ment of a dimethylallyl 2-indolyl sulfonium salt. It is of interest that a number of related metabolites, such as euchinulin,[9] the brevinamides,[5] and austamide,[10] contain the inverted C_5 unit at C-2.[11]

Experimental Section

The melting points were determined on a Fisher-Johns melting point block. Nmr spectra were recorded with a Varian A-60D in $CDCl_3$; shifts are expressed in δ values (parts per million) from tetramethylsilane as internal standard, and coupling constants are expressed in cycles per second (hertz). In nmr descriptions, s = singlet, d = doublet, t = triplet, m = multiplet, and q = quartet. Infrared spectra were taken on a Perkin-Elmer Model 137 Infracord and ultraviolet spectra on a Cary Model 11.

Isolation of I.—The whole mash from a 30-l. fermentation was extracted with an equal volume of ethyl acetate at pH 5.0. The extract was concentrated to dryness and the residue was partitioned between methanol and heptane to remove fatty material. Evaporation to dryness of the methanol portion gave ~25 g of a crude residue. Twelve grams of this residue was chromatographed over a 500-g silica gel column (acid washed) packed in methylene chloride. A gradient elution between 0.5% methanol–methylene chloride and 3% methanol–methylene chloride provided cladosporin (II, 110 mg) after evaporation of the solvent and crystallization from ethyl acetate–benzene, mp 186–187°. Further elution gave the benzodiazepinedione I (185 mg) after removal of the solvent and crystallization from ethyl acetate–benzene: mp 238–240°; $[\alpha]_D$ +425° (*c* 0.20, MeOH); ir (KBr) 3300, 1689, and 1647 cm^{-1}; λ_{max}^{MeOH} 210 nm (ϵ 61,000), 245 (22,000), and 284 (sh, 3940); nmr ($CDCl_3$) δ 1.02 and 1.21 (3 H, s), 2.60 (3 H, s), 2.46 (q, J_{AB} = 14, J_{AX} = 8.0 Hz), 3.42 (q, J_{AB} = 14, J_{BX} = 8.5 Hz), 3.90 (t, J = 8 Hz), 5.16 (m, AB of vinylidene), 5.92 (q, J_{trans} = 18, J_{cis} = 9.5 Hz, X of vinylidene), 6.00 (1 H, s), 6.83–8.17 (8 H, m), and 8.45 (1 H, s); mass spectrum *m/e* 415.18919 (calcd for $C_{25}H_{25}N_3O_3$, 415.18959).

Chromatography of the remaining portion of the crude ethyl acetate concentrate gave a total of 225 mg of II and 389 mg of I.

Acknowledgments.—We wish to thank Dr. H. Tresner and Miss Jean Hayes for culture isolation and identification, Mr. A. Shay for large-scale fermentations, Mr. M. Dann for large-scale work-ups, Mr. W. Fulmor and Mr. G. Morton for the uv and nmr spectra, and Dr. G. Van Lear for the mass spectrum [direct inlet MS 9 (AEI)].

Registry No.—I, 42230-55-7; II, 35818-31-6.

(9) A. Quilico, *Res. Progr. Org.-Biol. Med. Chem.*, **1**, 1964 (1964); for a recent study on the biosynthesis of echinulin, see C. M. Allen, Jr., *Biochemistry*, **11**, 2154 (1972).

(10) P. S. Steyn, *Tetrahedron Lett.*, 3331 (1971).

(11) A proposal for the echinulin-type metabolites has been put forth by Cosnati and Pochini [*Chem. Commun.*, 1328 (1970)]. On the basis of model reactions, they point out the feasibility of a primary attack at N-1 (*e.g.*, lanosulin[12]) followed by rearrangement to introduce the inverted γ,γ-dimethylallyl group at C-2. This postulate does not appear to be relevant to the introduction of the C_5 moiety at C-3.

(12) D. T. Dix, J. Martin, and C. E. Moppett, *Chem. Commun.*, 1168 (1972).

Cyclization of Azidoformates

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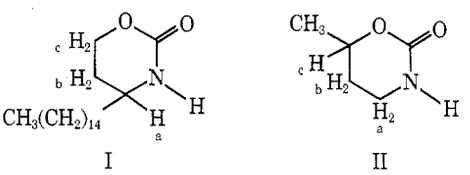
The major product of the thermolysis of *n*-octadecyl azidoformate in cyclohexane is *n*-octadecyl *N*-cyclohexylcarbamate. In addition, two isomeric minor products, with the empirical formula $C_{19}H_{37}O_2N$, are found. One, obtained in 5% yield, is the five-membered ring compound formed by "backbiting" of the nitrene, 4-*n*-hexadecyloxazolidin-2-one, as shown by comparison of its infrared and nmr spectra with those of an authentic sample of the 4-ethyl derivative.[2,3]

