



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.

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.

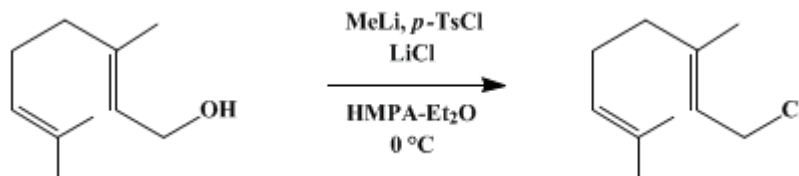
The procedures described in *Organic Syntheses* are provided as published and are conducted at one's own risk. *Organic Syntheses, Inc.*, its Editors, and its Board of Directors do not warrant or guarantee the safety of individuals using these procedures and hereby disclaim any liability for any injuries 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. 6, p.638 (1988); Vol. 54, p.68 (1974).*

## ALLYLIC CHLORIDES FROM ALLYLIC ALCOHOLS: GERANYL CHLORIDE

### [2,6-Octadiene, 1-chloro-3,7-dimethyl-, (E)-]



Submitted by Gilbert Stork<sup>1</sup>, Paul A. Grieco<sup>2</sup>, and Michael Gregson.  
Checked by P. A. Aristoff and R. E. Ireland.

### 1. Procedure

*Caution! Hexamethylphosphoric triamide (HMPA) vapors have been reported to cause cancer in rats.<sup>3</sup> All operations with hexamethylphosphoric triamide should be performed in a good hood, and care should be taken to keep the liquid off the skin.*

A dry, 1-l., three-necked, round-bottomed flask is equipped with an overhead mechanical stirrer, a 125-ml. pressure equalizing dropping funnel fitted with a rubber septum, and a nitrogen inlet tube. The system is flushed with nitrogen, and 15.4 g. (0.100 mole) of geraniol (Note 1), 35 ml. of dry hexamethylphosphoric triamide (Note 2), 100 ml. of anhydrous diethyl ether (Note 3), and 50 mg. of triphenylmethane (Note 4) are placed in the flask. The stirred solution is cooled to 0° with an ice bath, and 63 ml. (0.1 mole) of 1.6 M methyllithium in ether (Note 5) is injected into the addition funnel. The methyllithium solution is added dropwise over a period of 30 minutes. After the addition is complete, the funnel is rinsed by injecting 5 ml. of dry ether.

A solution of 20.0 g. (0.105 mole) (Note 6) of *p*-toluenesulfonyl chloride in 100 ml. of anhydrous ether is injected into the addition funnel and added over a period of 30 minutes to the stirred, red, 0° reaction mixture. The red color immediately disappears upon addition. After addition is complete, 4.2 g. (0.0990 mole) of anhydrous lithium chloride (Note 7) is added. The reaction mixture is warmed to room temperature and stirred overnight (18–20 hours), during which time lithium *p*-toluenesulfonate precipitates.

After a total of 20–22 hours, 100 ml. of ether is added, followed by 100 ml. of water. The layers are separated, and the organic phase is washed four times with 100-ml. portions of water, and finally with 100 ml. of saturated sodium chloride. After drying the organic phase over anhydrous magnesium sulfate, the solvent is removed on a rotary evaporator. The crude product is transferred to a 50-ml. flask and distilled through a 20-cm. Vigreux column, yielding 14.1–14.6 g. (82–85%) of geranyl chloride as a colorless liquid, b.p. 78–79° (3.0 mm.) (Note 8) and (Note 9).

### 2. Notes

- Geraniol (+99%) can be purchased from the Aldrich Chemical Company, Inc.
- Hexamethylphosphoric triamide was purchased from the Fisher Scientific Company and the Aldrich Chemical Company, Inc., and distilled from calcium hydride prior to use.
- Anhydrous ether, available from J. T. Baker Chemical Company, can be used without further drying.
- Triphenylmethane is available from Eastman Organic Chemicals. Although not necessary, it was used as an indicator to check the molarity of the methyllithium used.
- Methyllithium (prepared from methyl chloride), available from Foote Mineral Company, can be used without further purification. Attention should be drawn to the following: methyllithium purchased from

Alfa Inorganics is prepared from [methyl bromide](#) and, thus, produces a mixture of geranyl bromide and chloride.

6. [p-Toluenesulfonyl chloride](#) available from either the Aldrich Chemical Company, Inc., or Matheson, Coleman and Bell, Inc., was used without further purification.

