Pergamon

Tetrahedron Vol. 51, No. 1, pp. 89-106, 1995

0040-4020/95 $9.50+0.00

0040-4020(94)00966-X

Synthesis of Novel Bicyclic Nitrogen Heterocycles by the Intramolecular Dipolar Cycloaddition Reaction of Nitrones with Allenes and Alkynes

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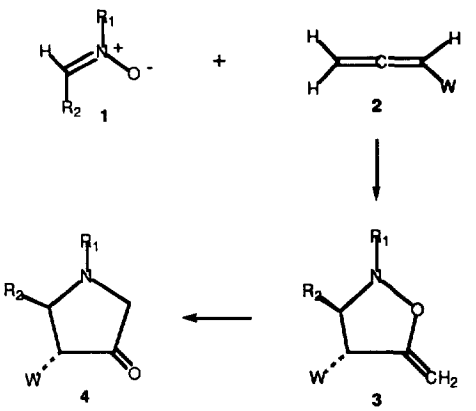
Abstract: A study of the intramolecular dipolar cycloaddition reactions of a series of allenyl and alkynyl nitrones has been carried out. Phenylhydroxylamine readily reacts with *o*-(1,2-propadienyloxy)benzaldehyde to give a dioxaazabicyclo[3.2.1]octene. The intramolecular 3+2-cycloaddition of 2-(1,2-propynyloxy)benzaldehyde and N-methylhydroxylamine was also studied. In this case, the major cycloadduct formed was identified as 4-methyl-2,5-*endo*-oxo-2,3,4,5-tetrahydro[1,4]benzoxazepin. The formation of this novel rearranged product involves an initial dipolar cycloaddition across the acetylenic π-bond to give the expected 4-isoxazoline as a transient intermediate. The next step proceeds by homolysis of the O-N linkage and this is followed by ring closure to produce an aziridine which undergoes further C-C bond cleavage. The resulting azomethine ylide is converted to the final rearranged product by means of an *ortho*-quinone methide intermediate. Phenylsulfonyl activated allenes were also found to react with alkylhydroxylamines to give nitrones which undergo cycloaddition with the neighboring π-bond to afford the resulting bicyclic nitrogen heterocycles.

The development of procedures for efficiently constructing pyrrolidine, piperidine, and perhydroazepine ring systems with simultaneous functionalization α to the nitrogen atom is of crucial importance in alkaloid synthesis.[1,2] A variety of nitrogen ring-forming methodologies has emerged in recent years[3-12] including the 1,3-dipolar cycloaddition reaction.[13-18] Through the use of nitrone cycloaddition chemistry, numerous pyrrolidine natural products have been synthesized with excellent stereochemical control.[19] In this connection, we have investigated the 1,3-dipolar cycloaddition of nitrones with allenes followed by their thermal rearrangement.[20] In earlier work from our laboratory,[21] we showed that the 1,3-sigmatropic rearrangement of 5-methylene isoxazolidines **3** to pyrrolidones **4** proceeded readily at 80°C and in high yield.

Allenes are an intriguing group of dipolarophiles since they contain two positions for attack.[22] The use of allenes in 1,3-dipolar cycloaddition chemistry has, however, been severely limited as a consequence of their unreactive nature as dipolarophiles.[23-27] One way to overcome this problem is to



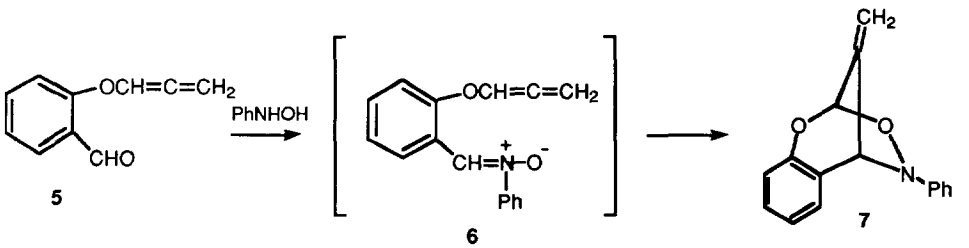
W=electron withdrawing group

incorporate an electron-withdrawing substituent onto the π-bond.[28] Indeed, the reaction of nitrones with electron deficient allenes proceeds in a highly regioselective fashion with cycloaddition occurring across the more activated C_1-C_2 π-bond.[29] An alternate way to promote the cycloaddition of a nitrone with an unactivated allene is to make use of an intramolecular dipolar cycloaddition since this process exhibits enhanced reactivity and stereoselectivity over its bimolecular counterpart.[26] The predictability and selectivity with which intramolecular dipolar cycloaddition reactions occur has led to their wide-spread use in organic synthesis.[30-32] Intramolecular dipolar cycloaddition of nitrones have been particularly useful in natural product synthesis,[33,34] especially since the resulting isoxazolidine ring can serve as a precursor to 1,3-amino alcohols.[35-38] As part of our ongoing interest in the synthetic applications of nitrone cycloaddition chemistry, we thought it worthwhile to examine the intramolecular cycloaddition reaction of nitrones with unactivated allenes and alkynes.[39] Here we report the results of these studies.

Results and Discussion

As our first model we chose to investigate the reaction of *o*-(1,2-propadienyloxy)benzaldehyde (**5**) with phenylhydroxylamine. This reaction proceeded at room temperature in ethanol to give dioxa-azabicyclo[3.2.1]octene **7** in 84% yield [NMR ($CDCl_3$, 300 MHz) δ 4.86 (s, 1H), 5.18 (s, 1H), 5.42 (s, 1H), 6.14 (s, 1H), and 6.96-7.40 (m, 9H)]. The formation of **7** can be readily accounted for in terms of initial formation of N-phenyl nitrone **6** followed by intramolecular cycloaddition across the C_1-C_2 π-bond of the allene. The regiochemistry of the intramolecular nitrone dipolar cycloaddition reaction is complicated by an interplay of factors such as alkene polarity, ring strain, and other nonbonded interactions.[30-32] In

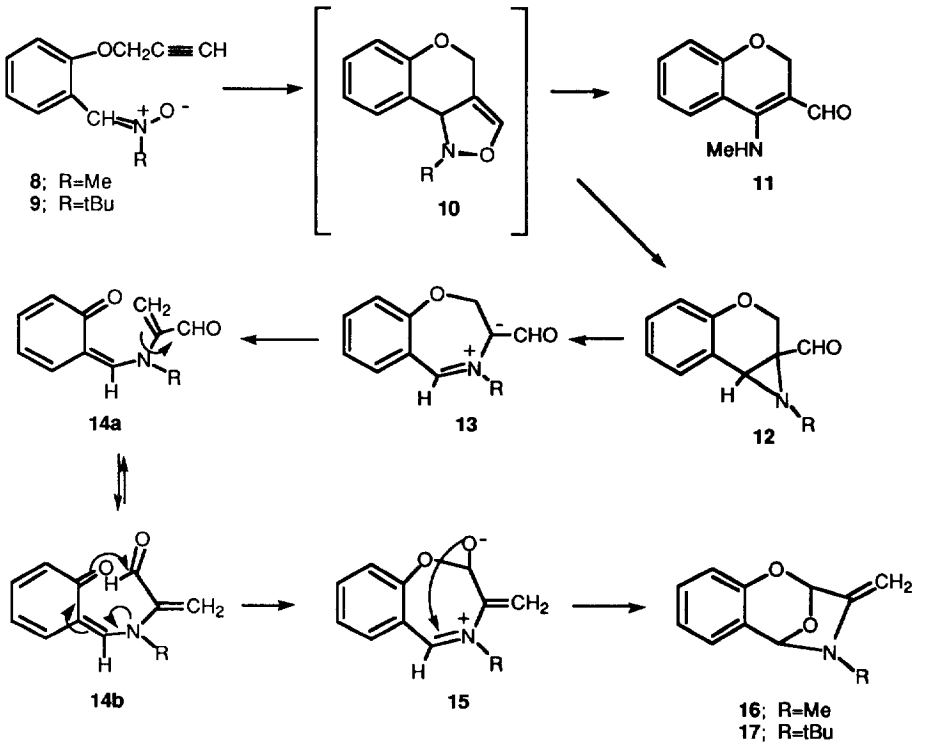
general, the intramolecular situation can be assessed as a competition between the bridged and fused modes of cycloaddition. In the above case, only the bridged bicyclic system **7** is formed. This is consistent with its transition state possessing both better orbital overlap and fewer nonbonded interactions.



