

MECHANISM ON THE PHOTOREARRANGEMENTS OF PHENYLTHIAZOLES<sup>1</sup>

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In the preceding communication,<sup>2</sup> we reported on the photorearrangements of 2,5- and 2,4-diphenylthiazole and suggested the possible mechanistic rationalization of the photorearrangements of thiazoles involving the formation of bicyclic intermediates ( valence bond isomers ) or tricyclic sulphonium cation intermediates. On the other hand, Vernin and co-workers<sup>3,4</sup> found the similar photorearrangement of 2-phenylthiazole (Ia) to 4-phenylthiazole (Id) and 3-phenylisothiazole (IIa), and have recently reported<sup>5</sup> that the photorearrangement of 2-phenyl-5-deuteriothiazole (Ic) in benzene gave 4-phenyl-5-deuteriothiazole (If) and 3-phenyl-4-deuterioisothiazole (IIc), while the yield of IIc considerably increased in contrast to the yield of If under the presence of iodine. On the bases of these results, they have proposed a valence bond isomerization mechanism.<sup>5</sup>

Independently of them, we have also been pursuing the photorearrangements of phenylthiazoles to acquire information about the mechanism on the photorearrangements of thiazoles, and found that the incorporation of deuterium was occurred in the photorearrangement of Ia or Id in benzene-deuterium oxide system. As a result, we assert the mechanism via tricyclic sulphonium cation intermediates in the photorearrangements of thiazoles.

Irradiation<sup>6</sup> of Ia in ethanol solution ( $2.6 \times 10^{-2}M$ , 14 hr) gave Id (20.6 %) and IIa ( 10.8 %), and in benzene solution ( $2.4 \times 10^{-2}M$ , 15 hr), Id (4.9 %) and IIa (9.9 %) together with unchanged Ia (38.3 %). On irradiation, 5-phenylthiazole (Ig) in ethanol solution (  $2.5 \times 10^{-2}M$ , 26 hr) led to the formation of 4-phenylisothiazole (IIg) in 11.9 % yield together with unchanged Ig (25.6 %), while in benzene solution ( $2.8 \times 10^{-2}M$ , 33 hr) IIg was produced in only 3 % yield together with unchanged Ig (51.4 %). These photoproducts were similar to those reported by Vernin et al.<sup>3,4</sup> Although it has been reported<sup>4</sup> that Id on irradiation gave no isomeric product, we have isolated IIa in a yield of 1.3 % in the case of ethanol solution (  $2.5 \times 10^{-2}M$ , 38.5 hr) and of 0.6 % in the case of benzene solution ( $2.5 \times 10^{-2}M$ , 48 hr),

