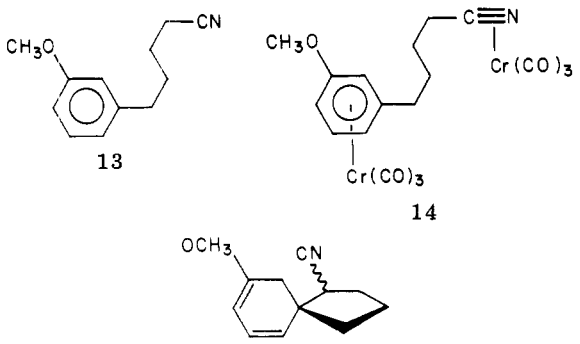
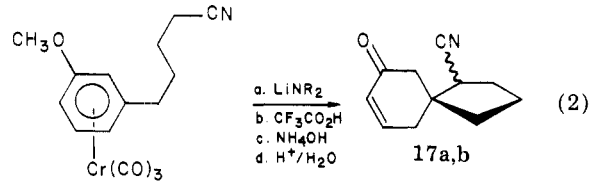


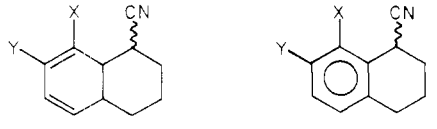
13 14 16a,b

concentrated aqueous ammonium hydroxide. After extraction procedures as before, short-path distillation (90 °C (0.01 torr)] afforded a liquid shown to be a mixture of **16a** and **16b** (278 mg, 70% yield together),[18] separable by analytical GLC. Treatment of the mixture **16** with a solution of aqueous hydrochloric acid (5 M) and THF (equivolume) at reflux for 24 h gave, after the usual isolation procedures, a mixture of diastereoisomeric spirocyclohexenones (**17a,b**; 96% yield) which were separable by preparative GLC.[19]



15 17a,b (2)

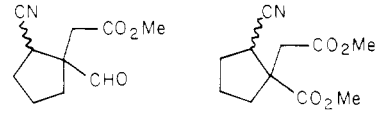
The analysis of the ^{1}H NMR spectral data for **16** is consistent with the proposed structures, especially using correlations with **4**. However, the fused ring isomers (e.g., **18** and **19**) are not easily ruled out using these data and



18, X = OCH_3; Y = H **20**, X = OCH_3; Y = H
19, X = H; Y = OCH_3 **21**, X = H; Y = OCH_3

are reasonable alternatives considering that: (1) cyclization of parent example of **15** (where $-OCH_3$ is $-H$) leads exclusively to ortho attack to give the fused ring (tetralin) system[20] and (2) treatment of **16** with DDQ (benzene, reflux) produced a mixture of 8-methoxy- and 7-methoxy-1-cyanotetralin (**20** and **21**).[21] This latter observation is consistent with structures **18** and **19**, and requires a spiro-to-fused ring rearrangement in order to be accommodated by structures **16**.

To verify structures **16**, the mixture was treated with ozone to produce **22**; the aldehyde unit was oxidized (Ag_2O) and esterified to form **23**. The diester **23** was prepared



22 23

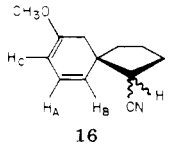
for comparison by alkylation of 2-(carbomethoxy)cyclopentanone with methyl 2-bromoacetate, followed by reaction of the ketone unit with tosylmethyl isocyanide.[23] The products **23** were identical (GLC retention time, ^{1}H NMR) with a mixture of diastereomeric cyano diesters from degradation of **16**.

We are currently undertaking tests of the scope of this new method of synthesis of 3-substituted cyclohexenones, including applications in the area of spirocyclic sesquiterpenes.[24]

