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CARBETHOXYNITRENE : REACTION WITH ALIPHATIC NITRILES

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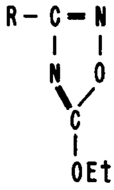
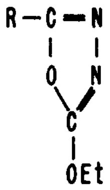
Carbethoxynitrene EtOOC-N can be generated by photolysis of ethyl azidoformate[1] and by treating N-p-nitrobenzenesulfonoxy urethane with base[2]. When generated in aliphatic nitriles, the main products are colorless oils, analyzing as 1:1 adducts of carbethoxynitrene and the nitrile used. Acetonitrile, isobutyronitrile, 3-ethoxypropionitrile and acrylonitrile were employed. The n.m.r. spectra of these products unequivocally show that all the C-H bonds in the nitrile and the nitrene have remained intact. The infrared spectra show no carbonyl absorption. Only two structures are compatible with these results:



1,2,4-OXADIAZOLE

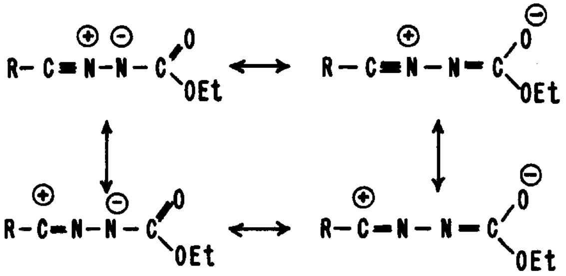


1,3,4- OXADIAZOLE

That the products are 2-alkyl-5-ethoxy-1, 3, 4-oxadiazoles is shown by acid hydrolysis. Hydrazine dihydrochloride was obtained in 96% yield from the 2-methyl-5-ethoxy-1, 3, 4-oxadiazole and in 84% yield from the 2-isopropyl compound.

Identical products are obtained whether the nitrene is generated by azide photolysis (with a low pressure mercury arc) or by α-elimination from N-p-nitrobenzenesulfonoxy urethane (employing triethylamine as the base). This shows that a nitrene intermediate is indeed involved, in contrast to an addition of azide followed by loss of nitrogen. When the nitrene is generated by α-elimination, the yields of urethane, $EtOOC\text{-}NH_2$, and of diethyl hydrazodiformate, EtOOC-NH-NH-COOEt, are larger. This is reasonable: In the photolysis the nitrene molecules are generated slowly throughout the solution, their concentration is low at all times. In the α-elimination reaction, every drop of base added generates a relatively high local concentration of nitrene. Thus hydrogen abstraction from the triethylamine and reaction with the nitrene precursor, with the urethane or with EtOOC-NH radicals are favoured. The radical concentration, however, must be very low, since no polymerization of the acrylonitrile was observed.

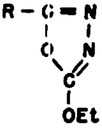
The reaction might involve the primary formation of a nitrilimine intermediate



It also could proceed by direct 1, 3-cycloaddition. The path involving a nitrilimine has ample analogy in the cyclizations of N'-acyl-benzonitrilimines to 2-phenyl-5-alkyl-1, 3, 4-oxadiazoles[3]. The addition of the nitrene would then be another example of the addition of an electron-deficient species to the nitrile nitrogen.

5-Alkoxyl-1, 3, 4-oxadiazoles have not been reported in the literature. The four prepared by us gave elemental analyses for C, H, and N within ± 0.3% of the theoretical values. The yields of formation, their boiling points and their spectral data are summarized in the table. The yields are based on the amount of nitrene precursor used, the nitriles being employed as solvents. In the case of acetonitrile, azide photolysis gave a 57%, α-elimination a 30% yield. No efforts to improve the yields were made. Acrylonitrile polymerized upon prolonged irradiation, the products reported were obtained with nitrene made by α-elimination. The double bond in the acrylonitrile added the nitrene 5.2 times as fast as did the nitrile group. Thus, 1-carbethoxy-2-cyano-aziridine was the main product. It gave an elemental analysis within ± 0.3% of the theoretical values. The IR spectrum showed C-H at 3045, 2990, 2945, 2915 and 2880 cm^{-1}, nitrile at 2260 cm^{-1} and carbonyl at 1740 cm^{-1}. The n.m.r. spectrum showed the ethoxy group at 5.81 τ (2) quartett, 8.7 τ (3) triplet. The single hydrogen on the ring gave a multiplet between 6.87 and 7.03 τ (1.0) and the methylene group in the ring a multiplet between 7.38 and 7.48 τ (2.0).

2-Alkyl-5-ethoxy-1, 3, 4-oxadiazoles

	R: CH_3	R: $CH(CH_3)_2$	R: CH_2CH_2OEt	R: $CH=CH_2$
boiling point	21-23°/1 38°/3	40°/0.4	114°/2	41°/0.25
yield % of theory	55 ^{x}	64	73	14 ^{x}
I R Spectrum				
CH	2988 cm^{-1} 2945 2910 2870	2988 2945 2912 2882	2989 2940 2828 2800	3110 3060 2990 2940 2910 2875
ring	1625 1570	1625 1575	1625 1570	1595
C=C	--	--	--	1640
NMR ^{xx} Spectrum				
-OEt	q 5.46 (2) t 8.53 (3)	q 5.5 (2) t 8.54 (3)	q 5.5 (2) t 8.53 (3)	q 5.45 (2) t 8.52 (3)
			q 6.51 (2) t 8.85 (3)	
R	s 7.57 (3)	m 6.99 (1) d 8.67 (6)	t 6.27 (2) t 7.08 (2)	m 3.23 - 4.47 (3)

^{x}) : see text

^{xx}) : in τ. q: quartet; m : multiplet ; d : doublet; t : triplet - The values in parentheses are the peak areas, usually standardized by the ethyl CH_2 or CH_3 groups

In a competition experiment, carbethoxynitrene was generated by azide photolysis in an equimolar mixture of acetonitrile and cyclohexane. The nitrile group reacted 2.14 times as fast as the CH_2 groups in the cyclohexane. (The latter gives cyclohexyl urethane [1]). This value was obtained by separating the products by v.p.c., measuring the peak areas with a planimeter and correcting for the number of CH_2 groups.

The 2-alkyl-5-ethoxy-1, 3, 4-oxadiazoles are rather sensitive towards hydrolysis. They decompose on alumina columns, but can be chromatographed on silica gel or cellulose. The analytical and spectral samples were purified by vapor phase chromatography.

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3) R. Huisgen, J. Sauer, H.J. Sturm and J. H. Markgraf Berichte 93, 2106 (1960).
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