prepared from ent-4 following the O-acetylation procedure described for the preparation of 8. Pure 12 was obtained as a colorless oil after purification of the crude product by flash chromatography (eluent Et_2O) in 92% yield: ^1H NMR (DMSO-d_6) δ 1.48 (s, 3 H), 1.51 (s, 3 H), 2.04 (s, 3 H), 2.10 (s, 3 H), 2.48 (s, 3 H), 4.26 (m, $\Delta\nu$ = 8.0, 2 H), 4.38 (m, $\Delta\nu$ = 13.9 Hz, 1 H), 5.05 (d, J = 4.0 Hz, 1 H), 7.26–7.41 (4 H, aromatics); IR (CCl_4) 1748, 1670, 1380, 1220 cm^{-1}; MS m/z (relative intensity) 338 (M^+ + 1; 53), 280 (100), 238 (22), 220 (35).

(4*R*,5*R*)-4-(Acetoxymethyl)-5-[4-(methylthio)phenyl]-2-methyl-1,3-oxazoline (10a and 10b) from 12. Compound 12 (5 g; 14.8 mmol) was added under nitrogen at 25 °C to a stirred solution of CH_3SO_3H (3.7 g; 39.0 mmol) and Ac_2O (1.5 g; 15 mmol) in $CHCl_3$ (EtOH free, 10 mL). The solution (solution B) was heated at 35 °C for 20 min.

The solution was poured into a stirred solution of Et_2O (250 mL) and Et_3N (4.6 g; 45 mmol). Water (220 mL) was added to the mixture, and the organic phase was washed with 10% aqueous NH_4Cl solution (50 mL) and with water (50 mL). The organic extract was dried over sodium sulfate and evaporated under vacuum to give a **10a,b** mixture **10a/10b** = 97/3)[19] (3.96 g; 14.2 mmol; 96% yield). In a parallel experiment, solution B was kept at 35 °C for 16 h. After workup, a **10a,b** mixture **10a/10b** = 90/10) (3.92 g; 95% yield) was obtained.

Enantiomerically Pure (+)-(1*S*,2*R*)-2-Amino-3-[4-(methylthio)phenyl]-1,3-propanediol (11) from 7. Sodium hydroxide (1.76 g; 44 mmol) was added at room temperature to a suspension of crude 7 (10 g; 33.9 mmol) in water (17 mL); the suspension was heated at reflux with stirring for 8 h. Water (25 mL) was added to the solution and the mixture was cooled to 15 °C over 1 h. The mixture was filtered, and the insoluble material was washed with water (3 × 5 mL) and dried under vacuum to give crude 11 (6.65 g). Crystallization from toluene gave enantiomerically pure 11 (6.0 g; 83% yield): $[\alpha]_D^{20}$ −32.8° (*c* 2, HCl 0.1 N) (lit.[14] $[\alpha]_D^{20}$ −35°); mp 117–119 °C; ^1H NMR (DMSO-d_6) δ 2.45 (s, 3 H), 2.78 (ddd, J = 7.00, 6.23, 4.54 Hz, 1 H), 3.26 (dd, J = 10.44, 7.00 Hz, 1 H), 3.38 (dd, J = 10.44, 4.54 Hz, 1 H), 4.37 (d, J = 6.23 Hz, 1 H), 7.23–7.28 (4 H, aromatics).

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Registry No. 1, 15318-45-3; 2, 73231-34-2; (+)-3, 16854-32-3; (−)-3, 23150-35-8; 4, 135204-34-1; 4 deacetyl derivative, 135204-38-5; *ent*-4, 135761-07-8; 5, 135761-08-9; 6, 135204-36-3; 7, 135761-09-0; 8, 135204-55-6; 9a, 13571-10-3; 9b, 135761-12-5; 10a, 96795-26-5; 10b, 135761-11-4; 11, 27348-48-7; 12, 135761-13-6.

Cycloaddition of (*N*-Alkyl-*N*-phenylamino)ketene with Imines

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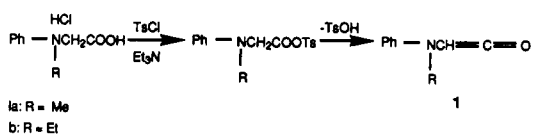
(*N*-Alkyl-*N*-phenylamino)ketenes were prepared in the presence of various imines, and a [2 + 2] cycloaddition reaction occurred to yield 3-(*N*-alkyl-*N*-phenylamino)-2-azetidinones. The size and electronic nature of the imine substituents were varied in order to probe those factors that influence the stereochemistry of the cycloaddition. The stereochemistry of the 2-azetidinone was determined by the substitution pattern of the imines. In general, the stereochemistry of the 2-azetidinone products are significantly influenced by the bulk of the N substituent on the imine. These results are discussed in terms of a two-step zwitterionic intermediate.

