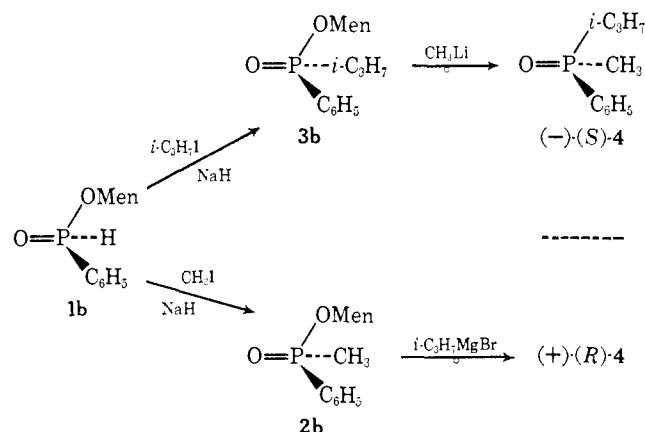


ilar treatment of a 30/70 mixture of **1a/1b** provided a 30/70 mixture of **2a/2b**. The methylation of **1** therefore proceeds stereospecifically with retention of configuration.¹⁰

Alkylation of **1** with secondary alkyl iodides is illustrated by the reaction of a 30/70 mixture of **1a/1b** with isopropyl iodide according to the above procedure. The product, menthyl isopropylphenylphosphinate (**3**), consisted of a 35/65 mixture of **3a/3b**, identified as *R_P/S_P* by the characteristic⁸ upfield shift of the H_a proton signal (τ 9.65) in **3b**. Similarly, alkylation of a 95/5 mixture of **1a/1b** with isopropyl iodide gave a 90/10 mixture of **3a/3b**. Therefore, alkylation of **1** proceeds with predominant retention of configuration.

The stereochemistry of this alkylation reaction was confirmed by the chemical correlation of **2b** and **3b** (Chart I). A 30/70 mixture of **3a/3b** was treated with

Chart I^a

^a Men = (-)-menthyl.

methyl lithium to provide (-)-isopropylmethylphenylphosphine oxide (**4**),¹¹ $[\alpha]^{26\text{D}} -9.1^\circ$ (methanol). Reaction of diastereomerically pure **2b** with isopropylmagnesium bromide afforded (+)-**4**, $[\alpha]^{24\text{D}} +25.3^\circ$ (methanol). Since reactions of Grignard^{2a} and alkyllithium^{2b} reagents with phosphinates proceed with predominant inversion of configuration at phosphorus, the chirality *S_P* at phosphorus in **3b** and the retention stereochemistry of the alkylation reaction are both corroborated.

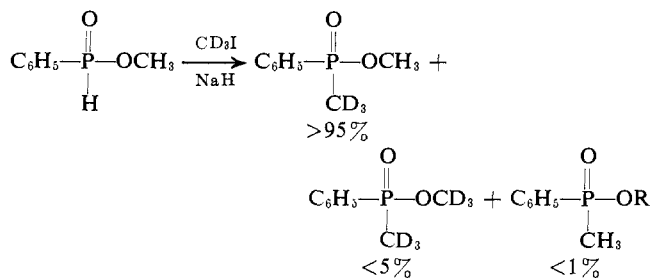
The alkylation of alkyl phenylphosphinates under the present conditions is presumed to occur by initial formation of the corresponding anion $[\text{Ph}(\text{AlkO})\text{PO}]^-$. Attack on carbon by this anion¹² may in principle occur by either one of two routes: through phosphorus, to give the final product directly, or through oxygen, to give a dialkyl phenylphosphonite intermediate, which then undergoes Michaelis-Arbuzov rearrangement by further reaction with the alkyl

(10) The anion derived from **1** is stereolabile under these conditions and significant deviations from the given procedure may therefore lead to epimerization. For example, reaction of a 30/70 mixture of **1a/1b** with sodium hydride in DMF, followed by the addition of methyl iodide after hydrogen evolution had ceased, gave an approximately equimolar mixture of **2a** and **2b**.

(11) The pmr spectrum of **4** featured: PCH_3 , d, τ 8.30, $^3J_{\text{PH}} = 12.5$ Hz; CH_3 , dd, τ 8.92, $^3J_{\text{PH}} = 16$ Hz, $^3J_{\text{HH}} = 7$ Hz; CH_2 , dd, τ 8.77, $^3J_{\text{PH}} = 16$ Hz, $^3J_{\text{HH}} = 7$ Hz; $\text{CH}(\text{CH}_3)_2$, m, τ 7.60-8.34; C_6H_5 , m, τ 2.0-2.6.

