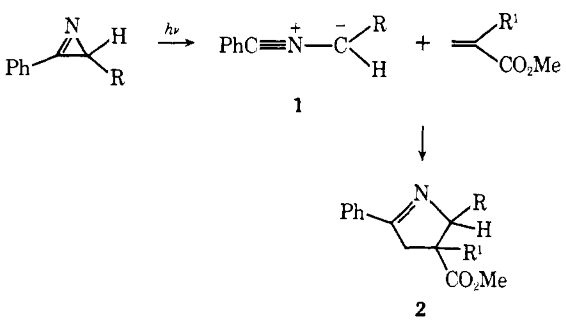
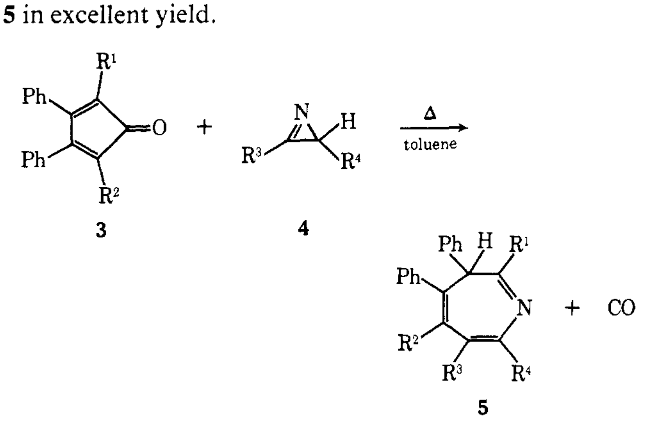
3*H*-Azepines from Azirines and Cyclopentadienones[1]

Sir:

Azirines[2] are potentially useful precursors to other heterocycles. A recent report[3] deals with the photochemical addition of azirines to α,β-unsaturated esters to give derivatives of pyrroline **2**. The reaction is believed to involve the nitrile ylide **1**.



We wish to report the facile thermal addition of 1-azirines **4** to cyclopentadienones **3** to give 3*H*-azepines **5** in excellent yield.

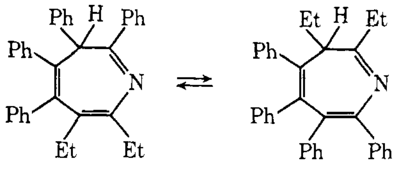


Reaction of 2-benzyl-1-azirine (**4g**) with tetracyclone (**3a**) led to **5g** in which the benzylic protons are not coupled to neighboring hydrogens.

Table I. Thermal Conversion of Cyclopentadienones **3** with Azirines **4** to Azepines **5**

5	R₁	R₂	R₃	R₄	% yield	τ (CDCl₃) R₁	τ (CDCl₃) R₂	τ (CDCl₃) R₃	τ (CDCl₃) R₄	τ (CDCl₃) 3 H
a	Ph	Ph	Ph	H	87				2.48	3.62
b	Ph	Ph	Ph	Me	65				8.23	3.77
c	Ph	Ph	Ph	Ph	61					3.63
d	Me	Me	Ph	H	86	7.72	8.24		3.06	4.71
e	Me	Me	Ph	Me	83	7.79	8.42		8.48	4.82
f	Me	Me	Ph	Ph	12	7.72	8.36			4.72
g	Ph	Ph	$C_6H_4CH_2$	H	57			6.72	2.74	3.80
h	Ph	Ph	Et	Et	48			8.01	7.79	
								9.68	8.90	3.94

When 2,3-diethyl-1-azirine (**4h**) and tetracyclone were allowed to react, two azepines **5h** and **6** were isolated in 85% overall yield.



5h **6**

The two azepines were inseparable by alumina and silica gel chromatography. However, fractional recrystallization afforded pure **5h**, mp 151° (28%), and pure **6**, mp 128° (13%). When either **5h** or **6** was refluxed in xylene for 3 days a 3:8 mixture of **5h**:**6** was formed. The equilibration of **5h** and **6** is presumed to involve [1,5]-hydrogen shifts. This appears to be the first example of a [1,5]-sigmatropic shift of the 3*H*-azepine system. Though similar [1,5] shifts in the cycloheptatriene system are well documented[4] they are inoperative in 1*H*-azepines.[5] It is interesting to note that the methylene protons of the 2-ethyl group in **6** display an AB pattern in the nmr spectrum due to the asymmetric center C-3.[6]

When 3,3-dimethyl-2-phenyl-1-azirine was refluxed in xylene for 13 days with tetracyclone, no reaction was observed. This may be compared to the inability of 3,3-dicarbon-substituted cyclopropenes to undergo cycloadditions.[7,8] Steric interactions in the transition state leading to an intermediate of type **8** probably account for the unreactivity. However, 3,3-dihalogeno-substituted cyclopropenes do undergo thermal cycloadditions at variable rates.[9] In this case, electronic factors are thought to be important.

