As shown in Fig. 2 heme peptides are not such simple electron acceptors of cytochrome c as ferricyanide but they show a catalytical property because they oxidize multiple times over an equimolecular quantity of ferrocytochrome c. In this connection, particular attention was directed to the fact that the oxidation was inhibited by cyanide and azide ions (Table I).

Table I. Inhibitions of the Oxidative Effect

Without oxygen		100% inhibition
Azide	(10^{-2} M)	39%
Cyanide	(10^{-2} M)	100%
	(10^{-3} M)	95%
	(10^{-4} M)	72%

Unlike cytochrome c, whose porphyrin–iron is fully and tightly occupied by four pyrrol nitrogens in porphyrin ring and other two ligands in protein moiety, the sixth coordination position of porphyrin iron in heme peptide is not rigidly held—in some cases unoccupied, and in other cases occupied loosely by a nitrogenous group of another heme peptide molecule intermolecularly. This unstable condition of the sixth coordination position gave heme peptides their characteristic properties. Thus, they connect easily with cyanide and azide ions at the sixth position, and, in particular they are extremely autoxidizable because of the interaction with oxygen at the position, hence heme peptides do not remain reduced in aerobic state.

The inhibitions by cyanide and azide ions, which are the strong ligands to the sixth position, indicate that the oxidation reaction proceeds through the functional porphyrin iron of heme peptides. This is also supported by the fact that under anaerobic condition heme peptide exhibited no oxidative effect (Table I). Probably, electron was transferred from ferrocytochrome c to porphyrin iron of heme peptide, followed by the immediate further migration to oxygen in reaction medium.

On the other hand, a marked difference was observed in the activity between the two heme peptides examined (Fig. 2). The variation must be attributed to the peptide moiety of heme peptide.

These problems arouse further interest if heme peptide is considered as an oxidase model. Subsequent investigations are now in progress with several kinds of heme peptides.

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Received January 19, 1968

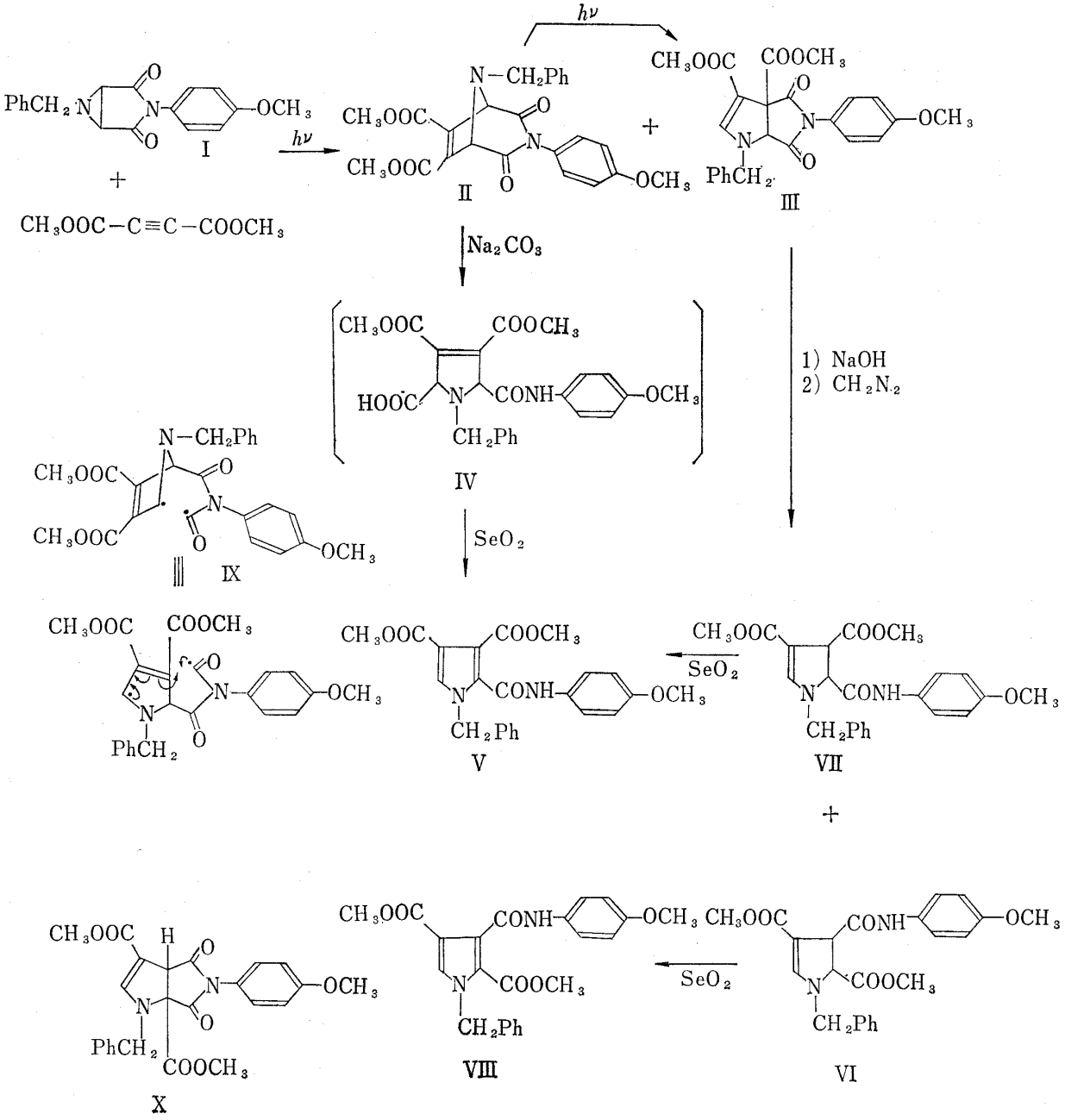
[Chem. Pharm. Bull. 16(4) 764—767 (1968)]

