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Competitive Epoxidation and Quinone Formation in the Dimethyldioxirane Oxidation of Diazoquinones as Ambident Nucleophiles

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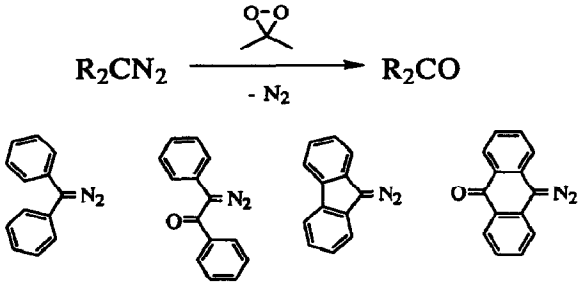
Abstract *: In addition to the expected dimethyldioxirane (DMD) oxidation of diazoquinones* ***1*** *to their quinones* ***2****, the corresponding epoxy quinones* ***3*** *are formed directly and not as secondary overoxidation products of the quinones* ***2*** *since the latter are persistent towards DMD under these conditions; this novel oxidation is rationalized in terms of the ambident nucleophilic nature of the diazoquinones and corroborated by MO (AM1) calculations.*

Despite the intensive use of dimethyldioxirane (DMD) in the epoxidation of alkenes, alkynes and allenes, C-H bond insertion of alkanes and alcohols, and heteroatom oxidation of nitrogen and sulfur compounds, it is surprising that diazo compounds have received little attention [1]. Nevertheless, recently it has been reported that terminal α-diazo ketones lead to labile α-keto aldehydes [2], while 2-diazo-1,3-diones afford the 1,2,3-triones with DMD [3].

Analogous to peroxy acids [4], we have observed that the oxidation of aryl-substituted diazo compounds with a small excess of DMD [5] at ambient temperature yielded quantitatively the corresponding ketones (Eq. 1). However, treatment of 1-diazo-4,4-dimethyl-2,5-cyclohexadi-



(Eq. 1)

ene with one equivalent of DMD at 0 °C for 1 min gave in addition to the corresponding ketone (95%) unexpectedly 2,3-epoxy-4,4-dimethylcyclohex-5-en-1-one (5%). A control experiment established that epoxide formation was negligible when the dienone was treated with DMD under the reaction conditions of the diazoalkane (Scheme 1). That this unusual epoxidation is general, in some cases even the major product, is herein demonstrated for a few diazoquinones **1** when treated with DMD (Table 1).

Scheme 1

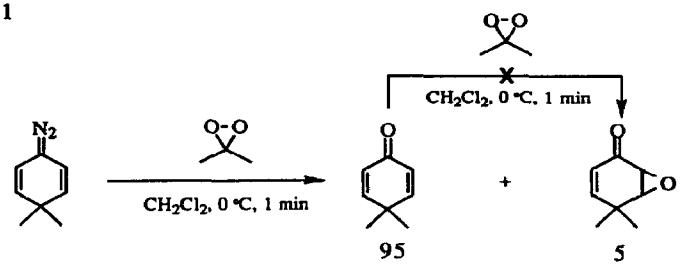


Table 1: Oxidation[a] of diazoquinones **1a-c** by dimethyldioxirane

entry	substrate (mmol)	DMD [equivalents]	conv.[c] [%]	mb[d] [%]	product distribution[b] 2	3
1	**1a** (0.250)	0.5-3.0	>95[e]	74	32	68
2	**1b** (0.235)	0.5	35	>95	65	35
3	**1b** (0.235)	1.0	70	>95	71	29
4	**1b** (0.235)	2.0	>95	>95	72	28
5	**1c** (0.588)	1.0-3.0	>95[e]	>95	30	70[f]

[a] In methylene chloride/acetone for 2 h at 20 °C under a nitrogen gas atmosphere and exclusion of light; [b] product distribution determined by ^{1}H NMR spectroscopy of the crude product mixture by using hexamethyldisiloxane as internal standard, normalized to 100%, error ca. 5% of stated values; [c] conversion, determined as in footnote b); [d] mass balance, determined as in footnote b); [e] conversion after addition of 3.0 equivalents of DMD; [f] includes the 3,4-epoxy-1,2-naphthoquinone hydrate (**4c**).