The 2-azetidinone (β-lactam) ring system is the center of reactivity of the penicillins and related antibiotics.[1-3] The first 2-azetidinone ring system was synthesized by Staudinger in 1907, but 2-azetidinones as a class of compounds became important only after it was established that penicillin contained a 2-azetidinone unit as the structural feature.[4,5]

The reaction of acid halides and imines serves as a general synthetic method to 2-azetidinones when the α-position of the acid halide contains an anion-stablizing group.[6-14] Examples of acid halides employed include

Scheme I



chloroacetyl chloride, azidoacetyl chloride, and phthaloylglycyl chloride. It is usually difficult to predict the stereochemistry of the products, as some reports describe the [2 + 2] cycloaddition to be stereospecific,[10,11,13] while others observe a mixture of *cis*- and *trans*-2-azetidinones.[7] Two different mechanisms have been proposed in the literature to explain the formation of the 2-azetidinones: (1) bonding of the imine nitrogen to the carbon atom of

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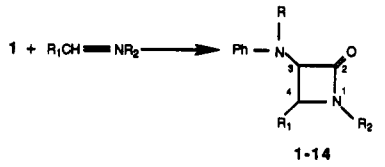
Scheme II



1-14

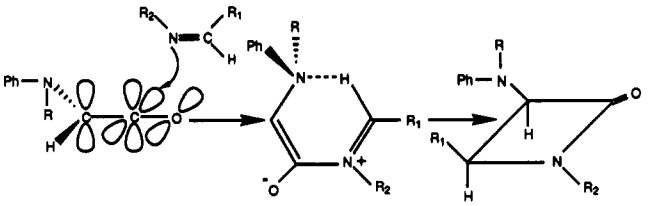
the carbonyl group of acyl chloride followed by ring closure in the presence of triethylamine[11,12,15-18] and (2) prior formation of a ketene by reaction of the acid chloride with base and subsequent cycloaddition of the ketene with the imine, via a zwitterionic intermediate.[18-25] Generally, the ketene pathway is assumed because treatment of an acid halide with triethylamine in the presence of an alkene results in the corresponding cyclobutanone by a [2 + 2] cycloaddition.

We describe an investigation of the cycloaddition of (*N*-alkyl-*N*-phenylamino)ketenes with various imines to yield 3-amino-2-azetidinones. The prime objective in initiating this work was to provide a systematic study of the cycloaddition of an aminoketene to imines. There are only a few scattered reports in the literature on the chemistry of aminoketenes, and these reports are limited to aminoketenes in which the nitrogen atom was substituted by an electron-withdrawing substituent such as succinoyl, maleyl, or phthaloyl group.[26] (*N*-Alkyl-*N*-phenylamino)ketenes are unusual ketenes because of the amino group and the large difference in the size of the two substituents bonded to the ketene functionality.

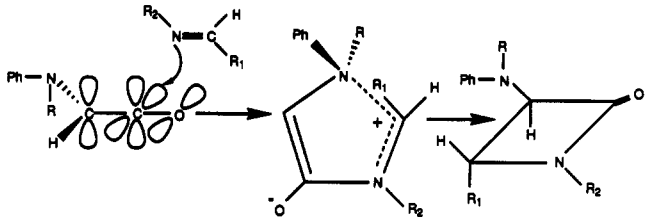
The conventional method of generating ketenes is treatment of an appropriate acid chloride with triethylamine. This method was unsuccessful for the generation of (*N*-alkyl-*N*-phenylamino)ketenes. An alternate method, as previously reported from this laboratory, involves treatment of the appropriate amino acid hydrochloride with *p*-toluenesulfonyl chloride.[27-30] A mixture of *N*-alkyl-*N*-phenylglycine hydrochloride and *p*-toluenesulfonyl chloride in benzene yields a mixed anhydride which in the presence of triethylamine undergoes elimination of *p*-toluenesulfonic acid to generate (*N*-alkyl-*N*-phenylamino)ketene 1 (Scheme I). We have previously demonstrated the intermediacy of the aminoketene by reaction of *N*-methyl-*N*-phenylglycine hydrochloride, *p*-toluenesulfonyl chloride, triethylamine, and an alkene to yield the corresponding cyclobutanone.[27]

Typically, *N*-alkyl-*N*-phenylglycine hydrochloride was

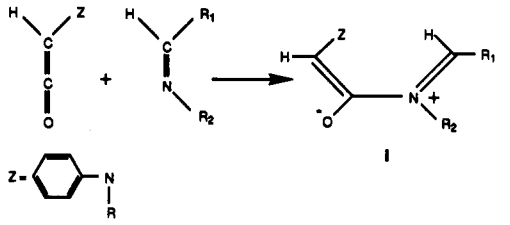
Scheme III



Scheme IV



Scheme V



I

Scheme VI

treated with 1 equiv of *p*-toluenesulfonyl chloride, 1 equiv of an imine, and 5 equiv of triethylamine in benzene at room temperature and stirred overnight. The corresponding 2-amino-2-azetidinones were obtained in moderate to good yield (Scheme II).

Various imines with different substitutents were prepared and used in this study as illustrated in Table I.

The structures of the 2-azetidinones were determined by IR and ^1H and ^{13}C NMR spectra. Attached proton test (APT) NMR experiments were performed to distinguish the different carbons. The stereochemistry at C_3 and C_4 of the 2-azetidinone rings was determined by ^1H NMR. Previous investigations have shown that coupling constants of vicinal protons in monocyclic azetidinones, $J_{cis} > J_{trans}$, may be used to distinguish the isomers.[31-33] The range of coupling constants in this study was 1.5–2.2 Hz for J_{trans} and 4.4–5.1 for J_{cis}. Only a single isomer (cis or trans) was observed in each cycloaddition reaction. Control experiments under the reaction conditions did not result in any isomerization of the 3-amino-2-azetidinones.

