

AN AZETINE FROM A PHOTOCYCLOADDITION REACTION
 FOLLOWED BY A RETRO DIELS-ALDER FRAGMENTATION¹

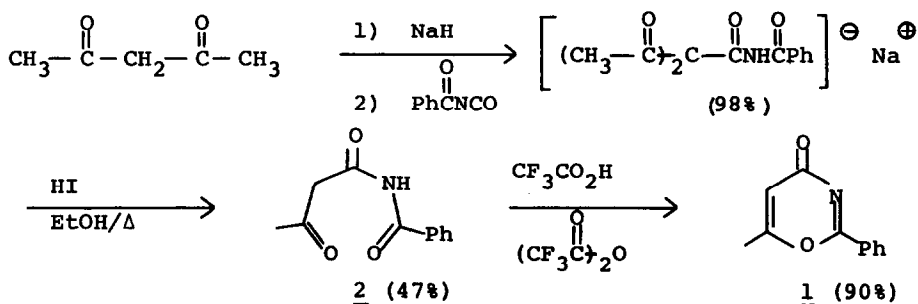
Tad H. Koch,* Robert H. Higgins, and Herbert F. Schuster

Department of Chemistry, University of Colorado, Boulder, Colorado 80309

(Received in USA 13 September 1976; received in UK for publication 6 January 1977)

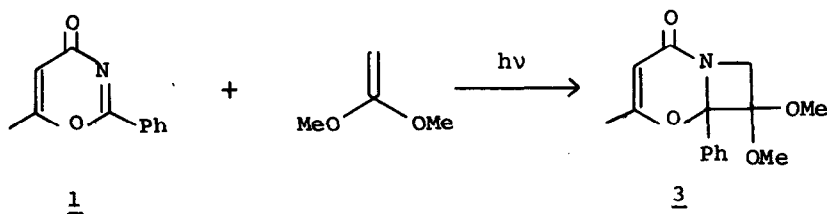
There are few definitive reports of the 1-azetine ring system in the chemical literature. 2-Alkoxy-1-azetines have been prepared by treatment of β -lactams with trialkyloxonium tetrafluoroborates.² Pyrolysis of cyclopropyl azides has been shown to give 1-azetines,³ and treatment of 2-trichloromethylaziridines with potassium *tert*-butoxide is reported by Hassner and coworkers to give 1,2-dichloro-1-azetine derivatives.⁴ We would like to report the preparation of a 1-azetine by 2+2-photocycloaddition of an olefin to the carbon-nitrogen double bond of a 1,3-oxazin-4-one followed by thermal retro Diels-Alder fragmentation.

5-Methyl-2-phenyl-1,3-oxazin-4-one (1) was prepared in 40% overall yield for this investigation by nucleophilic addition of sodium acetylacetonate to benzoyl isocyanate followed by reverse Claisen condensation catalyzed with hydroiodic acid. The resulting acetylimide (2) was cyclized with trifluoroacetic acid-trifluoroacetic anhydride. The spectral and analytical data for 1 were completely consistent with the assigned structure.⁵



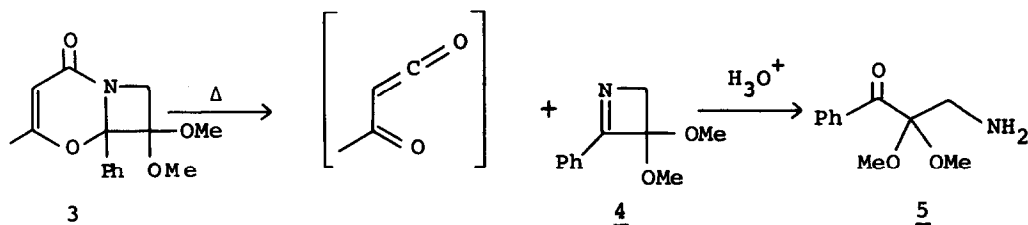
A methylene chloride solution of 1 (0.50 g) and 1,1-dimethoxyethene (5 ml) was irradiated for 2 hrs with a Hanovia, 450 watt, mercury lamp equipped with a

Pyrex filter. The methylene chloride was rotary evaporated and the solid residue dissolved in ether and extracted with dilute, aqueous potassium hydroxide solution to remove traces of unreacted starting material. Evaporation of the ether gave essentially pure 7,7-dimethoxy-4-methyl-6-phenyl-1-az-5-oxabicyclo[4.2.0]octan-2-one (3) (0.57 g, 78%) as indicated by nmr spectroscopy. An analytical sample (mp 103-4°) was prepared by vacuum distillation at 85°, 0.01 mm, followed by recrystallization from heptane. The structure was established from spectroscopic and analytical data⁶ and was consistent with photoreactivity predicted from previous studies of similar compounds.⁷ It is interesting to note that the photocycloaddition reaction occurred exclusively to the carbon-nitrogen double bond.