(12) G. M. Kosolapoff, *J. Amer. Chem. Soc.*, **72**, 4292 (1950). See also: K. Sasse in Houben-Weyl's "Methoden der organischen Chemie," Vol. 12, Part 1, Georg Thieme Verlag, Stuttgart, 1963, pp 446-453.

halide.¹³ The latter pathway was effectively eliminated by the observation that treatment of methyl phenylphosphinate¹⁴ with a tenfold excess of methyl-*d*₃ iodide gave almost exclusively methyl methyl-*d*₃-phenylphosphinate



(13) R. G. Harvey and E. R. De Sombre, "Topics in Phosphorous Chemistry," Vol. 1, M. Grayson and E. J. Griffith, Ed., Interscience, New York, N. Y., 1964, Chapter 3.

(14) A. N. Pudovik and D. Kh. Yarmukhametova, *Izv. Akad. Nauk SSSR, Otd. Khim. Nauk*, 902 (1952); *Chem. Abstr.*, **47**, 10469c (1953).

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Bicyclo[2.1.1]hexan-5-one via the Reaction of 2-Chloronorbornene with Phenyllithium

Sir:

Recently, we reported^{1,2} on the unusual reaction of **1** with ethereal methyl lithium to yield **2**. As part of our continuing interest in the reactions of vinyl halides



with organometallic reagents, we have investigated the reaction of **1** with commercially available phenyllithium.³ We now wish to report that phenyllithium reacts with **1** in an unprecedented manner to provide the first example of a new type of ring contraction reaction.

When a solution of 2-chloronorbornene (**1**) and phenyllithium in 70:30 benzene-ether³ was refluxed for 24 hr, a mixture consisting of 90% of 5-benzal-bicyclo[2.1.1]hexane (**3**) and 10% of 2-phenylnortricyclane (**4**) was obtained in 69% yield.^{4,5} The structural evidence for **3** was obtained through both spectroscopic and chemical means. The ir spectrum of **3** showed a

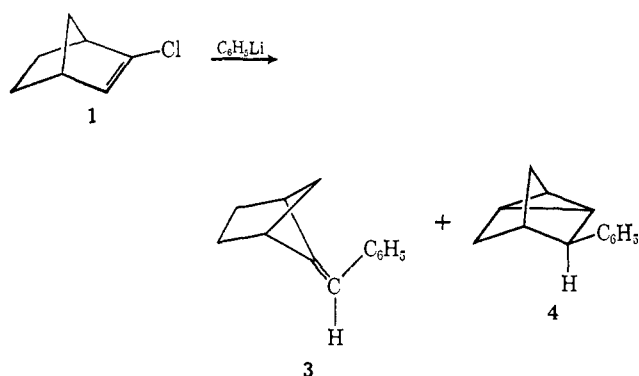
(1) P. G. Gassman, J. P. Andrews, Jr., and D. S. Patton, *Chem. Commun.*, 437 (1969).

(2) Certain mechanistic details of the conversion of **1** into **2** through the use of methyl lithium remain to be elucidated. However, it has been found that optically active **1** yields optically active **2** with retention of stereochemistry (T. J. Atkins, unpublished work).

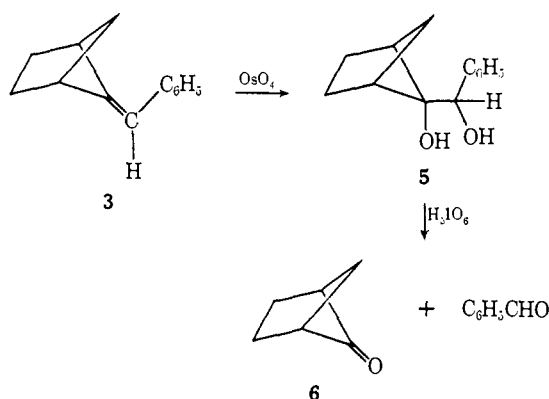
(3) Phenyllithium solution which was 2.2 M in 70:30 benzene-ether was purchased from Alfa Inorganics, Inc. The reaction was sensitive to the quality of the phenyllithium and to the solvent. The use of pure ether as a solvent results in poorer yields of **3**.

(4) These values represent yields of products isolated after chromatography on activity I basic alumina. Vpc of the crude reaction product vs. an internal standard indicated a 87% yield of **3** and a 9% yield of **4**.

(5) Satisfactory elemental analyses have been obtained for all new compounds.



characteristic olefinic stretching vibration at 5.90μ . The nmr spectrum showed the aromatic hydrogens as a five-proton singlet at τ 2.83. The aliphatic protons appeared at τ 4.22 (singlet, 1 H), 6.60 (multiplet, 1 H), 7.07 (multiplet, 1 H), 8.20 (singlet, 5 H), and 8.78 (doublet, $J = 7$ Hz, 1 H). Osmium tetroxide in pyridine converted **3** into **5** in 92% yield.⁶ Cleavage of **5** with periodic acid⁸ gave a 67% yield of **6**⁹ and 68% yield of benzaldehyde. The nmr spectrum of **6** was



identical with the published spectrum of bicyclo[2.1.1]hexan-5-one.^{7,10}

The structural assignment of **4** was based on its ir, nmr, and near-infrared spectra. This spectroscopic data demonstrated the presence of a monosubstituted benzene ring and of the nortricycyl skeleton. The single benzylic proton at τ 7.17 showed that the phenyl group was at the 2 position.

