Organic Syntheses

A Publication
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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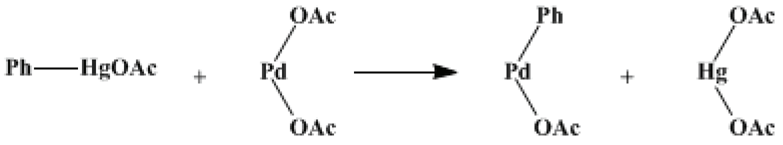
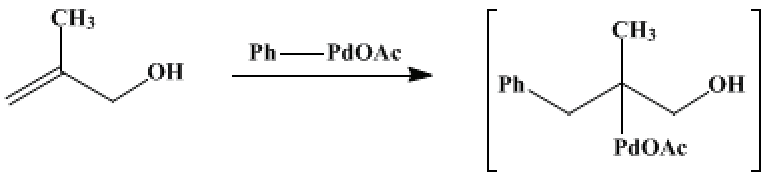
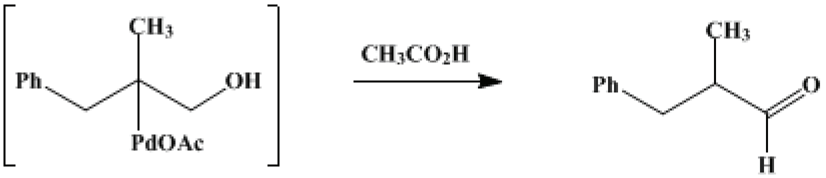
ALDEHYDES FROM ALLYLIC ALCOHOLS AND PHENYLPALLADIUM ACETATE: 2-METHYL-3-PHENYLPROPIONALDEHYDE

[Benzenepropanal, α-methyl-]







Submitted by R. F. Heck[1]
Checked by Robert A. Clement and Richard E. Benson.

1. Procedure

A slurry comprised of 33.6 g. (0.0998 mole) of commercial phenylmercury(II) acetate, 200 ml. of acetonitrile, and 14.4 g. (16.8 ml., 0.200 mole) of methallyl alcohol (Note 1) is prepared in a 500-ml., three-necked flask fitted with a mechanical stirrer, a condenser, and a thermometer. The slurry is stirred and cooled in an ice bath, and 22.4 g. (0.0998 mole) of powdered palladium(II) acetate (Note 2) is added over 1 minute. Stirring is continued with cooling for 1 hour, then at room temperature for 3 more hours (Note 3). The temperature of the reaction mixture reaches a maximum of 27° after removal of the ice bath.

The black reaction mixture is diluted with about 100 ml. of diethyl ether and poured onto 200 g. of ether-wet alumina (Woelm, Activity Grade 1) in a 45 × 2.5 cm. glass chromatographic column. The product is washed through the alumina with about 1 l. of ether. The brown eluate is concentrated by distilling the ether through a 45-cm. Vigreux column on a steam bath at atmospheric pressure. When the ether has been distilled, a slight vacuum is applied, removing most of the acetonitrile. After the volume reaches about 50 ml., the mixture is filtered into a 100-ml. distillation flask, removing some precipitated palladium metal. The flask is rinsed with 10-ml. of ether, and the rinse is combined with the product. The flask is equipped with a 10 cm. Vigreux column for distillation at reduced pressure. After removal of the solvent, 8.1–8.5 g. (55–58%) of 2-methyl-3-phenylpropionaldehyde is collected, b.p. 75–85° (3 mm.) (Note 4), n_D^{25} 1.5113 (Note 5).

2. Notes

1. Methallyl alcohol was obtained from Eastman Organic Chemicals.

2. Palladium(II) acetate was purchased from Engelhard Industries.
3. The yield improves slightly with stirring overnight; the checkers obtained the aldehyde in 69% yield in this manner.
4. The bulk of the product has b.p. 77–80° (3 mm.).
5. The product is 90–95% pure by GC and NMR analyses. The checkers estimated the purity to be at least 95% by these criteria. The ^1H NMR spectrum ($CDCl_3$) shows peaks at δ 0.95 (d, J = 6.5 Hz., 3H), ~2.7 (complex m, 3H), 7.20 (s, 5H) and 9.65 (d, J = 1.5 Hz., 1H).

