



A Publication
of Reliable Methods
for the Preparation
of Organic Compounds

Working with Hazardous Chemicals

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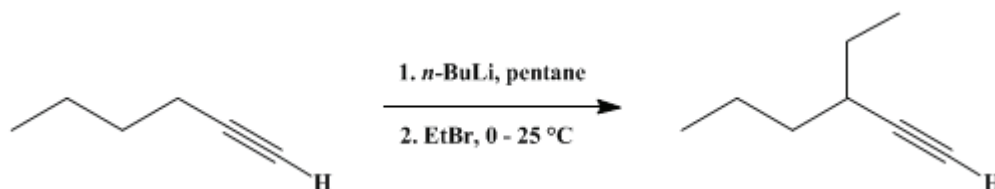
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These paragraphs were added in September 2014. The statements above do not supersede any specific hazard caution notes and safety instructions included in the procedure.

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3-ALKYL-1-ALKYNES SYNTHESIS: 3-ETHYL-1-HEXYNE

[1-Hexyne, 3-ethyl-]



Submitted by A. J. Quillinan and F. Scheinmann¹.

Checked by Y. Kita and G. Büchi.

1. Procedure

A dry, 2-l., three-necked, round-bottomed flask is fitted with a nitrogen inlet, a reflux condenser provided with a gas-outlet connected to a gas-bubbler, a rubber septum, and a magnetic stirrer. After being charged with 400 ml. of pure, dry **pentane** (Note 1) and 41 g. (0.50 mole) of **1-hexyne** (Note 1), the flask is flushed with **nitrogen** and immersed in a cold bath (Note 2), and the contents are stirred. The **nitrogen** atmosphere is maintained, and a solution of *n*-**butyllithium** in **hexane** or **pentane** (500 ml. of a 2.5 *N* solution, or 1.25 mole) is transferred to the flask with a 100-ml. syringe or a cannula (Note 3). The mixture is allowed to warm to 10° and stirred for 30 minutes, until the initially formed precipitate has completely dissolved.

The clear yellow solution is recooled to 0° in an ice bath before a solution of 88 g. (0.80 mole) of freshly-distilled **ethyl bromide** (Note 4) in 100 ml. of pure **pentane** is added dropwise with stirring over a 30-minute period while the solution warms to room temperature. Formation of a precipitate begins after an hour and is virtually complete after 6 hours (Note 5). After the mixture has been stirred for 2 days, 400 ml. of 4 *N* **hydrochloric acid** is carefully added with cooling (ice bath) and stirring. The layers are separated, and the organic phase (Note 6) is washed with 15 ml. of water, dried over anhydrous **potassium carbonate**, and filtered. Low-boiling materials are removed by distillation through an efficient Vigreux column (Note 7). The residue is distilled using a spinning-band apparatus (Note 8), yielding 35.2–35.8 g. (64–65%) of **3-ethyl-1-hexyne** as a colorless, pungent oil (Note 9), b.p. 113–114°, n_D^{20} 1.4101 (Note 10).

2. Notes

1. Solvents must be pure since higher-boiling impurities will accumulate in the reaction product, making the final distillation much more difficult and reducing the purity of the product. Commercial **pentane** was purified by redistillation through an efficient Vigreux column (Note 7) and collected at 33–34°. **1-Hexyne** is available from Fluka A G, Tridom Chemical, Inc., and Koch-Light Laboratories, Ltd., or by synthesis from **sodium acetylide** and **1-bromobutane** (L. Brandsma, "Preparative Acetylene Chemistry," Elsevier, Amsterdam, 1971, p. 45.).
2. The temperature is not critical; the submitters used a bath temperature of –35 to –20°, but claimed that an acetone–dry-ice bath is satisfactory or that an ice-water bath with slow addition of *n*-**butyllithium** can also be used.
3. All operations involving alkyllithium reagents should be carried out under an inert gas, since they tend to ignite spontaneously in air.
4. Commercial **ethyl bromide** was dried over anhydrous **potassium carbonate**, filtered, and redistilled prior to use.
5. The reaction may be conveniently terminated here, but reaction for two days gives a slightly higher yield at the expense of some hydrocarbon impurity formed from the slow reaction of excess alkyllithium with the alkyl bromide. If this impurity can contaminate the final product, the side reaction may be suppressed by conducting the reaction in the minimum amount of solvent necessary to dissolve the

dilithium complex.

