

Saturation constants² of some resin-cations by diastereomeric crown ethers in CH₂Cl₂ are different. For resin-H₃O⁺, -Na⁺, -K⁺, -NH₄⁺, and -Cs⁺, respectively, K_s's of (±)-4 are 0.19, 0.18, 0.078, 0.043, and 0.011; *meso*-4 gave 0.087, <0.093, 0.061, 0.042, and 0.014.

Chiral differentiation in complexation of optically pure (+)-(*R*) and (-)-(*S*)- α -phenylethylamine⁶ salts ((+)-(*R*)-5 and (-)-(*S*)-5) by optically pure (+)-(*RR*)-4 was measured (HA-100 nmr, TMS) by partitioning salts between water and chloroform. In run 1, 90 mg of (+)-4 in 0.7 ml of CDCl₃ was shaken 1 min with 150 mg of (-)-5·HBr in 0.8 ml of D₂O at ~25°. The spectrum of the CDCl₃ layer (dried) showed 5 to be absent. Run 2 duplicated 1, except that 125 mg of NaPF₆ was present. The spectrum showed ~0.7 mol of (-)-5 salt per mole of (+)-4 in the CDCl₃ layer (methyl doublet, *J* = 7.0 Hz, total methylenes minus methine integrations were compared; CH₃, δ 1.40⁷). The crown ether's spectrum was dramatically different from that of run 1. The methyl doublet was unchanged but the crown spectrum was further averaged by addition of 13.5 mg of (+)-4. Dilution by a factor of 2 of the CDCl₃ solution produced little chemical shift changes. The aqueous layer contained no crown. Run 3 duplicated 2 except (+)-5·HBr was substituted for (-)-5·HBr. The spectrum showed ~0.5 mol of (+)-5 salt per mole of (+)-4 in the CDCl₃ layer (methyl doublet, *J* = 7.0 Hz, δ 1.11⁷). The spectrum of the crown was changed, but was closer to that of run 2 than to that of run 1. Dilution by a factor of 2 of the CDCl₃ layer produced little shift changes. Run 4 duplicated 2 except that (±)-5·HBr was substituted for (-)-5·HBr. The spectrum showed 0.74 mol of salt per mole of (+)-4 in the CDCl₃ layer and two methyl doublets (59% (-)-5, δ 1.40,⁷ 41% (+)-5, δ 1.14⁷). Run 5 duplicated 2 except that (±)-4 was substituted for (+)-4. The spectrum of the CDCl₃ layer showed 0.67 mol of salt per mole of (±)-4, and one methyl doublet (δ 1.33⁷). Run 6 duplicated 4 except (-)-4 was substituted for (+)-4, and the partitioning temperature was 0°. The spectrum of the CDCl₃ layer showed 0.93 mol of salt per mole of (-)-4 (62% (+)-5, 38% (-)-5).

For most protons large chemical shift differences are visible in the spectra between complexed and noncomplexed components and between diastereomeric complexes. The ArOCH₂ and CH₃ peaks differ most obviously. Complexed and noncomplexed crowns' spectral differences probably reflect mainly Ar-Ar and Ar-O-CH₂ dihedral angle differences between relatively flexible crowns and rigid complexes. Asymmetrically disposed binaphthyls magnetically differentiate in complexes between the methyls of uncomplexed enantiomerically related amines. Averaging between complexed and noncomplexed crown signals and between methyls of (+)-4·(-)-5 and (-)-4·(-)-5 demonstrates that the complexes and their components equilibrate rapidly on the pmr time scale.

Pure (-)-4 (3.00 g), (±)-5·HCl (3.9 g), and NaPF₆

1491 (1969); (c) I. Hanazaki and H. Akimoto, *J. Amer. Chem. Soc.*, **94**, 4102 (1972); (d) H. Akimoto and S. Yamada, *Tetrahedron*, **27**, 5999 (1971).

(6) (a) W. Theilacker and H. G. Winkler, *Chem. Ber.*, **87**, 690 (1954); (b) W. Leithe, *ibid.*, **64**, 2827 (1931).

(7) Downfield peak.