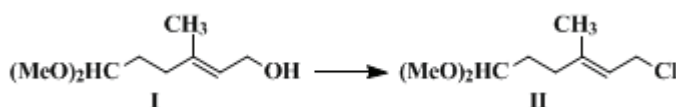
7. Available from Alfa Inorganics. If necessary, finely powdered [lithium chloride](#) can be dried by heating under vacuum (0.1 mm.) at 100° for several hours.

8. Our sample of [geranyl chloride](#) was identical (IR, <sup>1</sup>H NMR, and mass spectrum) to a sample prepared by an alternate route (Professor John Hooz, Department of Chemistry, University of Alberta).

9. The IR spectrum (neat) shows major absorptions at 2970, 2920, 2855, 1660, 1450, 1375, 1380, 1255, 835, and 660 cm.<sup>-1</sup> The <sup>1</sup>H NMR spectrum (CCl<sub>4</sub>) has a four-line multiplet at δ 1.55–1.85, characteristic of the olefinic methyl protons, two peaks at δ 2.0–2.2, due to the four allylic methylene protons, a d at δ 4.02 (*J* = 7.0 Hz.), due to the allylic methylene protons adjacent to the chlorine, a very broad t at δ 5.09, and a broad t at δ 5.45. (*J* = 7.0 Hz.), both due to the vinyl protons.

### 3. Discussion

The reaction described here illustrates a general procedure for the preparation of allylic chlorides from allylic alcohols without rearrangement and under conditions allowing the retention of sensitive groups.<sup>4</sup> For example, the sensitive [acetal alcohol](#) I with geraniol geometry was similarly treated with [ether-hexamethylphosphoric triamide](#), with [methyllithium](#) in [ether](#), and then with [p-toluenesulfonyl chloride](#) and [lithium chloride](#). Workup afforded the corresponding chloride II in 80% yield with no detectable rearrangement. The method was equally successful with the *cis*-isomer of I.



In addition, 85–90% yields of [neryl chloride](#) can be obtained from [nerol](#), the geometrical isomer of [geraniol](#). A modification<sup>5</sup> of the above method has appeared which employs [methanesulfonyl chloride](#) and a mixture of [lithium chloride](#), [N,N-dimethylformamide](#), and [2,4,6-collidine](#) at 0°; however, its applicability to compounds possessing sensitive groups was not demonstrated.

Initial attempts at preparing  $\gamma,\gamma$ -disubstituted allyl chlorides employing [thionyl chloride](#) in the presence of [tri-\*n\*-butylamine](#)<sup>6</sup> led to appreciable amounts of rearranged (tertiary) halides.

This preparation is referenced from:

- [Org. Syn. Coll. Vol. 6, 634](#)
- [Org. Syn. Coll. Vol. 8, 190](#)

---

### References and Notes

1. Department of Chemistry, Columbia University, New York, New York 10027.
  2. Present address: Department of Chemistry, Indiana University, Bloomington, Indiana 47405.
  3. J. A. Zapp, Jr., *Science*, **190**, 422 (1975).
  4. G. Stork, P. A. Grieco, and M. Gregson, *Tetrahedron Lett.*, 1393 (1969).
  5. E. W. Collington, and A. I. Meyers, *J. Org. Chem.*, **36**, 3044 (1971).
  6. See W. G. Young, F. F. Caserio, Jr., and D. D. Brandon, Jr., *J. Am. Chem. Soc.*, **82**, 6163 (1960).
- 

### Appendix

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

geranyl bromide and chloride

ether,  
diethyl ether (60-29-7)

thionyl chloride (7719-09-7)

sodium chloride (7647-14-5)

nitrogen (7727-37-9)

methyl chloride (74-87-3)

methyl bromide (74-83-9)

Triphenylmethane (519-73-3)

magnesium sulfate (7487-88-9)

N,N-dimethylformamide (68-12-2)

2,4,6-collidine (108-75-8)

geraniol (106-24-1)

Methylithium (917-54-4)

Lithium chloride (7447-41-8)

calcium hydride (7789-78-8)

Methanesulfonyl chloride (124-63-0)

tri-n-butylamine (102-82-9)

hexamethylphosphoric triamide (680-31-9)

p-Toluenesulfonyl chloride (98-59-9)

Geranyl chloride,  
2,6-Octadiene, 1-chloro-3,7-dimethyl-, (E)- (5389-87-7)

acetal alcohol

neryl chloride

nerol (106-25-2)

lithium p-toluenesulfonate