

A Photochemical Generation of Nitrosocarbonyl Intermediates

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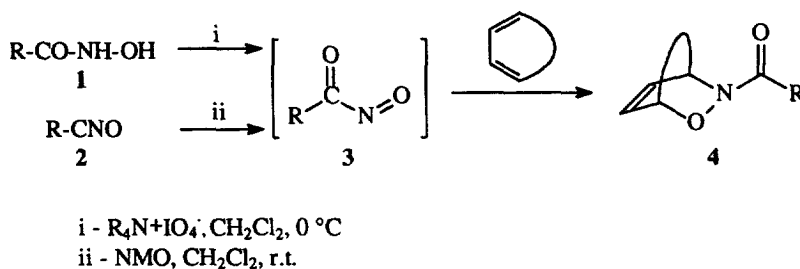
Abstract

Nitrosocarbonyl intermediates are photochemically generated from 1,2,4-oxadiazole-4-oxides and efficiently trapped with enes and dienes. © 1999 Elsevier Science Ltd. All rights reserved.

Keywords: Cycloadditions; Ene reactions; Nitrile oxides; Nitroso compounds.

Nitrosocarbonyl intermediates are well known versatile intermediates for organic synthesis due to their high reactivity as π^2 components in hetero Diels-Alder (HDA) cycloadditions. They are usually generated by periodate oxidation of hydroxamic acids **1** as G. W. Kirby pointed out in his extensive work [1].

Recently we reported a convenient alternative generation of **3** involving the mild oxidation of nitrile oxides **2** with N-methyl morpholine N-oxide (NMO) [2] (Scheme 1).

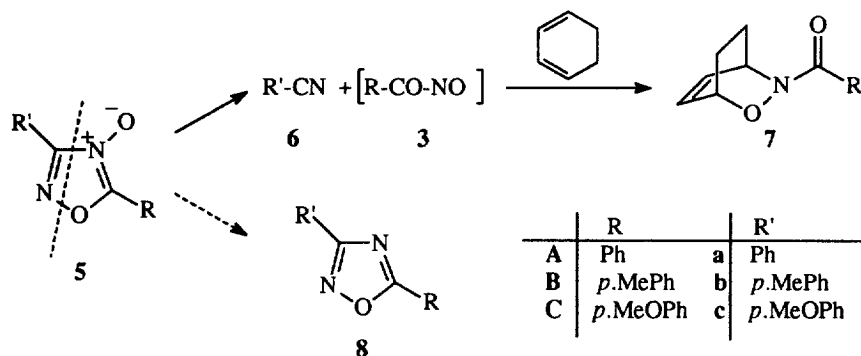


Scheme 1

The trapping process of the nitrosocarbonyl intermediates **3** with several dienes to afford dihydro-1,2-oxazines **4** often represents the key step in complex total natural products synthesis because of the variety of transformations feasible on the HDA adducts **4** [3,4].

We wish to report here the clean and rather unexpected formation of nitrosocarbonyls by photochemical fragmentation of 1,2,4-oxadiazole-4-oxides, a class of compounds easily available by cycloaddition of nitrile oxides to amidoximes [5].

Sun-light irradiation or exposure to six 15W lamps centered at 313 nm of a degassed solution of 3,5-diphenyl-1,2,4-oxadiazole-4-oxide **5Aa** in methanol in the presence of 1,3-cyclohexadiene (1.5 equiv.) afforded, after 5 h, benzonitrile **6Aa** and the HDA adduct **7Aa** in almost quantitative yields along with traces (1-2%) of oxadiazole **8Aa** (Scheme 2). Similar results have been achieved with substituted oxadiazole-4-oxides and the yields of fragmentation and trapped products are given in Table 1. A related photochemical cycloreversion was studied in the late sixties by T. S. Cantrell *et al.* [6] and T. Mukai *et al.* [7], who observed the cleavage of furazan **9** (3,5-diphenyl-1,2,5-oxadiazole) to afford benzonitrile and benzonitrile oxide (Scheme 3). On the other hand the isomeric 1,2,4-oxadiazoles **10** undergo a photoinduced molecular rearrangement to 1,3,4-oxadiazoles **11** as recently reported by N. Vivona *et al.* [8].

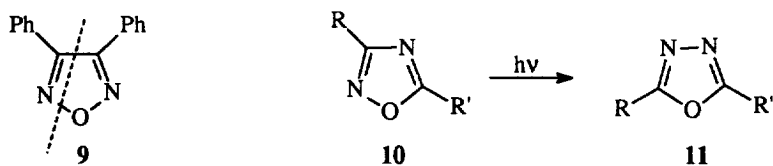


Scheme 2

Table 1
Yields of fragmentation and trapped products.

| | R | R' | 6 | 7 [a] | 8 |
|----|-----------------|-----------------|----|-------|---|
| Aa | Ph | Ph | 93 | 95 | 2 |
| Bb | <i>p</i> .MePh | <i>p</i> .MePh | 67 | 61 | 5 |
| Cc | <i>p</i> .MeOPh | <i>p</i> .MeOPh | 74 | 71 | 1 |
| Ab | Ph | <i>p</i> .MePh | 79 | 80 | 1 |
| Ac | Ph | <i>p</i> .MeOPh | 70 | 74 | 5 |
| Ba | <i>p</i> .MePh | Ph | 65 | 68 | 2 |
| Ca | <i>p</i> .MeOPh | Ph | 74 | 74 | 7 |

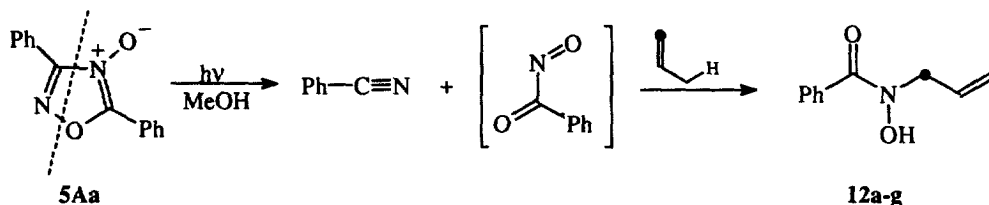
[a]. For spectroscopic and physical data see ref. [2].



