COMMUNICATIONS

A Convenient Synthesis of Propargylic Esters and γ-Keto Esters. The Reaction of Trialkynylboranes with Ethyl Diazoacetate, and the Unidirectional Hydration of Propargylic Esters

JOHN HOOZ AND ROBERT B. LAYTON[1]
Department of Chemistry, University of Alberta, Edmonton, Alberta

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Trialkynylboranes react with ethyl diazoacetate to provide propargylic esters. The process occurs under mild conditions (−20°) and in good yields. Propargylic esters undergo unidirectional mercuric ion-promoted hydration to afford good yields of γ-ketoesters.

Les trialcynylboranes réagissent avec le diazoacétate d'éthyle pour conduire aux esters propargyliques. La réaction se fait dans des conditions douces (−20°) et avec de bons rendements. Les esters propargyliques subissent une hydration unique, provoquée par les ions mercuriques, pour conduire aux esters γ-cétoniques avec de bons rendements.

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Although exploration of the synthetic applications of trialkylboranes is an area of active burgeoning development (1), the chemistry of their triacetylenic analogs, in marked contrast, has been almost completely unexplored. Studies directed toward elucidating the organochemical synthetic potential of these interesting derivatives have understandably been hampered by their intrinsic instability. Since they decompose above *ca.* −30°, trialkynylboranes[2] are usually synthesized as (stabilized) amine complexes (eq. 1).

$$[1]\quad 3RC{\equiv}CNa + BF_3{\cdot}Py \xrightarrow{\text{Pyridine}} (RC{\equiv}C)_3B{\cdot}Py$$

We have prepared solutions of triacetylenic boranes *in the absence of amine donors*, and utilized these reagents for a convenient mild synthesis of propargylic esters. The requisite organoborane is easily obtained by treating a lithium acetylide (from a terminal alkyne and *n*-butyllithium) with boron trifluoride etherate in tetrahydrofuran solvent[3] at −20° (eq. 2). Subsequent reaction with ethyl diazoacetate provides good yields of the corresponding propargylic ester after hydrolysis (eq. 3). The reaction proceeds readily at −20°, and organoborane decomposition does not seriously interfere, as indicated by the results summarized[4] by eqs. 4–7.

$$[2]\quad 3RC{\equiv}CLi + BF_3{\cdot}OEt_2 \xrightarrow[-20^\circ]{\text{THF}} (RC{\equiv}C)_3B$$

$$[3]\quad (RC{\equiv}C)_3B + N_2CHCOOC_2H_5 \xrightarrow[-N_2]{\text{THF, }-20^\circ} \xrightarrow{H_2O} RC{\equiv}CCH_2COOC_2H_5$$

$$[4]\quad (n\text{-}C_4H_9C{\equiv}C)_3B \xrightarrow[(88\%)]{100\%} n\text{-}C_4H_9C{\equiv}CCH_2COOC_2H_5$$

$$[5]\quad (C_6H_5C{\equiv}C)_3B \xrightarrow[(92\%)]{100\%} C_6H_5C{\equiv}CCH_2COOC_2H_5$$

$$[6]\quad (n\text{-}C_5H_{11}C{\equiv}C)_3B \xrightarrow[(87\%)]{97\%} n\text{-}C_5H_{11}C{\equiv}CCH_2COOC_2H_5$$

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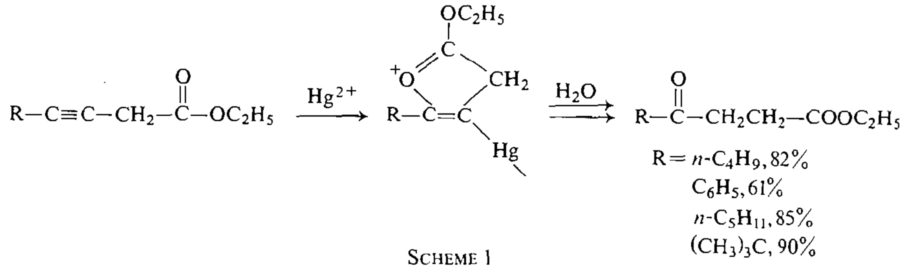
[1] Holder of a 1967 Science Scholarship.

[2] Evidence for their existence has been obtained at −60°, but attempts at isolation, under a variety of conditions, have led only to polymeric products (2). Reviews on unsaturated organoboron compounds are available (3, 4).

[3] In view of the fact that tris(phenylethynyl)borane forms a complex with tetrahydrofuran (5), the trialkynylboranes described herein may exist as THF complexes. No studies have been made of this matter, and these species are depicted as if uncomplexed merely for convenience and simplification.

[4] Numbers above and below the arrows represent g.l.p.c. and (unoptimized) isolated yields, respectively. The molar ratio of organoborane: diazoacetic ester varied from 1:1.3 to 1:2.

