THE FRIES REARRANGEMENT OF BENZOATES OF 3-HYDROXY-6,7-DIMETHOXYCOUMARIN

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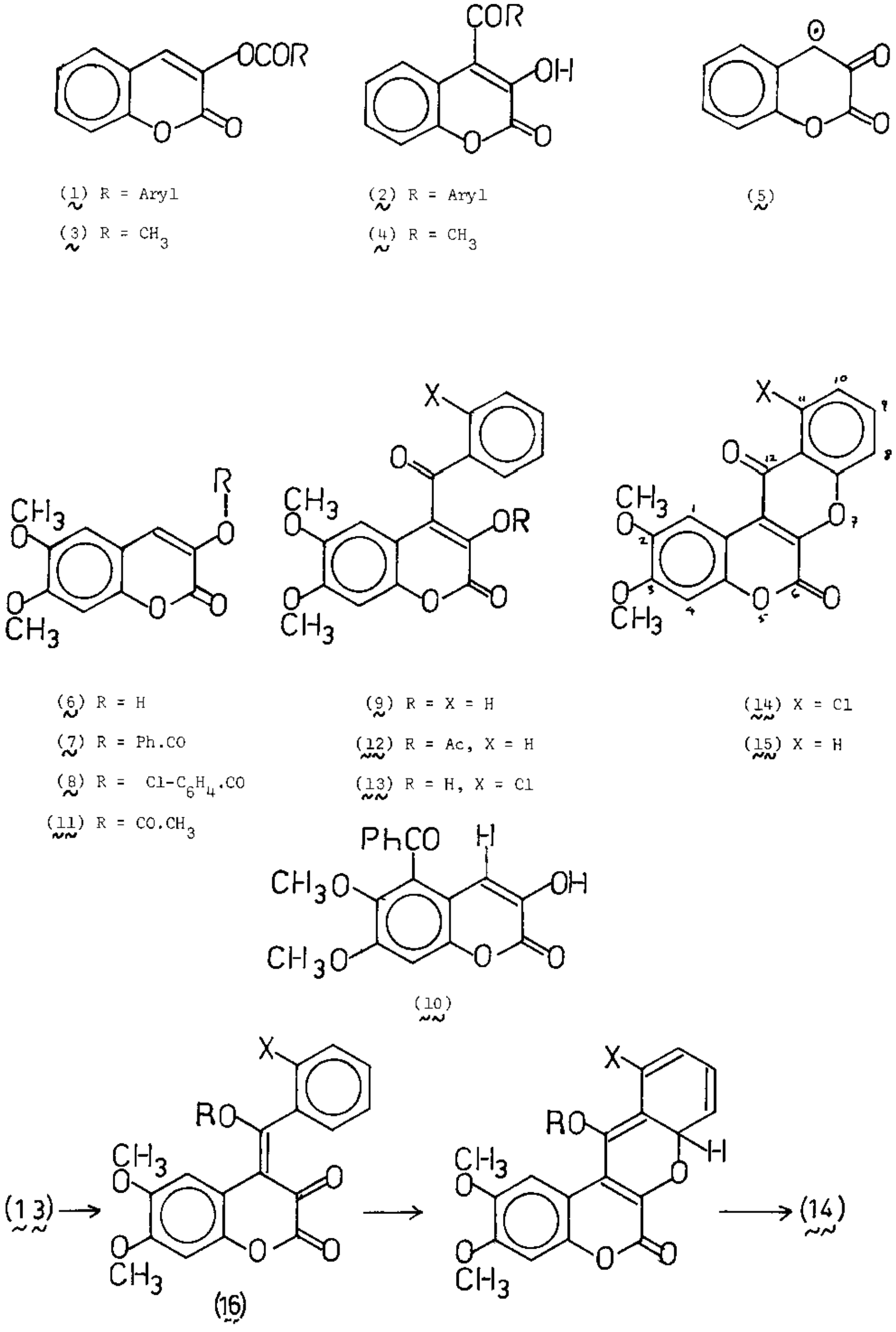
Abstract - The Fries rearrangement of benzoates of 3-hydroxy-6,7-dimethoxycoumarin lead to intermediates suitable for [1]benzopyran[3,4-b][1]benzopyran syntheses. The synthesis of a 11-chloro-6a,12a-dehydro-[1]benzopyran[3,4-b][1]benzopyran-6,12-dione is described.

