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SYNTHESES OF AN ISOANNELATED ANNULENE, A BISDEHYDRO[14]ANNULENO[c]FURAN AND BISDEHYDRO[14]ANNULENE DERIVATIVES

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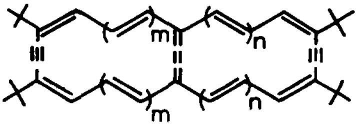
Summary: A bisdehydro[14]annuleno[c]furan, an isoannelated diatropic annulene, has been synthesized. Cyclic glycol, a precursor of the annuleno[c]furan, could be converted into bisdehydro[14]annulene derivatives under mild acidic conditions.

We have already prepared a series of annelated [4n+2]annulenes fused with naphthalene or benzene and clarified the effect of annelation on π-electron delocalization of the annulene ring$^{1)}$.

Recently we have prepared [4n+2]annuleno[4n'+2]annulenes (**1**) consisting of two same or different size diamagnetic 'acetylene-cumulene' dehydroannulenes, and their NMR properties strongly suggest that they are fused systems of two diatropic moieties$^{2)}$.

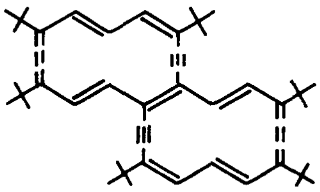
With the purpose to get further insight into the nature of ring current induced in annulenoannulene system, we have intended to prepare *ortho*-fused annulenoannulenes (**2**) consisting of two 'acetylene-cumulene' dehydroannulenes. A bisdehydro[14]annuleno[c]furan (**3**), a 14π-electron analogue of isobenzofuran, seemed to be a key substance for the preparation of **2**.

In this paper, we wish to report the synthesis of bisdehydro[14]annuleno[c]furan (**3**) and the formation of bisdehydro[14]annulene derivatives (**4**, **5**) from the cyclic glycol, the precursor of **3**.



1

a, m=n=1; b, m=n=2
c, m=1, n=2; d, m=1, n=3



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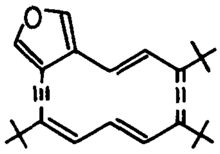
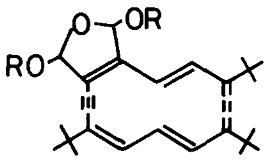


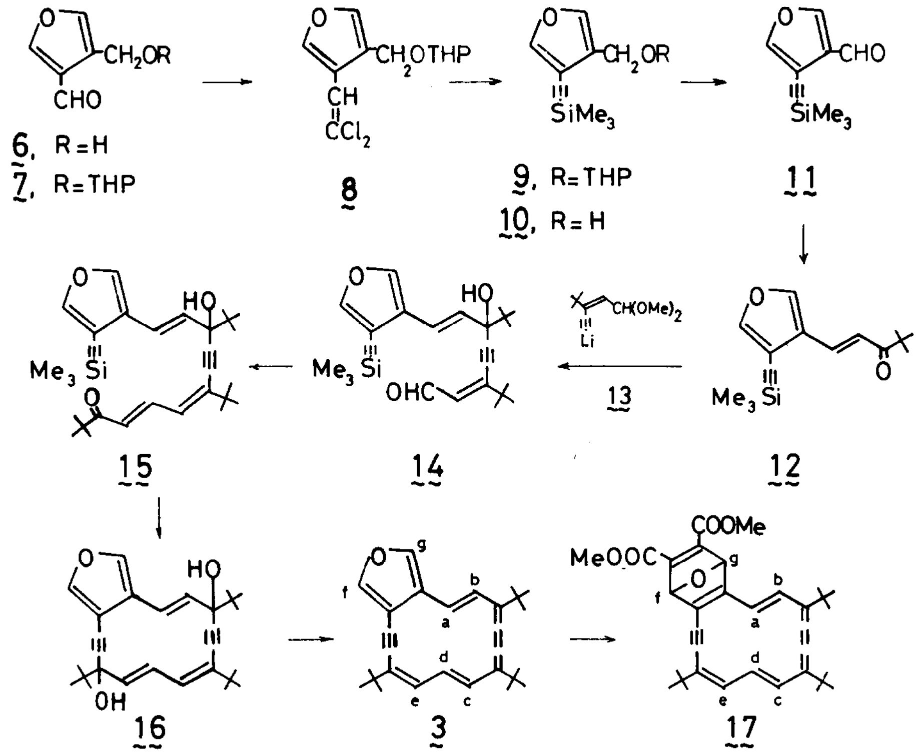
3



4, R=Me ; **5**, R=Ac

The synthesis of the bisdehydro[14]annuleno[c]furan (**3**) was carried out by the reaction sequence outlined in Scheme 1. 3-Hydroxymethylfuran-4-carboxaldehyde (**6**)$^{3)}$ was converted into tetrahydropyranyl ether (**7**, colorless oil, bp 89-90°C / 1.0×10^{-4}mmHg, 82%). The Wittig-Horner reaction of **7** with $LiCCl_2$-P(O)$(OEt)_2$ in THF / ether (2:3) gave *gem*-dichloroalkene (**8**, pale yellow oil, bp 102-106°C / 7×10^{-5}mmHg, 74%)$^{4)}$. Treatment of **8** with butyllithium in ether at

