

Figure 1. A computer generated perspective drawing of the *N*₆-*p*-bromobenzyltetraacetylvincoside derivative. Hydrogens are omitted for clarity.

readily obtainable **1a** (hydrochloride) via its 2,2,2-trichloroethoxycarbonyl derivative, **1d**, as well as **1b** via **1e**.

Small acicular crystals of *N*₆-*p*-bromobenzyltetraacetylvincoside¹¹ (**1c**) were used for an X-ray diffraction experiment. This derivative crystallizes in the common, chiral space group *P*₂₁, with *a* = 8.447(1) Å, *b* = 18.515(3) Å, *c* = 14.188(2) Å, and β = 104.26(1)°. A calculated (*Z* = 2) and approximately measured density of 1.34 g cm⁻³ indicated that one molecule of composition C₄₂H₄₇N₂O₁₃Br formed the asymmetric unit.

All unique reflections with 2θ ≤ 114° were measured using graphite monochromated Cu K_α (1.5418 Å) X-rays and an ω-scan technique on an automated four-circle diffractometer. After corrections for Lorentz, polarization, and background effects 2050 (68%) of the measured intensities were judged observed (*F*_o² > 3σ(*F*_o²)).

The bromine atom was easily located by standard Patterson techniques. Further elaboration of the structure from the bromine-phased electron density maps was frustrated by a pseudo-mirror plane generated by having only one atom in the asymmetric unit. The tangent formula recycling procedure¹² resolved this dilemma and after several cycles all nonhydrogen atoms had been located. Full-matrix, least-squares refinements with anisotropic temperature factors for the nonhydrogen atoms and no hydrogen atoms have reduced the standard crystallographic discrepancy index to its current minimum of 0.068 for the observed reflections.¹³

Figure 1 is a computer generated drawing of the current X-ray model. As can be seen, the configuration of the hydrogen at C-3 of **1c** is clearly β. Full crystallographic details will be published in a subsequent paper.

Hydrogenolysis (5% Pd/C, 3 atm, MeOH–AcOH) of **1c**, treatment with aqueous Na₂CO₃, and Zemplen deacetylation² gave 18,19-dihydro-**2a**, whose melting point (189.5–190.5°), mixture melting point, and TLC behavior were identical with a reference sample of 18,19-dihydrovincoside lactam prepared according to Battersby et al.² The 18,19-dihydro-**2a** can be shown also to be identical with **3a** by the reported chemical conversions.⁹

Treatment at 0° of a chloroform (4 ml) suspension of the freeze-dried reaction mixture (120 mg) obtained from the synthesis of **1a** and **1b**² with dry pyridine (1 ml) followed immediately with 2,2,2-trichloroethylchloroformate¹⁴ (0.36 ml, twofold excess) gave a homogeneous red solution, which was allowed to stir for 12–18 hr (25°). The work-up described^{15a} readily gave **1d**^{15b} and **1e**^{15c} as chromatographically pure compounds. Upon deblocking of **1d** (or **1e**) (Zn dust, glacial AcOH, 25°, 4 hr) **1a** (or **1b**) could be obtained (70%) as its hydrochloride,¹⁶ which was shown to be uncontaminated with **1b** (or **1a**) by its conversion to **2a** (or **2b**). Thereby, the structure and stereochemistry of the actual biochemical intermediates are confirmed by correlation to **1c**. These results are being confirmed biologically in *Campylothecha acuminata*⁸ and *Catharanthus roseus*.^{2,17}