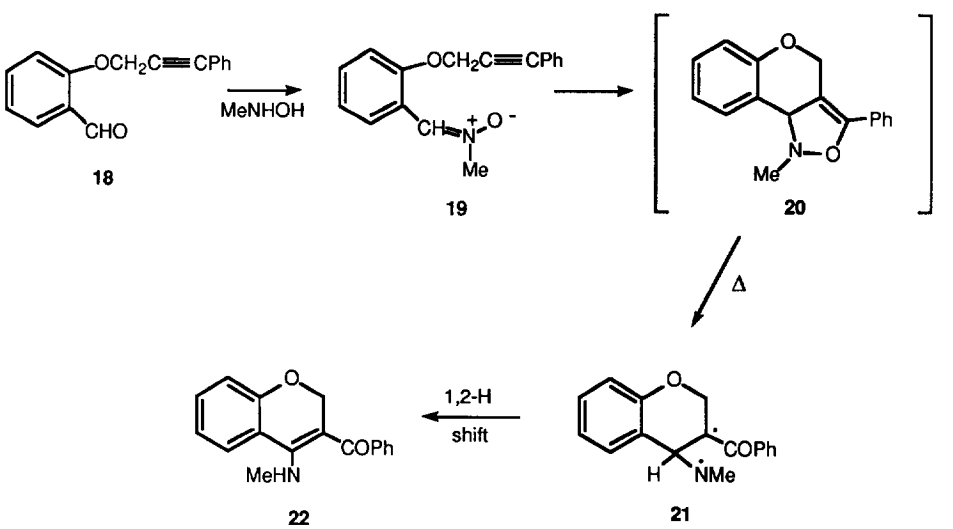
As a comparison, we also investigated the intramolecular dipolar-cycloaddition of the related acetylenic nitrone **8**. Heating a sample of **8** in benzene at 95°C for 4.5 h afforded a 1:5 mixture of compounds **11** and **16**. The structure of **16** was assigned on the basis of its characteristic spectral data. An analogous reaction occurred with t-butylnitrone **9** producing the rearranged cycloadduct **17** in 82% as the only characterizable product that could be isolated from the crude reaction mixture. A reasonable mechanism to rationalize the rearrangement is outlined in Scheme I. The first step involves an initial dipolar cycloaddition across the acetylenic bond to give the expected 4-isoxazoline **10** as a transient intermediate.[40-42] The next step proceeds by thermal cleavage of the weak O-N linkage and this is followed by ring closure to give aziridine **12**.[43] Subsequent C-C bond cleavage generates azomethine ylide **13**[44-46] which readily collapses to *ortho*-quinone methide **14**. This transient species is ultimately converted to **16** (or **17**) by the series of reactions outlined in Scheme I. In addition to producing aziridine **12**, the diradical derived from 4-isoxazoline **10** can also undergo a hydrogen shift to afford aldehyde **11** in the case where R=Me. Good analogy exists for most of the transformations depicted in the Scheme.[40-47]

We also examined the reaction of methylhydroxylamine with 2-(3-phenyl-2-propynyloxy)benzaldehyde (**18**) so as to probe what effect the substituent group on the alkyne would have on the reaction pathway. Heating the initially formed nitrone **19** in toluene at 120°C for 2 h gave rise (60%) to a single rearranged product, the structure of which has been assigned as 3-benzoyl-4-N-methyl-amino-2*H*-1-benzopyran (**22**) on the basis of its spectroscopic properties. In this case, intramolecular dipolar cycloaddition produces 4-isoxazoline **20** which undergoes preferential N-O bond scission affording diradical **21**. A subsequent rearrangement by way of a 1,2-hydrogen shift ultimately gives benzopyran **22**. Alternatively, the isomerization of **20** to **22** could follow an acid catalyzed path. The presence of a

Scheme I

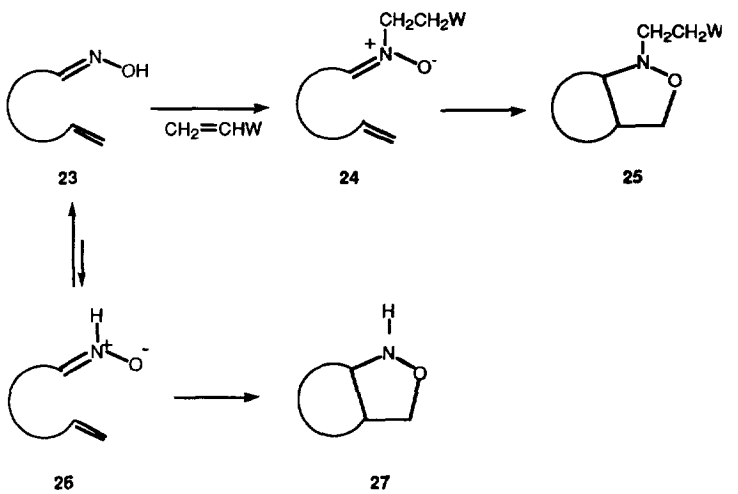


phenyl substituent on the alkyne has clearly influenced the rearrangement pathway and is presumably the result of a conjugative interaction between the carbonyl and aromatic ring.



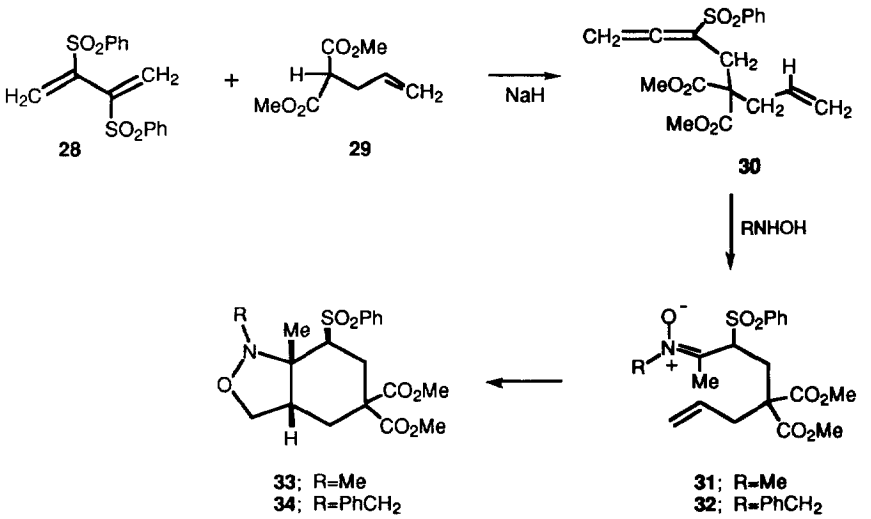
Recently, a number of groups have studied the reaction of an oxime with an activated π-bond as a method for the preparation of a variety of substituted nitrones.[48-51] The reaction generally requires the presence of a Michael acceptor olefin in order to produce the nitrone. Once formed, the nitrone has been observed to undergo both inter- and intramolecular dipolar cycloaddition. The reaction was first discovered by Ochiai and co-workers in 1967[48] and has been nicely exploited by both the Grigg[50] and Hassner[51] teams over the past several years. The intramolecular version of the oxime cyclization has been employed in a number of natural product syntheses.[52,53] A few examples are also known where the oxime undergoes an unassisted thermal cyclization, believed to involve a proton transfer from O to N to generate a 1,3-dipole (*i.e.*, **26**) as a reactive intermediate.[53-56]

