



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.

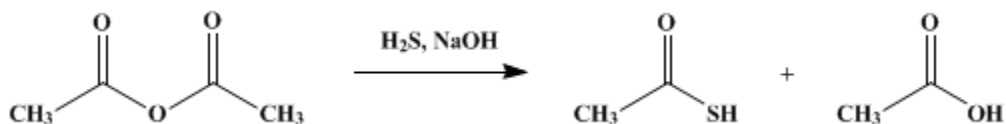
The procedures described in *Organic Syntheses* are provided as published and are conducted at one's own risk. *Organic Syntheses, Inc.*, its Editors, and its Board of Directors do not warrant or guarantee the safety of individuals using these procedures and hereby disclaim any liability for any injuries or damages claimed to have resulted from or related in any way to the procedures herein.

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. 4, p.928 (1963); Vol. 31, p.105 (1951).

THIOLACETIC ACID

[Acetic acid, thiol-]



Submitted by E. K. Ellingboe¹

Checked by Arthur C. Cope and Malcolm Chamberlain.

1. Procedure

Caution! All the steps of this procedure should be carried out under a hood because of the highly toxic nature of hydrogen sulfide and the probable toxicity and persistent unpleasant odor of thiolacetic acid.

A 200-ml. three-necked flask is fitted with a mercury-sealed glass stirrer, a reflux condenser, and a gas inlet tube and thermometer, both of which extend into the lower half of the flask. The top of the condenser is connected to a mercury bubbler tube, and the gas inlet tube is attached to the inlet tube of a gas-washing bottle which serves as a safety trap to prevent liquid from being drawn into the hydrogen sulfide source. The gas-washing bottle is connected through a drying tube containing anhydrous calcium sulfate (Drierite) to a T-tube. The vertical arm of the T-tube dips into mercury and forms a safety valve; the other arm is connected to a commercial cylinder (Note 1) or other source of hydrogen sulfide. To the flask are added 107 g. (100 ml., 1 mole) of 95% acetic anhydride and 1 g. (0.025 mole) of powdered sodium hydroxide. The assembly of the flask, condenser, inlet tube, and thermometer is weighed and arranged so that the amount of hydrogen sulfide introduced can be determined by subsequent weighing. The stirrer is started, and hydrogen sulfide is passed into the mixture as rapidly as possible without much loss of the gas through the bubbler connected to the top of the condenser. The temperature of the mixture rises to 55° within 30 minutes and is kept at 50–55° by intermittent cooling. The temperature begins to drop after 14–17 g. of hydrogen sulfide has been absorbed and is maintained at 50–55° by external heating. After a total reaction period of 6 hours, hydrogen sulfide ceases to be absorbed and the gain in weight amounts to about 31 g.

The reaction mixture is transferred to a 250-ml. Claisen flask (Note 2) and distilled rapidly at 200 mm. in order to separate the sodium salts (Note 3). The distillate of thiolacetic acid and acetic acid, b.p. 35–82°/200 mm., amounts to 120–124 g. It is fractionally distilled at atmospheric pressure through an efficient, variable take-off type column² with a 30- to 40-cm. section packed with glass helices. The fraction boiling at 86–88°, n_D^{25} 1.4612, is nearly pure thiolacetic acid and amounts to 55–57.5 g. (72–76%) based on the acetic anhydride (Note 4) and (Note 5). The residual liquid is mainly acetic acid. If distillation is continued after separation of the thiolacetic acid, the vapor temperature rises rapidly to the boiling point of acetic acid.

2. Notes

1. Cylinders of hydrogen sulfide are available from the Matheson Company, Inc., East Rutherford, New Jersey.
2. An all-glass distillation assembly equipped with ground joints is advisable because the hot vapor of thiolacetic acid rapidly softens rubber stoppers.
3. The product decomposes excessively if fractionation is attempted in the presence of the sodium salts. In larger-scale preparations the initial distillation should be conducted in small batches or, preferably, in a continuous stripping still.
4. Refractionation yields pure thiolacetic acid (with about 10% loss) with the following physical

