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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.

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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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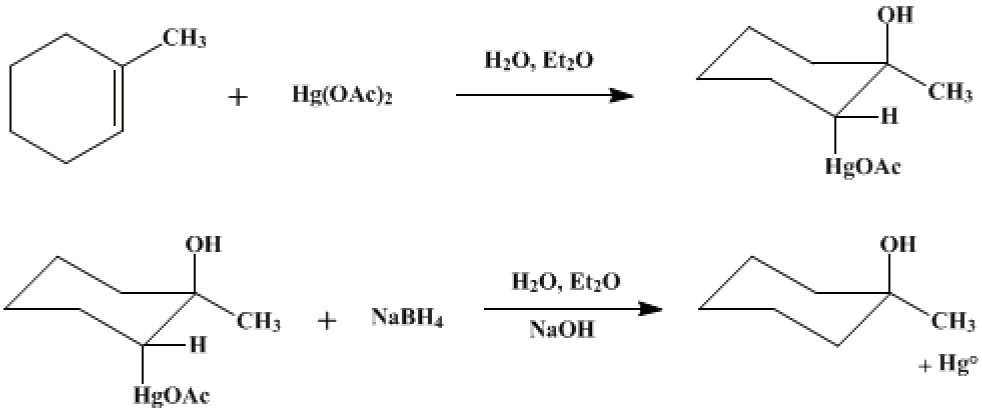
OXYMERCURATION-REDUCTION: ALCOHOLS FROM OLEFINS: 1-METHYLCYCLOHEXANOL

[Cyclohexanol, 1-methyl-]



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1. Procedure

A 3-l, three-necked flask fitted with a thermometer and a mechanical stirrer is charged with 95.7 g. (0.300 mole) of mercury(II) acetate (Note 1) and 300 ml. of water. After the acetate dissolves, 300 ml. of diethyl ether is added. While this suspension is stirred vigorously 28.8 g. (0.300 mole) of 1-methylcyclohexene (Note 2) and (Note 3) is added, and stirring is continued for 30 minutes at room temperature (Note 4). A solution of 150 ml. of 6 *N* sodium hydroxide is added followed by 300 ml. of 0.5 *M* sodium borohydride in 3 *N* sodium hydroxide. The borohydride solution is added at a rate such that the reaction mixture can be maintained at or below 25° with an ice bath.

The reaction mixture is stirred at room temperature for 2 hours, after which time the mercury is found as a shiny liquid. The supernatant liquid is separated from the mercury (Note 5), the ether layer is separated, and the aqueous solution is extracted with two 100-ml. portions of ether. The combined ether solutions are dried over magnesium sulfate and distilled, giving 24.1–25.8 g. (70.5–75.4%) of 1-methylcyclohexanol, b.p. 154.5–156°; n_{D}^{21} 1.4596 (Note 6).

2. Notes

1. The mercury(II) acetate was purchased from Mallinckrodt Chemical Works.
2. 1-Methylcyclohexene was purchased from K & K Laboratories and used without further purification.
3. Sometimes a yellow color [mercury(II) oxide] appears at this point and disappears as the reaction proceeds. If the yellow color does not disappear in about 10 minutes, 1.5 ml. of 70% perchloric acid per mole of mercury(II) acetate may be added to accelerate the reaction. Under these conditions even unreactive olefins are completely oxymercurated in about an hour.
4. The checkers found that extending the time of oxymercuration to 2 hours did not improve the yield.
5. The checkers found that the reaction mixture could be decanted from the mercury only if the mixture was allowed to stand for at least one hour after stirring was stopped. An alternate procedure, which proved quite satisfactory, was filtration of the entire reaction mixture through a Celite pad immediately after the stirring was stopped.
6. The distilled product slowly deposits mercury. In an effort to determine whether extent of this deposition is reduced by extending the time of reduction, the checkers found that stirring the crude alcohol with Celite for 15 hours, followed by filtration and distillation, did not diminish the amount of mercury deposited. However, in a typical run where the yield of distilled alcohol was 24.6 g. (72.0%),

after standing for 24 hours, the distillate was decanted from the deposited mercury and redistilled to give 21.4 g. of 1-methylcyclohexanol, which did not deposit mercury upon standing for one week at room temperature. The yield of twice-distilled alcohol was 62.6%.

3. Discussion

This method of preparing alcohols is an adaptation of an oxymercuration procedure of Sand and Genssler[2] and the reduction methods of Henbest and Nicholls.[3] Other methods for preparing 1-methylcyclohexanol are oxymercuration followed by reduction in tetrahydrofuran-water;[4] [5] [6] reaction of cyclohexanone with methylmagnesium halides;[7] and reduction of 1-methylcyclohexene epoxide or methylenecyclohexane epoxide with lithium aluminum hydride.[8]

Although the reaction proceeds faster in tetrahydrofuran–water[4,5,6] or in acetone–water, ether was used as solvent in this reaction for convenience of product separation and purification. However, the oxymercuration is acid catalyzed;[9] oxymercuration of unreactive olefins such as *cis*-cycloöctene can be accelerated by adding acid (Note 3). Rapid stirring also accelerates the reaction. An additional advantage of using ether is that less olefin is produced during the reduction using this solvent than when tetrahydrofuran is used. Elimination can be a serious side reaction during the reduction, amounting to 30% of total demercurated product when the oxymercurial from *cis*-cycloöctene is reduced in tetrahydrofuran–water. In ether–water, however, less than 10% olefin is produced.

As a general procedure, if the olefin is impure, the oxymercuration-reduction process may include an olefin purification step. Alternatively, this process may be used to purify the olefin for other purposes.[2,6] In such cases, acetone is substituted for ether, and after oxymercuration for the same length of time as suggested above, the solution is poured with stirring into two volumes of water containing one equivalent each of sodium hydrogen carbonate and sodium chloride. The mercury derivative is filtered, recrystallized from ethanol–water, ether, dioxane, or ethyl acetate–heptane,[10] then either reduced, as described above (in 70–80% yield), producing pure alcohol, or deoxymercurated with cold 6 *N* hydrochloric acid,[2] ethereal lithium aluminum hydride[11] (added cautiously), or high concentrations of alkali halides,[6,11,12] producing the pure olefin.

Oxymercuration may also be used to prepare ethers, acetates, amines, or amides (Markownikoff adducts). Several excellent procedures for these syntheses have been published by Brown and co-workers.[5]

References and Notes

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Appendix

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

ethanol (64-17-5)

hydrochloric acid (7647-01-0)

ethyl acetate (141-78-6)

ether,
diethyl ether (60-29-7)

sodium hydroxide (1310-73-2)

sodium hydrogen carbonate (144-55-8)

Cyclohexanone (108-94-1)

sodium chloride (7647-14-5)

mercury(II) acetate (1600-27-7)

mercury (7439-97-6)

mercury(II) oxide (21908-53-2)

acetone (67-64-1)

magnesium sulfate (7487-88-9)

dioxane (123-91-1)

Tetrahydrofuran (109-99-9)

heptane (142-82-5)

lithium aluminum hydride (16853-85-3)

1-methylcyclohexene

perchloric acid (7601-90-3)

sodium borohydride (16940-66-2)

1-Methylcyclohexanol,
Cyclohexanol, 1-methyl- (590-67-0)

methylenecyclohexane epoxide (185-70-6)

borohydride (16971-29-2)

1-methylcyclohexene epoxide

cis-cyclooctene (931-87-3)