Although common sense dictated that the other isomer, obtained in 8% yield, should be the corresponding six-membered ring compound, 4-*n*-pentadecyltetrahydro-2*H*-1,3-oxazin-2-one (I), the nmr spectrum in comparison with an "authentic" sample of the corresponding 4-methyl derivative seemed to eliminate this possibility; the difficulty arose because in the "4-methyl derivative" spectrum the two protons adjacent to O are upfield from the one adjacent to N, whereas in the octadecyl compound the reverse is true.[2]

Edwards[4] suggested that the large alkyl group in I imparts conformational rigidity to the ring and causes the signal of one of the hydrogens in the 6 position to overlap that of the hydrogen in the 4 position, adjacent to the N atom. We did not consider this a very likely explanation and decided to reinvestigate the problem.[5]

There is now no doubt that the unknown is indeed the six-membered ring isomer (I), whereas the "authentic 4-methyl derivative" is 6-methyltetrahydro-2*H*-1,3-oxazin-2-one (II). Table I summarizes the nmr chemical shifts observed for the various proton groups in the two compounds. Time averaging in the presence of $Eu(dpm)_3$ showed H_a in I to be a quintet, consistent with the assigned structure. The fact that the H_c protons occur as a narrow (*ca.* 13 Hz) multiplet is consistent with a six-membered ring, as is the absence of an amide II band in the infrared spectrum.[2] The fact that the single proton (H_a) occurs at higher field than the two



I II

TABLE I

NMR SPECTRA AND PEAK ASSIGNMENTS FOR ISOMERIC ALKYL-2*H*-1,3-OXAZIN-2-ONES

Proton group	δ, ppm from TMS (rel area) I	II
H_a	3.4 (1)	3.36 (2.1)
H_b	1.9 (1.8)	1.9 (2)
H_c	4.23 (2)	4.41 (1.0)
NH	6.45 (0.8)	7.1

(1) Hercules Research Center Contribution No. 1617.

(2) D. S. Breslow, T. J. Prosser, A. F. Marcantonio, and C. A. Genge, *J. Amer. Chem. Soc.*, **89**, 2384 (1967).

(3) Our recent nmr studies have shown that the nmr chemical shift assignments given in ref 1 for 4-*n*-hexadecyloxazolidin-2-one and the corresponding ethyl derivative, which were based on poorly resolved spectra obtained on a primitive instrument, were in error. Spectra run on a modern high-resolution instrument, confirmed by proton decoupling and the use of lanthanide shift reagents, show that the ring methylene protons adjacent to oxygen are nonequivalent and occur at δ 4.0 and 4.6. The ring methyne proton adjacent to nitrogen is observed at δ 3.8.

(4) O. E. Edwards, "Nitrenes," W. Lwowski, Ed., Interscience, New York, N. Y., 1970, p 236.

(5) We are indebted to Dr. C. A. Genge and Mrs. E. I. Edwards of the Hercules Research Center for the preparation and isolation of a fresh sample of isomer.

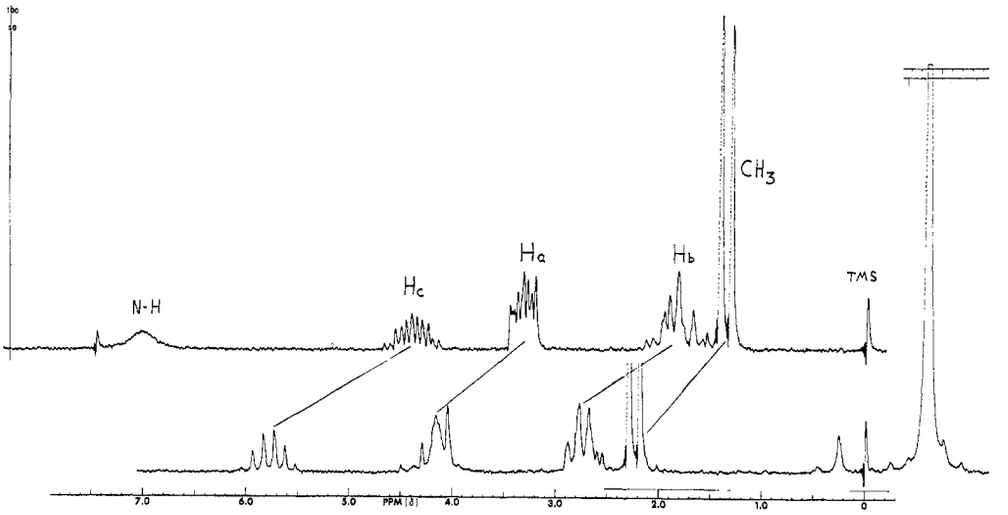


Figure 1.—Effect of Eu(dpm)$_3$ on the nmr spectrum of 6-methyltetrahydro-2*H*-1,3-oxazin-2-one: upper spectrum, no shift reagent; lower spectrum, Eu/substrate = 0.148.

