ring), 2.63 (10 H, monosubstituted aromatic ring)] *dl*-IIIb [mp 136–140°, $\lambda_{\max}^{\mathrm{EtOH}}$ 281 mμ (ε 3200), nmr signals at τ 7.43 (3 H, NCH_3), 6.15, 6.47 (6 H, two OCH_3), 5.18 (2 H, two OH), 4.23 (1 H, C-8 H), 3.11, 3.29 (4 H, two doublets, J = 8.5 cps)] differed from that of phenol A. Hence phenol A was assumed to have the 4′,5-diphenol structure IIIc, and thalidasine, an unprecedented diphenyl ether terminus at C-5. Evidence for both structures was adduced from the experimental results which follow.

Characterization of the *minor* phenolic products of reduction with sodium in liquid ammonia and mass spectroscopic evidence[10] strongly support assignment of structure Ia for thalidasine. One minor phenolic cleavage product was L-armepavine (IIIe), $[\alpha]^{27}D$ +99° (c 0.14, $CHCl_3$), infrared and nmr spectra superimposable with those of authentic sample.[13] A second minor phenolic product was L-1-(4-methoxybenzyl)-2-methyl-6,7-dimethoxy-8-hydroxy-1,2,3,4-tetrahydroisoquinoline (IIb), $[\alpha]^{27}D$ +32° (c 0.40, $CHCl_3$), infrared and nmr spectra superimposable with those of a sample of *dl* compound.[14] The most intense peak in the mass spectrum of thalidasine is a doubly charged ion (IV) of m/e 213 ($C_{24}H_{30}N_2O_5$). This type of fragmentation has been shown to be characteristic of alkaloids of the unsymmetrical bisbenzylisoquinoline type.[5b,15] Fragments with compositions $C_{27}H_{29}NO_4$, $C_{15}H_{14}O_2$, $C_{14}H_{11}O_2$, $C_{12}H_{16}NO_3$, and $C_{12}H_{16}NO_2$, are readily explicable on the basis of structure Ia.

Thalfoetidine's chemistry supports the structural features assumed earlier,[9] apart from the termini of the diphenyl ether linkage. Methylation of thalfoetidine with diazomethane yielded O-methylthalfoetidine,[9,16] and direct comparison (infrared, nmr) has established the identity of the methylation product with thalidasine. Hence thalfoetidine possesses structure Ib.

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[13] S. M. Kupchan, B. Dasgupta, E. Fujita, and M. L. King, *Tetrahedron*, **19**, 227 (1963).

[14] A. Brossi and S. Teitel, *Helv. Chim. Acta*, **49**, 1757 (1966). We thank Dr. Brossi cordially for a sample of *dl*-IIb.

[15] M. Tomita, T. Kikuchi, K. Fujitani, H. Kato, H. Furukawa, Y. Aoyagi, M. Kitano, and T. Ibuka, *Tetrahedron Letters*, 857 (1966); D. C. DeJongh, S. R. Shrader, and M. P. Cava, *J. Am. Chem. Soc.*, **88**, 1052 (1966).

[16] We thank Dr. N. Mollov cordially for a sample of thalfoetidine.

S. Morris Kupchan, T.-H. Yang, George S. Vasilikiotis
Michael H. Barnes, M. L. King
Department of Pharmaceutical Chemistry
University of Wisconsin, Madison, Wisconsin 53706

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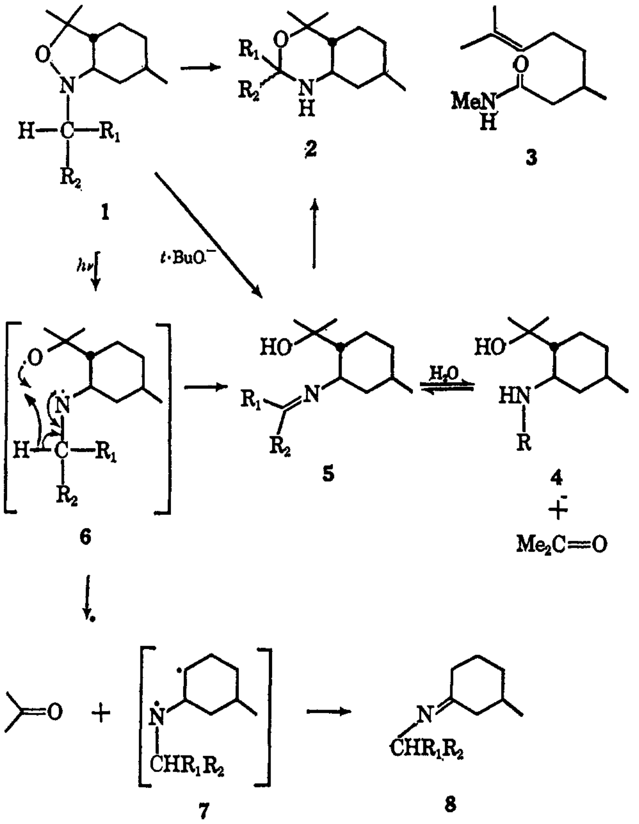
Photochemical and Base-Catalyzed Rearrangements of Isoxazolidines