Scheme II

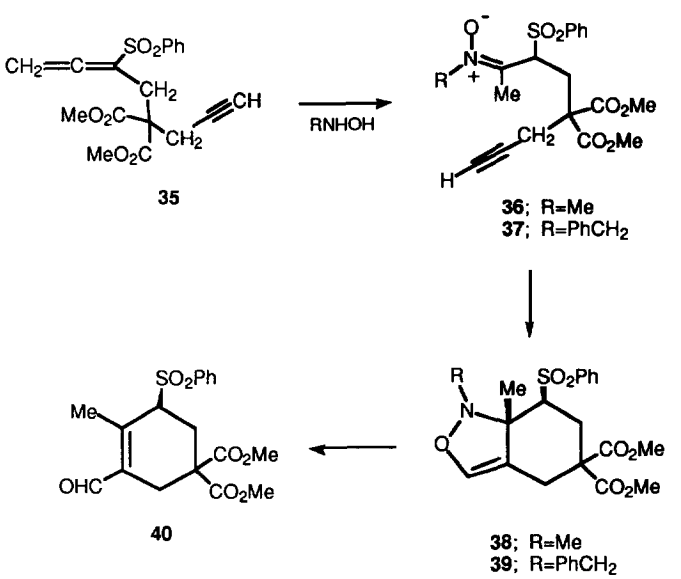


As part of our ongoing interest in the synthetic applications of nitrone-allene cycloaddition chemistry, we examined the reaction of the phenylsulfonyl activated allene **30** with methyl and benzylhydroxylamines. We reasoned that the initially formed nitrone **31** (or **32**) would undergo dipolar-cycloaddition to the neighboring π-system. The formation of the activated allene **30** involved treating 2,3-*bis*(phenylsulfonyl)-1,3-butadiene (**28**)[57] and 4,4-dicarbomethoxy-1-butene (**29**) with NaH. The reaction proceeded by attack of the malonate anion onto the terminal position of the diene followed by elimination of $PhSO_2^-$ to give the phenylsulfonyl-substituted allene **30**.[58] Stirring a sample of **30** with the hydroxylamine at 25°C afforded the expected nitrone **31** (or **32**) which cyclized to the isoxazolidine (**33** or **34**) in 80% yield on heating in benzene for 4 h.

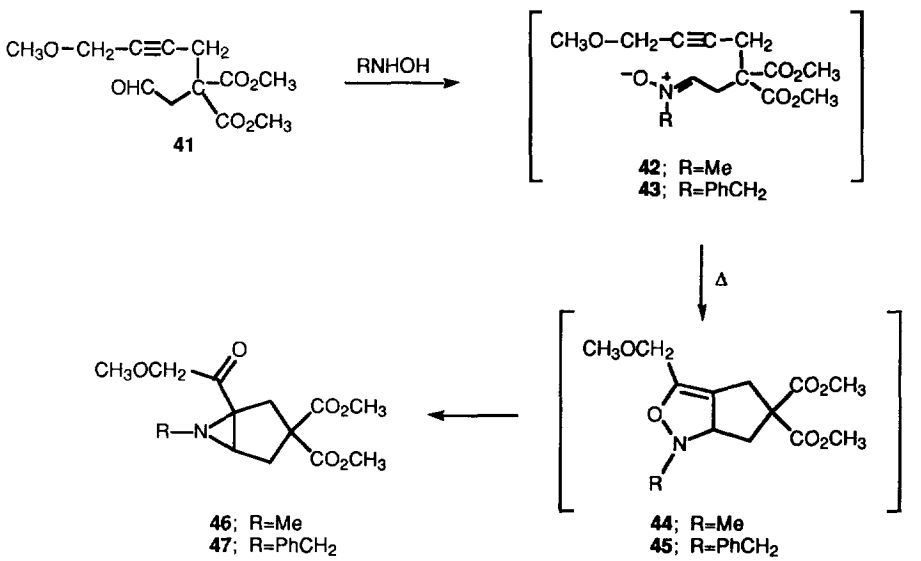
A similar reaction occurred upon treating the acetylenic allene **35** with methyl or benzyl hydro-



xylamine producing 4-isoxazolines **38** and **39** in 89% and 85% yield, respectively. By carrying out the reaction of the alkylhydroxylamine with allene **35** at room temperature, it was possible to isolate the initially formed nitrones **36** (85%) and **37** (69%). Catalytic hydrogenation of 4-isoxazoline **39** resulted in N-O bond cleavage and this was followed by spontaneous benzylamine elimination which resulted in the formation of the cyclohexenyl substituted aldehyde **40** in 63% yield.



We also examined the reaction of methyl and benzylhydroxylamine with the acetylenic aldehyde **41** so as to probe whether an internal cycloaddition of a transient nitrone would occur across the triple bond. Heating a sample of **41** with methylhydroxylamine gave rise to a single product, the structure of which was assigned as azabicyclo[3.1.0]hexane **46** on the basis of its spectroscopic properties (see Experimental Section). Most importantly, the ^{1}H-NMR spectrum showed the presence of three sets of AB quartets with couplings of 17.0, 13.5 and 13.2 Hz. A related reaction also occurred when **41** was heated with benzylhydroxylamine at 75°C which afforded azabicyclohexane **47**. Formation of compounds **46** and **47** can be accounted for in terms of the intramolecular cycloaddition process followed by a subsequent rearrangement of the resulting cycloadduct (**44** or **45**). Substituted isoxazolines are known to readily undergo N-O bond cleavage,[42,43,59,60] thereby providing good analogy for the formation of **46** and **47**.



In conclusion, the results reported here clearly show that the intramolecular 3+2-cycloaddition of nitrones with allenes and alkynes provides ready access to a variety of novel heterocyclic systems in synthetically useful yields. Further generalizations of these observations and their implications for alkaloid synthesis are the object of ongoing investigations.

Experimental Section

Melting points were determined on a Thomas-Hoover capillary melting point apparatus and are uncorrected. Infrared spectra were run on a Perkin Elmer Model 283 infrared spectrometer. Proton NMR spectra were obtained on a Varian EM-390 and a GE QE-300 spectrometer. ^{13}C-NMR spectra were

recorded on an GE QE-300 75 MHz spectrometer. Microanalyses were performed at Atlantic Microlabs, Atlanta, Ga. Mass spectra were determined with a VG MM-7070S mass spectrometer at an ionizing voltage of 70 eV.