Molecular orbital studies suggest that nucleophilic attack of the imine will occur in the plane of the ketene and would involve reaction with the LUMO of the ketene.[34,35] The lone pair of electrons on the aniline nitrogen atom is in conjugation with the LUMO of the ketene in the ground state, so it is reasonable to assume the LUMO orbitals will be polarized in the direction of the aniline nitrogen for

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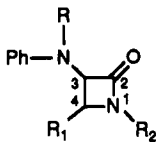
Table I. 3-(*N*-Alkyl-*N*-phenylamino)-2-azetidinone



compd	R	R_1	R_2	isomer	yield, %
1	Me	C_6H_5	$CH_2C_6H_5$	cis	66
2	Et	C_6H_5	$CH_2C_6H_5$	cis	60
3	Me	C_6H_5	o-$CH_3C_6H_4$	trans	57
4	Me	p-$CH_3OC_6H_4$	$CH_2C_6H_5$	cis	86
5	Me	o-$CH_3OC_6H_4$	$CH_2C_6H_5$	cis	59
6	Me	p-FC_6H_4	$CH_2C_6H_5$	cis	62
7	Me	p-ClC_6H_4	α-naphthyl	trans	73
8	Me	p-$NO_2C_6H_5$	α-naphthyl	trans	79
9	Me	p-ClC_6H_4	2,6-dimethyl-phenyl	trans	67
10	Me	p-$NO_2C_6H_4$	2,6-dimethyl-phenyl	trans	59
11	Me	p-$NO_2C_6H_4$	biphenylyl	cis	83
12	Me	α-naphthyl	p-$CH_3OC_6H_4$	cis	58
13	Me	α-naphthyl	C_6H_5	cis	84
14	Me	2,4,6-trimethyl-phenyl	p-$CH_3OC_6H_4$	cis	64

maximum overlap.[36] The stereochemistry of the products suggests that the p lobe on the sp-hybridized carbon of the aminoketene syn to the large amino group interacts with lone-pair electrons of the nitrogen atom of the imine. It is also reasonable to assume hydrogen bonding with the imine C-α hydrogen atom in the reaction involving the syn configuration of the imine (Scheme III). This hydrogen bond will help to stabilize the developing positive charge in the transition state.

In reactions involving the anti configuration of the imine, stabilization of the dipolar intermediate could occur as a result of the nitrogen atom of the ketene component donating a pair of electrons to the positive center of the dipolar intermediate (Scheme IV). The resultant dipolar intermediate could then undergo a conrotatory ring closure to yield the 2-azetidinone.

Imines exist as both the syn and anti isomer except when there are large substituents on the nitrogen or the sp^2-hybridized carbon atom of the imine. Steric interaction between such large substituents results in only the anti isomer being present. Addition of the syn isomer of the imine to the ketene is preferred because (1) the nonbonding electrons on the nitrogen in the syn isomer are more accessible to the sp carbon atom of the ketene and (2) the dipolar intermediate from the syn isomer is less crowded (1, 2, 4–6, 11) (Scheme V).

Syn and anti imines equilibrate in solution due to the greater electronegativity of the nitrogen atom compared to that of carbon, which causes a lowering of the double-bond character of the imino linkage as illustrated (Scheme VI).[37,38]

The stereoselectivities of all the cycloadditions are directly related to the steric bulk of the N substituents.[19] Generally, as the steric bulk of the N-substituent of the imine increases in size, the stereochemistry of the 2-azetidinone changes from the cis to the trans isomers (3, 7–10). The anti isomer of the imine is responsible for the formation of the trans isomer of the 2-azetidinone (Scheme VII).

(36) Ab initio 6-31G*//6-31G* calculations indicate that the conformation of aminoketene in which the LP—N—C=C torsional angle is 0° is 7.6 kcal/mol more stable compared to the 90° conformation (unpublished result), as per reviewer 1

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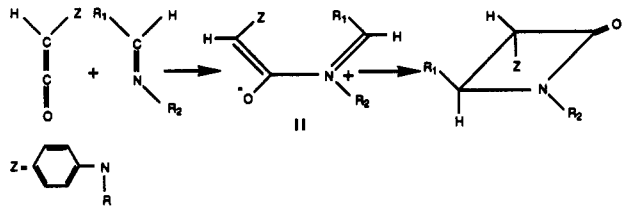
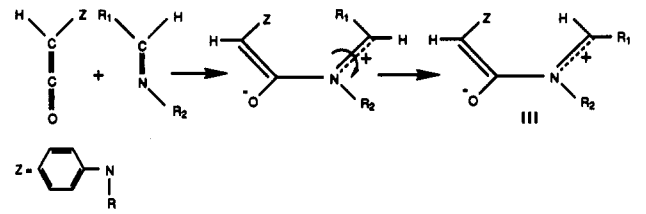
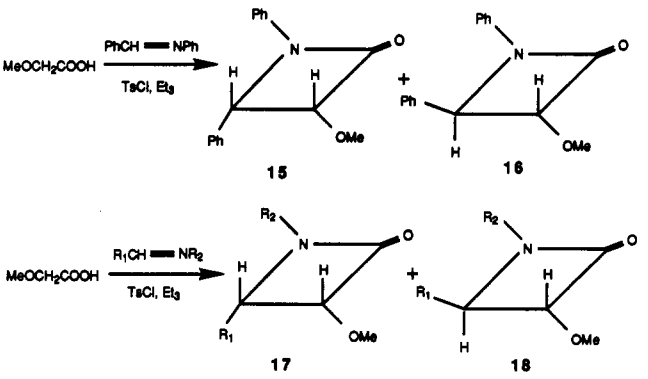
Scheme VII



