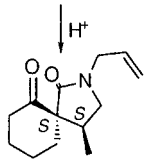
The condensation of β-keto amides with (*R*)-phenylethylamine led to the corresponding nonracemic secondary β-carboxamido enamines which were thermolyzed at 150 °C (neat) for 5 h. The results are summarized in Table 4.

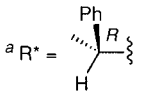
The thermolyses of **11**, **12**, and **13** each produced two diastereoisomers: (−)-**26a′**, (+)-**26a″** (77/23), (−)-**27a′**, (−)-**27a″** (75/25), and (+)-**28a′**, (−)-**28a″** (76/24), respectively, in good yields (77−95%). The diastereoisomers were separated by flash chromatography on silica gel.

The absolute and relative configurations of compounds (−)-**26a′** and (+)-**26a″** were established by X-ray diffraction (Figure 1).[12]

(12) The author has deposited atomic coordinates for this structure 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, U.K.

Table 4. Thermolysis of Nonracemic Secondary β-Carboxamido Enamines and Hydrolysis of the Imino Spirolactams

Starting Material[a, b]	Products	Global Yield % (**a′**/**a″**)[c]
 **(-)-11** $R^1 = R^2$ = allyl	 **(-)-26a′** R^1 = allyl	 **(+)-26a″** R^1 = allyl	90 (77/23)
(-)-12 R^1 = Me, R^2 = allyl	**(-)-27a′** R^1 = Me	**(-)-27a″** R^1 = Me	77 (75/25)
	 **(-)-29a** (98%) R^1 = allyl **(-)-30a** (99%) R^1 = Me	 **(+)-26a″** (98%) R^1 = allyl **(+)-30a** (96%) R^1 = Me	
 **(-)-13**	 **(+)-28a′**	 **(-)-28a″**	95 (76/24)
	 **(-)-33a**	 **(+)-33a**	

[a] R* =  , [b] Heated neat at 150 °C for 5 h, [c] Determined by ^{1}H NMR

Hydrolysis of the imino spirolactams (−)-**26a′**, (+)-**26a″**, (−)-**27a′**, (−)-**27a″**, (+)-**28a′**, and (−)-**28a″** (CH_3CO_2H, H_2O) gave quantitatively the corresponding nonracemic keto spirolactams (−)-**29a**, (+)-**29a**, (−)-**30a**, (+)-**30a**, (−)-**33a**, and (+)-**33a** (Table 4).

Neither spectral analysis of the keto spirolactams nor HPLC analysis showed the presence of any other isomer. The α_D values of isomers **a** and **b**, measured in ethanol, confirmed that these compounds were enantiomers. In these reactions the diasteroselectivity is thus higher than 99:1 and the enantiomeric excesses were 50−54%. The enamino and imino spirolactams are most probably formed from an ene reaction.

The cyclization of the tertiary β-carboxamido enamines arises from a carba-ene reaction. The diastereoselectivity of the reaction varies from 78/22 to 90/10, and the compound where the methyl group and the enamine group have a *cis*-relationship with respect to the C(4)−C(5) bond of the lactam ring is the major isomer. This latter compound is probably generated from an *exo* transition state where overlap of the π system can take place without any steric constraint. The minor isomer results from an *endo* transition state. In this transition state, the system is strained and steric interactions exist between H_b and H_d (Figure 2).

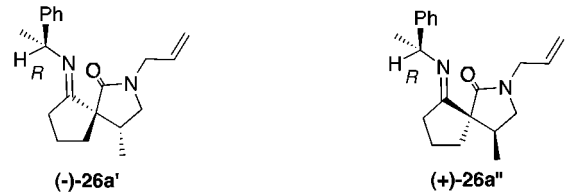


Figure 1. Structures of compounds (−)-**26a′** and (+)-**26a″** determined by X-ray diffraction.

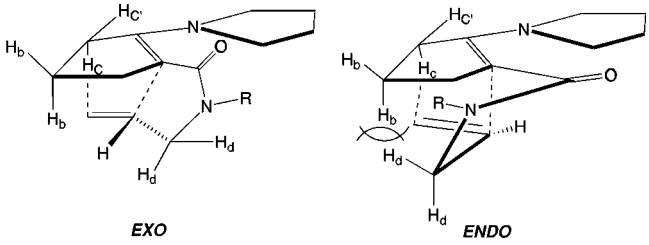
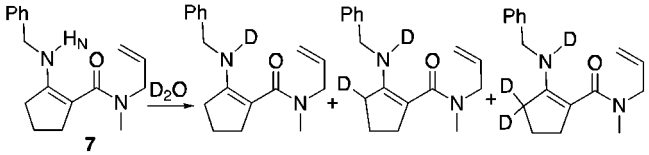


Figure 2. *Endo* and *exo* transition states.

In the case of secondary β-carboxamido enamines, the ene adduct has the imine group and the methyl group also in a *cis*-relationship with respect to the C(4)−C(5) bond of the lactam ring. The spiroannulation process described here can be explained *a priori* in terms of an aza-ene reaction involving the abstraction of H_N by the allylic chain or in terms of a carba-ene reaction involving the abstraction of H_c at the α′ position by the allylic chain (Figure 3).

In order to prove which pathway occurs, we tried to replace H_N by a deuterium atom in compound **7**. Unfortunately, selective deuteriation was not possible because the protons at the allylic position of the enamine were also exchanged in an imine−enamine equilibrium (Scheme 2).

Scheme 2. Deuteriation of the Enamine 7



According to the transition states, the aza-ene reaction can produce only the *cis*-isomer. This process will not allow the formation of the *trans*-isomer because overlap with the π-system is impossible. If the carba-ene reaction took place, the *cis*-adduct should be the major product and should be accompanied by the *trans*-adduct. According to the transition states outlined above and the experimental results obtained (only the *cis*-adduct is formed), it appears that the aza-ene reaction is responsible for the formation of the imino spirolactams from secondary β-carboxamido enamines in analogy with the imino-Michael reaction although through a different geometry of the transition state.[13]

We have shown for the first time that enamines can be involved in ene reactions without any electron-withdrawing group present in the enophile and that these reactions can produce enamino or imino spirolactams from β-carboxamido enamines. In the case of secondary carboxamido enamines, the diastereoselectivity is higher than 99:1. If chiral nonracemic analogs are used, 50−54% enantiomeric excesses can be achieved in the final products.

Experimental Section

General. All experiments were run under an Ar atmosphere. ^{1}H NMR and ^{13}C NMR spectra were obtained at 300 and 75 MHz, respectively. IR spectra were recorded in $CDCl_3$. Mass spectra were run on a Hewlett-Packard instrument (EI mode at 70 eV). Microanalysis, HRMS, and X-ray diffraction were performed at Paris VI University. Flash chromatography was accomplished with petroleum ether (PE) and ethyl acetate on Merck silica gel 0.043−0.063 mm. Analytical thin layer chromatography (TLC) was performed on Merck silica gel 60 F_{254}. Acetonitrile, toluene, and amines were distilled from CaH_2.

Synthesis of β-Enamino Carboxamides. To a solution of β-keto amide[11] (10 mmol) in toluene (25 mL) was added the amine [pyrrolidine and piperidine (30 mmol), primary amines (13 mmol)]. After 12 h at reflux in a Dean−Stark apparatus, the solvent was evaporated under reduced pressure. The tertiary enamino carboxamides **1**−**6** were purified by distillation (0.1 mmHg), and the secondary enaminocarboxamides **7**−**13** were purified by flash chromatography. Yields of β-carboxamido enamines were quantitative.

***N*,*N*-Diallyl-2-pyrrolidinocyclopent-1-enecarboxamide (1):** yellow oil; yield 98%; IR 1660, 1625, 1480, 1450 cm^{-1}; ^{1}H NMR (C_6H_6) δ 1.70−1.90 (m, 6H), 2.53−2.65 (m, 4H), 3.17−3.25 (m, 4H), 3.07−3.25 (m, 4H), 3.86−4.05 (m, 4H), 5.08−5.27 (m, 4H), 5.69−5.85 (m, 2H); ^{13}C NMR (C_6D_6) δ 22.9 (t), 26.1 (2t), 35.4 (t), 35.8 (2t), 38.8 (t), 50.2 (2t), 99.2 (s), 117.1 (2t), 135.6 (2d), 149.2 (s), 171.3 (s); MS *m*/*z* 260 (M^+, 20), 219 (15), 191 (10), 176 (10), 164 (100), 137 (50), 136 (80), 111 (60); HRMS *m*/*z* (M^+) calcd for $C_{16}H_{24}N_2O$ 260.1888, found 260.1881.