protons (H_c) leaves little doubt as to the assigned structure; $-CH_2NHC{=}O$ is reported in the range of δ 3.0–3.5, whereas $-CH_2OC{=}O$ is reported at δ 4.1–4.3.[6]

Proton assignments in II were confirmed by proton–proton decoupling studies and shift enhancement with Eu(dpm)$_3$. The paramagnetic shift reagent was particularly useful in this work because it provided simplification of the complex, non-first-order spectra of the ring protons as well as resolution of overlapping multiplets. As an example, Figure 1 shows the unshifted and shifted spectra of II. In the shifted spectrum, run at a molar ratio of Eu/substrate of only 0.148, the NH proton occurs at δ 9.3, off the low-field end of the spectrum. H_c, shifted from δ 4.4 to 5.8, is clearly a sextet, coupled to the methyl group and the H_b methylene protons. The H_b multiplet, shifted from δ 1.9 to 2.7, is now clearly recognizable as a quartet, although some evidence of non-first-order coupling is still present at this Eu/substrate ratio. In the case of I, run at a similar Eu(dpm)$_3$/substrate ratio, the NH proton was observed at δ 9.1 and H_a was shifted from δ 1.9 to 2.9 and H_c from δ 4.2 to 5.8. In the shifted spectrum of I, the proton multiplets were also simplified, although they were not completely first order, and area measurements were significantly improved.

The only synthesis of 4-methyltetrahydro-2*H*-1,3-oxazin-2-one in the literature involves the condensation of 1,3-butanediol with urea.[7] Since this reagent would be expected to yield a mixture of isomers, and in any case could not be considered an unequivocal synthesis, we chose to prepare it by the reaction of diethyl carbonate and purchased "3-amino-1-butanol."[8] It is most unlikely that an isomerization would take place under the reaction conditions used, and, since there is no doubt that the product obtained is the 6-methyl isomer, the starting material must therefore have been 4-amino-2-butanol.[9]

(6) L. M. Jackman and S. Sternhell, "Applications of Nuclear Magnetic Resonance Spectroscopy in Organic Chemistry," 2nd ed, Pergamon Press, Elmsford, N. Y., 1969, p 164.
(7) A. M. Paquin, *Z. Naturforsch.*, **1**, 518 (1946).
(8) K & K Laboratories, Inc.
(9) Unfortunately, the structure of the amino alcohol was not investigated at the time the preparation was run, and the compound is no longer available.

Experimental Section

6-Methyltetrahydro-2*H*-1,3-oxazin-2-one (II).—To a solution of 12.3 g (0.14 mol) of "1-amino-3-butanol"[8] in 35.1 g (0.30 mol) of diethyl carbonate was added 10 mg of sodium. The reaction was heated at 130–140° and ethanol was distilled off through a short Vigreux column as it formed. The white crystals which formed on cooling in a deep freeze were filtered and recrystallized once from acetone, mp 91–92° (6.30 g, 39% of theory). One recrystallization from benzene raised the melting point to 98.5–99.5° (lit.[6] mp 91°).

Anal. Calcd for $C_5H_9O_2N$: C, 52.16; H, 7.88; N, 12.17. Found: C, 52.15, 52.10; H, 7.98, 7.80; N, 12.05, 12.23.

Nmr spectra were run at 90 MHz on a Bruker HFX-90 spectrometer and at 60 MHz on a Varian A-60A spectrometer in standard 5-mm-o.d. sample tubes, using $CDCl_3$ as a solvent and tetramethylsilane as an internal reference and lock signal.

Registry No.—I, 42202-88-0; II, 42202-89-1; *n*-octadecyl azidoformate, 822-04-8; *n*-octadecyl *N*-cyclohexylcarbamate, 16307-63-4; 4-*n*-hexadecyloxazolidin-2-one, 16392-84-0; 1-amino-3-butanol, 39884-48-5.

Quinazolines and 1,4-Benzodiazepines. LXII.[1] Reaction of Oxaziridines with Water or Alcohols Catalyzed by Iron Salts

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We have reported[2–4] on the preparation and chemistry of oxazirinobenzodiazepinones **1** and **5**. It was found[3] that **5** undergoes ring contraction reactions to form quinazolinones when alcoholic or aqueous solutions were simply allowed to stand at room temperature. We wish to report here that, when ferrous sulfate or

(1) Paper LXI: R. Y. Ning, P. B. Madan, and L. H. Sternbach, *J. Heterocycl. Chem.*, in press.
(2) R. Y. Ning, G. F. Field, and L. H. Sternbach, *J. Heterocycl. Chem.*, **7**, 475 (1970).
(3) R. Y. Ning, I. Douvan, and L. H. Sternbach, *J. Org. Chem.*, **35**, 2243 (1970).
(4) R. Y. Ning, W. Y. Chen, and L. H. Sternbach, *J. Org. Chem.*, **36**, 1064 (1971).