Reaction of o-(1,2-Propadienyloxy)benzaldehyde (5) with Phenylhydroxyl amine. A solution containing 1.0 g (6.24 mmol) of 2-(1,2-propynyloxy)benzaldehyde (**1**) (mp 68-69°C, lit.[61,62]) and 2.0 mL of a 0.75 M potassium *t*-butoxide solution in 4 mL of HMPA was warmed to 60°C for 2.5 h. The mixture was poured into 20 mL of ice water and extracted with ether. The combined ether extracts were washed with a saturated NH_4Cl solution, dried over anhydrous $MgSO_4$ and the solvent was removed under reduced pressure. The residue was subjected to silica gel chromatography to give 0.76 g (76%) of *o*-(1,2-propadienyloxy)benzaldehyde (**5**) as a clear oil; IR (neat) 2770, 1970, 1600, 1455, 1230, and 760 cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 5.42 (d, 2H, J=5.9 Hz), 6.85 (t, 1H, J=5.9 Hz), 7.14 (m, 2H), 7.49-7.78 (m, 2H), and 10.39 (s, 1H); ^{13}C-NMR ($CDCl_3$, 300 MHz) δ 90.5, 116.6, 117.8, 123.0, 126.0, 128.2, 135.6, 159.3, 189.1, and 202.5; UV (95% ethanol) 318 nm (ε 2200), 252 nm (ε 6100), 224 nm (ε 8500), and 212 nm (ε 8200); m/e 160, 131, 121, 118, 103, 93, 84, 77 and 65; HRMS Calcd. for $C_{10}H_8O_2$: 160.0524. Found: 160.0522.

A solution containing 710 mg (6.5 mmol) of phenylhydroxylamine and 940 mg (5.87 mmol) of *o*-(1,2-propadienoxy)benzaldehyde (**5**) in 15 mL of ethanol was stirred in the dark at 25°C for 24 h. The solvent was removed under reduced pressure and the residue was subjected to silica gel chromatography to give 1.38 g (84%) of 2,3-benzo-4,6-dioxo-7-aza-7-phenyl-8-methylenebicyclo[3.2.1]-octene (**7**) as a crystalline solid, mp 77-78°C; IR (KBr) 1610, 1595, 1585, 1490, 1210, 950, and 755 cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 4.86 (s, 1H), 5.18 (s, 1H), 5.42 (s, 1H), 6.14 (s, 1H), and 6.96-7.40 (m, 9H); ^{13}C-NMR ($CDCl_3$, 300 MHz) δ 67.5, 97.7, 108.8, 116.4, 117.5, 121.5, 123.8, 124.8, 127.6, 128.7, 130.4, 140.1, 149.8 and 151.6; m/e 251, 234, 222, 196, 159, 144, 131, 115, 83, and 77; Anal. Calcd. for $C_{16}H_{13}NO_2$: C, 76.47; H, 5.22; N, 5.58. Found: C, 76.28; H, 5.09; N, 5.43.

Preparation and Thermolysis of N-Methyl-α-(2-prop-2-ynyl-1-oxybenzylidenyl)nitrone (8). A solution containing 1.18 g (7.38 mmol) of 2-(1,2-propynyloxy)benzaldehyde[61] and 929 mg (11.13 mmol) of N-methylhydroxylamine hydrochloride in 17 mL of CH_2Cl_2 was treated with 1.09 g (10.8 mmol) of triethylamine. After stirring at 25°C for 14 h, the reaction was quenched with a saturated NH_4Cl solution and extracted with CH_2Cl_2. The organic layer was washed with water, brine and dried over Na_2SO_4. The solvent was removed under reduced pressure. Purification by flash silica gel chromatography afforded 1.09 g (78 %) of N-methyl-α-(2-prop-2-ynyl-1-oxybenzylidenyl)nitrone (**8**); mp 99-100°C; IR (KBr) 2104, 1595, 1469, 1152, and 751 cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 2.52 (t, 1H, J=2.4 Hz), 3.85 (s, 3H), 4.72 (d, 2H, J=2.4 Hz), 6.95-7.07 (m, 2H), 7.34 (t, 1H, J=7.8 Hz), 7.79 (s, 1H), and 9.24 (d, 1H, J=7.8 Hz); ^{13}C-NMR ($CDCl_3$, 75 MHz) δ 54.8, 56.3, 76.0, 77.9, 111.3, 120.2, 121.7, 128.6, 129.4, 131.2, and 154.6;

HRMS Calcd. for $C_{11}H_{11}O_2N$: 189.0790. Found 189.0787.

A solution containing 80 mg (0.42 mmol) of nitrone **8** in 8 mL of benzene was heated at reflux for 4.5 h. The solvent was removed under reduced pressure. The major compound (70%) obtained by silica gel chromatography was identified as 4-methyl-2,5-*endo*-oxo-2,3,4,5-tetrahydro[1,4]benzoxazepin (**16**) as a clear oil; IR (neat) 1659, 1609, 1474, 1183, and 749 cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 2.55 (s, 3H), 3.98 (d, 1H, J=1.3 Hz), 4.28 (d, 1H, J=1.3 Hz), 5.48 (s, 1H), 6.16 (s, 1H), 6.79-6.94 (m, 3H), and 7.16-7.22 (m, 1H); ^{13}C-NMR ($CDCl_3$, 75 MHz) δ 30.1, 80.9, 90.8, 99.7, 116.7, 120.1, 122.0, 124.8, 129.9, 150.1, and 150.6; HRMS Calcd. for $C_{11}H_{11}O_2N$: 189.0790. Found 189.0790.

The second compound (14%) isolated from the column was clear oil and was assigned as 4-N-methylamino-2H-1-benzopyran-3-carboxaldehyde (**11**); IR (neat) 1723, 1617, 1332, and 756 cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 3.22 (d, 3H, J=5.4 Hz), 4.65 (s, 2H), 7.00-7.05 (m, 2H), 7.38 (t, 1H, J=8.0 Hz), 7.63 (d, 1H, J=8.0 Hz), 9.06 (s, 1H), and 10.95 (bs, 1H); ^{13}C-NMR ($CDCl_3$, 75 MHz) δ 33.3, 67.2, 101.6, 118.1, 118.4, 120.9, 128.3, 133.0, 156.1, 159.4, and 183.3; HRMS Calcd. for $C_{11}H_{11}O_2N$: 189.0790. Found 189.0794.

Preparation and Thermolysis of *N*-*t*-Butyl-α-(2-prop-2-yn-1-oxybenzylidenyl)nitrone (9). To a solution containing 2.7 g (36.9 mmol) of *t*-butylamine and 2.5 mL of a 5 M methanolic HCl solution in 15.6 mL of methanol was added 1.0 g (6.24 mmol) of 2-(1,2-propynyloxy)benzaldehyde followed by 235 mg (3.7 mmol) of sodium cyanoborohydride. Stirring was continued for 24 h and then 4 g of activated 3Å molecular sieves was added. After stirring for an additional 24 h, the reaction was filtered through Celite and quenched with a 0.1 N NaOH solution. The aqueous solution was extracted with ether and the combined organic extracts were dried over $MgSO_4$, filtered and concentrated under reduced pressure. Purification by flash silica gel chromatography afforded 882 mg (64%) of *o*-(1,2-propynyloxy)benzyl-*t*-butylimine as a colorless oil; IR (neat) 1610, 1500, 1130, and 770 cm^{-1}; ^{1}H-NMR ($CDCl_3$, 90 MHz) δ 1.20 (s, 9H), 2.47 (m, 1H), 3.70 (s, 2H), 4.73 (s, 2H), and 6.87-7.33 (m, 4H); m/e 217 (M^+), 202, 163, 145, 117 (base) 106, 91, 78, 65, and 57.

