Tetrahedron Letters,Vol.26,No.23,pp 2797-2800,1985 0040-4039/85 $3.00 + .00
Printed in Great Britain

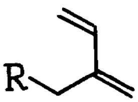
2-DIPROPYLBORYLMETHYL-1,3-BUTADIENE - A NEW REAGENT FOR ISOPRENYLATION. EFFICIENT SYNTHESIS OF IPSENOL AND IPSDIENOL

Yuri N. Bubnov* and Marina Yu. Etinger

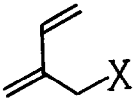
N.D.Zelinsky Institute of Organic Chemistry,
U.S.S.R. Academy of Sciences, Moscow, U.S.S.R.

Summary: A simple and convenient method for isoprenylation of carbonyl compounds and ethoxyacetylene using the titled new boron containing "isoprene C-5 synthon" and application of this efficient procedure to the synthesis of ipsenol and ipsdienol are described.

The introduction of isoprene unit into various compounds (isoprenylation) presents an important and urgent problem in organic synthesis since isoprene derivatives with the conjugated diene system of the type A (e.g. myrcene, β-farnesene, ipsenol, ipsdienol) are widely distributed in Nature and play the significant role in vital processes.



A



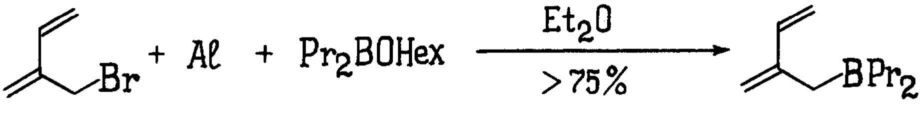
B

X= $SiMe_3$ [1]
$SnMe_3$ [2]
H [1]
ZnBr [4,5]
[OCOMes, Li] [5]

Several reagents are known allowing to incorporate isoprene fragment into various substances. Thus isoprenylation of carbonyl compounds with 2-trimethylsilylmethyl-1,3-butadiene [1], its Sn analogue [2] and with isoprene itself (ene condensation) [3], initiated with a Lewis acid or Bu_4NF, has been reported. Isoprenylation using Zn derivative B (X=ZnBr) has also been described [4,5]. Attempts to prepare and apply 2-bromomagnesiummethyl-1,3-butadiene (B, X=MgBr) or its Li analogue with the same aim resulted in failure [4]. The Li salt was generated (~10%) from B (X=OCOMes) [5].

We have developed a method for the preparation of a series of boron containing reagents of the type B. Here we wish to report the synthesis of the first boron-isoprenyl derivative, 2-dipropylborylmethyl-1,3-butadiene (I), and its use for the isoprenylation of carbonyl compounds and ethoxyacetylene.

The reagent I is easily obtained in over 75% yield by interaction between 2-bromomethyl-1,3-butadiene, hexyloxy(dipropyl)borane and aluminum turnings activated with $HgCl_2$.

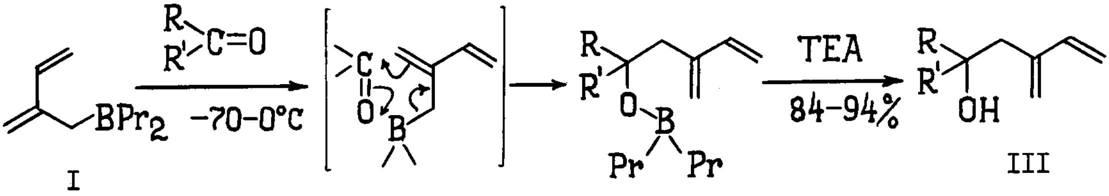


I

Compound I (b.p. 39-41°C (1.5 mm Hg), n_D^{20} 1.4569) [6,7] is stable in an inert atmosphere and can thus be stored for a long time.

Being a specific allylborane, compound I reveals high reactivity typical of this type of organoboranes [8]. On treatment with water, alcohols or amines (-30 ÷ 0°C) the boron-isoprenyl bond in I undergoes a cleavage to produce isoprene, Pr_2BOR or Pr_2NR_2.

Compound I reacts with aldehydes and ketones at -70 ÷ 0°C by adding to the C=O bond to yield the borinic esters II transesterification of which with higher alcohols (e.g. triethanolamine, TEA) or oxidation (H_2O_2, OH^-) lead to respective diene alcohols III.