(4.2 g) were distributed between 25 ml of chloroform and 30 ml of water at 0°. Extraction procedures separated the chloroform layer's cyclic ether and amine. Distilled 5 (0.333 g, 65%) was 62% (+)-5 and 38% (-)-5, [α]_{D²⁵}²⁵ +9.41° (*c* 7.56, CHCl₃). These results were predicted from those of runs 1-6.

By chiral recognition in complexation equilibria, (SS)-4 selects (*R*)-5 over (*S*)-5 salt, and (SS)-4·(*R*)-5 is ~266 cal/mol more stable (0°) than (SS)-4·(*S*)-5 complex. Molecular models (CPK) of these diastereomeric complexes differ visibly, and the more stable complex looks more stable in its model. Optically active host cycles with C₂ axes (*e.g.*, (-)-4) present identical faces to potential chiral guest amines, and "sidedness" problems are avoided. Multiplate partitioning by liquid-liquid or solid-liquid processes should allow complete resolution of racemic primary amines by optically active cyclic ethers, or of racemic cycles by optically active amines. These and future generation chiral cyclic ethers will find use in optical resolution by partitioning and in determining configuration and optical purity.

(8) (a) National Research Council of Canada Postdoctoral Fellow, 1971-1972; (b) Public Health Service International Postdoctoral Research Fellowship, 1971-1972; (c) National Institutes of Health Postdoctoral Fellow, 1971-1972.

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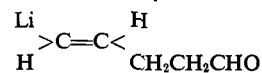
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A New Synthesis of Aldehydes Using 1-Vinylthioallyllithium. A Facile Route to Propylure

Sir:

The present paper describes a general two-step sequence which permits the highly stereoselective conversion of a halide (RX) to the trans γ,δ -unsaturated aldehyde (RCH=CHCH₂CH₂CHO). This involves the alkylation of 1-vinylthioallyllithium (1) and the subsequent thio-Claisen rearrangement.^{1,2} The method is applicable to a variety of R groups and is certainly an addition to the host of recently developed aldehyde syntheses.³

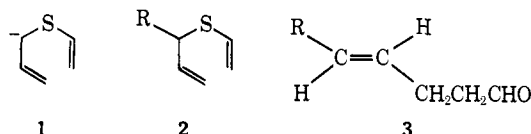
(1) For recent practical modifications of the Claisen rearrangement of allyl vinyl ethers, see (a) H. Meerwein, W. Florian, N. Schön, and G. Stopp, *Justus Liebigs Ann. Chem.*, **641**, 1 (1961); D. Felix, K. Gschwend-Steen, A. E. Wick, and A. Eschenmoser, *Helv. Chim. Acta*, **52**, 1030 (1969); (b) W. S. Johnson, L. Werthemann, W. R. Bartlett, T. J. Brocksom, T. T. Li, D. J. Faulkner, and M. R. Petersen, *J. Amer. Chem. Soc.*, **92**, 741 (1970). Both of these methods allow the easy, high-yield addition of an *acetic acid* unit to the γ carbon of an allylic alcohol. The present method, in contrast, could introduce a *five carbon* unit at one time, and 1-vinylthioallyllithium has been shown to serve effectively as the equivalent of the unknown vinylic anion as shown below.



(2) Thio-Claisen rearrangement: (a) H. Kwart and T. J. George, *Chem. Commun.*, 433 (1970), and references cited therein; (b) E. J. Corey and J. I. Shulman, *J. Amer. Chem. Soc.*, **92**, 5522 (1970); (c) K. Kondo and I. Ojima, *J. Chem. Soc., Chem. Commun.*, 62 (1972).

(3) (a) 1,3-Dithiane method: E. J. Corey and D. Seebach, *Angew. Chem., Int. Ed. Engl.*, **4**, 1075, 1077 (1965); (b) dihydro-1,3-oxazine method: A. I. Meyers, A. Nabeya, H. W. Adickes, and I. R. Politzer, *J. Amer. Chem. Soc.*, **91**, 763 (1969); (c) 1,3-bis(methylthio)allyllithium method: E. J. Corey, B. W. Erickson, and R. Noyori, *ibid.*, **93**, 1724 (1971).

