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ADDITION REACTIONS OF ETHOXYCARBONYLNITRENE AND ETHOXYCARBONYLNITRENIUM ION TO ALLYLIC ETHERS[1]

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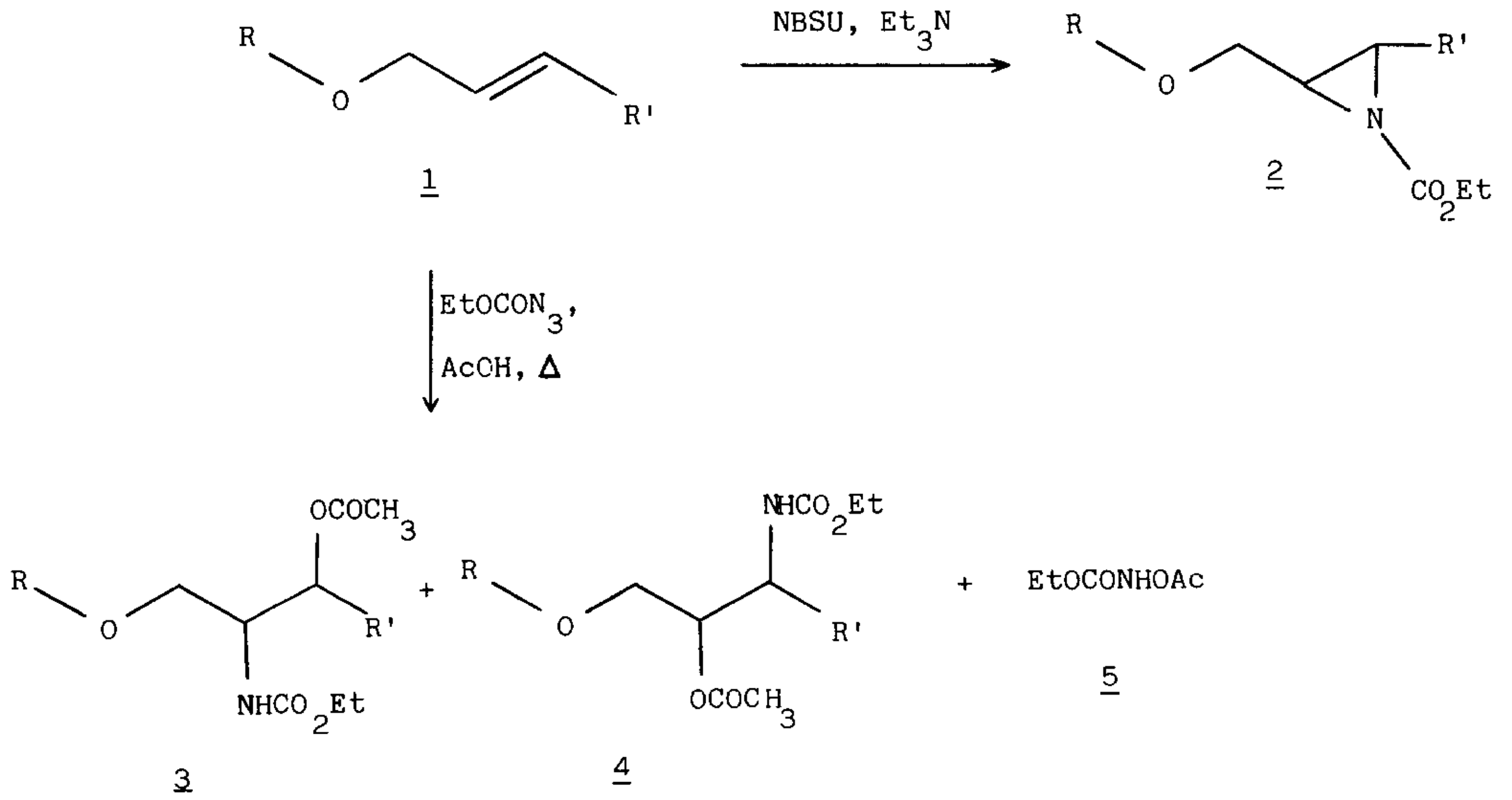
SUMMARY. Ethoxycarbonylnitrene (EtOCON) generated by α-elimination adds cleanly to allylic ethers giving substituted aziridines. Similar addition via nitrenium ion (EtOCONH$^+$) gives derivatives of β-amino alcohols.

