HETEROCYCLES, Vol.12, No.8, 1979

INTRAMOLECULAR RING FORMATION OF PHENYL AZIDE AND FURAN

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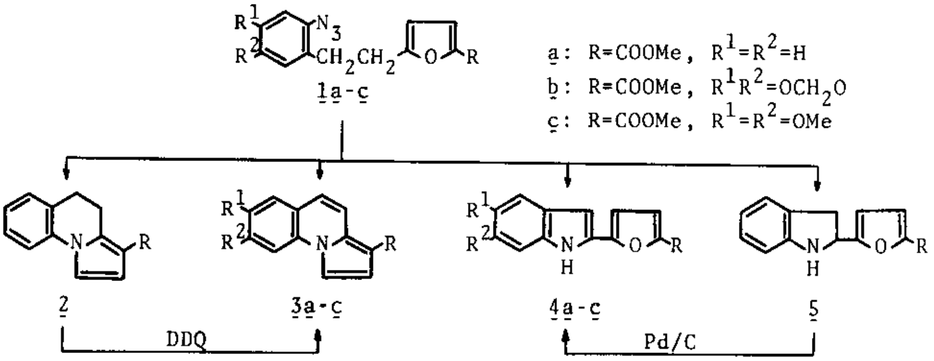
Abstract — Thermal and photochemical reaction of *o*-azidophenylethylfurans (1a-c) gave pyrrolo[1,2-a]quinolines (2, 3a-c and 6a,b) along with the usual nitrene products.

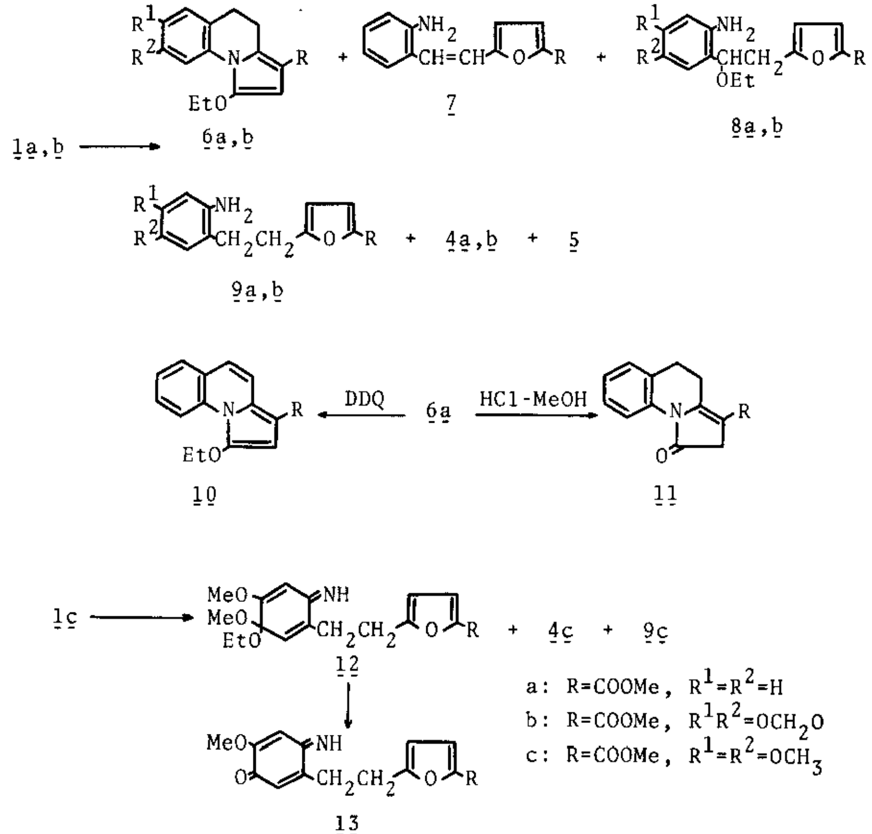
We have reported the synthesis of the various fused furans by the applying the reaction of azide groups[1]. The intramolecular 1,3-dipolar cycloaddition of the dipolarophiles bearing phenyl azide in the molecule has been recently described by Fusco et al.[2]. We assumed that *o*-azidophenylethylfurans (1a-c) were possible causing above the reaction. Therefore, we expect the intramolecular cyclization between phenyl azide and furan, and the thermal and photochemical reaction of 1a-c were carried out. In this paper we report the thermal and photochemical decomposition reactions of 1a-c which lead to the formation of pyrrolo[1,2-a]quinolines (2, 3a-c and 6a,b) along with the usual nitrene products.