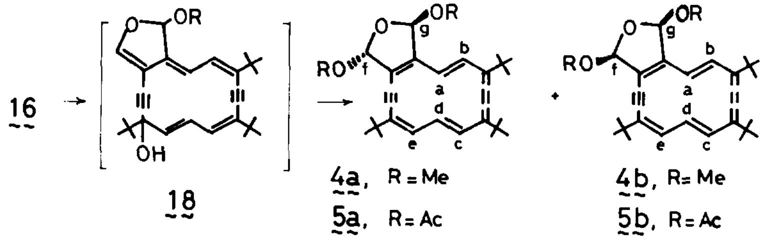
-90 ∿ -70°C afforded the corresponding lithium alkynide which was converted directly into trimethylsilyl derivative (9) by the reaction with Me_3SiCl. Removal of the tetrahydropyranyl protecting group of 9 with catalytic amounts of pyridinium *p*-toluenesulonate[5] in methanol yielded silylethynyl alcohol (10, colorless oil, bp 58-59°C / 1.2×10^{-3}mmHg, 71%). Oxidation of 10 with $BaMnO_4$[6] in CH_2Cl_2 gave aldehyde (11, colorless oil, bp 52-56°C / 1×10^{-3}mmHg, 78%). The reaction of 11 with carbanion derived from *t*-$BuCOCH_2P(O)(OEt)_2$[7] afforded ketone (12, colorless crystals, mp 73.2-75.2°C, 91%). Reaction of lithio derivative (13) of 3-*t*-butylpentenynal dimethyl acetal[8] with 12 gave hydroxy acetal, which was hydrolyzed without purification with aqueous acetic acid to give hydroxy aldehyde (14, yellow needles, mp 120.8-121.2°C, 97%). The Wittig-Horner reaction of 14 with *t*-$BuCO\bar{C}HP(O)(OEt)_2$ yielded hydroxy ketone (15, yellow amorphous solid, 73%), which was treated with KOH in liquid ammonia to give cyclic glycol (16, pale yellow plates, mp 153.0-154.5°C, 79%)[9].



Scheme 1

Although the transformation of 16 to the [14]annuleno[c]furan (3) was found to be difficult under the usual conditions owing to the instability of 3, the desired conversion could be realized under limited conditions. To a solution of 16 in ether was added tin(II) chloride and a small amount of ether saturated with hydrogen chloride and the reaction mixture was neutralized by introducing gaseous ammonia at -60°C. After being worked up at a low temperature, the product was chromatographed on alumina at 0°C. Bisdehydro[14]annuleno[c]furan (3, ES: $\lambda_{max}^{pentane}$ 270, 313, 324, 485, 508 nm) was obtained as unstable red solid, which easily isomerized to unidentifiable [14]annulene derivative[10]. The structure of 3 was confirmed by the Diels-Alder reaction with dimethyl acetylenedicarboxylate. The adduct (17, mp *ca* 210 °C (dec.), 31% based on 16, Mass(m/e): 528(M^+); IR(KBr-disk): 2090, 2010 cm^{-1}; ES: λ_{max}^{THF} (ε) 246.5sh (12300), 257 (12700), 321.5 (79500), 422 (11000), 448 (18300), 542 (318), 593 (525) nm) was obtained as stable red fine crystals.

