## SYNTHESIS OF SOME POLYCYCLIC QUINONES THROUGH

## 1-METHOXYCYCLOHEXA-1,3-DIENES

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Conversions have been described<sup>1</sup> of Diels-Alder adducts of a quinone and a 1-methoxycyclohexa-1,3-diene into fully aromatic quinones by re-oxidation to a quinone and thermal loss of the ethano-bridge, e.g. (1) into (2). The utility of this procedure in a case involving a quinone which can give rise to only one adduct has been exemplified by the simple synthesis of the tetramethyl ether (3, R = Me) of the naphthaquinonoid phenol spinochrome-B (3, R = H), the principal pigment of spines and tests of a number of echinoderms<sup>2</sup>. The pigment has already been synthesised<sup>3</sup>.

The adduct (4) was readily obtained from 2,3-dimethoxyquinone and 1,3-dimethoxycyclohexa-1,3-diene, but because of the labile enol-ether function it was directly converted by enolisation with 1N KOH and reaction with air into the quinone (5). A higher yield could be obtained by enolisation with potassium hydrogen carbonate and oxidation with Fremy's salt<sup>4</sup> (potassium nitrosodisulphonate). Pyrolysis of the quinone (5) at  $150^{\circ}$  until ethylene evolution ceased gave the tetramethyl ether of spinochrome-B (3, R = Me) m.p.  $130-131^{\circ}$ , identical with a specimen kindly supplied by Dr M.D. Sutherland.

A drawback to the general method is the frequent production of mixtures of adducts when the quinone contains substituents such as OMe or Me which are not in the same spatial relations to both carbonyl groups. The 1-OMe group of the diene results in completely specific orientation using  $\alpha$ , $\beta$ -unsaturated ketones as addenda<sup>5</sup>, e.g. 1-methoxycyclohexa-1,3-diene and but-2-enone give only (6) in high yield. If one of the  $\alpha$ , $\beta$ -unsaturated carbonyl systems of a quinone can be appropriately activated, or the other appropriately deactivated, similar specific addition could be expected.

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Carbomethoxybenzoquinone and 1-methoxycyclohexa-1,3-diene gave the expected enedione (7), m.p. 168-170<sup>0</sup>, with no sign of the alternative product (8); the carbomethoxy-group is clearly an activator of the attached system since addition occurs only to this system. The chief evidence for the structure (7) is its facile acid-catalysed conversion<sup>6</sup> into the salicyclic ester (9, R =  $CH_z$ ), m.p. 151-152<sup>0</sup>, the structure of which is fully supported by spectral data :  $\lambda_{max}$  350 nm;  $v_{max}$  1672, 1720 cm<sup>-1</sup>;  $\delta$  10.54s (1H, exchanged D<sub>2</sub>O), 6.91d, 6.79d (2H, J<sub>AB</sub> = 9Hz); m/e 262, 230, 55, and by its chemical properties such as the formation of a diacetyl-derivative. The isomeric product to be expected from (8) would be non-aromatic and contain an angular CO.Me. Although a single adduct (7) can be obtained its conversion into the quinone by removal of the CO,Me and oxidation was found to be difficult owing to the ease of rearrangement to the salicyclic acid (9, R = H), which occurred on attempted base-hydrolysis. Reaction with sodium dimsyl in DMSO for 24 hrs, followed by the action of silver oxide gave in low yield the quinone obtainable from 1-methoxycyclohexadiene and benzoquinone. Although potentially solving the orientation problem this type of process is not experimentally attractive unless an efficient method can be found for removal of the CO\_Me.

Hydrogen-bonding from a peri-hydroxyl group in an hydroxynaphthaquinone might provide an effective polarisation for orientation of addition. Accordingly reaction of juglone (10) with 1-methoxycyclohexa-1,3-diene in benzene at room temperature was examined, and gave a quantitative yield of the adduct (11, R = H), m.p. 145°, converted by enolisation and oxidation as above into (12, R = H), m.p. 128°, which on pyrolysis gave the expected 1-hydroxy-8-methoxyanthraquinone (13, R = H), m.p. 194-195° (1it.<sup>7</sup> m.p. 198°). The spectral properties of this and its Me ether, m.p. 223-224° (1it.<sup>7</sup> 221°) were identical to those recorded. Chrysophanic acid (1,8-dihydroxy-3-methylanthraquinone) was similarly synthesised from juglone (10) and 1-methoxy-3-methylcyclohexa-1,3-diene in 80% yield based on the former. The adduct (11, R = Me), m.p. 116-118° was enolised, oxidised to (12, R = Me) and sublimed to yield (13, R = Me), demethylated to chrysophanic acid, m.p. 194-196°, identical with a specimen kindly provided by Dr C.J. Dah1.

Juglone and 1,3-dimethoxycyclohexa-1,3-diene gave the adduct (11, R = OMe) in very good yield. This adduct is unstable and rapidly rearranges into (14), m.p.  $145^{\circ}$ , the structure of which is supported by u.v., i.r., n.m.r., and mass spectra, and by chemical reactions. Immediate reaction of (11, R = OMe) with potassium hydrogen carbonate, followed by Fremy's salt<sup>4</sup>, gave the naphthaquinone (12, R = OMe), converted by heating at  $180^{\circ}/15$  mins. into

1,3-dimethoxy-8-hydroxyanthraquinone (13, R = OMe), m.p.  $215-216^{\circ}$ , methylated to 1,3,8trimethoxyanthraquinone, m.p.  $196^{\circ}$  (lit.<sup>9</sup> m.p.  $196^{\circ}$ ) with u.v. and i.r. spectra identical to those reported<sup>10</sup>.

A particularly useful feature of the synthesis is its potential applicability for the production of anthraquinones of the polyketide series, because of the availability through metal-ammonia reductions of dienes with OMe and, or Me in 1,3-positions, and because of the orientation of addition of the quinone with the phenolic OH in the correct orientation to the diene OMe.

## REFERENCES

- 1. A.J. Birch, D.N. Butler, and J.B. Siddall, J. Chem. Soc., 2941 (1964).
- 2. J.H. Gough and M.D. Sutherland, Tetrahedron Letters, 269 (1964).
- 3. J. Smith and R.H. Thomson, J. Chem. Soc., 1008 (1961).
- 4. V.H. Powell, Tetrahedron Letters, see accompanying letter.
- 5. A.J. Birch and J.S. Hill, J. Chem. Soc. (C), 419 (1966).
- 6. A.J. Birch, D.N. Butler, and J.B. Siddall, J. Chem. Soc., 2932 (1960).
- 7. R.A. Morton and W.T. Earlane, J. Chem. Soc., 159 (1941).
- 8. C. Graebe and C. Liebermann, Ann. 7, 257, 306 (1870).
- 9. N. Parkash and K. Venkataraman, J. Sci. Ind. Res. B13, 825 (1954).
- 10. N.R. Ayyanger, B.S. Joshi, and K. Venkataraman, Tetrahedron 6, 331 (1959).