Scheme VIII



Scheme IX



R_1 = p- chlorophenyl
R_2 = a-naphthyl

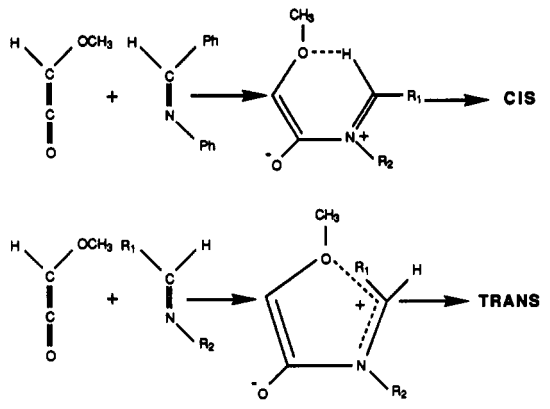
The steric bulk of the aldehyde component R_1 of the imine did not effect the stereochemistry of the 2-azetidinone. Apparently, the imine reacts as the anti isomer and then a rotation occurs between the N and carbon atom of the imine (as in the imine isomerization as described above) to minimize the steric interaction in the dipolar intermediate. That is, when R_1 becomes large, zwitterion III is favored since the Z/R_1 interaction is relieved, and thus the *cis*-2-azetidinone results as exclusive product (12–14) (Scheme VIII).

The above approach will yield the zwitterionic intermediates I–III in which the steric interaction has been minimized. The dipolar intermediates I and III would be expected when either R_2 is small or R_1 is large since the steric interactions between Z and R_1 are relieved. The dipolar intermediate II would be expected when R_2 becomes bulky since R_2/R_1 interaction is relieved. Conrotatory ring closure of I and III results in the *cis*-2-azetidinone, and conrotatory ring closure of II provides the *trans*-2-azetidinone.

To further test the above-described model, we treated methoxyacetic acid with *p*-toluenesulfonyl chloride in the presence of an excess of triethylamine with the imine of benzaldehyde and aniline. The 2-azetidinones **15** and **16** were obtained in 58% yield with a cis/trans ratio of 15:1.[11] The 2-azetidinone from methoxyketene and the imine of *p*-chlorobenzaldehyde and α-naphthylamine, **17** and **18**, were obtained in 55% yield with a cis/trans ratio of 1:12 (Scheme IX).

The stereoselectivities of the above cycloadditions are consistent with those previously described for the amino-

Scheme X



ketene and dependent on which isomer of the imine undergoes cycloaddition. The addition of the syn isomer of the imine is responsible for the formation of the *cis*-2-azetidinone, and the anti isomer provides the *trans*-2-azetidinone (Scheme X).

In conclusion, the structure of the dipolar intermediate that is formed in the reaction of a ketene and an imine is determined by both electronic and steric considerations as described above. The stereochemistry of the resulting 2-azetidinone depends on the structure of the dipolar intermediate, which is determined by the substitution on the imine. It is the bulk of the N substituent on the imine that significantly influences the stereochemistry of the 2-azetidinones.

Experimental Section

Benzene and triethylamine were dried over sodium and freshly distilled before use. All melting points are uncorrected. The imines were prepared by treating a benzene solution of the appropriate aldehyde with 1 equiv of an amine and azeotropically removing the water. The imines were vacuum distilled or recrystallized from 95% ethanol.

General Procedure for the Preparation of 2-Azetidinone. A mixture of an *N*-alkyl-*N*-phenylglycine hydrochloride with 1 equiv of *p*-toluenesulfonyl chloride, 1 equiv of an imine, and 5–8 equiv of triethylamine in benzene at room temperature were stirred overnight under a nitrogen atmosphere. The benzene solution was washed with water and dried over magnesium sulfate. After filtration and evaporation of the solvent, the oily product was crystallized by ethanol. Recrystallization was accomplished with CH_2Cl_2 and ethanol.

***cis*-1-Benzyl-3-(methylphenylamino)-4-phenyl-2-azetidinone (1).** From 2 g of Ia and 1.94 g of the *N*-benzylimine of benzaldehyde was obtained 2.2 g (66%) of compound 1: mp 147–148 °C; IR ($CDCl_3$) 1740, 1600, 1510 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.5–6.5 (m, 15 H), 5.26 (d, 1 H, J = 4.6 Hz), 5.12 (d, 1 H), 4.58 (d, 1 H, J = 4.6 Hz), 4.15 (d, 1 H), 2.8 (s, 3 H); ^{13}C NMR (APT) δ (166.8 (C), 147.9 (C), 135.2 (C), 134.9 (C), 129.1 (CH), 128.9 (CH), 128.8 (CH), 128.4 (CH), 117.6 (CH), 112.4 (CH), 72.1 (CH), 62.1 (CH), 45.0 (CH_2), 35.78 (CH_3). Anal. Calcd for $C_{23}H_{22}N_2O$: C, 80.67; H, 6.48; N, 8.18. Found: C, 80.97; H, 6.30; N, 8.16.