UDC 547.717.04 : 547.462.8.04

1,3-Dipolar Cycloaddition Reaction of Aziridinedicarboximide

Recently, many examples of 1,3-dipolar cycloaddition reaction of aziridines onto ethylene or acethylene bonds to form substituted pyrrolidines or pyrrolines have been reported.[1)]

1) A. Padwa and L. Hamilton, *Tetrahedron Letters*, 4363 (1965); *J. Heterocyclic Chem.*, 4, 118 (1967). H.W. Heine and P.E. Peavy, *Tetrahedron Letters*, 3123 (1965). H.W. Heine, P.E. Peavy, and A.J. Durbetaki, *J. Org. Chem.*, 31, 3924 (1966). R. Huisgen, W. Scheer, G. Szeimies, and H. Huber, *Tetrahedron Letters*, 397 (1966).



Huisgen, Scheer, and Huber,[2] in particular, illustrated that this cyclization proceeds through a dipolar intermediate, azomethine ylide, which is produced from aziridine under ring opening, controlled stereospecifically as predicted with Woodward–Hoffmann postulates.[3] The present paper is concerned with the analogous cycloaddition of 1-benzyl-N-(*p*-methoxyphenyl)-2, 3-aziridinedicarboximide (I) to dimethyl acetylenedicarboxylate, which would offer with heating a poor condition for the conrotatory cycloaddition predicted, but with irradiation an ideal condition for the disrotatory cycloaddition.

The aziridinedicarboximide (I), mp 137.5—139° (*Anal.* Calcd. for $C_{18}H_{16}O_3N_2$: C, 70.11; H, 5.23; N, 9.09. Found: C, 70.45; H, 5.21; N, 9.07), was prepared *cf.*[4] in a fair yield by

2) R. Huisgen, W. Scheer, and H. Huber, *J. Am. Chem. Soc.*, **89**, 1753 (1967).
3) R.B. Woodward and R. Hoffmann, *J. Am. Chem. Soc.*, **87**, 395 (1965).
4) A. Mustafa, S.M.A.D. Zayed, and S. Khattab, *J. Am. Chem. Soc.*, **78**, 145 (1956). W.I. Awad, S.M.A.R. Omran, and F. Nagieb, *Tetrahedron*, **19**, 1591 (1963).