The photocycloadduct 3 was pyrolyzed at 225° C in the injection port of a gas chromatograph. The product, 3,3-dimethoxy-2-phenyl-1-azetine (4), was isolated in 57% yield by collection from a 0.25 in by 5 ft glpc column of 3% SE-30 on Varaport 30 at 150° with a helium flow of 60 ml/min. The anticipated by-product of the pyrolysis, acetylketene, was not observed, presumably because of instability to the glpc conditions. 6-Methyl-2-phenyl-1,3-oxazin-4-one (1) was also not observed as a product from the pyrolysis of 3, although it is stable to the glpc conditions.

The azetine structure 4 was assigned on the basis of spectroscopic data⁸ and the structure of the product from acid catalyzed hydrolysis of 4. When the azetine 4 was stirred at ambient temperature for 15 min with 3N hydrochloric acid, 3-amino-2,2-dimethoxy-1-phenylpropanone (5) was isolated after neutralization and chloroform extraction. The nmr and ir spectra of 5 were identical to the spectra of 5 prepared by an independent route.⁷



The regioselectivity of the thermal fragmentation is consistent with orbital symmetry control.⁹ Fragmentation to **1** plus 1,1-dimethoxyethene is a thermally forbidden [$\sigma_2s + \sigma_2s$] process whereas fragmentation to **4** plus acetylketene is a thermally allowed [$\sigma_2s + \sigma_2s + \pi_2s$] process. Cyclobutenes have also been prepared via thermal retro Diels-Alder fragmentation of unrelated cycloadducts.¹⁰

References and Notes

1. We gratefully acknowledge financial support from the National Institutes of Health (GM-18349).
2. G. Pifferi, P. Consonni, G. Pelizza, and E. Testa, *J. Heterocycl. Chem.*, **4**, 619 (1967); D. Bormann, *Justus Liebigs Ann. Chem.*, **752**, 124 (1969).
3. A. B. Levy and A. Hassner, *J. Am. Chem. Soc.*, **93**, 2051 (1971); G. Szeimies, U. Seifken, and R. Rinck, *Angew. Chem.*, **85**, 173 (1973).
4. A. Hassner, J. O. Currie, A. S. Steinfeld, and R. F. Atkinson, *J. Am. Chem. Soc.*, **95**, 2982 (1973).
5. Oxazinone **1** showed the following spectroscopic absorptions and elemental analysis: ir ($CHCl_3$) 6.0, 6.24, and 6.29 μ ; nmr ($CDCl_3$) δ 2.01 (3H, d, $J = 1.0$ Hz), 5.75 (1H, q, $J = 1.0$ Hz), 7-7.4 (3H, m), and 7.8-8.1 ppm (2H, m); mass spectrum (70 ev) m/e 188(8), 187(55), 159(37), 105(14), 104(29), 103(20), 84(31), 77(23), 69(39), 51(11), 43(base); uv (THF) 252(19,100), 228 sh (14,700), and 206 nm (16,000); anal: calcd for $C_{11}H_9NO_2$: C, 70.58; H, 4.85; found: C, 70.59; H, 4.89.

6. The spectroscopic data and elemental analysis for the cycloadduct 3 are as follows: ir (CHCl₃) 6.01 and 6.04 μ ; nmr (CDCl₃) δ 1.93 (3H, d, J = 0.9 Hz), 3.03 (3H, s), 3.49 (3H, s), 4.00 (1H, d, J = 9.5 Hz), 4.27 (1H, d, J = 9.5 Hz), 5.17 (1H, q, J = 0.9 Hz), and 7.3-7.8 (5H, m); mass spectrum (70 ev) m/e 275(2), 203(44), 176(14), 118(24), 117(13), 105(17), 91(11), 89(25), 88(base), 77(32), 69(10), 58(81), 57(13), 51(11), 45(40), and 43(86); uv (MeOH) 260 sh (3,400), 214 sh (13,200), and 208 nm (13,300); anal. calcd. for C₁₅H₁₇NO₄: C, 65.44; H, 6.23; N, 5.09; found: C, 65.31; H, 6.28; N, 5.02.
7. J. S. Swenton and J. H. Hyatt, J. Am. Chem. Soc., 96, 4879 (1974); K. A. Howard and T. H. Koch, ibid., 97, 7288 (1975); R. M. Rodehorst and T. H. Koch, ibid., 97, 7298 (1975).
8. The azetine 4 gave the following spectroscopic absorptions: ir (CHCl₃) 6.38 μ ; nmr (CDCl₃) δ 3.43 (6H, s), 4.08 (2H, s), 7.28-7.61 (3H, m) and 7.71-8.01 ppm (2H, m); mass spectrum (70 ev) m/e 191(25), 176(13), 118(26), 117(18), 116(10), 89(19), 88(base), 77(35), 58(56), 45(98), and 43(91); the azetine was not sufficiently stable for elemental analysis.
9. R. B. Woodward and R. Hoffmann, Angew. Chem., Int. Ed. Engl., 8, 781 (1969).
10. M. Auram, I. G. Dinnlescu, M. Elian, M. Farcasu, E. Marica, G. Mateescu and C. D. Nenitzescu, Chem. Ber., 97, 372 (1964).