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$NaBH_4/(NH_4)_2SO_4$: A Convenient System for Reduction of Carbonyl Compounds to their Corresponding Alcohols in wet-THF

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ABSTRACT

$NaBH_4$ (1-2 equivalents) in the presence of $(NH_4)_2SO_4$ (1-2 equivalents) reduces varieties of organic carbonyl compounds such as aldehydes, ketones and á,â-unsaturated carbonyl compounds to their corresponding alcohols. Reduction reactions were carried out in THF-H_2O in high to excellent yields of products.

Key words: $NaBH_4$, Reduction, Carbonyl compounds, $(NH_4)_2SO_4$.

INTRODUCTION

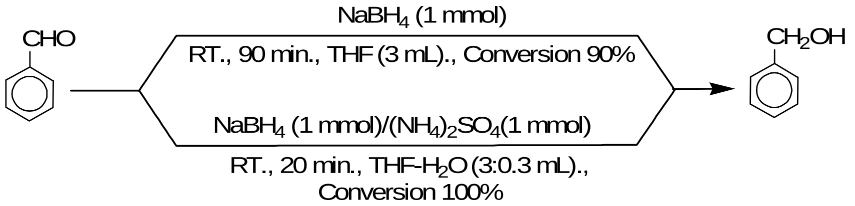
Preparation of alcohols from the reduction of carbonyl functional groups are importance in organic chemistry [1] and a large number of methods including catalytic reduction [2], hydride homogeneous catalysis [3], heterogeneous catalysis systems [4] and transfer reagents [5] have been reported to be effective towards carbonyl compounds reduction. But, most chemists employ lithium aluminum hydride ($LiAlH_4$) or sodium borohydride ($NaBH_4$). Controlling the reducing power of $NaBH_4$ has been achieved by different types of modifications [6-13]. A literature review also reveals that the reduction of carbonyl compounds can be achieved by $NaBH_4$ in the presence of mineral protic solids or under wet conditions with some limitations. In continuing our efforts for the development of new reducing systems, [14] we decided to investigate the reducing properties of $NaBH_4$ in the presence of $(NH_4)_2SO_4$ as the co-reagent for the reduction of a variety of carbonyl compounds. We now report the results of a parallel investigation of the role of $(NH_4)_2SO_4$ in the reduction of carbonyl compounds to their corresponding alcohols. Former, $(NH_4)_2C_2O_4$ has been proposed as a co-reactant.

RESULTS AND DISCUSSION

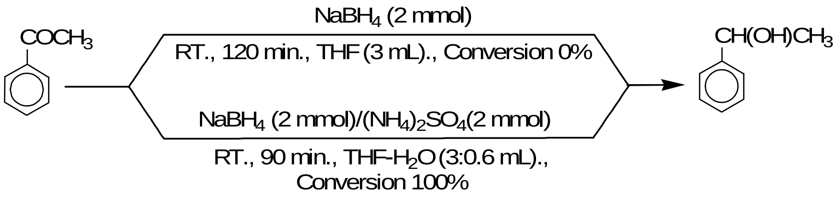
benzaldehyde as a model compound has been reduced with one molar equivalent of $NaBH_4$ in THF-H_2O (3:0.3 mL) within 20 in the presence of 1 molar equivalent of $(NH_4)_2SO_4$ at room temperature as shown in scheme 1.

The efficiency of this protocol was examined by the reduction of a variety of aldehydes. All reductions were completed within 20-80 minutes as shown in table 1, entries 1-7. The molar ratio of $NaBH_4$ is not different according to the nature of the substrates. 1 molar equivalents of $NaBH_4$ and 1 molar equivalents of $(NH_4)_2SO_4$ per one equivalents of the substrate were sufficient to complete conversion of aldehydes to the corresponding alcohols in excellent yields (91-96%).

Our next attempt was the reduction of ketones to the corresponding secondary alcohols with the $NaBH_4/(NH_4)_2SO_4$ system. We optimized the reaction conditions with the reduction of the model compound acetophenone by $NaBH_4/(NH_4)_2SO_4$ under different conditions. Reduction of ketones was obtained with this reducing system, but due to the lower reactivity of ketones relative to aldehydes, the reduction require higher molar amounts of $NaBH_4$ & $(NH_4)_2SO_4$. The reduction reactions were performed with 2 molar amounts of $NaBH_4$ in presence of 2 molar amounts of $(NH_4)_2SO_4$ at room temperature in wet-THF as shown in scheme 2.



