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of Reliable Methods
for the Preparation
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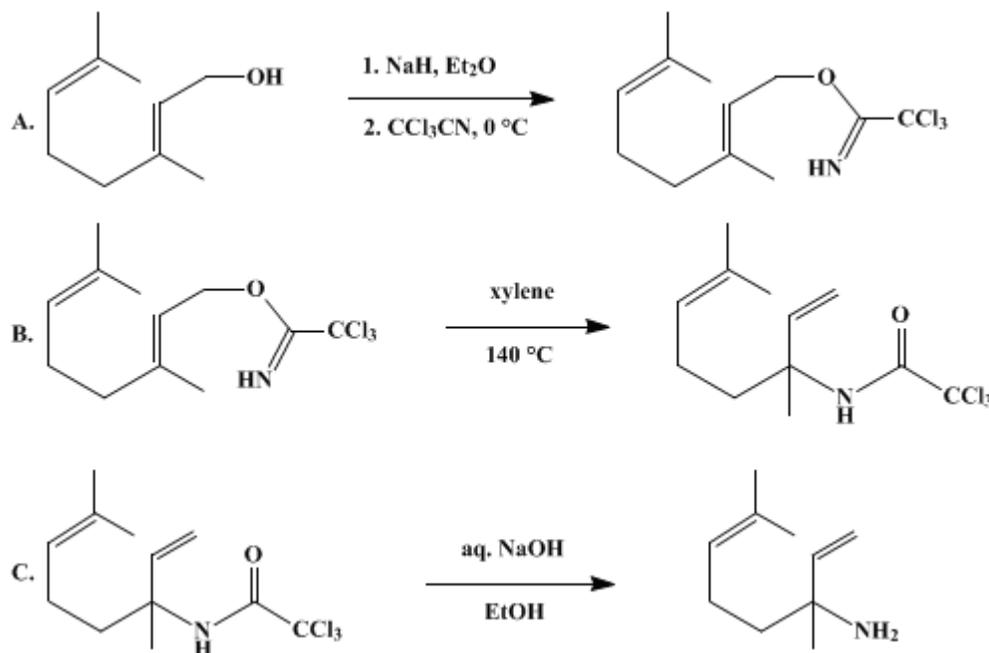
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ALLYLICALLY TRANSPOSED AMINES FROM ALLYLIC ALCOHOLS: 3,7-DIMETHYL-1,6-OCTADIEN-3-AMINE

[1,6-Octadien-3-amine, 3,7-dimethyl-]



Submitted by Lane A. Clizbe and Larry E. Overman¹.
Checked by A. Bossi, H. Mayer, and N. Kappeler.

1. Procedure

Caution! Part A should be carried out in a well-ventilated hood to avoid exposure to trichloroacetonitrile vapors.

A. *Geraniol trichloroacetimidate* (**1**). A dry, 250-ml., three-necked flask is equipped with a magnetic stirring bar, a pressure-equalizing dropping funnel, a thermometer, and a nitrogen inlet tube. The apparatus is flushed with nitrogen and charged with 410 mg. (0.0103 mole) of sodium hydride dispersed in mineral oil (Note 1) and 15 ml. of hexane. The suspension is stirred, and the hydride is allowed to settle. The hexane is removed with a long dropping pipette, 60 ml. of anhydrous diethyl ether is added, and a solution of 15.4 g. (0.0993 mole) of geraniol in 15 ml. of anhydrous ether is added over 5 minutes. After the evolution of hydrogen ceases (less than 5 minutes), the reaction mixture is stirred for an additional 15 minutes. The clear solution is then cooled to between -10 and 0° in an ice-salt bath. Trichloroacetonitrile (10.0 ml., 14.4 g., 0.0996 mole) is added dropwise to the stirred solution, while the reaction temperature is maintained below 0° (Note 2). Addition is completed within 15 minutes, and the reaction mixture is allowed to warm to room temperature. The light amber mixture is poured into a 250-ml., round-bottomed flask, and the ether is removed with a rotary evaporator. Pentane [150 ml., containing 0.4 ml. (0.01 mole) of methanol] is added, the mixture is shaken vigorously for 1 minute, and a small amount of dark, insoluble material is removed by gravity filtration. The residue is washed two times with pentane (50 ml. total), and the combined filtrate is concentrated with a rotary evaporator, yielding 27–29 g. (90–97%) of nearly pure (Note 3) imidate **1**.

