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(3) For a critique of the theoretical foundation of this procedure see (a) R. J. Buenker, S. D. Peyerimhoff and K. Hsu, *J. Am. Chem. Soc.*, **93**, 5005 (1971); (b) P. Merlet, S. D. Peyerimhoff, R. J. Buenker, and S. Shih, *ibid.*, **96**, 959 (1974).

(4) Reference 1, p 794. It should be noted that the symmetrization technique was recommended with reservations (ref 1, p 797) almost universally ignored in mechanistic rationalization.

(5) For example a calculation of potential minima MO's for a series of azapolyenes and the corresponding azaheterocycles led to the unsubstantiated conclusion that the W-H rules derived from symmetrical hydrocarbons are valid in the hetero series. No explicit consideration was given to the intervening potential energy surface: Z. Neiman, *J. Chem. Soc., Perkin Trans. 2*, 1746 (1972).

(6) Detailed calculations for the isomerization of Dewar benzene and its 1-chloro derivative and several unsymmetrical hydrocarbon potential surfaces support the qualitative argument.[7]

(7) M. J. S. Dewar and S. Kirschner, *J. Am. Chem. Soc.*, **96**, 5244 (1974).

(8) R. J. Boyd and M. A. Whitehead, *J. Chem. Soc., Dalton Trans.*, 73, 78, 82 (1972).

(9) (a) The absence of terminal substituents for **7**, **8**, **10**, and **11** renders the con/dis designations meaningless for these systems. Nonetheless **7**, **8**, and **10** ring closures can in principle occur by at least two stereoisomeric transition states which were considered as separate calculations. (b) In all cases potential surface minima were completely geometry-energy optimized.

(10) For a quantitative and detailed assessment of electrocyclic reactions, geometry optimization throughout the entire reaction is essential.[7] However, for a qualitative prediction of "allowedness"/"forbiddeness" and overall stereochemistry, our results indicate that judicious use of geometric constraints is valid. Needless to say, computer expenses are thereby significantly reduced.

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(12) Experiment: M. Newcomb and W. T. Ford, *J. Am. Chem. Soc.*, **96**, 2968 (1974); theory: ref 1, 3b, 7 and M. J. S. Dewar and S. Kirschner, *J. Am. Chem. Soc.*, **93**, 4290 (1971); cf. R. G. Weiss, *Tetrahedron*, **27**, 271 (1971).

(13) (a) The σ orbital in question, though weakly bonding between closure termini, is more accurately identified with the **1**-X lone electron pair. (b) This MO is not the HOMO, but that next highest in energy, the antisymmetric N/N or N/O combination. It is to be noted, however, that three of the eight pathways for **6** in fact connect by means of a π_{open}(HOMO) — π_{closed}(HOMO) correlation; (c) σ^* may be either an antisymmetric ring MO (**8**, **9**) or an antibonding CH_2 orbital (**10**).

(14) Electrocyclic ring opening reactions of certain radical-anions are found to be nonspecific: N. L. Bauld, C.Chang, and F. R. Farr, *J. Am. Chem. Soc.*, **94**, 7164 (1972).

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(16) A. D. Walsh, *J. Chem. Soc.*, 2266 (1953); R. S. Mulliken, *Rev. Mod. Phys.*, **14**, 204 (1942); cf. E. F. Hayes and G. V. Pfeiffer, *J. Am. Chem. Soc.*, **90**, 4773 (1968); R. J. Buenker and S. D. Peyerimhoff, *Chem. Rev.* **74**, 127 (1974); L. Salem, *J. Am. Chem. Soc.*, **96**, 3486 (1974).

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(19) This result applies to a wide variety of four-membered ring heterocycles as well, J. P. Snyder unpublished work.

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(21) J. P. Snyder, *J. Am. Chem. Soc.*, **96**, 5005 (1974).

(22) Camille and Henry Dreyfus Teacher-Scholar Grant Recipient, 1971–1976.

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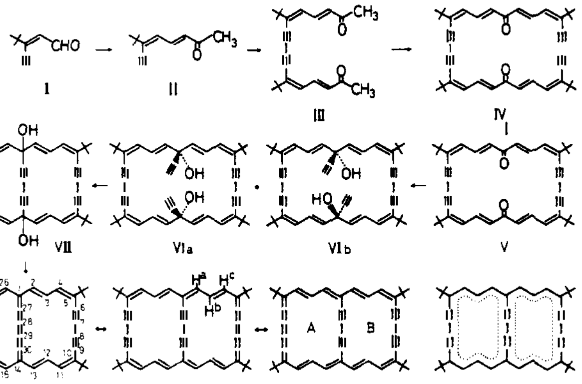
Synthesis of a Condensed Nonbenzenoid Aromatic System. An Annulenoannulene Consisting of Two 18π-Electron Systems

Sir:

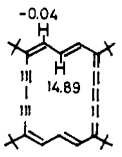
In spite of fascinating developments in the chemistry of nonbenzenoid aromatic compounds, condensed systems of aromatic annulenes corresponding to naphthalene still remain unknown. In view of the strong diatropicity and high conformational stability of symmetrical tetradehydro- or didehydro[4*n* + 2]annulenes containing formal acetylenic and cumulenic linkages in the cyclic system,[1] it seemed of considerable interest to synthesize a fused dehydroannulene system of this type. We now describe the preparation of an annulenoannulene (VIII) consisting of two tetradehydro-[18]annulene nuclei.