While reactions of carbenes and carbenoids on allylic compounds have been thoroughly investigated,[2] little attention has been paid to the reaction between nitrenes and allylic derivatives.[2,3] Our interest in the reaction of ethoxycarbonylnitrene (EtOCON) on unsaturated systems[4] and consideration of recent results of addition reactions of ethoxycarbonylnitrenium ion (EtOCONH$^+$) to alkenes[5] prompts us to report the addition of EtOCON and EtOCONH$^+$ to the allylic ethers:[6] diallyl ether 1a, allyl phenyl ether 1b, and 2,5-dihydrofuran 1c.

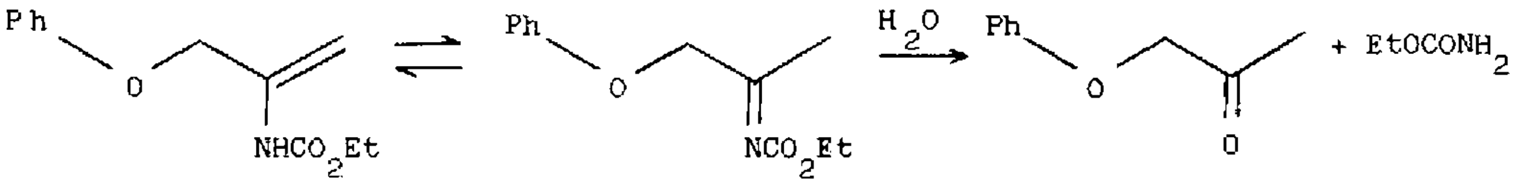
Using EtOCON generated by α-elimination from 4-nitrobenzenesulfonyloxyurethan (NBSU) we confirmed that there is a large preference for addition of EtOCON over insertion into a C-H bond: the only products detectable were the aziridines 2a-c.



a: R = CH_2=CH-CH_2, R' = H b: R = C_6H_5, R' = H c: R·····R' = CH_2

GLC analysis and proton NMR spectra of crude reaction mixtures pointed to high yields of aziridines (up to 77 %, 73 %, and 95 % respectively by GLC), but only low yields (16 %, 7 %, and 10 %) were isolated after silica gel column chromatography. This parallels the results of Ando[3a] using MeOCON generated by photolysis of methyl azidoformate in other allylic ethers, but he found up to 30 % of products of formal insertion.

However, we obtained a large amount (32 %, GLC) of a byproduct in the thermolysis of ethyl azidoformate ($EtOCON_3$) in allyl phenyl ether 1b, which we identified as phenoxyacetone, probably formed as shown below:



Similarly, thermolysis of $EtOCON_3$ in diallyl ether 1a gave the aziridine 2a (77 %, GLC) but accompained by an isomeric (GC-MS) product (22 %, GLC).

Nitrene insertion into a vinylic C-H bond is a common reaction with alkenes. We did not observe the usual insertion product into the α C-H bonds of saturated ethers,[7] nor the product of a [2,3]-sigmatropic rearrangement as reported by Ando.[3a]

On the basis of our results and Ando's, and considering the results of the photolysis and thermolysis of $ROCON_3$ in the presence of Pd catalysts,[8] the α-elimination route is the method of choice for a clean addition of EtOCON to the double bond of allylic ethers.

The aziridines 2a-c are potentially useful precursors of β-amino alcohols[9] of potential interest as β-blockers.[10] Thus the acetolysis[11] of the aziridine 2c gave the acethoxyurethan 3c in 52 % yield. However, the same reaction products might be obtained in a one-pot reaction via a nitrenium ion.[5] Thermolysis of $EtOCON_3$ in 2,5-dihydrofuran (equimolar amounts, 5:5 mmol) dissolved in acetic acid (160 mmol) gave the same acethoxyurethan 3c in 16 % yield (55 %, GLC). The main byproduct (32 %, GLC) was identified as ethyl O-acetyl-N-hydroxycarbamate 5 from its spectroscopic data as reported by Takeuchi.[5] When the thermolysis of $EtOCON_3$ in AcOH was run with the ether 1a (1:160:5) the expected products 3a and 4a were produced in 15 and 38 % yields in addition to 5 (47 % yield). The amount of 5 was substantially reduced when the thermolysis was carried out with less acetic acid ($EtOCON_3$:AcOH:1a = 1:6:2).

