Cycloaddition of Cyclopropanone Acetals to Tetracyanoethylene

P. G. Wiering and H. Steinberg*

Laboratory for Organic Chemistry, University of Amsterdam, Nieuwe Achtergracht 129, 1018 WS Amsterdam, The Netherlands

Received October 15, 1980

The cyclopropanone acetals **1a–e** and tetracyanoethylene give in a thermal [$_\sigma$2 + $_\pi$2] cycloaddition 2,2,3,3-tetracyanocyclopentanone acetals **2a–e**. In the case of 2-methylcyclopropanone acetal **1c** the corresponding 5-methylcyclopentanone acetal **3c** is also formed in minor amounts. With respect to the parent compound methyl substituents in the cyclopropane ring (**1b–c,e**) retard the cycloaddition reaction, whereas a phenyl group (**1d**) accelerates the reaction. The cycloadducts **2** are converted by water mainly into the ring-opened esters **4**. The structures of compound **2** have been determined by ^{1}H and ^{13}C NMR.

Introduction

The thermal [2 + 2] cycloaddition of tetracyanoethylene (TCNE) to enol ethers has been reviewed by Huisgen.[1] This reaction takes place very smoothly at moderate temperature. Much evidence has been presented for a two-step process via zwitterions, which can be trapped, e.g., by alcohol.

In a previous paper[2] we reported the thermal [$_\sigma$2 + $_\pi$2] cycloaddition of cyclopropanone acetal and the 2-phenyl-substituted acetal to TCNE. It was shown that the latter acetal reacted very rapidly with TCNE at room temperature, whereas the parent compound disappeared slowly at higher temperature.

In this paper we describe the addition of some methyl-substituted dialkoxycyclopropanes (cyclopropanone acetals) to TCNE, the hydrolysis of the adducts with water, and the elucidation of the structure of the adducts by ^{1}H and ^{13}C NMR.

Results and Discussion

Diethoxycyclopropane (**1a**) and TCNE in refluxing methylene chloride at 42 °C for 17 h gave in about 80% the cycloadduct 1,1-diethoxy-2,2,3,3-tetracyanocyclopentane (**2a**, Scheme I).

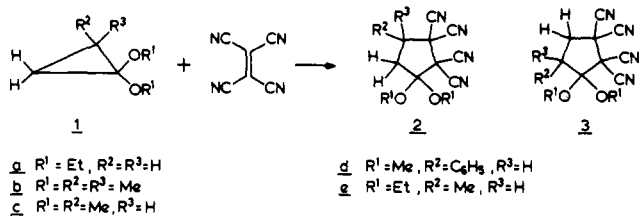
A remarkable decrease in the addition rate is observed when one or two methyl groups are introduced in the three-membered-ring acetal. With one methyl group (**1c**), the reaction in methylene chloride at 42 °C is complete in about 1 week and the *gem*-dimethyl-substituted acetal **1b** disappears in the same solvent (sealed tube) at 65 °C only after 2 weeks (NMR). The ^{1}H and ^{13}C NMR spectra of the cycloadducts from **1b** and **1d** show that only the 4-substituted isomers **2b** and **2d** are formed, whereas the NMR spectra of the reaction mixture of **1c** and **1e** and TCNE display more absorptions than can be expected from the cycloadducts **2c** and **2e**. It can be shown that the additional absorptions originate from the isomeric cycloadducts **3c** and **3e** (vide infra). The ratio of **2c** and **3c** is about 3:1, thus pointing to a preferred rupture of the C1–C2 cyclopropane bond. Unfortunately we are unable to separate both isomeric products by crystallization and column chromatography. The outcome of these reactions together with some kinetic results will be discussed in a forthcoming paper.

