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STRUCTURE OF KERMESIC ACID*

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According to Thomson,[1] "kermes is a dyestuff of very great antiquity and is probably the earliest of which we have records".[2] Extensive work on kermesic acid, the colouring matter of kermes, was carried out by Dimroth,[3] who assigned to it the structure (Ia).[4] It was shown by Overeem and van der Kerk[5] and by us[6] independently that in carminic acid, the colouring matter of cochineal, the carboxyl group in the A-ring is in the β-position. Since both carminic and kermesic acids yield cochinellic acid (IIa) by oxidation, Overeem and van der Kerk concluded that kermesic acid is constituted as (Ib). Two different routes for the synthesis of cochinellic acid methyl ether (IIb) were followed by the Dutch authors[5] and by us.[6] The former converted (IIb) into the corresponding phthalic anhydride (m.p. 234-235°) by sublimation at 200-210° and 0.1 mm, but we have found it preferable to reflux (IIb) with acetic anhydride for 30 min. We tried to synthesise (Ib) by condensing the anhydride of (IIb) with 3,6-dihydroxy-2-methoxyacetophenone[7] in an aluminium chloride-sodium chloride melt at 180°. After chromatography on oxalated silica gel plates and benzene-alcohol

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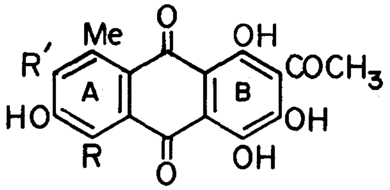
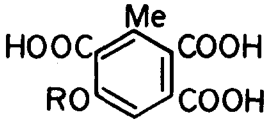
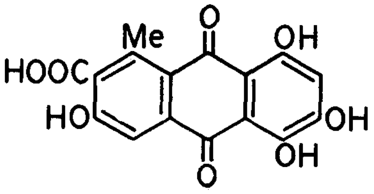
(8:2) as the solvent, a product was isolated in about 10 per cent yield, which ultimately proved to be the isomer of (Ib) with the OH and Ac groups in the B-ring interchanged. It crystallised in red needles (*dec*. above 260°) from acetic acid and the colour reactions were similar to those described by Dimroth. The NMR spectrum in NaOD-D_2O (three singlets of intensity 1:3:3, the 3-proton singlets appearing at 4.46 and 4.65 ppm higher than the aromatic proton signal) confirmed the structure as (Ib) or its isomer. Since we had difficulty in preparing the tetra-acetate and trimethyl ether (dimethyl ether of the methyl ester?) described by Dimroth, it was clear that a direct comparison with natural kermesic acid was necessary before any conclusion can be drawn. After an extensive search, we were fortunate in obtaining from Professor Karl Dimroth a sample of O. Dimroth's kermesic acid. Except for a minor impurity readily isolated by chromatography on oxalated silica gel plates, the product, more than fifty years old, was remarkably pure. The NMR spectrum in dimethyl sulphoxide shows two single-proton signals at 2.34 and 3.40 (chemical shifts on the τ scale). The former corresponds to the α-proton in the A-ring of (Ib), but the signal at 3.4 can only be assigned to a β-proton



(Ia ; R = COOH ; R' = H)
(Ib ; R = H ; R' = COOH)



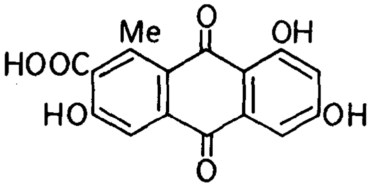
(IIa ; R = H)
(IIb ; R = Me)



