Tetrahedron Letters Vol. 21, pp 4097 - 4100 0040-4039/80/1015-4097$02.00/0

OXYGENATION OF 4-(N-ALKYLIMINO)METHYL-2,6-DI-t-BUTYLPHENOLS MEDIATED BY Co(II)-SCHIFF BASE COMPLEX

A. Nishinaga,* T. Shimizu, and T. Matsuura

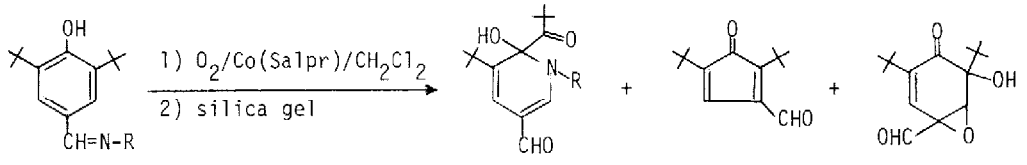
Department of Synthetic Chemistry, Faculty of Engineering, Kyoto University, Kyoto, Japan

4-(N-Alkylimino)methyl-2,6-di-t-butylphenols (1), Schiff bases of 3,5-di-t-butyl-4-hydroxybenzaldehyde can be oxygenated in the presence of Co(Salpr), a five coordinate Co(II)-Schiff base complex to give N-alkyl-3-t-butyl-5-formyl-2-hydroxy-2-pivaloyl-1,2-dihydropyridines (2) as the main product together with 3-formyl-2,5-di-t-butyl-2,4-cyclopentadienone (3) and 2,6-di-t-butyl-4-formyl-6-hydroxy-4,5-epoxy-2-cyclohexenone (4). These products result from dioxygen incorporation into the ortho position of 1.

Five coordinate Co(II)-Schiff base complexes, Co(Salpr) and its derivatives have been shown to mediate regioselective dioxygen incorporation into t-butylated phenols depending on the nature of substituent of the substrate: 4-alkyl-2,6-di-t-butylphenols are oxygenated exclusively at the para position[1] whereas with 4-aryl-2,6-di-t-butylphenols dioxygen is incorporated selectively into the ortho position.[2] In the case of 4-(N-arylmethylene)amino-2,6-di-t-butylphenols, the imino carbon in the side chain is selectively oxygenated.[3] Although 3,5-di-t-butyl-4-hydroxybenzaldehyde is normally unsusceptible to the oxygenation, we now find that Schiff bases of this phenol, 4-(N-alkylimino)methyl-2,6-di-t-butylphenols (1) are easily oxygenated in the presence of Co(Salpr) to give new products resulting from intramolecular decomposition of peroxidic intermediates in which dioxygen is incorporated into the ortho position of 1.

The phenols 1 were obtained by the condensation of 3,5-di-t-butyl-4-hydroxybenzaldehyde with alkylamines in nearly quantitative yield. The oxygenation was carried out by bubbling dioxygen through a solution of equimolar amounts of 1 and Co(Salpr) in CH_2Cl_2 at 0 °C. Separation of the resulting products (silica gel layer chromatography developed with CH_2Cl_2) gave N-alkyl-3-t-butyl-5-formyl-2-hydroxy-2-pivaloyl-1,2-dihydropyridine (2), 3-formyl-2,5-di-t-butyl-2,4-cyclopentadienone (3), and 2,6-di-t-butyl-4-formyl-6-hydroxy-4,5-epoxy-2-cyclohexenone (4). The results are sum-

marized in Table 1. In all cases except for 1e, the formation of 2 was predominant. Analytical and spectral data of 2 (Table 2) are in good agreement with the structure. The structure of 2a

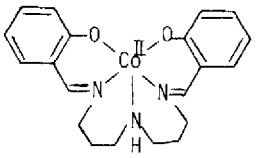


1 2 3 4

a; R = CH_2Ph d; R = cyclohexyl

b; R = $CH_2CH(CH_3)_2$ e; R = $C(CH_3)_3$

c; R = $CH(CH_3)_2$



Co(Salpr)

Table 1. Oxygenation of 1 with Co(Salpr).[a]

1	Conversion[b] (%)	Product, Yield (%)[b] 2	3	4	Others[c]
1a	72	70	trace	27	3
1b	89	81	trace	14	5
1c	85	65	15	15	5
1d	90	70	15	10	5
1e	85	-[d]	40	15	35[e]

[a] Conditions: 1 (1 mmol), Co(Salpr) (1.1 mmol), CH_2Cl_2 (20 ml), O_2 for 2 h. [b] Determined by NMR. [c] Not identified. [d] The compound 2e seemed to be formed (ca. 10%) but not confirmed. [e] Containing 6 (R = t-Bu) (20%).

was confirmed by its X-ray analysis.[4] The structures of new products 3 and 4 were determined by their analytical and spectral data.[5]

Treatment of 2a with an equimolar amount of t-BuOK and of other 2 with an excess of t-BuOK in t-BuOH at room temperature under N_2 followed by an acid treatment gave the formylcyclopentadienone (3) in quantitative yield. Thus, the present results provide a unique method for the preparation of 3 from 3,5-di-t-butyl-4-hydroxybenzaldehyde via oxygenation. This is analogous to the oxygenation of 4-t-butyl- and 4-aryl-2,6-di-t-butylphenols giving rise

Table 2. Physical Data of 2.

