



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](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.

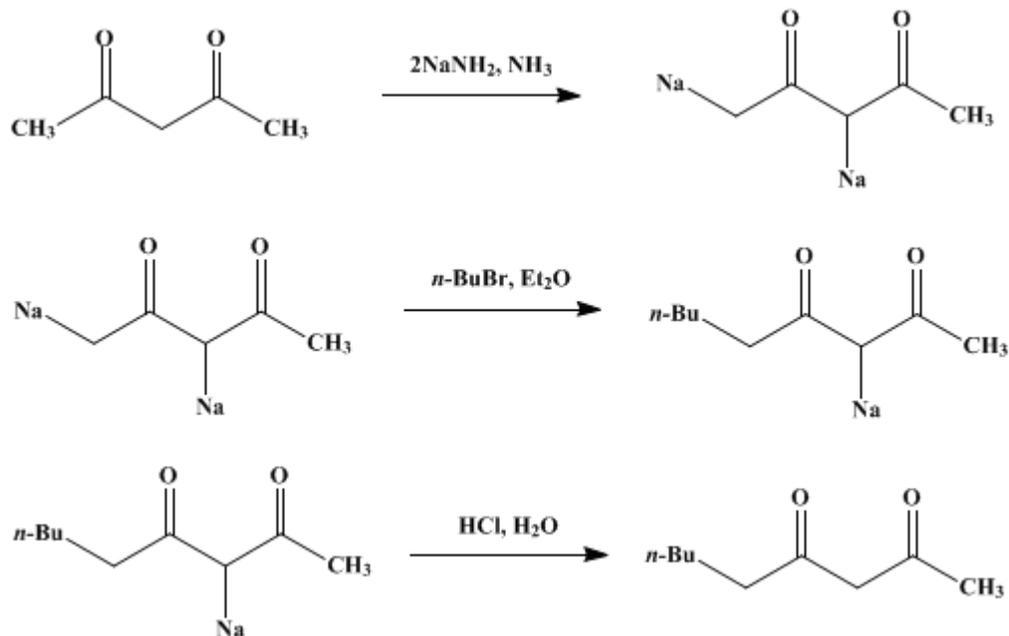
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*These paragraphs were added in September 2014. The statements above do not supersede any specific hazard caution notes and safety instructions included in the procedure.*

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## 2,4-NONANEDIONE



Submitted by K. Gerald Hampton, Thomas M. Harris, and Charles R. Hauser<sup>1</sup>.  
Checked by Eugene Gosselink and Peter Yates.

### 1. Procedure

*Caution! This preparation should be carried out in a hood to avoid exposure to ammonia.*

A suspension of sodium amide (1.10 moles) in liquid ammonia is prepared in a 1-l. three-necked flask equipped with an air condenser (Note 1), a ball-sealed mechanical stirrer, and a glass stopper. In the preparation of this reagent commercial anhydrous liquid ammonia (800 ml.) is introduced from a cylinder through an inlet tube. To the stirred ammonia is added a small piece of sodium. After the appearance of a blue color a few crystals of ferric nitrate hydrate (about 0.25 g.) are added, followed by small pieces of freshly cut sodium until 25.3 g. (1.10 moles) has been added. After the sodium amide formation is complete (Note 2), the glass stopper is replaced by a pressure-equalizing dropping funnel containing 60.0 g. (0.600 mole) of 2,4-pentanedione (Note 3) in 40 ml. of anhydrous ether. The top of the addition funnel is fitted with a nitrogen inlet tube. The reaction flask is immersed at least 3 in. into a dry ice-acetone bath (Note 4), and simultaneously the slow introduction of dry nitrogen through the inlet tube is begun. After the reaction mixture is thoroughly cooled (about 20 minutes), 2,4-pentanedione is added intermittently in small portions (Note 4) over 10 minutes. The cooling bath is removed. After 20 minutes the nitrogen purge is stopped, and 68.5 g. (0.500 mole) of 1-bromobutane (Note 5) in 40 ml. of anhydrous ether is introduced dropwise during 10–20 minutes. The addition funnel is rinsed with a small volume of anhydrous ether, which is added to the reaction mixture. After 30 minutes 400 ml. of anhydrous ether is added, and the ammonia is removed by cautious heating on the steam bath. Crushed ice (200 g.) is added causing a thick slurry to form. Next a mixture of 60 ml. of concentrated hydrochloric acid and 10 g. of crushed ice is added. The reaction mixture is stirred until all solids are dissolved and then is transferred to a separatory funnel, the flask being washed with a little ether and dilute hydrochloric acid. The ethereal layer is separated, and the aqueous layer (Note 6) is further extracted three times with 100-ml. portions of ether. The combined ethereal extracts are dried over anhydrous magnesium sulfate. After filtration and removal of the solvent the residue is distilled through a 12-in. Vigreux column to give 63.0–63.6 g. (81–82%) of 2,4-nonanedione, b.p. 100–103° (19 mm.), as

a colorless liquid (Note 7).

