Tetrahedron Letters No. 21, pp. 1793-1796, 1971. Pergamon Press. Printed in Great Britain.

# THE SYNTHESIS OF 6,7-BENZO-4,9-OXIDO[11]ANNULENONE*

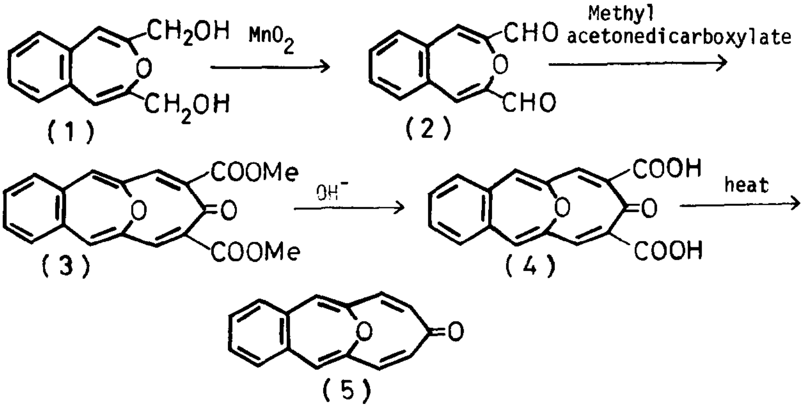
Haru Ogawa**, Hidefumi Kato*** and Mitutaka Yoshida
Department of Pharmaceutical Sciences, Kyushu University,
Katakasu 1276, Fukuoka, Japan

(Received in Japan 2 April 1971; received in UK for publication 16 April 1971)

Planar conjugated ketones having a ring larger than a seven membered one are potentially interesting macrocycles, because these compounds are expected to be aromatic if they contain a (4n+3) membered ring and nonaromatic if they contain a (4n+1) membered ring. To these compounds, F. Sondheimer[1)] proposed a generic name " annulenones ", and they have already reported some derivatives of [13]-[1a)], [15]-[1b)]and [17][1c)]annulenones. Very recently, 4,9-methano[11]annulenone has been synthesized by E. Vogel and his coworkers[2)].

We now report the synthesis of 6,7-benzo-4,9-oxido[11]annulenone (5), an eleven membered (4n+3) ketone, which is therefore expected to be aromatic, if the conjugated system of the molecule is reasonably coplanar.

Despite a report[3)] to the contrary, 3-benzoxepin-2,4-dialdehyde (2), mp 132-3°, was obtained by active manganese dioxide oxydation of 2,4-bis( hydroxymethylene )-3-benzoxepin (1) in chloroform in 50 % yield. The condensation of the dialdehyde (2) with dimethyl acetonedicarboxylate in the presence of piperidinium acetate in chloroform yielded 54.5 % of 6,7-benzo-2,11-dicarbomethoxy-4,9-oxido[11]annulenone (3), as yellow prisms ( from dichloroethane ), mp 285°, λ max ( dichloroethane ) 302 mμ ( ε 51500 ); mass spectrum ( 70 eV ) showed molecular ion at <u>m/e</u> 338, together with other prominent peaks at 310 ( M - CO ), 279 ( M - COOMe ) and 251 ( M - CO - COOMe ); $\nu_{max}^{KBr}$ cm$^{-1}$ : 1703, 1690 ( ν c=o ester ), 1650 ( ν c=o ketone ). The nmr spectrum in



$CDCl_3$ was in accord with the assigned structure; 2H singlet at $\delta$ 7.72 ( the protons adjacent to carbomethoxy groups ), another 2H singlet at 6.95 ( the oxepin protons ), 4H doublet at 7.52 and 7.58 ( benzenoid protons ) and 6H singlet at 3.85 ( carbomethoxy protons ).