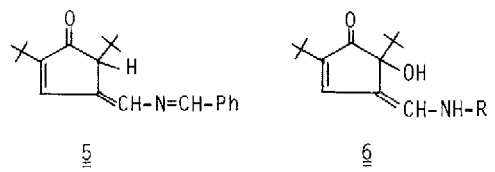
2[a]	mp (°C)	IR(Nujol), cm^{-1} ν_{OH}	$\nu_{C=O}$	^1H NMR($CDCl_3$), δ t-Bu	OH	CH=C-CH=C-N[b]	CHO	$\lambda_{max}(C_6H_{12})$ nm (log ε)
2a	117-118	3370	1690, 1630	1.18, 1.32	6.08	6.80, 6.87	8.97	387 (3.39)
2b	131-133	3420	1680, 1630	1.14, 1.25	5.85	6.80, 6.88	9.04	397 (3.38)
2c	99-101	3380	1690, 1630	1.15, 1.25	5.95	6.85, 7.02	9.07	390 (3.36)
2d	96-98	3420	1680, 1630	1.15, 1.23	5.97	6.85, 7.03	9.03	396 (3.35)

[a] All the products show satisfactory analytical results. [b] d, d; J = 1.0 Hz.

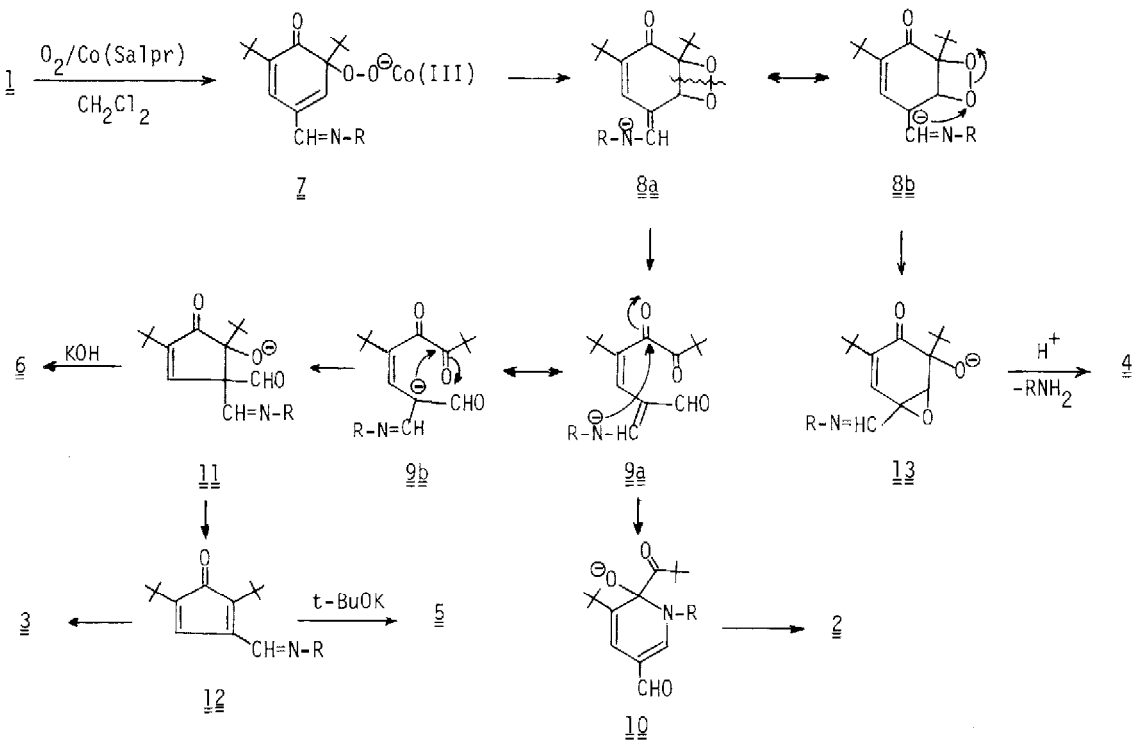
to the corresponding cyclopentadienones.[6, 7]

When 2a was treated with an excess of t-BuOK in t-BuOH, 4-(N-benzylideneamino)methylene-2,5-di-t-butyl-2-cyclopentenone (5)[8] was obtained in quantitative yield. Treatment of 2 in MeOH containing KOH at room temperature, on the other hand, resulted in deformylation to give 4-(N-alkylamino)methylene-2,5-di-t-butyl-5-hydroxy-2-cyclopentenones (6)[9] in quantitative yield.