I C II III

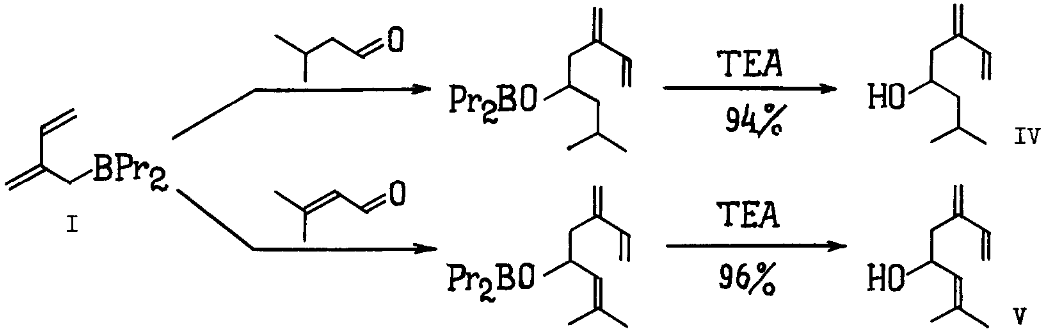
In this way, 2-vinyl-1-penten-4-ol (III, R=H, R'=Me, b.p. 67-68°C (19 mm Hg), n_D^{20} 1.4678, yield 84%) [7,9] and 2-vinyl-4-methyl-1-penten-4-ol (III, R=R'=Me, b.p. 55-56°C (15 mm Hg), n_D^{20} 1.4706, yield 94%) [7,9] were prepared from acetaldehyde or acetone, respectively.

Allylboration of carbonyl and other compounds with multiple bonds (-C≡N, >C=N-, -C≡C-, >C=C<) has previously been shown to proceed totally with allylic rearrangement [8,10] (a concerted $_{\sigma}2_s + _{\pi}2_s + _{\pi}2_s$ process). There is no doubt that the addition of I to carbonyl group also occurs with the rearrangement via a 6-membered transition state (C).

Reagent I was successfully used for the preparation of two acyclic monoterpenes: 2-methyl-6-methylene-7-octen-4-ol (IV, ipsenol) and 2-methyl-6-methylene-2,7-octadien-4-ol (V, ipsdienol), principal components of the aggregational pheromones of Ips confusus and Pityokteines [9a,b].

(±)-Ipsenol (4.5 g, b.p. 92-94°C (19 mm Hg), n_D^{20} 1.4654) [7,9] was synthesised in 94% yield by reacting I (5.2 g) with isovaleraldehyde (2.7 g) followed by transesterification of the intermediate IIa with triethanolamine.

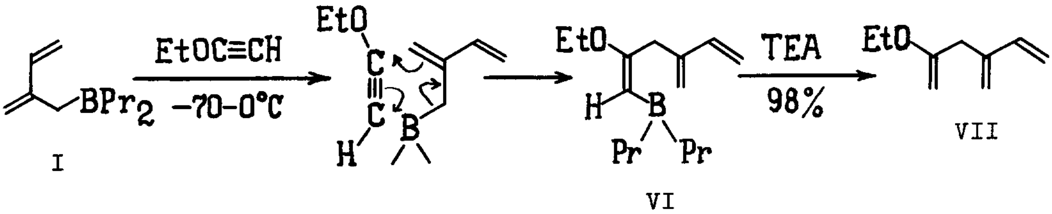
Similarly, (±)-ipsdienol (3.2 g, b.p. 51-54°C (1.5 mm Hg), n_D^{20} 1.4879) [7,9] was prepared in 96% yield by interaction of I (3.6 g) and 3,3-dimethylacrolein (1.9 g).



Isoprenylation of aldehydes and ketones with I is carried out as follows: the carbonyl compound is added to I (1:1) at -70 ÷ 0°C, the mixture is then allowed to stay for 30 min. at r.t. whereupon triethanolamine (1.1 mol) is added and III or IV (or V) is distilled off in vacuo. The isoprenylation may be performed both with no solvent and in any inert one (ether, THF, hexane, benzene, CCl_4 etc.).

Thus the results presented indicate I to be an excellent C-5 synthon for isoprenylation of carbonyl compounds. The efficiency of the procedure was demonstrated by the preparation of ipsenol and ipsdienol nearly with quantitative yields starting with readily available substances. It should be noted that yields of IV and V previously reported were substantially lower (52-74%) [1,4,5].

