

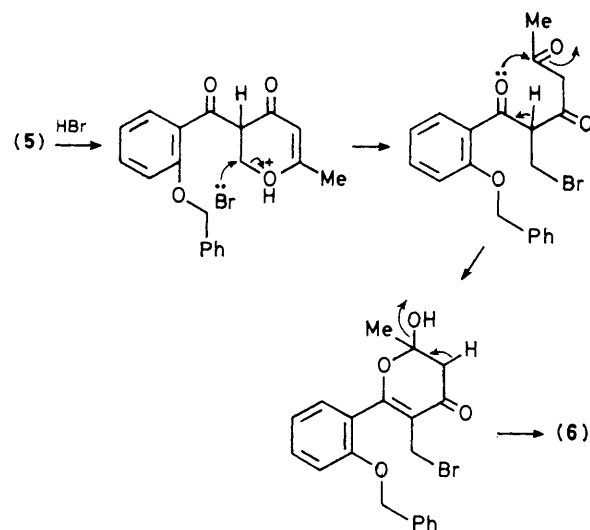
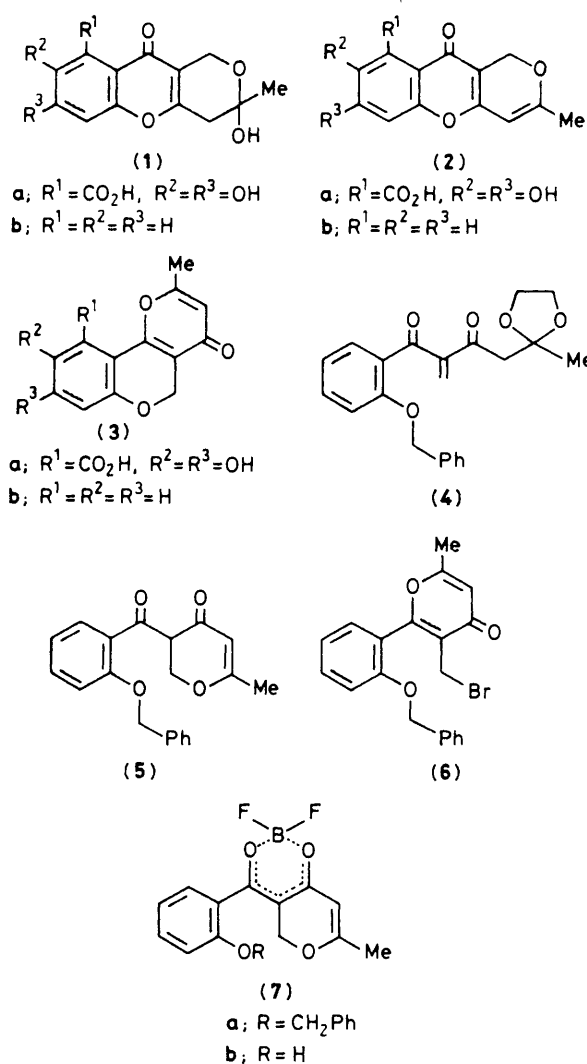
Regioselective Synthesis of 4,10-Dihydro-3-hydroxy-3-methyl-1*H*,3*H*-pyrano[4,3-*b*][1]benzopyran-10-one, the Basic Skeleton in Fulvic Acid

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The first synthesis of 4,10-dihydro-3-hydroxy-3-methyl-1*H*,3*H*-pyrano[4,3-*b*][1]benzopyran-10-one, the basic skeleton in fulvic acid, was achieved by sequential cyclization, which involved hydrogenation of the boron complex of the dione (**5**) obtained by regioselective cyclization of the acetal (**4**) with HCl in tetrahydrofuran.

Fulvic acid (**1a**),¹ the metabolite produced by several fungi including *Penicillium*, *Carpenteles*, and *Cereospora* species,

has the pyrano[4,3-*b*][1]benzopyran ring. Despite several attempts² the synthesis of this ring system has not been



Scheme 1

Although catalytic hydrogenation of (7a) gave complex products, application of Fujita's method to (7a) gave (7b) in 88% yield. Acid catalysed cyclization of (7b) with conc. HCl-acetic acid (1:10) gave the pyranobenzopyran (2b) in 79% yield. The ^1H and ^{13}C n.m.r. spectra of (2b) had similarities to those⁵ of dehydrofulvic acid (2a). Treatment of (2b) with 5% HCl-acetone (1:1) at ambient temperature for 4 days afforded 4,10-dihydro-3-hydroxy-3-methyl-1*H*,3*H*-pyrano[4,3-*b*][1]benzopyran-10-one (1b) (m.p. 182–183.5 °C) in 78% yield. The spectral data of (1b) [ν_{max} 3300, 1645, 1595 cm^{-1} ; λ_{max} (log ϵ) (EtOH) 226 (4.44), 265 (3.89), 297 nm (3.93); ^1H n.m.r. δ 1.57 (3H, s, CH₃), 2.79 (2H, q, *J* 17.6 Hz, 4-H), 4.65 (2H, s, 1-H), 7.32–7.81 (3H, m, 6-, 7-, 8-H), 8.11 (1H, dd, *J* 8.3, 1.5 Hz, 9-H): ^{13}C n.m.r. 28.6 (CH₃), 38.0 (C-4), 56.9 (C-1), 115.8 (C-10a), 160.3 (C-4a), 175.6 p.p.m. (C-10)] showed a great resemblance to the data⁶ reported for fulvic acid (1a).

successful. We reported the synthesis of 2-methyl-4*H*,5*H*-pyrano[3,2-*c*][1]benzopyran-4-one (3b),³ the basic skeleton in citromycetin (3a) and a structural isomer of unsubstituted dehydrofulvic acid (2b). We report herein the first synthesis of 4,10-dihydro-3-hydroxy-3-methyl-1*H*,3*H*-pyrano[4,3-*b*][1]benzopyran-10-one (1b), the basic skeleton in fulvic acid (1a).

Treatment of the acetal (4)³ with 5% HCl-tetrahydrofuran (1:2) at ambient temperature gave the pyrone (5), (positive FeCl_3 test), as a single cyclization product in 97% yield. Hydrogenolysis of (5) with palladium-carbon resulted in the cleavage of not only the benzyl group but also the pyrone ring to afford complex products. Debonylation of (5) with dry hydrogen bromide in acetic acid gave the pyrone (6) for which the synthesis and conversion into (3b) has been reported.³ The rearrangement of (5) into (6) can be explained by the reaction mechanism shown in Scheme 1. Treatment of (5) with $\text{BF}_3 \cdot \text{OEt}_2 - \text{Me}_2\text{S} - \text{CH}_2\text{Cl}_2$ (Fujita's method)⁴ gave the debenzylated boron complex (7b) in ca. 15% yield. These facts suggest that prior formation of the boron complex (7a) would improve the yield of the debonylation product (7b). In fact the pyrone (5) afforded the boron complex (7a) in 70% yield on treatment with boron trifluoride-diethyl ether in dichloromethane.

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