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SUBSTITUENT EFFECT ON THE REACTION OF BENZONITRILE N-OXIDES WITH ARYLACETYLENES

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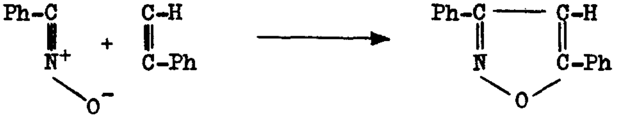
The reaction of nitrile oxides (I) with arylacetylenes (II) yielding 3,5-diarylisoxazoles (III), was discovered several years ago by A. Quilico and G. Speroni (1) and its general applicability widely investigated (1, 2).



(I) (II) (III)

Such a reaction was recently reported as an example of "1-3 dipolar cycloaddition" (3). Kinetic data by Beltrame, Veglio, and Simonetta (4) on the reactivity of several phenylacetylenes with an hindered benzonitrile oxide (2,4,6-trimethyl, 3,5-dichloro benzonitrile oxide), seem to support this point of view.

Following a previous investigation on the dimerization of a series of substituted benzonitrile N-oxides to furoxans (5), the rate of addition of these nitrile oxides to phenylacetylene and to substituted phenylacetylenes have now been measured.

Kinetic experiments were run in CCl_4 as solvent and followed by measurements of the infrared absorption near to 2290 cm^{-1} characteristic of the C≡N band of nitrile oxides (6, 7).

All reactions follow a second order kinetic law in the range 0-80% or more, being first order with respect to each reagent. The rate constants were calculated by standard methods taking into account the parallel reaction of dimerization of the benzonitrile N-oxide.

Rate constants are collected in Table 1. Each value is the average of at least five independent runs.

TABLE 1

Rate constants for the reaction of benzonitrile N-oxides with phenylacetylenes in CCl_4 at 25 ± 0.1 °C.

X	10^3 k (1 mole^{-1} sec^{-1}) $X-C_6H_4-CNO + C_6H_5-C\equiv CH$	 $C_6H_5-CNO + X-C_6H_4-C\equiv CH$
$p-NO_2$	---	4.29 ± .08
m-Cl	3.02 ± .05	---
p-Cl	2.63 ± .1	2.23 ± .06
H	1.78 ± .08	1.78 ± .08
$p-CH_3$	1.50 ± .02	1.87 ± .06
$p-OCH_3$	1.29 ± .04	2.24 ± .05

The rate is effected by substituents in phenyl ring of the benzonitrile N-oxide in the order

$$m-Cl > p-Cl > H > p-CH_3 > p-OCH_3$$

and an Hammett's type relationship is followed ($\rho \sim + 0.6$).

For substituents in the phenylacetylene, the reactivity order is

$$p-NO_2 > p-Cl > H \ll p-CH_3 < p-OCH_3$$

In this case when the rate data are plotted versus the Hammett's σ (8), a V shaped relationship with a minimum on the unsubstituted term, is obtained.

The slopes of the two branches are : $\rho \sim - 0.3$ for the line connecting the points H, $p-CH_3$, $p-OCH_3$, and $\rho \sim + 0.5$ for that connecting $p-NO_2$, p-Cl and H.

The same mild acceleration by both electron-withdrawing and electron-releasing substituents was previously reported by Simonetta and co-workers (4) for cycloaddition of 3,5-dichloro-2,4,6-trimethyl-benzonitrile N-oxide to the same series of arylacetylenes.

From rate data at different temperatures the activation parameters for a selected benzonitrile oxide and phenylacetylene have been evaluated (table 2).

TABLE 2

Rate constants and activation parameters for the reaction of p-Cl-C_6H_4-CNO with $C_6H_5C\equiv CH$ in CCl_4

t°C	K.10^3 (1 mole^{-1}sec^{-1})	E (K cal mole^{-1})	log A	ΔS (e.u.)
25	2.63 ± 0.1			
40	8.90 ± 0.2			
50	17.2 ± 1			
		14.4 ± 0.9	7.98	-24.1 ± 3

The V shaped substituent effect on the rate of cycloaddition, as well as the low entropy of activation, even if lower values are usually reported for such a kind of reaction (3), are in agreement with the hypothesis of an "1,3 dipolar" addition.

On the other hand the positive value of rho found for the effect of substituents on the benzonitrile oxide, quite similar to that previously reported for the dimerization to furoxans (5), suggests a predominance of the electrophilic character of the nitrile oxide in the reaction.

However the situation could also be rationalised on the basis of a different weight of the effect of substituents on the positive and negative ends of the dipole.

Further work on this problem is in progress.

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