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of Reliable Methods
for the Preparation
of Organic Compounds

Working with Hazardous Chemicals

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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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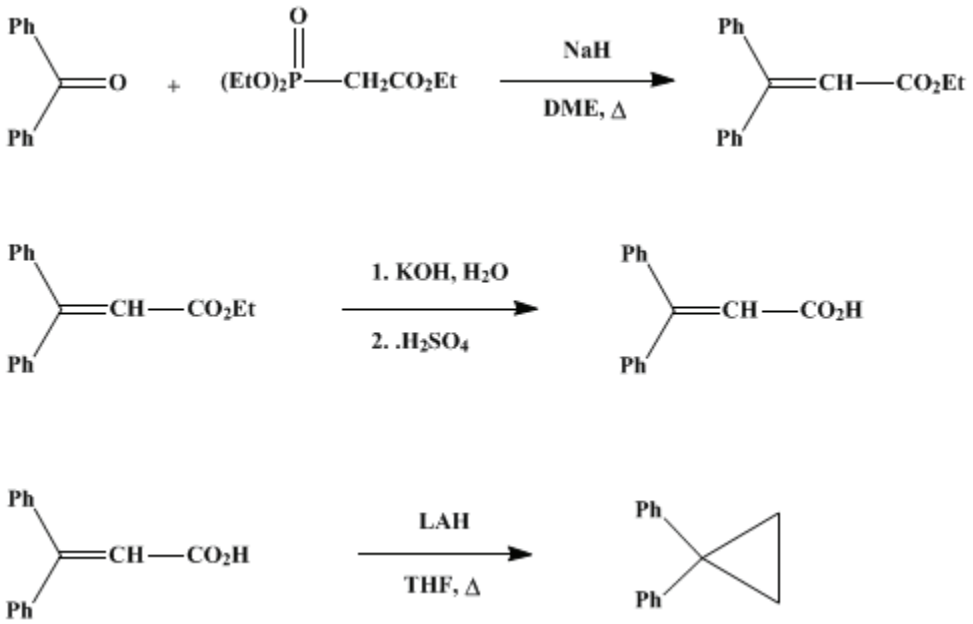
Organic Syntheses, Coll. Vol. 5, p.509 (1973); Vol. 48, p.75 (1968).

1,1-DIPHENYLCYCLOPROPANE

[Cyclopropane, 1,1-diphenyl-]



Submitted by M. J. Jorgenson and A. F. Thacher[1].
Checked by John J. Miller and William D. Emmons.

1. Procedure

A. β-*Phenylcinnamic acid*. A suspension of 8.8 g. (0.20 mole) of a 55.1% sodium hydride dispersion in mineral oil (Note 1) and 300 ml. of 1,2-dimethoxyethane (Note 2) are added to a dry, 1-l., three-necked flask equipped with a stirrer, a condenser with drying tube, and a pressure-equalizing dropping funnel. The flask is immersed in an ice bath, and 44.8 g. (0.20 mole) of triethyl phosphonoacetate (Note 3) is added through the dropping funnel over a 20-minute period. After the addition the solution is stirred at room temperature for 30 minutes, and then 36.4 g. (0.20 mole) of benzophenone is added in one portion. The solution is heated at reflux for 4 days. The two-phase reaction mixture is cooled, and the flask is filled with water. The ester is extracted from the solution with three 100-ml. portions of ether. The ethereal extracts are combined, dried over anhydrous sodium sulfate, and evaporated to as small a volume as possible on the steam bath. The resulting mixture of ester and unreacted benzophenone is added to 140 ml. of water, 45 ml. of dioxane, and 26.4 g. (0.40 mole) of 85% potassium hydroxide in a 500-ml. one-necked flask, and the mixture is refluxed overnight (17 hours). The solution is cooled and extracted with 50 ml. of ether to remove benzophenone and any unhydrolyzed ester. The aqueous fraction is acidified with 10*N* sulfuric acid, and the resulting solid product is isolated by filtration, washed with two 50-ml. portions of water, and dried. Recrystallization from 200 ml. of benzene gives 28.3–33.9 g. (63–75%) of β-phenylcinnamic acid, m.p. 161–163° (Note 4) and (Note 5).