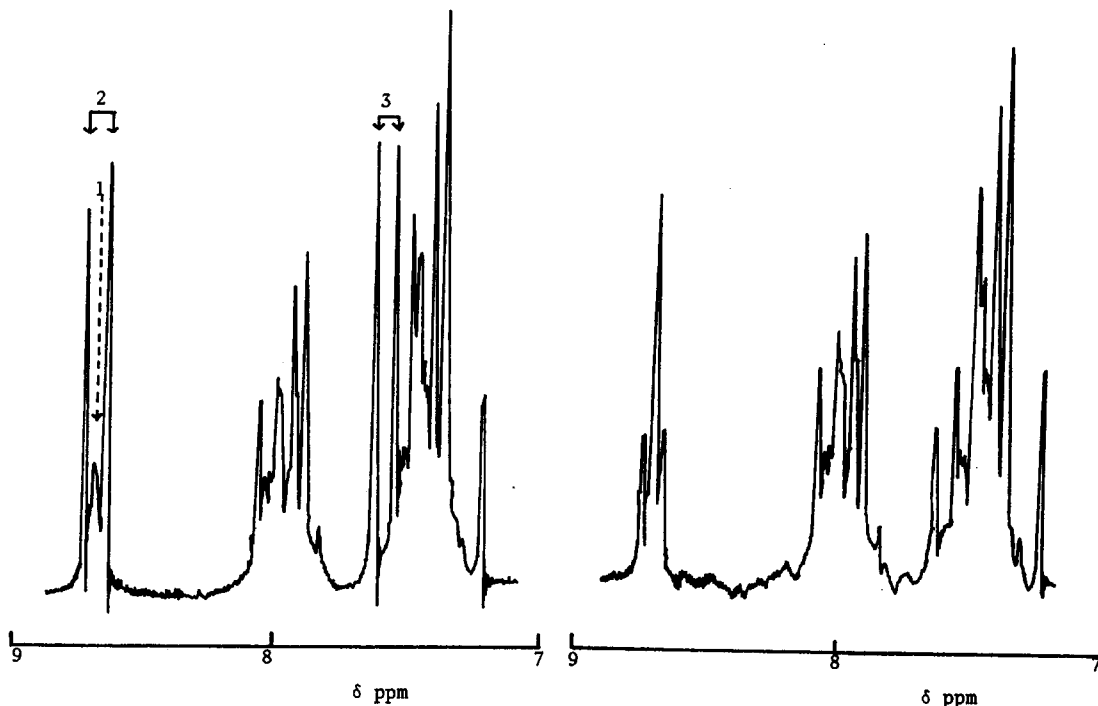
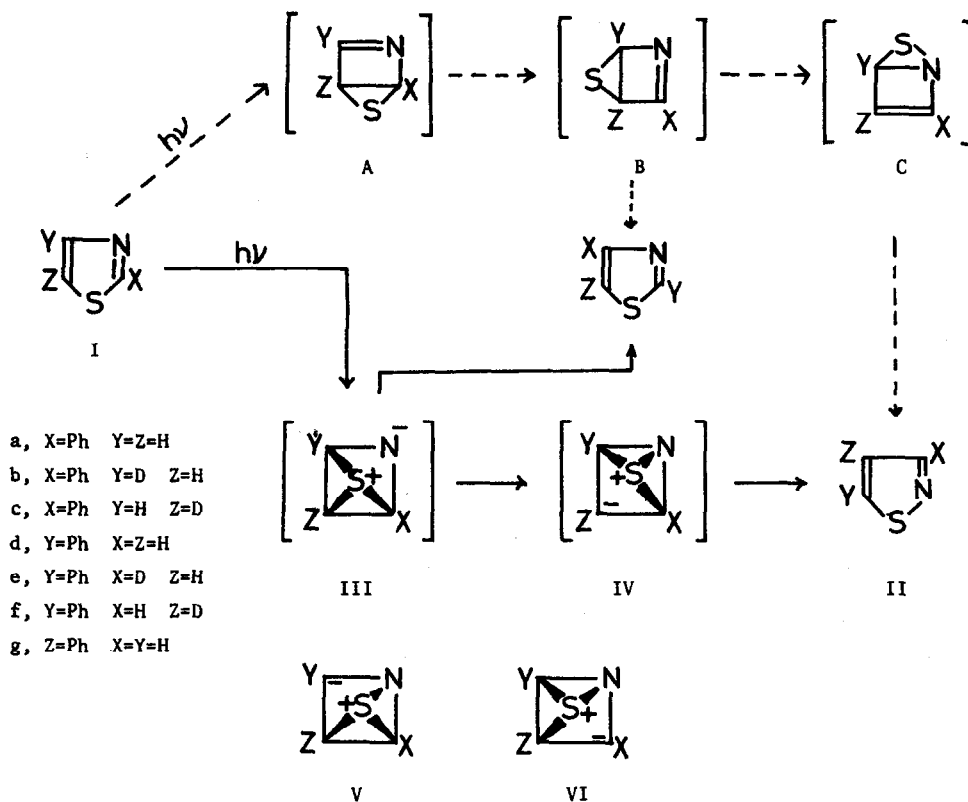


Figure 1.

Figure 2.

respectively.

