



A Publication
of Reliable Methods
for the Preparation
of Organic Compounds

Working with Hazardous Chemicals

The procedures in *Organic Syntheses* are intended for use only by persons with proper training in experimental organic chemistry. All hazardous materials should be handled using the standard procedures for work with chemicals described in references such as "Prudent Practices in the Laboratory" (The National Academies Press, Washington, D.C., 2011; the full text can be accessed free of charge at http://www.nap.edu/catalog.php?record_id=12654). All chemical waste should be disposed of in accordance with local regulations. For general guidelines for the management of chemical waste, see Chapter 8 of Prudent Practices.

In some articles in *Organic Syntheses*, chemical-specific hazards are highlighted in red "Caution Notes" within a procedure. It is important to recognize that the absence of a caution note does not imply that no significant hazards are associated with the chemicals involved in that procedure. Prior to performing a reaction, a thorough risk assessment should be carried out that includes a review of the potential hazards associated with each chemical and experimental operation on the scale that is planned for the procedure. Guidelines for carrying out a risk assessment and for analyzing the hazards associated with chemicals can be found in Chapter 4 of Prudent Practices.

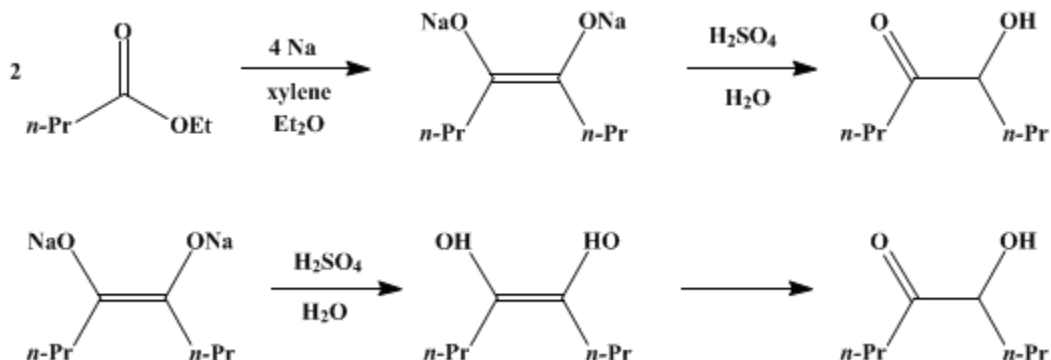
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These paragraphs were added in September 2014. The statements above do not supersede any specific hazard caution notes and safety instructions included in the procedure.

Organic Syntheses, Coll. Vol. 2, p.114 (1943); Vol. 13, p.24 (1933).

BUTYROIN

[4-Octanone, 5-hydroxy-]



Submitted by John M. Snell and S. M. McElvain.

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1. Procedure

In a 3-l. three-necked, round-bottomed flask, fitted with a long reflux condenser and an efficient mechanical stirrer, are placed 92 g. (4 gram atoms) of clean [metallic sodium](#) and about 150 cc. of [xylene](#). The [sodium](#) is finely powdered by heating the flask until the [sodium](#) melts and then cooling with very vigorous stirring. The cooled [xylene](#) is decanted, and the powdered [sodium](#) is thoroughly washed with four or five portions of dry, alcohol-free [ether](#). About 1.2 l. of absolute [ether](#) is added ([Note 1](#)), and the flask is fitted with a reflux condenser, a 250-cc. separatory funnel, and a mechanical stirrer ([Note 2](#)).

The stirrer is started, and 232 g. (2 moles) of purified [ethyl n-butylate](#) ([Note 3](#)) is slowly run in from the separatory funnel. It is advisable to add first a portion of about 25 cc.; the heat of reaction soon causes the [ether](#) to boil; the rest of the ester is then run in at such a rate that gentle ebullition is maintained. Stirring is continued until there is no further reaction and practically all the [sodium](#) has been converted into the voluminous yellow-white solid which begins to appear almost at once ([Note 4](#)).

The reaction flask is now surrounded by an ice bath, and the contents are vigorously stirred while a cooled solution of 210 g. of [sulfuric acid](#) (sp. gr. 1.84) in 350 cc. of water is carefully run in from the separatory funnel. The stirrer is now removed and the flask is allowed to stand in the ice bath until the lower layer of hydrated [sodium sulfate](#) ($\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O}$) has solidified. The [ether](#) solution is decanted and the [sodium sulfate](#) crystals washed with 100–200 cc. of [ether](#).