We believe that the mechanism of the formation of the initial 3*H*-azepine in our case proceeds according to Scheme I. The azanorcaradiene intermediate **7** undergoes a [1,5]-hydrogen shift to give the 3*H*-azepine directly.

Some evidence favoring this mechanism is provided by the reaction of 1,2,3-triphenylcyclopropene and the dimer of 2,5-dimethyl-3,4-diphenylcyclopentadienone. When the two were refluxed briefly in toluene, the initial adduct **8** was formed in quantitative yield. When this adduct was refluxed in xylene overnight, it was converted cleanly to the cycloheptatriene **10**. This cyclo-

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(1) (a) Chemistry of Small Ring Heterocycles. XVIII. For paper XVII see A. B. Levy and A Hassner, *J. Amer. Chem. Soc.*, **93**, 2051 (1971). (b) This work was supported by a grant from the National Cancer Institute, Public Health Service.

(2) 1-Azirines are now readily available from olefins *via* vinyl azides: A. Hassner and F. W. Fowler, *J. Amer. Chem. Soc.*, **90**, 2869 (1968).

(3) A. Padwa and J. Smolanoff, *ibid.*, **93**, 549 (1971).

(4) R. B. Woodward and R. Hoffmann, *Angew. Chem., Int. Ed. Engl.*, **8**, 781 (1969).

(5) L. A. Paquette, D. E. Kuhla, and J. H. Barrett, *J. Org. Chem.*, **34**, 2879 (1969).

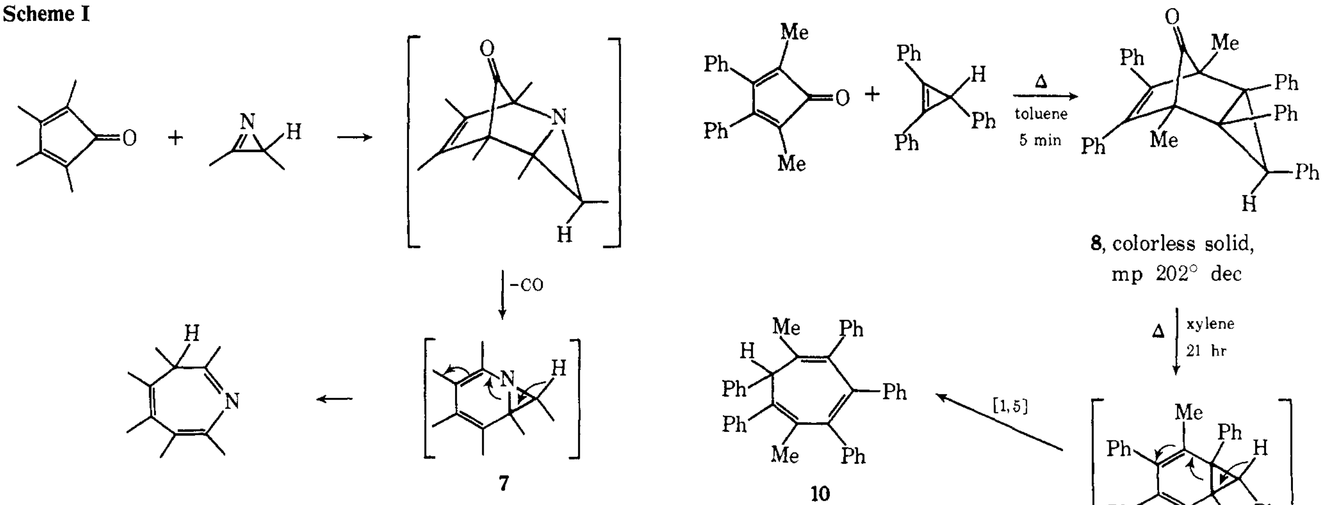
(6) The methylene protons of the ethoxy group in 2-ethoxy-3,5,7-trimethyl-3*H*-azepine also show nonequivalence: L. A. Paquette, *J. Amer. Chem. Soc.*, **86**, 4096 (1964).

(7) G. L. Closs, L. E. Closs, and W. A. Boll, *ibid.*, **85**, 3796 (1963).