Next, irradiation<sup>6</sup> of Ia was carried out in benzene containing ca. 2 % deuterium oxide, and the n.m.r. spectral analyses of the products<sup>7</sup> were made after careful silica gel chromatography of the reaction mixture. The n.m.r. spectra of the recovered Ia and the product, 4-phenylthiazole, showed that there were no detectable incorporation of deuterium. However, the n.m.r. spectrum of the product, 3-phenylisothiazole, showed that it consists of 3-phenylisothiazole (IIa) and 3-phenyl-4-deuterioisothiazole (IIc), and the ratio is estimated as 78 : 22 respectively ; as shown in Fig. 1, signal 1 at  $\delta$  8.67 ppm (singlet) is assigned to hydrogen of position 5 of the isothiazole ring, in addition, signal 2 at  $\delta$  8.67 ppm (doublet,  $J=4.8$  Hz) is assigned to hydrogen of position 5 coupling with hydrogen of position 4, and signal 3 at  $\delta$  7.58 ppm (doublet,  $J=4.8$  Hz) is assigned to hydrogen of position 4 coupling with hydrogen of position 5.<sup>8</sup> When Ia or IIa in benzene-deuterium oxide system was refluxed in the dark, there was no detectable incorporation of deuterium. Irradiation of Ic in benzene afforded If, while the n.m.r. spectrum of the product, 3-phenylisothiazole, showed that the deuterium was exchanged by



hydrogen in some degree, and the ratio of IIc and IIa is estimated as 69 : 31 respectively ( Fig. 2 ).

When Id was irradiated in benzene-deuterium oxide system under similar conditions, there was no incorporation of deuterium into the recovered Id, but the n.m.r. spectrum of the product, 3-phenylisothiazole, showed that it consists of IIa and IIc, and the ratio is estimated as 67 : 33 respectively. However, on irradiation of 2-deuterio-4-phenylthiazole (Ie) in benzene, the exchange of deuterium of the recovered Ie or the product, 3-phenyl-5-deuterioisothiazole (IIb), with hydrogen was not observed in the n.m.r. spectra.

On irradiation of Ig in benzene-deuterium oxide system, the incorporation of deuterium into both the recovered Ig and the product, 4-phenylisothiazole, was not observed.

It is of mechanistic interest that the incorporation of deuterium was observed in the course of the photorearrangement of Ia or Id to II in benzene-deuterium oxide system. If the rearrangement proceeded through a valence bond isomerization mechanism involving bicyclic intermediates (A, B or C) in the photorearrangement of Ia, there should be scarcely any chance of

incorporating deuterium into the product. If it is the case, the incorporation of deuterium must be observed into not only 3-phenylisothiazole but also 4-phenylthiazole. Such a phenomenon was not observed. Therefore a valence bond isomerization mechanism could be excluded. The results of our experiments suggest a mechanism involving a charged intermediate species. Namely, it seems more probable that the photorearrangements of thiazoles are interpreted by the mechanism involving tricyclic sulphonium cation intermediates as follows. By irradiation, thiazoles (I) are converted to a product holding substituents, X and Y, at the reverse position of I via III. When the intermediate (III) is transformed to the intermediate (IV), which involves carbanion, it incorporates deuterium to give the deuterio product (II). It is not necessary to consider other asymmetrical tricyclic sulphonium cation intermediates (V or VI), because the exchange of hydrogen with deuterium was not observed in the photorearrangement of Ig.

Moreover, it is possible to explain all the photorearrangements of thiazoles<sup>2-5</sup> by the mechanism involving the tricyclic sulphonium cation intermediates III and IV. The detailed discussion about our newly proposed mechanism will be described in full paper.

#### REFERENCES AND FOOTNOTES

1. Photochemistry of Heterocyclic Compounds. IV.
2. M. Kojima and M. Maeda, Chem. Comm., 386(1970).
3. G. Vernin, H. J. M. Dou, and J. Metzger, C. R. Acad., Ser. C. 271, 1616(1970).
4. G. Vernin, J.-C. Poite, J. Metzger, J. P. Aune, and H. J. M. Dou, Bull. Soc. Chim. Fr., 1103(1971).
5. C. Riou, G. Vernin, J. J. M. Dou, and J. Metzger, Bull. Soc. Chim. Fr., 2673(1972).
6. All irradiations were carried out at 80° using 100-W high pressure mercury lamp with a quartz filter, and dry nitrogen was bubbled through the solution during irradiation.
7. All n.m.r. spectra were taken with TMS as an internal reference at 60 MHz and all samples were taken as 10 % solutions in CDCl<sub>3</sub>.
8. R. A. Olofson, J.M. Landesberg, R. O. Berry, D. Leaver, W. A. H. Robertson, and D. M. Mckinnon, Tetrahedron, 22, 2119(1966).