B. *3,7-Dimethyl-3-trichloroacetamido-1,6-octadiene* (**2**). A 500-ml., round-bottomed flask equipped with a condenser, a magnetic stirring bar, and a calcium chloride drying tube is charged with imidate **1**

and 300 ml. of *xylene*. The solution is refluxed for 8 hours (Note 4). After cooling to room temperature the dark *xylene* solution is filtered through a short column (4.5 cm. in diameter) packed with silica gel (70 g.) and *toluene*. The column is eluted with an additional 250 ml. of *toluene*, and the combined light yellow eluant is concentrated with a rotary evaporator. Vacuum distillation through a 15-cm. Vigreux column yields 20–22 g. (67–74% for the two steps) of octadiene **2** as a colorless liquid, b.p. 94–97° (0.03 mm.) (Note 5).

C. *3,7-Dimethyl-1,6-octadien-3-amine* (**3**). A 500-ml., round-bottomed flask equipped with a magnetic stirring bar, a condenser, and a nitrogen inlet tube is charged with 9.0 g. (0.030 mole) of octadiene **2**, 160 ml. of 95% *ethanol*, and 150 ml. of aqueous 6 *N* *sodium hydroxide*. The air is replaced with *nitrogen* (Note 6), and the solution is stirred at room temperature for 40 hours (Note 7). *Ether* (300 ml.) is added, the organic layer is separated, and the aqueous layer is washed twice with 50 ml. of *ether*. After drying over anhydrous *potassium carbonate* and filtration, the organic extracts are concentrated with a rotary evaporator, affording a white, semisolid residue, which is extracted four times with 50 ml. of boiling *hexane*. The extract is concentrated with a rotary evaporator, and the residual yellow liquid is distilled under reduced pressure using a short-path apparatus, yielding 2.99–3.45 g. (65–75%) of amine **3**, b.p. 58–61° (2.6 mm.) (Note 8) and (Note 9).

2. Notes

1. The reagents used in this procedure were obtained from the following sources: *geraniol* (99+%), Aldrich Chemical Company, Inc.; *sodium hydride* (58% dispersion in mineral oil), Alfa Products, Division of the Ventron Corporation; *trichloroacetonitrile*, Aldrich Chemical Company, Inc.; *xylene* (a mixture of isomers, b.p. 137–144°), Mallinckrodt Chemical Works; anhydrous *ether*, Mallinckrodt Chemical Works; Silica Gel (Grade 62), Grace Davidson Chemical. The reagents used by the checkers were obtained from the following sources: *geraniol* (98.7%), *sodium hydride* (58% dispersion in mineral oil), *trichloroacetonitrile*, and *xylene* (a mixture of isomers, b.p. 137–143°), Fluka A G, Chemische Fabrik, Buchs, Switzerland; Silica gel (70–230 mesh ASTM), E. Merck A G, Darmstadt, Germany.
2. For secondary or tertiary alcohols, the yields are improved by adding the alcohol–alkoxide solution dropwise to a solution of *trichloroacetonitrile* and *ether* at 0°.
3. The crude imidate **1** is sufficiently pure (checked by ¹H NMR) for most purposes and can be used in the next step without further purification. IR (neat) cm⁻¹: 3340 weak (N-H), 1660 strong (C=N); ¹H NMR (CCl₄), δ (multiplicity, coupling constant *J* in Hz., number of protons, assignment): 1.58 (s, 3H, CH₃), 1.66 (s, 3H, CH₃), 1.73 (s, 3H, CH₃), 4.77 (d, *J* = 7, 2H, H₁), 5.1 (broad s, 1H, H₆), 5.5 (approx. t, *J* = 7, 1H, H₂), 8.3 (broad s, 1H, NH). The crude imidate **1** may be distilled rapidly through a short Vigreux column to give 24–28 g. (80–93%) of distilled product, b.p. 109–111° (0.1 mm.). However, the checkers found by ¹H NMR analysis that this product already contains substantial amounts of octadiene **2** formed by thermal rearrangement during distillation.
4. The reaction can be conveniently monitored in the IR by observing the decrease in the C=N stretching absorption at 1660 cm⁻¹ or by TLC [silica, developed with *hexane–ethyl acetate* (9 : 1) or (4 : 1)].
5. The octadiene **2** appears pure by ¹H NMR and elemental analysis. A TLC [silica, developed with *hexane–ethyl acetate* (4 : 1), visualized with 5% *ceric ammonium nitrate* in 20% *sulfuric acid* and heating] shows a major spot at *R_f* = 0.4 and a very small impurity at 0.7. The trace impurity may be removed by crystallization from *hexane* at –78°. The checkers found that a GC (2% Silicone OV-17 on Gaschrom Q., 80–100 mesh, 200 × 0.22 cm., 120°) showed one major peak (97.0–97.2%) at a relative retention value of 1.00 (17.3 minutes, *nitrogen*, 30 ml. per minute), and a minor peak at 0.94 (<3%). The octadiene **2** has the following spectral properties: IR (neat) cm⁻¹: 3423 and 3355 weak (N-H), 1722 strong (C=O), 1504 strong (CO-NH-, amide II band), 983 weak and 915 medium (CH=CH₂); ¹H NMR (CCl₄), δ (multiplicity, coupling constant *J* in Hz., number of protons, assignment): 1.49 (s, 3H, CH₃), 1.60 (s, 3H, CH₃), 1.67 (s, 3H, CH₃), 4.9–5.3 (m, 3H, H₁ and H₆), 5.96 (approx. d of d, *J* = 9.5 and 18.5, 1H, H₂), 6.6 (broad s, 1H, NH); ¹³C NMR (acetone-*d*₆), δ (assignment): 159.8 (C=O), 141.1 (C₂), 132.4 (C₇), 123.4 (C₆), 113.2 (C₁), 93.3 (CCl₃), 58.7 (C₃), 38.8 (C₄), 25.7 (CH₃), 23.9 (CH₃), 22.5 (C₅), 17.5 (CH₃).
6. The apparatus described in *Org. Synth.*, **Coll. Vol. 4**, 132 (1963) was used to maintain a nitrogen atmosphere.
7. The reaction time may be cut to less than 1 hour by running the reaction at reflux, but the yield is 5–

