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REGIOSELECTIVITY IN ELECTROPHILIC ADDITIONS TO ACETYLENES[1]

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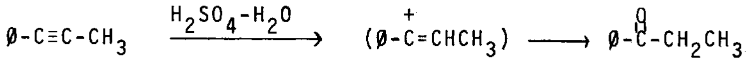
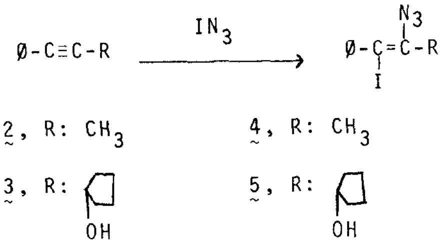
The addition of iodine azide to olefins has been shown to be useful in determining stereoselectivity as well as regioselectivity in addition reactions. Thus styrene or n-butylethylene lead exclusively to N_3-R regiospecific [2] products, whereas tert butylethylene gives the opposite regioisomer.[3] Very little is known about both stereochemistry and orientation in additions to acetylenes. 1-Phenylpropyne undergoes acid hydration in quantitative yield to propiophenone and this can be attributed to the preferred formation of 1, the vinyl carbonium ion α to phenyl.[4] Similar results were recently observed in the ionic bromination of acetylenes in the presence of acetic acid.[5]

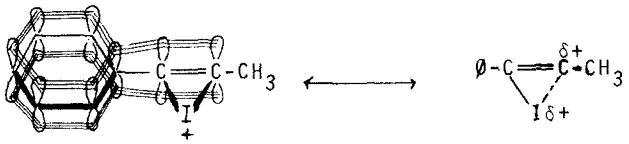


$$\phi\text{-C}\equiv\text{C-CH}_3 \xrightarrow{H_2SO_4\text{-}H_2O} (\phi\text{-}\overset{+}{\text{C}}\text{=CHCH}_3) \longrightarrow \phi\text{-}\overset{\text{O}}{\overset{\|}{\text{C}}}\text{-CH}_2\text{CH}_3$$

1

In the addition of IN_3 to 1-phenylpropyne two regioisomers may be formed. We would like to report that this reaction proceeds in the opposite regiochemical sense from hydration leading to 2-azido-1-iodo-1-phenylpropene (4). A similar result was obtained in the addition of IN_3 to phenyl (1-hydroxycyclopentyl) ethyne (3) indicating that the neighboring hydroxyl group did not affect the reaction. These findings suggest the formation of an intermediate unsaturated 3-membered ring iodonium ion analogous to a cyclopropenylium ion. The π-electrons of the phenyl ring are able to contribute more to resonance stabilization of the double bond than to interaction with the iodine-bridged positive ion, whereas in a vinyl carbonium ion 1 more stabilization is derived by overlap between the phenyl ring and the carbonium ion. The resonance form 6a experiences stabilization purely by inductive effects, an alkyl group being able to stabilize a positive charge better than a phenyl group.

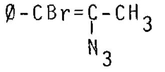




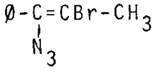
6

6a

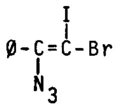
Free radical addition of IN_3 in acetonitrile is unlikely because BrN_3, which has a much greater tendency for radical additions,[6] gives a mixture of regioisomers 14 and 15. Presumably regioisomer 15 is the result of an ionic addition involving a vinyl carbonium ion 1, whereas 14 results from the bromo equivalent of 6a or from a free radical addition. The lower stability of three-membered bromonium vs iodonium ions α to phenyl has recently been demonstrated.[7] The addition of IN_3 to bromo phenyl ethyne proceeds in the opposite sense, leading to 7, the phenyl group being more effective than bromine in stabilizing a positive charge. The structure proof for the adducts was furnished by zinc reduction to the corresponding ketone. It was shown on model systems such as 8 that