cycloaddition of N-(*p*-methoxyphenyl)maleimide and benzylazide, followed by pyrolysis of the resulting Δ^2-1,2,3-triazoline, mp 161° (decomp.) (*Anal.* Calcd. for $C_{18}H_{16}O_3N_4$: C,64.27; H, 4.80; N,16.66. Found: C,64.14; H, 4.95; N, 16.90). Irradiation[5] of a mixture of I and two equivalent amount of dimethyl acetylenedicarboxylate in dioxane at 15° for 2 hr afforded a cycloadduct (II), mp 122.5—124° (*Anal.*Calcd. for $C_{24}H_{22}O_7N_2$: C, 63.99; H, 4.92; N, 6.22. Found: C, 64.33; H, 5.06; N, 6.12) in 4% yield and another isomeric adduct (III), mp 159—160° (*Anal.* Found: C, 63.90; H, 4.99; N, 6.03) in 36% yield, which were accompanied with the unchanged I (18%).

The infrared spectrum of II showed no NH or OH absorption, but exhibited the presence of ester and imide groups at 1751, 1733 and 1701 cm^{-1}. The NMR spectrum of II showed singlet absorptions at 3.80, 3.84, 3.86 and 4.65 ppm in the ratio of 3:2:6:2 as peak areas, indicating the presences of one methoxyl group, two protons at carbons bearing the amino function, two methyl groups of the esters, and two protons of the benzyl methylene group respectively. Accordingly, the minor product was designated as a normal cycloadduct (II) just as predicted from the reaction. Mild saponification of II with sodium carbonate gave an amorphous dimethyl ester of Δ^3-pyrrolinetetracarboxylic acid dimethylester (IV) which was dehydrogenated with decarboxylation into a pyrroletricarboxylic acid derivative (V), mp 152—153°, in a good yield,by selenium dioxide oxidation in boiling dioxane. The assignment of the structure of V was supported by elemental analysis (*Anal.* Calcd. for $C_{23}H_{22}O_6N_2$: C, 65.39; H, 5.25; N, 6.63. Found: C, 65.26; H, 5.26; N, 6.91), spectral data and analogy with other pyrroline reaction.

The structure of the main cycloadduct (III) was assignable in the following way. The infrared spectrum of III also showed no NH or OH absorption, only to suggest the presences of ester and imide groups by absorptions at 1750, 1733 and 1692 cm^{-1}. Quite different from the case of II, III had characteristic ultraviolet absorptions at 231 mμ (ε 17,600) and 302 mμ (ε 15,700). The NMR spectrum of III exhibited nine aromatic protons as multiplets at 6.9—7.5 ppm, three O-methyl absorptions at 3.57, 3.67 and 3.80 ppm as singlets and benzyl methylene protons at 4.68 ppm as an AB-pattern quartet (J=15.5). The remaining two protons fell into 4.84 and 7.76 ppm as singlets; the latter absorption corresponded to a β-vinyl proton of β-aminoacrylate, –N–CH=C–COO–.[6] These spectral data suggested that the structure of the main cycloadduct would be III or its possible alternates. It was found that III resisted selenium dioxide oxidation, even under a drastic condition. Saponification of III with sodium hydroxide at room temperature, followed by treatment with diazomethane, gave an isomeric mixture of the dimethyl ester of pyrroline tricarboxylic acid dimethyl esters (VI and VII), from which the amorphous major isomer (VI) was isolated by chromatography on silica gel. Data supporting the structure of VI was obtained from consideration of elemental analysis and the IR, UV and NMR spectra; the ultraviolet spectrum had maxima at 253 mμ and 305 mμ, showing that saponification of III had no effect on the unsaturated system. The NMR spectrum indicated one of the annular hydrogens as a broad doublet (J=5) at 4.23 ppm, which was coupled with the other annular hydrogen (sharp doublet, J=5 at 5.30 ppm and one vinyl proton (broad singlet) at 7.13 ppm. Accordingly, formation of VI indicated that saponification of III occurred under decarboxylation, suggesting that III had a base-labile β-dicarboxylic acid function in the molecule. Selenium dioxide oxidation of VI in boiling dioxane afforded an isomeric pyrroletricarboxylic acid derivative (VIII), mp 129.5—130.5° (*Anal.* Calcd. for $C_{23}H_{22}O_6N_2$: C,65.39; H, 5.25; N, 6.63. Found: C,65.27; H, 5.26; N, 6.55), while another isomeric pyrrolinetricarboxylic acid ester[7] was oxidized with selenium dioxide into the same pyrrole derivative (V) as the product derived from II. By