A solution containing 285 mg (1.33 mmol) of the above imine and 7.2 mg (0.06 mmol) of selenium dioxide in 3 mL of acetone at 0°C was treated with 0.41 mL of a 30% aqueous hydrogen peroxide solution. Stirring was continued for 18 h while allowing the reaction to warm to 25°C. The mixture was concentrated under reduced pressure and this was followed by extraction with CH_2Cl_2. The combined organic extacts were dried over Na_2SO_4, filtered and concentrated under reduced pressure. Purification of the residue by flash silica gel chromatography using a 33% ethyl acetate-hexane mixture as the eluent afforded 203 mg (67%) of *N*-*t*-butyl-α-(2-prop-2-yn-1-oxybenzylidenyl)nitrone (**9**) as a white solid, mp 121-122°C; IR ($CHCl_3$) 1610, 1580, 1030, and 770 cm^{-1}; NMR ($CDCl_3$, 90 MHz) δ 1.30 (s, 9H), 2.13 (m, 1H), 4.20 (m, 2H), 6.50-7.23 (m, 3H), 8.03 (s, 1H) and 10.0-10.2 (m, 1H); Anal. Calcd. for $C_{14}H_{17}NO_2$: C, 72.69; H, 7.41;

N, 6.06. Found: C, 72.43; H, 7.25; N, 5.87.

A solution containing 65 mg (0.28 mmol) of the above nitrone in 0.6 mL of benzene was heated at reflux. Removal of the solvent under reduced pressure followed by silica gel chromatography afforded 4-*t*-butyl-2,5-*endo*-oxo-2,3,4,5-tetrahydro[1,4]-benzoxazepin (**17**) (82%) as a clear oil; IR (neat) 1720, 1660, 1400, 1040, and 760 cm^{-1}; ^{1}H-NMR (benzene-d_6, 300 MHz) δ 0.93 (s, 9H), 3.97 (s, 1H), 4.07 (s, 1H), 5.49 (s, 1H), 5.84 (s, 1H), and 6.53-7.07 (m, 4H); HRMS Calcd. for $C_{14}H_{17}O_2N$: 231.1259. Found 231.1257.

Preparation and Thermolysis of N-Methyl-α-[2-(3-phenylprop-2-ynyl-1-oxy)benzylidenyl]nitrone (19). A sample of 1-bromo-3-phenylprop-2-yne was prepared by a modification of the procedure of Lai.[63] To a mixture of 5.0 g (37.9 mmol) of 3-phenyl-2-propyn-1-ol in 6 mL of ether and 0.4 mL of pyridine in a 100 mL two neck flask fitted with reflux condensor and dropping funnel was added dropwise 5 g (48.0 mmol) of PBr_3 at 0°C. When the addition of PBr_3 was complete, the reaction mixture was heated for 2.5 h at 50°C. The cooled mixture was added to 300 mL of ice water and the aqueous layer was extracted with ether. The organic layer was washed with a $NaHCO_3$ solution, water, brine, and dried over Na_2SO_4. After filtration, the solvent was removed under reduced pressure and the residue was distilled to give 5.69 g (77%) of 1-bromo-3-phenylprop-2-yne; bp 92°C (2 mm) (lit.[64] bp 92°C (2 mm)); IR (neat) 1719, 1589, 1263, and 750 cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 4.16 (s, 2H), 7.31-7.35 (m, 3H), and 7.43-7.47 (m, 2H); ^{13}C-NMR ($CDCl_3$, 75 MHz) δ 15.3, 84.2, 86.7, 122.0, 128.3, 128.8, and 131.8.

A mixture containing 864 mg (15.4 mmol) of KOH, 1.88 g (15.4 mmol) of salicylaldehyde and 20 mL of dry ethanol was stirred for 15 min at rt. To this suspension was added 3.0 g (15.4 mmol) of 1-bromo-3-phenylprop-2-yne. The mixture was heated at reflux for 17 h. The solvent was removed under reduced pressure and the residue was partitioned between ether and water. The ether layer was separated and washed with a 10% aqueous NaOH solution, water and brine. The solution was then dried over anhydous Na_2SO_4 and after filtration, the solvent was removed under reduced pressure. The residue was subjected to silica gel chromatography to give 2.76 g (76%) of 2-(3-phenyl-2-propynyloxy)benzaldehyde (**18**); mp 82-83°C (lit.[62] mp 83-84°C).

A solution containing 963 mg (4.08 mmol) of the above aldehyde and 513 mg (6.14 mmol) of N-methylhydroxylamine hydrochloride in 11 mL of CH_2Cl_2 was treated with 0.6 g of triethylamine. After stirring at 25°C for 14 h, the reaction was quenched with a saturated NH_4Cl solution and extracted with CH_2Cl_2. The organic layer was washed with water, brine and dried over Na_2SO_4. The solvent was removed under reduced pressure and the residue was purified by flash silica gel chromatography to give 1.02 g (94%) of N-methyl-α-[2-(3-phenylprop-2-yn-1-oxy)benzylidenyl]nitrone (**19**); mp 104-105°C; IR (KBr) 1624, 1588, 1197, and 748 cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 3.87 (s, 3H), 4.95 (s, 2H), 7.04-7.09 (m, 1H), 7.24-7.42 (m, 7H), 7.86 (s, 1H), and 9.26 (m, 1H); ^{13}C-NMR ($CDCl_3$, 75 MHz) δ 54.8, 57.2, 83.2,

87.7, 111.6, 120.3, 121.6, 121.9, 128.3, 128.7, 128.9, 129.7, 131.3, 131.7, and 154.9; Anal. Calcd. for $C_{17}H_{15}NO_2$: C, 76.95; H, 5.70; N, 5.28. Found: C, 76.74; H, 5.58; N, 5.13.

A solution containing 70 mg (0.26 mmol) of nitrone **19** in 7 mL toluene was heated at reflux for 2 h. The solvent was removed under reduced pressure. The resulting oil was purified by flash silica gel chromatography to give 42 mg (60%) of 3-benzoyl-4-N-methylamino-2H-1-benzopyran (**22**); IR (neat) 1723, 1666, 1318, and 756 cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 3.24 (d, 3H, J=5.4 Hz), 4.67 (s, 2H), 7.00-7.07 (m, 2H), 7.34-7.44 (m, 6H), 7.67 (m, 1H) and 11.79 (s, 1H); ^{13}C-NMR ($CDCl_3$, 75 MHz) δ 33.6, 68.3, 100.4, 118.0, 118.6, 120.8, 126.9, 128.2, 128.4, 129.5, 132.6, 141.3, 157.8, 159.8 and 190.8; HRMS Calcd. for $C_{17}H_{15}O_2N$: 265.1103. Found 265.1104.

Preparation of 4,4-Dicarbomethoxy-1-methyl-N-methyl-2-(phenylsulfonyl)-8-oxa-9-azabicyclo[4.3.0]nonane (33). To a solution containing 300 mg (1.78 mmol) of 4,4-dicarbomethoxy-1-butene (**29**) in 20 mL of THF at 0°C was added 78 mg (1.96 mmol) of 60% NaH. After stirring for 20 min, a solution of 535 mg (1.60 mmol) of 2,3-*bis*(phenylsulfonyl)-1,3-butadiene[57] (**28**) in 40 mL of THF was added. The mixture was stirred for an additional 10 min and the reaction was quenched with a saturated NH_4Cl solution and extracted with CH_2Cl_2. The organic layer was washed with water, brine and dried over Na_2SO_4. The solvent was removed under reduced pressure. Purification by flash silica gel chromatography gave 480 mg (82%) of 5,5-dicarbomethoxy-(2-phenylsulfonyl)-octa-1,2,7-triene (**30**) as a clear oil; IR (neat) 1964, 1732, 1430, 1306, and 1151 cm^{-1}; ^{1}H-NMR (300 MHz, $CDCl_3$) δ 2.62 (t, 2H, J=7.2 Hz), 3.44 (t, 1H, J =7.2 Hz), 3.71 (s, 6H), 4.98-5.09 (m, 2H), and 5.64-5.78 (m, 1H); ^{13}C-NMR (75 MHz, $CDCl_3$) δ 32.7, 51.2, 52.3, 117.5, 133.8, and 169.1; HRMS for $C_{18}H_{20}O_6S$: 364.0980. Found: 364.0972.