***cis*-1-Benzyl-3-(ethylphenylamino)-4-phenyl-2-azetidinone (2).** From 2 g of Ib and 1.81 g of the *N*-benzylimine of benzaldehyde was obtained 1.99 g (60%) of compound 2: mp 114–115 °C; IR ($CDCl_3$) 1740, 1600, 1510 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.5–6.5 (m, 15 H), 5.21 (d, 1 H, J = 4.6 Hz), 5.12 (d, 1 H), 4.78 (d, 1 H, J = 4.6 Hz), 4.1 (d, 1 H), 3.5 (m, 1 H), 3.1 (m, 1 H), 0.9 (t, 3 H); ^{13}C NMR (APT) δ 166.7 (C), 146.6 (C), 135.1 (C), 134.8 (C), 129.2 (CH), 128.9 (CH), 138.6 (CH), 128.3 (CH), 128.0 (CH), 127.9 (CH), 127.4 (CH), 117.3 (CH), 112.8 (CH), 72.3 (CH), 62.1 (CH), 44.8 (CH_2), 43.6 (CH_2) 12.9 (CH_3). Anal. Calcd for $C_{24}H_{24}N_2O$: C, 80.87; H, 6.79; N, 7.86. Found: C, 81.00; H, 6.84; N, 7.92.

***trans*-1-(*o*-Methylphenyl)-3-(methylphenylamino)-4-phenyl-2-azetidinone (3).** From 2 g of Ia and 1.94 g of the *N*-(*o*-methylphenyl)imine of benzaldehyde was obtained 1.94 g (57%) of compound 3: mp 105–106 °C; IR ($CDCl_3$) 1750, 1600, 1505 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.5–6.6 (m, 14 H), 5.16 (d, 1 H, J = 1.5 Hz), 4.94 (d, 1 H, J = 1.5 Hz), 3.2 (s, 3 H), 2.4 (s, 3 H); ^{13}C NMR (APT) δ 165.3 (C), 148.9 (C), 137.3 (C), 134.4 (C), 132.3 (C), 131.7 (CH), 129.9 (CH), 129.2 (CH), 128.7 (CH), 126.8 (CH), 126.6 (CH), 126.4 (CH), 123.0 (CH), 119.1 (CH), 114.7 (CH), 76.4 (CH), 62.9 (CH), 34.9 (CH_3), 19.4 (CH_3). Anal. Calcd for $C_{23}H_{22}N_2O$: C, 80.67; H, 6.48; N, 8.18. Found: C, 80.49; H, 6.38; N, 8.12.

***cis*-1-Benzyl-3-(methylphenylamino)-4-(*p*-methoxyphenyl)-2-azetidinone (4).** From 2 g of Ia and 2.22 g of the *N*-benzylimine of *p*-methoxybenzaldehyde was obtained 3.18 g (86%) of compound 4: mp 129–130 °C; IR ($CDCl_3$) 1745, 1605, 1520 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.4–6.5 (m, 14 H), 5.20 (d, 1 H, J = 4.4 Hz), 5.09 (d, 1 H), 4.75 (d, 1 H, J = 4.4 Hz), 4.10 (d, 1 H), 3.7 (s, 3 H), 2.8 (s, 3 H); ^{13}C NMR (APT) δ 166.8 (C), 159.5 (C), 148.0 (C), 135.2 (C), 129.1 (CH), 129.0 (CH), 128.5 (CH), 128.1 (CH), 126.5 (C), 117.5 (CH), 113.8 (CH), 112.3 (CH), 112.1 (CH), 71.9 (CH), 61.7 (CH), 55.0 (CH_3), 44.7 (CH_2), 35.8 (CH_3). Anal. Calcd for $C_{24}H_{24}N_2O_2$: C, 77.39; H, 6.49; N, 7.52. Found: C, 77.11; H, 6.42; N, 7.50.

***cis*-1-Benzyl-3-(methylphenylamino)-4-(*o*-methoxyphenyl)-2-azetidinone (5).** From 2 g of Ia and 2.22 g of the *N*-benzylimine of *p*-methoxybenzaldehyde was obtained 2.18 g (59%) of compound 5: mp 106–107 °C; IR ($CDCl_3$) 1740, 1605, 1505 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.4–6.6 (m, 14 H), 5.40 (d, 1 H, J = 4.7 Hz), 5.17 (d, 1 H), 5.12 (d, 1 H, J = 4.70 Hz), 4.20 (d, 1 H), 3.4 (s, 3 H), 2.7 (s, 3 H); ^{13}C NMR (APT) δ 167.9 (C), 157.4 (C), 148.2 (C), 135.4 (C), 129.1 (CH), 129.0 (CH), 128.7 (CH), 128.6 (CH), 128.0 (CH), 126.7 (CH), 123.6 (C), 120.1 (CH), 117.2 (CH), 112.7 (CH), 110.0 (CH), 72.1 (CH), 57.9 (CH), 54.3 (CH_3), 45.1 (CH_2), 35.5 (CH_3). Anal. Calcd for $C_{24}H_{24}N_2O_2$: C, 77.39; H, 6.49; N, 7.52. Found: C, 77.29; H, 6.51; N, 7.51.