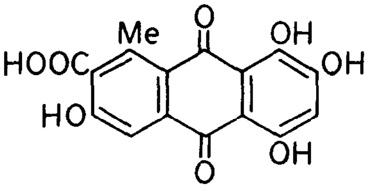
(III)

in anthraquinone flanked by hydroxyl groups as in purpurin. A signal at -3.62 and a broad signal at -2.90 exchange with D_2O, and can be assigned to chelated hydroxyl groups. The NMR spectrum in pyridine shows only one signal at 6.75, assignable to an α-methyl group in anthraquinone adjacent to a carboxyl group as in (Ib); the corresponding methyl group in carminic acid appears at 6.7. The absence of the *C*-acetyl group thus indicated was confirmed by the NMR spectrum of the ether-ester (yellow needles from methanol, m.p. 196°) of kermesic acid prepared by the usual dimethyl sulphate-potassium carbonate method. In $CDCl_3$ there are two single-proton signals at 2.45 and 3.19 corresponding to the α- and β-proton in the pentamethyl ether-ester of (III), the latter being comparable to the β-proton in purpurin trimethyl ether; two singlets at 6.01 and 6.04 integrating for 6 and 9 protons respectively correspond to five methoxyl groups, and a 3-proton singlet at 7.35 to an α-methyl group. The mass spectral molecular weight is 400, showing conclusively that kermesic acid is constituted as (III).

A careful study of Dimroth's papers[3] shows that no positive evidence for the *C*-acetyl group in the structure (Ia) was obtained. Its presence was surmised from elemental analysis and molecular weights of kermesic acid and some of its derivatives.



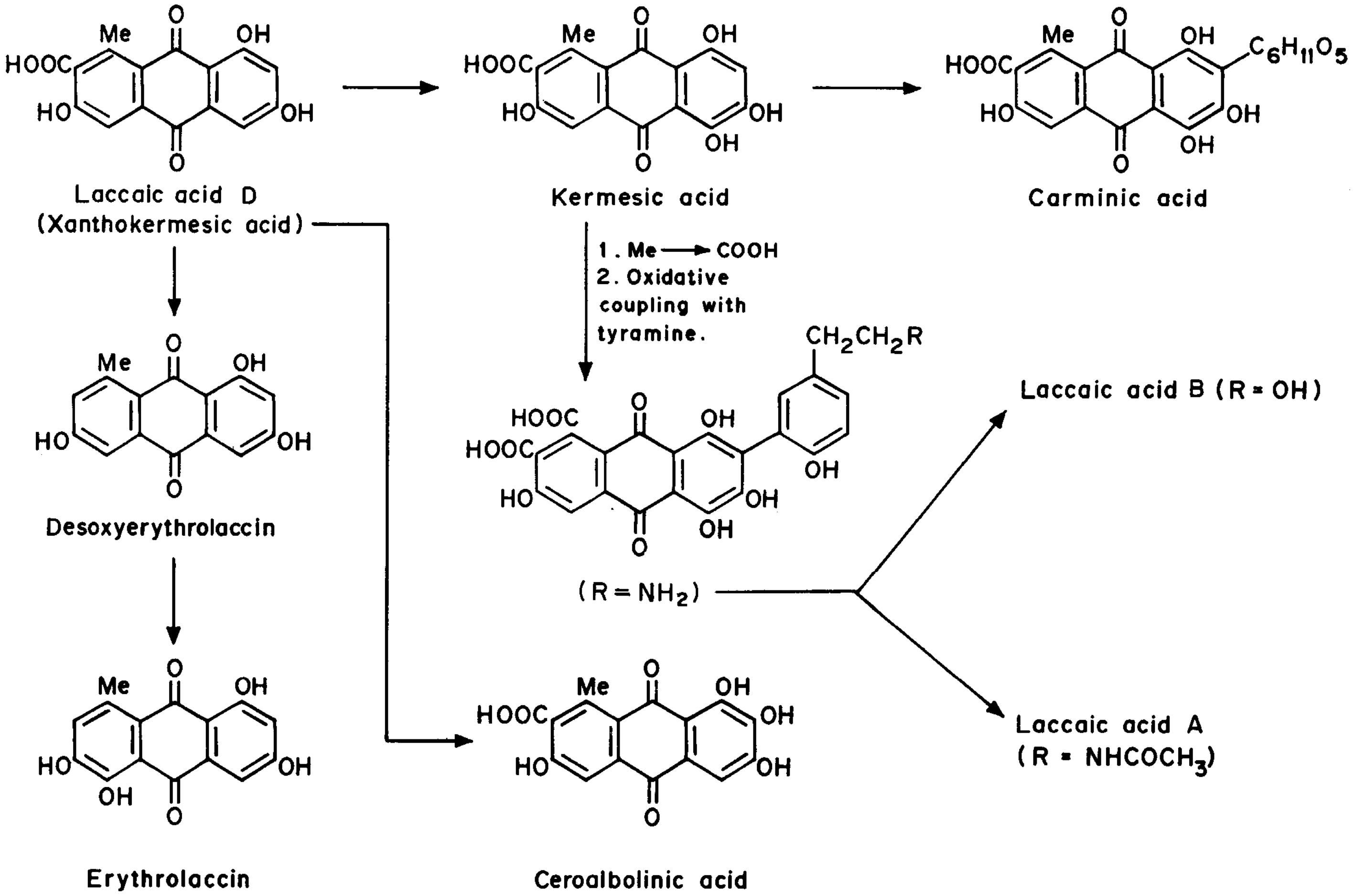
(IV)