3. Discussion

The formation of 3-aryl-substituted aldehydes and 3-aryl-substituted ketones by the reaction of "arylpalladium salts" with allylic alcohols is general.[2] Illustrations of the preparation of two aldehydes and two ketones are given in Table I.

TABLE I
3-ARYLCARBONYL COMPOUNDS FROM ALLYLIC ALCOHOLS AND "PHENYLPALLADIUM ACETATE"[2]

Allylic Alcohol	Product	Yield, %	Boiling Point, °C.
CH_2=$CHCH_2OH$	$C_6H_5CH_2CH_2CHO$	35	220–225°[a]
trans-CH_3CH=$CHCH_2OH$	$C_6H_5CH(CH_3)CH_2CHO$	36	67–75° (1 mm.)
trans-CH_3CH=$CHCH(OH)CH_3$	$C_6H_5CH(CH_3)CH_2COCH_3$	51	70–75° (3 mm.)
$(CH_3)_2C$=$CHCH(OH)CH_3$	$C_6H_5C(CH_3)_2CH_2COCH_3$	29	83–87° (2 mm.)

[a] Purification by careful distillation is necessary in this example to remove cinnamaldehyde which is also formed in the reaction (b.p. 252°).

The presence of nitro, carboalkoxy, carboxyl, chloro, formyl, alkyl, and acyl groups does not interfere with the reaction. A single alkoxy group also does not interfere, but if two or more are present the yields are markedly decreased. The reaction is inhibited by the presence of unhindered, basic nitrogen substituents, by the phenolic group, and probably by the thiol group.

A variation of this procedure involves the use of a catalytic amount of palladium(II) chloride with copper(II) chloride as a reoxidant.[2] This method, however, generally gives lower yields and less pure products. Another related preparation uses palladium(II) acetate with two equivalents of triphenylphosphine, catalyzing the reaction of iodo-[3] or bromo-[4] benzene with methallyl alcohol in the presence of weak bases. Phenyldiazonium salts also may be used to react with methallyl alcohol and a palladium(0) catalyst to form the propionaldehyde.

Other preparations of 2-methyl-3-phenylpropionaldehyde include the pyrolysis of a mixture of the calcium salts of 2-methyl-3-phenylpropionic acid and formic acid,[5] the pyrolysis of the glycidic ester obtained from 2-phenyl-2-propanone and ethyl chloroacetate,[6] the hydroformylation of allylbenzene,[7] the benzylation of 2-ethylthiazoline followed by reduction with aluminum amalgam and cleavage with mercury(II) chloride,[8] and the reaction of phenylmagnesium bromide with 2-vinyl-5,6-dihydro-1,3-oxazine followed by methylation and hydrolysis.[9]

This preparation is referenced from:

- Org. Syn. Coll. Vol. 7, 361

[10]

References and Notes

1. Contribution No. 1504 from the Research Center, Hercules Incorporated, Wilmington, Delaware

19899. [Present address: Department of Chemistry, University of Delaware, Newark, Delaware 19711.]

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

alumina

calcium salts of 2-methyl-3-phenylpropionic acid

ether,
diethyl ether (60-29-7)

acetonitrile (75-05-8)

formic acid (64-18-6)

aluminum (7429-90-5)

palladium,
palladium(0) (7440-05-3)

Ethyl chloroacetate (105-39-5)

mercury(II) chloride (7487-94-7)

copper(II) chloride (7758-89-6)

Phenylmagnesium bromide (100-58-3)

phenylmercury(II) acetate

cinnamaldehyde

palladium(II) chloride (7647-10-1)

methallyl alcohol (513-42-8)

allylbenzene (300-57-2)

triphenylphosphine (603-35-0)

palladium(II) acetate (3375-31-3)

PHENYLPALLADIUM ACETATE

2-Methyl-3-phenylpropionaldehyde,
Benzenepropanal, α-methyl- (5445-77-2)

2-phenyl-2-propanone

2-ethylthiazoline

2-vinyl-5,6-dihydro-1,3-oxazine