Scheme 1:



Scheme 2:

All reductions were completed within 90-120 minutes with high to excellent yields (94-97%) as shown in table 1, entries 8-14.

The mechanism for the influence of $(NH_4)_2SO_4$ is not clear, but we observed that with the addition of $(NH_4)_2SO_4$ hydrogen gas slowly is liberated *in situ*. Hydrogen gas generation seems to be directly related to the solubility of the $NaBH_4$ and $(NH_4)_2SO_4$ in the reaction solvent. Because water causes an increase in solubility of the $NaBH_4$ & $(NH_4)_2SO_4$, so hydrogen gas generation increase dramatically.

EXPERIMENTAL

General

All substrates and reagents were purchased from commercially sources with the best quality. IR and ^1H NMR spectra were recorded on PerkinElmer FT-IR RXI and 300 MHz Bruker spectrometers, respectively. The products were characterized by their ^1H NMR or IR spectra and comparison with authentic samples (melting or boiling points). Organic layers were dried over anhydrous sodium sulfate. All yields referred to isolated pure products. The purity of products was determinate by TLC and ^1H NMR. Also, reactions

Table 1: The Reduction of Carbonyl Compounds by $NaBH_4/(NH_4)_2SO_4$ in wet-THF at Room Temperature

Entry	Aldehydes	Products	Time/min.	Yield[c]/%
1[a]	benzaldehyde	benzyl alcohol	20	96
2[a]	4-bromobenzaldehyde	4-bromobenzyl alcohol	30	96
3[a]	4-methylbenzaldehyde	4-methylbenzyl alcohol	60	96
4[a]	4-nitrobenzaldehyde	4-nitrobenzyl alcohol	30	93
5[a]	2-methoxylbenzaldehyde	2-methoxylbenzyl alcohol	60	93
6[a]	4-methoxybenzaldehyde	4-methoxybenzyl alcohol	80	95
7[a]	3-methylbenzaldehyde	3-methylbenzyl alcohol	30	95
8[b]	acetophenone	1-phenylethanol	90	96
9[b]	4-methylacetophenone	1-(4-methylphenyl)ethanol	120	94
10[b]	4-methoxyacetophenone	1-(4-methoxyaphenyl)ethanol	120	97
11[b]	4-methoxybenzophenone	(4-methoxyphenyl)(phenyl)methanol	120	95
12[b]	Benzophenone	diphenylmethanol	110	95
13[b]	9*H*-fluoren-9-one	9*H*-fluoren-9-ol	120	95
14[b]	4-phenylcyclohexanone	4-phenylcyclohexanol	90	97

[a] The reaction has been carried out by $NaBH_4/(NH_4)_2SO_4$ (1/1 mmol) in THF-H_2O (3:0.3 mL). [b] The reaction has been carried out by $NaBH_4/(NH_4)_2SO_4$ (2/2 mmol) THF-H_2O (3:0.6 mL). [c] Yields refer to isolated pure products.

are monitoring over silica gel 60 F_{254} aluminum sheet.

A typical procedure for Reduction of aldehydes with the $NaBH_4/(NH_4)_2SO_4$ system in wet-THF

In a round-bottomed flask (10 mL) equipped with a magnetic stirrer, a solution of benzaldehyde (0.106 g, 1 mmol) in THF-H_2O (3:0.3 mL) was prepared. To this solution, $NaBH_4$ (0.038 g, 1 mmol) and then $(NH_4)_2SO_4$ (0.132 g, 1 mmol) was added and the mixture was stirred at room temperature for 20 minutes. Completion of the reaction was monitored by TLC (Hexane/EtOAc: 9/1). Then, water (5 mL) was added to the reaction mixture and it was stirred for an additional 1 minute. The mixture was extracted with CH_2Cl_2 (3×10 mL) and dried over anhydrous Na_2SO_4. Evaporation of the solvent and a short column chromatography of the resulting crude material over silica gel (Hexane/EtOAc: 9/1) afforded the pure liquid benzyl alcohol (0.104 g, 96%, Table 1, entry 1).