***N*-Allyl-*N*-methyl-2-pyrrolidinocyclopent-1-enecarboxamide (2):** yellow oil; yield 96%; IR 1655, 1630, 1480, 1450 cm^{-1}; ^{1}H NMR (C_6D_6) δ 1.30−1.46 (m, 4H), 1.62−1.72 (m, 2H), 2.25 (m, 2H), 2.68 (m, 2H), 2.80 (s, 3H); 3.80 (s, 3H), 2.90 (m, 4H), 3.65−4.00 (m, 2H), 4.95−5.05 (m, 2H), 5.60−5.80 (m, 1H); ^{13}C NMR (C_6D_6) δ 22.8 (t), 26.1 (2t), 35.4 (t), 35.54 (t), 39.2 (q), 50.0 (2t), 50.2 (t), 99.4 (s), 116.9 (t), 135.5 (d), 148.6 (s), 171.4 (s); MS *m*/*z* 234 (M^+, 20), 164 (100), 136 (68), 118 (18), 111 (52); HRMS *m*/*z* (M^+) calcd for $C_{14}H_{22}N_2O$ 234.1732, found 234.1729.

***N*-Methyl-*N*-propargyl-4,4-dimethyl-2-pyrrolidinocyclopent-1-enecarboxamide (3):** yellow oil; yield 98%; IR 1650, 1625, 1450 cm^{-1}; ^{1}H NMR (C_6D_6) δ 1.08 (s, 6H), 1.38−1.45 (m, 4H), 2.02 (m, 1H), 2.15 (m, 2H), 2.50 (s, 2H), 2.93 (s, 3H), 3.00−3.05 (m, 4H), 4.10 (s, 2H); ^{13}C NMR (C_6D_6) δ 25.6 (2q), 25.5 (2t), 36.0 (q), 40.5 (s), 49.3 (t), 49.5 (t), 49.8 (2t), 53.2 (t), 71.8 (d), 80.2 (s), 96.6 (s), 148.2 (s), 170.5 (s); MS *m*/*z* 260 (M^+, 20), 245 (100), 235 (25), 192 (60), 124 (22); HRMS *m*/*z* (M^+) calcd for $C_{16}H_{24}N_2O$ 260.1888, found 260.1892.

***N*,*N*-Diallyl-2-pyrrolidinocyclohex-1-enecarboxamide (4):** yellow oil; yield 98%; IR 1655, 1630, 1450 cm^{-1}; ^{1}H NMR (C_6D_6) δ 130−1.60 (m, 8H), 1.85−2.20 (m, 4H), 2.80−3.20 (m, 4H), 3.50−4.20 (m, 4H), 4.92−5.12 (m, 4H), 5.40−5.80 (m, 2H); ^{13}C NMR (C_6D_6) δ 23.6 (t), 24.0 (t), 25.9 (2t), 28.3 (2t), 29.3 (t), 48.5 (t), 49.6 (2t), 97.9 (s), 117.5 (2t), 134.8 (2d), 141.4 (s), 173.5 (s); MS *m*/*z* 274 (M^+, 25), 233 (10), 205 (10), 178 (45), 150 (50), 124 (25), 96 (80), 56 (55), 41 (100). Anal. Calcd for $C_{17}H_{26}N_2O$: C, 74.41; H, 9.55; N, 10.21. Found: C, 74.47; H, 9.48; N, 10.15.

***N*-Allyl-*N*-methyl-2-pyrrolidinocyclohex-1-enecarboxamide (5):** yellow oil; yield 96%; IR 1655, 1630, 1480, 1450 cm^{-1}; ^{1}H NMR (C_6D_6) δ 1.20−1.63 (m, 8H), 2.00−2.52 (m, 4H), 2.48 (s, 3H), 2.60−3.10 (m, 4H), 3.75−4.15 (m, 2H), 4.80−5.10 (m, 2H), 5.50−5.82 (m, 1H); ^{13}C NMR (C_6D_6) δ 23.6 (t), 24.1 (t), 25.6 (t), 26.0 (2t), 28.4 (t), 34.7 (q), 46.7 (t), 49.4 (2t), 102.5 (s), 117.2 (t), 134.2 (d), 141.1 (s), 174.7 (s); MS *m*/*z* 248 (M^+, 30), 178 (68), 164 (22), 150 (63), 136 (20), 123 (22), 70 (100).

(13) (a) Sevin, A.; Tortajada, J.; Pfau, M. *J. Org. Chem.* **1986**, *51*, 2671−2675. (b) Sevin, A.; Masure, D.; Giessner-Prettre, C.; Pfau, M. *Helv. Chim. Acta* **1990**, *73*, 552−573. (c) Pfau, M.; Tomas, A.; Lim, S.; Revial, G. *J. Org. Chem.* **1995**, *60*, 1143−1147. (d) Jabin, I.; Revial, G.; Tomas, A.; Lemoine, P.; Pfau, M. *Tetrahedron: Asymmetry* **1995**, *6*, 1795−1812.

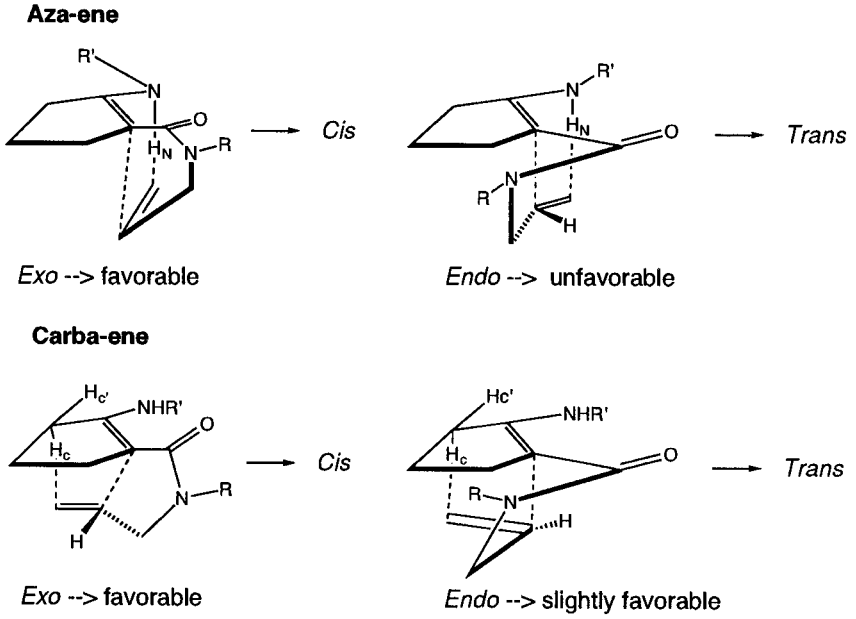


Figure 3. Transition states of the aza-ene and carba-ene reactions.

Anal. Calcd for $C_{15}H_{24}N_2O$: C, 72.53; H, 9.74; N, 11.29. Found: C, 72.59; H, 8.68; N, 11.35.

***N,N*-Diallyl-2-piperidinocyclopent-1-enecarboxamide (6):** yellow oil; yield 98%; IR 1660, 1630, 1460, 1420 cm^{-1}; ^1H NMR (C_6D_6) δ 1.40−1.60 (m, 4H), 1.70−1.92 (m, 2H), 2.10−2.52 (m, 6H), 2.70−3.40 (m, 4H), 3.60−4.00 (m, 4H), 5.10−5.25 (m, 4H), 5.60−5.80 (m, 2H); ^{13}C NMR (C_6D_6) δ 20.0 (2t), 24.0 (t), 27.4 (t), 34.9 (t), 38.4 (2t), 49.1 (t), 48.1 (t), 49.6 (t), 102.4 (s), 116.2 (2t), 132.5 (2d), 147.6 (s), 168.8 (s); MS *m/z* 274 (M^+, 20), 259 (10), 233 (20), 178 (100), 150 (85), 125 (62), 110 (15). Anal. Calcd for $C_{17}H_{26}N_2O$: C, 74.41; H, 9.55; N, 10.21. Found: C, 74.48; H, 9.49; N, 10.25.

***N,N*-Diallyl-2-(benzylamino)cyclopent-1-enecarboxamide (7):** yellow oil; yield 95%; R_f 0.45 (PE/AcOEt 80/20); IR 3250, 1680, 1600, 1550, 1460 cm^{-1}; ^1H NMR ($CDCl_3$) δ 1.60−1.67 (m, 2H), 2.38 (t, J = 7.5 Hz, 2H), 2.58 (t, J = 7.0 Hz, 2H), 3.85 (d, J = 5.1 Hz, 4H), 4.28 (d, J = 6.5 Hz, 2H), 5.00−5.10 (m, 4H), 5.50−5.80 (m, 2H), 7.10−7.30 (m, 5H), 8.50 (s, 1H); ^{13}C NMR ($CDCl_3$) δ 22.4 (t), 31.3 (t), 32.5 (t), 48.2 (t), 48.5 (2t), 116.1 (2t), 126.7 (2d), 126.9 (d), 128.4 (2d), 134.6 (2d), 139.6 (d), 164.5 (s), 171.2 (s), 178.2 (s); MS *m/z* 296 (M^+, 30), 281 (25), 268 (19), 205 (35), 201 (40), 200 (100), 177 (30), 147 (40), 91 (80); HRMS *m/z* (M^+) calcd for $C_{19}H_{24}N_2O$ 296.1888, found 296.1893.