The rate of ring-opening of the cycloadducts **2a–c** (and **3c**) by water decreases appreciably by increasing the number of methyl groups. While the quantitative formation of the ester **4a** is complete within 8 hours at room temperature,[2] the methyl- and dimethyl-substituted cycloadducts require about 24 h of heating at 50 and 80 °C, respectively, before they are completely hydrolyzed. Furthermore it appears that the hydrolysis of **2b** ($R^2 = R^3$ = Me) gives also the fragmentation products **6**, **7**, and **8**, (Scheme II). The tetracyanoethane **8** was identical with an authentic sample obtained from TCNE and mercaptoacetic acid (NMR).[3] The methyl 3-methyl-2-butenoate **7** is not formed from methyl 3,3-dimethyl-4,4,5,5-tetracyanopentanoate (**4b**) by a control experiment with **4b** and water under similar conditions which leads only to some elimination of HCN. After **2b** was heated in aqueous acetontrile at 50 °C for 2 days a mixture was obtained consisting of 28% starting material, 40% **4b**, 24% **7** and **8**, and 8% **6**. On prolonged heating for three days the mixture contains, besides some starting material (8%), about 44% **4b**, 35% **7** and **8**, and 13% **6** (NMR). This result points to a relative increase of the ester **6** by elimination of HCN from the ester **4b**. We assume that in the polar medium acetonitrile/water ring cleavage takes place between the C1–C2 bond (path a) or the C3–C4 bond (path b), which in both cases gives rise to a stabilized zwitterion, **9** or **10**, respectively (Scheme III).

The dissociation process a predominates by a factor of about two (**4b** + **6**/**7**). This can be explained on the basis of an effective delocalization of the developing positive charge on the acetal carbon atom C1 and of the negative charge on carbon atom C2 in the transition state that leads to the zwitterion **9**. In the transition state that gives the zwitterion **10**, the positive charge is formed on a tertiary carbon atom C4, which is less effective in delocalizing the charge than C1. The dissociation of the C3–C4 bond in **2c** (with only one methyl group on C4), leading to a zwitterion with a secondary carbenium ionic part, is unfavorable. In general, this is also found with substitution or elimination reactions at a secondary carbon atom.

NMR Spectra of Cycloadducts. In the ^{1}H NMR spectrum the CH_2CH_2 protons in **2a** display a multiplet in the region of 2.0–3.2 ppm. The question arises which

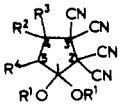
Scheme I



(1) R. Huisgen, *Acc. Chem. Res.*, 10, 117 (1977).
(2) A. A. P. Noordstrand, H. Steinberg, and Th. J. de Boer, *Tetrahedron Lett.*, 2611 (1975).
(3) W. J. Middleton, R. E. Hickert, E. L. Little, and C. G. Krespan, *J. Am. Chem. Soc.*, 80, 2783 (1958).

0022-3263/81/1946-1663$01.25/0

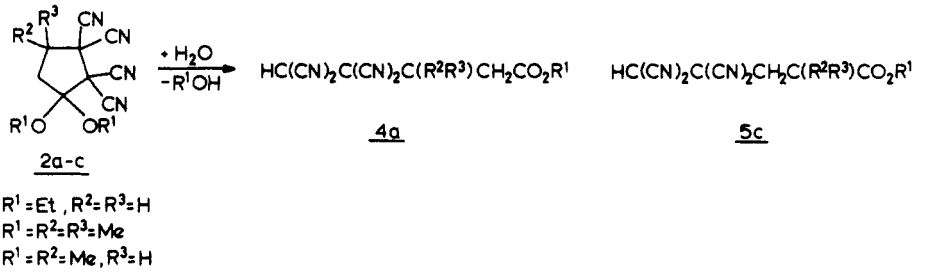
Table I. ^{13}C NMR Chemical Shifts of 2a–d, 3c, and 3e

