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of Reliable Methods
for the Preparation
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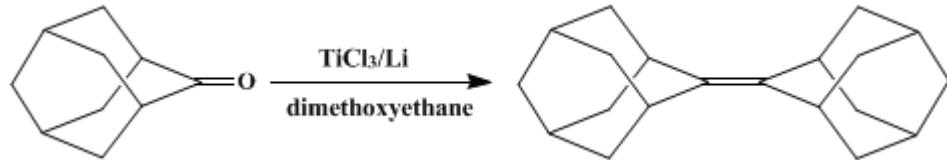
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REDUCTIVE COUPLING OF CARBONYLS TO ALKENES: ADAMANTYLIDENEADAMANTANE

[Tricyclo[3.3.1.1^{3,7}]decane, tricyclo[3.3.1.1^{3,7}]decylidene-]



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1. Procedure

A 2-L, three-necked flask is thoroughly flamed while being flushed with argon and is then fitted with three rubber septa. Anhydrous titanium trichloride (63.16 g, 0.409 mol) (Note 1) and (Note 2) is added to the weighed flask in an argon-filled glove bag. The flask is reweighed, and one of the rubber septa is replaced with a dry (12 hr at 120°C) reflux condenser through which a stream of argon is flowing (Note 3). The flask is fitted with a mechanical stirrer equipped with a glass shaft and Teflon paddle (Note 4). Into the flask is syringed 600 mL of 1,2-dimethoxyethane (Note 5), and the remaining rubber septum is exchanged for a glass stopper. Lithium (8.52 g, 1.23 mol) (Note 6) is etched to brilliance in methanol, quickly washed in petroleum ether (Note 7), and cut into small pieces directly into the stirred suspension. The mixture is heated at reflux for 1 hr by an oil bath that is then removed (Note 8). Immediately after the solvent has ceased to reflux, 2-adamantanone (15.36 g, 0.102 mol) (Note 1) is added in one portion, and the mixture is heated at reflux for 18 hr.

Stirring is maintained as the mixture is allowed to cool to room temperature, and 600 mL of petroleum ether (Note 7) is added in 100-mL portions at 5-min intervals (Note 9). The stirrer is disconnected from its motor, and the solution is poured into a sintered-glass funnel containing 50 g of Florisil (approximately 7 cm in depth) (Note 1). The black material remaining in the reaction vessel is washed with eight 50-mL portions of petroleum ether, which are poured into the same pad of Florisil (Note 10) and (Note 11). The filter pad is then washed with 400 mL of petroleum ether. Removal of the solvent from the combined filtrates by means of a rotary evaporator followed by high vacuum (0.05 mm) gives 12–13 g of a white crystalline solid. This crude product is dissolved in 3.5 L of hot methanol (Note 1), and the volume is reduced to 2 L by boiling. The solution is allowed to slowly cool to room temperature. The colorless needles are vacuum filtered through sintered glass (medium frit) and washed with 50 mL of ice-cold methanol. The crystals are dried under vacuum (0.05 mm Hg) to give 10.3–10.4 g (75–76%) of adamantylideneadamantane, mp 184–186°C; ¹H NMR (CDCl₃) δ: 1.5–2.1 (br m, 24 H) 2.7–3.1 (br m, 4 H). Concentration of the mother liquor to 350 mL and crystallization as described above yields an additional 1.2–1.5 g (9–11%) of product, mp 182–184°C (Note 12).

2. Notes

1. The following reagents were used as supplied: titanium trichloride from Alfa Products, Morton Thiokol, Inc.; 2-adamantanone from Aldrich Chemical Company, Inc.; methanol from MCB, Inc.; and acetone from Mallinckrodt, Inc.
2. Because of its sensitivity toward oxygen and water, anhydrous titanium trichloride should always be handled under an inert atmosphere. The submitters report that titanium trichloride in bottles that have been opened and resealed undergoes a slow deterioration that causes erratic results in the coupling reaction. This decomposition is frequently detectable by the evolution of white fumes from the titanium trichloride during transfer. If a number of small-scale reactions are to be performed, the use of a Schlenk tube is advisable to extend the useful life of the titanium trichloride.