***cis*-1-Phenyl-3-(methylphenylamino)-4-(*p*-fluorophenyl)-2-azetidinone (6).** From 2 g of Ia and 1.98 g of the *N*-benzylimine of *p*-fluorobenzaldehyde was obtained 2.14 g (62%) of compound 6: mp 130–131 °C; IR ($CDCl_3$) 1745, 1605, 1510 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.5–6.6 (m, 14 H), 5.48 (d, 1 H, J = 5.12 Hz), 5.42 (d, 1 H, J = 5.12 Hz), 2.7 (s, 3 H); ^{13}C NMR (APT) δ 165.1 (C), 164.1 (C), 147.9 (C), 137.6 (C), 130.0 (CH), 129.9 (CH), 129.4 (CH), 128.8 (CH), 124.7 (CH), 118.0 (CH), 117.4 (CH), 115.3 (CH), 112.3 (CH), 71.2 (CH), 62.0 (CH), 35.9 (CH_3). Anal. Calcd for $C_{22}H_{19}H_2FO_2$: C, 76.28; H, 5.53; N, 8.09. Found: C, 76.45; H, 5.67; N, 8.01.

***trans*-1-α-Naphthyl-3-(methylphenylamino)-4-(*p*-chlorophenyl)-2-azetidinone (7).** From 2 g of Ia and 2.64 g of the *N*-α-naphthylimine of *p*-chlorobenzaldehyde was obtained 3.0 g (73%) of compound 7: mp 166–168 °C; IR ($CDCl_3$) 1750, 1605, 1510 cm^{-1}; ^1H NMR ($CDCl_3$) δ 8.3–6.7 (m, 16 H), 5.38 (d, 1 H, J = 2.16 Hz), 5.09 (d, 1 H, J = 2.16 Hz), 3.2 (s, 3 H); ^{13}C NMR (APT) δ 166.1 (C), 149.2 (C), 135.9 (C), 135.1 (C), 134.9 (C), 132.3 (C), 129.5 (CH), 128.6 (CH), 127.7 (C), 127.6 (CH), 126.8 (CH), 126.7 (CH), 123.5 (CH), 123.8 (CH), 119.6 (CH), 119.3 (CH), 114.7 (CH), 76.0 (CH), 62.2 (CH), 35.1 (CH_3). Anal. Calcd for $C_{26}H_{21}N_2ClO_2$: C, 75.63; H, 5.13; N, 6.78. Found: C, 75.21; H, 5.15; N, 6.72.

***trans*-1-α-Naphthyl-3-(methylphenylamino)-4-(*p*-nitrophenyl)-2-azetidinone (8).** From 2 g of Ia and 2.75 g of the *N*-α-naphthylimine of *p*-nitrobenzaldehyde was obtained 3.32 g (79%) of compound 8: mp 155–156 °C; IR ($CDCl_3$) 1750, 1605, 1520 cm^{-1}; ^1H NMR ($CDCl_3$) δ 8.3–6.7 (m, 16 H), 5.48 (d, 1 H, J = 2.12 Hz), 5.08 (d, 1 H, J = 2.10 Hz), 3.2 (s, 3 H); ^{13}C NMR (APT) δ 166.5 (C), 148.9 (C), 135.9 (C), 144.9 (C), 135.1 (C), 132.2 (C), 129.9 (CH), 128.3 (CH), 127.5 (C), 127.2 (CH), 125.6 (CH), 125.1 (CH), 124.9 (CH), 124.8 (CH), 124.7 (CH), 124.0 (CH), 120.2 (CH), 119.7 (CH), 115.3 (CH), 77.0 (CH), 62.2 (CH), 35.5 (CH_3). Anal. Calcd for $C_{26}H_{21}N_3O_3$: C, 73.74; H, 5.00; N, 9.92. Found: C, 73.44; H, 4.96; N, 9.37.

***trans*-1-(2,6-Dimethylphenyl)-3-(methylphenylamino)-4-(*p*-chlorophenyl)-2-azetidinone (9).** From 2 g of Ia and 2.42 g of the *N*-(2,6-dimethylphenyl)imine of *p*-chlorobenzaldehyde was obtained 2.60 g (67%) of compound 9: mp 175–176 °C; IR ($CDCl_3$) 1745, 1600, 1510 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.4–6.7 (m, 12 H), 5.2 (d, 1 H, J = 2.18 Hz), 5.16 (d, 1 H, J = 2.18 Hz), 3.3 (s, 3 H), 2.4 (s 6 H); ^{13}C NMR (APT) δ 165.2 (C), 148.8 (C), 135.3 (C), 134.6 (C), 133.4 (C), 132.3 (C), 129.4 (CH), 129.1 (CH), 128.2 (CH), 128.0 (CH), 119.3 (CH), 114.9 (CH), 75.4 (CH), 63.5 (CH),

34.9 (CH_3), 19.7 (CH_3). Anal. Calcd for $C_{24}H_{23}N_2ClO$: C, 73.74; H, 5.93; N, 7.17. Found: C, 73.94; H, 5.97; N, 7.13.