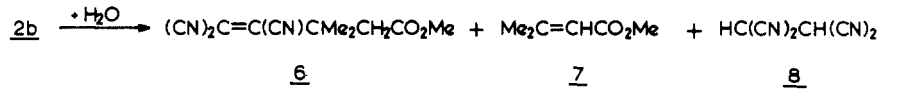


	R^2	R^3	R^4	C1	C2	C3	C4	C5	CN	$R^1 = CH_3$	$R^1 = CH_2CH_3$	$R^2 = R^3 = R^4 = CH_3$
2a	H	H	H	110.6	51.9	42.7	31.1	33.4	109.2, 111.1		60.2, 14.6	
2b	CH_3	CH_3	H	110.1	53.3	52.3	44.7	45.7	105.9, 109.7	51.5		28.9
2c	H	CH_3	H	110.4[a]	52.5	49.3	41.1	39.1	108.4, 108.9, 109.0, 110.0	50.9, 51.8		15.9
2d	H	C_6H_5	H	110.2	53.7	53.2	50.9	37.1	109.4, 110.2	50.9		128.5, 129.7, 130.5, 131.5
2e	H	CH_3	H	109.5[a]	52.5	48.9	40.6	39.3	108.3, 108.8, 108.9, 109.2		59.4, 14.2, 60.0	15.7
3c	H	H	CH_3	110.4[a]	52.5	41.4	38.5	42.1	*b*	50.4, 52.1		15.9
3e	H	H	CH_3	110.5[a]	52.6	41.1	38.6	41.6	*c*		58.8, 14.2, 60.2	15.4

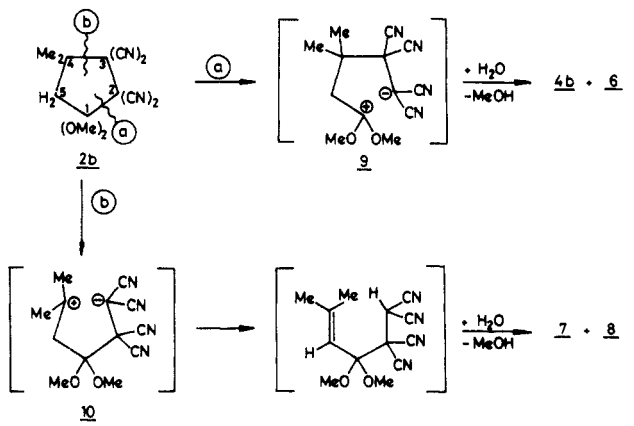
[a] These assignments may be interchanged with the CN absorptions. [b] See 2c. [c] See 2e.

Scheme II





Scheme III

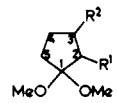


part of the multiplet in **2a** originates from the CH_2 group next to the acetal function. Also the position of the CH_3 group(s) in **2b,c** and **3c** cannot be determined with certainty. In other words we cannot decide from ^1H NMR data whether the cycloadduct has structures **2b,c** or **3b,c** (see Scheme I). The ^{13}C NMR spectra of the reaction mixtures obtained from **1a,b,d** and TCNE (see Table I) show the absorptions for the carbon atoms which are expected for the single adducts. The ^{13}C NMR spectrum of the reaction mixture obtained from 1,1-dimethoxy-2-methylcyclopropane (**1c**) and TCNE displays more absorptions, which indicate that at least a second reaction product is present.

We may conclude from the ^1H NMR spectra of all reaction mixtures the presence of the structural unit $CH_2C(R^2R^3)$. Furthermore the combined β effects of the OR and the CN groups on the ^{13}C chemical shift of the C2 carbon atom of the cyclopentane ring can be considered equal in each adduct. A similar consideration holds for the β and γ effects of the CN and OR groups, respectively, on the chemical shift of the C3 carbon atom. The set of three (**2a,bd**) or five (**2c,e, 3c,e**) absorptions between δ 108–111 must be ascribed to the acetal carbon (C1) and the cyanide carbon atoms (see Table I). We assume that the latter nuclei have similar T_1 relaxation times, so these carbon absorptions have comparable heights. One absorption of the set is observed to be higher and it seems reasonable to ascribe this absorption to the acetal carbon C1. It is remarkable that the chemical shifts of the acetal carbon C1 of the different cycloadducts and of the simple (2- and 3-methyl) cyclopentanone dimethyl acetal (see Table II) are very similar.

Similar small β-effects are also observed on the C=O carbon in the spectra of substituted cyclopentanones and

Table II. ^{13}C NMR Chemical Shifts of Some Cyclopentanone Acetals



R^1	R^2	C1	C2	C3	C4	C5	C6
H	H	112.2 (s)	34.2 (t)	23.3 (t)	23.3 (t)	34.2 (t)	49.2 (q)
CH_3	H	111.8 (s)	38.9 (d)	32.4 (t)	20.4 (t)	32.4 (t)	48.2, 49.6 (q)
H	CH_3	112.0 (s)	43.0 (t)	32.0 (d)	32.1 (t)	34.4 (t)	48.6, 49.0 (q)

cyclohexanones.[4] It can be deduced from off-resonance experiments that the monoether carbon atom absorbs at δ ~60 (OCH_2) and 51–52 (OCH_3) (see Table I).