Scheme 3

Nitrosocarbonyl intermediates also undergo ene reactions [4,9]. We have recently reported that the mild oxidation of nitrile oxides works well for the ene reaction with tetra- and tri-substituted ethylenes [10]. This procedure fails however with less substituted ethylenes because of competing 1,3-dipolar cycloaddition of the nitrile oxide to the alkene. This shortcoming can be avoided by using the photochemical generation of nitrosocarbonyls. Table 2 reports the results obtained by irradiation of oxadiazole 5Aa in the presence of several differently substituted ethylenes (10 equivs.). Evaporation of volatile products leaves the crystalline ene adducts 12a-f in excellent yields.

Table 2
Yields of ene adducts.



| Entry | Olefin [a] | 12 [b] | Yield % |
|-------|------------|--------|---------|
| 1 | | a | 99 |
| 2 | | b | 99 |
| 3 | | c | 99 |
| 4 | | d | 99 |
| 5 | | e | 95 |
| 6 | | f | 93 |
| 7 | 1-octene | g [c] | 90 |

[a]. In the formulas the dot indicates the site of the attachment to the nitroso carbonyl N in the formation of 12a-g; [b]. For spectroscopic and physical data of the crystalline adducts 12a-f see ref. [10]; [c]. Oil, see ref.[9].

When the oxadiazole-4-oxides 5 of Table 1 are irradiated in the presence of Et_3N (2-3 equivs.) in a methanol degassed solution, deoxygenation of the oxadiazole-4-oxides becomes the predominant path and oxadiazoles 8 can be obtained quantitatively, even in the presence of dienes or olefins. This is in agreement with the reported behaviour of Et_3N as an electron-donor partner in photo-deoxygenation processes of heterocyclic N-oxides [11].

Finally, in the absence of additives, complex mixtures of products are formed (Scheme 4). Table 3 reports the yields of the isolated compounds [12]. The N,N-diaroylamides 13 and the O,N-diaroylamidoximes 14 are formally related to the reaction of nitrosocarbonyls with nitriles 6 and oxadiazoles 8 and arise presumably in a photochemical step [13]. In the case of the 5-anisyl-oxadiazoles-4-oxides 5Ca and 5Cc significant amounts of methyl anisoate 15 were isolated. The ester 15 derives presumably from an easier solvolysis of the corresponding nitrosocarbonyl.

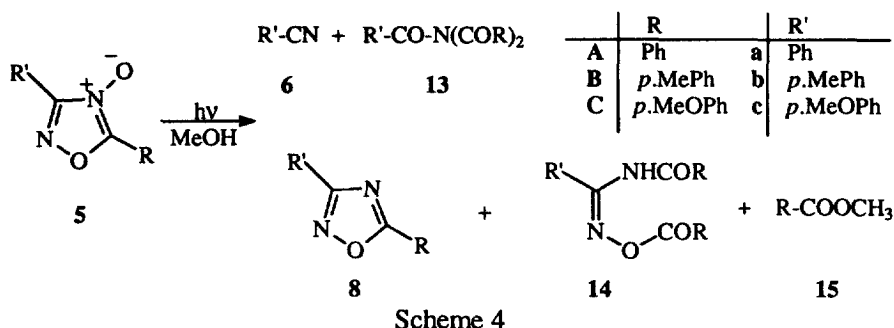


Table 3
Yields of fragmentation products.

| | R | R' | 6 | 8 | 13 [a] | 14 [a] | 15 |
|----|-----------------|-----------------|----|----|------------|------------|----|
| Aa | Ph | Ph | 14 | 14 | 27 | 46 | / |
| Bb | <i>p</i> .MePh | <i>p</i> .MePh | 30 | 5 | 7 | 13 (170-1) | / |
| Cc | <i>p</i> .MeOPh | <i>p</i> .MeOPh | 30 | 8 | / | 8 (171-2) | 20 |
| Ab | Ph | <i>p</i> .MePh | 30 | 10 | 3 (194-5) | 17 (190-2) | / |
| Ac | Ph | <i>p</i> .MeOPh | 50 | 6 | 11 (162-5) | / | / |
| Ba | <i>p</i> .MePh | Ph | 30 | 6 | 3 (201-2) | 12 (186-8) | / |
| Ca | <i>p</i> .MeOPh | Ph | 38 | 1 | / | / | 30 |

[a]. Mps of unreported compounds are given between parentheses; see note [12].

The 1,2,4-oxadiazole-4-oxides **5** are thermally stable and can be stored indefinitely if kept in the dark, but they easily undergo a photochemical cycloreversion to nitriles and nitrosocarbonyls, which can be trapped with dienes or enes to afford HDA cycloadducts or ene adducts in fair yield. In the presence of electron donors (Et₃N) the deoxygenation becomes the preferred path. Further studies on the detection of nitrosocarbonyl intermediates in these reactions are in progress.

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- [13] Thermal generation of nitrosocarbonyls in the presence of nitriles and oxadiazoles does not lead to products **13** or **14**.