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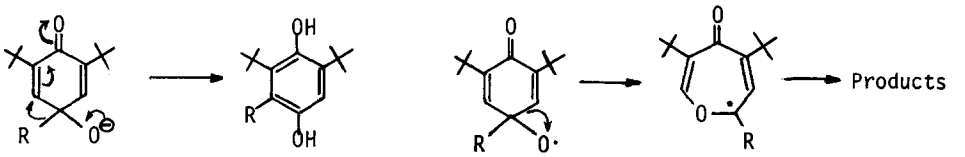
ACID-CATALYZED REACTION OF 2,6-DI-T-BUTYL-4-HYDROPEROXY-2,5-CYCLOHEXADIENONES AND THEIR ACETATES

A. Nishinaga,* K. Nakamura, and T. Matsuura
Department of Synthetic Chemistry, Faculty of Engineering,
Kyoto University, Kyoto, Japan
A. Rieker* and D. Koch
Institut für Organische Chemie, Universität Tübingen,
Auf der Morgenstelle, 7400 Tübingen, Germany

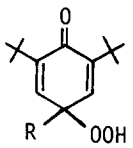
Highly regioselective oxygenation products from 2,6-di-t-butylphenols display interesting chemical behavior under strongly basic conditions, being efficiently utilized for synthesis of hydroquinones,[1] o-benzoquinones,[2] cyclopentadienones,[3] 3-hydroxyphenylacetic acids,[4] cyclopentenones,[5] and p-quinoxyacetic acids.[6] These investigations have revealed the chemical reactivity of p-quinolate anion (i) and p-quinoxy radical (ii): i readily undergoes ketonization in aprotic polar solvents such as DMF leading to the quantitative formation of hydroquinones, and ii is involved in the base-catalyzed rearrangement of p-peroxyquinol esters (2) giving p-quinoxyacetic acids. p-Quinoxy radical (ii) is also found to undergo intramolecular rearrangement with ring expansion.[7]



i ii

The reaction of p-quinoxy cation is not yet known. We have therefore investigated the acid-catalyzed reaction of 2,6-di-t-butyl-4-hydroperoxy-2,5-cyclohexadienones (1) and their acetates (2) expecting the generation of the p-quinoxy cations by protonation at the peroxy group. We find that the acid-treatment of 1 or 2 results in ring opening, migration of the substituent R to the

cationic oxygen, and/or loss of the substituent R depending on the nature of R. When 2a is treated with trifluoroacetic acid (TFA) in CH_2Cl_2 or in ether at 0° C for 30 min, product 3a resulting from the ring opening was obtained in quantitative yield. The structure of 3a is in good agreement with its spectral and analytical data. Reduction of 3a with $NaBH_4$ in MeOH gave alcohol 4 (56% yield), which was quantitatively reoxidized to 3a with CrO_3, providing further evidence for the structure of 3a. The acid-catalyzed reaction of 2b and 2c gave the corresponding 3 and 2,6-di-t-butyl-p-benzoquinone (5). The yield of 3 decreases with increase in size of the substituent R, whilst the amount of 5 increases simultaneously. A characteristic sharp absorption around 3100 cm^{-1}



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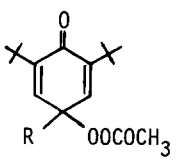

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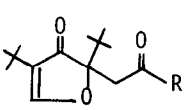

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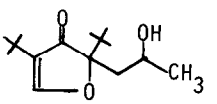

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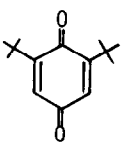

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a; R = Me b; R = Et c; R = i-Pr d; R = t-Bu e; R = 4-MeOPh

Table. Acid-Catalyzed Reaction of 2 at 0° C.[a)]

	Yield of Product (%)		IR(Nujol)	Spectral Data of 3 ^{1}HNMR($CDCl_3$) δppm				λ_{max}(EtOH)
2	3	5	cm^{-1}	t-Bu	CH_2CO	R	O-CH=C-CO	(log ε)
a	100	0	3100,1730,1690	0.96, 1.21	2.97	2.06	7.71	271 (4.2)
b	78	22	3100,1710,1685	0.97, 1.22	2.98	0.95[b)] 2.40	7.72	270 (4.2)
c	53	47	3115,1715,1685	0.97, 1.21	2.99[c)] 3.04	1.02[c)] 1.04 2.54	7.72	271 (4.1)
d	0	100						

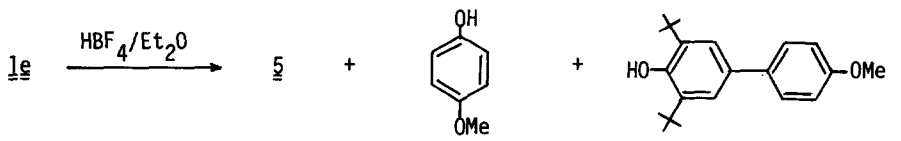
a) A solution of 2 (3 mmol) in CH_2Cl_2 or ether (1 ml) was added into TFA (3 ml) at 0° C. The reaction was complete within 30 min. Products are 3 and 5 only.

b) A typical Et signal with J=7 Hz.

c) Methyl groups in i-Pr (doublet of doublets; J=7 Hz) and methylene protons (AB quartet; J_{AB}=15 Hz) are magnetically inequivalent.