3. Substitution of **nitrogen** for **argon** does not significantly decrease the yield.
4. The coupling reaction may be adversely affected if metallic stirrers are employed. The bore of the stirrer should be water-cooled. Lubricants such as mineral oil are to be avoided since they complicate product isolation.
5. The **1,2-dimethoxyethane** was obtained from Aldrich Chemical Company, Inc., and was allowed to stand over molecular sieves (type 4A in 1/16-in. pellet form from Union Carbide Corporation) for several days. Final purification was accomplished by heating at reflux over **potassium** in a **nitrogen** atmosphere for at least 10 hr, followed by distillation from **potassium**. The solvent was used on the same day that it was distilled to minimize the formation of peroxides.
6. **Lithium wire** (3.2-mm diam, 0.02% **sodium**) was obtained from Alfa Products, Morton Thiokol, Inc., and was washed in petroleum ether before weighing.
7. Petroleum ether (bp 35–65°C) was obtained from Fisher Scientific Company and was distilled from **potassium permanganate**.
8. The color of the reaction mixture at this point varies from gray-green to gray-black. The success of the reaction seems to be independent of the color.
9. Addition of petroleum ether causes a viscous black precipitate to cling to the walls of the flask, leaving a milky-white solution that can be conveniently poured into the filter.
10. The black residue, which consists of inorganic salts, **titanium**, and unreacted **lithium**, is retained in the reaction vessel, where it is washed with petroleum ether while the mass is manually stirred with the paddle. No problem has been encountered in exposing the black material to the air during the washing procedure.
11. The black residue is destroyed in the following manner. The stirrer motor is reattached, and the flask is flushed with **argon**. The flask is cooled in an ice–water bath before adding 300 mL of petroleum ether and 300 mL of **acetone**. As the mixture is vigorously stirred, ca. 10 mL of **methanol** is added from a dropping funnel. After reaction has begun (an induction period of up to 0.5 hr may occur before gas evolution becomes noticeable), an additional 590 mL of **methanol** is added dropwise over a 6–10-hr period. Stirring is continued at 0°C until pieces of **lithium** can no longer be seen (approximately 1 hr after the addition of the **methanol** has been completed).
12. The second crop is slightly impure, as shown by its NMR spectrum.

3. Discussion

Adamantylideneadamantane has been prepared by (1) photolysis of 2-adamantylketene dimer,² (2) reduction of **4e-chloroadamantylideneadamantane** with **sodium** in liquid **ammonia**,³ (3) rearrangement of spiro[adamantane-2,4'-homoadamantan-5'-ol] with Lewis acids,^{4, 5} (4) reduction of **2,2-dibromoadamantane** with **magnesium**⁶ or **zinc-copper** couple,⁷ and (5) treatment of the azine of 2-adamantanone with **hydrogen sulfide**, followed by oxidation with **lead tetraacetate** and heating with **triphenylphosphine**.⁸

The present method is a modification of a previous procedure by the submitters.⁹ Handling of **lithium** in the air is less hazardous and more convenient than that of **potassium**, which was originally used. Higher yields were obtained when the higher-boiling solvent **1,2-dimethoxyethane** was employed rather than **tetrahydrofuran**. Although the titanium trichloride-lithium system results in slightly lower yields for aliphatic ketones than the corresponding **potassium** method, the former is considerably more convenient for large-scale reactions. The **lithium** procedure is applicable to both aromatic and aliphatic aldehydes and ketones (Table I). Reductive coupling of unsymmetrical carbonyl compounds usually results in a mixture of geometric isomers.

Details of the **titanium**-induced dicarbonyl coupling reaction can be found in a full paper¹⁰ and in a review article.¹¹

TABLE I
REACTION OF KETONES AND ALDEHYDES
WITH TITANIUM TRICHLORIDE-LITHIUM IN
1,2-DIMETHOXYETHANE

Carbonyl Compound Yield of Alkene Product (%)

Acetophenone	94
Benzaldehyde	97
Benzophenone	96
Cholestanone	84
Cyclododecanone	90
Cycloheptanone	85
Cyclohexanone	81
Decanal	59
Hexanal	58 (28 : 72, <i>cis</i> : <i>trans</i>)

References and Notes

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

petroleum ether

2-adamantylketene dimer

spiro[adamantane-2,4'-homoadamantan-5'-ol]

azine of 2-adamantanone

titanium trichloride-lithium

ammonia (7664-41-7)

methanol (67-56-1)

magnesium (7439-95-4)

Cyclohexanone (108-94-1)

potassium permanganate (7722-64-7)

hydrogen sulfide (7783-06-4)
oxygen (7782-44-7)
nitrogen (7727-37-9)
benzaldehyde (100-52-7)
acetone (67-64-1)
Acetophenone (98-86-2)
Benzophenone (119-61-9)
sodium (13966-32-0)
potassium (7440-09-7)
lithium,
Lithium wire (7439-93-2)
Cholestanone (566-88-1)
zinc-copper
Tetrahydrofuran (109-99-9)
Cycloheptanone (502-42-1)
argon (7440-37-1)
1,2-dimethoxyethane (110-71-4)
triphenylphosphine (603-35-0)
cyclododecanone (830-13-7)
2-adamantanone (700-58-3)
Decanal (112-31-2)
titanium (7440-32-6)
Hexanal (66-25-1)
Adamantylideneadamantane,
Tricyclo[3.3.1.1^{3,7}]decane, tricyclo[3.3.1.1^{3,7}]decylidene- (30541-56-1)
titanium trichloride (7705-07-9)
2,2-dibromoadamantane

4e-chloroadamantylideneadamantane

lead tetraacetate (546-67-8)

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