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PHOTO-SENSITIZED OXYGENATION OF MONOCYCLIC 1H-1,3-DIAZEPINES

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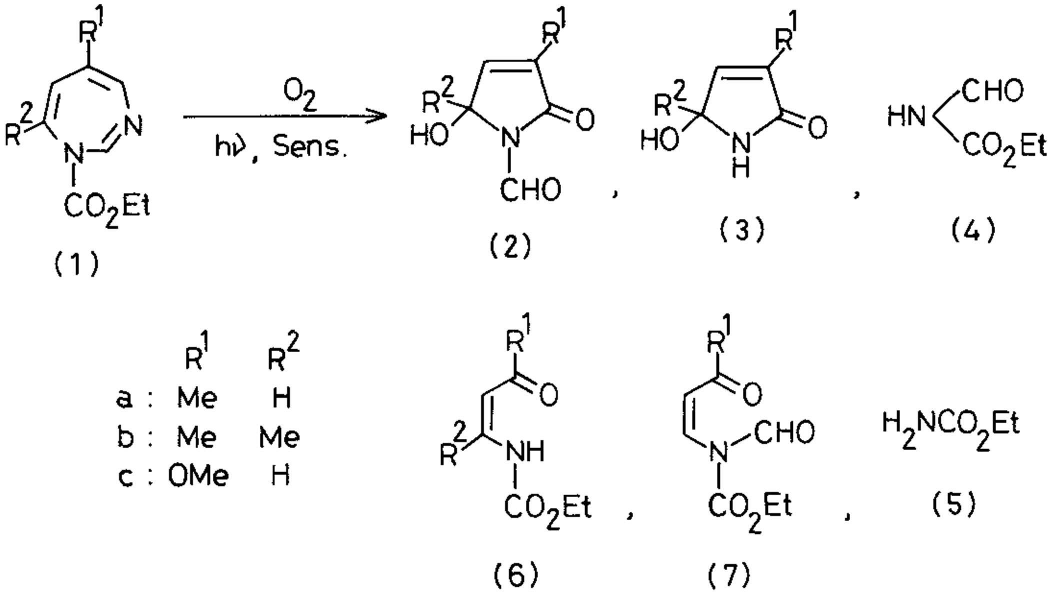
Abstract —— The sensitized photooxygenation of monocyclic 1H-1,3-diazepines (1a-c) affords fragment products (2) to (7), which may be derived from the corresponding 4,7-endoperoxides (8) or the 4,5-dioxetanes (9) initially formed. The other possible dioxides and their decomposition products are not detected.

In connection with the interesting photooxygenations of various five- and six-membered N-heterocycles[1] and seven-membered conjugated trienes such as cycloheptatrienes[2] and tropolones,[3] we were interested in examining such reaction of seven-membered conjugated N-heterocycles. We have already reported that the photooxygenation of monocyclic azepines[4] and 1H-1,2-diazepines[4,5] gave the corresponding relatively stable 4,7-endoperoxides as the sole oxidized products, whereas 1H-1,2-benzodiazepines afforded several fragment products via 3- or 5-hydroperoxides initially formed.[6] On the other hand, 2-phenyl-1,3-oxazepine is shown to undergo initial 1,2- (or 1,6-) and 1,4-addition of singlet oxygen followed by decomposition to give several products.[7] These results prompted us to examine the photooxygenation behavior of 1H-1,3-diazepines which are new N-heterocycles recently prepared[8] and now report our results.

A solution of a monocyclic 1H-1,3-diazepine (1) in carbon tetrachloride was irradiated with a halogen lamp at room temperature using meso-tetraphenylporphine as a sensitizer for 1-2 h while oxygen was slowly passed through the solution. After evaporation of the solvent, the photolysate given a positive test for peroxide with acidified KI was treated with water in tetrahydrofuran and then chromatographed on silica gel to give the products (2) to (7) shown in Scheme 1.[9] The yields of these products are also shown in the Scheme. When the photolysate was chromatographed without the treatment with water, these yields were remarkably decreased. These facts may indicate that the initial formed peroxides are unstable and water is required for the formation of these stable products obtained.