For example, 1,4-diazobenzoquinone (**1a**) with 3.0 equivalents of DMD for 2 h at ambient temperature resulted in a ca. 35:65 mixture of 1,4-benzoquinone (**2a**) and its 2,3-epoxide **3a**. Clearly, the epoxide **3a** was the major product, but again the quinone **2a** did not react with DMD under these conditions (entry 1, Table 1). In contrast, the 1,2-benzoquinone and also its diazo derivative gave with DMD a complex product mixture even at lower reaction temperatures.

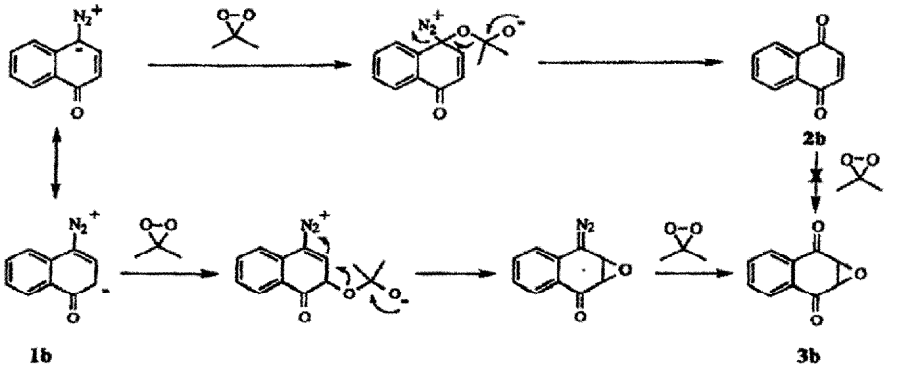
The stepwise oxidation of 1,4-diazonaphthoquinone (**1b**) with 0.5 to 2.0 equivalents of DMD for 2 h at ambient temperature also afforded a mixture of 1,4-naphthoquinone (**2b**) and its 2,3-epoxide **3b** in a ratio of ca. 70:30 (entries 2-4, Table 1). Again, the ratio of the products **2b** and **3b** did not change on successive addition of DMD and a control experiment confirmed that the quinone **2b** did not become epoxidized under these conditions. The related 1,2-diazonaphthoquinone (**1c**) gave with 1.0 to 3.0 equivalents of DMD at room temperature a mixture of three products (entry 5, Table 1), namely 1,2-naphthoquinone (**2c**), 3,4-epoxy-1,2-naphthoquinone (**3c**) and its hydrate **4c**. The two oxidation products **3c** and **4c** sum up to ca. 70% and, therefore, also for this diazoquinone direct epoxidation by DMD prevails. The hydrate **4c** was previously observed in the Weitz/Scheffer-type epoxidation of 1,2-naphthoquinone (**1c**) with sodium hypochlorite in aqueous solution, dehydration over molecular sieves regenerated the epoxy naphthoquinone **3c**; our ^{1}H and ^{13}C NMR data for the

epoxide **3c** and its hydrate **4c** match those reported [6].

When 2,3-diazonaphthoquinone [7] was treated with one equivalent of DMD at 0 °C, only intractable higher-molecular-weight material was obtained. The 2,3-naphthoquinone and its epoxide could not be detected in the ^{1}H NMR spectrum of the crude reaction mixture.

Since the control experiments proved that the epoxy quinones **3** are not secondary products of quinone **2** epoxidation but are directly formed from the diazoquinones **1**, we propose competitive S_N2 attack of the ambident diazoquinone nucleophile on the peroxide bond of DMD, as is illustrated for the 1,4-diazonaphthoquinone (**1b**) in Scheme 2. Thus, nucleophilic

Scheme 2



attack of the diazo carbon atom (path A, Scheme 2) and subsequent loss of molecular nitrogen and acetone yields the quinone **2b**, while nucleophilic attack of the α-carbonyl carbon atom (path B, Scheme 2) results first the epoxy diazoquinone, which is further oxidized by DMD to the epoxy quinone **3b**. Unfortunately, the epoxy diazoquinone does not accumulate in sufficient amounts for NMR detection since apparently it is faster oxidized by DMD than the starting diazoquinone **1b**.