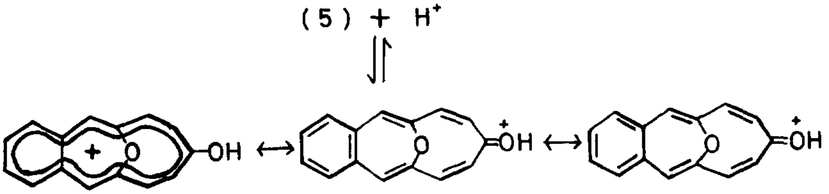
The subsequent hydrolysis of (3) with potassium hydroxide in dioxane-water for 2 hr at 80 - 90° led to the corresponding dicarboxylic acid (4) in 97.4 % yield, yellow prisms, $\lambda$ max ( MeOH ) 293 mμ ( 43300 ); $\nu_{max}^{KBr}$ $cm^{-1}$: 1695 ( $\nu$ c=o carbomethoxy group ), 1653 ( $\nu$ c=o ketone ). Substance (4) was decomposed at 210 - 30° on an attempted melting point determination by the loose of carbon dioxide, and transformed to annulenone (5), which was found to be isolable from the pyrolysis mixture by virtue of its high sublime character. A large scale pyrolysis of (4) on a hot plate and the subsequent sublimation yielded 50.6 % of pure sample of (5) as lemon yellow prisms, mp 225° (from carbon tetrachloride); $\nu_{max}^{KBr}$ $cm^{-1}$: 1642 ( $\nu$ c=o ketone ); $\lambda$ max ( MeOH ) 238 mμ ( 19900 ), 269 ( 32900 ) and 289 ( 28200 ); mass spectrum, molecular ion at $m/e$ 222. The nmr spectrum in $CDCl_3$ confirmed the structure; an AB quartet 4H centered at $\delta$ 6.91 and 6.10 ( J = 11 cps ) was assigned to the cis olefinic protons, a series of peaks 4H at 7.30 - 7.70 to benzenoid protons and a 2H singlet at 6.72 to the oxepin protons [ see Figure 2-a ].

No outer proton of (5) showed a definite deshielding effect due to a diamagnetic ring current. This leads to an unambiguous conclusion that the molecule is best represented by polyenone structure in ground state, as similar as it was found in the case of methano[11]annulenone [2].

Likewise in some derivatives of benzotropolone[4], annulenone (5) was protonated with trifluoroacetic acid or with concentrated sulfuric acid giving rise to a stable deep purple solution, being 1-hydroxy-6,7-benzo-4,9-oxido-cyclododecapentaenylium cation ( 6a, see below ) involved. As seen from Figure 1, when (5) was protonated with 85 % sulfuric acid, two new bands appeared at 345 mμ ( 42000 ) and 480 mμ ( 12400 ), but conversely, these two new bands disappeared by diluting the protonated solution with water. In fact, the spectrum of (6a) measured in 40 % sulfuric acid was principally coincided with that of the parent ketone itself (5).

The above uv spectra strongly suggest that, in concentrated sulfuric acid, (5) is in equilibrium with (6a), and that (6a) is considered to be isoelectronic with an aromatic 14$\pi$ electon system rather than the original 10$\pi$ electon system, because a $C_{14}$-perimeter may also be capable of existence.

It is interesting to compare the uv spectrum of (6a) with that of methano[11]annulenone,[2] measured in sulfuric acid. It can be seen now that the longest wavelength absorption of (6a) is shifted by 165 mu to longer wavelength, as compared with the main absorption maximum of protonated methano[11]annulenone in sulfuric acid, 315 mμ ( 80000 ), supporting the existence of $C_{14}$-



( 6a ) ( 6b )

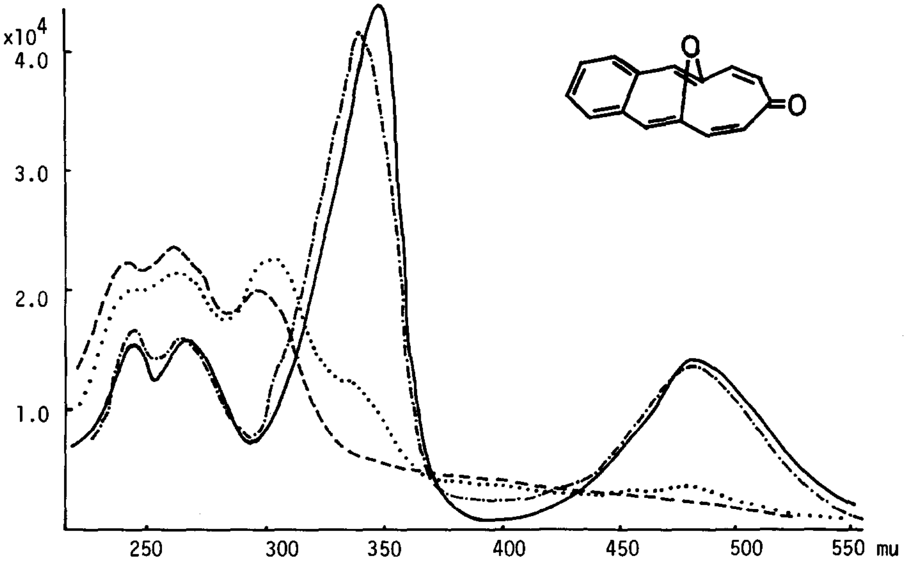


Figure 1. UV Spectra of 6,7-Benzo-4,9-oxido [11]annulenone (5) in various Concentrations of Sulfuric Acid; ——— 85 %, -·-·- 65 %, ········ 50 % and ------- 40 %.

