



A Publication
of Reliable Methods
for the Preparation
of Organic Compounds

Working with Hazardous Chemicals

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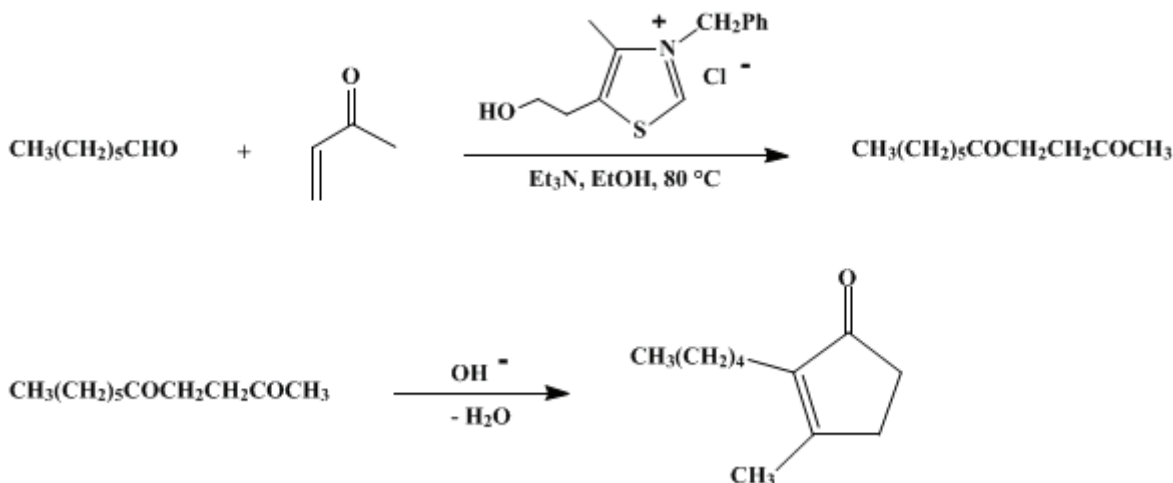
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These paragraphs were added in September 2014. The statements above do not supersede any specific hazard caution notes and safety instructions included in the procedure.

Organic Syntheses, Coll. Vol. 8, p.620 (1993); Vol. 65, p.26 (1987).

THE STETTER REACTION: 2,5-UNDECANEDIONE AND 3-METHYL-2-PENTYL-2-CYCLOPENTEN-1-ONE (DIHYDROJASMONE)

[2-Cyclopenten-1-one, 3-methyl-2-pentyl-]



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1. Procedure

A. *2,5-Undecanedione*. A 1000-mL, three-necked, round-bottomed flask equipped with a mechanical stirrer, a short gas inlet tube, and an efficient reflux condenser fitted with a potassium hydroxide drying tube is charged with 26.8 g (0.1 mol) of 3-benzyl-5-(2-hydroxyethyl)-4-methyl-1,3-thiazolium chloride (Note 1), 500 mL of absolute ethanol, 77.2 g (1.1 mol) of 3-buten-2-one (Note 2), 60.6 g (0.6 mol) of triethylamine (Note 3), and 114.2 g (1.0 mol) of heptanal (Note 4). A slow stream of nitrogen (Note 5) is started and the mixture is stirred and heated in an oil bath at 80°C. After 16 hr the reaction mixture is cooled to room temperature and concentrated by rotary evaporation. Then 500 mL of chloroform is added to the residue and the mixture is washed with 200 mL of dilute hydrochloric acid (5%), 200 mL of saturated sodium hydrogen carbonate solution, and, finally, with two 200-mL portions of water. After the solution is dried with anhydrous magnesium sulfate, the chloroform is distilled off and the residue is fractionated under reduced pressure through a 30-cm Vigreux column. The main fraction is collected at 80–82°C/0.3 mm. The yield is 130–138 g (71–75% based on heptanal) of a colorless distillate, which solidifies on standing at room temperature, mp 33–34°C (Note 6) and (Note 7).