The ethynyl ketone (II, pale yellow liquid, 56%) obtained by the aldol condensation of I[2] with acetone (NaOH-H_2O-EtOH, room temperature, 8 min) was oxidatively coupled by cupric acetate in pyridine to give III (yellow crystals, mp 121.5–123.5°, 71%; Anal. ($C_{24}H_{30}O_2$) C, H).[3] Treatment of III in benzene with an excess of I in the presence of sodium ethoxide (4°, 2 hr) yielded IV (yellow crystals, mp 128.5–129.0°, 92%; Anal. ($C_{42}H_{50}O_2$) C, H; ir (KBr) 1659 cm^{-1} (C=O)). Oxidative coupling of IV by cupric acetate in pyridine–ether–methanol under high dilution conditions (46°, 16 hr) resulted in the 26-membered cyclic diketone (V, yellow crystals; mp ca. 183° dec, 97%; Anal. ($C_{42}H_{48}O_2$) C, H; ir (KBr) 1666 cm^{-1} (C=O)). Bisethynylation of V (2°, 2 hr) using the lithium acetylide–ethylenediamine complex in THF saturated with acetylene gave a mixture (VI_a and VI_b) which, upon chromatography on alumina, yielded a high melting isomer (pale yellow crystals; mp 167–170° dec; Anal. ($C_{46}H_{52}O_2$) C, H) and a low melting isomer (light brown crystals, mp 162–165° dec; Anal. ($C_{46}H_{52}O_2$) C, H) in ca. 4:1 ratio (total yield 88%). The isomerism can be reasonably ascribed to the differing disposition of the ethynyl and hydroxyl groups. Treatment of the high melting isomer with cupric acetate in pyridine–methanol–ether under high dilution conditions (46°, 6 hr) yielded the bicyclic glycol (VII, yellow crystals, mp 168–170° dec; 61%; Anal. ($C_{46}H_{50}O_2$) C, H; *m/e* 634 (M^+)).[4]

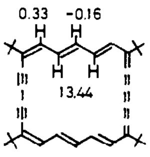


Glycol (VII) in ether was mixed at −60° with a solution of stannous chloride dihydrate in the same solvent saturated with hydrogen chloride. After 10 min, the resulting deep green reaction mixture was quenched with water and worked up in the usual way, and the product was recrystallized from THF to yield 5,10,18,23-tetra-*tert*-butyl-6,8,19,21,27,29-hexadehydro[26]bi[12.12.4]annulene (VIII: dark green crystals; mp 230° dec; 79%; Anal. ($C_{46}H_{48}$) C, H; *m/e* 600 (M^+)).[5] VIII gave a 1:1 CT complex with 2,4,7-trinitrofluorenone (dark green crystals; mp ca. 250° dec; Anal. ($C_{59}H_{53}N_3O_7$) C, H, N). VIII was found to be a fairly stable and sparingly soluble compound, whose electronic spectrum consists of three main absorption bands ($\lambda_{\max}^{\text{THF}}$ 446 nm (ϵ 630,000), 641 (88,900), 855 (2200)) clearly showing features characteristic of [4*n* + 2]annulenes; *i.e.*, the spectrum of VIII was found to be closely related with that of tetra-*tert*-butyltetradehydro-[18]annulene (IX) except for bathochromic shift and hyperchromism in VIII. The 100-MHz ^{1}H FT NMR spectrum in CDCl$_3$ of VIII exhibits inner proton (H^b) signals at τ 12.85 (dd, J = 13-14 Hz) and outer proton (H^a and H^c) signals at τ −0.64 (d, J = 14 Hz) and τ −0.06 (d, J = 13 Hz), respectively. An appreciable downfield shift of the *tert*-butyl signal (τ 7.81, s) was also observed. (The electronic spectrum of VIII and IX and the 100-MHz ^{1}H FT NMR spectrum of VIII in CDCl$_3$ will appear in the microfilm edition of the journal; see paragraph at end of paper regarding supplementary material.) The assignment of the outer protons was made using the tetradeuterio derivative of VIII which was prepared from I and acetone-d_6 by an analogous reaction sequence. The NMR spectrum indicates clearly that VIII sustains a strong diamagnetic ring current. Consequently, whether VIII is a perturbed peripheral [26]annulene or an annulenoannulene consisting of two 18π-electron systems becomes the most interesting problem.