Sir:

Intra-[1] and intermolecular[2] cycloadditions of nitrones and olefins have provided a new method for the formation of carbon–carbon bonds. Adaptation of this reaction as a synthetic method of broadest possible scope has stimulated investigations of the chemistry of the product isoxazolidine ring system. It is the purpose of this report to disclose our discovery of a rearrangement of N-alkylisoxazolidines to tetrahydro-1,3-oxazines, an isomerization that can be effected both by ultraviolet irradiation and by strong base.

Irradiation of the fused bicyclic isoxazolidine **1a** ($\lambda_{\max}^{\mathrm{isooctane}}$ 213 mμ (ε 1940)) in hexane solution (0.027 *M*) with 2537-A light[3] afforded a product mixture from which the bicyclic tetrahydro-1,3-oxazine **2a** could be isolated. Minor amounts of the amide **3** were also obtained, and the identity of **3** was established by synthesis from citronellic acid. The photochemical conversion of **1a** to **2a** could be efficiently photosensitized by the use of benzophenone and fluorenone (anthracene, $E_T \sim$ 42 kcal/mole, proved to be a poor sensitizer). Under these conditions, the yields of **2a** were 43 and 54%, respectively, and no amide **3** was detected. Similarly, isoxazolidine **1b** was photoisomerized to **2b**.



a, $R_1 = R_2 = H$; b, $R_1 = H$, $R_2 = CH_3$; c, $R_1 = R_2 = CH_3$

The structures of **2a** and **2b** were supported by their nmr spectra, which for the former showed an AB quartet at 4.25 ppm (2 H, J_{AB} = 10.5 cps), whereas **2b** showed a regular quartet at 4.35 ppm (1 H, J = 5.6 cps). Reduction of each with lithium aluminum hydride produced the known[1] secondary amino alcohols **4**, R = CH_3, and **4**, R = C_2H_5, respectively.

When **1a** and **1b** were heated with 0.5 equiv of potassium *t*-butoxide in DMSO for 5 hr at ~80°, the tetrahydro-1,3-oxazines were again obtained in good yield.

We propose that these reactions are mechanistically similar in that the imino alcohol **5** is a common intermediate. Cyclization of γ-hydroxy imines to tetrahydro-1,3-oxazines is well established.[4] For the photochemical transformation, energy transfer from triplet

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[1] N. A. LeBel, M. E. Post, and J. J. Whang, *J. Am. Chem. Soc.*, **86**, 3759 (1964).

[2] R. Huisgen, *Angew. Chem. Intern. Ed. Engl.*, **2**, 565 (1963), and references cited therein.

[3] A. Srinivasan-Griffin "Rayonet" reactor was employed, with a quartz vessel for the direct photolysis; 3000- and 3500-A sources and a Pyrex vessel were used for the sensitized runs.

[4] R. C. Elderfield, "Heterocyclic Compounds," Vol. 6, John Wiley and Sons, Inc., New York, N. Y., 1957, p 541.

sensitizer to give the excited triplet of **1** followed by bond cleavage would result in the diradical **6**. Intramolecular hydrogen transfer *via* a seven-membered transition state leads directly to **5**. Because **6** is a *t*-alkoxy radical, competing fragmentation could occur. In support of this postulated mechanism, we have succeeded in trapping acetone (as the 2,4-DNP) by sweeping the reaction mixture with nitrogen. The newly generated diradical **7** would be expected to rearrange to an imine (**8**), and 3-methylcyclohexanone was characterized after work-up with aqueous acid.[5]

Production of **5** in the base-promoted rearrangements can take place *via* β elimination. Direct evidence for the occurrence of this pathway in the reaction of **1c** and *t*-butoxide has been obtained by isolation of imino alcohol **5c**. When the reaction mixture was quenched by pouring into water, the primary amino alcohol **4** (R = H) was obtained; however, if sufficient acid was present to neutralize the base, both **4** (R = H) and **5c** were detected. The isopropylideneimine **5c** was synthesized by condensation of **4** (R = H) with acetone. Presumably **5c** does not cyclize readily to a tetrahydro-1,3-oxazine because of steric hindrance.

Other polycyclic isoxazolidines have been subjected to these rearrangement conditions, and studies to define the limitations of such reactions are in progress

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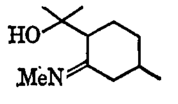
[5] An alternate pathway to acetone and **8** is also possible: intramolecular hydrogen transfer involving a five-membered ring to give i which could undergo a retroaldol reaction.