***N*-Allyl-*N*-methyl-2-(benzylamino)cyclopent-1-enecarboxamide (8):** yellow oil; yield 90%; R_f 0.35 (PE/AcOEt 70/30); IR 3300, 1680, 1650, 1550, 1480 cm^{-1}; ^1H NMR ($CDCl_3$) δ 1.72−1.82 (m, 2H), 2.45 (t, J = 7.0 Hz, 2H), 2.67 (t, J = 7.0 Hz, 2H), 2.91 (s, 3H), 3.94 (dt, J = 5.2 and 1.5 Hz, 2H), 4.38 (d, J = 7.6 Hz, 2H), 5.15 (m, 2H), 5.80−5.90 (m, 1H), 7.20−7.40 (m, 5H), 8.50 (s, 1H); ^{13}C NMR ($CDCl_3$) δ 22.5 (t), 31.4 (t), 32.8 (t), 34.7 (q), 48.4 (t), 51.5 (t), 95.1 (s), 116.2 (t), 127.0 (2d), 127.1 (d), 128.5 (2d), 134.6 (d), 139.8 (s), 164.1 (s), 171.8 (s); MS *m/z* 270 (M^+, 10), 201 (14), 200 (53), 179 (17), 172 (21), 91 (100). Anal. Calcd for $C_{17}H_{22}N_2O$: C, 75.52; H, 8.20; N, 10.36. Found: C, 75.67; H, 8.29; N, 10.25.

***N*-Methyl-*N*-propargyl-2-(benzylamino)cyclopent-1-enecarboxamide (9):** yellow oil; yield 92%; R_f 0.45 (PE/AcOEt 80/20); IR 3300, 1675, 1650, 1555, 1470 cm^{-1}; ^1H NMR ($CDCl_3$) δ 1.80 (m, 2H), 2.20 (t, J = 2.5 Hz, 1H), 2.45 (t, J = 2.5 Hz, 2H), 2.70 (t, J = 6.8 Hz, 2H), 3.04 (s, 3H), 4.10 (d, J = 2.5 Hz, 2H), 3.37 (d, J = 6.8 Hz, 2H), 7.20−7.35 (m, 5H), 8.55 (s, 1H); ^{13}C NMR ($CDCl_3$) δ 22.3 (t), 31.2 (t), 32.40 (t), 34.5 (q), 38.0 (t), 48.1 (t), 70.9 (s), 80.1 (d), 94.3 (s), 102.5 (s), 126.5 (2d), 126.5 (d), 128.2 (2d), 139.3 (s), 164.8 (s); MS *m/z* 268 (M^+, 20), 240 (15), 214 (10), 177 (50), 149 (15), 120 (10), 91 (100), 79 (20). Anal. Calcd for $C_{17}H_{20}N_2O$: C, 76.09; H, 7.51; N, 10.43. Found: C, 76.12; H, 7.43; N, 10.49.

***N,N*-Diallyl-2-(benzylamino)cyclohex-1-enecarboxamide (10):** yellow oil; yield 90%; mixture of enamine/imine (NMR ratio 50/50). Enamine−imine IR 3350, 1680, 1650, 1610, 1450 cm^{-1}; enamine ^1H NMR ($CDCl_3$) δ 1.50−2.20 (m, 8H), 3.40−4.05 (m, 4H), 4.50 (s, 2H), 5.00−5.25 (m, 4H), 5.40 (s, 1H), 5.60−5.90 (m, 2H), 7.15−7.37 (m, 5H); ^{13}C NMR ($CDCl_3$) δ 22.4 (t), 26.5 (t), 28.5 (t), 30.3 (t), 48.24(t), 53.8 (2t), 116.6 (2t), 126.8 (d), 127.6 (2d), 128.0 (2d), 133.1 (2d), 140.35 (s), 170.8 (s), 172.2 (s), 174.2 (s); imine ^1H NMR ($CDCl_3$) δ 1.50−2.20 (m, 8H), 2.80 (m, 1H), 3.40−4.05 (m, 4H), 4.20−4.45 (m, 2H), 5.30−5.20 (m, 4H), 5.60−5.90 (m, 2H), 7.10−7.40 (m, 5H); ^{13}C NMR ($CDCl_3$) δ 23.8 (t), 25.6 (t), 26.5 (t), 30.3 (t), 47.9 (t), 51.2 (d), 53.8 (2t), 117.1 (2t), 126.8 (d), 127.95 (2d), 128.4 (2d), 133.8 (2d), 145.3 (s), 169.5 (s), 172.2 (s); enamine−imine MS *m/z* 310 (M^+, 30), 214 (100). Anal. Calcd for $C_{20}H_{26}N_2O$: C, 77.38; H, 8.44; N, 9.02. Found: C, 77.29; H, 8.51; N, 9.11.

(−)-*N,N*-Diallyl-2-[(1-phenylethyl)amino]cyclopent-1-enecarboxamide [(−)-11]: yellow oil; yield 96%; R_f 0.40 (PE/AcOEt 70/30); $[\alpha]^{22}_D = -320$ (*c* 5, ethanol); IR 3250, 1680, 1630, 1600, 1550, 1450 cm^{-1}; ^1H NMR ($CDCl_3$) δ 1.48 (d, J = 6.6 Hz, 3H), 1.60−1.80 (m, 2H), 2.05−2.20 (m, 1H), 2.40−2.50 (m, 1H), 2.60 (t, J = 6.8 Hz, 2H), 3.95 (d, J = 4.9 Hz, 4H), 4.55 (q, J = 6.6 Hz, 1H), 5.10−5.20 (m, 4H), 5.25−5.40 (m, 2H), 7.15−7.35 (m, 5H), 8.65 (m, 1H); ^{13}C NMR ($CDCl_3$) δ 23.2 (t), 25.8 (q), 32.4 (t), 33.1 (t), 49.1 (2t), 55.0 (d), 95.5 (s), 116.9 (2t), 126.3 (2d), 127.4 (d), 129.2 (2d), 135.5 (2d), 146.6 (s), 164.9 (s), 172.1 (s); MS *m/z* 310 (M^+, 15), 214 (40), 205 (25), 186 (22), 152 (20), 124 (15), 110 (40), 105 (100). Anal. Calcd for $C_{20}H_{26}N_2O$: C, 77.38; H, 8.44; N, 9.02. Found: C, 77.29; H, 8.49; N, 9.11.

(−)-*N*-Allyl-*N*-methyl-2-[(1-phenylethyl)amino]cyclopent-1-enecarboxamide [(−)-12]: yellow oil; yield 95%; R_f 0.35 (PE/AcOEt 65/35); $[\alpha]^{22}_D = -375$ (*c* 2, ethanol); IR 3500, 1650, 1630, 1550 cm^{-1}; ^1H NMR ($CDCl_3$) δ 1.48 (d, J = 6.9 Hz, 3H), 1.58−1.80 (m, 2H), 2.08−2.20 (m, 1H), 2.38−2.50 (m, 1H), 2.60 (t, J = 6.8 Hz, 2H), 2.93 (s, 3H), 3.95 (d, J = 5.2 Hz, 2H), 4.55 (q, J = 7.0 Hz, 1H), 5.15 (m, 2H), 5.75−5.90 (m, 1H), 7.15−7.35 (m, 5H), 8.58 (d, J = 7.6 Hz, 1H); ^{13}C NMR ($CDCl_3$) δ 23.2 (t), 25.8 (q), 32.4 (t), 33.3 (t), 35.4 (q), 52.2 (t), 54.9 (d), 95.7 (s), 116.9 (t), 126.3 (2d), 127.4 (d), 129.2 (2d), 135.3 (d), 146.0 (s), 164.5 (s), 172.5 (s); MS *m/z* 284 (M^+, 5), 214 (15), 213 (53), 184 (83), 156 (100). Anal. Calcd for $C_{18}H_{24}N_2O$: C, 76.02; H, 8.50; N, 9.85. Found: C, 76.07; H, 8.62; N, 9.76.

(−)-*N,N*-Diallyl-2-[(1-phenylethyl)amino]cyclohex-1-enecarboxamide [(−)-13]: yellow oil; yield 90%; R_f 0.40 (PE/AcOEt 70/30); $[\alpha]^{22}_D = -328$ (*c* 5, ethanol); IR 3250, 1655, 1630, 1600, 1550, 1450 cm^{-1}; ^1H NMR ($CDCl_3$) δ 1.50 (d, J = 6.6 Hz, 3H), 1.60−1.80 (m, 4H), 2.05−2.20 (m, 1H), 2.40−2.50 (m,

1H), 2.60 (t, J = 6.8 Hz, 2H), 3.95 (d, J = 4.9 Hz, 4H), 4.55 (q, J = 6.6 Hz, 1H), 5.10−5.20 (m, 4H), 5.25−5.40 (m, 2H), 7.15−7.35 (m, 5H), 8.65 (m, 1H); ^{13}C NMR ($CDCl_3$) δ 22.2 (t), 25.8 (q), 32.5 (t), 33.1 (t), 34.5 (t), 49.1 (2t), 56.0 (d), 96.5 (s), 117.8 (2t), 126.3 (2d), 127.4 (d), 130.2 (2d), 134.5 (2d), 146.6 (s), 166.9 (s), 174.1 (s); MS m/z 324 (M^+, 10), 309 (40), 228 (25), 200 (20), 166 (25), 138 (15), 119 (100). Anal. Calcd for $C_{21}H_{28}N_2O$: C, 77.73; H, 8.69; N, 8.63. Found: C, 77.64; H, 8.49; N, 8.75.