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- (10) Designates C-3 *R* stereochemistry for the glucoside; **2b** and **3b** designate C-3 *S* stereochemistry.
- (11) Prepared analogously to the procedure of R. T. Brown and C. L. Chapple, *J. Chem. Soc., Chem. Commun.*, 740 (1974), as follows: *N*₆-*p*-bromobenzyltryptamine hydrochloride was synthesized from tryptamine and *p*-bromobenzaldehyde by reduction of their Schiff base with NaBH₄ in EtOH: 36%; mp 230–233° dec (EtOH–hexane). Anal. Calcd for C₁₇H₁₈BrN₂: C, 55.83; H, 4.96; N, 7.66; Br, 21.85. Found: C, 55.94; H, 4.91; N, 7.39; Br, 22.12. This amine hydrochloride and secologanin underwent Pictet–Spengler condensation in glacial AcOH containing NaOAc (1 equiv) at 60° for 7 days. Acetylation (pyridine, Ac₂O) of the crude product followed by chromatography of the tetraacetate gave **1c**: 32–63%; mp 162–164° (MeOH–H₂O); [α]_D²⁵ -65° (c 0.11, MeOH); mass spectrum *m/e* (relative intensity) 698 (0.65), 521 (0.65), 519 (0.65), 341 (29.4), 339 (30.0), 171 (13.7), 169 (28.5), 43 (100); ir (KBr) cm⁻¹ 1750, 1698, 1620; NMR (90 MHz, CDCl₃) δ 1.95 (s, 3 H); 2.03 (s, 6 H), 2.11 (s, 3 H), 3.61 (s, 3 H), 3.71 (m, 2 H).
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- (15) (a) The solvent and excess reagents were removed in vacuo at 40°. The resulting residue was partitioned between Et₂O and ice cold H₂O; the Et₂O layer was dried (MgSO₄) and evaporated. The resulting crude solid residue was PLC'd on silica gel PF₂₅₄ (E-Merck & Co.) in hexane–ethyl acetate (3:1) to obtain **1d** and **1e** as colorless solids. (b) *R*_f = 0.26; NMR (CDCl₃) δ 3.68 (s, 3 H), 4.74 (s, 2 H), 4.78 (s, 8 H); ir (KBr) cm⁻¹ 1780 (br s), 1710 (br s), 1635 (w); [α]_D²⁵ = -90° (c 0.10; CHCl₃), [M]_D²⁵ -1266°. (c) *R*_f = 0.37; NMR (CDCl₃) δ 3.73 (s, 3 H), 4.74 (s, 2 H), 4.78 (s, 8 H); ir (KBr) cm⁻¹ 1780 (br s), 1710 (br s), 1635 (w); [α]_D²⁵ -44° (c 0.094; CHCl₃), [M]_D²⁵ -623°.
- (16) The calculated amount of hydrochloric acid must be added to the filtered acetic acid solution before solvent evaporation to avoid formation of **2a** (or **2b**).
- (17) This research was supported in part by a grant from the National Institutes of Health (CA 17127) to C.R.H.
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Structure of Crystalline (Hexatriene dianion)dilithium, an Ion-Paired *Z,Z*-Dianion

Sir:

Hoffmann and Olofson predicted on the basis of extended Hückel calculations that the most stable shape of hexa-

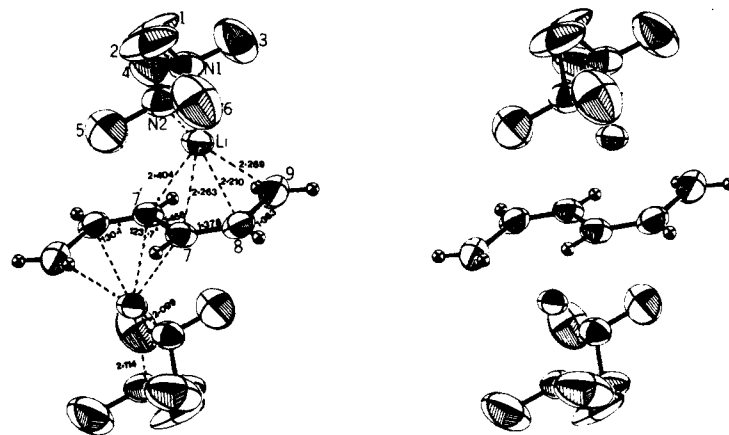
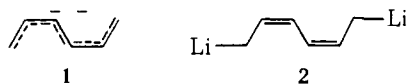