	R^1	R^2
a :	Me	H
b :	Me	Me
c :	OMe	H

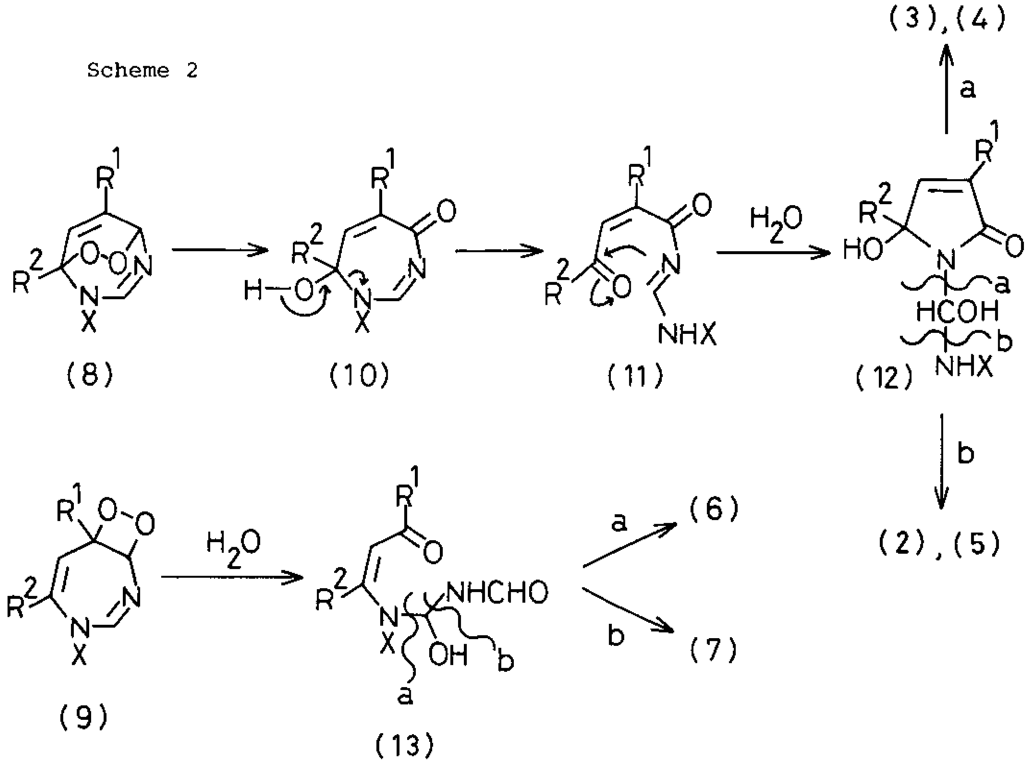
Scheme 1

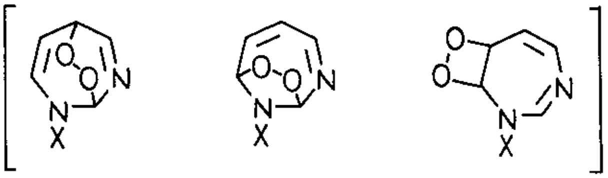
Yields of Products

(1)	(2)	(3)	(4)	(5)	(6)	(7)
1a	19%	53%	32%	18%	——	——
1b	8%	40%	28%	11%	2%	2%
1c	——	47%	40%	——	11%	8%

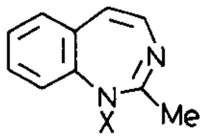
Although no adducts of the 1,3-diazepines with singlet oxygen have been isolated, the formation of the products in the present photooxygenation can be understood in terms of the initial formation of the 4,7-endoperoxides (8) and the 4,5-dioxetanes (9), which are then transformed to the products (2 – 7) presumably via the pathways shown in Scheme 2. The ring-opened intermediates (11) formed from the 4,7-endoperoxides (8) via 10 undergo cyclization with addition of water to give the pyrrolinone derivatives (12). The cleavage of the N-C bond (a) of 12 gives the N-unsubstituted pyrrolinones (3) and ethyl N-formylaminoformate (4), and the C-N bond fission (b) affords the N-formylpyrrolinones (2) and ethyl

Scheme 2





(14) (15) (16)



(17)

amino formate (5). On the other hand, the dioxetanes (9) give the ring-opened products (6) and (7) via the intermediates (13) by similar bond fissions. The result for the 5-methoxydiazepine (1c), in which the yields of 6 and 7 are higher than those for 1a and 1b, shows that the electron-donating group increases the formation of the oxetanes (9).

It should be noted that no products from the 2,5- (14) and 2,7-endoperoxides (15) and the 6,7-dioxetanes (16) have been detected, and therefore 1,4- and 1,6-addition of singlet oxygen do not occur in the aza-diene and aza-triene moieties, analogous to the cases of monocyclic 1,2-diazepines[5] and 1,2-benzodiazepines,[6] but contrast to 1,3-oxazepines,[7] imidazoles,[10] and pyrazines.[11]

In addition, the 1H-1,3-benzodiazepines (17)[12] were irradiated under a similar oxygenation condition to give no detectable reaction.

REFERENCES AND NOTES

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9. Satisfactory elemental analyses and spectral data were obtained for the new compounds (2) to (7), *e.g.*, (2a): m.p. 89-90 °C; ν (KBr) cm^{-1} 3400 (OH), 1735 (C=O), 1705 (C=O); δ ($CDCl_3$) 1.96 (3H, br, 3-Me), 4.6 (1H, br, OH), 6.07 (1H, br s, 5-H), 6.86 (1H, m, 4-H), 9.01 (1H, s, CHO); (3a): m.p. 119-121 °C; ν (KBr) cm^{-1} 3300 and 3200 (OH and NH), 1685 (C=O); δ (acetone-d_6) 1.78 (3H, br d, 3-Me), 4.9 (1H, br, OH), 5.48 (1H, br, 5-H), 6.60 (1H, m, 4-H), 7.5 (1H, br, NH).
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