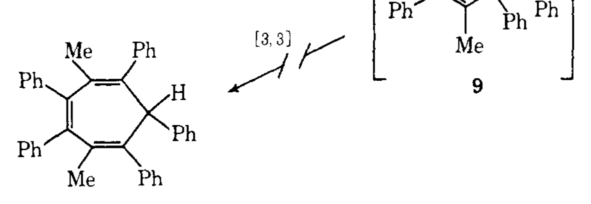
(8) M. A. Battiste, *Tetrahedron Lett.*, 3795 (1964).

(9) D. C. F. Law and S. W. Toby, *J. Amer. Chem. Soc.*, **90**, 2376 (1968).

Scheme I



8, colorless solid, mp 202° dec



11

heptatriene is readily distinguished from the symmetrical isomer **11** (expected from a [3,3] shift of the intermediate norcaradiene **9**) by the nonequivalence of the two methyl groups at τ ($CDCl_3$) 8.80 and 8.15 in the nmr spectrum. Only one product from the thermolysis of **8** could be detected by tlc and nmr techniques even when the reaction was conducted under milder conditions. For example, the decarbonylation was only 60% complete in refluxing toluene after 6 days. These observations suggest that the symmetry-allowed [1,5]-hydrogen shift mechanism is operative in both the multisubstituted carbocyclic and heterocyclic systems. A similar observation of the norcaradiene–cycloheptatriene rearrangement has also been tentatively suggested.[10]

In a typical experiment, tetracyclone (1.4 g, 3.65 mmol) and 3-methyl-2-phenyl-1-azirine (0.65 g, 5.0 mmol) were heated under reflux in toluene (50 ml) in an atmosphere of nitrogen for 6 days. After this time the solvent was removed and the residue was recrystallized from ethanol to afford 7-methyl-2,3,4,5,6-pentaphenyl-3*H*-azepine (**5b**) (1.15 g, 65% based on tetracyclone) as yellow hexagonal plates, mp 212°.

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[10] T. Mukai, H. Kubota, and T. Toda, *Tetrahedron Lett.*, 3581 (1967).

*Book Reviews**

Cement and Concrete Research. Edited by DELLA M. ROY (Pennsylvania State University). Pergamon Press, New York, N. Y. 1971 (bimonthly). $30.00 per year.

This is a new journal, devoted to the chemistry and physics of cement and related materials, and publishing articles on fundamental research and reviews.

The Basis of Organic Chemistry. By R. J. FESSENDEN and J. S. FESSENDEN (University of Montana). Allyn and Bacon, Inc., Boston, Mass. 1971. x + 420 pp. $12.95.

This is a textbook for introductory organic chemistry for students of various backgrounds. The approach is a departure from the traditional one and begins with types of bonds and their reactions, proceeds rapidly through the traditional descriptive material, and dwells for the last third of the book on subjects of biochemical interest (sample chapter headings: "Addition Reactions and Reduction of Compounds Containing Pi Bonds"; "Nucleic Acids and the Chemistry of Heredity").

Structure and Bonding. Volume 8. Edited by P. HEMMERICH, *et al.* Springer-Verlag, New York–Heidelberg–Berlin. 1970. 198 pp. $11.60.

This publication stands between a periodical and a softbound book. It "appears at irregular intervals, according to the material received," the publisher states, but the criteria for selection of manuscripts are not disclosed. Volume 8 is essentially biochemical and contains four chapters: "Iron Electronic Configurations in Proteins: Studies by Mössbauer Spectroscopy," by Bearden and Dunham; "Structural Studies of Hemes and Hemoproteins by NMR Spectroscopy," by Wuthrich; "The Chemical Nature and Reactivity of Cytochrome P-450," by Hill, Roder, and Williams; and "Cobalt(II) in Metalloenzymes," by Lindskog. These are review papers that apparently include some original work of the authors, but there are no explicit experimental sections. There is a cumulative table of contents for Volumes 1 to 8, but no index.

Tables for Group Theory. By P. W. ATKINS, M. S. CHILD, and C. S. G. PHILLIPS (University of Oxford). Oxford University Press, New York, N. Y. 1970. 32 pp. $1.00.

This little pamphlet contains essential tables for using group theoretical methods: character tables, direct products, descent in symmetry and subgroups. There are notes and illustrations, but no discursive text.

Microtechniques. A Laboratory Guide. By R. L. WILLEY (University of Illinois at Chicago Circle). The Macmillan Co., New York, N. Y. 1971. viii + 99 pp. $3.95.

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* Unsigned book reviews are by the Book Review Editor.