Thermolysis of Enamines and Imines. The enamines and imines were thermolyzed neat at 150 or 80 °C under an argon atmosphere. The spirolactams were purified by distillation under reduced pressure (0.1 mmHg) or by flash chromatography. The mixture of diastereoisomers **14**, **15**, **17**, **18**, and **19** could not be separated.

2-Allyl-4-methyl-6-pyrrolidino-2-azaspiro[4.4]non-6-en-1-one (14): yellow oil; yield 85%; IR 1680, 1610, 1490, 1430 cm^{-1}; ^{1}H NMR (C_6D_6) major isomer **14a** δ 0.91 (d, J = 7.0 Hz, 3H), 4.53 (t, J = 3.0 Hz, 1H); minor isomer **14b** δ 0.82 (d, J = 7.0 Hz, 3H), 4.48 (t, J = 3.0 Hz, 1H); for both isomers δ 1.40−1.50 (m, 4H), 1.50−1.62 (m, 1H), 1.98−2.07 (m, 1H), 2.20−2.28 (m, 2H), 2.58 (t, J = 9.0 Hz, 1H), 2.70−3.00 (m, 6H), 3.55 (dd, J = 9.0 and 6.0 Hz, 1H), 4.00 (dd, J = 9.0 and 6.0 Hz, 1H), 4.90−5.02 (m, 2H), 5.50−5.65 (m, 1H); ^{13}C NMR (C_6D_6) major isomer **14a** δ 14.7 (q), 25.04 (2t), 28.3 (t), 38.6 (d), 39.0 (t), 45.9 (t), 49.6 (2t), 51.7 (t), 61.0 (s), 101.9 (d), 117.7 (t), 133.0 (d), 149.5 (s), 177.0 (s); minor isomer **14b** δ 11.7 (q), 24.9 (2t), 29.1 (t), 35.5 (d), 39.0 (t), 45.2 (t), 48.7 (2t), 50.8 (t), 61.2 (s), 99.1 (d), 117.0 (t), 133.4 (d), 149.0 (s), 177.5 (s); MS m/z 260 (M^+, 25), 245 (52), 231 (25), 217 (58), 190 (20), 164 (100), 152 (58), 136 (36), 108 (30), 97 (45). Anal. Calcd for $C_{16}H_{24}N_2O$: C, 73.80; H, 9.29; N, 10.76. Found: C, 73.87; H, 9.32; N, 10.75.

2,4-Dimethyl-6-pyrrolidino-2-azaspiro[4.4]non-6-en-1-one (15): yellow oil; yield 76%; IR 1680, 1610, 1495 cm^{-1}; ^{1}H NMR (C_6D_6) major isomer **15a** δ 0.90 (d, J = 7.0 Hz, 3H); minor isomer **15b** δ 0.75 (d, J = 7.0 Hz, 3H); for both isomers δ 1.40−1.50 (m, 4H), 1.50−1.60 (m, 1H), 1.95−2.05 (m, 1H), 2.20−2.33 (m, 2H), 2.40−2.60 (m, 4H), 2.60−3.00 (m, 6H), 4.55 (t, 1H); ^{13}C NMR (C_6D_6) major isomer **15a** δ 14.5 (q), 25.1 (2t), 28.3 (t), 29.9 (t), 38.7 (q), 44.9 (d), 49.5 (2t), 54.3 (t), 60.7 (s), 102.1 (d), 149.5 (s), 177.3 (s); minor isomer **15b** δ 15.4 (q), 24.5 (2t), 28.3 (t), 29.4 (t), 37.6 (q), 44.9 (d), 49.5 (t), 53.5 (t), 60.7 (s), 102.1 (d), 149.4 (s), 173.3 (s); MS m/z 234 (M^+, 80), 219 (35), 191 (50), 181 (33), 164 (100), 136 (25), 126 (65), 108 (25), 91 (12). Anal. Calcd for $C_{14}H_{22}N_2O$: C, 71.75; H, 9.46; N, 12.02. Found: C, 71.81; H, 9.37; N, 11.95.

2,8,8-Trimethyl-4-methylene-6-pyrrolidino-2-azaspiro[4.4]non-6-en-1-one (16): yellow oil; yield 95%; IR 1690, 1660, 1625, 1490 cm^{-1}; ^{1}H NMR (C_6D_6) δ 1.25 (s, 3H), 1.42 (s, 3H), 1.47 (m, 4H), 1.85 (d, J = 12.5 Hz, 1H), 2.40 (d, J = 12.5 Hz, 1H), 2.57 (s, 3H), 2.85−2.95 (m, 4H), 3.35−3.60 (m, 2H), 4.45 (s, 1H), 4.70 (m, 1H), 5.20 (m, 1H); ^{13}C NMR (C_6D_6) δ 25.6 (2q), 28.8 (t), 32.6 (2t), 42.1 (s), 48.1 (q), 49.5 (t), 49.8 (2t), 62.5 (s), 108.1 (d), 110.9 (t), 144.6 (s), 148.2 (s), 176.2 (s); MS m/z 260 (M^+, 22), 245 (100), 124 (50), 91 (12), 68 (30). Anal. Calcd for $C_{16}H_{24}N_2O$: C, 73.80; H, 9.29; N, 10.76. Found: C, 73.85; H, 9.22; N, 10.67.

2-Allyl-4-methyl-6-pyrrolidino-2-azaspiro[4.5]dec-6-en-1-one (17): yellow oil; yield 92%; IR 1680, 1490, 1350 cm^{-1}; ^{1}H NMR (C_6D_6) major isomer **17a** (C_6D_6) δ 0.97 (d, J = 7.0 Hz, 3H); minor isomer **17b** δ 0.67 (d, J = 7.0 Hz, 3H); for both isomers δ 1.10−1.70 (m, 8H), 1.85−1.95 (m, 1H), 2.00−2.25 (m, 2H), 2.42−2.58 (m, 1H), 2.62−2.78 (m, 3H), 2.85−3.08 (m, 2H), 3.50−4.00 (m, 2H), 4.90−5.10 (m, 3H), 5.45−5.70 (m, 1H); ^{13}C NMR (C_6D_6) major isomer **17a** (C_6D_6) δ 16.0 (q), 18.7 (t), 24.4 (2t), 24.6 (t), 37.9 (t), 39.9 (d), 45.7 (t), 50.9 (2t), 52.3 (s), 52.5 (t), 109.2 (d), 117.5 (t), 133.2 (d), 144.7 (s), 177.5 (s); minor isomer **17b** δ 12.9 (q), 21.4 (t), 25.0 (2t), 25.5 (t), 34.8 (2t), 40.12 (d), 45.3 (t), 51.4 (t), 52.3 (s), 52.5 (t), 109.2 (d), 117.0 (t), 133.0 (d), 144.7 (s), 177.52 (s); MS m/z 274 (M^+, 93), 259 (20), 245 (40), 231 (30), 221 (30), 178 (87), 162 (27), 150 (50), 123 (58), 97 (55), 41 (100). Anal. Calcd for $C_{17}H_{26}N_2O$: C, 74.41; H, 9.55; N, 10.21. Found: C, 74.51; H, 9.61; N, 10.25.

2,4-Dimethyl-6-pyrrolidino-2-azaspiro[4.5]dec-6-en-1-one (18): yellow oil; yield 85%; IR 1675, 1490, 1400 cm^{-1}; ^{1}H NMR (C_6D_6) major isomer **18a** (C_6D_6) δ 0.98 (d, J = 7.0 Hz, 3H); minor isomer **18b** δ 0.91 (d, J = 7.0 Hz, 3H); for both isomers δ 1.20−1.70 (m, 8H), 1.80−2.00 (m, 1H), 2.00−2.20 (m, 2H), 2.40−3.00 (m, 6H), 2.52 (s, 3H), 5.00 (m, 1H); ^{13}C NMR (C_6D_6) major isomer **18a** (C_6D_6) δ 15.8 (q), 18.7 (t), 24.0 (t), 24.6, (2t), 29.7 (t), 37.8 (t), 38.8 (d), 40.0 (t), 50.5 (2t), 55.1 (s), 108.5 (d), 144.5 (s), 177.7 (s); minor isomer **18b** δ 13.0 (q), 21.4 (t), 24.0 (t), 25.0 (2t), 29.5 (t), 34.8 (q), 39.1 (d), 41.7 (t), 51.9 (2t), 53.8 (s), 109.2 (d), 144.5 (s), 177.7 (s); MS m/z 248 (M^+, 50), 219 (20), 195 (30), 178 (55), 150 (30), 126 (40), 110 (100), 97 (50). Anal. Calcd for $C_{15}H_{24}N_2O$: C, 72.54; H, 9.74; N, 11.28. Found: C, 74.51; H, 9.61; N, 11.21.