To a solution containing 106 mg (0.29 mmol) of the above allene and 29 mg (0.35 mmol) of N-methylhydroxylamine hydrochloride in 5 mL of CH_2Cl_2 was added 0.1 mL (0.72 mmol) of NEt_3 at rt. After being stirred for 3 h at rt, the solvent was removed and 5 mL of benzene was added. The solution was heated at reflux for 3 h and the solvent was removed under reduced pressure. The mixture was purified by flash chromatography on silica gel to give 93 mg (80%) of 4,4-dicarbomethoxy-1-methyl-N-methyl-2-(phenylsulfonyl)-8-oxa-9-azabicyclo[4.3.0]nonane (**33**) as a clear oil; IR (neat) 1730, 1140, and 727 cm^{-1}; ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.54 (s, 3H), 2.02 (t, 1H, J =13.8 Hz), 2.17-2.31 (m, 2H), 2.54-2.58 (m, 2H), 2.60 (s, 3H), 3.31 (dd, 1H, J=8.1 and 6.9 Hz), 3.49 (s, 3H), 3.61 (dd, 1H, J=13.5 and 2.7 Hz), 3.69 (s, 3H), 4.04 (t, 1H, J=8.7 Hz), 7.52-7.65(m, 3H), and 7.91 (d, 2H, J=7.5 Hz); ^{13}C NMR (75 MHz, $CDCl_3$) δ 15.6, 28.0, 28.4, 38.3, 48.1, 52.0, 52.8, 53.1, 63.3, 67.1, 67.9, 128.8, 133.3, 140.0, 170.8, and 171.0; HRMS for $C_{18}H_{23}NO_7S$: 397.1196. Found: 397.1197.

Preparation of 7-(Benzenesulfonyl)-1-benzyl-7a-methyl-hexahydrobenzo[c]isoxazole-5,5-dicarboxylic Acid Dimethyl Ester (34). A solution of 83 mg (0.23 mmol) of 5,5-dicarbo-

methoxy-2-(phenylsulfonyl)-octa-1,2,7-triene (**30**) and 40 mg (0.32 mmol) of N-benzylhydroxylamine in 10 mL of benzene was heated at reflux for 19 h. Purification on silica gel gave 85 mg (79%) of 7-(benzenesulfonyl)-1-benzyl-7a-methyl-hexahydrobenzo[c]isoxazole-5,5-dicarboxylic acid dimethyl ester (**34**) as a clear oil; IR (neat) 1733, 1446, 1138, and 722 cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 1.70 (s, 3H), 2.08 (t, 1H, J=13.8 Hz), 2.27 (d, 2H, J=5.7 Hz), 2.59-2.71 (m, 2H), 3.31-3.38 (m, 1H), 3.46 (s, 3H), 3.70 (s, 3H), 3.76 (dd, 1H, J=13.5 and 2.7 Hz), 4.03 (t, 1H, J=8.4 Hz), 4.23 (d, 1H, J=13.5 Hz), 7.20-7.29 (m, 5H), 7.51-7.65 (m, 3H), and 7.94 (d, 2H, J=7.5 Hz); ^{13}C-NMR ($CDCl_3$, 75 MHz) δ 16.5, 27.9, 28.6, 49.3, 52.0, 52.7, 53.1, 54.2, 64.3, 67.4, 67.5, 126.8, 128.0, 128.2, 128.6, 128.9, 133.2, 140.4, 171.0, and 170.8; HRMS Calcd for $C_{25}H_{30}NO_7S$ (M^++1): 488.1743. Found 488.1739.

Preparation of 4,4-Dicarbomethoxy-1-methyl-N-methyl-2-(phenylsulfonyl)-8-oxa-9-azabicyclo[4.3.0]nona-6-ene (38). To a solution containing 340 mg (2.0 mmol) of dimethyl propargylmalonate[65] in 30 mL of THF was added 96 mg (2.4 mmol) of 60% NaH at 0°C. After stirring for 20 min, 634 mg (1.9 mmol) of 2,3-*bis*(phenylsulfonyl)-1,3-butadiene (**28**) in 40 mL of THF was added. After stirring for an additional 10 min, the reaction mixture was quenched with a saturated NH_4Cl solution and extracted with CH_2Cl_2. The organic layer was washed with water, brine and dried over Na_2SO_4. The solvent was removed under reduced pressure and the residue was purified by flash silica gel chromatography to give 446 mg (65 %) of 5,5-dicarbomethoxy-(2-phenylsulfonyl)-octa-1,2-diene-7-yne (**35**) as a clear oil; IR (neat) 2119, 1964, 1732, and 1143 cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 1.86 (t, 1H, J=2.7 Hz), 2.82 (d, 2H, J=2.7 Hz), 3.03 (t, 2H, J=2.7 Hz), 3.65 (s, 6H), 5.36 (t, 2H, J=2.7 Hz), 7.48-7.63 (m, 3H), and 7.86 (d, 2H, J=7.5 Hz); ^{13}C-NMR ($CDCl_3$, 75 MHz) δ 22.5, 28.2, 52.9, 56.1, 71.9, 78.0, 85.4, 108.6, 128.2, 129.0, 133.5, 139.6, 168.9, and 208.2; HRMS for $C_{18}H_{18}O_6S$: 362.0824. Found: 362.0809.

To a solution containing 100 mg (0.28 mmol) of **35** and 26 mg (0.31 mmol) of N-methylhydroxylamine hydrochloride in 10 mL of CH_2Cl_2 at rt was added 0.1 mL (0.72 mmol) of NEt_3. After being stirred for 2h, the solvent was removed under reduced pressure and the residue was chromatograph-ed on silica gel to give 93 mg (85%) of 4,4-dicarbomethoxy-6-(phenylsulfonyl)-octa-1-yn-7-ylidenyl-N-methylnitrone (**36**) as a clear oil; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 2.01 (t, 1H, J=2.4 Hz), 2.08 (brs, 3H), 2.54 (dd, 1H, J=15.0 and 9.0 Hz), 2.74 (dd, 1H, J=17.1 and 2.7 Hz), 2.84 (dd, 1H, J=17.1 and 2.7 Hz), 2.98 (dd, 1 H, J=15.3 and 1.8 Hz), 3.26 (d, 3H, J=0.9 Hz), 3.68 (s, 3H), 3.73 (s, 3H), 4.66 (dd, 1H, J=9.0 and 2.1 Hz), 7.58-7.74 (m, 3H), and 7.85 (d, 2H, J=7.5 Hz); ^{13}C-NMR ($CDCl_3$, 75 MHz) δ 15.3, 24.9, 29.7, 48.1, 53.4, 53.6, 55.5, 64.1, 72.8, 77.2, 128.7, 129.8, 134.7, 137.4, 138.6, 169.5, and 169.6.