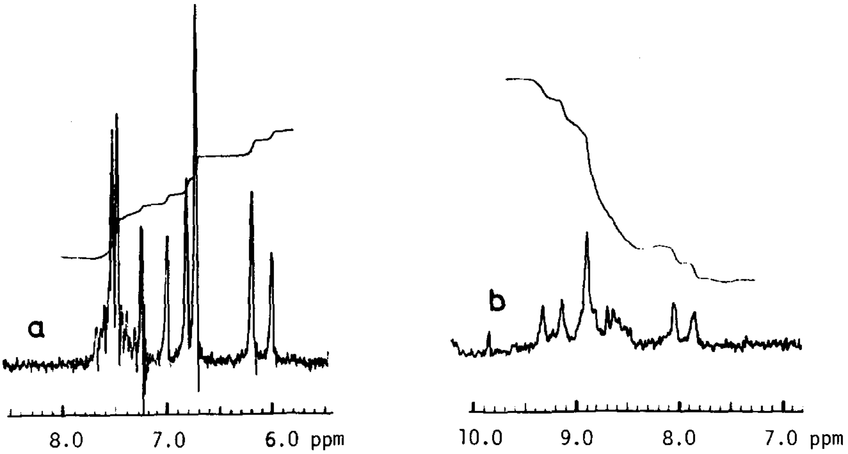


Figure 2. Nmr Spectra of 6,7-Benzo-4,9-oxido[11]annulenone (5)
(a) in $CDCl_3$ ( TMS as internal standard ) and (b) in sulfuric acid ( TMS as external standard )

perimeter. In order to gain further insight on the consideration that (6a) is aromatic in character as 14π electron system, we must await the uv spectral data of protonated 4:13, 6:11-dibridged [15]annulenone for refference which is unknown at present.

As seen from Figure 2-b, the nmr spectrum of (6a) in sulfuric acid indicates the existence of a diamagnetic ring current, since all olefinic protons resonate at considerably lower field; a singlet at δ 8.90, the complex multiplet centered at 8.58, and a AB quartet centered at 7.96 and 9.22 with J = 11 cps ( TMS as external standard ).

Syntheses of 6,7-benzo-4,9-methano- and 4,9-thiano[11]annulenones are currently in progress and will be later reported.

## Acknowledgements

The authors wish to thank Professor Haruo Saikachi, Kyushu University, for his interest during this work. The authors are deeply grateful to Professor F. Sondheimer, University College London, for reading this manuscript and offering valuable suggestions. The authors are also grateful to Professor E. Vogel, Köln University, for kind supply of authentic methano[11]annulenone for uv measurement. Finally, we wish to express our thanks to Kureha Chemical Company for a supply of o-phthaldehyde.

## REFFERENCES

* Presented at 71th Kyushu Regional Meeting of Pharmaceutical Society of Japan, 13th, February, 1971.

** Adress correspondence to this author.

*** Present adress, Kurume Technical College, Department of General Chemistry, Komorino 5341, Kurume City, Japan.

1a) G. M. Pilling, F. Sondheimer, J. Am. Chem. Soc., 90, 5610 (1968).

1b) F. Sondheimer, " Recent Progress in the Annulene Field ,,, Special Lecture at the International Symposium on the Chemistry of Nonbenzenoid Aromatic Compounds, held at 24th, August, 1970, at Sendai, Japan; G. P. Cotterrell, G. H. Mitchell, F. Sondheimer and G. M. Pilling, J. Am. Chem. Soc., 93, 259 (1971).

1c) G. M. Brown, F. Sondheimer, ibid, 91, 760 (1969).

2) W. Grimme, J. Reisdorff, W. Jünemann and E. Vogel, J. Am. Chem. Soc., 92, 6335 (1970).

3) M. J. Jorgenson, J. Org. Chem., 27, 3224 (1962).

4) E. Kloster-Jensen, N. Tarköy, A. Eschenmoser, E. Heilbronner, Helv. Chim. Acta., 39, 786 (1956).