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INDOLE FORMATION BY PYROLYSIS OF β-STYRYLAZIDES

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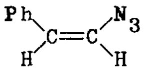
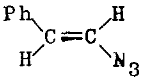
Cyclization to indole ring from β-styrylnitrene or other intermediates related to it was ambiguous. In case of the deoxygenation of β-nitrostyrene, accompanied with the formation of phenylacetonitrile in low yield, a positive indole test was reported, but not yet specified (1). Recently Boyer and his coworkers found that photolyses of β-styrylazide and β-styrylisocyanate and pyrolysis of the former gave the same nitrile (2). They proposed that β-styrylnitrene might be possible common intermediate for these three reactions. Neither cyclization to indole nor formation of 2-phenyl-2H-azirine, which could be expected from usual decomposition of vinylazides (3), have been confirmed in these reactions of β-styrylnitrene.

Now we wish to report the formation of indoles by pyrolyses of β-styrylazides through azirine intermediate (4).

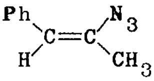
The following azides were synthesized by the methods developed in our laboratory. These azides were carefully separated into cis- and trans-isomers, respectively, by column chromatography (5).



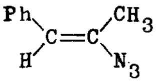
(I)



(II)



(III)

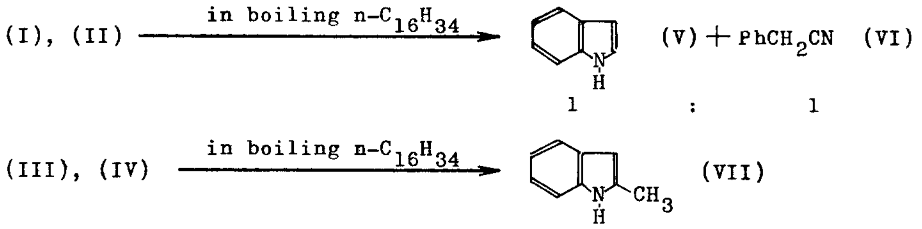


(IV)

The pyrolyses were carried out by dropwise addition of these azides into boiling n-hexadecane (b.p. 287°C). Reaction products of (I) and (II) were separated into indole (V), phenylacetonitrile (VI) and unidentified black tar by means of alumina column chromatography.

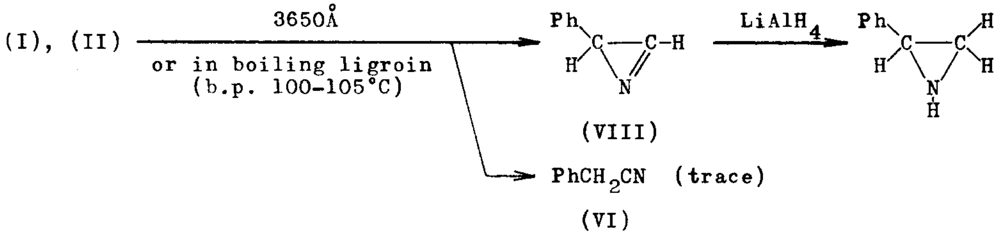
Equal product ratio (V/VI = 1) and same yield (about 85%) were determined for the pyrolysates of both cis (I) and trans (II) isomer by glpc analysis using fluorene as an internal standard.

Pyrolyses of (III) and (IV) gave only 2-methylindole (VII) in 86% yield.



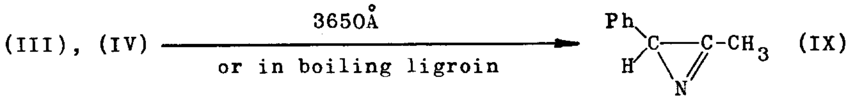
From the above results, the same intermediates which had no stereoisomer were assumed for the pyrolyses of (I), (II) and (III), (IV) respectively.

Methylenechloride solutions of (I) and (II) were irradiated with 3650A light supplied by 100W high pressure mercury lamp at -30°C in nitrogen atmosphere for 2 hours. The nmr spectra of the photolysates, measured in $CDCl_3$ at -20°C in nitrogen atmosphere, were identical and showed doublet at 0.4τ (J: 2cps 1H), multiplet at 2.8-3.4τ (5H) and doublet at 7.2τ (J: 2cps 1H). Characteristic IR band at 1655cm^{-1} was assigned to νC=N. 2-Phenyl-2H-azirine (VIII) should be the only acceptable structure for these spectral results. This structure was confirmed by lithium aluminum hydride reduction of the photolysates to 2-phenylaziridine which was identified by comparing its IR spectrum and glpc retention time with authentic sample, synthesized through known route (6). Trace amount of phenylacetonitrile (<2%) was detected in nmr spectra of photolysates.



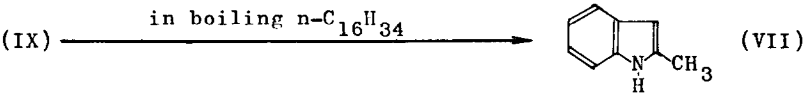
Compound (VIII) and trace amount of phenylacetonitrile (<2%) were also obtained by thermal decompositions which were carried out by dropwise addition of (I) and (II) into boiling ligroin (b.p. 100-105°C).

The photolyses and the thermal decompositions in boiling ligroin of (III) and (IV) gave only 2-phenyl-3-methyl-2H-azirine (IX) quantitatively.



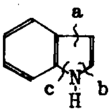
The obvious differences of these azirines, (VIII) and (IX), were observed in their reactivity with oxygen and in IR spectra. Standing overnight in contact with air at room temperature, (VIII) turned black tar and its characteristic IR band at 1655cm^{-1} disappeared completely. In nitrogen atmosphere this band remained after (VIII) was heated in boiling ligroin for 5 hours. On the contrary, (IX) was stable in air, and had νC=N at 1770cm^{-1} which fell in the region of ν C=N of known azirines (3). In comparison with νC=N of open chain compounds, observed in the region of 1640-1690cm^{-1} (7), νC=N at about 1750cm^{-1} for usual azirines is regarded as abnormal and characteristic band for 3-substituted azirines. Same phenomenone has been observed in cyclopropenes. Closs and his coworker found that νC=C of 1,2-disubstituted cyclopropenes is observed at about 100cm^{-1} higher wave number than 1-hydro-derivatives (8).

Thermal treatment of (VIII) under the same condition as the pyrolyses of the azides (in boiling n-hexadecane) gave a mixture of equal mole ratio of indole (V) and phenylacetonitrile (VI). In the same way, (IX) gave only 2-methylindole (VII). The yields were above 86% in both cases.



Now it is apparent that 2-phenyl-2H-azirines are common intermediates for the formation of indoles and phenylacetonitrile from pyrolyses of cis- and trans-β-styrylazides.

Since usual methods of indole synthesis involve the formation of bond a or b of the heterocyclic ring at the end of reaction sequence, it is regarded as novel method for indole to be obtained by formation of bond c. Such an uncommon reaction was found only in case of pyrolysis of 2-phenylcyclohexanone oxime (9).



Firm evidence for the presence of β-styrylnitrene is not available, but the ready formation of azirines from photolyses and thermal decompositions of β-styrylazides may be compared with the formation of cyclopropenes from alkenylcarbenes (10).

Further mechanistic study is attempted and will be reported in near future.

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