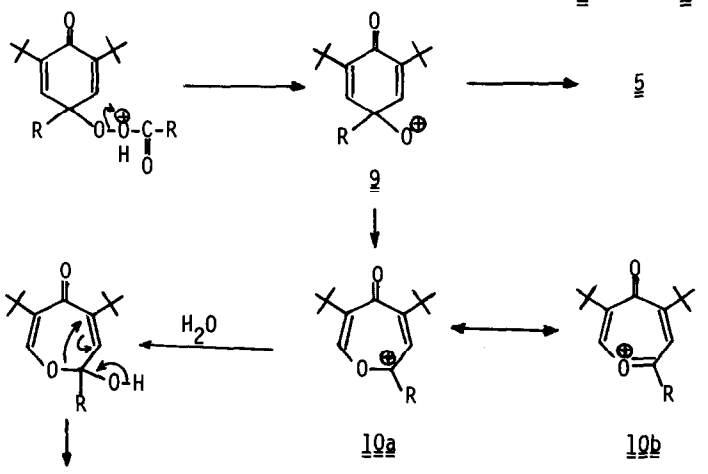
may be assigned for ν_{C-H} of the enone system bearing the ether bond. Acid-treatment of the hydroperoxides 1a - d gave results comparable to those found when 2 is similarly treated, although the reaction is more complicated.

The reaction of 1e with acids led to quite different results. When 1e was treated with TFA at room temperature, a complicated reaction mixture was obtained, in which 3-t-butyl-5-(4-methoxyphenyl)-o-benzoquinone (6) was detected. Treatment of 1e with HBF_4 in ether at 0° C or at room temperature gave p-benzoquinone 5 (ca.90%), 4-methoxyphenol (7)(ca.70%), and 2,6-di-t-butyl-4-(4-methoxyphenyl)phenol (8)(ca.10%). Similar results were obtained in the reaction of 1e with acetic anhydride containing sulfuric acid at room temperature.



7 8

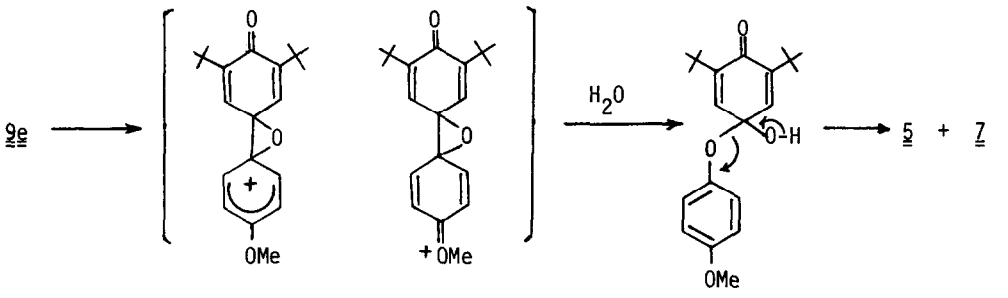
The formation of all these products from 1 or 2 is reasonably interpretable in terms of the quinoxy cation intermediate 9 resulting from the heterolysis of the peroxy bond by protonation; 9 undergoes different follow-up reactions depending on the nature of the substituent R. Alkyl substituents R susceptible to ß-scission lead to the formation of 5 from 9. Thus, 2d quanti-



tatively gave 5. The formation of 3 is realized by assuming migration of the ring carbon to the cationic oxygen to give the ring expanded cation 10 (re-

sonance structures a ⟷ b) followed by hydration during working-up. When 2a or 1a was dissolved in acetic anhydride containing sulfuric acid an intense blue color was observed, suggesting the formation of 10 . Working up this solution also gave 3a.

The formation of 5 and 7 from 1e is interpreted as migration of the aromatic substituent to the cationic oxygen of 9e presumably via the intramolecular σ-complex 11 as depicted in the following scheme. Protonation at the other oxygen atom of the peroxy group in 1e may also occur to form the corresponding phenoxy cation which will give 8 after reduction [8]. A similar migra-



tion of the alkyl substituent R to the cationic oxygen can be considered for the formation of 5 from 2b - d. Further detailed investigations are in progress.

References and Notes

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8) The o-benzoquinone 6 was obtained treating 1e with TFA. In this case the phenoxy cation is hydrated in ortho position. The resulting o-quinol is successible to acid-catalyzed fragmentation of isobutene and 3-t-butyl-5-(4-methoxyphenyl)catechol which may be further oxidized by a second phenoxy cation to give 6 and 8.

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