10% lower. The checkers found that under these conditions the weight yield of the distilled product was 67–70%. However, GC (3% Silicone GE-SE-30 on Gaschrom Q, 80–100 mesh, 200 × 0.22 cm., 60°) showed that the product contained substantial amounts (19–23%) of an unidentified by-product having a relative retention value of 1.22 (nitrogen, 30 ml. per minute) and a minor peak at 0.96 (<2%). The checkers also found that the reaction can be conveniently monitored by TLC [silica, [hexane–ethyl acetate](#) (4 : 1)].

8. The checkers found that the crude amine **3** ([linalylamine](#)) is more conveniently distilled at a pressure of 11–12 mm.

9. A GC (10% Carbowax 20 M–2% KOH on Chromosorb W, AW, 80–100 mesh, 180 × 0.3 cm., 90°) showed one major peak (99%) at a relative retention value of 1.00 (3.5 minutes, nitrogen, 50 ml. per minute), and a minor peak at 1.1 (<1%). Temperature programming to 200° detected the presence of several higher-boiling trace impurities (<1%). The checkers found that a GC (3% Silicone GE-SE-30 on Gaschrom Q, 80–100 mesh, 200 × 0.22 cm., 60°) showed one major peak (97.9–98.4%) at a relative retention value of 1.00 (11.8 minutes, nitrogen, 30 ml. per minute), and a minor peak at 0.96 (<2.1%). IR (neat) cm.⁻¹: 3345 and 3301 weak (N-H), 996 and 912 medium (CH=CH₂); ¹H NMR (CCl₄), δ (multiplicity, coupling constant *J* in Hz., number of protons, assignment): 1.08 (s, 3H, CH₃), 1.55 (s, 3H, CH₃), 1.63 (s, 3H, CH₃), 4.7–5.2 (m, 3H, H₁ and H₆), 5.84 (approx. d of d, *J* = 10.1 and 17.8, 1H, H₂).

3. Discussion

This procedure illustrates a general method for the preparation of rearranged allylic amines from allylic alcohols.^{2,3} The method is experimentally simple and has been used to prepare a variety of allylic *n*-, *sec*-, and *tert*-carbonyl amines, as illustrated in Table I. The only limitation encountered so far is a competing ionic elimination reaction which becomes important for trichloroacetimidic esters of 3-substituted-2-cyclohexenols.^{3,4} The rearrangement is formulated as a concerted [3,3]-sigmatropic rearrangement on the basis of its stereo- and regiospecificity^{3,5} which are similar to those observed in related [3,3]-sigmatropic processes.⁶ In certain cases the allylic imidate rearrangement may be accomplished at or below room temperature by the addition of catalytic amounts of mercury(II) salts.^{2,3}

