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3,4-DIMETHYLENE FIVE-MEMBERED HETEROCYCLES AND SYMMETRICALLY DISUBSTITUTED 1,3-BUTADIENES FROM 2,3-BIS(BROMOMETHYL)-1,3-BUTADIENE

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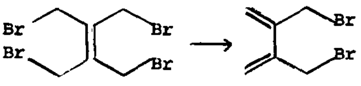
2,3-Bis(bromomethyl)-1,3-butadiene (1) has been obtained before by thermal decomposition of its sulfone and was described as a light-senstivie solid, which polymerized readily in most solvents.[1] We have now prepared 1 by a different procedure and found that although it polymerized quite rapidly in the crystalline state (even in the absence of light), it was stable in solution and could be reacted under a variety of conditions either as a highly reactive 1,4- twice allylic dibromide in displacement reactions, or as a 1,3-diene in Diels-Alder[1] or cheletropic additions. The primary products thus obtained constitute in themselves other new reactive intermediates since they conserve the feature of either a 1,3-diene or a 1,4-dibromo-2-ene derivative.

The dibromo-diene 1 is prepared by zinc-copper couple[2] debromination of the tetrabromide 2,[3] in a variety of solvents, the best yields (∿ 90%) being obtained by refluxing the reactants in methylal-hexamethylphosphoramide or ether-HMPA (9:1) for 3-4 h. The dibromide, m.p. 57-58°, has the described[1] spectral features, with $\lambda_{max}^{isooctane}$ 225 nm (ε 10800; same in ethanol).[4]

Dibromide 1 permits single-step preparations of 3,4-dimethylene five-membered heterocycles, such as the thiolan derivative 3, the tetrahydrofuran 4 or the pyrrolydine derivatives 5a,b. The much sought for 3,4-dimethylenethiolan 3,[5,6] obtained from 1 by reaction with sodium sulfide in aq. ethanol, is described in a separate communication.[7]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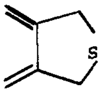
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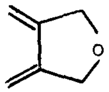
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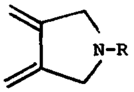
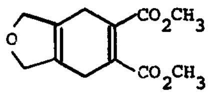

5 a. $R=CH_3$
b. $R=C_6H_5$

The tetrahydrofuran 4[8] was prepared in ≈15% yield by boiling 1 with sodium hydroxide in aq. dioxan. It was obtained pure as an unstable liquid by preparative vpc, or could better be codistilled with the dioxan for chemical uses. Its spectral properties fit those described,[8] but the ir spectrum (in chloroform) lacks a "strong absorption" at 1725 cm^{-1} (acetic acid ?). Adduct 6[9], m.p. 127-128°, was readily obtained with dimethyl acetylenedicarboxylate.



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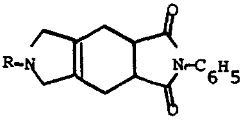
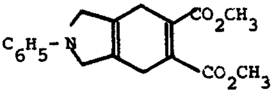


7 a. R=CH_3
b. R=C_6H_5



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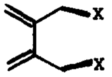
Reaction of 1 with representative amines, such as methylamine (in acetonitrile) or aniline (in methanol, in the presence of sodium carbonate[10]) yielded the 3,4-dimethylene pyrrolidines 5a and 5b. The first 3,4-dimethylene pyrrolydine derivative, obtained in one particular case through its sulfone, has been reported last year.[11] A general method for the preparation of such sulfones was later published,[10] but their conversion to the dienes was not described.

Compound 5a obtained as an oil was purified by extraction with dilute acid and liberation by base (estimated yield by U.V. ≈60%) and then by distillation, b.p. ≈50° (bath temperature) at 25 mm. $\lambda_{max}^{isooctane}$ 240 (sh), 245 nm (ε 8300, 8700); δ($CDCl_3$) 2.35 s (N-$C\underline{H}_3$), 3.27 t (N-$C\underline{H}_2$, J≈2 Hz), 4.39 s, br and 5.37 t (C=$C\underline{H}_2$, J≈2 Hz); $\nu_{max}^{CHCl_3}$ 2920, 2750, 1633, 900, 880 cm^{-1}. It was characterized as the adduct 7a, with N-phenylmaleimide, m.p. 109-110°.

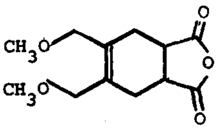
Compound 5b, obtained as a solid in 70-75% yield, was purified by chromatography on silica-gel and recrystallization from hexane. M.p.: instant melting at ≈127° (by slow warming a transformation to an insoluble dimer occurs; cf. ref. 11). $\lambda_{max}^{isooctane}$ 246, 300, 310, 330 (sh) nm (ε 20140, 3300, 2710, 1070); δ($CDCl_3$) 4.04 t (N-$C\underline{H}_2$, J=1.5 Hz), 5.04 s, br and 5.51 t (C=$C\underline{H}_2$, J=1.5 Hz), 6.50-7.40 m (C_6H_5); ν_{max}^{KBr} strong absorptions at 1602, 1506, 1370, 885, 746 cm^{-1}.