Wherever the phenyl or methyl group is attached at the cyclopentane ring (C4 or C5) it is always located in the γ position with respect to the ring atom C2 and in the β or γ position with respect to carbon atom C3. Evidence for the correct assignment of the different carbon atoms is given by a comparison with the reference compounds mentioned in Table II. So we ascribe the absorption with the practically constant chemical shift δ 51.9–53.2 to C2 and the absorption between δ 42.7–53.2 to C3. By taking the absorption of C3 of the unsubstituted cycloadduct **2a** as a reference (δ 42.7), we observe a small negative (γ) effect for the absorption of **3c** and **3e** and an appreciable (β) effect for the corresponding C3 absorption of **2b–e** (see Table I).

It can be shown from off-resonance experiments that the remaining absorptions between δ 37–51 must be ascribed to the ring carbon atoms C4 and C5 at indicated in Table I. For the cycloadduct **2b**, the smaller absorption (δ 44.7) probably originates from the quaternary carbon atom C4.

Experimental Section

General Procedures. ^1H NMR spectra were recorded on a Varian A60D instrument. The ^{13}C spectra were taken on a XL-100-FT spectrometer at 25.2 MHz with proton noise decoupling. Off-resonance ^{13}C spectra were obtained with continuous-wave decoupling by irradiating at the proton frequency of Me_4Si. A flip angle of 60° and time delay of 1 s were used. Chemical shifts (δ) in parts per million were determined relative to the $CDCl_3$ absorption and converted to the Me_4Si scale by using $\delta_{CDCl_3} = 76.9$. All compounds had the correct elemental composition to ±0.2%.

1-Ethoxy-1-(methylthio)cyclopropane. After a solution of 7.3 g of 1-(methylthio)cyclopropyl bromide[5] in 30 mL of ethanol was stirred with sodium bicarbonate (4 g) at room temperature for 20 h, water was added and the solution was extracted with pentane. After distillation and further purification by VPC (2 m, 15% SE-30), 3.3 g of 1-ethoxy-1-(methylthio)cyclopropane was isolated: yield 58%; NMR 0.92 (m, 4 H), 1.12 (t, 3 H), 2.12 (s, 3 H), 3.60 (q, 2 H).

1,1-Diethoxycyclopropane (1a). To a solution of 1-ethoxy-1-(methylthio)cyclopropane (4.02 g) in 15 mL of dry CH_2Cl_2 was slowly added at 0 °C methyl fluorosulfonate (4.4 g) in 15 mL of CH_2Cl_2. Stirring was continued for 2 h at room temperature and the solvent was evaporated. Ethanol (33 mL), sodium bicarbonate (4 g), and magnesium sulfate (3 g) were added and the mixture was heated to about 70 °C for 5 h. After vacuum distillation, water (45 mL) was added to the distillate. The aqueous solution was extracted with pentane, and the pentane extract was dried over $MgSO_4$ and distilled to yield 1.5 g of **1a** (40%); NMR 0.8 (s, 4 H), 1.2 (t, 6 H), 4.65 (q, 4 H).

1,1-Dimethoxy-2,2-dimethylcyclopropane (1b). Dimethylketene dimethyl acetal[6] (5 g) was slowly added to a stirred solution of 17 g of methylene iodide and 8.5 g of Zn/Ag couple[7] in 100 mL of dry ether at room temperature. Stirring was continued for 3 h at 35 °C and after cooling to 0 °C, 100 mL of dry ether was added. The Zn complex was converted into the acetal **1b** by careful addition of pyridine. After filtration, distillation, and purification by VPC, **1b** was obtained: yield 1 g (18%); NMR 0.4 (s, 2 H), 1.1 (s, 6 H) 3.25 (s, 6 H).