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Norman A. LeBel, Thomas A. Lajiness, David B. Ledlie
Department of Chemistry, Wayne State University
Detroit, Michigan 48202

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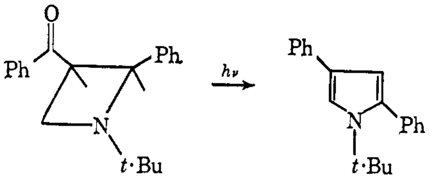
A Novel Photoinduced Ring Expansion of 1-*t*-Butyl-2-phenyl-3-benzoylazetidine[1]

Sir:

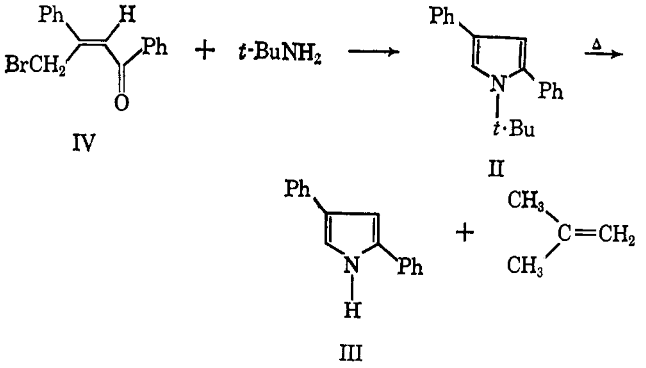
As part of our broad interest in the ground-state and electronically excited-state behavior of small-membered rings,[2] we have investigated the photochemical behavior of *cis*-1-*t*-butyl-2-phenyl-3-benzoylazetidine[3] (I) and wish to describe an unusual photoinduced ring expansion of the four-membered azetidine ring. To our knowledge this represents the first example of a photochemical migration of an alkyl group from the α position to the carbonyl carbon of an n–π^* excited state.

$* = +, -, \cdot$

The initial experiments were carried out in a nitrogen atmosphere using an internal water-cooled mercury arc lamp (Hanovia Type L, 450 w) with a Pyrex filter to eliminate wavelengths below 300 mμ. In a typical case a solution of 0.5 g of I in 150 ml of 95% ethanol was flushed with nitrogen and irradiated for 3 hr. Conventional isolation procedures afforded 0.46 g of a solid (95%), mp 102–103°, whose structure is assigned as 1-*t*-butyl-2,4-diphenylpyrrole (II) on the basis of the chemical and physical data cited. The infrared spectrum of II was characterized by a series of sharp bands at 6.24, 8.21, 12.47, 13.08, 13.50, 14.25, and 14.40 μ. The ultraviolet spectrum (λ_{max} (95% alcohol) 235 mμ (ϵ 15,800) and 276 mμ (ϵ 16,200)) of II shows an absorption curve very similar to 2,4-diphenylfuran, with peaks occurring at approximately the same wavelengths (λ_{max} (95% alcohol) 242 mμ (ϵ 19,400) and 277 mμ (ϵ 20,000)).[5] The nmr spectrum in deuteriochloroform exhibits a singlet at τ 8.60, a pair of doublets at τ 3.80 and 2.96 (J = 1.9 cps), and a multiplet centered at τ 2.62. The peak areas are in the ratio of 9:1:1:10. The doublet pattern of the 3- and 5-protons is to be expected, as it has been shown that the cross-ring or *meta* coupling constant ($J_{3,5}$) in the pyrrole system has a value of approximately 2 cps.[6] The elemental analysis of this component (*Anal.* Calcd for $C_{20}H_{21}N$: C, 87.22; H, 7.69; N, 5.09. Found: C, 87.20; H, 7.85; N, 5.09) is also consistent with structure II. Chemical confirmation was obtained by pyrolysis of II at 225°. The product obtained in better than 97% yield was identical with an authentic sample of 2,4-diphenylpyrrole (III) synthesized by the method of Allen and Wilson.[7] Structure II was further confirmed by its unequivocal synthesis from 1,3-diphenyl-4-bromobuten-2-one-1 (IV) and *t*-butylamine.



I II



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[1] Photochemical Transformations of Small Ring Carbonyl Compounds, part XV. For part XIV, see A. Padwa, D. Crumrine, R. Hartman, and R. Layton, *J. Am. Chem. Soc.*, in press.

[2] A. Padwa in "Organic Photochemistry," Vol. I, O. L. Chapman Ed., Marcel Dekker, Inc., New York, N. Y., 1967, p 91.

[3] Before the completion of our investigation a report appeared describing the synthesis of azetidine I.[4] Our spectral data are in good agreement with those reported.

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[5] S. M. King, C. R. Bauer, and R. E. Lutz, *J. Am. Chem. Soc.*, **73**, 2253 (1951).

[6] R. J. Abraham and H. J. Bernstein, *Can. J. Chem.*, **37**, 1056 (1959).

[7] C. F. H. Allen and C. V. Wilson, "Organic Syntheses," Coll. Vol. III, John Wiley and Sons, Inc., New York, N. Y., 1955, p 348.