Tetrahedron Letters,Vol.28,No.41,pp 4891-4892,1987
Printed in Great Britain

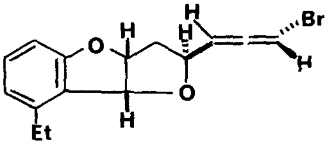
0040-4039/87 $3.00 + .00
Pergamon Journals Ltd.

1,4-ADDITION OF 2-TRIMETHYLSILYLOXYFURAN TO QUINONES: A FACILE ROUTE TO THE FURO[3,2-b]BENZOFURAN NUCLEUS

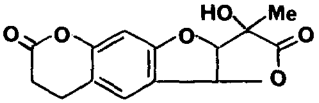
Margaret A. Brimble* and Jennifer J. Gibson
Department of Chemistry and Biochemistry
Massey University, Palmerston North, New Zealand
and Raymond Baker*, Mark T. Brimble, Alex A. Kee and Mary J. O'Mahony
Department of Chemistry, The University, Southampton SO9 5NH, England

The uncatalysed addition of 2-trimethylsilyloxyfuran (3) to a range of activated quinones (4) and (6) yields the crystalline adducts (5) and (7) in 51-91% yield. This novel furofuran-annulation to a quinone system provides a facile entry to the furo[3,2-b]benzofuran ring system.

Panacene (1), a potent fish antifeedent, is one of several halogenated marine natural products isolated from the sea hare *Aplysia brasiliana*[1]. Spectroscopic techniques revealed the presence of the uncommon *cis*-3a,8b-dihydrofuro[3,2-b]benzofuran ring system also present in the alkaloid rutagravine[2] and in a decomposition product (2) of the coumarin micromelin[3].



(1)

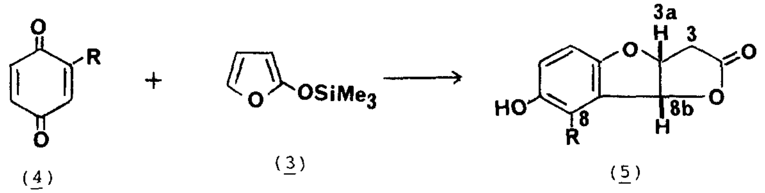


(2)

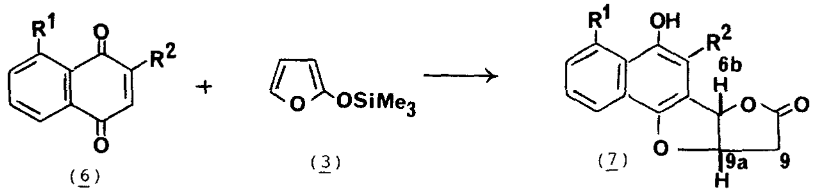
Previous syntheses[4-7] of the *cis*-3a,8b-dihydrofuro[3,2-b]benzofuran ring system include the oxidation of a benzofuran with manganic acetate[4], Fétizon oxidation of a primary ß-alkoxycyclopropylcarbinol[5], reduction of a 2-coumaranonylacetic acid[6] and an electrophilic cyclisation of an unsaturated alcohol[7a,b]. All the above approaches, however, involved a stepwise construction of the desired ring system.

We now wish to report the addition of 2-trimethylsilyloxyfuran (3) to a range of activated benzoquinones (4) which provide an elegant entry into the furo[3,2-b]benzofuran ring system. It was anticipated that after initial 1,4-addition of 2-trimethylsilyloxyfuran (3) *ortho* to the activating group on the quinone ring, aromatization, followed by a second 1,4-addition of the resulting phenoxy group onto the neighbouring butenolide moiety might occur, providing the desired heterocycle (5).