The magnitude of a diamagnetic ring current, estimated approximately by the difference in chemical shifts ($\Delta\tau = \tau_i - \tau_o$) between inner ($\tau_i$) and outer ($\tau_o$) proton signals, in a series of conformationally stable tetra-*tert*-butyldidehydro[4n + 2]annulenes decreases markedly with increase of ring size (n = 3, $\Delta\tau$ = 13.76; n = 4, $\Delta\tau$ = 13.29; n = 4, $\Delta\tau$ = 9.99; n = 6, $\Delta\tau$ = 6.28; n = 7, $\Delta\tau$ = 4.0).[6] In view of the same trend observed in the tetradehydro[18]- (IX) ($\Delta\tau$ = 14.93)[2] and the tetradehydro[22]annulenes (X) ($\Delta\tau$ = 13.11-13.60),[7] the value found for VIII ($\Delta\tau$ = 12.91-13.49) seems to be larger than that anticipated for tetradehydro[26]annulene as well as for VIII as regarded as a perturbed peripheral [26]]annulene, in which the central diacetylene behaves only as a bridging chain. The downfield shifts of all signals of VIII compared with IX and X can be reasonably ascribed to an additive diatropicity effect of both 18-membered rings; i.e., the protons H^a, H^b, and H^c in the ring A suffer a deshielding effect of the diamagnetic ring current of the ring B and vice versa. The ^{1}H NMR spectral behavior of VIII indicates that the bicyclic annulene (VIII) is a fused aromatic compound consisting of two 18π-electron systems being a hybrid of structures, VIII$_a$, VIII$_b$, and VIII$_c$. In other words, the annulenoannulene (VIII) can be represented most properly by the symmetrical formula, VIII$_d$.



IX



X

Supplementary Material Available. The electronic spectrum of VIII together with that of IX and the 100 MHz ^{1}H-FT-nmr spectrum of VIII in CDCl$_3$ at 36° will appear following these pages in the microfilm edition of this volume of the journal. Photocopies of the supplementary material from this paper only or microfiche (105 × 148 mm, 24× reduction, negatives) containing all of the supplementary material for the papers in this issue may be obtained from the Journals Department, American Chemical Society, 1155 16th St., N.W., Washington, D.C. 20036. Remit check or money order for $4.00 for photocopy or $2.50 for microfiche, referring to code number JACS-75-4424.

References and Notes

(1) For a review, see M. Nakagawa, "Topics in Nonbenzenoid Aromatic Chemistry", Vol. 1, Hirokawa Publishing Co., Tokyo, 1974, p 191.

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(3) The ir, NMR, and mass spectral data of all new compounds described in this communication are consistent with the assigned structures.

(4) In contrast, the low melting isomer (VI) gave no VII upon attempted oxidative coupling under the same reaction conditions, and only starting material was recovered in 62% yield. The failure to intramolecularly cyclize this isomer of VI is attributable to the inaccessible mutual disposition of the ethynyl groups in the molecule of trans structure with respect to the ethynyl and the hydroxyl groups (VI$_b$). On this basis, we assign the cis structure (VI$_a$) to the high melting isomer in which the ethynyl groups are favorably positioned for intramolecular oxidative coupling.

(5) The authors wish to propose this abbreviated name for the condensed annulene, although according to IUPAC rules, VIII is 5,10,18,23-tetra-*tert*-butylbicyclo[12.12.4]triaconta-1,3,11,13,15,17,23,25-octaene-6,8,19,21,27,29-hexayne. The authors are grateful to Dr. K. Hirayama, Fuji Photo Film Co. Ltd. and Mr. K. Fukui, Mitsui Petrochem. Ind. Co. Ltd. for their valuable suggestions with regard to annulenoannulene nomenclature.

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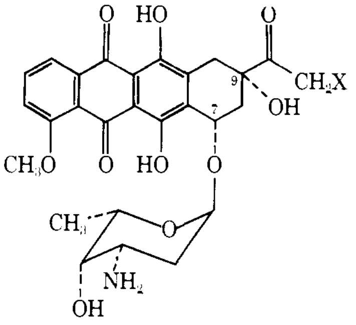
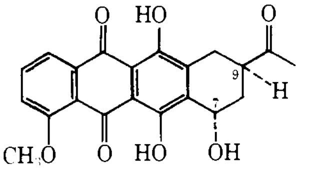
Regiospecific Total Synthesis of (±)-9-Deoxydaunomycinone

Sir:

The anthracycline antibiotics daunomycin (**1**) and adriamycin (**2**) are antineoplastic agents of established clinical utility.[1] Their scarcity has led to continuing efforts toward their total synthesis, and recent progress in that direction has been reported.[2] We wish to describe a short, mild, and completely regiospecific approach to antibiotics of this class which has resulted in the first total synthesis of (±)-9-deoxydaunomycinone (**3**).



1, X = H
2, X = OH



3

The reaction which maintains regiospecificity in our synthetic sequence is the photochemical Fries rearrangement of the o-cyanobenzoate ester **9**. This crystalline intermediate was prepared in 54% overall yield by a five-step route from the dihydroxytetralone (**5**), itself available in 76% yield by BBr$_3$ demethylation (CH$_2$Cl$_2$, −78° to 0°, 25 min) of the known[3] dimethyl ether **4**. The corresponding ketal **6** (ethylene glycol, p-TSA, C$_6$H$_6$, 4 hr reflux, 91%) was reduced by sodium borohydride in dry tetrahydrofuran (reflux, 16 hr) to give 83% of trihydroxy ketal **7**, which was