Registry No. 1, 12116-44-8; **2**, 71076-33-0; **3**, 55440-70-5; **4**, 71060-35-0; **5**, 71060-36-1; **6**, 71060-37-2; **7**, 71060-38-3; **8**, 17653-93-9; **9**, 71060-39-4; **10**, 71060-40-7; **11**, 1195-98-8; **12**, 21653-33-8; **13**, 62248-72-0; **14**, 71076-34-1; **15**, 62259-89-6; *trans*-**16**, 71060-41-8; *cis*-**16**, 71060-42-9; *cis*-**17**, 71060-43-0; *trans*-**17**, 71060-44-1; **18**, 71060-45-2; **19**, 71060-46-3; **20**, 62248-74-2; **21**, 62248-73-1; **22**, 71060-47-4; **23**, 71060-48-5; *m*-methoxycinnamic acid, 6099-04-3; 2-(carbomethoxy)cyclopentanone, 10472-24-9; methyl 2-bromoacetate, 96-32-2; 2-methylpropionitrile, 78-82-0; 3-(*m*-methoxyphenyl)-1-propanol, 7252-82-6; 3-(*m*-methoxyphenyl)-1-iodopropane, 57822-33-0; chromium hexacarbonyl, 13007-92-6; 2-(carbomethoxy)-2-(carboethoxymethyl)cyclopentanone, 41301-65-9.

Supplementary Material Available: Full experimental details (10 pages). Ordering information is given on any current masthead page.

(18) The diastereoisomers **16** were not separated. The region δ 4.7–6.3 (vinyl H) in the ^{1}H NMR spectrum was particularly revealing.



16

H_A: overlapping doublet of doublets, centered at δ 6.00 and 5.86; J_{AB} = 9.0 Hz, J_{AC} = 6.0 Hz. H_B: overlapping doublets centered at δ 5.10 and 5.38; J_{AB} = 9.0 Hz, $J_{BC} \simeq 0$. H_C: overlapping doublets (broadened) centered at δ 4.96 and 4.92; J_{AC} = 6.0 Hz.

(19) Eluted first (OV-17, 190 °C) was **17a**: ^{1}H NMR ($CDCl_3$) δ 6.8–7.1 (m, 1 H, vinyl H), 6.1 (dt, 1 H, vinyl H), 1.6–2.7 (m, 11 H); IR ($CHCl_3$) 2250 (m), 1680 (s) cm^{-1}; mass spectral molecular weight, 175.0971; calcd for $C_{11}H_{13}NO$, 175.0946. Eluted second was **17b**: ^{1}H NMR ($CDCl_3$) δ 6.8–7.0 (m, 1 H, vinyl H), 6.1 (br d, 1 H, vinyl H), 1.6–2.8 (m, 11 H); IR ($CHCl_3$) 2250 (m), 1625 (s) cm^{-1}; mass spectral molecular weight, 175.0968; calcd for $C_{11}H_{13}NO$, 175.0946.

(20) M. F. Semmelhack, Y. Thebtaranonth, and L. Keller, *J. Am. Chem. Soc.*, **99**, 959 (1977).

(21) Compounds **20** and **21** showed ^{1}H NMR, IR, and mass spectral data consistent with the assigned structures. They were conclusively identified by oxidative decyanation[22] and comparison of the resulting 8-methoxy- and 7-methoxy-1-tetralones with commercial samples (GLC retention time, ^{1}H NMR data).

(22) S. J. Selikson and D. S. Watt, *J. Org. Chem.*, **40**, 267 (1975).

(23) O. H. Oldenziel and A. M. VanLeusen, *Tetrahedron Lett.*, 1357 (1973).

(24) We are please to acknowledge financial support of our research program by the National Science Foundation, the National Institutes of Health, and the donors of the Petroleum Research Fund, administered by the American Chemical Society. Mass spectra were obtained at the Cornell Mass Spectrometry Facility under the direction of Dr. Tim Wachs, to whom we are grateful.

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(26) Recipient of a postdoctoral research fellowship from the National Science Foundation.

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Synthesis of Cyclopropanes via the Addition of Organometallics to 3-Substituted-1-alkenyl Sulfones

Summary: 3-Bromo-1-(phenylsulfonyl)-1-propene reacts with allylic, propargyl, aryl, and benzyl Grignard reagents to give *trans*-2-substituted-cyclopropyl phenyl sulfones in yields up to 80%.

