58-1; **8e**, 37614-57-6; **8g**, 37614-58-7; **8b**, 37614-59-8; **11**, 37614-60-1; dicyclohexylcarbodiimide, 538-75-0; diisopropylcarbodiimide, 693-13-0; *p*-bromophenylacetylene, 766-96-1; α-phenylpropargyl alcohol, 4187-87-5; propargyl alcohol, 107-19-7

Furazans and Furazan Oxides. III.[1] Acenaphtho[1,2-*c*]furazan

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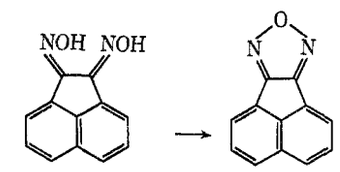
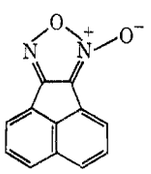
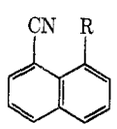
Some years ago, Boyer pointed out[2a] that very few representative furazans and furazan oxides fused to five-membered rings were known, and he also reported[2b] an unsuccessful attempt to prepare the title compound (**1**). Since that date, the number of strained furazan oxides known has increased,[3] but the only strained furazan has remained the rather doubtful example of Ingold and Shoppee.[4] Phosphite deoxygenation of acenaphtho[1,2-*c*]furazan oxide (**2**) has been found to occur under mild conditions, to form 1,8-dicyanonaphthalene (**3**), through the postulated intermediate furazan (**1**).[3] We now report the preparation of **1**, and some of its properties.

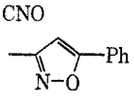


4 **1**



2



3, R = CN
5, R = CNO
6, R = 

Dehydration of the dioxime **4** was effected by thionyl chloride in methylene chloride, a convenient modification of the method of Tokura, *et al.*,[5] who used sulfur dioxide as solvent. The product **1** was indefinitely stable at room temperature, but slowly decomposed to the nitrile oxide **5** on warming. The decomposition was followed by infrared, at 72° in toluene, and the appearance of two bands was observed, at 2285 (s, CNO) and 2210 cm^{-1} (m, CN). The nitrile oxide band reached a maximum after about 30 min, and then slowly decreased in intensity, falling to about 80% of its maximum after 2 hr. We were unable to isolate the expected furazan oxide dimer of **5**, after prolonged heating, and it is probable that other modes of polymerization had occurred, the product being oily and dark red in color.

The nitrile oxide **5** was not isolated in pure form, but brief (2–3 min) heating of the furazan **1** to 125° gave a product shown by infrared spectroscopy to contain largely the oxide. A number of stable 1-naphthonitrile oxides are known,[6a] although the examples quoted by Grundmann and Grünanger all have a 2 substituent.

The furazan **1** with phenylacetylene gave the adduct **6**, and with trimethyl phosphite formed 1,8-naphthalonitrile (**3**). These results tend to confirm the proposed scheme[3] for the phosphite deoxygenation of strained furazan oxides of type **2**, in that the furazan is now shown to ring open to the dinitrile monoxide under the conditions of the experiment. The finding that the reaction of the furazan oxide **2** with phosphite is rate dependent on phosphite concentration led us to attempt to prepare **1** from **2** using a high concentration of phosphite at temperatures at which **1** is stable. We did indeed isolate the furazan, but in poor yield.[6b]

A recent note[7] has reported that, under more forcing conditions (reflux in tri*phenyl* phosphite), even unstrained furazan oxides can be deoxygenated, with ring cleavage, to nitriles. We have found that 4,5,6,7-tetrahydrobenzofurazan and its oxide are slowly converted into adiponitrile on prolonged reflux in triethyl phosphite.[8] We also observe that the acenaphthofurazan oxide (**2**) is unchanged on heating alone to temperatures 20–30° higher than those at which the furazan **1** is converted into the dinitrile monoxide **5**. We suggest that this apparent greater thermal lability of the furazans, compared with their *N*-oxides, is a result of the greater thermodynamic stability of the nitrile group, compared with the nitrile oxide.[9] The lower energy of formation of the product of ring opening of the furazan oxide, compared with the furazan, is reflected in a slightly increased energy of activation for the ring opening. We have, however, been unable to trap any products of addition of phenylacetylene to 1,8-naphthalonitrile dioxide, which is expected to be formed by this ring opening, although the furazan oxide does decompose spontaneously at temperatures of 100° and above.

