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PHOTOCHEMICAL RING OPENING OF BARBITAL

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Abstract: Photolysis of barbital yields derivatives of urea and biuret. The mechanism of ring opening involves an isocyanate intermediate.

Otsuji et al.[1] found that the UV irradiation /254 nm/ of barbital 1 /5,5-diethyl-2,4,6(1H,3H,5H)-pyrimidinetrione/ in an aqueous alkaline medium yields 2-ethylbutanoylurea 2. When the aqueous solution of 1 was irradiated in the presence of dimethylamine, a mixture of 2 and N,N-dimethylbiuret 3 was obtained. This first reaction was explained in terms of photochemical hydrolysis of 1 with the ring opening in 1-6 position. The singlet excited state, tetrahedral complex with the OH^- ion and 2-allophanoyl-2-ethylbutanoic acid were postulated as intermediate products. The formation of 3 was not elucidated in terms of this mechanism.

We investigated the photolysis of 1 under the similar conditions and additionally in 96% and absolute ethanol solutions in the presence of ammonia or amines. The products had the structure of 2-ethylbutanoyl derivatives of urea or biuret /Table 1/.

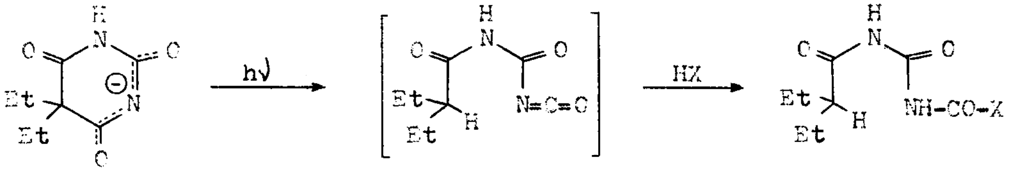
Table 1: Reaction conditions and products of photolysis of barbital[2]

$Et_2CHCONHCONH-R$

	Medium	Reagent	Time h	R	mp[a]	Yield %
2	carbonate buffer pH 10	H_2O	2	H	209-211°	68
4	absolute EtOH	NH_3	6	$CONH_2$	172-173°	62
5	absolute EtOH + Et_3N	EtOH	2.5	COOEt	108-112°	26
6	96% EtOH	Me_2NH	1.5	$CONMe_2$	133-135°	56
7	96% EtOH	$/CH_2/_5NH$	2.5	$CON/CH_2/_5$	114-115°	66

[a] uncorrected, for compounds 4-7 after crystallization from EtOH/H_2O

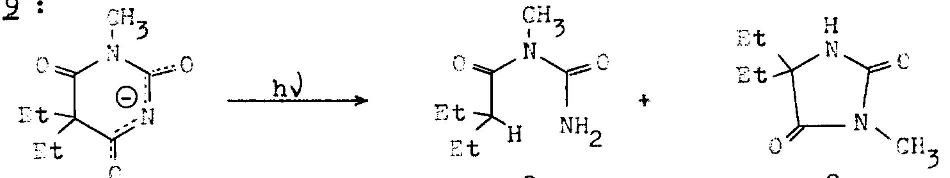
These results can be explained assuming the ring opening in 4-5 position, the formation of an intermediate of the isocyanate type and a subsequent attack of the nucleophilic reagent:



X = OH /with subsequent decarboxylation/, NH_2, OEt, NMe_2, $N/CH_2/_5$

Photochemical formation of the isocyanate group from =N-CO- moiety was recently reported in the literature[3] and is additionally supported by the formation of 2249 cm^{-1} IR absorption peak during the UV irradiation /254 nm/ of sodium salt of barbital in the nujol suspension. The formation of 3 reported by Otsuji et al.[1] can be easily explained by the alkaline hydrolysis of 6 under the experimental conditions employed /alkaline medium, 60 h irradiation time/.

The ring opening of 1 at the ionized side of the ring is suggested by the results of photolysis of N-methylbarbital in the aqueous alkaline medium. This compound reacts ca. 10 times slower than 1 under the similar conditions and yields the mixture of N-(2-ethylbutanoyl)-N-methylurea 8 and 5,5-diethyl-3-methylhydantoin 9[2]:



8 9

This last compound evidences a new pathway, i.e. a contraction of the ring, in the photodegradation of barbituric acids. The details of this process are under investigation.

References and Notes:

1. Y. Otsuji, T. Kuroda, E. Imoto, Bull. Chem. Soc. Japan, 41, 2713 /1968/.
2. Satisfactory elemental analyses were obtained for all new compounds. Spectral data /IR in CCl_4, ^{1}H-NMR in $CDCl_3$/: 4 NMR 0.81 /6H, t, J=7/, 2.28 /1H, m/, 6.0-7.4 /2H, bd/, 9.25 /1H, bs/, 10.38 /1H, bs/; 5 IR 1798 cm^{-1} C=OOEt, 3160, 3230 cm^{-1} NH; 6 IR 1766 cm^{-1} C=ONMe$_2$, 3130, 3210, 3270 cm^{-1} NH; 7 IR 1764 cm^{-1} C=ON/CH$_2$/$_5$, 3150, 3200, 3260 cm^{-1} /broad/ NH; 8 mp 91-94° /cyclohexane/, IR 1674, 1714 cm^{-1} C=O, 3302, 3502 /free/ cm^{-1} NH; 9 mp 60-62° /CCl_4/, NMR 0.86 /6H, t, J=7/, 1.5-2.0 /4H, m/, 3.0 /3H, s/, 7.1 /1H, bs/, IR 1721, 1784 cm^{-1} C=O, 3100, 3230, 3460 /free/ cm^{-1} NH.
3. T. Nishio, K. Katahira, A. Kato, C. Kashima, Y. Omote, Tetrahedron Lett., 4211 /1979/; A. Cánovas, J. Fonrodona, J.-J. Bonet, M.C. Briansó, J.L. Briansó, Helv. Chim. Acta, 63, 2380 /1980/; B.J. Swanson, G.C. Crockett, T.H. Koch, J. Org. Chem., 46, 1082 /1981/.

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