***trans*-1-(2,6-Dimethylphenyl)-3-(methylphenylamino)-4-(*p*-nitrophenyl)-2-azetidinone (10).** From 2 g of Ia and 2.53 g of the *N*-(2,6-dimethylphenyl)imine of *p*-nitrobenzaldehyde was obtained 2.35 g (59%) of compound 10: mp 156–157 °C; IR ($CDCl_3$) 1745, 1605, 1525 cm^{-1}; ^1H NMR ($CDCl_3$) δ 8.2–6.7 (m, 12 H), 5.34 (d, 1 H, J = 2.2 Hz), 5.15 (d, 1 H, J = 2.2 Hz), 3.2 (s, 3 H), 2.4 (s, 6 H); ^{13}C NMR (APT) δ 164.9 (C), 148.6 (C), 148.1 (C), 144.5 (C), 133.1 (C), 132.2 (C), 129.9 (CH), 129.7 (CH), 128.6 (CH), 127.9 (CH), 124.8 (CH), 120.12 (CH), 115.4 (CH), 76.6 (CH), 63.6 (CH), 35.2 (CH_3), 20.13 (CH_3). Anal. Calcd for $C_{24}H_{23}N_3O_3$: C, 71.80; H, 5.77; N, 10.47. Found: C, 71.94; H, 5.70; N, 10.50.

***cis*-1-(4-Biphenylyl)-3-(methylphenylamino)-4-(*p*-nitrophenyl)-2-azetidinone (11).** From 2 g of Ia and 3.0 g of the *N*-biphenylimine of *p*-nitrobenzaldehyde was obtained 3.7 g (83%) of compound 11: mp 184–185 °C; IR ($CDCl_3$) 1745, 1600, 1525 cm^{-1}; ^1H NMR ($CDCl_3$) δ 8.2–6.6 (m, 18 H), 5.60 (d, 1 H, J = 5.06 Hz), 5.51 (d, 1 H, J = 5.06 Hz), 2.7 (s, 3 H); ^{13}C NMR (APT) δ 163.9 (C), 148.3 (C), 142.6 (C), 140.6 (C), 138.4 (C), 136.9 (C), 129.8 (CH), 129.7 (CH), 128.6 (CH), 127.8 (CH), 127.3 (CH), 124.1 (CH), 119.1 (CH), 118.0 (CH), 112.9 (CH), 72.13 (CH), 62.3 (CH), 36.0 (CH_3). Anal. Calcd for $C_{28}H_{23}N_3O_3$: C, 74.82; H, 5.16; N, 9.35. Found: C, 75.09; H, 5.16; N, 9.44.

***cis*-1-(*p*-Methoxyphenyl)-3-(methylphenylamino)-4-(α-naphthyl)-2-azetidinone (12).** From 2 g of Ia and 2.59 g of the *N*-(*p*-methoxyphenyl)imine of α-naphthaldehyde was obtained 2.36 g (58%) of compound 12: mp 204–205 °C; IR ($CDCl_3$) 1740, 1605, 1510 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.9–6.4 (m, 16 H), 6.01 (d, 1 H, J = 5.06 Hz), 5.82 (d, 1 H, J = 5.06 Hz), 3.7 (s, 3 H), 2.4 (s, 6 H); ^{13}C NMR (APT) δ 165.2 (C), 134.0 (C), 131.9 (C), 131.3 (C), 130.6 (C), 129.9 (CH), 129.0 (CH), 126.3 (CH), 125.5 (CH), 125.0 (CH), 124.9 (CH), 123.5 (CH), 119.2 (CH), 118.4 (CH), 114.9 (CH), 113.7 (CH), 113.6 (CH), 71.8 (CH), 61.1 (CH), 35.7 (CH_3), 36.0 (CH_3). Anal. Calcd for $C_{27}H_{24}N_2O_2$: C, 79.39; H, 5.92; N, 6.82. Found: C, 79.38; H, 5.90; N, 6.85.

***cis*-1-Phenyl-3-(methylphenylamino)-4-(α-naphthyl)-2-azetidinone (13).** From 2 g of Ia and 2.29 g of the *N*-phenylimine of α-naphthaldehyde was obtained 3.16 g (84%) of compound 13: mp 200–201 °C; IR ($CDCl_3$) 1740, 1600, 1505 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.8–6.5 (m, 17 H), 6.05 (d, 1 H, J = 5.1 Hz), 5.87 (d, 1 H, J = 5.1 Hz), 2.3 (s, 3 H); ^{13}C NMR (APT) δ 165.9 (C), 148.6 (C), 138.3 (C), 134.0 (C), 131.2 (C), 130.4 (C), 129.8 (CH), 139.3 (CH), 129.0 (CH), 128.8 (CH), 126.4 (CH), 125.6 (CH), 125.5 (CH), 125.4 (CH), 124.9 (CH), 123.5 (CH), 118.5 (CH), 118.0 (CH), 113.7 (CH), 71.9 (CH), 61.0 (CH), 36.1 (CH_3). Anal. Calcd for $C_{26}H_{22}N_2O$: C, 82.51; H, 5.86; N, 7.40. Found: C, 82.00; H, 5.64; N, 7.31.

