Mechanism of the Photomethylation of Phenanthro[9,10-*d*]oxazole in Ethanol

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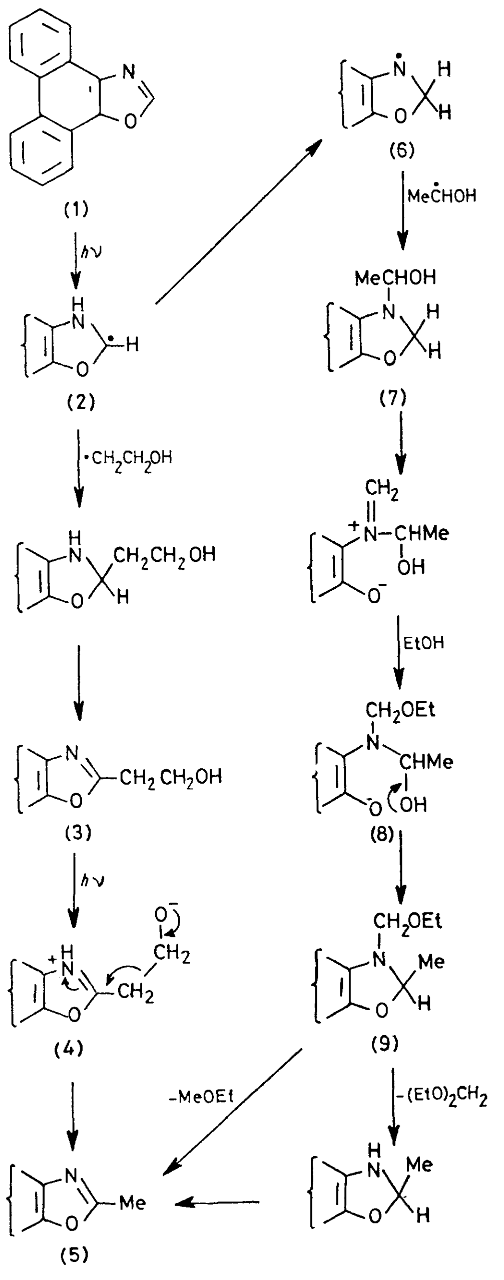
Summary A ^{14}C-labelling experiment has been performed in order to elucidate the mechanism of the photomethylation of phenanthro[9,10-*d*]oxazole (**1**) in ethanol; the result supports a mechanism involving an *N*-(1-hydroxy ethyl)oxazoline intermediate (**7**).



SCHEME

We have recently reported[1] that irradiation of phenanthro-[9,10-*d*]oxazole (**1**) in ethanol gives the 2-methyl compound (**5**) as the major product, providing a novel example of C-methylation with ethanol, and two structurally distinct mechanistic paths have been suggested. One mechanism involves the formation of (**3**), arising by β-hydrogen abstraction from ethanol solvent, which undergoes further elimination to the observed product (**5**) *via* the intermediate (**4**).[2] An alternative one-step route involves the formation of the unusual intermediate (**7**) by coupling of an α-hydroxy radical with the *N*-radical (**6**) which might be produced by a 1,2-hydrogen shift from nitrogen to carbon in the C-radical (**2**) formed initially. The fate of the labelled carbon at the 2-position in the oxazole (**1**) should unequivocally distinguish between these two mechanisms. The former predicts that the labelled carbon should be retained in the 2-position of the product (**5**) while the latter predicts that no labelled carbon should be found in (**5**)

Thus [2-^{14}C]phenanthro[9,10-*d*]oxazole[3] with a specific activity of 0·491 ± 0·007 mCi mol^{-1}† in ethanol was irradiated.[1] The resulting oxazole (**5**), isolated by column chromatography on silica gel, was formed with nearly complete disappearance of radioactivity (0·018 ± 0·002 mCi mol^{-1}). Also the specific radioactivity of recovered (**1**) (0·470 ± 0·007 mCi mol^{-1}) was the same as that before irradiation.

This evidence clearly indicates that the oxazole (**2**) is derived by replacement of C-2 of the original oxazole ring with a carbon atom from the ethanol solvent. Therefore, a possible route for forming (**5**) by extrusion of C-2 from the oxazole ring should involve the dihydro-intermediate (**7**) by a ring-opening and ring closure sequence. Although the final stage for the formation of (**5**) is not clear at present, the intermediate (**7**) is expected to add to ethanol to give (**8**) which could undergo ring closure to (**9**). The species (**9**) could subsequently remove either ethyl methyl ether or acetal to give the oxazole (**5**) as shown in the Scheme. One precedent for the initial step [(**2**) → (**6**)] in this pathway is found in the mechanism suggested for the photoconversion of naphthylimine into a quinoline derivative.[4]

Irradiation of phenanthro[9,10-*d*]thiazole in ethanol gave the corresponding 2-ethyl (12·5%) and 2-(1-hydroxyethyl) (4·4%) compounds,‡ similar to the photoalkylation of other C=N systems in alcohols.[5] This suggests that the oxygen atom plays an important role in the formation of the *N*-radical (**6**) in the photomethylation of (**1**) in ethanol.

The partial support of this work by a Grant-in-Aid for Scientific Research from the Ministry of Education, Japan, is gratefully acknowledged.

(*Received, 23rd March* 1977; *Com.* 276.)

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† The activity measurements were performed using a Packard liquid-scintillation spectrometer (Model 3375).

‡ Products were confirmed by elemental analyses and spectral data.

[1] M. Maeda, Y. Iwase, and M. Kojima, *J. Heterocyclic Chem.*, 1976, **13**, 221.

[2] 2-Substituted quinolines, isoquinolines, or pyridines having a γ-hydrogen on the side chain undergo photoelimination to give the methyl substituted heterocycles; see F. R. Stermitz, C. C. Wei, and C. M. O'Donnel, *J. Amer. Chem. Soc.*, 1970, **92**, 2745; F. R. Stermitz, W. H. Huang, D. J. Blythin, A. Hoeft, D. K. Kim, and C. M. O'Donnel, *J. Heterocyclic Chem.*, 1972, **9**, 1289.

[3] The synthesis of radioactive (**1**) from phenanthrenequinone mono-oxime and di[^{14}C]methyl sulphate was carried out according to R. Pschorr and F. Brüggemann, *Ber.*, 1902, **35**, 2742.

[4] F. R. Stermitz, R. P. Seiber, and D. E. Nicodem, *J. Org. Chem.*, 1968, **33**, 1136.

[5] Nitrogen is the hydrogen abstractor in photoalkylation or photoreduction reactions; see A. Padwa, *Chem. Rev.*, 1977, **77**, 37.