1,1-Dimethoxy-2-methylcyclopropane (1c). The acetal **1c** was prepared according to the method described for **1b**. The acetal **1c** was obtained in 59% (0.61 g) yield from methylketene dimethyl acetal (0.9 g),[8] methylene iodide (3 g), and Zn/Ag couple (1.5 g); NMR 0.3–1.4 (m, 6 H), 3.32 (s, 3 H), 3.37 (s, 3 H).

1,1-Diethoxy-2-methylcyclopropane (1e). The acetal **1e** was prepared according to the method described for **1b**. The acetal **1e** was obtained in 60% yield from methylketene diethyl acetal (1 g),[9] methylene iodide (3.5 g), and Zn/Ag couple (1.7 g); NMR 0.15–0.40 (m, 3 H), 0.6–1.35 (m, 9 H), 3.3–3.8 (m, 4 H).

Reaction of Tetracyanoethylene (TCNE) with Acetal 1a. The cycloaddition of TCNE with acetal **1a** has already been described.[2]

Reaction of TCNE with Acetal 1b. A mixture of TCNE (2.5 mmol) and acetal **1b** (2.5 mmol) in 12.5 mL of dry methylene chloride was heated in a sealed tube for 2 weeks at about 65 °C. After evaporation of the solvent 2,2,3,3-tetracyano-4,4-dimethylcyclopentanone dimethyl acetal (**2b**) was obtained in 90% yield; NMR 1.54 (s, 6 H), 2.32 (s, 2 H), 3.50 (s, 6 H).

Reaction of TCNE with Acetal 1c. According to the method described for the cycloaddition of **1b** with TCNE, equivalent amounts of acetal **1c** and TCNE were heated in methylene chloride at 42 °C for 1 week. A mixture of 2,2,3,3-tetracyano-4-methylcyclopentanone dimethyl acetal (**2c**) and its 5-methyl isomer **3c** was obtained in 100% yield (ratio **2c**/**3c** = 3/1); NMR of **2c** 1.95–3.2 (m, 6 H), 3.42 (s, 3 H), 3.62 (s, 3 H); NMR of **3c** 1.95–3.2 (m, 6 H), 3.47 (s, 3 H), 3.53 (s, 3 H).

Reaction of Cycloadduct 2b with Water. The cycloadduct **2b** (0.24 mmol) was heated in a mixture of 12 mg of water and 0.5 mL of acetonitrile at 80 °C for about 12 h. After evaporation of the solvent, 5 mL of methylene chloride was added to the residue. The solution was extracted with aqueous sodium bicarbonate. The aqueous layer was acidified and extracted with methylene chloride. After the solution was dried over $MgSO_4$ and the solvent was evaporated, pure methyl 3,3-dimethyl-4,4,5,5-tetracyanopentanoate (**4b**) was obtained in 63% yield: ^1H NMR (CD_3CN) 1.45 (s, 6 H), 2.69 (s, 2 H), 3.67 (s, OCH_3), 5.24 (s, 1 H); ^{13}C NMR 25.4 (CH_3), 28.8 (C5), 42.8 and 43.0 (C2,3), 49.4 (C4), 53.0 (OCH_3), 108.6 (CN), 110.4 (CN), 170.3 (C=O).

From the methylene chloride solution, obtained after the bicarbonate extraction, methyl 3,3-dimethyl-4,5,5-tricyano-4-pentenoate (**6**) and methyl 3-methyl-2-butenoate (**7**) were obtained; NMR of **6** (CD_3CN) 1.45 (s, 6 H), 2.86 (s, 2 H), 3.64 (s, OCH_3); NMR of **7** (CD_3CN) 1.86 (d, CH_3), 2.12 (d, CH_3), 3.59 (s, OCH_3), and 5.6–5.7 (m, 1 H).

Reaction of Cycloadducts 2c and 3c with Water. The mixture of the cycloadducts **2c** and **3c** (0.8 mmol) was heated in a mixture of water (1.2 mmol) and acetonitrile (0.6 mL) at 50 °C for 1 day. After the solvent was evaporated and the residue was dried, a mixture of methyl 3-methyl-4,4,5,5-tetracyanopentanoate (**4c**) and methyl 2-methyl-4,4,5,5-tetracyanopentanonate (**5c**) was obtained in 92% yield: ^1H NMR 1.39 (d, CH_3), 2.1–3.2 (m, 3 H), 3.74 (s, OCH_3), 4.78 (s, 1 H), 4.81 (s, 1 H) (ratio of the integrals of the last singlets was about 1:2.5); ^{13}C NMR 16.7 and 18.3 (CH_3), 30.8 and 32.7 (C5), 36.9 and 37.7 (C2, 3), 37.5 and 38.6 (C2, 3), 38.8 and 41.1 (C4), 53.0 (OCH_3), 107.9–110.4 (CN), 170.3 and 174.1 (C=O).