***cis*-1-(*p*-Methoxyphenyl)-3-(methylphenylamino)-4-(2,4,6-trimethylphenyl)-2-azetidinone (14).** From 2 g of Ia and 2.52 g of the *N*-(methoxyphenyl)imine of 2,4,6-trimethylbenzaldehyde was obtained 2.55 g (64%) of compound 14: mp 170–171 °C; IR ($CDCl_3$) 1735, 1600, 1515 cm^{-1}; ^1H NMR ($CDCl_3$) δ 7.4–6.6 (m, 11 H), 5.59 (d, 1 H, J = 5.12 Hz), 5.49 (d, 1 H, J = 5.12 Hz), 3.8 (s, 3 H), 2.9 (s, 3 H), 2.4 (s, 3 H), 2.3 (s, 3 H), 2.2 (s, 3 H); ^{13}C NMR (APT) δ 165.2 (C), 156.6 (C), 149.0 (C), 137.4 (C), 136.3 (C), 132.9 (C), 131.9 (CH), 129.9 (CH), 129.0 (C), 128.4 (C), 127.2 (C), 118.9 (CH), 117.8 (CH), 114.7 (CH), 114.6 (CH), 71.0 (CH), 61.0 (CH), 55.7 (CH_3), 36.0 (CH_3), 21.2 (CH_3), 20.3 (CH_3). Anal. Calcd for $C_{26}H_{28}N_2O_2$: C, 77.97; H, 7.05; N, 6.99. Found: C, 77.90; H, 6.79; N, 6.96.

***cis*-4-(Chlorophenyl)-3-methoxy-1-α-naphthyl-2-azetidinone (17).** From 2 g of methoxyacetic acid and 5.89 g of the *N*-α-naphthylimine of *p*-chlorobenzaldehyde was obtained 0.32 g (4.3%) of compound 17 as a yellow oil: IR 1750, 1600, cm^{-1}; ^1H NMR ($CDCl_3$) δ 8.3–7.2 (m, 11 H), 5.21 (d, 1 H, J = 4.65 Hz), 4.62 (d, 1 H, J = 4.65 Hz), 3.2 (s, 3 H); ^{13}C NMR (APT) δ 165.5 (C), 135.4 (C), 135.0 (C), 134.9 (C), 132.2 (C), 129.7 (CH), 128.9 (CH), 128.1 (CH), 128.0 (CH), 127.1 (CH), 125.6 (CH), 124.3 (CH), 119.6 (CH), 90.3 (CH), 64.4 (CH), 58.9 (CH_3).

***trans*-4-(Chlorophenyl)-3-methoxy-1-α-naphthyl-2-azetidinone (18).** From 2 g of methoxyacetic acid and 5.89 g of the *N*-α-naphthylimine of *p*-chlorobenzaldehyde was obtained 4.12 g (50.7%) of compound 18 as a yellow oil: IR 1750, 1600, cm^{-1}; ^1H NMR ($CDCl_3$) δ 8.3–7.2 (m, 11 H), 5.25 (d, 1 H, J = 1.86 Hz), 4.66 (d, 1 H, J = 1.86 Hz), 3.1 (s, 3 H); ^{13}C NMR (APT) δ 165.5 (C), 135.4 (C), 135.0 (C), 134.9 (C), 132.2 (C), 129.7 (CH), 128.9 (CH), 128.1 (CH), 128.0 (CH), 127.1 (CH), 125.6 (CH), 124.3 (CH), 119.6 (CH), 90.1 (CH), 64.0 (CH), 58.4 (CH_3).

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Registry No. 1, 135569-37-8; 2, 135569-38-9; 3, 135569-39-0; 4, 135569-40-3; 5, 135569-41-4; 6, 135569-42-5; 7, 135569-43-6; 8, 135569-44-7; 9, 135569-45-8; 10, 135569-46-9; 11, 135569-47-0; 12, 135569-48-1; 13, 135569-49-2; 14, 135569-50-5; 17, 135569-51-6; 18, 135569-52-7; $PhCH{=}NCH_2Ph$, 780-25-6; o-$MeC_6H_4N{=}CHPh$, 5877-55-4; p-$MeOC_6H_4CH{=}NCH_2Ph$, 622-72-0; o-$MeOC_6H_4CH{=}NCH_2Ph$, 119405-95-7; p-$FC_6H_4CH{=}NCH_2Ph$, 67907-60-2; p-$O_2NC_6H_4CH{=}NC_6H_4Ph$-p, 71478-76-7; $MeOCH_2CO_2H$, 625-45-6; $Ph(Me)NCH_2CO_2H{\cdot}HCl$, 21911-75-1; $Ph(Et)NCHG_2CO_2H{\cdot}HCl$, 21911-78-4; *N*-(α-naphthyl)-4-chlorobenzylimine, 135569-53-8; *N*-(α-naphthyl)-4-nitrobenzylimine, 967-13-5; *N*-(2,6-dimethylphenyl)-4-chlorobenzylimine, 79937-64-7; *N*-(2,6-dimethylphenyl)-4-nitrobenzylimine, 60165-04-0; *N*-(4-methoxyphenyl)-(α-napthyl)methylimine, 3525-60-8; *N*-phenyl-(α-naphthyl)methylimine, 890-50-6; *N*-(4-methoxyphenyl)-(2,4,6-trimethylphenyl)methylimine, 58896-48-3.