B. *3-Methyl-2-pentyl-2-cyclopenten-1-one (Dihydrojasmone)*. 2,5-Undecanedione (92.1 g, 0.5 mol) is added to a solution of 16.0 g (0.4 mol) of sodium hydroxide in 800 mL of water and 200 mL of ethanol in a 2000-mL round-bottomed flask. The mixture is refluxed for 6 hr, cooled to room temperature, and extracted with ether. The combined ether phases are dried with magnesium sulfate, and the solution is separated from the drying agent and concentrated at room temperature under reduced pressure. The residual oil is distilled through a 30-cm Vigreux column. The pure compound boils at 65–67°C/0.5 mm and weighs 70–73 g (84–88% based on the diketone) (Note 8).

2. Notes

1. 3-Benzyl-5-(2-hydroxyethyl)-4-methyl-1,3-thiazolium chloride is supplied by Fluka AG, Buchs, Switzerland and by Tridom Chemical, Inc., Hauppauge, New York. The thiazolium salt may also be

prepared as described in *Org. Synth., Coll. Vol. VII, 1990, 95*.

2. **3-Buten-2-one** was used as obtained from Fluka AG, Buchs, Switzerland.

3. **Triethylamine** was dried with **potassium hydroxide** and distilled. Instead of **triethylamine**, **sodium acetate** (32.8 g, 0.4 mol), which has been dried under vacuum at 100°C for 1 day, can also be used.

4. **Heptanal** was supplied by Aldrich Chemical Company, Inc. It was freshly distilled before use.

5. The **nitrogen** flow rate should be one bubble per second.

6. A boiling point of 141°C at 14 mm and a melting point of 33°C is recorded.² The diketone exhibits the following spectral characteristics: IR (CDCl₃) cm⁻¹: 1710, ¹H NMR (CDCl₃) δ: 0.77–1.67 (m, 11 H, CH₂ and CH₃); 2.13 (s, 3 H, C-CH₃); 2.30–2.60 (m, 2 H, CH₂); 2.67 (s, 4 H, COCH₂CH₂CO).

7. The checkers obtained a second fraction from the distillation (13.5 g, 7.4%), bp 97–105°C at 0.15 mm, which solidified on cooling. Recrystallization of this material from **hexane** gave a colorless solid, mp 26–27°C, which was identified from its infrared, NMR, and mass spectra as **8-hydroxy-7-tetradecanone**. This product arises via a "benzoin-type" condensation, catalyzed by the thiazolium salt, of **heptanal**.

8. A boiling point of 122–124°C at 12 mm is recorded.² The **cyclopentenone** exhibits the following spectral characteristics: IR (neat) cm⁻¹: 1695 and 1640; ¹H NMR (CDCl₃) δ: 0.77–1.50 (m, 9 H, CH₂ and CH₃); 2.03 (s, 3 H, CH₃); 2.13–2.57 (m, 6 H, CH₂). For fragrance it is advisable to destroy malodorous byproducts by the method described in (Note 9).

9. The use of **sodium acetate** instead of **triethylamine** (see (Note 3)) is an alternative and is followed by an oxidizing treatment of the diketone: 100 g of **2,5-undecanedione** is dissolved in 500 mL of **methylene chloride** and treated with 10 g of an oxidizing reagent (Note 10). The mixture is refluxed for 3 hr, filtered, and washed with three 100-mL portions of water. The organic phase is dried with **sodium sulfate** and distilled. This material is converted into dihydrojasnone by Procedure B, and a last, efficient distillation (Fisher, slit-tube system, HMS 500) leads to chromatographic purity greater than 99%.

10. Oxidizing reagent:³ To a solution of 500 g (0.5 mol) of **chromium(VI) oxide** and 300 mL of water is added 250 g of silica gel (silica gel 60, E. Merck, Darmstadt, Germany). The mixture is shaken at 30–35°C for 1 hr. After this, the water is removed on a rotary evaporator to yield a yellow-orange, free-flowing powder.