5) High pressure Hanovia mercury lamp (550 W) was used.
6) J.E. Dolfini, *J. Org. Chem.*, **30**, 1298 (1965).
7) The analytically pure sample of VII was not obtained.

consideration of these chemical and physical data, the major cycloadduct was conclusively designated as III.[8]

The formation of III may adequately be explained in terms of photochemical rearrangement of the initially-produced cycloadduct (II) through a biradical intermediate (IX) or the likes, which seems similar to the photochemical behavior of β,γ-unsaturated ketone system.[9] This was also verified by the fact that irradiation of II in dioxane actually afforded III, accompanied with an unidentified product.

In contrast to the above case, heating of I and dimethyl acetylenedicarboxylate at 100° did not yield II nor III; a considerable amount of I was recovered and any other 1:1 cycloadduct was not successful to be characterized.

Acknowledgement We are greatly indebted to Dr. G. Sunagawa, Director, and Dr. I. Iwai, Assistant Director of this laboratories, for their encouragement, and to Mr. Y. Ohashi for his technical assistance.

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Received January 29, 1968

8) We also can not deny the possibility of an alternative formula (X) which, however, based on its mechanistic rationalization, is very unlikely. In addition, precise analysis, including decoupling study, of the signals at 4.84 and 7.76 ppm in the NMR spectrum of III did not exhibit any mutual coupling, also ruling out the possibility of X.

9) G.C. Schenck and R. Steinmetz, *Chem. Ber.*, **96**, 520 (1963); D.I. Schuster, M. Axelrod, and J. Auerbach, *Tetrahedron Letters*, 1911 (1963); E.F. Keifer and D.A. Carlson, *Tetrahedron Letters*, 1617 (1967); D.E. Bays and R.C. Cookson, *J. Chem. Soc.*, Sect. B, 226 (1967); L.A. Paquette and R.F. Eizenber, *J. Am. Chem. Soc.*, **89**, 6205 (1967); J.K. Crandall, J.P. Arrington, *ibid.*, **89**, 6208 (1967).

[Chem. Pharm. Bull. 16(4) 767—769 (1968)]

UDC 547.466.04.07

Photo-induced Oxygenation of Hydrocarbons by Pyridazine N-oxides[1]

Recently, many works concerning to the photolyses of aromatic amine N-oxides have been reported.[2] However, none of the N-oxides so far examined photochemically contains an internal azoxy function (I) in their structures such as pyridazine, cinnoline, and phthalazine. This fact together with an interesting photochemical intramolecular rearrangement of oxygen atom in azoxybenzene[3] has prompted us to examine the photochemical behavior of several pyridazine N-oxides (IIa[4] and IIb[5]).

As the result, we have found that the photolyses of these N-oxides in benzene solution resulted in the formation of the corresponding pyridazines (IIIa,b) and phenol as the main

1) This paper forms part IX of a series entitled to "Syntheses of Pyridazine Derivatives". For previous paper, see, *Chem. Pharm. Bull.* (Tokyo), **15**, 2000 (1967).

2) C. Kaneko, Sa. Yamada, I. Yokoe, and M. Ishikawa, *Tetrahedron Letters*, 1873 (1967); J. Streith, H.K. Darrah, and M. Weil, *ibid.*, 5555 (1966); O. Buchardt, B. Jensen, and I.K. Larsen, *Acta Chem. Scand.*, **21**, 1841 (1967); N. Ikekawa and Y. Homma, *Tetrahedron Letters*, 1197 (1967).

3) G.M. Badger and R.G. Buttery, *J. Chem. Soc.*, 2243 (1954); R. Tanikaga, K. Maruyama, R. Goto, and A. Kaji, *Tetrahedron Letters*, 5925 (1966).

4) T. Itai and S. Natsume, *Chem. Pharm. Bull.* (Tokyo), **11**, 83 (1963).

5) H. Kano, M. Ogata, H. Watanabe, and I. Ishizuka, *Chem. Pharm. Bull.* (Tokyo), **9**, 1017 (1963); T. Nakagome, *Yakugaku Zasshi*, **82**, 249 (1962).