The combined solution and washings are shaken with about 100 cc. of 20 per cent [sodium carbonate](#) solution ([Note 5](#)) and are then dried over anhydrous [potassium carbonate](#). The [ether](#) and alcohol are removed rapidly by distillation, and the residue is fractionated under reduced pressure in a 250-cc. modified Claisen flask ([Note 6](#)). The main fraction boils at 80–86° at 12 mm.; a fraction boiling up to about 15° above the main fraction should also be collected. The low-boiling and high-boiling fractions can be refractionated for recovery of a small additional amount of [butyroin](#). The total yield is 94–101 g. (65–70 per cent of the theoretical amount) of product that is colored yellow by traces of the diketone ([Note 7](#)) and ([Note 8](#)).

2. Notes

1. The reaction can be run in [benzene](#), but it is much slower than in [ether](#).
2. For powdering the [sodium](#) a small, rapid stirrer is best; for stirring the reaction mixture, a fairly large, slower stirrer is best.
3. The ester is purified as follows: It is washed once with 10 per cent [sodium carbonate](#) solution and

twice with an equal volume of saturated [sodium chloride](#) solution; it is then dried twenty-four hours over anhydrous [potassium carbonate](#). The [potassium carbonate](#) is filtered and the ester allowed to stand overnight with about 2 per cent of its weight of [phosphorus pentoxide](#). The ester is then distilled through a column directly from the [phosphorus pentoxide](#); a fraction that distils over a range of 2 degrees or less should be taken. Lower yields of [butyrolin](#) may be obtained from less carefully purified ester.

4. Addition of the ester requires one and one-half to two hours, and the mixture should then be refluxed an hour longer.

5. Small amounts of [butyric acid](#) and [dipropylglycollic acid](#) are present in the reaction mixture.

6. The [ether](#) should be removed rapidly and the distillation should not be too slow, for long heating favors the formation of a high-boiling by-product of unknown structure at the expense of the [butyrolin](#).

7. Usually the amount of diketone present is negligible. The diketone may be removed by shaking the [butyrolin](#) vigorously from time to time during one hour with 100 cc. of a saturated [sodium bisulfite](#) solution, washing with strong [sodium chloride](#) solution, and then redistilling.

8. These directions have been used for the following acyloins:

[Propionoin](#) b.p. 60–65°/12 mm.; 50–55 per cent yield.

[Isobutyrolin](#) b.p. 70–75°/14 mm.; 70–75 per cent yield.

[Pivaloin](#) m.p. 80–81°; b.p. 85–95°/12 mm.; 52–60 per cent yield

3. Discussion

Aliphatic acyloins can be obtained by the saponification of the reaction product of [sodium](#) on moist ethereal solutions of acid chlorides, the first product being the diester of the dienolic modification of the acyloin.¹ Of greater preparative interest, however, is the reaction between ethereal solutions of aliphatic esters and [sodium](#)² or [potassium](#).³

This preparation is referenced from:

- [Org. Syn. Coll. Vol. 7, 95](#)

References and Notes

1. Klinger and Schmitz, *Ber.* **24**, 1273 (1891); Basse and Klinger, *ibid.* **31**, 1218 (1898); Anderlini, *Gazz. chim. ital.* **25** (II) 51, 128 (1895); Egorova, *J. Russ. Phys.-Chem. Soc.* **60**, 1199 (1928) [*C. A.* **23**, 2935 (1929)].
2. Bouveault and Locquin, *Bull. soc. chim.* (3) **35**, 629 (1906); Feigl, *Ber.* **58**, 2299 (1925); Corson, Benson, and Goodwin, *J. Am. Chem. Soc.* **52**, 3988 (1930).
3. Scheibler and Emden, *Ann.* **434**, 265 (1923).

Appendix

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

[potassium carbonate](#) (584-08-7)

[sulfuric acid](#) (7664-93-9)

[Benzene](#) (71-43-2)

[ether](#) (60-29-7)

[sodium chloride](#) (7647-14-5)

sodium carbonate (497-19-8)

sodium sulfate (7757-82-6)

sodium bisulfite (7631-90-5)

sodium,
metallic sodium (13966-32-0)

butyric acid (107-92-6)

potassium (7440-09-7)

xylene (106-42-3)

Butyrolin,
4-Octanone, 5-hydroxy- (496-77-5)

dipropylglycollic acid

Propionoin (4984-85-4)

Isobutyrolin (815-77-0)

Pivaloin (815-66-7)

ethyl n-butyrate (105-54-4)

phosphorus pentoxide (1314-56-3)