B. *1,1-Diphenylcyclopropane*. A 500-ml. three-necked flask is equipped with a nitrogen-inlet tube, a condenser, and a dropping funnel. The flask is charged with 100 ml. of dry tetrahydrofuran (Note 6) and 5.13 g. (0.135 mole) of lithium aluminum hydride (Note 1), and the system is purged with dry nitrogen. To the stirred solution is added dropwise over a period of 15–20 minutes a solution of 20 g. (0.089 mole) of β-phenylcinnamic acid (Note 7) in 100 ml. of tetrahydrofuran. The addition results in an exothermic reaction which causes the solution to reflux. The refluxing is allowed to subside after addition is complete, and then the mixture is carefully reheated to reflux. A mild exotherm occurs a few minutes after reflux is reached. This is easily controlled by removing the heat source or by cooling with

ice. After the occurrence of this exothermic reaction, which is accompanied by a color change from rust to deep red, the mixture is heated at the reflux temperature for an additional 2 hours. The mixture is then cooled in an ice bath, and sufficient 10% sulfuric acid (*ca.* 5 ml.) is carefully *(Caution! Vigorous evolution of hydrogen.)* added dropwise to destroy excess lithium aluminum hydride. Another 100 ml. of 10% sulfuric acid is added after decomposition of the hydride is complete to dissolve the aluminum salts (Note 8). The acidified solution is worked up immediately (Note 9) by dilution with 200 ml. of water and extraction with one 100-ml. portion and three 50-ml. portions of ether. The combined ethereal extracts are washed with three 50-ml. portions of saturated aqueous sodium bicarbonate. The bicarbonate extracts are combined and washed with 50 ml. of ether, and all the ethereal extracts are combined. The ethereal solution is dried over anhydrous sodium sulfate, and the ether is removed at atmospheric pressure. The residue is distilled under reduced pressure to give 10.0–10.7 g. (57–62%) of diphenylcyclopropane (Note 10), b.p. 132–134° (10 mm.), n^{20}D 1.590.

2. Notes

1. Sodium hydride dispersions in mineral oil and lithium aluminum hydride are available from Metal Hydrides, Inc.
2. Before use, 1,2-dimethoxyethane (ethylene glycol dimethyl ether) was partially dried over anhydrous calcium chloride and then distilled from lithium aluminum hydride. It was stored over sodium ribbon.
3. Triethyl phosphonoacetate is available from Aldrich Chemical Co.
4. About half of the solid is insoluble in the hot benzene and is removed by filtration.
5. The submitters obtained 28.2 g. (63%) of β-phenylcinnamic acid, m.p. 162–163°.
6. Tetrahydrofuran is best dried according to the procedure described on page 976 of this volume. *(Caution! Note warning of danger in drying tetrahydrofuran containing peroxides.)* The checkers employed a peroxide-free grade of anhydrous tetrahydrofuran which is available from Fisher Scientific Co.
7. In the preparation of other phenylcyclopropanes by this method, esters rather than acids were employed. Use of the ester in the present preparation gave a poor yield of product. Since the acid can easily be purified, its use here is also more expedient.
8. The checkers found this amount of acid insufficient to dissolve all of the salts, and an additional 5 ml. of concentrated sulfuric acid was added.
9. In general it has been found that yields of cyclopropanes are lowered if the acidic solutions are permitted to stand before workup.
10. Fractionation is not essential because the main contaminant is high-boiling polymer. The checkers obtained two fractions: b.p. 138–142° (11 mm.), 10.0–10.2 g., 99% pure by vapor-phase chromatography; and b.p. 142–148° (11 mm.), 0.6–0.9 g., 96% pure.