$\phi\text{-CBr=}\underset{N_3}{C}\text{-CH}_3$

14


$\phi\text{-}\underset{N_3}{C}\text{=CBr-CH}_3$

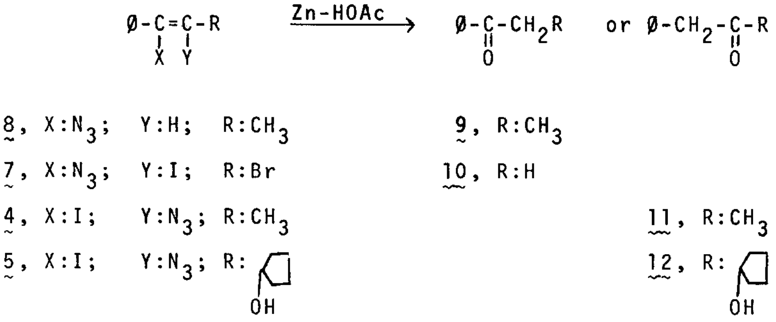
15



$\phi\text{-}\underset{N_3}{C}=\overset{I}{C}\text{-}Br$

7

the reduction with zinc in aqueous acetic acid leads in nearly quantitative yield to the formation of ketone 9 marking the position of the azide function. In this manner vinyl azide 4, although a (1:2) mixture of stereoisomers as indicated by



$\phi\text{-}\underset{X}{C}=\underset{Y}{C}\text{-}R \xrightarrow{Zn\text{-}HOAc} \phi\text{-}\underset{O}{\overset{\|}{C}}\text{-}CH_2R$ or $\phi\text{-}CH_2\text{-}\underset{O}{\overset{\|}{C}}\text{-}R$

8, X:N_3; Y:H; R:CH_3

7, X:N_3; Y:I; R:Br

4, X:I; Y:N_3; R:CH_3

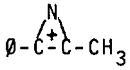
5, X:I; Y:N_3; R:

9, R:CH_3

10, R:H

11, R:CH_3

12, R:

the methyl absorption at τ7.64 and 8.05, gave on zinc reduction phenylacetone.[8] The mass spectrum of 4 was also indicative of its structure with m/e peaks among others at 285 (7%, parent peak), 216 (54%, $C_6H_5\text{-}\overset{+}{C}I$), 89 (100%, $C_6H_5\overset{+}{C}$), 130 (99%, ).

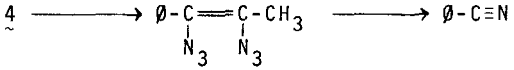
In this connection, it is important to mention that whereas zinc-acetic acid causes the conversion of vinyl azides to ketones, acid hydrolysis (aqueous sulfuric acid) leads to the formation of a mixture of ketone and amides. For instance 8 gives on hydrolysis propiophenone, N-phenylpropionamide and N-ethylbenzamide in a ratio of 70:25:5. These results indicate that protonation of vinyl azides leads to an analogous intermediate 13 as is formed on treatment of ketones with hydrazoic acid in the Schmidt reaction.[9]

$\underset{H}{C}\text{-}\overset{+}{\underset{R}{C}}\text{-}\overset{-}{N}\text{-}\underset{+}{N}\equiv N \longleftrightarrow \underset{H}{C}\text{-}\underset{R}{C}=N\text{-}\overset{+}{N_2}$

13

The formation of two stereoisomers in the IN_3 addition to 1-phenylpropyne (their ratio remains constant during the addition) suggests that two mechanisms might be operating simultaneously, one leading to *cis* addition and one via the iodonium ion **6**.[10]

As a by-product in the addition reaction, 25% of benzonitrile was isolated. It was shown that this product is also formed upon treatment of **4** with iodine azide solution at 25° and therefore probably arises by displacement of the vinylic iodide with azide followed by fragmentation to a nitrile. Similar fragmentations of α,β-diazides, albeit under more vigorous conditions, have recently been reported.[11]



$$\mathbf{4} \longrightarrow \emptyset\text{-}\underset{N_3}{C}{=}\underset{N_3}{C}\text{-}CH_3 \longrightarrow \emptyset\text{-}C{\equiv}N$$

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(1) Paper XLII on Stereochemistry. Presented in part before the Gordon Research Conferences on Heterocyclic Compounds, New Hampton, N.H., July 1968.

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(b) A. Hassner and F.W. Fowler, *J. Org. Chem.*, **33**, 2686 (1968).

(4) D.S. Noyce and M.D. Schiavelli, *J. Org. Chem.*, **33**, 845 (1968).

(5) J.A. Pincock and K. Yates, *J. Am. Chem. Soc.*, **90**, 5643 (1968).

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(8) There were *no* ethyl absorptions in the nmr of the crude product.

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