AM1 calculations on the diazoquinones **1a-c** provide support for this mechanistic rationalization, as reflected by the HOMO coefficients of the diazoquinones **1a-c** (Figure 1).

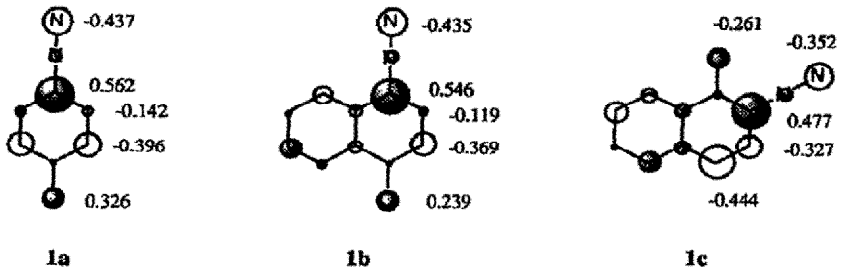


Figure 1: HOMO coefficients of the diazoquinones **1a-c**

As is evident, for all three diazoquinones the highest HOMO coefficient is as expected located at the diazo carbon atom, but the coefficient at the α carbonyl carbon atom is appreciable; in fact, except for the external nitrogen atom, it is the next highest. Consequently, sufficient electron density resides at the α carbonyl carbon atom in the ambident diazoquinone nucleophile for DMD attack at this site to become feasible. That the relative size of the HOMO coefficients (Figure 1) does not faithfully reproduce the ratio of quinone **2** *versus* epoxide **3** products (Table 1) may derive from steric effects on the attacking dioxirane.

In summary, unprecedented reactivity of the dimethyldioxirane has been uncovered, in that this powerful oxidant permits the conversion of the formally electron-poor diazoquinones **1** directly to the epoxy quinones **3** without trespassing the denitrogenated quinones **2**; the latter are formed in competition. In this respect, DMD is distinct in its oxidation behavior from the peroxy acids, which exclusively afford the quinones. Since the yield of epoxy quinones **3** can be quite high, e.g. diazoquinones **2a,c**, this direct oxidation may constitute a useful synthetic alternative to the Weitz-Scheffer epoxidation of quinones, but under neutral conditions.

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References

[1] a) Murray, R.W. *"Molecular Structures and Energetics. Unconventional Chemical Bonding"* (Eds: J.F. Liebman and A. Greenberg), VCH, New York. 1988, Vol. 6, pp. 311-351; b) Adam, W.; Curci, R.; Edwards, J.O. *Acc. Chem. Res.* **1989**, *22*, 205-211; c) Murray, R.W. *Chem. Rev.* **1989**, *89*, 1187-1201; d) Curci, R. *"Advances in in Oxygenated Processes"* (Ed.: A.L. Baumstark) JAI Press, Greenich, CT. 1990, Vol 2, Ch. 1; e) Adam, W.; Hadjiarapoglou, L.; Curci, R.; Mello, R. *"Organic Peroxides"*; J. Wiley & Sons: New York. 1992, pp. 195-217; f) Adam, W.; Hadjiarapoglou, L. *Topics Curr. Chem.* **1993**, *49*, 2227-2238.

[2] Prato, M.; Ihmels, H.; Maggini, M.; Scorrano, G. *Tetrahedron Lett.* **1991**, *32*, 6215-6218.

[3] Saba, A. *Synth. Comm.* **1994**, *24*, 695-699.

[4] Curci, R.; DiFuria, F.; Marcuzzi, F. *J. Org. Chem.* **1971**, *36*, 3774-3778.

[5] Adam, W.; Bialas, J.; Hadjiarapoglou, L. *Chem. Ber.* **1991**, *124*, 2377.

[6] Gleiter,R.; Dobler, W. *Chem.Ber.* **1985**, *118*, 4725-4742.

[7] Zeller, K.-P.; Blocher, A. *Ang. Chem.* **1991**, *103*, 1489-1490.

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