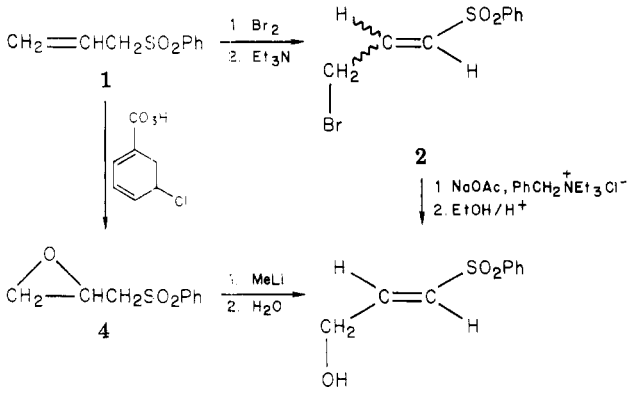
Sir: The stabilization of carbanionic centers by adjacent sulfur groups is the basis of many valuable transformations

in organic synthesis. Recently, vinylic sulfides, sulfoxides, and sulfones have been shown to undergo selective metalations[1-3] or Michael additions[4,5] with various organometallic reagents. Furthermore, such sulfur-mediated reactions have led to novel organic transformations, such as the conversion of α,β-unsaturated compounds into substituted cyclopropanes[6] and of β,γ-epoxycycloalkyl phenyl sulfones into α,β-disubstituted-2-cycloalkenones.[5]

In evaluating the possible competition between metalation and Michael addition for vinylic sulfones,[3] we have examined the behavior of various 3-substituted-1-alkenyl sulfones toward organometallic reagents. In so doing, we have uncovered novel routes to substituted cyclopropyl sulfones. Since such cyclopropanes can be desulfurized by heating with sodium amalgam and an alcohol,[7] this procedure provides a route to the sulfur-free cyclopropanes as well.

As suitable cyclopropane precursors, 3-bromo-1-(phenylsulfonyl)-1-propene (**2**) and 3-(phenylsulfonyl)-2-propen-1-ol (**3**) proved most useful. These are readily obtained from allyl phenyl sulfone (**1**) by the conversions shown in Scheme I.[8,9]

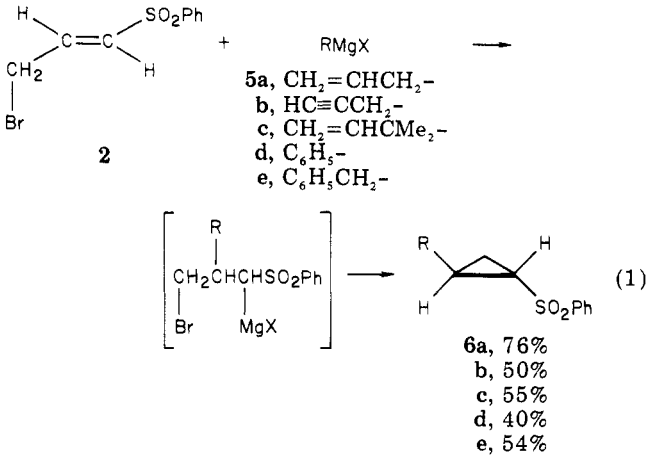
Scheme I



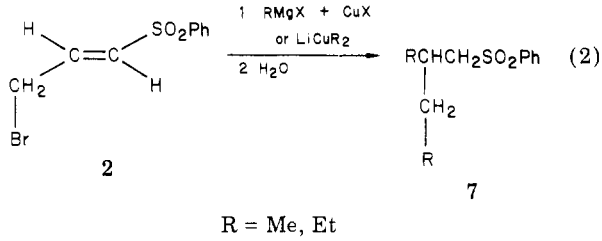
3 (mp 139–141 °C)

Bromo derivative **2** was obtained as a 75:25 mixture of trans and cis isomers, which ordinarily was used for the cyclopropane synthesis without separation. Hydrolysis of **2** led to the trans alcohol **3**, but alternatively, **1** could be epoxidized to give **4**, which opened cleanly with 1 equiv of MeLi to yield **3** after hydrolysis.