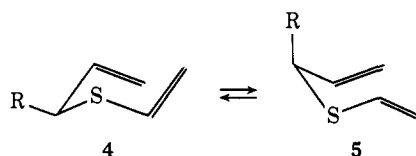
Treatment of allyl vinyl sulfide, bp 38° (37 mm),^{4,5} in dry tetrahydrofuran at -78° with 1 equiv of *sec*-butyllithium in pentane gave a yellow solution containing the anion **1**, which is stable at that temperature but which decomposes slowly at 0°. The formation of the anion **1** was verified by reaction with 1 equiv of benzyl bromide (-78° for 30 min, then -30° for 30 min) to give the sulfide **2** (R = CH₂C₆H₅), shown by nmr analysis to be >85% pure. The crude sulfide was dissolved in dimethoxyethane (DME) and water (3:1) in the presence of calcium carbonate (~3 equiv), and the mixture was heated at reflux for 12 hr. After purification by thin layer chromatography (tlc), the desired aldehyde **3** (R = CH₂C₆H₅) was obtained in 62% over-all yield: mass *m/e* 174 (M⁺); ir (neat) 2730, 1730 (s, C=O), 970 cm⁻¹ (s, trans C=C); nmr (CCl₄, TMS) δ 5.4-5.7 (m, 2 H, olefinic proton), 9.76 (t, 1 H, *J* = 1 Hz, CHO). The gas chromatographic (glpc, *t_r* 4.50 min, using 1-m of 5% OV-1 column at 130°) and silver nitrate-silica gel tlc (*R_f* 0.67, CH₂Cl₂) analyses showed the absence of detectable amounts (<1%) of the geometrically isomeric olefin.



3 (R = CH₂C₆H₅) was obtained in 62% over-all yield: mass *m/e* 174 (M⁺); ir (neat) 2730, 1730 (s, C=O), 970 cm⁻¹ (s, trans C=C); nmr (CCl₄, TMS) δ 5.4-5.7 (m, 2 H, olefinic proton), 9.76 (t, 1 H, *J* = 1 Hz, CHO). The gas chromatographic (glpc, *t_r* 4.50 min, using 1-m of 5% OV-1 column at 130°) and silver nitrate-silica gel tlc (*R_f* 0.67, CH₂Cl₂) analyses showed the absence of detectable amounts (<1%) of the geometrically isomeric olefin.

In a similar experiment⁶ octyl bromide and geranyl bromide gave the corresponding aldehyde **3**, R = *n*-C₈H₁₇ (57%)⁷ and R = geranyl (62%),⁸ respectively.

The basis for the high stereoselectivity in this reaction can be explained by essentially the same arguments used to rationalize the stereochemical outcome of Claisen rearrangement,⁹ conformer **4**, a precursor to trans olefin in the transition state, is favored over **5**



which leads to cis product, because the alkyl substituent has preference for occupying an equatorial position.

Comment is required on the choice of conditions for the above described reaction sequence.

1. In general, the combination of 1,4-diazabicyclo-[2.2.2]octane (DABCO) and *n*-butyllithium is the most satisfactory base for the metalation of allyl sulfides,^{10,11}

(4) Prepared from lithium ethenethiolate [L. Brandsma and P. J. W. Schuijl, *Recl. Trav. Chim. Pays-Bas*, **88**, 513 (1969)] and allyl bromide in liquid ammonia (62% after distillation).

(5) All new compounds reported in this communication have been characterized spectrometrically and analytically.

(6) Alkyl bromides and iodides were found to give most satisfactory results for this reaction. Alkyl chlorides were much less reactive to **1** except for benzylic and allylic cases.

(7) Mass *m/e* 196 (M⁺); ir (neat) 2725, 1730 (s, C=O), 970 cm⁻¹ (s, trans C=C); nmr (CCl₄, TMS) δ 5.3-5.5 (m, 2 H, olefinic proton), 9.65 (t, 1 H, *J* = 1 Hz, CHO); homogeneous by glpc and AgNO₃-SiO₂ tlc assay.

(8) Mass *m/e* 220 (M⁺); ir (neat) 2720, 1728 (s, C=O), 970 cm⁻¹ (s, trans C=C); nmr (CCl₄, TMS) δ 9.63 (t, 1 H, *J* = 1 Hz, CHO); homogeneous by glpc and AgNO₃-SiO₂ tlc assay.

