OLEFINIC AND ACETYLENIC COMPOUNDS. I. IMPROVED SIMPLE SYNTHESIS OF [18]ANNULENE; NEW STEREOSPECIFIC SYNTHESIS OF 1,5-HEXADIYNE-3-ENE <u>CIS</u> H.P. FIGEYS^{*} and M. GELBCKE

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Some years ago, Sondheimer et al.^(1,2) reported the synthesis of [18]annulene (I), the first known homologue of benzene in the (4n + 2) m electrons cyclic polyolefines (annulenes). The scheme involved the oxydative coupling of 1,5-hexadiyne, followed by prototropic rearrangement of the cyclic trimer (obtained among higher cyclic and open-chain "polymers") with potassium-t-butoxide in t-butyl-alcohol to a mixture of completely conjugated tridehydro- and tetradehydro-[18]annulenes (predominantly 1,7,13-tridehydro[18]annulene) in ca. 2,1g

overall yield (3, 4, 5); subsequent catalytic hydrogenation on a palladium charcoal catalyst in benzene solution led to I in ca. 30 % yield; 1,5-hexadiyne itself is obtained by a three-step synthesis (6,7) from allyl chloride (II) with a 34 % yield. Sondheimer's work thus constitutes a six-step synthesis of I from the commercial starting material (II) with an overall yield of 0,21 %.

We wish to report a new and rapid six-step, 0.42 % overall yield, synthesis of [18]annulene, avoiding the long and difficult chromatographic separations encountered in Sondheimer's method; our scheme however implied the work up of a stereospecific synthesis of 1,5-hexadiyne-3-ene cis (V).

The oxidation of propargyl alcohol with chromic anhydride in acidic medium yielded propargyl aldehyde in 35-45 % yield⁽⁸⁾; electrodimerisation of this rather unstable colourless liquid (115 g-2,1 mole) on a zinc-copper couple⁽⁹⁾ (prepared from 140.2 g of zinc and 94.2 g of anhydrous $CuSO_4$) in a mixture of 575 ml. of THF and 126.5 g (2,1 mole) of acetic acid during 3 hours at room

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temperature, gave a brownish solid, which after sublimation (80-85°/0,1 Torr) yielded 58 g (50 %) of <u>meso</u> 1,5-hexadiyne-3,4-diol (III) as white crystals, m.p. 101°⁽¹⁰⁾. Longer reaction times, more acidic solutions or the use of zinc-copper couples containing a smaller amount of copper decreased drastically the yield obtained.

Hydrogenation of III over a 30 % palladium-charcoal catalyst in ethanol gave the known⁽¹¹⁾ <u>meso</u> hexane-3,4-diol, m.p. 89°; treatment of 2,2 g of <u>meso</u>-1,5 hexadiyne-3,4-diol with 4 g of LiAl H_4 in 200 ml. of THF for 20 h. resulted in a brownish solution from which pure <u>meso</u>-hexadiene-3,4-diol was isolated by extraction with ethyl acetate followed by distillation (yield 68%, b.p.86°/2Torr).

^{*}EEE stands for 2-(2-ethoxy-ethoxy)ethanol.

In the next step, 11 g (0.1 mole) of III are treated with 42 g (0.22 mole) of p-toluene-sulfonyl chloride for 3 days in 26,5 ml (0.33 mole) of pyridine at 0°; excess pyridine is eliminated by washing with a cold solution of 10 % HCl and the product is extracted with chloroform; after evaporation and recrystali-sation of the white resulting powder in $CHCl_3/petroleum$ ether (b.p. 60-70°), 39 g (93 %) of 1,5-hexadiyne-3,4-ditosylate (IV), m.p. 157-158° are obtained (identified by mass, I.R. and N.M.R. spectroscopy).

Detosylation of IV is achieved with NaI in a high-boiling solvent under vacuum. After several experimentations, it was found that the best reaction conditions are the use of refluxing 2-(2-ethoxy-ethoxy)ethanol at 0.2 Torr., hexadiyne-3-ene (V) being evacuated from the reaction mixture as it is formed and collected in four traps cooled with liquid nitrogen. In a typical experiment, 3.14 g of IV were treated with 9.9 g of NaI at 0.2 Torr for 62 h. in 60 ml of 2-(2-ethoxy-ethoxy)ethanol with magnetic stirring and protection from daylight; the traps contained 0.416 g pure V (yield 73 %). A mixture of V and of the trans-isomer was synthetized by W.H. Okamura and F. Sondheimer⁽¹²⁾ in good overall yield, but the synthesis described here constitutes a stereospecific preparation of cis-1,5-hexadiyne-3-ene.

