The β-Alkylation of Pyridine and Quinoline 1-Oxides with Acetylenes: Studies of the Mechanism

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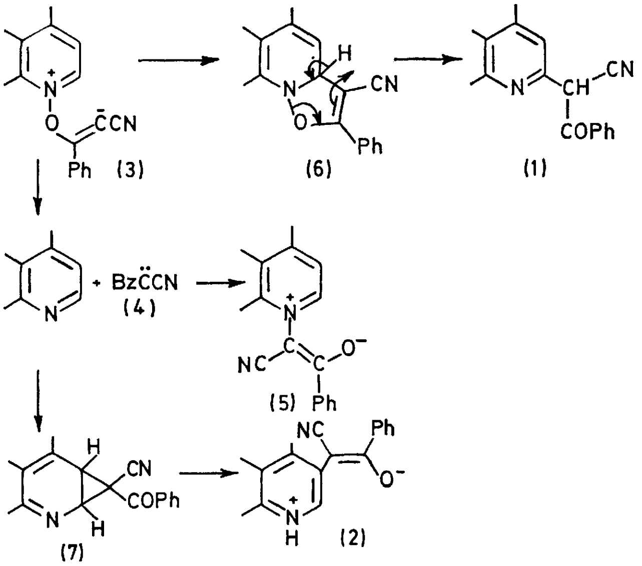
Summary Reaction of pyridine and quinoline 1-oxides with phenylcyanoacetylene give products which arise, in part, from the benzoylcyanocarbene but possibly in the main from intermediate (**6**), ring-opening of which could either lead to 2-alkylated product or to resonance-stabilized zwitterion (**8**); this could close to (**7**) and thence open to (**2**); concerted opening of (**6**) and closure to (**7**) is also feasible.

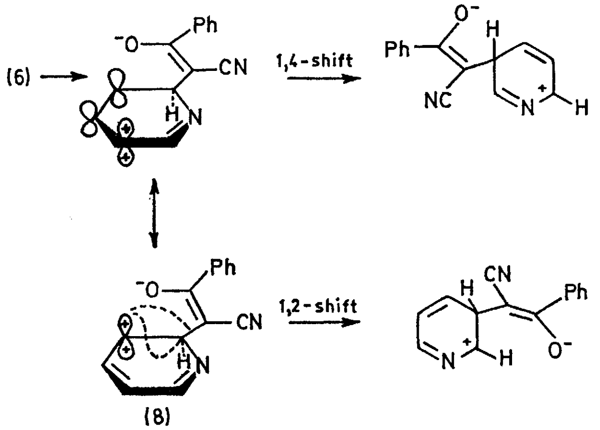
To account for the formation of β-alkylated products (**2**) in the reaction of pyridine and quinoline 1-oxide with phenylpropiolonitrile[1] and of an *N*-ylide in the reaction of isoquinoline 2-oxide with ethyl phenylpropiolate[2] it was suggested that an intermediate (**3**) underwent cleavage to give pyridine and benzoylcyanocarbene (**4**) which could recombine to give the ylide (**5**) or an azanorcaradiene (**7**) which would ring-open to give (**2**).



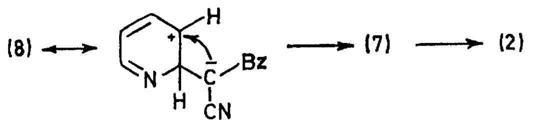
In partial support of this we find that the ylide is formed in very small amounts from pyridine 1-oxide and PhC≡CCN [the main product (60·8%) is (**2**)] and in *ca.* 6% yield from quinoline 1-oxide and isoquinoline 2-oxide.

Two routes to the authentic carbene (**4**) have been investigated. Thermolysis of $Ph\overset{+}{I}\overset{-}{C}(CN)COPh$ [m.p. 85—88° (82%) from benzoylacetonitrile and iodosylbenzene diacetate] in pyridine gave (**5**) (58%) in what is probably a concerted process not involving a free carbene. On the other hand, decomposition of benzoylcyanodiazomethane [m.p. 47—48° (72%) from benzoylacetonitrile and 2-azido-3-ethylbenzothiazolium tetrafluoroborate;[3] triphenylphosphazine, m.p. 162—163°] in pyridine gave (**2**) (2·8%) and (**5**) (23%). It appears, therefore, that while ylides of the type (**5**) are probably formed from the carbenes as suggested, this can at best only be minor route to the β-alkylated products (**2**). Ylides (**5**) do not rearrange to (**1**) or (**2**) under the reaction conditions.

If the 3- and 5-positions are blocked, as in 3,5-lutidine 1-oxide, the 2-alkylation product (**1**) is obtained in good yield (77%). Reaction of 2- and 3-picoline 1-oxides with PhC≡CCN gives the 5-alkylated product in each case (43·4 and 31·3%, respectively). No product of 3-alkylation is observed with 2-picoline 1-oxide. 2,6-Lutidine 1-oxide gives only a very low yield of 3-alkylated product (much tar is formed) and, whereas quinoline 1-oxide gives an 18% yield of the corresponding (**2**), 2-methylquinoline 1-oxide leads only to tar formation. Thus, in contrast to the reaction of dimethyl acetylenedicarboxylate with 1-benzoyliminopyridinium ylides,[4] attack at a methyl-bearing carbon occurs reluctantly here.



A 1,4-shift of a C(2)-vinyl group has been suggested[4,5] to account for the observed β-alkylation products in the above iminopyridinium ylide reactions and may also account for some of the β-alkylation products observed here since such a shift $({}_{\sigma}2_{a} + {}_{\pi}2_{a} + {}_{\omega}0_{a})$ is allowed with inversion at the migrating C.[6] On the other hand, the proposed[4,5] 1,2-shift $({}_{\omega}0_{s} + {}_{\sigma}2_{s})$ is symmetry allowed but physically unrealizable.[6] This latter fact, together with the orientation observed with 2-picoline 1-oxide, the reaction with quinoline 1-oxide (a 1,4-shift is impossible here) and the apparent reluctance of a 2-methylated carbon to undergo attack (2,6-lutidine- and 2-methylquinoline 1-oxides) suggests that the 1,4-shift cannot account successfully for all the β-alkylations observed here. Instead, we propose a simpler process below which, together with some carbene formation, could explain all the known facts. Competition between ring-opening of (**6**) to (**1**) (with loss of a proton) or to (**8**) {a concerted opening of (**6**) and closure to (**7**) can also be visualized and, indeed, might explain why loss of a proton from (**8**) to give (**1**) is not more prevalent. Such a con-



certed process is symmetry allowed $[_{\sigma}2_{s} + {}_{\pi}2_{a} + {}_{\pi}4_{s}]\}$ is supported by the fact that if the reaction of pyridine 1-oxide and PhC≡CCN is carried out in the presence of Et_3N the yield of (**1**) increases at the expense of that of (**2**).

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