## 2. Notes

1. The checkers used a dry ice condenser during the introduction of ammonia to the reaction flask and replaced it with an air condenser before the addition of sodium.
2. Conversion to sodium amide is indicated by the disappearance of the blue color. This generally requires about 20 minutes.
3. Eastman Organic Chemicals 2,4-pentanedione was dried over potassium carbonate and distilled before use, the fraction boiling at 133–135° at atmospheric pressure being used.
4. The addition of 2,4-pentanedione to liquid ammonia is a highly exothermic process. Also, ammonia vapor reacts with the  $\beta$ -diketone to produce an insoluble ammonium salt, which tends to clog the tip of the addition funnel. Cooling the reaction mixture in dry ice-acetone reduces the vigor of the reaction and minimizes the clogging of the addition funnel. The 2,4-pentanedione should be added in spurts which fall on the surface of the reaction mixture rather than on the wall of the flask.
5. Eastman Organic Chemicals 1-bromobutane was used without purification.
6. The aqueous layer should be acidic to litmus paper. If it is basic, indicating that the ammonia was not completely removed from the reaction mixture, more hydrochloric acid should be added until an acidic test is obtained.
7. A small forerun of 2,4-pentanedione, b.p. 32–100° (19 mm.), is obtained. The purity of the product may be demonstrated by gas chromatography on a 2-ft. column packed with silicone gum rubber (F and M Scientific Co., Avondale, Pennsylvania) programmed linearly from 100° to 300°. The chromatogram obtained is a single sharp peak. The three conceivable impurities, 2,4-pentanedione, 3-butyl-2,4-pentanedione, and 6,8-tridecanedione, would have been observed under these conditions if they had been present.

## 3. Discussion

The method described is that of Hampton, Harris, and Hauser<sup>2</sup> and is an improvement over the earlier procedures<sup>3,4</sup> of Hauser and co-workers, which employed potassium amide. 2,4-Nonanedione has been prepared by the condensation of ethyl caproate with acetone in the presence of sodium hydride (54–80%),<sup>5,6</sup> and by the acylation of ethyl acetoacetate followed by cleavage and decarboxylation (51%).<sup>7</sup> Other preparations include the acetylation of 2-heptanone with ethyl acetate and sodium amide (61%),<sup>8</sup> the acetylation of 1-heptyne with acetic anhydride and boron fluoride (42%),<sup>9</sup> and the sulfuric acid-catalyzed hydration of 3-nonyl-2-one.<sup>10</sup> Low yields (6–7%) of 2,4-nonanedione were obtained by the acetylation of 2-heptanone with acetic anhydride and boron fluoride,<sup>11</sup> and by the pyrolysis of the enol acetates of 2-heptanone.<sup>12</sup> The last two methods afforded substantial amounts of the isomeric 3-butyl-2,4-pentanedione.

## 4. Merits of the Preparation

This procedure represents a novel, convenient, and fairly general method for preparing higher  $\beta$ -diketones. By this method the submitters have alkylated 2,4-pentanedione at the 1-position with methyl iodide to give 2,4-hexanedione (59–65%) and with *n*-octyl bromide to give 2,4-tridecanedione (66–79%).<sup>2</sup> Alkylation at the 3-position is not observed, and little or no 1,5-dialkylation occurs. By similar procedures employing potassium amide, 2,4-pentanedione has been alkylated with benzyl chloride,<sup>3,4</sup> allyl bromide,<sup>4</sup> *n*-heptyl bromide,<sup>4</sup> and isopropyl bromide.<sup>4</sup> Numerous other  $\beta$ -diketones have been alkylated similarly. They include benzoylacetone,<sup>3</sup> 6-phenyl-2,4-hexanedione,<sup>4,13</sup> 2-acetylclopentanone,<sup>13</sup> 2-acetylcyclohexanone,<sup>13</sup> and 2,4-tridecanedione.<sup>4</sup> In contrast to 2,4-pentanedione, these  $\beta$ -diketones may be added readily to the liquid ammonia solution without employing a dry ice cooling bath.

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## References and Notes

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

2-acetylclopentanone

potassium carbonate (584-08-7)

hydrochloric acid (7647-01-0)

ammonia (7664-41-7)

ethyl acetate (141-78-6)

ether (60-29-7)

acetic anhydride (108-24-7)

1-bromobutane (109-65-9)

n-octyl bromide (111-83-1)

Isopropyl bromide (75-26-3)

nitrogen (7727-37-9)

acetone (67-64-1)

sodium (13966-32-0)

benzyl chloride (100-44-7)

Methyl iodide (74-88-4)

Ethyl acetoacetate (141-97-9)  
ethyl caproate (123-66-0)  
2-Heptanone (110-43-0)  
1-heptyne (628-71-7)  
magnesium sulfate (7487-88-9)  
Ammonium (14798-03-9)  
boron fluoride (7637-07-2)  
n-heptyl bromide (629-04-9)  
sodium amide (7782-92-5)  
2,4-pentanedione (123-54-6)  
benzoylacetone (93-91-4)  
sodium hydride (7646-69-7)  
potassium amide  
ferric nitrate hydrate  
2,4-Nonanedione (6175-23-1)  
6,8-tridecanedione  
3-nonyl-2-one  
3-Butyl-2,4-pentanedione (1540-36-9)  
2,4-hexanedione (3002-24-2)  
2,4-tridecanedione  
6-phenyl-2,4-hexanedione  
2-acetylcyclohexanone (874-23-7)