(4) J. B. Stothers in "Carbon-13 NMR Spectroscopy", Academic Press, New York, 1972, p 296.
(5) R. Jorritsma, H. Steinberg, and Th. J. de Boer, *Recl. Trav. Chim. Pays-Bas*, submitted for publication.
(6) S. M. McElvain and W. R. Davie, *J. Am. Chem. Soc.*, **73**, 1400 (1951).
(7) J. M. Denis, C. Girard, and J. M. Conia, *Synthesis*, 549 (1972).
(8) S. M. McElvain and C. Aldridge, *J. Am. Chem. Soc.*, **75**, 3989 (1953).
(9) P. Walters and S. M. McElvain, *J. Am. Chem. Soc.*, **62**, 1482 (1940).

Heating of Ester 4b with Water. After prolonged heating of the tetracyano ester **4b** in acetonitrile at 80 °C for several days, the unsaturated tricyano ester **6** was formed, but not a trace of the unsaturated ester **7** could be detected (VPC).

Acknowledgment. We thank Professor Th. J. de Boer for stimulating discussions and Mr. C. Kruk for the ^{13}C NMR spectra and skillful assistance in their interpretation.

Registry No. 1a, 41330-13-6; **1b**, 30451-99-1; **1c**, 76430-11-0; **1e**, 76430-12-1; **2a**, 57260-86-3; **2b**, 76430-13-2; **2c**, 76430-14-3; **2d**, 57260-85-2; **2e**, 76430-15-4; **3c**, 76430-16-5; **3e**, 76430-17-6; **4b**, 76430-18-7; **4c**, 76430-19-8; **5c**, 76430-20-1; **6**, 76430-21-2; **7**, 924-50-5; 1-(methylthio)cyclopropyl bromide, 54376-40-8; 1-ethoxy-1-(methylthio)cyclopropane, 76430-22-3; dimethylketene dimethyl acetal, 5634-54-8; methylketene dimethyl acetal, 5634-52-6; methylketene diethyl acetal, 21504-43-8; tetracyanoethylene, 670-54-2; cyclopentanone dimethyl acetal, 931-94-2; 2-methylcyclopentanone dimethyl acetal, 76430-23-4; 3-methylcyclopentanone dimethyl acetal, 76430-24-5; **1d**, 18523-34-7.

Bimanes. 6. Reactive Halogen Derivatives of *syn*- and *anti*-1,5-Diazabicyclo[3.3.0]octadienediones (9,10-Dioxabimanes)

Edward M. Kosower,*[1a,b] Barak Pazhenchevsky,[1a] Hanna Dodiuk,[1a] Hannah Kanety,[1a] and Dov Faust[1a]

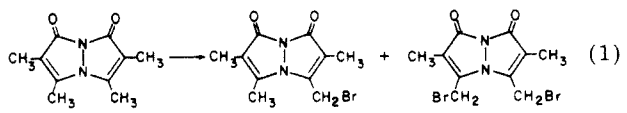
Department of Chemistry, Tel-Aviv University, Ramat-Aviv, Tel-Aviv, Israel, and the Department of Chemistry, State University of New York, Stony Brook, New York 11794