It seems likely that a single intermediate may be involved in the formation of both **3** and **4**. Addition of phenyllithium to **1** could give **7** which, *via* α elimination of chloride, would give the carbenoid intermediate **8**. Intramolecular insertion into the C-H bond across the ring would give **4**, while ring contraction would produce **3**. The chemical fate of **7** can be compared to that of diazocamphor (**9**) which on treatment with copper powder gives primarily the insertion product **10**¹¹ and on irradiation undergoes a

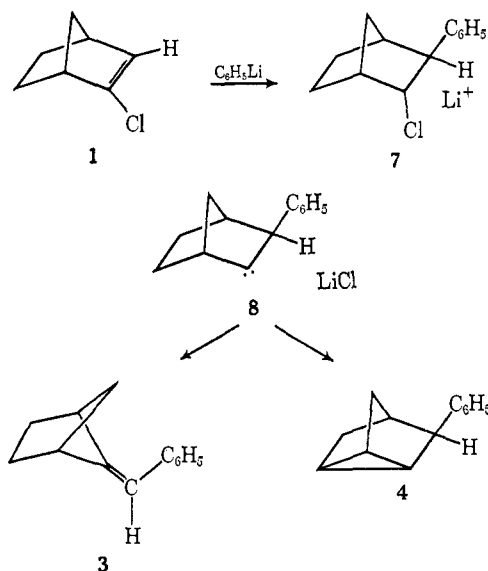
(6) The stereochemistry of **5** was based on a comparison of its nmr spectrum with those of *exo*- and *endo*-5-hydroxybicyclo[2.1.1]hexane.⁷

(7) K. B. Wiberg, B. R. Lowry, and B. J. Nist, *J. Amer. Chem. Soc.*, **84**, 1594 (1962).

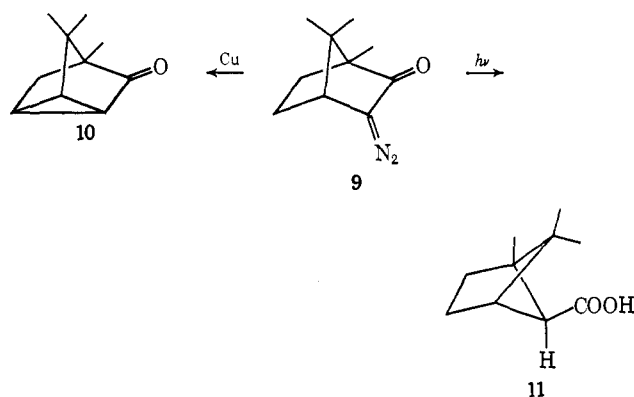
(8) A saturated ethereal solution of periodic acid was used, as described in L. Feiser and M. Fieser, "Reagents for Organic Synthesis," Vol. 1, Wiley, New York, N. Y., 1967, p 817.

(9) The preparation of **6** described in this communication provides an improved method for the synthesis of numerous derivatives of the bicyclo[2.1.1]hexyl system, including bicyclo[2.1.1]hexan-5-one.

(10) K. B. Wiberg, B. R. Lowry, and T. H. Colby, *J. Amer. Chem. Soc.*, **83**, 3998 (1961).



photochemical ring contraction to yield **11** as the major product.¹² This photochemical Wolff rearrangement



has served as a major route to the bicyclo[2.1.1]hexane ring system. In this regard the formation of **3** from **1** provides one of the few nonphotochemical routes to derivatives of bicyclo[2.1.1]hexane.

The formation of **3** observed in the reaction of **1** with phenyllithium provides the first example of a new type of ring contraction. In view of the strained nature of **3**, it is evident that this procedure can be utilized in the synthesis of small rings. We are currently investigating the scope and detailed mechanistic aspects of this unusual ring contraction.

(11) J. Bredt and W. Holz, *J. Prakt. Chem.*, **203**, 133 (1917); A. Angeli, *Gazz. Chim. Ital.*, **24**, II, 317 (1894).

(12) L. Horner and E. Spietschka, *Chem. Ber.*, **88**, 934 (1955); J. Meinwald, A. Lewis, and P. G. Gassman, *J. Amer. Chem. Soc.*, **82**, 2649 (1960); **84**, 977 (1962).

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Biosynthesis of Ergosta-4,6,8(14),22-tetraen-3-one. In Vivo Incorporation of a 1,4-Dioxide

Sir:

The participation of dioxides in biological oxygenation has been suggested by Hayaishi¹ and, more re-