A solution containing 81 mg (0.20 mmol) of nitrone **36** in 5 mL of benzene was heated at reflux for 3 h. The solvent was removed under reduced pressure and the residue was chromatographed on silica gel to give 72 mg (89%) of 4,4-dicarbomethoxy-1-methyl-N-methyl-2-(phenylsulfonyl)-8-oxa-9-azabicyclo[4.3.0]-nona-6-ene (**38**) as a clear oil; IR (neat) 1730, 1439, 1140, and 784 cm^{-1}; ^{1}H NMR

(C_6D_6, 360 MHz) δ 1.63 (s, 3H), 2.45 (dd, 1H, J=14.4 and 2.0 Hz), 2.56 (dd, 1H, J=14.1 and 13.0 Hz), 2.66 (ddd, 1H, J =14.1, 3.8, and 2.3 Hz), 2.91 (dd, 1H, J=14.4 and 2.3 Hz), 3.03 (s, 3H), 3.09 (s, 3H), 3.22 (d, 3H, J = 0.8 Hz), 4.20 (dd, 1H, J=13.0 and 3.7 Hz), 5.77 (brd, J=1.0 Hz), 6.81-6.88 (m, 3H), and 7.84-7.87 (m, 2H); ^{13}C NMR ($CDCl_3$, 75 MHz) δ 14.7, 26.9, 29.7, 40.3, 52.7, 53.1, 55.3, 58.9, 70.7, 110.1, 128.2, 129.0, 133.7, 136.5, 139.0, 169.0, and 170.2; HRMS Calcd for $C_{18}H_{21}NO_7S$: 395.1039. Found: 395.1045.

Preparation of 7-(Benzenesulfonyl)-1-benzyl-7a-methyl-4,6,7,7a-tetrahydro-1H-benzo-[c]isoxazole-5,5-dicarboxylic Acid Dimethyl Ester (39). A solution of 54 mg (0.15 mmol) of 5,5-dicarbomethoxy-(2-phenylsulfonyl)-octa-1,2-diene-7-yne (**35**) and 20 mg (0.16 mmol) of N-benzylhydroxylamine in 10 mL of CH_2Cl_2 was stirred for 6 h. Removal of the solvent and purification on silica gel gave 50 mg (69%) of 4,4-dicarbomethoxy-6-(phenylsulfonyl)-octa-1-yn-7-ylidenyl-N-benzylnitrone (**37**) as a clear oil; IR (neat) 1728, 1447, 1306, and 723 cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 1.90 (t, 1H, J=2.4 Hz), 2.47 (dd, 1H, J=15.5 and 2.4 Hz), 2.53-2.63 (m, 2H), 2.88 (dd, 1H, J=15.5 and 2.4 Hz), 3.52 (s, 3H), 3.70 (s, 3H), 4.66 (d, 1H, J=14.1 Hz), 4.88 (dd, 1H, J=9.3 and 1.9 Hz), 4.94 (d, 1H, J=14.1 Hz), 7.30-7.38 (m, 5H), 7.55 (t, 2H, J=7.8 Hz), 7.67 (t, 1H, J=7.5 Hz), and 7.75 (d, 2H, J=7.5 Hz), ; ^{13}C-NMR ($CDCl_3$, 75 MHz) δ ;15.8, 24.6, 30.3, 53.2, 53.5, 55.3, 63.6, 63.9, 128.5, 129.0, 129.6, 132.5, 134.5, 137.5, and 169.5.

A solution of 15 mg of the above nitrone in 5 mL of benzene was heated for 2 h. Removal of the solvent and purification of the residue gave 13 mg (85%) of 7-(phenylsulfonyl)-1-benzyl-7a-methyl-4,6,7,7a-tetrahydro-1H-benzo[c]isoxazole-5,5-dicarboxylic acid dimethyl ester (**39**) as a clear oil; IR (neat) 1735, 1442, 1250, and 721 cm^{-1}; ^{1}H-NMR (C_6D_6, 300 MHz) δ 1.78 (s, 3H), 2.58 (t, 2H, J=13.8 Hz), 2.74 (ddd, 1H, J=14.7, 3.6 and 2.1 Hz), 2.96 (dd, 1H, J=14.7 and 2.1 Hz), 3.06 (s, 3H), 3.14 (s, 3H), 4.04 (d, 1H, J=13.5 Hz), 4.33 (dd, 1H, J=12.9 and 3.6 Hz), 5.28 (d, 1H, J=13.5 Hz), 5.76 (s, 1H), 6.87-6.94 (m, 3H), 7.33 -7.38 (m, 3H), 7.85 (d, 2H, J=7.5 Hz), and 7.96 (d, 2H, J=8.1 Hz); ^{13}C-NMR ($CDCl_3$, 75 MHz) δ 15.2, 26.8, 29.8, 52.8, 53.2, 55.4, 57.6, 69.6, 71.2, 109.7, 127.2, 128.2, 128.3, 129.2, 129.3, 133.8, 136.5, 138.6, 139.2, 169.0, and 170.4; HRMS Calcd for $C_{25}H_{28}NO_7S$ (M^++1): 486.1586. Found 486.1579.

A mixture of 250 mg (0.51 mmol) of **39** and 40 mg of PtO_2 in 50 mL of ethyl acetate under a hydrogen atmosphere (65 psi) was shaken overnight. The solvent was removed and the residue was purified on silica gel to give 123 mg (63%) of 5-(phenylsulfonyl)-3-formyl-4-methyl-cyclohex-3-ene-1,1-dicarboxylic acid dimethyl ester (**40**) as a clear oil; IR (neat) 1730, 1666, 1438, and 1068 cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 1.81 (dt, 1H, J=15.8 and 2.4 Hz), 2.18 (dd, 1H, J=14.4 and 7.8 Hz), 2.43 (d, 3H, J=1.8 Hz), 2.59 (ddd, 1H, J=14.1, 9.0 and 3.3 Hz), 3.20 (dd, 1H, J=16.8 and 3.0 Hz), 3.58 (s, 3H), 3.70 (s, 3H), 4.27 (t, 1H, J=8.1 Hz), 7.56 (t, 2H, J=7.8 Hz), 7.68 (t, 1H, J=7.2 Hz), and 7.85 (d, 2H, J=7.5Hz); ^{13}C-NMR

($CDCl_3$, 75 MHz) δ 18.0, 27.0, 30.4, 52.9, 53.1, 53.4, 67.7, 128.9, 129.3, 134.4, 136.8, 145.1, 170.1, 170.4, and 188.7; HRMS Calcd for $C_{18}H_{20}O_7S$: 380.0930. Found 380.0924.

Preparation of 1-(2-Methoxy-acetyl)-6-methyl-6-aza-bicyclo[3.1.0]hexane-3,3-dicarboxylic Acid Dimethyl Ester (46). A sample of 4-methoxy-but-2-yn-1-ol was prepared in 30% yield by the procedure of Franzen[66] from but-2-yn-1,4-diol; bp 69°-70°C (2 mm); IR (neat) 1454, 1355, 1008, and 894 cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 2.02 (s, 1H), 3.36 (s, 3H), 4.11 (s, 2H), and 4.28 (s, 2H); ^{13}C-NMR ($CDCl_3$, 75 MHz) δ 50.9, 57.6, 59.8, 81.3, and 84.8.

To a mixture of 4.5 g (45 mmol) of 4-methoxy-but-2-yn-1-ol in 7 mL of ether and 0.48 mL pyridine in a 50 mL two neck flask fitted with a reflux condensor and dropping funnel was added dropwise 5.9 g (21.8 mmol) PBr_3 over a 20 min period at 0°C. When the addition was complete, the reaction mixture was heated for 2.5 h at 50°C. The cooled mixture was added to 300 mL of ice water and the aqueous layer was extracted with ether. The organic layer was washed with a $NaHCO_3$ solution, water, brine, and dried over Na_2SO_4. After filtration, the solvent was removed under reduced pressure to give 7.29 g (99%) of 1-bromo-4-methoxy-but-2-yne; IR (neat) 1446, 1354, 1093, and 902 cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 3.35 (s, 3H), 3.93 (t, 2H, J=1.8 Hz), and 4.12 (t, 2H, J=1.8 Hz); ^{13}C-NMR ($CDCl_3$, 75 MHz) δ 14.1, 57.7, 59.9, 81.4, and 82.7.