Reaction of **2** with the Grignard reagents (**5a–e**) prepared from allyl bromide, propargyl bromide, 1-bromo-3-methyl-2-butene, bromobenzene, and benzyl chloride gave good to excellent isolated yields of 2-substituted-cyclopropyl phenyl sulfones (eq 1). Noteworthy is that



the Grignard reagent from 1-bromo-3-methyl-2-butene (γ,γ-dimethylallyl bromide) gave only 2-(α,α-dimethylallyl)cyclopropyl phenyl sulfone. In contrast, the propargyl and benzyl Grignard reagents produced only the 2-propargyl- and 2-benzylcyclopropyl phenyl sulfones; no 2-allenyl- or 2-(*o*-tolyl)cyclopropyl isomers were detected. Finally, based upon the physical homogeneity and spectral properties of **6a–e**, only a single stereoisomer was obtained in each case. For the α,α-dimethylallyl product, **6c**, the NMR spectrum displayed a $CHSO_2Ph$ proton sufficiently separated from other protons so that its coupling pattern could be analyzed. This proton was split into a doublet (J = 8.5 Hz) of triplets (J = 4.5 Hz), as is consistent with a trans configuration of the α,α-dimethylallyl and phenylsulfonyl groups on the cyclopropane ring.



R = Me, Et

Treatment of **2** with methyl, ethyl, or *tert*-butyl Grignard reagents, on the other hand, gave no detectable amounts of cyclopropyl sulfones. Furthermore, when the geometrical isomers of **2** were separated by chromatography on silica gel and treated separately with phenylmagnesium bromide, only the trans isomer of **2**, but not the cis isomer, was found to give **6d**. The use of alkyl Grignard reagents with catalytic amounts of cuprous salts or of lithium dialkylcuprate reagents gave moderate to good yields of products resulting from bromide displacement, followed by Michael addition (eq 2).[10]

The failure of alkyl Grignard reagents to yield cyclopropyl sulfones with **2** could be overcome by employing alcohol **3**. By use of an excess of an alkyl or aryl Grignard reagent **3** could be converted into the isolable 3-(phenylsulfonyl)-1-propanol (**8**) (eq 3). But this conversion

(1) Lithiation of sulfides: K. Oshima, K. Shimoji, H. Takahashi, H. Yamamoto, and H. Nozaki, *J. Am. Chem. Soc.*, **95**, 2694 (1973); J. J. Fitt and H. W. Gschwend, *J. Org. Chem.*, **44**, 303 (1979).

(2) Lithiation of sulfoxides: G. H. Posner, P.-W. Wang, and J. P. Mallamo, *Tetrahedron Lett.*, 3995 (1978).

(3) Lithiation of sulfones: J. J. Eisch and J. E. Galle, *J. Org. Chem.*, following paper in this issue.

(4) G. H. Posner and D. J. Brunelle, *J. Org. Chem.*, **38**, 2747 (1973).

(5) P. C. Conrad and P. L. Fuchs, *J. Am. Chem. Soc.*, **100**, 346 (1978).

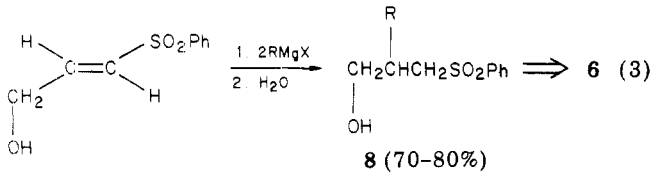
(6) Y.-H. Chang and H. W. Pinnick, *J. Org. Chem.* **43**, 373 (1978).

(7) B. M. Trost, H. C. Arndt, P. E. Strege, and T. R. Verhoeven, *Tetrahedron Lett.*, 3477 (1976).

(8) Allyl phenyl sulfone (**1**) was prepared according to the procedure of H. J. Backer and N. Dost [*Recl. Trav. Chim. Pays-Bas*, 68, 1143 (1949)] and converted into **2** by treating it with 1 molar equiv of Br_2 in CCl_4. After solvent removal addition of ether caused the deposition of 72% of the dibromide of **1**, mp 78–79 °C. This adduct was dissolved in THF and at 0 °C was treated with a slight excess of Et_3N. The mixture was made acidic with 1 N HCl and extracted with ether. Drying and evaporating the ether gave 80% of **2** as a 75:25 mixture of trans (NMR: d at δ 6.92) and cis (NMR: m at δ 5.83-6.55) isomers.

(9) (a) 3-(Phenylsulfonyl)-2-propen-1-ol (**3**) has been made by several procedures (cf. C. C. J. Culvenor, W. Davies, and W. E. Savige, *J. Chem. Soc.*, 2198 (1949)). (b) β,γ-Epoxypropyl phenyl sulfone (**4**) can be made by heating **1** in refluxing chloroform with a 10% excess of *m*-chloroperbenzoic acid. Isolated in 60% yield, **4** is a colorless oil [NMR ($CDCl_3$) δ 7.35–8.0 (m, 5), 3.3 (s, 3), 2.74 (m, 1), and 2.4 (m, 1)].