2,4-Dimethyl-6-piperidino-2-azaspiro[4.4]non-6-en-1-one (19): yellow oil; yield 65%; IR 1680, 1610, 1495, 1400, 1260 cm^{-1}; ^{1}H NMR (C_6D_6) major isomer **19a** (C_6D_6) δ 0.92 (d, J = 7.0 Hz, 3H); minor isomer **19b** δ 0.85 (d, J = 7.0 Hz, 3H); for both isomers δ 1.40−1.55 (m, 4H), 1.55−2.07 (m, 2H), 2.20−2.32 (m, 4H), 2.62 (t, J = 9.0 Hz, 1H), 2.70−3.00 (m, 6H), 3.60 (dd, J = 9.0 and 6.0 Hz, 2H), 4.10 (dd, J = 9.0 and 6.0 Hz, 1H), 4.90−5.02 (m, 2H), 5.50−5.65 (m, 1H); ^{13}C NMR (C_6D_6) major isomer **19a** δ 15.9 (q), 20.1 (t), 25.04 (2t), 27.3 (t), 37.6 (d), 38.9 (t), 46.9 (t), 50.6 (2t), 50.7 (t), 61.3 (s), 102.9 (d), 116.5 (t), 135.0 (d), 148.5 (s), 177.3 (s); minor isomer **19b** δ 11.7 (q), 21.2 (t), 24.9 (2t), 30.1 (t), 36.5 (d), 40.0 (t), 44.2 (t), 48.9 (2t), 51.8 (t), 60.2 (s), 100.1 (d), 117.3 (t), 131.4 (d), 145.0 (s), 176.5 (s); MS m/z 274 (M^+, 30), 233 (52), 219 (58), 191 (20), 130 (100), 83 (45). Anal. Calcd for $C_{17}H_{26}N_2O$: C, 74.41; H, 9.54; N, 10.20. Found: C, 74.57; H, 9.32; N, 10.55.

2-Allyl-6-(benzylimino)-4-methyl-2-azaspiro[4.4]nonan-1-one (22): yellow oil; yield 81%; R_f 0.38 (PE/AcOEt 95/05); IR 1680, 1610, 1480 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 1.01 (d, J = 6.8 Hz, 3H), 1.65−1.75 (m, 1H), 1.80−1.95 (m, 1H), 2.00−2.50 (m, 5H), 3.13 (dd, J = 9.5 and 9.5 Hz, 1H), 3.38 (dd, J = 9.5 and 9.5 Hz, 1H), 3.80 (m, 1H), 4.05 (m, 1H), 4.45 (d, J = 6.5 Hz, 2H), 5.00−5.30 (m, 2H), 5.55−5.75 (m, 1H), 7.15−7.35 (m, 5H); ^{13}C NMR ($CDCl_3$) δ 12.2 (q), 22.4 (t), 30.5 (t), 33.9 (t), 39.2 (d), 45.3 (t), 51.5 (t), 57.1 (t), 60.1 (s), 117.0 (t), 126.1 (d), 127.5 (2d), 128.4 (2d), 132.6 (d), 140.3 (s), 176.6 (d), 178.9 (s); MS m/z 296 (M^+, 20), 281 (15), 203 (80), 201 (30), 200 (100), 147 (20), 91 (60). Anal. Calcd for $C_{19}H_{24}N_2O$: C, 76.99; H, 8.16; N, 9.45. Found: C, 77.10; H, 8.21; N, 9.39.

6-(Benzylimino)-2,4-dimethyl-2-azaspiro[4.4]nonan-1-one (23): yellow oil; yield 76%; R_f 0.38 (PE/AcOEt 70/30); IR 1680, 1480, 1420 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 0.98 (d, J = 6.9 Hz, 3H), 1.62−2.50 (m, 7H), 2.84 (s, 3H), 2.80 (dd, J = 9.4 and 4.2 Hz, 1H), 3.62 (dd, J = 9.4 and 4.2 Hz, 1H), 4.45 (d, J = 8.5 Hz, 2H), 7.25−7.35 (m, 5H); ^{13}C NMR ($CDCl_3$) δ 15.01 (q), 21.6 (t), 29.6 (t), 29.9 (q), 34.8 (t), 39.1 (d), 54.7 (t), 57.0 (t), 60.2 (s), 126.3 (d), 127.1 (2d), 128.5 (2d), 140.2 (s), 176.8 (s), 179.5 (s); MS m/z 270 (M^+, 20), 600 (60), 179 (22), 170 (30), 91 (100). Anal. Calcd for $C_{17}H_{22}N_2O$: C, 75.52; H, 8.20; N, 10.36. Found: C, 75.61; H, 8.27; N, 10.41.

6-(Benzylimino)-2-methyl-4-methylene-2-azaspiro-[4.4]nonan-1-one (24): yellow oil; yield 77%; R_f 0.35 (PE/AcOEt 70/30); IR 1660, 1490, 1455 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 1.65−2.05 (m, 3H), 2.15−2.50 (m, 3H), 2.92 (s, 3H), 3.85 (dt, J = 13.2 and 1.8 Hz, 1H), 4.17 (dt, J = 13.2, 2.3 Hz, 1H), 4.48 (s, 2H), 4.97 (t, J = 2.2 Hz, 1H), 5.07 (t, J = 2.1 Hz, 1H), 7.10−7.35 (m, 5H); ^{13}C NMR ($CDCl_3$) δ 22.4 (t), 28.8 (t), 29.4 (q), 34.4 (t), 53.7 (t), 56.9 (t), 60.7 (s), 106.5 (t), 126.2 (d), 126.7 (2d), 128.0 (2d), 139.8 (s), 147.0 (s), 175.1 (s), 181.2 (s). Anal. Calcd for $C_{17}H_{20}N_2O$: C, 76.08; H, 7.51; N, 10.44. Found: C, 76.19; H, 7.57; N, 10.51.

2-Allyl-4-methyl-6-(benzylimino)-2-azaspiro[4.5]decan-1-one (25): yellow oil; yield 95%; R_f 0.30 (PE/AcOEt 70/30); IR 1680, 1635, 1480 cm^{-1}; ^{1}H NMR ($CDCl_3$) δ 1.02 (d, J = 7.0 Hz, 3H), 1.50−2.40 (m, 9H), 2.93 (dd, J = 9.3 and 9.3 Hz, 1H), 3.12 (dd, J = 9.0 and 7.7 Hz, 1H), 3.75−4.00 (m, 2H), 4.50 (m, 2H), 5.10 (m, 2H), 5.60−5.70 (m, 1H), 7.25−7.35 (m, 5H); ^{13}C NMR ($CDCl_3$) δ 15.4 (q), 21.17 (t), 24.0 (t), 28.6 (t), 35.5 (t), 41.3 (d), 45.6 (t), 51.5 (t), 53.7 (t), 57.3 (t), 117.3 (t), 126.2 (d), 127.9 (2d), 128.4 (2d), 133.0 (d), 140.9 (s), 170.3 (s), 177.5 (s); MS m/z 310 (M^+, 25), 295 (15), 281 (10), 219 (80), 214 (100), 106 (21), 91 (70). Anal. Calcd for $C_{20}H_{26}N_2O$: C, 77.38; H, 8.44; N, 9.02. Found: C, 77.44; H, 8.43; N, 9.01.

(−)-(4*R*,5*R*)-2-Allyl-4-methyl-6-[(*R*)-(1-phenylethyl)-imino]-2-azaspiro[4.4]nonan-1-one [(−)-26a′]: white solid; yield 69%; R_f 0.35 (PE/AcOEt 70/30); mp = 58 °C; $[\alpha]^{22}_D$ = −117

(*c* 5, ethanol); IR 1680, 1480, 1440 cm^{-1}; ^1H NMR ($CDCl_3$) δ 1.12 (d, J = 6.8 Hz, 3H), 1.41 (d, J = 6.6 Hz, 3H), 1.65−1.77 (m, 1H), 1.80−1.95 (m, 1H), 2.03−2.17 (m, 1H), 2.23−2.40 (m, 4H), 3.16 (dd, J = 8.3 and 8.3 Hz, 1H), 3.52 (dd, J = 10.0 and 8.8 Hz, 1H), 3.70 (ddt, J = 15.6 Hz, 6.0 and 1.3 Hz, 1H), 4.18 (ddt, J = 15.6, 4.9 and 1.5 Hz, 1H), 4.50 (q, J = 6.6 Hz, 1H), 5.10 (m, 1H), 5.26 (m, 1H), 5.55−5.70 (m, 1H), 7.15−7.30 (m, 5H); ^{13}C NMR ($CDCl_3$) δ 12.0 (q), 22.72 (t), 24.9 (q), 29.9 (t), 33.6 (t), 39.2 (d), 45.6 (t), 51.8 (t), 59.2 (s), 61.9 (d), 117.2 (t), 126.3 (d), 126.4 (2d), 128.0 (2d), 132.9 (d), 145.6 (s), 176.4 (s), 176.7 (s); MS *m*/*z* 310 (M^+, 17), 281 (41), 214 (100), 207 (80), 152 (34), 110 (49), 105 (94). Anal. Calcd for $C_{20}H_{26}N_2O$: C, 77.38; H, 8.44; N, 9.02. Found: C, 77.42; H, 8.46; N, 9.02.