(V)

Treatment of kermesic acid with aqueous sodium hydroxide and dithionite (or absorption of two mols of hydrogen in presence of palladium on carbon) gave xanthokermesic acid (IV), which proved to be identical with laccaic acid D.[8] Methylation by the usual method gave the tetramethyl ether-ester, m.p. 226°, identical with the ether-ester of laccaic acid D (m.p., mixed m.p. and superimposable IR spectra).[8]

Biosynthesis of some insect pigments derived from anthraquinone



As indicated in the accompanying chart, xanthokermesic acid (laccaic acid D), built from one acetate and seven malonate units, appears to play a central role in the biosynthesis of kermesic acid, carminic acid, laccaic acids A, B and D, desoxyerythrolaccin,[8] erythrolaccin, and ceroalbolinic acid.[8]

Condensation of the anhydride of (IIb) with 2-methoxyhydroquinone in presence of boron trifluoride-etherate at 100° for 4 hours gave in about 60 per cent yield a product which was found on methylation yielded a pentamethyl ether-ester, m.p. 182°, different from methyl tetramethyl kermesate, m.p. 196°. The NMR spectrum in $CDCl_3$ shows five methoxyl groups (6.00 and 6.05), a methyl group (7.35), and two uncoupled aromatic protons (2.40 and 3.27), and closely resembles the spectrum of methyl tetramethyl kermesate. The condensation product therefore is isokermesic acid (V), which was also obtained by carrying out the condensation in an aluminium chloride-sodium chloride melt at 180°. The synthesis of kermesic acid is in progress.

ACKNOWLEDGEMENT

We are greatly indebted to Professor K. Dimroth for a sample of kermesic acid.

References

1. R.H. Thomson, *Naturally Occurring Quinones*, p. 227 (1957).
2. This statement is debatable because the purple dye on a scrap of cotton material found at Mohenjo-daro (fourth and third millenia B.C.) has been shown to be probably of the madder class by A.N. Gulati and A.J. Turner, *Bull. No.17*, *Technological series No.12*, Indian Central Cotton Committee, cited by Sir John Marshall, *Mohenjo-daro and the Indus Civilization*, p. 33, Arthur Probsthain, London, 1931.
3. O. Dimroth and W. Scheurer, *Ann*. 399, 43(1913); O. Dimroth and R. Fick, *ibid*. 411, 315 (1916).
4. See also A.J. Birch and F.W. Donovan, *Aust. J. Chem*. 8, 529 (1955).
5. J.C. Overeem and G.J.M. van der Kerk, *Rec. Trav. Chim*. 83,1023(1964).
6. S.B. Bhatia and K. Venkataraman, *Ind. J. Chem*. 3, 92 (1965).
7. W. Baker, *J. Chem. Soc*. 956 (1939).
8. See the following papers.