Received October 14, 1980

The preparation of reactive halogen derivatives of *syn*- and *anti*-1,5-diazabicyclo[3.3.0]octadienediones (9,10-dioxabimanes) is accomplished through the intermediate monobromo- and dibromobimanes previously described. Mono- and dihydroxy compounds are produced from the bromides by reaction with wet sodium trifluoroacetate in CH_3CN and are used to prepare the (a) monochlorides and dichlorides ($SOCl_2$) and (b) the monofluorides and difluorides (Et_2NSF_3). Monofunctional halides react with nucleophiles (amines, thiols, carboxylates) to yield direct substitution products, with some reduction accompanying the thiol reaction. Difunctional halides react with excess nucleophile to give direct disubstitution products. *syn*-Dihalides react with difunctional nucleophiles (actual or potential, e.g., RNH_2, S^{2-}, $(CN)_2C<$) to yield a new series of heterocyclic compounds, the "bridged" 9,10-dioxabimanes. The absorption spectra of both *syn*- and *anti*-$(XCH_2,CH_3)B$ are markedly affected by the nature of X. Most *syn*-bromobimanes are nonfluorescent and are moderately photosensitive, due to thermally reversible isomerizations and additional irreversible reactions. *syn*-Chlorobimanes are nonfluorescent to weakly fluorescent. *syn*-Monofluoro- and difluorobimanes are strongly fluorescent. At 77 K, the halogenated compounds are all phosphorescent to some extent and many of the syn derivatives are strongly fluorescent.

Introduction

In the course of investigating the reactions of *syn*-(methyl,methyl)bimane[2,3] (**1**), it was found that bromination led to either a monobromobimane (**2**) or a dibromobimane (**3**), the proportions depending on the number of equivalents of bromine used for the reaction (eq 1). The



(1)

1 2 3

usefulness of the bromobimanes in producing many other 9,10-dioxabimane derivatives as well as their successful application to the labeling of proteins and cells[4,5] suggested that it would be appropriate to describe their characteristics in detail, as we now do in the present article. We report also the preparation of chloro- and fluorobimanes.

Results

The properties and reactions of monobromo- and dibromobimanes are the primary subject of the present article. It was, however, of importance to make a comparison of their photophysical properties with other reactive halobimanes, and for this purpose, the transformation of the bromides into the corresponding alcohols and then to the desired halides has been carried out.

The conversion of *syn*-bromides to the alcohols in aqueous buffer, pH 7.4, at 50 °C proceeds slowly, and the alcohols produced are accompanied by more polar materials, which we suppose to be ring-opened products like those obtained in the reaction of hydroxide ion with dioxa-*syn*-bimanes.[2] More effective is the classical procedure of displacing halide with a carboxylate, using wet sodium trifluoroacetate in acetonitrile, which leads directly to the

(1) (a) Tel-Aviv University. (b) State University of New York.

(2) The formation and some of the uses of the bromobimanes were briefly mentioned in a communication: Kosower, E. M.; Pazhenchevsky, B.; Hershkowitz, E. *J. Am. Chem. Soc.* **1978**, *100*, 6516. A description of the bromination of some 9,10-dioxabimanes is given in Bimanes 5: Kosower, E. M.; Pazhenchevsky, B. *Ibid.* **1980**, *102*, 4983-4993.

(3) The nomenclature of the *syn*- and *anti*-1,5-diazabicyclo[3.3.0]octadienediones (9,10-dioxabimanes) is thoroughly discussed in Bimanes 5. Briefly, a group in the position α to the carbonyl is labeled R_1, a group β is denoted R_2, the relationship of the carbonyl groups is indicated by syn or anti prefixes, and the 9,10-dioxabimane structure is referred to as 9,10-dioxabimane, bimane, or B.

(4) Kosower, N. S.; Kosower, E. M.; Newton, G. L.; Ranney, H. M. *Proc. Natl. Acad. Sci. U.S.A.* **1979**, *76*, 3382.

(5) Kosower, N. S.; Newton, G. L.; Kosower, E. M.; Ranney, H. M. *Biochim. Biophys. Acta* **1980**, *622*, 201. (a) Goldberg, I., unpublished results. Crystal structures for related bimanes have been reported: Bernstein, J.; Goldstein, E.; Goldberg, I. *Cryst. Struct. Commun.* **1980**, *9*, 285; *Ibid.* **1980**, *9*, 301; Goldberg, I. *Ibid.* **1980**, *9*, 329; Kosower, E. M.; Bernstein, J.; Goldberg, I.; Pazhenchevsky, B.; Goldstein, E. *J. Am. Chem. Soc.* **1979**, *101*, 1620.

0022-3263/81/1946-1666$01.25/0