To a stirred ice-cold suspension containing 472 mg (11.8 mmol) of 60% NaH in 115 mL of THF under N_2 was slowly cannulated 1.72 g (10 mmol) of dimethyl allyl malonate. The solution was stirred for 30 min at 0°C and then 1.63 g (10 mmol) of 1-bromo-4-methoxy-but-2-yne was added *via* syringe over 15 min. The solution was stirred for 1.5 h at 0°C and then it was allowed to warm to rt. After stirring for an additional 1.5 h at rt, the reaction mixture was quenched with a saturated NH_4Cl solution. The mixture was extracted with CH_2Cl_2 and the organic layer was collected, washed with water, brine, and dried over anhydrous Na_2SO_4. Evaporation of the solvent under reduced pressure left a crude residue which was subjected to silica gel chromatography. The major fraction contained 2.29 g (90%) of 2-allyl-2-(4-methoxy-but-2-ynyl)-malonic acid dimethyl ester; IR (neat) 1728, 1433, 1216, and 1085 cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 2.77 (d, 2H, J=7.5 Hz), 2.82 (t, 2H, J=2.1 Hz), 3.31 (s, 3H), 3.70 (s, 6H), 4.02 (t, 2H, J=2.1 Hz), 5.07-5.16 (m, 2H), and 5.53-5.67 (m, 1H); ^{13}C-NMR ($CDCl_3$, 75 MHz) δ 23.0, 36.6, 52.7, 57.0, 57.3, 59.9, 79.0, 81.1, 119.8, 131.7, and 170.2.

A solution of 515 mg (2.0 mmol) of 2-allyl-2-(4-methoxy-but-2-ynyl)malonic acid dimethyl ester in 50 mL of CH_2Cl_2 was subjected to ozonolysis for 20 min at -78°C. The reaction was then quenched with 0.7 mL of dimethyl sulfide and 2-3 drops of acetic acid at -78°C. The solution was allowed to warm to rt and was stirred at rt for 15 h. The excess dimethyl sulfide and the solvent was removed under reduced pressure. The resulting oil was taken up in an ether-water mixture. The aqueous solution was extracted with ether and the organic layer was washed with water, brine, and dried over Na_2SO_4. The solvent was

removed under reduced pressure and the residue was subjected to silica gel chromatography to give 232 mg (46%) of 2-[(4-methoxy)-but-2-ynyl]-2-(2-oxo-ethyl)malonic acid dimethyl ester; IR (neat) 2236, 1730, 1204, and 1090 cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 2.94 (d, 2H, J=1.8 Hz), 3.17 (s, 2H), 3.25 (s, 3H), 3.68 (s, 6H), 3.96 (t, 2H, J=1.8 Hz), and 9.66 (s, 1H); ^{13}C-NMR ($CDCl_3$, 75 MHz) δ 24.1, 45.9, 53.1, 53.9, 57.2, 59.7, 79.7, 80.8, 169.2, and 198.3.

A solution containing 63 mg (0.25 mmol) of the above aldehyde and 30 mg (0.36 mmol) of N-methylhydroxylamine hydrochloride in 13 mL of dry THF was treated with 0.06 mL of triethylamine. After stirring at 75°C for 5 h, the solvent was removed under reduced pressure. The residue was washed with water, brine, and dried over Na_2SO_4. The solvent was removed under reduced pressure. Purification by flash silica gel chromatography afforded 40 mg (57%) of 1-(2-methoxy-acetyl)-6-methyl-6-aza-bicyclo[3.1.0]hexane-3,3-dicarboxylic acid dimethyl ester (**46**) as a clear oil; IR (neat) 1730, 1432, 1254, 1054, and 727 cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 2.02 (d, 1H, J=13.2 Hz), 2.30 (s, 3H), 2.37 (d, 1H, J=13.5 Hz), 2.64 (s, 1H), 2.82 (d, 1H, J=13.5 Hz), 3.06 (d, 1H, J=13.2 Hz), 3.41 (s, 3H), 3.67 (s, 3H), 3.71 (s, 3H), 4.25 (d, 1H, J=17.0 Hz), and 4.38 (d, 1H, J=17.0 Hz); ^{13}C-NMR ($CDCl_3$, 75 Mz) δ 35.3, 35.4, 36.9, 51.5, 52.2, 52.8, 53.1, 58.4, 59.3, 77.2, 171.1, 171.5, and 201.1; HRMS for $C_{13}H_{19}NO_6$: 285.1212. Found: 285.1207.

Preparation of 6-Benzyl-1-(2-methoxy-acetyl)-6-aza-bicyclo[3.1.0]hexane-3,3-dicarboxylic acid dimethyl ester (47). A solution containing 80 mg (0.31 mmol) of 2-[(4-methoxy)-but-2-ynyl]-2-(2-oxo-ethyl)malonic acid dimethyl ester and 38 mg (0.31 mmol) of N-benzylhydroxylamine in 20 mL of dry THF was stirred at 75°C for 15 min. The solvent was removed under reduced pressure to give 109 mg (97%) of N-benzyl-α-(7-methoxy-hept-5-ynylidene-3,3-dicarboxylic acid dimethyl ester)nitrone; IR (neat) 2241, 1730, 1594, 1493, 1428, 1083, and 724 cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 2.84 (d, 2H, J=1.6 Hz), 3.10 (d, 2H, J=5.7 Hz), 3.26 (s, 3H), 3.62 (s, 6H), 3.96 (d, 2H, J=1.6 Hz), 4.83 (s, 2H), 6.91 (t, 1H, J=5.7 Hz), and 7.30-7.33 (m, 5H); ^{13}C-NMR ($CDCl_3$, 75 Mz) δ 25.1, 30.8, 53.0, 55.4, 57.3, 59.7, 69.3, 79.8, 80.5, 128.7, 128.8, 129.1, 132.7, 134.9, and 169.6.

A solution containing 75 mg (0.21 mmol) of the above nitrone in 16 mL of dry THF was stirred and heated at 75°C for 8 h. The solvent was removed under reduced pressure and the residue was purified by flash silica gel chromatography to give 34 mg (45%) of 6-benzyl-1-(2-methoxy-acetyl)-6-azabicyclo-[3.1.0]hexane-3,3-dicarboxylic acid dimethyl ester (**47**) as a clear oil; IR (neat) 1730, 1495, 1254, 1054, and 727 cm^{-1}; ^{1}H-NMR ($CDCl_3$, 300 MHz) δ 2.07 (dd, 1H, J=13.5 and 2.1 Hz), 2.35 (d, 1H, J=12.9 Hz), 2.92 (m, 3H), 3.14 (s, 3H), 3.53 (d, 1H, J=14.5 Hz), 3.69 (s, 3H), 3.73 (s, 3H), 3.82 (d, 1H, J=17.7 Hz), 3.96 (d, 1H, J=14.5 Hz), 4.24 (d, 1H, J=17.7 Hz), and 7.15-7.28 (m, 5H); ^{13}C-NMR ($CDCl_3$, 75 Mz) δ 35.6, 35.7, 50.3, 50.4, 51.5, 52.5, 52.9, 53.0, 58.1, 76.9, 126.9, 127.5, 128.2, 139.1, 171.0, 171.4, and 201.1; HRMS for $C_{19}H_{23}NO_6$: 361.1525. Found: 361.1531.

Acknowledgement: We gratefully acknowledge support of this work by the National Institutes of Helath (CA-26750) and for a scholarship to M. M. from the Deutschen Akademischen Austauschdienst. Use of the high-field NMR spectrometer used in these studies was made possible through equipment grants from the NIH and NSF.

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(*Received in USA* 12 *August* 1994; *accepted* 24 *October* 1994)