3. Discussion

1,1-Diphenylcyclopropane has been prepared in 24% yield by the Simmons-Smith reaction,[2] in 78% yield by treatment of 3,3-diphenylpropyltrimethylammonium iodide with sodium or potassium amide,[3] in 61% yield by reaction of 1,1-diphenylethylene with dimethylsulfonium methylide,[4] and in unspecified yields from 1,1-diphenylethylene by reaction with diazomethane followed by pyrolysis of the resulting pyrazoline or by reaction with ethyl diazoacetate followed by distillation of the corresponding acid over calcium oxide.[5]

β-Phenylcinnamic acid has been prepared previously by a variety of methods, the best of which appear to be the dehydration of ethyl β-hydroxy-β,β-diphenylpropionate by treatment with sodium acetate in acetic acid[6] and the reaction of 1,1-diphenylethylene with oxalyl chloride.[7]

4. Merits of the Preparation

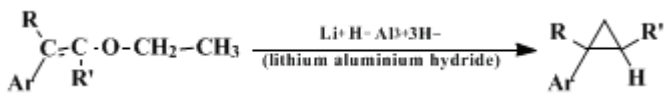
This procedure illustrates a general method for the preparation of phenylcyclopropanes from cinnamic acids, esters, aldehydes, or alcohols.[8] It complements the Simmons-Smith reaction as a general method for the preparation of such cyclopropanes. It offers advantages over the Simmons-Smith method in cases in which electron-withdrawing substituents in the benzene ring or steric crowding around the double bond lead to low yields in the Simmons-Smith reaction. Also, in the case of possible stereo-

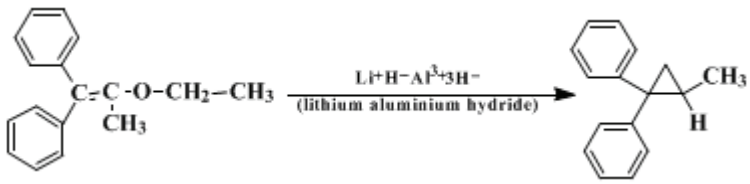
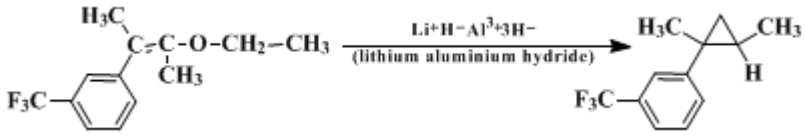
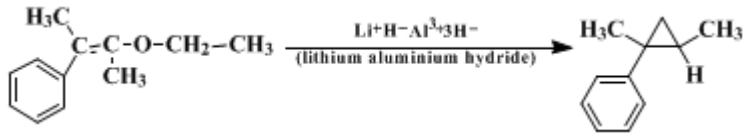
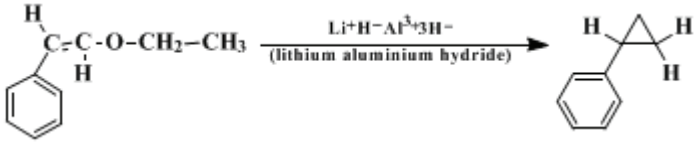
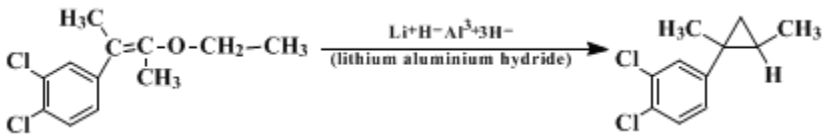
isomerism in the starting material or product, the present method leads stereospecifically to a single cyclopropane. It has the disadvantage that reducible substituents on the benzene ring do not survive the reductive treatment. The present method is an exceptionally simple, one-step preparative process employing starting materials that are commercially available, or readily accessible from aldehydes and ketones via the phosphono ester addition procedure of Wadsworth and Emmons.[9] Cyclopropane formation is particularly facile when electron-withdrawing substituents are present on the aromatic ring or when the β-position is substituted by another aryl group. Alkyl substitution on the double bond also facilitates cyclopropane formation. The exames recorded in Table I illustrate these effects. An excess of dride is necessary for producing good yields of cyclopropanes.