3. Discussion

2,5-Undecanedione and the cyclization to dihydrojasnone were first described by H. Hunsdiecker.² The natural jasmine odor components and the artificial substitutes have been the goal of many investigations.⁴ Our method of preparing **2,5-undecanedione** by addition of **heptanal** to **3-buten-2-one**⁵ is only one example of a wide range of reactions involving the conjugate addition to electron-deficient double bonds.⁶

A large variety of aldehydes has been used in the addition to **butenone** (we give some characteristic examples):

1. Simple straight-chain aliphatic aldehydes (C₂ to C₁₂ tested) and mono α -branched aldehydes.⁷
2. Conjugated unsaturated aldehydes (e.g., **citral**, β,β -dimethylacrolein⁸).
3. Aldehydes that contain isolated double bonds, such as **10-undecenal**, **citronellal**, **3-cyclohexene-1-carboxaldehyde**, and **norbornene carboxaldehyde**.^{8,9}
4. Aldehydes containing a variety of other functional groups, such as ether groups,¹⁰ the phthalimido group,¹¹ and keto, ester, and nitrile groups.^{12,13}
5. Heterocyclic and aromatic aldehydes^{7,12} (e.g., **furan-2-carboxaldehyde**, **thiophene-2-carboxaldehyde**, and pyridinecarboxaldehydes, **benzaldehyde**, and diverse substituted benzaldehydes).

Variations have been made in the activated system also. Higher homologues of **butenone** (e.g., **1-penten-3-one**, **tert-butyl vinyl ketone**) react in the same manner as does **phenyl vinyl ketone**. The same variety of functional groups as shown before may be possible in the side chain of the ketone.¹⁴

Additions to acrylic esters and **acrylonitrile**¹⁵ and to arylidene and alkylidene- β -dicarbonyl compounds¹⁶ are possible.

The addition of aldehydes to α,β -unsaturated sulfones yields γ -diketones.¹⁷

The mechanism of the thiazolium ion-catalyzed conjugate addition reactions⁶ is considered to be analogous to the Lapworth mechanism for the cyanide-catalyzed [benzoin](#) condensation, the [thiazolium ylide](#) playing the role of cyanide. The resulting intermediate carbanion is presumed to be the actual Michael donor. After conjugate addition to the activated olefin, the [thiazolium ylide](#) is eliminated to form the product and regenerate the catalyst.

References and Notes

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Appendix

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

silica gel

[ethanol](#) (64-17-5)

[hydrochloric acid](#) (7647-01-0)

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

[sodium acetate](#) (127-09-3)

[sodium hydroxide](#) (1310-73-2)

[chloroform](#) (67-66-3)

[sodium hydrogen carbonate](#) (144-55-8)

sodium sulfate (7757-82-6)

nitrogen (7727-37-9)

benzaldehyde (100-52-7)

Benzoin (119-53-9)

potassium hydroxide (1310-58-3)

furan-2-carboxaldehyde (98-01-1)

methylene chloride (75-09-2)

magnesium sulfate (7487-88-9)

chromium(VI) oxide (1333-82-0)

acrylonitrile (107-13-1)

hexane (110-54-3)

3-buten-2-one,
butenone (78-94-4)

citral (5392-40-5)

thiophene-2-carboxaldehyde (98-03-3)

triethylamine (121-44-8)

Heptanal (111-71-7)

cyclopentenone (930-30-3)

3-cyclohexene-1-carboxaldehyde

citronellal (106-23-0)

3-benzyl-5-(2-hydroxyethyl)-4-methyl-1,3-thiazolium chloride

thiazolium ylide

1-penten-3-one (1629-58-9)

phenyl vinyl ketone (768-03-6)

2,5-Undecanedione (7018-92-0)

3-Methyl-2-pentyl-2-cyclopenten-1-one,
2-Cyclopenten-1-one, 3-methyl-2-pentyl- (1128-08-1)

8-hydroxy-7-tetradecanone

10-undecenal (112-45-8)

norbornene carboxaldehyde

Dihydrojasmone

tert-butyl vinyl ketone