of groups IV and V.[1] The synthesis of $H_5Ta(DMPE)_2$ (**1**) (DMPE = $(CH_3)_2PCH_2CH_2P(CH_3)_2$, 1,2-bisdimethylphosphinoethane) is now reported. This synthesis extends to group V the series of third-row, formally d^0, polyhydrides illustrated by $H_7Re(Ph_2PCH_2CH_2PPh_2)$[2] and $H_6W(PMe_2Ph)_3$.[3]

Compound **1** was synthesized by two routes

(1) $TaCl_5 \xrightarrow[DMPE]{K,H_2}$

(2) $[TaPh_6^-]$[4] $\xrightarrow[DMPE]{H_2}$

$\longrightarrow H_5Ta(DMPE)_2$

1

In reaction 1, a mixture of 1.8 g (5.0 mmol) of $TaCl_5$, 3.8 g (25 mmol) of DMPE, and 2.0 g (51 mmol) of potassium, in 10 ml of benzene, was agitated overnight at 115° in a Hastelloy-C pressure vessel under 1500 psi of hydrogen. After filtration and evaporation of the solvent, the product was crystallized from hexane to yield 0.45 g of **1**. The yields from this type of reaction have varied from 0 to 40%. In reaction 2, a mixture of 54 g (0.058 mol) of $[Li(THF)_4][TaPh_6]$ (THF = tetrahydrofuran), 27 g (0.18 mol) of DMPE, and 250 ml of THF was agitated for 5 hr at 45° in a pressure vessel under 1500 psi of hydrogen. Volatiles were removed from the soluble portion of the reaction mixture and the residue was crystallized from hexane to yield 7.6 g of **1**. An orange THF-insoluble solid, 4.9 g, present in the product mixture is presumably an anionic derivative of **1**. Treatment of a benzene suspension of the solid with 1.2 ml of ethanol produced an additional 2.3 g of **1**. Excess alcohol reduced the yield. Yields from reaction 2 are reproducible, 30–40%. The pentahydride is an air-sensitive white crystalline solid (mp 133–135° dec; mol wt calcd 486, found (cryoscopic in benzene) 464; ir (Nujol) 1544 cm^{-1} (Ta–H stretch)).

The hydride ligands in **1** are readily substituted. Exposure of the pentahydride to hydrogen chloride, water, or ethanol results in rapid generation of hydrogen. Deuterium exchange at the hydride sites (ν_{Ta-D}, 1110 cm^{-1}) occurs when the complex is heated in benzene-d_6 solution at 80° under 900 psi of deuterium. Like $(C_5H_5)_2MH_3$[5] (M = Nb or Ta), **1** catalyzes the exchange of hydrogen with benzene.[6] At 80° in benzene solution under 1500 psi of carbon monoxide, it is converted to the hydridotantalum carbonyl $HTa(CO)_2(DMPE)_2$ (**2**) in 58% yield.[7] (Orange crystals from hexane; mp 140–141°; mol wt calcd 538, found 538 (mass spectrum); ir (C_6D_6 solution) 1737 (C≡O stretch) and 1589 cm^{-1} (Ta–H stretch)). The corresponding deuteride (ν_{Ta-D} = 1137 cm^{-1}), *ca.* 40% enriched, was obtained by a similar procedure from $(H,D)_5Ta(DMPE)_2$.

The compositions and molecular dynamics of **1** and **2** are verified by nmr data.[8] For **1**, the hydride count is obtained from the multiplicity of the ^{31}P spectrum (toluene-d_8, ligand protons noise decoupled, 1:5:10:10:5:1 sextet, 22.4 ppm below 85% H_3PO_4). The hydride nmr spectrum, a 1:4:6:4:1 quintet (C_6D_6, τ 10.70, J_{PH} = 35.0 Hz), is consistent with stereochemical nonrigidity of the molecule over the accessible temperature range ($CHClF_2$, to −140°). Compound **2** is fluxional at 90°, but rigid near 0°.[9]

All of the previously known niobium and tantalum hydride complexes are derivatives of $(\pi\text{-}C_5H_5)_2M$.[10] The cyclopentadienyl ligands formally occupy six of the available coordination sites in these complexes by π bonding[11] and in some cases further deactivate the metal by forming carbon to metal σ bonds as in $[(C_5H_5)(C_5H_4)TaH]_2$.[12] Comparison of the chemistry of the cyclopentadienyl derivatives with the potentially more reactive $(DMPE)_2TaH_5$ is in progress.

Acknowledgments. I thank P. Meakin for the nmr data, N. Schlichter for ir data, and U. Klabunde for permission to quote results prior to publication.