(9) P. Vittorelli, T. Winkler, H. J. Hansen, and H. Schmid, *Helv. Chim. Acta*, **51**, 1457 (1967).

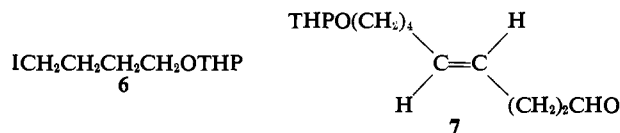
(10) The combination of DABCO-*n*-butyllithium: E. J. Corey and D. Seebach, *J. Org. Chem.*, **31**, 4097 (1966).

(11) J. F. Biellmann and J. B. Ducep, *Tetrahedron Lett.*, 5629 (1968); see also, V. Rautenstrauch, *Helv. Chim. Acta*, **54**, 739 (1971); E. E. van Tamelen, R. A. Holton, R. E. Hopla, and W. E. Konz, *J. Amer. Chem. Soc.*, **94**, 8228 (1972).

while *n*-alkyllithium reagents alone are poor. However, the lithiation of allyl phenyl sulfide with the DABCO-*n*-butyllithium system followed by alkylation gave a mixture of α and γ alkylated product (α/γ = ca. 7:3).¹¹ In contrast, *sec*-butyllithium without DABCO in tetrahydrofuran proved to be an excellent reagent for the metalation-alkylation process of allyl phenyl sulfide to give the α-alkylated product almost exclusively (>95% selectivity and quantitative yield with methyl iodide).

2. Heating **2** (R = CH₂C₆H₅) at 180-200° with or without red mercuric oxide^{2b} afforded only an intractable tar but no desired aldehyde **3** (R = CH₂C₆H₅). The DME-water method, on the contrary, gave most satisfactory results under sufficiently mild conditions and therefore should broaden the scope and utility of the thio-Claisen rearrangement.

The remarkably stereoselective and simple synthesis of **3** (R = CH₂C₆H₅) provided the essential information leading to a facile stereoselective synthesis of the sex attractant of the pink bollworm moth, *Pectinophora gossypiella* Saunders, so-called propylure.¹² Starting with readily available iodide **6**,¹³ and using the same procedure as described for the conversion of benzyl bromide to the aldehyde **3** (R = CH₂C₆H₅), we obtained 9-(2'-tetrahydropyranyloxy)-*trans*-4-nonenal (**7**)¹⁴ cleanly in 55% yield. In view of the earlier syn-



thesis of propylure from **7** (simple Wittig reaction),¹⁵ the synthesis of the latter by the route described above constitutes a formal total synthesis of this hormone. This route is apparently most advantageous in comparison to the previous ones^{15,16} requiring a lengthy and conventional chain-extension reaction and giving very low yields of the final product.

(12) Isolated and identified as 1-acetoxy-10-*n*-propyltrideca-*trans*-5,9-diene: W. A. Jones, M. Jacobson, and D. F. Martin, *Science*, **152**, 1516 (1966); W. A. Jones and M. Jacobson, *ibid.*, **159**, 99 (1968).

(13) This iodide was prepared by the sequence: 1,4-butanediol monotetrahydropyranyl ether [E. J. Corey, H. Yamamoto, D. K. Herron, and K. Achiwa, *J. Amer. Chem. Soc.*, **92**, 6635 (1970)] → ROTs (*p*-toluenesulfonyl chloride-pyridine at 0°) → RI (sodium iodide-acetone at 25°) (65% over-all yield).

(14) Identical in all respects with the reported one (ref 15).

(15) G. Pattenden, *J. Chem. Soc. C*, 2385 (1968).

(16) A. I. Meyers and E. W. Collington, *Tetrahedron*, **27**, 5979 (1971), and references cited therein.

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A New Synthesis of Ketones Using 1-(Alkylthio)vinylithium

Sir:

Addition of *sec*-butyllithium to a solution of vinyl sulfides in tetrahydrofuran-hexamethylphosphoric triamide (THF:HMPA = 9:1) at -78° results in essentially quantitative formation of 1-(alkylthio)vinylithium **1** (eq 1), which is stable at this temperature for