This preparation is referenced from:

- Org. Syn. Coll. Vol. 9, 372

TABLE I PREPARATION OF PHENYLCYCLOPROPANES FROM CINNAMIC ESTERS



Substituents	Solvent	Reflux Time, Hours	Yield Cyclopr %
$R = C_6H_5$, $R' = CH_3$ $Ar = C_6H_5$ 	Tetrahydrofuran	10	78
$R = R' = CH_3$ $Ar = m\text{-}CF_3C_6H_4$ 	Tetrahydrofuran	10	54
$R = R' = CH_3$ $Ar = C_6H_5$ 	Dimethoxyethane	48	52
$R = R' = H$ $Ar = C_6H_5$[a] 	Dimethoxyethane	320	66[
$R = R' = CH_3$ $Ar = 3,4\text{-}Cl_2C_6H_3$ 	Tetrahydrofuran	1	45[

[a] Aldehyde rather than ester was employed; the yield was 28% after 3 days.
[b] From Reference [8].

References and Notes

1. Department of Chemistry, University of California, Berkeley, California 94720.
2. H. E. Simmons and R. D. Smith, *J. Am. Chem. Soc.*, **81**, 4256 (1959).
3. C. L. Bumgardner, *J. Am. Chem. Soc.*, **83**, 4420 (1961).
4. E. J. Corey and M. Chaykovsky, *J. Am. Chem. Soc.*, **87**, 1353 (1965).
5. H. Wieland and O. Probst, *Ann.*, **530**, 274 (1937).
6. W. R. Dunnavant and C. R. Hauser, this volume, p. 564.
7. F. Bergmann, M. Weizmann, E. Dimant, J. Patai, and J. Szmuskowicz, *J. Am. Chem. Soc.*, **70**, 1612 (1948).
8. M. J. Jorgenson and A. W. Friend, *J. Am. Chem. Soc.*, **87**, 1815 (1965).
9. W. S. Wadsworth, Jr., and W. D. Emmons, this volume, p. 547.

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

sodium or potassium amide

phenylcyclopropanes

cinnamic acids

cyclopropanes

calcium chloride (10043-52-4)

sulfuric acid (7664-93-9)

acetic acid (64-19-7)

Benzene (71-43-2)

ether (60-29-7)

sodium acetate (127-09-3)

hydrogen (1333-74-0)

sodium bicarbonate (144-55-8)

sodium sulfate (7757-82-6)

nitrogen (7727-37-9)

potassium hydroxide (1310-58-3)

Benzophenone (119-61-9)

calcium oxide

1,1-Diphenylethylene (530-48-3)

hydride

cyclopropane (75-19-4)

dioxane (123-91-1)

Diazomethane (334-88-3)

ethyl diazoacetate (623-73-4)

Tetrahydrofuran (109-99-9)

oxalyl chloride (79-37-8)

lithium aluminum hydride (16853-85-3)

sodium hydride (7646-69-7)

ethylene glycol dimethyl ether,
1,2-dimethoxyethane (110-71-4)

dimethoxyethane (534-15-6)

1,1-Diphenylcyclopropane,
Cyclopropane, 1,1-diphenyl-,
diphenylcyclopropane (3282-18-6)

triethyl phosphonoacetate (867-13-0)

β-Phenylcinnamic acid (606-84-8)

3,3-diphenylpropyltrimethylammonium iodide

dimethylsulfonium methylide

pyrazoline

Ethyl β-hydroxy-β,β-diphenylpropionate (894-18-8)

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