Experimental Section

Melting points are corrected. Nmr spectra are of $CDCl_3$ solutions, measured on a Perkin-Elmer R12 60-MHz instrument.

Acenaphtho[1,2-*c*]furazan (1). A.—Acenaphthoquinone dioxime[10] (5.0 g, 0.024 mol) was finely powdered and suspended in dry dichloromethane (20 ml). Thionyl chloride (3.1 g, 0.025 mol) was added, and the mixture was stirred at 20° for 24 hr. It was poured onto ice and extracted with dichloromethane (3 × 25 ml). The extracts were dried ($MgSO_4$) and the solvent was

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(7) S. M. Katzman and J. Moffat, *J. Org. Chem.*, **37**, 1842 (1972).

(8) A. J. Boulton and S. S. Mathur, unpublished work (1971).

(9) Since we have been unable to locate any references to thermochemical data on nitrile oxides, this must remain an assertion unsupported by other than intuition.

(10) F. M. Rowe and J. S. H. Davies, *J. Chem. Soc.*, **117**, 1344 (1920).

removed (below 30°). Chromatography [Al_2O_3; eluent Et_2O (10%) in light petroleum] of the residue gave the furazan 1 (2.5 g, 55%) as pale buff needles: mp 140° (decomposing, depending on the rate of heating, above *ca.* 100°); ir (Nujol and $CHBr_3$) 1615 (w), 1600 (w), 1480 (m), 1410 (m), 1350 (m), 1315 (m), 1200 (m), 1150 (w), 1040 (w), 1020 (m), 940 (w), 820 (s), 810 (s), 770 (s); nmr τ_A 1.85, τ_B 2.00, τ_C 2.27 (J_{AC}, J_{BC} = 7 Hz).

Anal. Calcd. for $C_{12}H_6N_2O$: C, 74.2; H, 3.1; N, 14.4. Found: C, 74.5; H, 3.3; N, 14.1.

B.—Acenaphthofurazan oxide (2)[10] (0.1 g, 0.5 mmol) was allowed to stand for 48 hr with triethyl phosphite (5 g) at 20°. At the end of that period the solid had disappeared and the solution had become red-brown. It was poured into water (100 ml) containing 2–3 drops of HCl, and stirred until the smell indicated that the excess of phosphite had been hydrolyzed. Extraction (CH_2Cl_2) and chromatography on alumina as above gave the furazan 1 (0.01 g, 10%).

3-(8-Cyano-1-naphthyl)-5-phenylisoxazole (6).—The furazan 1 (0.1 g, 0.5 mmol) and phenylacetylene (0.07 g, 0.7 mmol) were heated to 125–130° for 15–20 min in xylene (3 ml). After cooling, the reaction mixture was chromatographed on alumina, eluting xylene and phenylacetylene with light petroleum, and then the adduct 6 with diethyl ether. The product formed needles (0.09 g, 55%): mp 142–143° (from ethanol); ir ($CHBr_3$) 3120 (m) (isoxazole CH), 2210 (m) (CN); nmr τ 3.22 (1 H, isoxazole), 1.8–2.6 (11 H).

Anal. Calcd for $C_{20}H_{12}N_2O$: C, 81.1; H, 4.05; N, 9.45. Found: C, 81.1; H, 4.25; N, 9.3.

1,8-Dicyanonaphthalene (3).—Heating the furazan 1 (0.1 g) to 80° for 4 hr with trimethyl phosphite (5 ml), followed by work-up in the usual way, gave the dinitrile 3 (95%), identical with a sample prepared previously[1] by reduction of the furazan oxide 2.

Registry No.—1, 206-28-0; 3, 5690-48-2; 4, 1932-08-7; 5, 37439-76-2; 6, 37439-77-3; phenylacetylene, 536-74-3.