2-Trimethylsilyloxyfuran (3) was prepared[8] from butenolide using triethylamine and chlorotrimethylsilane. The 2-substituted benzoquinones (4a-e) were prepared from the corresponding hydroquinones by oxidation with manganese dioxide or silver oxide. Addition of a solution of the furan (3) in acetonitrile to a solution of the quinones (4a-c) in acetonitrile, cooled to 0°C, rapidly provided the adducts (5a-c)[9] in 51-75% yields. Typically, (5a) was obtained in a yield of 75%, m.p. 171.5-172°C (Found: C, 57.23; H, 3.9. $C_{12}H_{10}O_6$ requires C, 57.61; H, 4.03%); δ_H (80 MHz, d^6-acetone) 2.93-3.17 (2H, m, 3-H and 3'-H), 4.01 (3H, s, OMe), 5.47 (1H, ddd, $J_{3a,8b}$ 5.9, $J_{3a,3}$ 6.1, $J_{3a,3'}$ 1.4Hz, 3a-H), 6.44 (1H, d, $J_{3a,8b}$ 5.9Hz, 8b-H), 6.99 (1H, d, $J_{5,6}$ 9.2Hz, Ar-H), 7.15 (1H, d, $J_{5,6}$ 9.2Hz, Ar-H) and 10.51 (1H, s, -OH); ν_{max} (nujol) 3600-3100, 1770 and 1680 cm^{-1}.



(a) R = $-CO_2Me$, (b) R - -COMe, (c) R = -SOPh, (d) R = $-CO_2CH_2CCl_3$, (e) $-CO_2CH_2COPh$



(5) (a) R^1 = H, R^2 = CO_2Me, (b) R^1 = OMe, R^2 = CO_2Me

Similarly, reactions of the naphthoquinones (6a) and (6b) yielded (7a), 91%, m.p. 247-247.5°C δ_H (360MHz, $CDCl_3$), 3.13 (2H, d, $J_{9,9a}$ 3.9Hz, $9-H_{ax}+9-H_{eq}$), 4.08 (3H, s, CO_2CH_3), 5.48 (1H, dt, $J_{9a,9}$ 3.9Hz, $J_{9a,6b}$ 6.3Hz, 9a-H), 6.47 (1H, d, $J_{9a,6b}$ 6.3Hz, 6b-H), 7.64 (1H, dd, J 7Hz and 7Hz Ar-H), 7.70 (1H, dd, J 7Hz and 7Hz, Ar-H), 7.95 (1H, d, J 7Hz, Ar-H), 8.42 (1H, d, J 7Hz, Ar-H), 11.98 (1H, s, O-H) ν_{max} (nujol) 3400, 1770, 1660 cm^{-1}; and (7b), 70%, m.p. 209°C (decomp). In all cases, the addition reactions took place in a matter of seconds and the use of other solvents such as acetone, methanol, chloroform and dimethylformamide resulted in the same products in comparable yields.

This novel furofuran-annulation to a quinone ring system was established from the ^1H nmr spectrum of the adducts (5a-c). The magnitude of the coupling constant $J_{3a,8b}$ 5.7-6.2Hz found in (5a) was in agreement with that found in panacene (1)[1], consistent with the cis fusion of the furofuran rings.

REFERENCES

1. R. Kinnel, A.J. Duggan, T. Eisner and J. Meinwald, Tetrahedron Lett., 1977, 18, 3913

2. A. Nahrstedt, V. Wray, B. Engel and R. Reinhard, Planta Med., 1985, 6, 517

3. S.K. Talapatra, N.C. Ganguly, S. Goswami and B. Talapatra, J.Nat.Prod., 1983, 46, 401

4. A. Kasahara, T. Izumi, A. Suzuki and T. Takeda, Bull.Chem.Soc.Jpn., 1976, 49, 3711

5. E. Wenkert, M.E. Alonso, B.L. Buckwater and R.L. Sanchez, J.Am.Chem.Soc., 1983, 105, 2021

6. P.C. Arora and P. Brassard, Can.J.Chem., 1971, 49, 3477

7. (a) K.S. Feldman, C. Crawford Mechem and L. Nader, J.Am.Chem.Soc., 1982, 104, 4011; (b) K.S. Feldman, Tetrahedron Lett., 1982, 23, 3031

8. E. Yoshii, T. Koizumi, R. Kitatsuji, T. Kawazoe and T. Kaneko, Heterocycles, 1976, 4, 1663

9. (5b), m.p. 162-164°C, (72% yield); (5c), m.p. 154.5-155.5°C, (51%); (5d), m.p. 188-188.5°C, (76%); (5e), m.p. 201-204°C, (70%).

(Received in UK 31 July 1987)