(+)-(4*S*,5*S*)-2-Allyl-4-methyl-6-[(*R*)-(1-phenylethyl)-imino]-2-azaspiro[4.4]nonan-1-one [(+)-26a″]: white solid; yield 21%; R_f 0.30 (PE/AcOEt 70/30); mp = 58 °C; $[\alpha]^{22}_D$ = +34 (*c* 1.5, ethanol); IR 1680, 1480, 1440 cm^{-1}; ^1H NMR ($CDCl_3$) δ 0.80 (d, J = 6.8 Hz, 3H), 1.37 (d, J = 6.6 Hz, 3H), 1.58−1.68 (m, 1H), 1.70−1.85 (m, 1H), 2.03−2.55 (m, 1H), 2.01−2.55 (m, 4H), 3.10 (dd, J = 8.3 and 8.3 Hz, 1H), 3.45 (dd, J = 10.0 and 8.8 Hz, 1H), 3.70 (ddt, J = 15.7, 6.0 and 1.3 Hz, 1H), 4.22 (ddt, J = 15.7, 4.9 and 1.5 Hz, 1H), 4.40 (q, J = 6.6 Hz, 1H), 5.18 (m, 1H), 5.42 (m, 1H), 5.73−5.87 (m, 1H), 7.15−7.30 (m, 5H); ^{13}C NMR ($CDCl_3$) δ 11.8 (q), 22.6 (t), 24.8 (q), 29.9 (t), 33.5 (t), 39.4 (d), 45.4 (t), 51.7 (t), 59.3 (s), 62.8 (d), 116.9 (t), 126.3 (d), 126.6 (2d), 128.1 (2d), 132.6 (d), 146.0 (s), 176.2 (s), 176.6 (s); MS *m*/*z* 310 (M^+, 17), 281 (41), 214 (100), 207 (80), 152 (34), 110 (49), 105 (94). Anal. Calcd for $C_{20}H_{26}N_2O$: C, 77.38; H, 8.44; N, 9.02. Found: C, 77.44; H, 8.49; N, 9.07.

(−)-(4*R*,5*R*)-2,4-Dimethyl-6-[(*R*)-(1-phenylethyl)imino]-2-azaspiro[4.4]nonan-1-one [(−)-27a′]: white solid; yield 58%; R_f 0.35 (PE/AcOEt 70/30); mp = 60 °C; $[\alpha]^{22}_D$ = −47 (*c* 2.5, ethanol); IR 1675, 1490, 1450, 1430 cm^{-1}; ^1H NMR ($CDCl_3$) δ 1.10 (d, J = 6.9 Hz, 3H), 1.40 (d, J = 7.0 Hz, 3H), 1.63−1.73 (m, 1H), 1.75−1.90 (m, 1H), 2.00−2.15 (m, 1H), 2.20−2.45 (m, 4H), 2.88 (s, 3H), 3.20 (dd, J = 8.0 and 8.0 Hz, 1H), 3.42 (dd, J = 8.0 and 8.0 Hz, 1H), 4.45 (m, 1H), 7.12−7.36 (m, 5H); ^{13}C NMR ($CDCl_3$) δ 12.8 (q), 23.5 (t), 25.6 (q), 30.5 (q), 30.6 (t), 34.2 (t), 39.9 (d), 54.9 (s), 59.8 (t), 126.2 (d), 126.9 (d), 126.9 (2d), 128.8 (2d), 146.4 (s), 177.2 (s), 177.8 (s); MS *m*/*z* 284 (M^+, 47), 214 (91), 180 (23), 165 (17), 126 (45), 110; (52), 105 (100). Anal. Calcd for $C_{18}H_{24}N_2O$: C, 76.02; H, 8.50; N, 9.85. Found: C, 76.08; H, 8.55; N, 9.86.

(−)-(4*S*,5*S*)-2,4-Dimethyl-6-[(*R*)-(1-phenylethyl)imino]-2-azaspiro[4.4]nonan-1-one [(−)-27a″]: white solid; yield 19%; R_f 0.30 (PE/AcOEt 70/30); mp = 112 °C; $[\alpha]^{22}_D$ = −3.6 (*c* 1.5, ethanol); IR 1670, 1490 cm^{-1}; ^1H NMR ($CDCl_3$) δ 0.83 (d, J = 6.8 Hz, 3H), 1.35 (d, J = 7.0 Hz, 3H), 1.63−1.73 (m, 1H), 1.75−1.90 (m, 1H), 2.00−2.55 (m, 5H), 2.93 (s, 3H), 3.17 (dd, J = 8.0 and 8.0 Hz, 1H), 3.49 (dd, J = 10.0 and 8.0 Hz, 1H), 4.40 (q, J = 6.7 Hz, 1H), 7.12−7.36 (m, 5H); ^{13}C NMR ($CDCl_3$) δ 12.8 (q), 23.4 (t), 25.5 (q), 30.6 (q), 30.8 (t), 34.4 (t), 40.2 (d), 54.9 (t), 60.0 (s), 63.4 (d), 127.1 (d), 127.4 (2d), 128.8 (2d), 146.9 (s), 177.0 (s), 177.9 (s); MS *m*/*z* 284 (M^+, 74), 214 (91), 180 (23), 126 (45), 110 (52), 105 (100). Anal. Calcd for $C_{18}H_{24}N_2O$: C, 76.02; H, 8.51; N, 9.85. Found: C, 76.12; H, 8.60; N, 9.92.

(+)-(4*R*,5*R*)-2-Allyl-4-methyl-6-[(*R*)-(1-phenylethyl)-imino]-2-azaspiro[4.5]decan-1-one [(+)-28a′]: white solid; yield 72%; R_f 0.35 (PE/AcOEt 70/30); mp = 57 °C; $[\alpha]^{22}_D$ = +62 (*c* 1.5, ethanol); IR 1680, 1480, 1440 cm^{-1}; ^1H NMR ($CDCl_3$) δ 0.85 (d, J = 7.0 Hz, 3H), 1.41 (d, J = 7.0 Hz, 3H), 1.50−2.00 (m, 6H), 2.12−2.38 (m, 2H), 2.80−2.88 (m, 1H), 2.98 (m, 1H), 3.10 (m, 1H), 3.75−3.85 (m, 1H), 4.06−4.15 (m, 1H), 4.70 (q, J = 7.0 Hz, 1H), 5.12−5.30 (m, 2H), 5.75−5.90 (m, 1H), 7.15−7.25 (m, 5H); ^{13}C NMR ($CDCl_3$) δ 15.4 (q), 21.85 (t), 24.8 (t), 25.7 (q), 28.9 (t), 36.2 (t), 42.4 (d), 46.4 (t), 52.2 (t), 55.7 (s), 59.2 (d), 118.0 (t), 127.1 (d), 127.6 (2d), 128.8 (2d), 138.8 (d), 174.0 (s), 168.5 (s), 178.2 (s); MS *m*/*z* 324 (M^+, 40), 309 (10), 228 (90), 219 (100), 124 (40), 105 (57). Anal. Calcd for $C_{21}H_{28}N_2O$: C, 77.73; H, 8.70; N, 8.63. Found: C, 77.49; H, 8.75; N, 8.67.

(−)-(4*R*,5*R*)-2-Allyl-4-methyl-6-[(*R*)-(1-phenylethyl)-imino]-2-azaspiro[4.5]decan-1-one [(−)-28a″]: white solid; yield 22.5%; R_f 0.30 (PE/AcOEt 70/30); mp = 54 °C; $[\alpha]^{22}_D$ = −99 (*c* 1.5, ethanol); IR 1680, 1645 cm^{-1}; ^1H NMR ($CDCl_3$) δ 1.20 (d, J= 7.0 Hz, 3H), 1.35 (d, J = 7.0 Hz, 3H), 1.48−1.80 (m, 4H), 1.85−2.00 (m, 1H), 2.00−2.15 (m, 1H), 2.20−2.35 (m, 2H), 2.70 (m, 1H), 3.05−3.12 (m, 2H), 3.82 (m, 1H), 4.05 (m, 1H), 4.77 (q, J = 7.0 Hz, 1H), 5.05−5.25 (m, 2H), 5.67−5.83 (m, 1H), 7.15 (m, 1H), 7.25 (m, 4H); ^{13}C NMR ($CDCl_3$) δ 15.6 (q), 21.8 (t), 24.8 (t), 26.0 (q), 28.7 (t), 36.0 (t), 42.0 (d), 46.3 (t), 52.3 (t), 57.6 (s), 58.1 (d), 117.9 (t), 126.8 (d), 127.1 (2d), 128.8 (2d), 133.9 (d), 146.9 (s), 168.5 (s), 178.1 (s); MS *m*/*z* 324 (M^+, 40), 309 (10), 228 (90), 219 (100), 124 (40), 105 (75). Anal. Calcd for $C_{21}H_{28}N_2O$: C, 77.43; H, 8.70; N, 8.63. Found: C, 77.44; H, 8.72; N, 8.70.

