BULLETIN OF THE CHEMICAL SOCIETY OF JAPAN, VOL. 47, 2323—2324 (1974)

The Mechanism of the Reduction of Tosylhydrazones with B_2H_6 and with $NaBH_4$ in Aprotic Solvents

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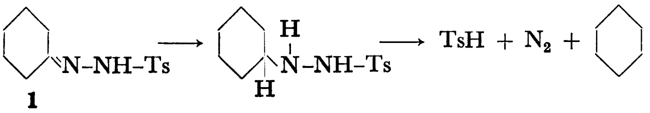
(Received May 4, 1973)

Synopsis. Cyclohexanone tosylhydrazone was reduced with $NaBH_4$ and B_2H_6 in aprotic solvents; results indicate that the reduction affords cyclohexyl-tosylhydrazine or an equivalent organometallic adduct confirming the mechanism previously proposed by us in the case of $NaBH_4$ in protic solvents.

The reduction of tosylhydrazones of aldehydes and ketones with reducing hydrides such as B_2H_6, $LiAlH_4$ and $NaBH_4$[1] constitutes an efficient method for conversion of carbonyls to CH_2 under mild conditions. The reactions can be carried out in either protic ($NaBH_4$)[2,3] or aprotic solvents ($NaBH_4$, B_2H_6, and $LiAlH_4$).[2,4,5]

As far as the mechanism of the reaction is concerned, we have demonstrated[6] that in protic solvents the treatment of tosylhydrazones with $NaBH_4$ leads to tosylhydrazines followed by subsequent thermal decomposition to TsH, N_2 and Alkanes.



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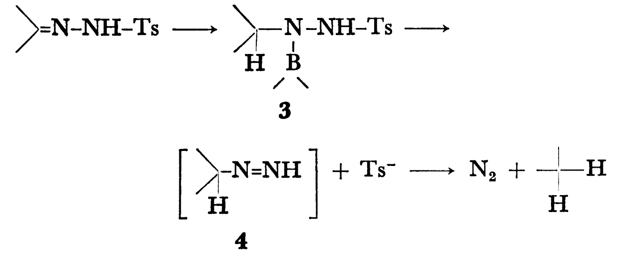
In aprotic solvents, it has been shown [4,8] that the reaction of tosylhydrazones with $LiAlH_4$ and B_2H_6 proceeds in two steps: reduction to an intermediate compound followed by decomposition of the intermediate.

The mode of action of $LiAlH_4$ and B_2H_6 towards C=N bonds,[9] and other considerations, induced us to postulate the formation of intermediary organometallic compounds, whose oxidation level is identical to that of a substituted tosylhydrazine. With B_2H_6 as reducing agent, this conclusion is well substantiated by the observation that no hydrogen is evolved during the first step of the reaction and that the intermediate compound contains all the theoretical nitrogen. The following mechanism[10] is proposed:



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In order to complete our work, and to confirm our previous conclusions, this report presents results obtained upon reduction of cyclohexanone tosylhydrazone (**1**), with B_2H_6 and with $NaBH_4$ in aprotic solvents. Cyclohexanone tosylhydrazone (**1**) was chosen for study since the corresponding 1-cyclohexyl-2-tosylhydrazine (**2**) is well characterized and readily obtainable by reduction of **1** with $NaBH_4$ in protic solvents.[6]

From reduction of **1** with B_2H_6 in THF solution at room temperature, pure **2** in 55—60% yield was obtained.

These results substantiate the mechanism previously proposed for the reduction of tosylhydrazones with diborane: the reduction occurs at the C=N double bond to give an intermediate compound (**3**) which contains the fundamental skeleton of alkyltosylhydrazines.

Then, this intermediate decompose to alkanes *via* an unstable[7] alkyl diimide.

Compound **1** has been submitted to reduction with $NaBH_4$ in different aprotic solvents: ether–tetrahydrofuran (6: 1), 1,2-dimethoxyethane, diglyme and the course of the reaction was examined by thin layer chromatography. Compound **2** was isolated after reduction of **1** in ether–tetrahydrofuran (10—15%), 1,2-dimethoxyethane (50—55%) and diglyme (70—75%). The low yield in ether–tetrahydrofuran apparently results from the slow reduction rate in this solvent which allows decomposition of the intermediate (**2**).

The above results indicate that the reduction of **1** in aprotic solvent affords **2**, or an equivalent organometallic adduct that leads to the formation of **2** when treated with water or when subjected to thin layer chromatography.

However, when the action of the reducing agent is complete (excess hydride is neutralized by addition of acetone) the fundamental skeleton of **2** is present in the molecule. Thus the results obtained with B_2H_6 and $NaBH_4$ in aprotic solvents confirm our previous conclusions and are analogous to those observed with $NaBH_4$ in protic solvents.

Finally, it is noteworthy that the reduction of tosylhydrazones, at least with B_2H_6, and $NaBH_4$ in protic and aprotic solvents, leads to the formation of a substituted tosylhydrazines (or equivalent organometallic adducts (**3**)) as the first product. Subsequent elimination of Ts^- leads to the formation of an alkyl diimide (**4**), which decomposes rapidly to N_2 and alkane. One of the two hydrogens of the resulting CH_2 takes its origin from the reducing hydride, the second one from the NH originally present in the tosylhydrazone (B_2H_6 and $NaBH_4$) or from water added during the working up of the reaction mixture ($LiAlH_4$).

The experimental results reported by Djerassi and coworkers[11] are in perfect agreement with the mechanism proposed by us. With regard to the reaction pathway of tosylhydrazones with $NaBH_4$, a different mechanism has been suggested.[12] This mechanism is in contrast with our experimental data and with our conclusions.

Experimental

1-Cyclohexyl-2-tosylhydrazine from Reduction of Cyclohexanone Tosylhydrazone with B_2H_6. A solution of compound **1** (1 g, 3.75 mmol) in diglyme (20 ml) was treated at room temperature with excess of B_2H_6 (5.5 mmol) in THF (5 ml). After 15 min, the mixture was poured into a large excess of water and the resulting precipitate was filtered. Compound **2** (850 mg) was obtained, mixed with variable amounts of boron-containing compounds. This material was treated three-four times with aqueous methanol in the cold and passed through a column of Kieselgel (10-fold) in CH_2Cl_2 solution to obtain pure **2** (55—60%) identified by comparison with an authentic sample.⁶⁾

1-Cyclohexyl-2-tosylhydrazine from Reduction of Cyclohexanone Tosylhydrazone with $NaBH_4$. To a solution of **1** (1 g, 3.75 mmol) in diglyme (20 ml), 300 mg (7.94 mmol) of $NaBH_4$ were added and the solution was maintained at room temperature for 10 min. Acetone (20 ml) was added and then (30 s) H_2O (200 ml). The resulting precipitate of crude **2** (810 mg) was recrystallized from CH_2Cl_2–hexane to give **2** in 70—75% yield.

In a parallel experiment, 1 g of **1** in diglyme (20 ml) and 300 mg of $NaBH_4$ were mixed, and in a few seconds, acetone (20 ml) and H_2O (200 ml) were added to the solution. No **2** was obtained. When 1,2-dimethoxyethane was used as solvent, the reaction time was prolonged to 20 min in order to obtain a good yield.

We wish to thank C.N.R. for financial support (Contract N°72.00048.03).

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