Methyl 5-[2-(2-azidophenyl)ethyl]-2-furoates (1a-c) were prepared from the condensation of *o*-nitrobenzaldehydes with 5-carbomethoxy-2-furfuryl triphenylphosphonium chloride[3], followed by the catalytic hydrogenation, diazotization



Scheme 1

and the treatment of sodium azide. Thermolysis of 1a in refluxing *o*-dichlorobenzene for 2 hr gave methyl 4,5-dihydropyrrolo[1,2-a]quinoline-3-carboxylate (2) (colorless needles, mp 65-66°, 8%) and its dehydro compound (3a) (colorless needles, mp 129-130°, 8%), and 2-(2-furyl)indole (4a) (colorless needles, mp 165-166°, 11%) and 2-(2-furyl)indoline (5) (colorless prisms, mp 126-127°, 18%) by the purification with silica gel chromatography (C_6H_6, $CHCl_3$)[4]. 3a was established by the direct comparisons (mixed mp and IR) with the compound prepared from the method of Acheson et al.[5]. Treatments of 2 with DDQ in benzene and 5 with Pd/C in xylene afforded 3a and 4a in excellent yields, respectively. Similar thermolysis of 1b and 1c gave the corresponding 3b (colorless needles, mp 173-174°, 3%) and 3c (pale yellow needles, mp 184-185°, 3.5%) and 4b (colorless needles, mp 223-224°, 32%) and 4c (colorless needles, mp 176-177°, 41%). In the case of 1b,c, the reason why dihydro derivatives were not obtained, is