Hydrolysis. To a solution of an imine or a mixture of enamines **a**/**b** (0.5 mmol) in THF (5 mL) was added aqueous acetic acid (50%, 0.5 mL). After 2 h at reflux, the reaction mixture was extracted with ether (2 × 10 mL). The organic phase was washed with water (5 mL) and dried over $MgSO_4$. The solvent was removed in *vacuo*, and the residue was purified by flash chromatography. Ketones **a** and **b** arising from enamines **14**, **15**, **17**, and **19** could not be separated. However, the ^1H NMR spectra of the mixture of ketones **29a**,**b**, **30a**,**b**, and **33a**,**b** allowed one to distinguish, without any ambiguity, the spectra of the major isomer **a** and the minor isomer **b**.[14]

2-Allyl-4-methyl-2-azaspiro[4.4]nonane-1,6-dione (29) [from **14a**,**b**, **19a**,**b**, **22**, (−)-**26a′**, (+)-**26a″**]. (±)-**29a**, (−)-**29a**, and (+)-**29a**: yellow oils; R_f 0.35 (PE/AcOEt 70/30); IR 1740, 1690, 1480 cm^{-1}; ^1H NMR ($CDCl_3$) δ 1.02 (d, J = 7.0 Hz, 3H), 2.85 (dd, J = 9.4 and 4.3 Hz, 1H), 3.69 (dd, J = 9.4 and 8.2 Hz, 1H), 1.80−2.05 (m, 2H), 2.15−2.45 (m, 4H), 2.62 (m, 1H), 3.80−4.00 (m, 2H), 5.10−5.25 (m, 2H), 5.64−5.80 (m, 1H); ^{13}C NMR ($CDCl_3$) δ 15.5 (q), 19.3 (t), 27.9 (t), 32.9 (d), 37.6 (t), 45.1 (t), 51.9 (t), 61.9 (s), 117.6 (t), 131.9 (d), 173.1 (s); 216.5 (s); MS *m*/*z* 207 (M^+, 37); 152 (100), 97 (30). Anal. Calcd for $C_{12}H_{17}NO_2$: C, 69.53; H, 8.26; N, 6.76. Found: C, 69.58; H, 8.37; N, 6.82. (−)-**29a**: $[\alpha]^{22}_D$ = −128 (*c* 2.5, ethanol). (+)-**29a**: $[\alpha]^{22}_D$ = +128 (*c* 2.5, ethanol). (±)-**29b**: yellow oil; R_f 0.35 (PE/AcOEt 70/30); IR 1740, 1690, 1480, 1430 cm^{-1}; ^1H NMR ($CDCl_3$) δ 1.09 (d, J = 7.0 Hz, 3H), 1.85−2.00 (m, 2H), 2.10−2.45 (m, 4H), 2.60 (m, 1H), 3.20−3.38 (m, 2H), 3.82−4.00 (m, 2H), 5.20 (m, 2H), 5.67−5.80 (m, 1H); ^{13}C NMR ($CDCl_3$) δ 12.3 (q), 20.1 (t), 32.3 (t), 38.3 (d), 39.6 (d), 45.2 (t), 51.2 (t), 62.0 (s), 117.4 (t), 131.9 (d), 173.1 (s), 216.5 (s); MS *m*/*z* 207 (M^+, 37), 152 (100), 97 (36). Anal. Calcd for $C_{12}H_{17}NO_2$: C, 69.53; H, 8.27; N, 6.76. Found: C, 69.53; H, 8.35; N, 6.80.

2,4-Dimethyl-2-azaspiro[4.4]nonane-1,6-dione (30) [from **15a**,**b**, **23**, (−)-**27a′**, (−)-**27a″**]. (±)-**30a**, (−)-**30a**, and (+)-**30a**: yellow oils; R_f 0.30 (PE/AcOEt 70/30); IR 1730, 1675, 1490, 1430 cm^{-1}; ^1H NMR ($CDCl_3$) δ 1.01 (d, J = 7.0 Hz, 3H), 1.84−2.06 (m, 2H), 2.10−2.42 (m, 4H), 2.52−2.62 (m, 1H), 2.85 (s, 3H), 3.30 (m, 2H); ^{13}C NMR ($CDCl_3$) δ 15.6 (q), 19.5 (t), 28.0 (t), 29.9 (q), 33.0 (d), 37.7 (t), 54.7 (t), 62.5 (s), 173.9 (s), 216.0 (s); MS *m*/*z* 181 (M^+, 68), 140 (17), 126 (100), 111 (20), 98 (20). Anal. Calcd for $C_{10}H_{15}NO_2$: C, 66.27; H, 8.34; N, 7.72. Found: C, 66.37; H, 8.37; N, 7.71. (−)-**30a**: $[\alpha]^{22}_D$ = −94 (*c* 1.7, ethanol). (+)-**30a**: $[\alpha]^{22}_D$ = +94 (*c* 1.6, ethanol). (±)-**30b**: yellow oil; R_f 0.30 (PE/AcOEt 70/30); IR 1730, 1675, 1490, 1430, 1400 cm^{-1}; ^1H NMR ($CDCl_3$) δ 1.05 (d, J = 7.0 Hz, 3H), 1.90 (m, 2H), 2.10−2.40 (m, 4H), 2.55 (m, 1H), 2.87 (m, 3H), 3.20−3.30 (m, 2H); ^{13}C NMR ($CDCl_3$) δ 13.23 (q), 20.96 (t), 30.53 (q), 32.92 (t), 39.06 (d), 40.32 (t), 54.44 (t), 62.45 (s), 174.04 (s), 217.15 (s); MS *m*/*z* 181 (M^+, 68), 126 (100), 111 (20), 98 (20), 71 (42). Anal. Calcd for $C_{10}H_{15}NO_2$: C, 66.27; H, 8.34; N, 7.72. Found: C, 66.35; H, 8.33; N, 7.69.

2,8,8-Trimethyl-4-methylene-2-azaspiro[4.4]nonane-1,6-dione (31) [from **16**]: yellow oil; R_f 0.33 (PE/AcOEt 60/40); IR 1740, 1690, 1660, 1430, 1410 cm^{-1}; ^1H NMR ($CDCl_3$) δ 1.15 (s, 3H), 1.25 (s, 3H), 1.90 (d, J = 14.0 Hz, 1H), 2.35 (m, 1H), 2.55 (d, J = 14.0 Hz, 1H), 2.95 (s, 3H), 3.85 (dt, J = 13.5 and 2.0 Hz, 1H), 4.28 (dt, J = 13.5 and 2.1 Hz, 1H), 5.10 (t, J = 2.0 Hz, 1H), 5.17 (t, J = 2.0 Hz, 1H); ^{13}C NMR ($CDCl_3$) δ 28.87 (q), 29.60 (q), 29.69 (q), 33.11 (t), 45.71 (t), 53.08 (t), 53.67 (s), 65.08 (s), 107.91 (t), 144.25 (s), 171.82 (s), 211.97 (s); MS

(14) Cossy, J.; Bouzide, A. *Tetrahedron* **1997**, *53*, 5775−5784.

m/e 207 (M^+, 20), 125 (9), 124 (100), 107 (8), 81 (8), 77 (10). Anal. Calcd for $C_{12}H_{17}NO_2$: C, 69.53; H, 8.27; N, 6.76. Found: C, 69.61; H, 8.42; N, 6.88.

2-Methyl-4-methylene-2-azaspiro[4.4]nonane-1,6-dione (32) [from **24**]: yellow oil; R_f 0.55 (PE/AcOEt 20/80); IR 1740, 1680, 1650, 1485, 1425 cm^{-1}; ^1H NMR ($CDCl_3$) δ 1.90−2.15 (m, 2H), 2.25−2.45 (m, 2H), 2.60−2.70 (m, 2H), 2.95 (s, 3H), 3.85 (dt, J = 13.5 and 1.8 Hz, 1H), 4.17 (dt, J = 13.5 and 2.5 Hz, 1H), 5.03 (t, J = 2.0 Hz, 1H), 5.11 (t, J = 2.0 Hz, 1H); ^{13}C NMR ($CDCl_3$) δ 20.20 (t), 29.66 (q), 32.87 (t), 37.90 (t), 53.56 (t), 63.30 (s), 108.01 (t), 143.96 (s), 172.05 (s), 213.95 (s); MS *m/e* 179 (M^+, 40), 150 (24), 138 (20), 124 (100), 87 (59), 85 (91). Anal. Calcd for $C_{10}H_{13}NO_2$: C, 67.01; H, 7.31; N, 17.85. Found: C, 67.05; H, 7.35; N, 17.82.