We wish to synthesise the 6a,12a-dehydro-[1]benzopyran[3,4-b][1]benzopyran-6,12-dione skeleton by the Fries rearrangement of aroyl esters of 3-hydroxycoumarins (1) followed by the cyclisation of the resulting enediones (2). The thermal Fries rearrangement of this system has precedent in the transformation of (3) to (4)[1], but we found no examples of the photo-Fries reaction. These photo-Fries reactions would also shed some light on the stability of the radical intermediate (5)[2,3]. 3-Hydroxy-6,7-dimethoxycoumarin (6)[4] was converted into the benzoate (7) and the o-chlorobenzoate (8), by using the appropriate aroyl chloride and pyridine, in 80% and 85% yields respectively. The benzoate (7), m.p. 215-218°C; ν_{max} 1743 and 1750 cm^{-1}; $\delta_{CDCl_3 + D_6DMSO}$ 3.90 and 3.92 (each 3H, s), 6.87 and 6.92 (each 1H, s), 7.46 - 7.60 (4H, m), 8.17 (2H, m); did not undergo rearrangement in the presence of a variety of Lewis acids, rather it was cleaved to the compound (6) cleanly. Irradiation of a 0.2% solution of (7) in benzene/ethanol (3:1) by a medium pressure Hanovia lamp for 19 hours however, gave two products in 47% and 25% yields with respect to converted starting ester.

In order to assign structures to these compounds, a study of the effect of acetylation of (6), on the chemical shift of the H-4 proton was done. The compound (6) showed N.M.R. signals at δ_{CDCl_3} 3.88 (6H, s), 6.75, 6.82 and 6.95 (each 1H, s, H-8, H-5 and H-4 respectively). On acetylation of (6) with Ac_2O/pyridine, the product (11) showed N.M.R. signals at δ_{CDCl_3} 2.30(3H, s), 3.87 (6H, s), 6.77 (2H, s) and 7.23 (1H, s, H-4) revealing a significant downfield shift of H-4.

The major product of the photo-rearrangement had m.p. 192-4° and showed ν_{max} 1665 and 1730 cm^{-1}, and $\delta_{CDCl_3 + DMSO}$ 3.70 and 3.88 (each 3H, s), 6.55 and 6.87 (each 1H, s), 7.27 - 7.63 (3H, m) and 7.83 - 8.07 (2H, m). On acetylation of the major product with $Ac_2O/HClO_4$, an acetate was obtained in 55% yield and showed N.M.R. signals at δ_{CDCl_3} 2.00, 3.70 and 3.95 (each 3H, s), 6.53 and 6.93



(1) R = Aryl

(3) R = CH_3

(2) R = Aryl

(4) R = CH_3

(5)

(6) R = H

(7) R = Ph.CO

(8) R = $Cl-C_6H_4.CO$

(11) R = $CO.CH_3$

(9) R = X = H

(12) R = Ac, X = H

(13) R = H, X = Cl

(14) X = Cl

(15) X = H

(10)

(13)

(16)

(14)

Scheme I.

(each 1H, s), 7.47 - 7.71 (3H, m) and 7.87 - 8.07 (2H, m). Thus there was no pronounced shifting of any proton on acetylation of the major product, so indicating that it did not have a proton attached to C-4, so this major product was assigned the structure (9), and the acetate the structure (12).

The minor, unstable product of the photo-rearrangement (10) showed ν_{max} 1700 (sh) and 1730 cm^{-1}; δ_{CDCl_3} 3.80 and 3.90 (each 3H, s), 6.43 and 7.13 (each 1H, s), 7.23 - 7.60 (3H, m) and 7.93-8.20 (2H, m); and was the product of a 1, 5 migration. Both (9) and (10) gave a characteristic green colour with $FeCl_3$.

Irradiation of a 0.2% solution of the o-chlorobenzoate (8) in benzene, by sunlight, for one day yielded 27% of the compound (13) m.p. 274-276°C; ν_{max} 1670 and 1698 cm^{-1}; δ_{DMSO} 3.73 and 3.87 (each 3H, s), 6.80 and 6.98 (each 1H, s), 7.22 - 7.83 (4H, m) as the only significant product, with traces of other unidentified materials. The marked similarities of the spectroscopic properties of (13) and (9) prompted us to assign the structure shown. (13) gave a green colour with $FeCl_3$.

On refluxing a solution of (8) in glacial acetic acid containing BF_3-etherate, in addition to obtaining (6) in 71% yield, a new compound was formed in about 2% yield. This compound showed m.p. 229-231°C; ν_{max} 1680 and 1713 cm^{-1}; δ_{CDCl_3} 3.93 (6H, s), 6.83 (1H, s), 7.30 - 7.87 (3H, m) and 8.75 (1H, s, H-1)[5]; its molecular ion at 360 mass units; and did not give a positive $FeCl_3$ test. This data must be interpreted in terms of the structure (14) and represented an oxidative cyclisation of an intermediate like (16), which might be formed from (13). We suggest, without evidence, that the mechanism for the formation of (14) was as shown in scheme I.

We are now engaged in converting (13) to the rotenonone (15) and investigating the mechanism and scope of the oxidative cyclisation.

Acknowledgement

We wish to thank Professor P. Deslongchamps and Dr. L. Ruest for mass spectral data.

References and Notes

All the compounds described gave satisfactory analytical and mass spectral data, which, with their I.R., U.V. and N.M.R. data, could be interpreted unequivocally in terms of the given structures.

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Received, 28th May, 1980