TABLE I
CONVERSION OF ALLYLIC ALCOHOLS INTO REARRANGED TRICHLOROACETAMIDES³

Alcohol	Trichloroacetamide Product	Overall Isolated Yield (%)
(<i>E</i>)-2-Hexen-1-ol	3-Trichloroacetamido-1-hexene	72
Cinnamyl alcohol	3-Phenyl-3-trichloroacetamido-1-propene	76
1-Hepten-3-ol	(<i>E</i>)-1-Trichloroacetamido-2-heptene	74
2-Cyclohexen-1-ol	3-Trichloroacetamido-1-cyclohexene	61
Linalool	3,7-Dimethyl-1-trichloroacetamido-2,6-octadiene ^a	83
3,5,5-Trimethyl-2-cyclohexen-1-ol	3,5,5-Trimethyl-3-trichloroacetamido-1-cyclohexene	10–43
3-(4,4-Ethylenedioxybutyl)-2-cyclohexen-1-ol	3-(4,4-Ethylenedioxybutyl)-3-trichloroacetamido-1-cyclohexene	20

^a A mixture of *E* and *Z* isomers.

The experimental procedure for the addition of an alcohol to [trichloroacetonitrile](#), a modification of the procedure of Cramer,⁷ appears to be totally general. For hindered secondary or tertiary alcohols it is more convenient to form the catalytic alkoxide with [potassium hydride](#), and it is essential that the alcohol–alkoxide solution be added to (inverse addition) a solution of [trichloroacetonitrile](#) in [ethyl ether](#) at 0°. The thermal rearrangement of allylic imidates was first reported by Mumm and Möller⁸ in 1937, and has been noted in scattered reports since that time.⁹ In these cases the imidates were not available by a general route (as is the case for trichloroacetimidates), and as a result this rearrangement had not become a generally useful synthetic method. Alternative methods for the allylic transposition of [oxygen](#)

and nitrogen functions include the thermolysis of allylic sulfamate esters,¹⁰ phenylurethanes,¹¹ oxime *O*-allyl ethers,¹² and *N*-chlorosulfonylurethanes,¹³ as well as the S_N2' reaction of certain allylic alcohol esters with amines.¹⁴ These procedures are much less attractive than the method reported here, usually affording mixtures of allylic isomers.^{10,11,12,13,14} Other routes for the preparation of 3,7-dimethyl-1,6-octadien-3-amine have not, to our knowledge, been reported.

References and Notes

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Appendix

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

silica gel

ethanol (64-17-5)

potassium carbonate (584-08-7)

sulfuric acid (7664-93-9)

ethyl acetate (141-78-6)

methanol (67-56-1)

ether,
ethyl ether,
diethyl ether (60-29-7)

hydrogen (1333-74-0)

sodium hydroxide (1310-73-2)

oxygen (7782-44-7)

nitrogen (7727-37-9)

toluene (108-88-3)

xylene (106-42-3)

Pentane (109-66-0)

trichloroacetonitrile (545-06-2)

cinnamyl alcohol (104-54-1)

sodium hydride (7646-69-7)

hexane (110-54-3)

geraniol (106-24-1)

2-cyclohexen-1-ol

3,7-DIMETHYL-1,6-OCTADIEN-3-AMINE,
1,6-Octadien-3-amine, 3,7-dimethyl-,
linalylamine (59875-02-4)

ceric ammonium nitrate

3-Trichloroacetamido-1-hexene

3-Phenyl-3-trichloroacetamido-1-propene

1-Hepten-3-ol (4938-52-7)

3-Trichloroacetamido-1-cyclohexene

Linalool (78-70-6)

3,5,5-Trimethyl-2-cyclohexen-1-ol

3,5,5-Trimethyl-3-trichloroacetamido-1-cyclohexene

3-(4,4-Ethylenedioxybutyl)-2-cyclohexen-1-ol

3-(4,4-Ethylenedioxybutyl)-3-trichloroacetamido-1-cyclohexene

potassium hydride (7693-26-7)

(E)-2-Hexen-1-ol (928-95-0)

Geraniol trichloroacetimidate (51479-75-5)

(E)-1-Trichloroacetamido-2-heptene

3,7-Dimethyl-3-trichloroacetamido-1,6-octadiene (51479-78-8)

3,7-Dimethyl-1-trichloroacetamido-2,6-octadiene

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