(1) A recent review is "Transition Metal Hydrides," Vol. 1, E. L. Muetterties, Ed., Marcel Dekker, New York, N. Y., 1971.
(2) J. Chatt and R. S. Coffey, *J. Chem. Soc. A*, 1963 (1969).
(3) J. R. Moss and B. L. Shaw, *Chem. Commun.*, 632 (1968).
(4) The synthesis of this new anion by U. Klabunde will be reported separately.
(5) U. Klabunde and G. W. Parshall, *J. Amer. Chem. Soc.*, **94**, 9081 (1972).
(6) U. Klabunde, unpublished results.
(7) Compound **2** has been independently synthesized in the laboratory of J. A. Connor. J. A. Connor, personal communication.
(8) Microanalytical data are: Calcd for $C_{12}H_{37}P_4Ta$ (**1**): C, 29.6; H, 7.7; P, 25.5; Ta, 37.2. Found: C, 29.8; H, 7.8; P, 25.5; Ta, 37.5. Calcd for $C_{14}H_{33}O_2P_4Ta$ (**2**): C, 31.2; H, 6.2. Found: C, 31.2; H, 6.1.
(9) Spectra are analyzed as AA'BB'X systems. A detailed line shape analysis of the permutational process and X-ray diffraction studies of **2** are in progress. P. Meakin, L. J. Guggenberger, F. N. Tebbe, and J. P. Jesson, to be submitted for publication.
(10) M. L. H. Green, J. A. McCleverty, L. Pratt, and G. Wilkinson, *J. Chem. Soc.*, 4854 (1961); E. K. Barefield, G. W. Parshall, and F. N. Tebbe, *J. Amer. Chem. Soc.*, **92**, 5234 (1970); F. N. Tebbe and G. W. Parshall, *ibid.*, **93**, 3793 (1971).
(11) C. J. Ballhausen and J. P. Dahl, *Acta Chem. Scand.*, **15**, 1333 (1961).
(12) L. J. Guggenberger, *Inorg. Chem.*, **12**, 294 (1973).

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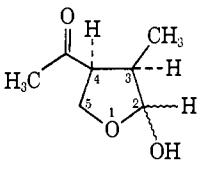
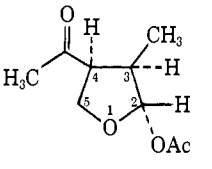
Stereochemistry and Synthesis of the Antileukemic Agent Botryodiplodin

Sir:

In 1968, Arsenault[1] defined the gross structure of an antibiotic isolated from *Botryodiplodia theobromae* Pat.[2] as 2-hydroxy-3-methyl-4-acetyltetrahydrofuran (I) by chemical ionization mass spectrometry. Aside from its antibiotic character, compound I (botryodiplodin) also exhibits antileukemia activity[3] and the interesting property of turning the skin of individuals various shades of pink[2] 2–3 hr after its application.



I



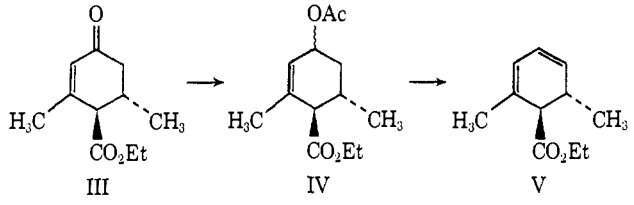
II

Although the nmr of I in CCl_4 was complicated, due to anomers at C_2, the corresponding acetate II appeared to be a single isomer and was tentatively assigned structure II,[1] based on the value of J_{H_3,H_4} (7 Hz). Because of the ambiguity of assigning stereochemistry

(1) G. P. Arsenault, J. R. Althaus, and P. V. Divekar, *Chem. Commun.*, 1414 (1969).
(2) R. Sen Gupta, R. R. Chandran, and P. V. Divekar, *Indian J. Exp. Biol.*, 4, 152 (1966).
(3) Results of preliminary testing by the National Institutes of Health.

to tetrahydrofuran derivatives based on coupling constants,[4] and the desire to obtain quantities of compound I for further studies, we undertook the synthesis of compound I in a manner which decisively bears on its stereochemistry. The results are summarized below.

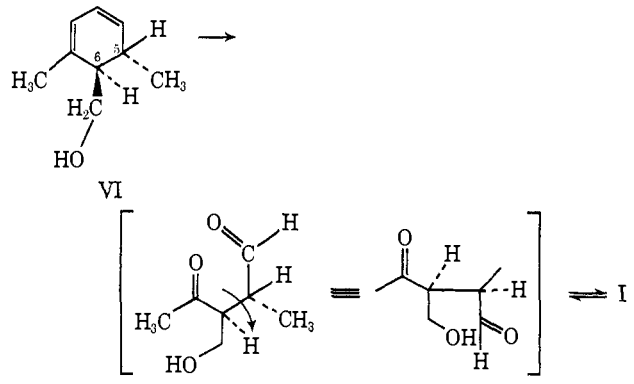
The readily available 3,5-dimethyl-4-carbethoxycyclohex-2-en-1-one (III)[5] was subjected to reduction with sodium borohydride and subsequent acetylation (Ac_2O–pyridine, 0°, overnight) to provide the allylic acetate mixture IV[6] in 75% yield (bp 93–97° (0.05 mm)). Pyrolytic elimination of acetic acid at 450° (0.1 mm) gave a mixture of three dienes[7] in 95% yield from which the major isomer V [40%; $\lambda_{max}^{95\%\ EtOH}$ 262 nm (log



III IV V

ϵ 4.44)] was separated by preparative glc. Reduction of V with lithium aluminum hydride afforded the homoannular dienol VI[8] [$\lambda_{max}^{95\%\ EtOH}$ 262 nm (log ϵ 4.13); bp 80–83° (0.1 mm)] in 95% yield.