constants: b.p. 87°/760 mm., 50°/200 mm., 34°/100 mm.; n_D^{25} 1.4630; d_4^{25} 1.0634. Higher boiling points at atmospheric pressure have been reported: 88–91°,³ 89°,⁴ and 93°.⁵ 5. The submitter has prepared **thiolacetic acid** in yields of 65–70 g. (85–92%) by a similar procedure in which the reaction mixture is placed in the glass bottle (provided with a heating jacket and thermometer or thermocouple) of a low-pressure hydrogenation apparatus.⁶ The mixture is shaken and **hydrogen sulfide** is introduced at 25–35 p.s.i., with repressuring to 35–40 p.s.i. whenever the pressure drops to 10 p.s.i. The heat of reaction raises the temperature to 60–65° in 12–15 minutes, after which the internal temperature is maintained at 60° by heating. **Hydrogen sulfide** absorption becomes negligible after 4 hours, and the mixture is allowed to cool while under pressure, vented, and the product is isolated in the manner described. The reaction also was conducted in a steel autoclave or hydrogenation bomb at the full pressure of **hydrogen sulfide** in a commercial cylinder (about 300 p.s.i. at room temperature). **Hydrogen sulfide** poisons the ordinary hydrogenation catalysts, and low-pressure cylinders or hydrogenation bombs exposed to **hydrogen sulfide** may not be suitable for subsequent use in catalytic hydrogenations.

3. Discussion

Thiolacetic acid has been prepared from **acetic acid** and **phosphorus pentasulfide**;⁵ from **acetyl chloride** and **potassium hydrosulfide**;⁷ by the hydrolysis of **diacetyl sulfide**;⁸ from **acetic anhydride** and **hydrogen sulfide**;^{3,4,9,10} and from **acetyl chloride** and **hydrogen sulfide** in the presence of **aluminum chloride**.¹¹ The procedure described⁹ differs from other procedures employing **acetic anhydride** and **hydrogen sulfide**^{3,4} most importantly in the use of alkaline rather than acidic catalysts, which the submitter found to cause slower absorption of **hydrogen sulfide** under pressure and to yield considerable **diacetyl sulfide** in addition to **thiolacetic acid**. Other alkaline catalysts which have been used to effect the reaction between **acetic anhydride** and **hydrogen sulfide** are **triethylamine**¹² and **pyridine**.¹³

References and Notes

1. E. I. du Pont de Nemours and Company, Inc., Wilmington, Delaware.
2. *Org. Syntheses*, **25**, 2 (1945).
3. Clarke and Hartman, *J. Am. Chem. Soc.*, **46**, 1731 (1924).
4. Hands and Whitt, *J. Soc. Chem. Ind.*, **66**, 173 (1947).
5. Kekulé, *Ann.*, **90**, 309 (1854).
6. *Org. Syntheses Coll. Vol. 1*, 66 (1941).
7. Jacquemin and Vosselmann, *Compt. rend.*, **49**, 371 (1859).
8. Davies, *Ber.*, **24**, 3551 (1891).
9. Ellingboe, U. S. pat. 2,412,036 [*C. A.*, **41**, 2074 (1947)].
10. McCool (to B. F. Goodrich Co.), U. S. pat. 2,568,020 [*C. A.*, **46**, 3557 (1952); U.S. pat. 2,587,580 [*C. A.*, **46**, 10192 (1952)]].
11. Arndt and Bekir, *Ber.*, **63**, 2390 (1930).
12. Behringer and Stein, Ger. pat. 800,412 [*C. A.*, **45**, 1622 (1951)].
13. Sjöberg, *Svensk Kem. Tidskr.*, **63**, 90 (1951) [*C. A.*, **47**, 8640 (1953)].

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

calcium sulfate (Drierite)

acetic acid (64-19-7)

acetic anhydride (108-24-7)

sodium hydroxide (1310-73-2)

acetyl chloride (75-36-5)

hydrogen sulfide (7783-06-4)

mercury (7439-97-6)

aluminum chloride (3495-54-3)

pyridine (110-86-1)

potassium hydrosulfide (1310-61-8)

phosphorus pentasulfide

triethylamine (121-44-8)

Thiolacetic acid

Acetic acid, thiol- (1918-77-0)

diacetyl sulfide (3232-39-1)