All the present results may be reasonably explained by the reaction scheme depicted in the following diagram, where unusual decomposition of peroxidic intermediates 7 and 8 is remarkable.



5 6



7 8a 8b 11 9b 9a 13 12 10

Although o-peroxyquinolato Co(III) complexes of type 7 from other phenols are normally stable in CH_2Cl_2,[2] no characteristic signals for 7 were observed in the NMR spectrum of the reaction mixture before work-up. The unusual instability of 7 may be attributable to the iminomethyl group which would accelerate ionic dissociation of Co-O bond leading to the dioxetane intermediate 8. Asymmetric cleavage of the peroxy bond (8b) giving rise to epoxy-o-quinols of type 13 is the normal case as seen in base-catalyzed oxygenation of 2,6-di-t-butylphenols.[6, 10] However, as the product ratio 4 to 2 and 3 was not changed with reaction time, it may be no doubt that the formation

of 2 and 3 results from symmetric cleavage of the dioxetane intermediate (8a) but not from the asymmetric one. Such a symmetric cleavage of dioxetane intermediate derived from peroxyquinols is the first example, providing an analogous cleavage type to that considered for the reaction of a dioxygenase, metapyrocatechase.[11] It may also be clear that the formation of 3 involves the intermediates 11 and 12 taking into account the formations of 6 and 5 which must be formed by deprotonation from the benzyl group in 12 (R = CH_2Ph). The intermediate of type 11 has been confirmed in base-catalyzed oxygenation of 4-aryl-2,6-di-t-butylphenols giving rise to the corresponding cyclopentadienones.[6] The low yield of 2e is probably due to steric hindrance of the t-Bu group against nucleophilic reaction of the amino nitrogen (9a), and consequently contribution of 9b becomes predominant leading to a high yield of 3.

References and Notes

1) A. Nishinaga, H. Tomita, and T. Matsuura, Tetrahedron Lett., 2893 (1979).
2) A. Nishinaga, K. Nishizawa, H. Tomita, and T. Matsuura, J. Am. Chem. Soc., 99, 1287 (1977).
3) A. Nishinaga, T. Shimizu, and T. Matsuura, Tetrahedron Lett., 1265 (1980).
4) A. Nishinaga, T. Shimizu, K. Hirotsu, and T. Matsuura, to be published.
5) The compound 3: orange prisms, mp 28-29 °C; ^{1}H NMR($CDCl_3$) δ 1.15 (s, 9H), 1.40 (s, 9H), 7.16 (s, 1H), 10.48 (s, 1H); IR(Nujol), 1715, 1665 cm^{-1}; UV(C_6H_{12}), 416 nm (ε, 570); Anal. C, ±0.2%; H, ±0.2%. The compound 4: colorless liquid, bp ca. 75 °C/10^{-2} mmHg; ^{1}H NMR($CDCl_3$) δ 0.95 (s, 9H), 1.23 (s, 9H), 4.08 (d, 1H, J=0.7 Hz), 4.13 (s, 1H, OH), 7.13 (d, 1H, J=0.7 Hz), 8.97 (s, 1H); IR(Nujol), 3500, 1725, 1675 cm^{-1}; Anal. C, ±0.2%; H, ±0.2%.
6) A. Nishinaga, T. Itahara, T. Matsuura, A. Rieker, D. Koch, K. Albert, and P. B. Hitchcock, J. Am. Chem. Soc., 100, 1826 (1978).
7) A. Nishinaga, T. Shimizu, and T. Matsuura, J. Org. Chem., 44, 2983 (1979).
8) The compound 5: yellow liquid, bp ca. 135 °C/10^{-2} mmHg; ^{1}H NMR($CDCl_3$) δ 1.04 (s, 9H), 1.28 (s, 9H), 2.60 (s, 1H), 6.88 (s, 1H), 7.3-8.0 (m, 5H), 8.23 (s, 1H), 8.37 (s, 1H); IR(Nujol) 1695 cm^{-1}; Anal. C, ±0.3%; H, ±0.2%; N, ±0.3%.
9) For example, 6 (R = CH_2Ph): light yellow prisms, mp 135-137 °C; ^{1}H NMR($CDCl_3$) δ 0.97 (s, 9H), 1.17 (s, 9H), 2.62 (s, 1H, OH), 4.26 (d, 2H, J=6 Hz), 5.04 (m, 1H, NH), 6.23 (d, 1H, J=12 Hz), 7.32 (s, 5H), 7.35 (s, 1H); IR(Nujol), 3440, 3370, 1650 cm^{-1}; Anal. C, ±0.1%; H, ±0.2%; N, ±0.1%.
10) A. Nishinaga, T. Itahara, T. Shimizu, and T. Matsuura, J. Am. Chem. Soc., 100, 1820 (1978).
11) M. Nozaki, "Molecular Mechanisms of Oxygen Activation", Ed. O. Hayaishi, Academic Press, Inc., New York and London, 1974, pp 144-151.

(Received in Japan 17 July 1980)