Ozonolysis of VI (CH_2Cl_2, −78°, Zn, HOAc) produced *dl*-botryodiplodin presumably *via* intermediate VII. It is seen that the trans relationship of the hydrogens at C_5 and C_6 in alicyclic structure VI is translated into a syn relationship in rotamer VII and thence into a cis relationship in the heterocyclic structure I. The stereochemical relationship of the nonanomeric



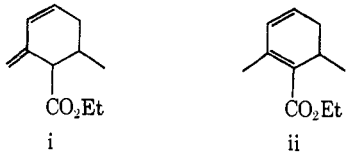
VI VII

(4) J. D. Stevens and H. G. Fletcher, Jr., *J. Org. Chem.*, 33, 1799 (1968).

(5) E. C. Horning, M. O. Denekas, and R. E. Field, "Organic Synthesis," Collect. Vol. III, John Wiley, New York, N. Y., 1955, p 317.

(6) All new compounds had ir, nmr (250 MHz), elemental analysis, and/or high-resolution mass spectra compatible with the structures proposed.

(7) Two isomeric products, shown to be i and ii, were also formed in this reaction, probably as a result of competitive rearrangement to a tertiary allylic acetate and subsequent loss of acetic acid.



i ii

(8) The stereochemistry of VI is trans as shown, this assignment resting on its mode of synthesis and the value of the vicinal coupling constant (*via* triple resonance) between the aliphatic ring hydrogens (1.1 Hz).

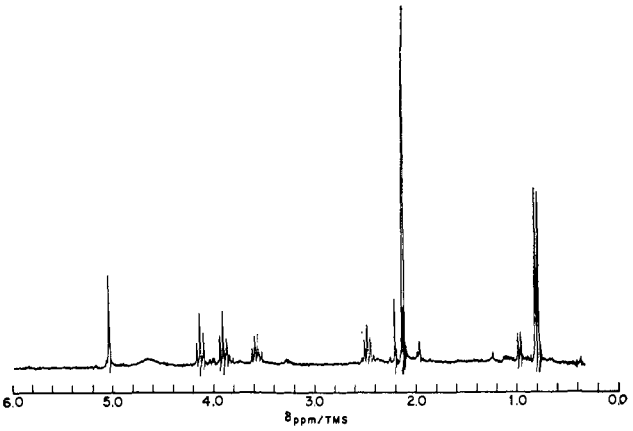


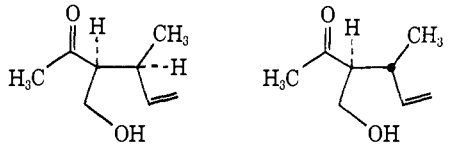
Figure 1. 250-MHz spectrum of synthetic botryodiplodin.

centers is thus defined.[9] The nmr spectra of synthetic (see Figure 1) and natural botryodiplodin[10] measured at 250 MHz[11] in CCl_4 were identical, except for slight differences in the ratio of anomers. The acetate derived from the synthetic material also displayed spectral properties identical with those of natural botryodiplodin acetate.

We are currently preparing analogs of I, by ozonolysis of appropriately substituted unsaturated alcohol derivatives, in order to define the structural features necessary for anti-cancer activity.

Acknowledgment. We thank the Research Corporation and the Chemistry Department of Carnegie-Mellon University for financial support of this work.

(9) A referee has raised the question of epimerization in the enolizable intermediate VII. We believe that this possibility can be discounted because we have shown that pure diastereomers iii and iv give *only* botryodiplodin and 3-*epi*-botryodiplodin, respectively, upon ozonolysis.



iii iv

(10) We wish to thank Professor Arsenault for a sample of natural botryodiplodin.

(11) The 250-MHz nmr spectra of all compounds in this study were taken at the National Institutes of Health Facility for Biomedical Studies (Grant No. RR20092), located at Carnegie-Mellon University.

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Construction of Additional Bridges across [2.2]Paracyclophane[1]

Sir:

The synthesis of the highly strained [2.2.2](1,3,5)-cyclophane (**1**) has been reported.[2] The key step involved an elegant reaction in which three three-atom bridges were contracted to three two-atom bridges. We report here the synthesis, and a novel reaction of [2.2.2](1,2,4)cyclophane (**2**), as well as the synthesis of

(1) This work was supported by a grant from the National Science Foundation (GP 4395).

(2) V. Boekelheide and R. A. Hollins, *J. Amer. Chem. Soc.*, 92, 3512 (1970).