Adducts 7b, m.p. 216-217°, and 8, m.p. 179-180°, were obtained with N-phenylmaleimide and dimethylacetylene dicarboxylate, respectively.

Besides the cyclic products, dibromide 1 yielded readily and in high yields a series of symmetrical butadiene derivatives 9a-d by reaction with various nucleophiles. Thus, reaction with sodium hydroxide in aq. methanol or with sodium methylate in methanol yielded 9a as a distillable oil (see Table), stable in solution but polymerizing slowly when neat. Solid derivatives 10, m.p. 93-94°, and 11, m.p. 61-62°, were obtained with maleic anhydride and N-phenylmaleimide, respectively.



9a-h



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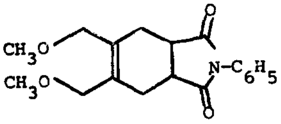

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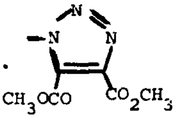
Table. Symmetrically Substituted 1,3-Dienes

Compound 9	M.p.	λ_{max}	Proton Chemical shifts[a]		
X	°C	nm (ε)	$C\underline{H}_2$-X	$=C\underline{H}_2$	Other
a. $-OCH_3$	b.p. 50-60 (bath)/1 mm	224 (14900)[b]	4.14	5.29, 5.36	3.35 ($-OC\underline{H}_3$)
b. $-N_3$	b.p. 75-80 (bath)/1 mm	220 (14100), 282 (49)[b]	4.00	5.40, 5.46	
c. $-CN$[12]	74-75	222 (15970)[12]	3.40	5.40, 5.62	
d. $-OCOCH_3$	38-39	223 (15500)[b]	4.80	5.33	2.07 ($-CO.C\underline{H}_3$)
e. $-OH$	64-65	223 (14250)[c]	4.33	5.29	1.50 ($-O\underline{H}$)
f. $-NH_2$	31-32[d]	224 (12900)[c]	3.50	5.20	1.60 ($-N\underline{H}_2$)
g. $-NH-CO-C_6H_5$	201-202	225 (28200)[c]	4.17, 4.26[e]	5.20, 5.42	7.4-8.1 (m, C_6H_5) 3.42 ($N\underline{H}$)
h. 	137-138	217 (24300)[c]	5.47[f, g]	5.00, 5.47[g]	3.94, 3.98 ($-OC\underline{H}_3$)

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[a] At 60 MHz in $CDCl_3$. All peaks were singlets. Correct ratios were obtained in all cases by integration of peak areas. [b] In isooctane. [c] In ethanol. [d] As a dihydrate. [e] Nmr in DMSO-d_6. [f] Considerably deshielded by the aromatic triazole ring. [g] The two superimposed singlets at δ 5.47 were separated by addition of $Eu(fod)_3$.

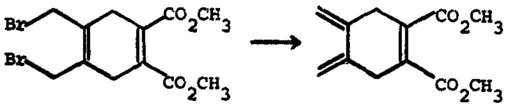
Reaction of 1 with sodium azide in aq. ethanol yielded the diazide 9b as a distillable oil.[13] It was stable in solution and could be kept unchanged in the free state in the darkness at 5°. Its reduction with lithium aluminium hydride in ether gave readily the diamine 9f, as a crystalline dihydrate or as a distillable oil; it was also isolated as the diamide 9g or as a *bis*-picrate, decomposing at ≃270°. With two equivalents of dimethyl acetylenedicarboxylate, 9b yielded the *bis*-triazole 9h, mass spectrum *m/e* 448 (M^+), 417 (M^+-OCH_3), 389 ($M^+-CO_2CH_3$), 264 (M^+- one triazole unit; base peak).

Reaction of the dibromide 1 with potassium cyanide in aq. HMPA yielded the known dinitrile 9c.[12]

With sodium acetate in acetic acid dibromide 1 gave the diacetate 9d, which could be readily hydrolyzed to the diol 9e. No simple way to dehydrate this diol to the tetrahydrofuran 4 has as yet been found.

A few addition products of 1 with dienophiles have been described before.[1] To these may be added now the addition product 12 with dimethyl acetylenedicarboxylate, m.p. 75-76°.

This is an important intermediate in a series of further transformations, starting with zinc debromination to 13.[14]



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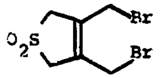

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Another addition reaction of diene 1 is the cheletropic addition of sulfur dioxide, yielding the known sulfolene 14.[1]

Further reactions of 1 and transformation of its primary reaction products are being studied.

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13. It was distilled in small batches of ≈0.2 g in a bulb-to-bulb distillation apparatus or collected by preparative vpc. A violent explosion occured, however, in the microanalysis tube.
14. Y. Gaoni, to be published.