A typical procedure for reduction of ketones with the $NaBH_4/(NH_4)_2SO_4$ system in wet-THF

In a round-bottomed flask (10 mL) equipped with a magnetic stirrer and a condenser, a solution of acetophenone (0.12 g, l mmol) in THF-H_2O (3:0.6 mL) was prepared and $NaBH_4$ (0.038 g, 1 mmol) and $(NH_4)_2SO_4$ (0.234 g, 2 mmol) were added and the mixture was stirred at room temperature for 90 minutes. TLC monitored the progress of the reaction (Hexane/EtOAc: 9/1). After completion of the reaction distilled water (5 mL) was added to the reaction mixture and it was stirred for an additional 1 minute. The mixture was extracted with CH_2Cl_2 (3×10 mL) and dried over anhydrous sodium sulfate. Evaporation of the solvent and short column chromatography of the resulting crude material over sil-ica gel (Hexane/EtOAc: 9/1) afforded the pure crystals of 1-phenylethanol (0.l1 g, 96% yield, Table 1, entry 8).

CONCLUSION

In conclusion, we have shown that the combination system of $NaBH_4/((NH_4)_2SO_4$ in wet-THF reduces a variety of carbonyl compounds to their corresponding alcohols in high to excellent yields at room temperature. Reduction reactions were carried out with 1-2 molar equivalents of $NaBH_4$ in the presence of 1-2 molar equivalents of $(NH_4)_2SO_4$. All reductions were accomplished with high efficiency of the reductions, using the appropriate molar ratios of $NaBH_4$ and $(NH_4)_2SO_4$, shorter reaction times and easy work-up procedure. Therefore this new protocol for reduction of carbonyl compounds could be a useful addition to the present methodologies.

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REFERENCES

1. Ji, H. B. and She, Y. B. *Green Oxidation and reduction*, China Petrochemical Press, Beijing, 2005.
2. Larock, R. C. *Comprehensive Organic Transformations: a guide to functional group preparations*, 2nd Ed.; Wiley-VCH, New York, 1999.
3. Brandt, P.; Roth, P.; Anderssson, P. G., *J. Org. Chem.* **2004**, *69***,** 4885-4890.
4. Liu , P. N.; Gu, P. M.; Wang, F. D.; Tu, Y. Q., *Org. Lett.* **2004**, *6*, 169-172.
5. Mohanazadeh F.; Hosini, M.; Tajbakhsh, M., *Monatshefe fur Chemie.* **2005**, *136***,** 2041**-**2043**.**
6. Hudlicky, M. *Reductions in Organic Chemistry*, Ellis Horwood Ltd. Chichester, 1984.
   (b) Seyden-Penne, J. *Reductions by the Alumino and Borohydrides in Organic Synthesis*, 2nd Ed.; Wiley-VCH, New York, 1997.
7. Narayana, C.; Periasamy, M. *Tetrahedron Lett.* **1985**, *26*, 1757-1760.
8. (a) Ranu, B. C. *Synlett*. **1993**, 885-892.
   (b) Narasimhan. S; Balakumar, A. *Aldrichimica Acta*. **1998**, *31*, 19-26.
   (c) Soai, K.; Ookawa, A. *J. Org. Chem.* **1986***,* *51*, 4000-4005.
9. Firouzabadi, H.; Afsharifar, G. R. *Bull. Chem. Soc. Jpn.* **1995**, *68*, 2595-2602.
10. Blough, B. E.; Carroll, F. I. *Tetrahedron Lett*. **1993**, *34*, 7239-7242.
11. Zeynizadeh, B.; Setamdideh, D. *Asian J. Chem*. **2009**, *21*, 3603-3610.
12. Zeynizadeh, B.; Setamdideh, D. *Asian J. Chem*. **2009**, *21*, 3588-3602.
13. Zeynizadeh, B.; Setamdideh, D *J. Chin. Chem. Soc.* **2005**, *52*, 1179-1184..
14. (a) Zeynizadeh, B.; Setamdideh, D *Zeit. Natur.* **2006**, *61b,* 1275-1281.
    (b) Zeynizadeh, B.; Setamdideh, D *Synth. Commun*. **2006**, *36*, 2699-2704.
15. Setamdideh. D.; Ghahremani, S. *S. Afr. J. Chem.* **2012**, 65, 91-97.