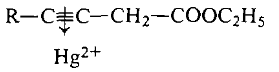


SCHEME 1

$$[7]\quad ((CH_3)_3C{-}C{\equiv}C)_3B \xrightarrow[(63\%)]{83\%} (CH_3)_3C{-}C{\equiv}CCH_2COOC_2H_5$$

Since propargylic esters are usually prepared by a multi-step sequence (6), this method offers a convenient, high-yield, abbreviated approach to these intermediates.

Moreover, mercuric ion-promoted hydration of β,γ-acetylenic esters occurs in a directionally-specific manner to produce γ-ketoesters. No β-ketoester formation could be detected. Although mechanistic studies have not as yet been undertaken, this regiospecific hydration may be



$$\underset{\displaystyle Hg^{2+}}{R{-}C{\equiv}C{-}CH_2{-}COOC_2H_5}$$

A

the ultimate outcome of an initial alkyne-Hg^{++} complex (**A**) leading to the more stable γ-carbonium ion as a consequence of the inductive (or field effect) exerted by carboethoxy.

Alternatively, regiospecificity may be the manifestation of carbonyl oxygen participation which results in formation of the more geometrically favorable five-membered ring.[5] Scheme 1 depicts this view, as well as isolated yields.

It is clear, however, that irrespective of which factor prevails, the present development provides a unique uncomplicated route to this class of compounds.[6]

However, in this propargylic ester synthesis, as in other organoborane-diazo reactions (9), only one organic moiety is utilized. In an attempt to circumvent this inherent difficulty, we briefly explored the reaction of dibutylheptynylborane[7] with ethyl diazoacetate in the hope of achieving selective migration of the alkynyl group. Surprisingly, the only ester product formed was ethyl hexanoate. This represents an interesting contrast to the behavior of the congeneric alanes, $R_2AlC{\equiv}CR$, which, in a variety of reactions, selectively transfer the ligand possessing the highest degree of *s*-character (11). We are continuing to explore the ramifications of these developments.

The experimental procedure is illustrated for the methylenecarbethoxylation of 1-heptyne, and the hydration of ethyl 3-nonynoate. To a solution of lithium 1-heptyne (from 1-heptyne (30 mmol) in 26 ml tetrahydrofuran and *n*-butyllithium[8] (30 mmol)) held at *ca.* −20° was added, gradually, a solution of boron trifluoride etherate (40 mmol). The resulting solution was stirred an additional 0.5 h at *ca.* −20°, and a solution of ethyl diazoacetate (1.46 g, 12.8 mmol) was slowly added. After stirring for 1.5 h, water was added, the mixture stirred (*ca.* 20 min), then poured into ice water (200 ml). The aqueous phase was extracted with ether (three 30-ml portions) and the combined organic extract was dried (Na_2SO_4). The g.l.p.c. analysis indicated a 97% yield of ethyl 3-nonynoate. Solvent was removed *in vacuo* (rotary evaporator), and the crude residue was distilled to afford 1.44 g (87%) of ethyl 3-nonynoate, b.p. 90–91° (2.5 mm); n_D^{22} 1.4440; i.r. (liquid film) 1735 cm^{-1}; n.m.r. (τ, $CDCl_3$) 5.75 (2H, q, OCH_2CH_3), 6.70 (2H, t, $CH_2C{=}O$), 7.80 (2H, m, $CH_2CH_2C{\equiv}C$), 8.30–8.80 (6H, m, $(CH_2)_3$), 8.69 (3H, t, CH_3CH_2O), 9.09 (3H, t, CH_3-$(CH_2)_3$); mass spectrum (70 eV) M^+ 182.

Anal. Calcd. for $C_{11}H_{18}O_2$: C, 72.49; H, 9.95. Found: C, 72.52; H, 9.76.

A mixture of ethyl 3-nonynoate (5.6 mmol),

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[5] This possibility is analogous to proposals advanced to account for the unidirectional hydration of γ-ketoacetylenes (7).

[6] A variety of other approaches has been summarized (8).

[7] Prepared by reaction of dibutylboron bromide (10) with lithium 1-heptyne.

[8] A solution of *n*-butyllithium in hexane, obtained from Alfa Inorganics, Inc., was employed.

ethanol (50 ml), water (10 ml), concentrated sulfuric acid (3 drops), and mercuric sulfate (10 mg) was refluxed for 5 h. Solvent was removed *in vacuo* and the oily residue was dissolved in ether. The ethereal solution was washed with saturated sodium bicarbonate solution, dried (Na_2SO_4), and evaporated. Molecular distillation of the residue provided 1.00 g (85%) of ethyl 4-oxononanoate, n_D^{21} 1.4369; i.r. (liquid film) 1735, 1710 cm^{-1}; n.m.r. (τ, $CDCl_3$) 5.88 (2H, q, OCH_2CH_3), 7.41 (6H, m, $CH_2CO(CH_2)_2CO$), 8.65 (6H, m, $(CH_2)_3$), 8.75 (3H, t, CH_3CH_2O), 9.11 (3H, t, CH_3CH_2).

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