Like other allylboranes [8,11] compound I readily adds to ethoxyacetylene at -70 ÷ 0°C with the formation of 1-dipropylboryl-E-2-ethoxy-4-methylene-1,5-hexadiene (VI, b.p. 75-78°C (1.5 mm Hg), yield 93%) [7,12]. The $B\text{-}C_{sp^2}$ bond in VI is easily cleaved by alcohols affording 2-ethoxy-4-methylene-1,5-hexadiene (VII, yield 98%, b.p. 56-57°C (19 mm Hg), n_D^{20} 1.4633) [7,13].



Preparation of the triene VII is more convenient to conduct without isolation of the borane VI. In this case, ethoxyacetylene (at -70 ÷ 0°C) and triethanolamine (at 20°C) are consequently added to I followed by distillation of the reaction mixture in vacuo to give VII in 98% yield.

The above reaction presents the first case of acetylene isoprenylation.

Several other boron containing isoprenylating reagents including some chiral derivatives have also been synthesized. Their application to organic synthesis will be described shortly.

The synthesis of (+)- and (-)-artemisia alcohols using chiral 3,3-dimethylallyldiisopinocampheylborane has recently been reported[14].

References and Notes

1. A.Hosomi, Y.Araki, H.Sakurai, J.Org.Chem., 48, 3122 (1983); A.Hosomi, M.Saito, H.Sakurai, Tetrahedron Lett., 1979, 429.
2. A.Hosomi, H.Iguchi, M.Endo, H.Sakurai, Chem.Lett., 1979, 977.
3. B.B.Snider, D.J.Rodini, Tetrahedron Lett., 1980, 1815.
4. R.G.Riley, R.M.Silverstein, J.A.Katzenellenbogen, R.S.Lenox, J.Org.Chem., 39, 1957 (1974).
5. J.A.Katzenellenbogen, R.S.Lenox, J.Org.Chem., 38, 326 (1973).
6. ^{1}H NMR (δ, $CDCl_3$, 250 MHz) 0.85 (t, J=7 Hz, 6H, $2CH_3$), 1.14 (t, J=7 Hz, 4H, $-CH_2-B$), 1.38 (m, 4H, $-CH_2-$), 2.17 (s, 2H, $=CH-CH_2-B$), 4.67-4-95 (m, $=CH_2$, 4H), 6.23-6.47 (d of d., J=17 Hz, J=7 Hz, 1H, =CH) ppm. IR (neat) 1590, 1635, 3090 cm^{-1}.
7. Satisfactory elemental analysis was obtained.
8. B.M.Mikhailov, Yu.N.Bubnov, Organoboron Compounds in Organic Synthesis, Harwood Academic Publishers, London, 1984.
9. Spectroscopic data of the compounds are in agreement with structures assigned.

9a. A.M.Moiseenkov, K.V.Lebedeva, B.A.Cheskis, Usp.Khim., 53, 1709 (1984).

9b. K.Mori, The Synthesis of Insect Pheromones, in: The Total Synthesis of Natural Products, J.Wiley & Sons, Ed. J.ApSimon, N-Y, 1981, p. 1.

10. B.M.Mikhailov, Yu.N.Bubnov, A.V.Tsyban', M.Sh.Grigorian, J.Organometal.Chem., 154, 131, (1978); B.M.Mikhailov, Yu.N.Bubnov, A.V.Tsyban', Izv.Akad.Nauk SSSR, Ser.Khim., 1978, 1892.
11. Yu.N.Bubnov, M.Sh.Grigorian, A.V.Tsyban', B.M.Mikhailov, Synthesis, 1980, 902.
12. ^{1}H NMR (δ, $CDCl_3$) 0.66-1.83 (17H, $2C_3H_7$, CH_3), 3.28 (s, 2H, $-CH_2-$), 3.88(quartet, J=7 Hz, 2H, $-CH_2-O-$), 4.93-5.45 (m, 4H, $=CH_2$), 6.43 (d of d., J=17 Hz, J= 7 Hz, 1H, =CH). IR (neat) 1590, 3090 cm^{-1}.
13. ^{1}H NMR (δ, CCl_4) 1.18 (t, J=7 Hz, 3H, CH_3), 2.85 (s, 2H, $-CH_2-$), 3.62 (quartet, J=7 Hz, 2H, $-CH_2-O-$), 4.83-5.30 (m, 4H, $=CH_2$), 6.25 (d of d., J=17 Hz, J=7 Hz, 1H, =CH) ppm. IR (neat) 1590, 1660, 3120 cm^{-1}.
14. H.C.Brown, P.K.Jadhav, Tetrahedron Lett., 25, 1215 (1984).

(Received in UK 11 April 1985)