6. Dark coloration is usually a result of insufficient acidity; the aqueous phase at the separation stage should have a pH between 2 and 4.

7. A vacuum-jacketed Vigreux column of 1.5-cm. internal diameter and *ca.* 90-cm. length is satisfactory. With shorter or less efficient columns, redistillation of the distillate may be necessary to reduce losses in yield.

8. The submitters used a Büchi spinning-band distillation apparatus by Abegg (*ca.* 30 theoretical plates resolution), operated at a reflux ratio of 10–15:1 and having a capacity of 50–100 ml. The checkers found that this distillation required four days to obtain the pure product.

9. 3-Ethyl-1-hexyne is an irritant to the membranes of the nose and throat and should only be handled in a well-ventilated hood. Other 3-substituted 1-alkynes prepared in this series^{2,3,4,5} have pleasant or neutral odors, but direct contact should be avoided, since toxicity data are not available.

10. The previously unknown 3-ethyl-1-hexyne was further characterized by the submitters as follows: IR cm^{-1} : 3338, 2975, 2940, 2881, 2103, 1460, 1380, 1240; ^{13}C NMR (CDCl_3), δ 88.0, 69.23, 37.12, 33.29, 28.23, 20.69, 13.97, 11.71; ^1H NMR (CDCl_3), δ (multiplicity, coupling constant J in Hz., number of protons, assignment): 0.99 (t, $J = 6$, 6H, 2CH_3), 1.2–1.7 (m, 6H, 3CH_2), 2.00 (d, $J = 2$, 1H, $\text{C}\equiv\text{CH}$), 2.3 (m, 1H, tertiary CH).

Hydrogenation at 20° over Adams catalyst, platinum oxide, at atmospheric pressure afforded the known 3-ethylhexane,⁶ b.p. 118–119° (lit.,^{2,3,4,5} b.p. 119°).

In an analogous synthesis,² 3-butyl-1-heptyne was also characterized by mercuric oxide–sulfuric acid hydration⁷ to the known 3-butyl-2-heptanone,^{8,9} which also formed the known semicarbazone.⁹

3. Discussion

This procedure has been shown^{2,3,4,5} to be extremely general and applicable to the reaction of a wide variety of straight-chain 1-acetylenes, 4-substituted 1-acetylenes, and α,ω -diacetylenes with primary halides, sterically hindered primary halides, secondary halides, and α,ω -dihalides.

Most of the compounds formed are new and were formerly inaccessible,¹⁰ available only by dehydrohalogenation of geminal or 1,2-dibromides which are often unavailable themselves.¹⁰ Alcoholic potassium hydroxide^{11,12} or sodamide in liquid paraffin^{10,13} under forceful conditions has been used for this elimination, but yields are generally not good.^{10,11,12,13}

The procedure described here is characterized by good yields and mild conditions, and affords an easy route to a pure compound from readily available starting materials. Since tertiary aliphatic acetylenes do not form readily under these conditions, the excess of alkyllithium used is not particularly critical. The small amount of by-products that also forms is readily removed at the distillation stage.

References and Notes

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Appendix
Chemical Abstracts Nomenclature (Collective Index Number);
(Registry Number)

potassium carbonate (584-08-7)

hydrochloric acid (7647-01-0)

1-bromobutane (109-65-9)

Ethyl bromide (74-96-4)

nitrogen (7727-37-9)

platinum oxide

potassium hydroxide (1310-58-3)

Pentane (109-66-0)

sodamide (7782-92-5)

n-butyllithium (109-72-8)

sodium acetylide

hexane (110-54-3)

1-Hexyne (693-02-7)

3-Ethyl-1-hexyne,
1-Hexyne, 3-ethyl- (76347-58-5)

3-ethylhexane (619-99-8)

3-butyl-1-heptyne

3-butyl-2-heptanone