(10) The sequence of bromide displacement, *followed* by Michael addition, was demonstrated by using 1 equiv of $LiCuMe_2$ with **2**: 1-butenyl phenyl sulfone resulted.

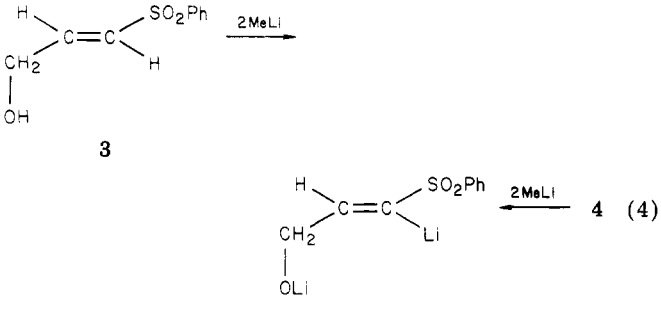


3 8 (70–80%) (3)

R = Et, Ph

is tantamount to an alternative route to 2-substituted-cyclopropyl sulfones (**6**), since by known methods[6] **8** could be tosylated and cyclized with lithium diisopropylamide.

Finally, by using methyllithium, the metalation of **3** at the vinyl position α to the phenylsulfonyl group[3] could be made to dominate over Michael addition, so that **9** was formed in high yield. Alternatively, **9** resulted directly from **4**, if 2 equiv of MeLi were employed. Derivative **9**



3 9 4 (4)

gives the expected products when treated with D_2O or Me_3SiCl, but alkylation with alkyl iodides does not proceed well. Nevertheless, its multifunctional character seems to warrant a further study of its properties.

A typical procedure for the preparation of 2-substituted-cyclopropyl phenyl sulfone is as follows. A stirred solution of 7.15 g (27.4 mmol) of **2**[8] in 20 mL of anhydrous ether was cooled to 0 °C under nitrogen and then treated dropwise with 15.3 mL of 2.0 M allylmagnesium bromide (30 mmol) in ether. The addition of 20 mL of ether and 20 mL of THF caused the initially gummy mixture to become granular. After 15 min at 20–25 °C the mixture was hydrolyzed with aqueous NH_4Cl solution and the separated ethereal layer was dried over anhydrous $MgSO_4$. After solvent removal the crude product (6.05 g) was chromatographed on silica gel with an ether–hexane eluent. The fractions emerging with 40% ether constituted 4.64 g (76%) of the colorless oil, 2-allylcyclopropyl phenyl sulfone (**6a**): NMR ($CDCl_3$) δ 7.38–7.95 (m, 5), 4.32–5.87 (m, 3), 1.22–2.44 (m, 5), and 0.73–1.15 (m, 1).

Acknowledgment. The authors wish to thank the Department of Energy for support of this work under Grant EF-77-G-01-2739.

Registry No. 1, 16212-05-8; *trans*-**2**, 28187-87-3; *cis*-**2**, 70941-72-9; **3**, 70941-73-0; **4**, 70941-74-1; **6a**, 70941-75-2; **6b**, 70941-76-3; **6c**, 70941-77-4; **6d**, 21309-15-9; **6e**, 70941-78-5; **6** (R = Et), 70941-79-6; **7** (R = Me), 34009-06-8; **7** (R = Et), 70941-80-9; **8** (R = Et), 70941-81-0; **8** (R = Ph), 70941-82-1; **9**, 70941-83-2; allyl bromide, 106-95-6; propargyl bromide, 106-96-7; 1-bromo-3-methyl-2-butene, 870-63-3; bromobenzene, 108-86-1; benzyl chloride, 100-44-7.

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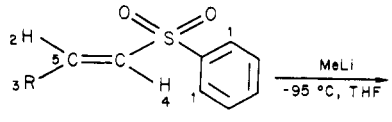
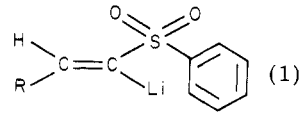
Generation of α-Sulfonylvinyllithium Reagents by the Lithiation of Vinylic Sulfones

Summary: Methyllithium lithiates phenyl vinylic sulfones at −95 °C in THF solution to yield α-(phenylsulfonyl)-vinyllithium reagents.