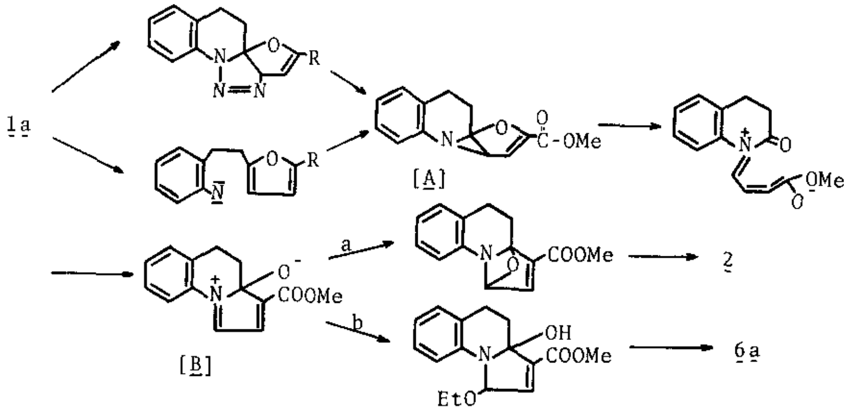


a: R=COOMe, $R^1=R^2=H$
b: R=COOMe, $R^1R^2=OCH_2O$
c: R=COOMe, $R^1=R^2=OCH_3$

Scheme 2

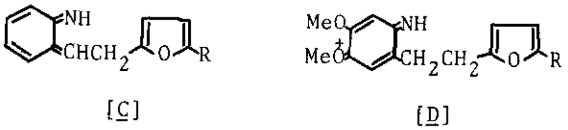
probably due to the effect of the electron-donating group in benzene ring[6]. Photolysis of 1a in EtOH[7] for 10 hr gave 4a (2.7%), 5 (16.7%), 6a (colorless needles, mp 126-127°, 24.6%) and three primary amines 7 (yellow needles, mp 123-124°, 1.6%), 8a (brownish oil, 10.1%) and 9a (colorless needles, mp 58-59°, 3.1%)[8]. Treatments of methyl 1-ethoxy-4,5-dihydropyrrolo[1,2-a]quinoline-3-carboxylate (6a) with DDQ in benzene and with 5% HCl-MeOH afforded methyl 1-ethoxypyrrolo[1,2-a]quinoline-3-carboxylate (10) (colorless needles, mp 114-116°, 97%) and methyl 1-oxo-1,2,4,5-tetrahydropyrrolo[1,2-a]quinoline-3-carboxylate (11) (colorless needles, mp 117-118°, 94%), respectively. *Trans*-methyl 5-[2-(2-aminophenyl)vinyl]-2-furoate (7) was identified with the compound prepared from the corresponding nitro vinyl derivative by the reduction with Zn and NH_4Cl in acetone[9] (mixed mp and IR). The structure of methyl 5-[2-(2-aminophenyl)-2-ethoxyethyl]-2-furoate (8a) was assigned confirmly on the basis of NMR, IR and mass spectra as followed: NMR δ ($CDCl_3$) 7.13 and 6.33 (2H, d x 2, J=3.6Hz, furan-H), 6.85 (4H, m, benzene-H), 4.60 (1H, m, CH), 4.00 (2H, b, NH_2), 3.90 (3H, s, CH_3), 3.45 and 1.13 (5H, C_2H_5), 3.02 (2H, m, CH_2); IR cm^{-1} ($CHCl_3$) 3430, 3350, 1720; UV nm (EtOH) 212, 259; MS *m/e* 289 (M^+). Similar photolysis of 1b afforded 4b (3%), 6b (colorless needles, mp 194-195°, 3%), 8b (brownish oil, 18%) and 9b (colorless needles, mp 119-120°, 12%). However, methyl 5-[2-(3-ethoxy-6-imino-3,4-dimethoxy-1,4-cyclohexadien-1-yl)ethyl]-2-furoate (12) (brownish oil, 13.7%) [IR cm^{-1} ($CHCl_3$) 1713; UV nm (EtOH) 206, 240 (sh), 263; NMR δ ($CDCl_3$) 7.03 and 6.10 (2H, d x 2, J=3.6Hz, furan-H), 6.24 (1H, s, $C_{2'}$-H), 5.58 (1H, s, $C_{5'}$-H), 3.84, 3.77 and 3.19 (9H, s x 3, CH_3 x 3), 3.36 and 1.16 (5H, C_2H_5), 2.84 (4H, m, CH_2 x 2)] was obtained from 1c along with 4c (5.7%) and 9c (colorless needles, mp 67-68°, 2.6%). Hydrolysis of 12 in H_2O at 90-95° for 24 hr gave methyl 5-[2-(6-imino-4-methoxy-3-oxo-1,4-cyclohexadien-1-yl)ethyl]-2-furoate (13) (colorless needles, mp 162-163°, 90%) [IR cm^{-1} ($CHCl_3$) 1718, 1675, 1648, 1602; UV nm (EtOH) 208, 262; NMR δ ($CDCl_3$) 6.98 and 6.06 (2H, d x 2, J=3.6Hz, furan-H), 6.38 (1H, s, $C_{2'}$-H), 5.85 (1H, s, $C_{5'}$-H), 3.82 and 3.77 (6H, s x 2, CH_3 x 2), 2.84 (4H, m, CH_2 x 2)]. The NMR spectral data of pyrrolo[1,2-a]quinolines is shown in Table I.

We propose the following mechanism for the formation of pyrrolo[1,2-a]quinolines (2) and (6a) by the decomposition of 1a (Scheme 3). Loss of the nitrogen after the addition of azide group to double bond or the addition of nitrene to double



Scheme 3

bond gives aziridine [A]. Recyclization after the cleavage of C-O bond forms pyrrolo[1,2-a]quinoline ring system [B] which led to 2 through the loss of oxygen atom (path a) or 6a by dehydration of EtOH adduct (path b), respectively. On the other hand, we assumed that the intermediate [C] or [D] gives amines 7 and 8a or 12 (*Scheme 4*).