Instability and enhanced reactivity of 3 as a diene seemed to suggest the possibility of conversion of 16 into bisdehydro[14]annulene ring system. In fact, as shown in Scheme 2, 16 could be transformed into bisdehydro[14]annulene derivatives under cooperation with the furan system. Development of red color was observed when a solution of 16 in methanol containing a small amount of hydrogen chloride was kept for 2 hr at 0°C. The product was chromatographed on alumina to give *trans*- and *cis*-dimethyl acetals (4a: *trans*-isomer[11], red prisms, mp 175.0-175.4°C, 58%, Mass (m/e): 448 (M^+); IR(KBr-disk) 2025 vw cm^{-1}; ES: λ_{max}^{THF} (ε) 305sh (34200), 330.5 (233000), 434sh (12500), 454 (244000), 524 (248), 545 (365), 589 (1390) nm; 4b: *cis*-isomer[11], red prisms, mp 150.0-151.5°C, 26%, Mass(m/e): 448 (M^+); IR(KBr-disk): 2030 cm^{-1}; ES: λ_{max}^{THF} (ε) 306 (30900), 330.5 (228000), 434sh (12500), 455 (24100), 524 (249), 546 (367), 589 (1400) nm). The similar reaction occurred when 16 was dissolved in acetic acid at room temperature. After being stirred for overnight, the reaction mixture was worked up and the product was isolated by chromatography on alumina. The diacetoxy derivative (5: *cis-trans* mixture, 35%, Mass (m/e): 504 (M^+); ES: λ_{max}^{THF} 306sh, 330.5, 434sh, 445, 523.5, 544.5, 589.5 nm) was obtained as rather unstable red solid. Formation of 4 and 5 from 16 can be reasonably explained assuming formation of rearranged intermediate (18) under acidic conditions. Accomplishment of highly stabilized 14π-electron system is a driving force of the transformation.



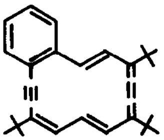
Scheme 2

The ^1H NMR parameters of 3, 4a, 4b, and 17 are summarized in Table. The difference in chemical shifts between inner (τ_i) and outer (τ_o) protons, $\Delta\tau = \tau_i - \tau_o$, can be regarded as an approximate measure of magnitude of ring current. As shown in the Table, a marked decrease of $\Delta\tau$-value for bisdehydro[14]annuleno[c]furan (3) as compared with those of bisdehydro[14]annulene derivatives (4a, 4b, and 17) was observed being consistent with the result for benzo- and naphthobisdehydro[14]annulenes (19 and 20)[12]. The order of decreasing diatropicity was found to be 20 > 19 > 3. Instability and reduction of diatropicity of 3 exhibit characteristic feature of isoannelated system like isobenzofuran. It should be noted that the isoannelated annulene (3) showed an appreciable diatropicity in contrast to hardly detectable diatropicity of another bisdehydro[14]annuleno[c]furan (21) synthesized by Sondheimer[13]. The tendency of 'acetylene-cumulene' dehydroannulene to form a highly stabilized π-electron system should be the cause of distinct diatropicity of 3.

Table. ^{1}H NMR Parameters of **3**, **4a**, **4b**, and **17** (τ-values).

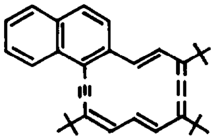
	H_a	H_b	H_c	H_d	H_e	H_f	H_g	OMe	*t*-Bu	Δτ
3$^{a)}$	5.65 d (16.5)	2.13 d (16.5)	2.60 d (15.0)	5.31 dd (11.5,15.0)	2.66 d (11.5)	1.53 d (1.5)	1.20 d (1.5)		8.59 s 8.60 s	2.71-3.52
4a$^{b)}$	14.91 d (14.0)	0.47 d (14.0)	0.56 d (13.5)	14.57 t (13.5)	0.56 d (13.5)	3.17 s	2.73 s	6.30 s 6.44 s	8.09 s 8.13 s	14.01-14.44
4b$^{b)}$	14.92 d (14.0)	0.47 d (14.0)	0.55 d (13.5)	14.58 t (13.5)	0.55 d (13.5)	2.84 d (1.5)	2.43 d (1.5)	6.47 s 6.58 s	8.08 s 8.09 s 8.12 s	14.03-14.45
17$^{b)}$	13.30 dd (1.0,13.0)	0.97 d (13.0)	1.02 d (12.5)	12.99 dd (12.5,14.0)	1.06 d (14.0)	3.43 d (1.5)	2.91 dd (1.0,1.5)	6.20 s 6.26 s	8.17 s 8.19 s 8.22 s	11.97-12.33

a) In acetone-d_6 at -40°C. b) In $CDCl_3$ at room temperature.



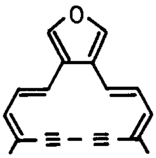
19

Δτ= 7.49 ~ 8.16



20

Δτ=10.54 ~ 11.10



21

τ_i =3.48, τ_o =3.28, 3.69

Further transformations of **4** and **5** into bisdehydro[14]annulenes having functional groups are now in progress.

Acknowledgement

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References and Notes

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9) Only one diastereomer of **16** was obtained.
10) The electronic spectrum of the product is similar to **4**, **5**, and **17**, whereas the ^{1}H NMR spectrum shows extremely broad signals even at a low temperature.
11) Long range coupling between H_f and H_g was observed in **4b**, but not in **4a**.
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