Figure 1. Stereoscopic view with selected bond lengths (Å) and angles (deg). Standard deviations in CC, LiC, and LiN lengths were 0.05, 0.07, and 0.07 Å, respectively, and in angles, 0.3°.

triene dianion would be **1**.¹ Recently, we prepared (hexatriene dianion)dilithium and obtained evidence from a ¹H NMR coupling constant that in solution this substance prefers the *Z,Z* shape as in **1**, but it was not clear whether a π -bonded ionic species like **1** or a σ -bonded covalent one like **2** was involved.² As this dilithiated substance apparently crystallized well from the tetramethylenediamine (TMEDA)-hexane solution in which it was generated, an X-ray study was initiated to gain further information regarding its structure.



The red twinned crystals were split and mounted in a capillary under argon. The space group is $P2_1/c$ with cell dimensions $a = 8.614$ (4) Å, $b = 8.356$ (4) Å, $c = 15.975$ (6) Å, $\beta = 96.1^\circ$, $d_c = 0.947$ g/cm³ for $C_6H_8Li_2 \cdot 2C_6H_{16}N_2$, and $Z = 2$. A set of 945 reflections $>3\sigma$ was obtained using a Picker FACS-I diffractometer with Cu $K\alpha$ radiation. The structure was solved using MULTAN³ and refined anisotropically to $R = 0.065$. Some disorder was not surprisingly⁴ noted in the TMEDA and was compensated for partly by anisotropic thermal motion and partly by refining Cl in two positions, with occupancy factors of 0.78 and 0.22.

As can be readily seen in Figure 1, the crystals consist of *Z,Z*-hexatriene dianions ion-paired with lithium-TMEDA, with a center of symmetry at the dianion center. The structure is quite similar to that of the corresponding complex of naphthalene dianion.⁵ The carbons and four of the hydrogens of the dianion **1** are within 0.02 Å of coplanarity; the C7 hydrogen is 0.17 Å and the internal C9 hydrogen is 0.87 Å out of this plane, both bending away from the nearest lithium atom. As expected from MO calculations, the C7-C8 and C8-C9 bonds in the dianion are about equally long and are noticeably shorter than the central bond. **1** can thus be roughly approximated as two allyl anions attached by a single bond, a situation reminiscent of butadiene (central bond, 1.483 Å).⁶ As in butadiene, some delocalization energy is very likely gained in **1** by having the two π systems coplanar.

Knowledge of the geometry of dianion **1** permits more accurate calculation of the electron densities on its carbons: INDO calculations suggest charges of -0.18, +0.07, and -0.49 on C7, C8, and C9, respectively.

It has been proposed by Brooks and Stucky⁴ that carbanion stability can be deduced in a complex of this sort from the Li-N bond lengths. If so, **1**, with Li-N bonds averaging

2.107 (7) Å, is about as stable as naphthalene dianion.⁵

The question remains why the dianion **1** prefers the *Z,Z* shape in the crystal and in solution.² MO calculations indicate this shape to be favored in the absence of cation due to attractive 1,4-overlaps.¹ However, another factor favoring this shape in the ion pair is coordination of each metal atom with *four* rather than three partially negatively charged carbons. It is not clear how much each of these factors contributes to making the observed shape the most stable.

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Supplementary Materials Available. A packing diagram and tables of coordinates, temperature factors, bond distances, bond angles, least-squares plane, and structure factors 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 Business Office, Books and Journals Division, American Chemical Society, 1155 16th St., N.W., Washington, D.C. 20036. Remit check or money order for \$4.50 for photocopy or \$2.50 for microfiche, referring to code number JACS-75-6271.

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Asymmetric Titanium(IV) Metal. First Example of a Resolved Titanocene Derivative

Sir:

Dynamic stereochemistry of ligand substitution has been studied in many cases for square-planar and octahedral