The oxidative coupling of V to 1,3,7,9,13,15-hexadehydro[18]annulene⁽¹²⁾ (VI) was realised by adding 2.0 g of (V) to a solution of 30 g of cupric acetate in 300 ml. of pyridine.

The solution is heated at 55° for three hours and allowed to stand overnight at room temperature. After removal of polymers and inorganic material, the reaction mixture is chromatographed on 100 g of Merck standard alumina; VI is the first eluated product (petroleum ether b.p. 60-70°) and is obtained in 20 % yield (identified by U.V.-, I.R.-, N.M.R.- and mass-spectrometry⁽¹²⁾.

The hydrogenation of VI was performed a number of times under various conditions. It was found that [18]annulene (I) is much more rapidly destroyed than the starting material either on a 10 % palladium-charcoal catalyst or on a Lindlar catalyst. However, the best results were obtained with a Lindlar catalyst, the reduction being stopped after the absorption of six equivalents of H_2 ; when 0.250 g of VI are hydrogenated with 50 mg of Pd/BaSO₄ and one drop of

quinoline in 100 ml. of benzene, the stoechiometric amount of hydrogen was taken up within 2-5 hours, after elimination of the catalyst by centrifugation, U.V.-examination of the resulting yellowish solution showed the characteristic spectrum of [18] annulene as the only absorbing species; the yield, based on the known extinctions at 456 and 378 nm.⁽²⁾, varied from 10 % to 20 %. No unchanged starting material was recovered by chromatography on 100 g of neutral alumina (Woelm, activity I) with ether-pentane 1/9 as eluant; [18]annulene was the first eluated compound; however, about one half of the product is lost in this purification. We have found that [18] annulene is completely destroyed on Merck standard or Merck neutral alumina of activity I. The N.M.R.-spectrum recorded at -60° (6 mg of VII in 0.4 ml of perdeuterio-tetrahydrofurane) is in complete agreement with Sondheimer's description (13). The synthesis of a symetrical dodecadeuterio [18] annulene by the same method is under investigation.

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References.

- F. Sondheimer and R. Wolovsky, Tetrahedron Lett. 3, 3 (1959).
 F. Sondheimer, R. Wolovsky and Y. Amiel, J.Am.Soc. 84, 274 (1962).
- (3) F. Sondheimer and R. Wolovsky, J.Am.Chem.Soc. 84, 260 (1962).
- (4) R. Wolovsky, J.Am.Chem.Soc. <u>87</u>, 3638 (1965).
 (5) F. Sondheimer, Proc.Roy.Soc. <u>297A</u>, 173 (1967).
 (6) A. Turk and H. Channan, Org.Synth. <u>27</u>, 7 (1949).
- (7) R.A. Raphael and F. Sondheimer, J.Chem.Soc., 120 (1950).
- (8) J.C. Sauer, Org.Synth., Coll. Vol. IV, 813 (1963).
- (9) J.H. Gladstone and A. Tribe, J.Chem.Soc. <u>31</u>, 561 (1877).
 (10) This product has been prepared by a slighty different method in a yielded of 27 % by S. Holland, R. Epsztein and I. Marszak, Comp.Rend., Série C, 265 936 (1967); Bull.Soc.Chim.France 9, 3213 (1969).
- (11) H. Van Risseghem, Bull.Soc.Chem.Belges 45, 21 (1936); H.Buc., Ann.Chim. (Paris) <u>8</u>, 409 (1963); J. Wiemann, G. Dana, T. Sa Le Thi et M. Brami, Compt.Rend. <u>258</u>, 3724 (1964); H. Van Risseghem, Bull.Soc.Chim.Belges <u>47</u>, 194, 221, 261 (1938).
- (12) W.H. Okamura and F. Sondheimer, J.Am.Chem.Soc. 89, 5591 (1967).
- (13) F. Sondheimer, I.C. Calder, J.A. Elix, Y. Gaoni, P.J. Garatt, K. Grohman, G. di Maio, J. Mayer and R. Wolovsky, in "Aromaticity", Special Publication nº 21 of the Chemical Society, London, 1967, p. 90.