2-Allyl-4-methyl-2-azaspiro[4.5]decane-1,6-dione (33) [from **17a**,**b**, **25**, (+)-**28a′**, (−)-**28a″**]. (±)-**33a**, (+)-**33a**, (−)-**33a**: yellow oils; R_f 0.35 (PE/AcOEt 70/30); IR 1700, 1675, 1495, 1455 cm^{-1}; ^1H NMR ($CDCl_3$) δ 1.09 (d, J = 7.0 Hz, 3H), 1.54−1.92 (m, 4H), 2.00−2.28 (m, 4H), 2.40−2.60 (m, 1H), 3.00−3.27 (m, 2H), 3.70−3.93 (m, 2H), 4.98−5.25 (m, 2H), 5.52−5.78 (m, 1H); ^{13}C NMR ($CDCl_3$) δ 13.8 (q), 20.9 (t), 24.3 (t), 34.23 (t), 39.2 (d), 41.5 (t), 45.2 (t), 51.3 (t), 61.6 (s), 117.4 (t), 131.9 (d), 173.5 (s), 208.6 (s); MS *m/z* 221 (M^+, 37), 193 (25), 165 (30), 152 (100), 97 (30). Anal. Calcd for $C_{13}H_{19}NO_2$: C, 70.55; H, 8.65; N, 6.33. Found: C, 70.49; H, 8.72; N, 6.29. (−)-**33a**: $[\alpha]^{22}_D = -33$ (*c* 3.5, ethanol). (+)-**33a**: $[\alpha]^{22}_D = +34$ (*c* 3.5, ethanol). (±)-**33b**: R_f 0.35 (PE/AcOEt 70/30); IR 1700, 1675, 1495, 1455 cm^{-1}; ^1H NMR ($CDCl_3$) δ 0.99 (d, J = 7.0 Hz, 3H), 1.63−1.79 (m, 3H), 1.95−2.14 (m, 2H), 2.17−2.30 (m, 1H), 2.38−2.50 (m, 1H), 2.83 (dd, J = 9.5 and 7.0 Hz, 1H), 2.96−3.10 (m, 2H), 3.35 (dd, J = 9.5 and 7.0 Hz, 1H), 3.83−3.93 (m, 2H), 5.13−5.21 (m, 2H), 5.63−5.87 (m, 1H); ^{13}C NMR ($CDCl_3$) δ 13.4 (q), 20.6 (t), 26.76 (t), 30.2 (t), 31.5 (d), 40.3 (t), 45.3 (t), 50.4 (t), 61.5 (t), 117.8 (t), 132.0 (d), 172.4 (s), 200.3 (s); MS *m/z* 221 (M^+, 37), 193 (25), 165 (30), 152 (100), 97 (30). Anal. Calcd for $C_{13}H_{19}NO_2$: C, 70.55; H, 8.65; N, 6.33. Found: C, 70.50; H, 8.80; N, 6.39.

2,4-Dimethyl-2-azaspiro[4.5]decane-1,6-dione (34) (hydrolysis of **18a**,**b**, followed by flash chromatography separation). **34a**: yellow oil; R_f 0.29 (PE/AcOEt 70/30); IR 1700, 1675, 1490 cm^{-1}; ^1H NMR ($CDCl_3$) δ 1.15 (d, J = 7.0 Hz, 3H), 1.62−1.98 (m, 4H), 2.08−2.33 (m, 4H), 2.50−2.65 (m, 1H), 2.85 (s, 3H), 3.33 (dd, J = 6.9 and 6.9 Hz, 1H), 3.62 (dd, J = 6.9 and 1.2 Hz, 1H); ^{13}C NMR ($CDCl_3$) δ 14.0 (q), 21.0 (t), 24.5 (t), 29.8 (q), 34.4 (t), 39.4 (d), 41.7 (t), 54.0 (t), 61.5 (s), 173.9 (s), 209.0 (s); MS *m/z* 195 (M^+, 50), 167 (14), 152 (16), 71 (100). Anal. Calcd. for $C_{11}H_{17}NO_2$: C, 67.66; H, 8.77; N, 7.17. Found: C, 67.72; H, 8.83; N, 7.27. **34b**: R_f 0.55 (PE/AcOEt); IR 1700, 1675, 1490, 1430, cm^{-1}; ^1H NMR ($CDCl_3$) δ 0.98 (d, J = 7.0 Hz, 3H), 1.60−1.75 (m, 3H), 1.90−2.30 (m, 4H), 2.35−2.42 (m, 1H), 2.83 (s, 3H), 2.90−3.10 (m, 2H), 3.30 (m, 1H); ^{13}C NMR ($CDCl_3$) δ 13.6 (q), 20.7 (t), 26.8 (t), 29.6 (d), 29.9 (t), 31.6 (q), 40.4 (t), 53.3 (t), 61.3 (s), 172.8 (s), 208.5 (s); MS *m/z* 195 (M^+, 50), 181 (8), 167 (14), 152 (16), 139 (24), 126 (35), 110 (10), 71 (100). Anal. Calcd. for $C_{11}H_{17}NO_2$: C, 67.66; H, 8.77; N, 7.17. Found: C, 67.78; H, 8.65; N, 7.11.

Alkylation of the Enamino Spirolactam 17. A solution of compound **17** (0.27 g, 1 mmol) in benzene (5 mL) was added dropwise to methyl vinyl ketone (0.14 g, 2 mmol), and the reaction mixture was stirred at rt for 15 h. After evaporation of the solvent, the residue was purified by flash chromatography.

2-Allyl-4-methyl-7-(3-oxobutyl)-6-pyrrolidino-2-azaspiro[4.5]dec-6-en-1-one (20): yellow oil; yield 53%; R_f 0.25 (PE/AcOEt 70/30); IR 1710, 1685, 1675, 1640, 1475, 1440, 1410, 1350, 1260, 1160 cm^{-1}; ^1H NMR ($CDCl_3$) δ 1.11 (d, J = 7.0 Hz, 3H), 1.45−1.80 (m, 8H), 1.90−2.40 (m, 6H), 2.16 (s, 3H), 2.50−2.60 (m, 2H), 2.90−3.05 (m, 4H), 3.20−3.25 (m, 1H), 3.90 (m, 2H), 5.12−5.25 (m, 2H), 5.62−5.80 (m, 1H); ^{13}C NMR ($CDCl_3$) δ 15.6 (q), 18.4 (t), 25.8 (2t), 26.1 (t), 28.9 (t), 29.8 (q), 35.9 (t), 40.5 (d), 41.9 (t), 45.7 (t), 52.4 (t), 52.7 (2t), 54.4 (s), 117.6 (t), 132.8 (d), 135.3 (s), 139.72 (s), 178.2 (s), 208.3 (s); MS *m/z* 344 (M^+, 37), 326 (7), 301 (67), 287 (100), 273 (35), 190 (20), 160 (11). Anal. Calcd for $C_{21}H_{32}N_2O_2$: C, 73.22; H, 9.36; N, 8.13. Found: C, 73.31; H, 9.44; N, 8.22.

Hydrolysis of Enamino Lactam 20. To a solution of compound **20** (0.17 g, 0.5 mmol) in THF (5 mL) was added aqueous acetic acid (50%) (0.5 mL). After 2 h at reflux, the reaction mixture was extracted with ether (2 × 10 mL). The organic phase was washed with water (5 mL), dried over $MgSO_4$, and filtered. The solvent was removed in *vacuo*, and the residue was purified by flash chromatography, yielding dione **21** as an isomeric mixture.

2-Allyl-4-methyl-7-(3-oxobutyl)-2-azaspiro[4.5]decane-1,6-dione (21): yellow oil; yield 67%; R_f 0.22 (PE/AcOEt 70/30); IR 1710, 1680, 1640, 1480 cm^{-1}; ^1H NMR ($CDCl_3$) δ 1.05 (d, J = 7.0 Hz, 3H), 1.50−2.80 (m, 7H), 2.13 (s, 3H), 2.23−2.41 (m, 3H), 2.52 (t, J = 7.0 Hz, 2H), 2.90 (dd, J = 9.5 and 7.5 Hz, 1H), 3.30 (dd, J = 9.5 and 7.4 Hz, 1H), 3.80−4.00 (m, 2H), 5.15−5.30 (m, 2H), 5.65−5.85 (m, 1H); ^{13}C NMR ($CDCl_3$) δ 15.8 (q), 20.9 (t), 23.7 (t), 29.7 (q), 30.8 (t), 34.2 (t), 38.6 (d), 40.8 (t), 45.4 (t), 49.2 (d), 51.2 (t), 62.1 (s), 117.8 (t), 132.3 (d), 174.0 (s), 208.7 (s), 209.8 (s); MS *m/z* 291 (M^+, 25), 273 (40), 234 (90), 221 (35), 206 (25), 195 (100), 152 (90), 137 (20), 97 (50), 82 (40). Anal. Calcd for $C_{17}H_{25}NO_3$: C, 70.07; H, 8.64; N, 4.80. Found: C, 70.12; H, 8.59; N, 4.75.

X-ray Determination. X-ray data were collected at 18 °C on an Enraf-Nonius CAD-4F diffractometer with Mo Kα radiation (graphite monochromator). Computations were performed by using CRYSTALS adapted to a Micro Vax II. The structures were solved by direct methods using the SHELX-86 program and subsequent Fourier maps.

Supporting Information Available: ^1H NMR spectra of **1**, **2**, **3** and **7**, ORTEP drawings for (−)-**26a′** and (+)-**26a″**, and details of the data acquisition (17 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.

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