The Structure and Partial Synthesis of Fabacein[1a,b]

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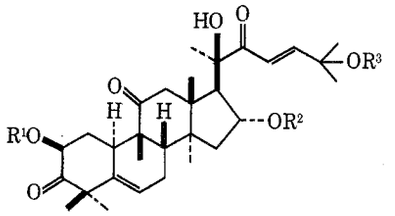
Received October 26, 1972

Fabacein is a bitter principle isolated from *Echinocystis fabacea* (Cucurbitaceae), and its isolation and preliminary characterization as a cucurbitacin diacetate derivative were described by Noller and coworkers.[2-4] In an extension of our recent studies of the structures of the cytotoxic cucurbitacins,[5-7] we have examined further the chemistry of fabacein. We report herein the structure elucidation and partial synthesis of fabacein (1), the first recognized naturally occurring cucurbitacin 16-acetate ester derivative.

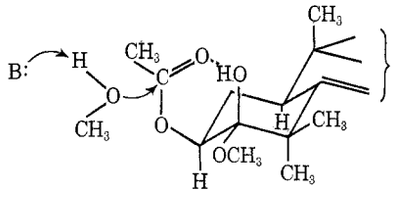


1, $R^1 = H$; $R^2 = R^3 = Ac$
2, $R^1 = R^2 = H$; $R^3 = Ac$
3, $R^1 = R^2 = R^3 = Ac$

Elemental analysis supported assignment of the molecular formula $C_{34}H_{48}O_9$[3] for fabacein (mp 198–201°, $[\alpha]^{25}D$ +36° absolute EtOH), and the spectral properties [$\lambda_{max}^{CHCl_3}$ 230 nm (ϵ 10,000); $\lambda_{max}^{CHCl_3}$ 2.91, 3.37, 3.43, 5.78, 5.91, 6.14, 6.84, 7.30, 8.00, 8.29, 8.87, 9.70, 10.2, and 10.8 μ; nmr ($CDCl_3$) τ 2.92 (1 H, d, J = 15 Hz), 3.68 (1 H, d, J = 15 Hz), 4.32 (1 H, m), 4.88 (1 H, b t, J = 8 Hz), 5.68 (1 H, d of d, J = 14, 6 Hz), 8.04 (3 H, s), 8.18 (3 H, s), 8.45 (3 H, s), 8.48 (3 H, s), 8.62 (3 H, s), 8.69 (3 H, s), 8.72 (3 H, s), 8.76 (3 H, s), 8.93 (3 H, s), and 8.99 (3 H, s); mass spectrum *m/e* 540, 445, 385, 369, 111, 96, and 43] supported its formulation as a cucurbitacin diacetate. The nmr signal at τ 4.88 (1 H, b t, J = 8 Hz) was characteristic of a C-16 proton in a 16-acetate derivative,[8] and, in view of the cooccurrence of fabacein with cucurbitacin B (2),[2] the hypothesis was entertained that fabacein is the 16-acetate ester (1) of cucurbitacin B (2).[3]

Interrelation of fabacein (1) with cucurbitacin B (2) was effected by acetylation of each to a common product, 3. The triacetate 3 was obtained in a chromatographically homogeneous but amorphous form; the identity of the samples obtained from the respective precursors 1 and 2 was established by ir, uv, nmr, mass spectrum, mixed tlc, and optical rotation comparisons.

The synthesis of fabacein (1) from cucurbitacin B (2) was effected *via* selective base-catalyzed solvolysis of the C-2 acetate group of the triacetate 3. Earlier studies in this laboratory have demonstrated a facilitation of the base-catalyzed solvolysis of the acetate esters of alcohols which bear carbonyl or hemiketal functions within hydrogen-bonding distance.[9] Accordingly, it was postulated that the alkaline solvolysis of the 2-acetate ester might be facilitated by the adjacent carbonyl group, possibly through hydrogen bonding of the acidic hydroxyl group of its hemiketal adduct with the carbonyl oxygen of the 2-acetate, as shown. In the event, treatment of 3 with triethylamine in 10% aqueous methanol for 12 hr at room temperature effected a smooth, selective solvolysis of the 2-acetate ester group, to yield fabacein (1).



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(3) W. Schlegel and C. R. Noller, *ibid.*, **26**, 1211 (1961).

(4) We thank Professor C. R. Noller cordially for a generous sample of fabacein.

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