Scheme 4

Table I. NMR (δ, $CDCl_3$) spectral data of pyrrolo[1,2-a]quinolines

2	7.27 (4H, m, C_{6-9}-H), 7.08 (1H, d, J=3.2Hz, C_1-H), 6.67 (1H, d, J=3.2Hz, C_2-H), 3.82 (3H, s, CH_3), 3.30, 2.90 (4H, m x 2, $C_{4,5}$-H)
3a	8.13 (1H, d, J=9.4Hz, C_4-H), 7.58 (4H, m, C_{6-9}-H), 7.75 (1H, d, J=3.2Hz, C_1-H), 7.32 (1H, d, J=9.4Hz, C_5-H), 7.21 (1H, d, J=3.2Hz, C_2-H), 3.90 (3H, s, CH_3)
3b	8.00 (1H, d, J=9.4Hz, C_4-H), 7.51 (1H, d, J=3.2Hz, C_1-H), 7.27, 7.02 (2H, s x 2, $C_{6,9}$-H), 7.18 (1H, d, J=9.4Hz, C_5-H), 7.17 (1H, d, J=3.2Hz, C_2-H), 6.05 (2H, s, CH_2), 3.89 (3H, s, CH_3)
3c	8.04 (1H, d, J=9.5Hz, C_4-H), 7.59 (1H, d, J=3.2Hz, C_1-H), 7.23 (1H, d, J=9.5Hz, C_5-H), 7.22, 7.06 (2H, s x 2, $C_{6,9}$-H), 7.20 (1H, d, J=3.2Hz, C_2-H), 4.02, 3.96, 3.89 (9H, s x 3, CH_3 x 3)
6a	8.02 (1H, m, C_9-H), 7.21 (3H, m, C_{6-8}-H), 5.74 (1H, s, C_2-H), 4.14, 1.47 (5H, C_2H_5), 3.83 (3H, s, CH_3), 3.27, 2.84 (4H, m x 2, $C_{4,5}$-H)
6b	7.47 (1H, s, C_9-H), 6.60 (1H, s, C_6-H), 5.85 (2H, s, CH_2), 5.60 (1H, s, C_2-H), 4.05, 1.45 (5H, C_2H_5), 3.75 (3H, s, CH_3), 3.16, 2.70 (4H, m x 2, $C_{4,5}$-H)
10	8.90 (1H, bd, J=9Hz, C_9-H), 8.08 (1H, d, J=9.4Hz, C_4-H), 7.51 (3H, m, C_{6-8}-H), 7.15 (1H, d, J=9.4Hz, C_5-H), 6.35 (1H, s, C_2-H), 4.30, 1.60 (5H, C_2H_5), 3.91 (3H, s, CH_3)
11	8.34 (1H, bd, J=8Hz, C_9-H), 7.22 (3H, m, C_{6-8}-H), 3.80 (3H, s, CH_3), 3.48 (2H, m, C_2-H), 3.31, 2.86 (4H, m, $C_{4,5}$-H)

References

1. A. Tanaka, K. Yakushijin and S. Yoshina, *J. Heterocyclic Chem.*, 1977, **14**, 975; K. Ito, K. Yakushijin, S. Yoshina, A. Tanaka and K. Yamamoto, *ibid.*, 1978, **15**, 301; K. Yakushijin and S. Yoshina, *Heterocycles*, 1977, **6**, 721.
2. R. Fusco, L. Garanti and G. Zecchi, *J. Org. Chem.*, 1975, **40**, 1906.
3. The diazotization of the compounds which had H and CH_3 instead of the carbomethoxy group of **1a** failed.
4. Thermolysis of *o*-azidodiphenylethane in *o*-dichlorobenzene gave 2-phenylindoline (80-90%) and 2-phenylindole (trace).

5. R. M. Acheson and M. S. Verlander, *J. Chem. Soc. (C)*, 1969, 2311.

6. E. F. Platt and T. P. McGovern, *J. Org. Chem.*, 1964, **29**, 1540.

7. Photolysis of **1a** in benzene gave **2**, **3a**, **4a** and **9a** similar to thermolysis.

8. Irradiation was carried out by the use of 100 W high pressure mercury lamp, Taika HLV-B.

9. J. H. Boyer and H. Alul, *J. Amer. Chem. Soc.*, 1959, **81**, 2136.

Received, 17th May, 1979