Sir: Although sulfone derivatives have come to play an expanding and versatile role in organic synthesis,[1] no direct or practical synthesis of 1-(organosulfonyl)vinylmetallic derivatives has yet been reported. In fact, only recently has the generation of 1-(arylsulfinyl)-1-alkenyllithium reagents from vinylic sulfoxides and lithium diisopropylamide been realized.[2-7] Even the α-lithiation of 1-alkenyl aryl sulfides has been achieved only in the last few years.[8-10] In view of this lacuna in the sulfone literature, therefore, we are pleased to report that methyllithium causes the remarkably facile and highly locoselective[11] α-lithiation of phenyl vinylic sulfones at −95 °C in THF solution. Although a vinylic sulfone, such as phenyl (*E*)-1-propenyl sulfone, could conceivably be lithiated also at the *o*-phenyl (1),[12] β-vinyl (2), or γ-allyl (3) site, lithiation occurs only at the α-vinyl position (4) (eq 1). Furthermore, even though such systems are also



1a, R = C_6H_5
b, R = CH_3



(1)

2a, R = C_6H_5
b, R = CH_3

prone to Michael additions of organometallics (5),[13] no such competing reaction is observed with **1** and methyllithium.

The resulting 1-(phenylsulfonyl)-1-alkenyllithium reagents (**2**) can be alkylated with methyl or *n*-butyl iodide in high yield (75–90%). In the case of **3a**, the stereochemistry shown is supported by obtaining the same product from bromo derivative **4**, of known configuration,[14]

(1) P. D. Magnus, *Tetrahedron*, **33**, 2019 (1977).
(2) G. H. Posner, P.-W. Tang, and J. P. Mallamo, *Tetrahedron Lett.*, 3995 (1978).
(3) For studies of the stabilizing influence of the sulfinyl group on an adjacent carbanion, cf. E. Block, "Reactions of Organosulfur Compounds", Academic Press, New York, N.Y., 1978, and ref 4–7.
(4) J. F. Biellmann and J. J. Vicens, *Tetrahedron Lett.*, 467 (1978).
(5) G. Chassaing, R. Lett, and A. Marquet, *Tetrahedron Lett.*, 471 (1978).
(6) S. Lavielle, S. Borg, B. Moreau, M. J. Luche, and A. Marquet, *J. Am. Chem. Soc.*, **100**, 1558 (1978).
(7) H. Sugihara, H. Tanikaga, K. Tanaka, and A. Kaji, *Bull. Chem. Soc. Jpn*, **51**, 655 (1978).
(8) K. Oshima, K. Shimoji, H. Takahashi, H. Yamamoto, and H. Nozaki, *J. Am. Chem. Soc.*, **95**, 2694 (1973).
(9) I. Vlattas, L. D. Vecchia and A. O. Lee, *J. Am. Chem. Soc.*, **98**, 2008 (1976).
(10) R. H. Everhardus, H. G. Euwhorst, and L. Brandsma, *J. Chem. Soc., Chem. Commun.*, 801 (1977).
(11) Term designating that site (L, *locus*), out of several possibilities, where chemical reaction occurs (J. J. Eisch and K. R. Im, *Adv. Chem. Ser.*, **No. 173**, 195 (1979); in substrate **1b**, out of four conceivable sites, only the α-vinyl proton is removed (locoselectively).
(12) W. E. Truce and M. F. Amos, *J. Am. Chem. Soc.*, **73**, 3013 (1951).
(13) G. H. Posner and D. J. Brunnelle, *J. Org. Chem.*, **38**, 2747 (1973).
(14) (a) J. C. Phillips, M. Aregullin, M. Oku, and A. Sierra, *Tetrahedron Lett.*, 4157 (1974). (b) The retention of configuration in transforming **1b** to **2b** to **3b** is also assured, since both **3b** and its *Z* isomer have previously been prepared and their configurations have been determined: cf. I. Sataty and C. Y. Meyers, *Tetrahedron Lett.*, 4161 (1974).

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