Finally, thermolysis of $EtOCON_3$ in AcOH with the ether 1b gave the two products 3b and 4b in 68 % and 25 % yield. Thus the major product 3b was derived from the attack of acetic acid on the less substituted carbon of the aziridinium ion, in contrast to the formation of 4a as the major product in the reaction with diallyl ether. It is known that the direction of aziridine opening is very sensitive to the structure of the aziridine.[11]

2a: ^{1}H-NMR (CCl_4) δ 5.75 (1H, m), 5.15 (2H, m), 4.05 (2H, q), 3.95 (2H, d), 3.50 (2H, m), 2.50 (1H, m), 2.15 (1H, d), 2.10 (1H, d), 1.2 (3H, t); MS: m/z 185 (M^+, 1 %), 41 (100 %); high resolution MS, calcd for $C_9H_{15}NO_3$: 185.1052, found: 185.1047.

2b: ^{1}H-NMR (CCl_4) δ 7.4-6.5 (5H, m), 4.4-3.7 (4H, q + 2d + 2d), 2.7 (1H, m), 2.35 (1H, d), 2.2 (1H, d), 1.2 (3H, t); MS: m/z 221 (M^+, 35 %), 56 (100 %); high resolution MS, calcd for $C_{12}H_{15}NO_3$: 221.1052, found: 221.1057.

2c: ^{1}H-NMR (CCl_4) δ 4.0 (4H, d, J=10 Hz + q), 2.95 (2H, dd, J=10 Hz, J<1 Hz), 2.45 (2H, d, J<1 Hz), 1.0 (3H, t); MS: m/z 157 (M^+, 1%), 56 (100 %); high resolution MS, calcd for $C_7H_{11}NO_3$ 157.0739, found: 157.0730.

3a: ^{1}H-NMR ($CDCl_3$) δ 5.75 (1H, m), 5.1 (3H, m), 4.1 (7H, m), 3.55 (2H, d), 2.05 (3H, s), 1.25 (3H, t); CI/CH_4 MS: m/z 246 (MH^+, 52 %), 188 (100 %).

3b: ^{1}H-NMR ($CDCl_3$) δ 7.3 (2H, m), 6.9 (3H, m), 5.1 (1H, broad), 4.1 (7H, m), 2.05 (3H, s), 1.25 (3H, t); MS: m/z 281 (M^+, 7 %), 188 (100 %); high resolution MS, calcd for $C_{14}H_{19}NO_5$ 281.1263, found: 281.1263.

3c: ^{1}H-NMR ($CDCl_3$) δ 6.6 (1H, broad), 4.5-3.6 (8H, m), 2.1 (3H, s), 1.3 (3H, t); MS: m/z 217 (M^+, 2 %), 157 (100 %); high resolution MS, calcd for $C_9H_{15}NO_5$ 217.0950, found: 217.0929.

4a: ^{1}H-NMR ($CDCl_3$) δ 5.75(1H, m), 5.2 (3H, m), 4.1 (7H, m), 3.5 (2H, m), 2.0 (3H, s), 1.25 (3H, t); CI/CH_4 MS: m/z 246 (MH^+, 62 %), 162 (100 %).

4b: ^{1}H-NMR ($CDCl_3$) δ 7.3 (2H, m), 6.9 (3H, m), 4.9 (1H, broad), 4.1 (5H, m), 3.55 (2H, m), 2.1 (3H, s), 1.25 (3H, t); MS: m/z 281 (M^+, 7 %), 188 (100 %); high resolution MS, calcd for $C_{14}H_{19}NO_5$ 281.1263, found: 281.1260.

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