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A New Method of the Zinc Promoted Transformation of Carbonyl Compounds to Homoallylic Alcohols

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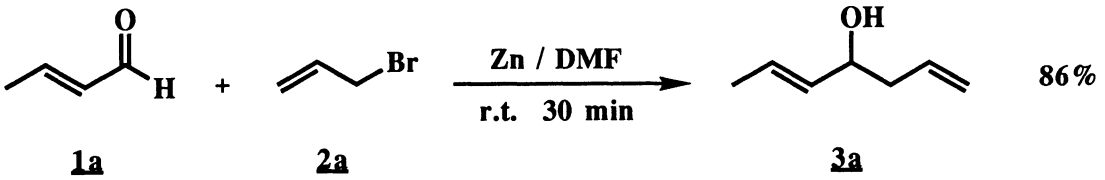
A Zn-promoted transformation of a variety of carbonyl compounds to homoallylic alcohols has been accomplished in excellent yields by using DMF as the solvent.

Since the transformation of carbonyl compounds to homoallylic alcohols is an important tool in organic synthesis, various types of method using allylic metal-reagents ($RCH=CHCH_2M$, M=Li,[1-3,7] Mg,[1,3,4-9,12] Zn,[1,3,7,10-17] Sn,[16,18-22] Al,[1,11] Cd,[1,12] Pb,[23,24] Ni,[25,26] Cr,[27] Mn,[28,29] Bi,[30] Sm,[31] B,[32] Si,[33] Ti,[34] Zr,[35] Ce[36]) have already been exploited so far. Among them, Zn has been known to be non-polluting, and readily available, while the low reactivity of the Zn reagents toward the carbonyl group often results in low yields.[9-11]

Although several attempts have already been made to improve the yields of Zn-promoted allylation of carbonyl compouds,[13-16] any remarkable success has not yet been reported. It is also rather surprising that almost all of the hitherto known Zn-promoted allylations have been investigated only by using ether-type solvents.[1,3,7,10-12,14-17]

We wish to report our new findings that using DMF as the solvent was highly effective to the Zn-promoted transformation of carbonyl compounds to the homoallylic alcohols and the reaction rate and yield were remarkably increased under mild and simple reaction conditions. This new method seems to be one of the bests among the methods cited above in its generality, simplicity in the operation and high yields. The reaction of crotonaldehyde (1a) with allyl bromide (2a) which was carried out in DMF (Scheme 1) by using some pieces of small Zn plate as

the promoter, for example, gave the homoallylic alcohol (3a) in 86% yield, while it has been reported that the yield of 3a obtained by using other types of solvent was generally low. For example, the yield of 3a obtained by using the system consisting of Zn dust and aqueous THF was 37%.[17]



1a 2a 3a

Scheme 1.

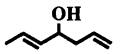
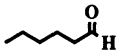
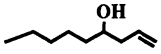
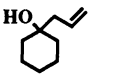
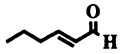
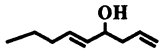
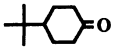
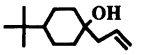
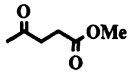
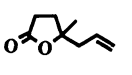
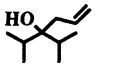
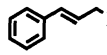
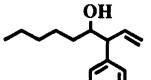
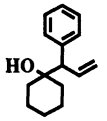
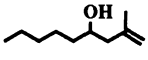
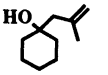
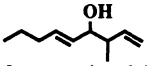
It is also noteworthy that this new method does not require anhydrous solvent, innert atmosphere, and the pre-activation of Zn.

A general procedure is as follows: Into a stirred solution of 1a (500 mg, 5.1 mmol) and 2a (900 mg, 7.4 mmol) in 5 ml of DMF,[37] some pieces of small zinc plate[38] (500 mg, 7.7 mmol) were added at room temperature under the atmosphere. An exothermic reaction started within 10 minutes and it ceased in 30 minutes. Then, the reaction mixture was poured into a saturated aqueous solution of NH_4Cl (100 ml), extracted with ether (30 ml x 3), and the combined organic phase was dried over $MgSO_4$. After it was worked up as usual, the product 3a was purified by Kugel rohr distillation under reduced pressure. The structure of 3a was confirmed by the comparison of its spectroscopic values with those of the authentic sample.[17]

As the other examples summarized in Table 1 show, this method is successfully applicable to the allylation of a variety of carbonyl compounds, and the yields of 3 are generally high. In addition, it is also surprising that the reaction of hexanal (1b) with cinnamyl bromide (2b) (run 8 in Table 1) yielded the corresponding homoallylic alcohol 3h in good yield, while it has been reported that the same reaction carried out in THF did not give 3h.[16]

In our own examination, Zn-promoted allylation of carbonyl compounds is highly influenced by the nature of solvent. As shown in Table 2, the reaction of cyclohexanone (1c) and allyl bromide (2a) using Zn-promoter afforded the homoallyl alcohol (3c) in good yields when the solvents were amides (runs 1 and 2 in Table 2), lactams (runs 3 and 4 in Table 2) and oxazoline (run 5 in Table 2), while the use of THF as the solvent did not give 3c under otherwise the same reaction conditions.

Table 1. Allylation of Carbonyl Compounds

Run	Carbonyl compd.	Allyl bromide	Product	Yield / %[a,b]
1	 (1a)	 (2a)	 (3a)	86
2	 (1b)	(2a)	 (3b)	94
3	 (1c)	(2a)	 (3c)	99
4	 (1d)	(2a)	 (3d)	90
5	 (1e)	(2a)	 (3e)	94[c]
	(OH axial : equatorial = 85 : 15)			
6	 (1f)	(2a)	 (3f)	94
7	 (1g)	(2a)	 (3g)	81
8	(1b)	 (2b)	 (3h)	87
			(erythro : threo = 75 : 15)[d]	
9	(1c)	(2b)	 (3i)	86
10	(1b)	 (2c)	 (3j)	99
11	(1c)	(2c)	 (3k)	93
12	(1d)	 (2d)	 (3l)	90
			(erythro : threo = 1 : 1)[e]	

a) Isolated yields. b) The structures were determined by the spectroscopic comparison with those of authentic samples. c) The ratio was determined by GLC.[17,39] d) The stereoisomers of 3h were transformed to the corresponding acetates and the ratio was determined by ^{1}H-NMR.[40] e) The ratio was determined by ^{1}H-NMR.

Table 2. Solvent Effect of the Allylation of 1c

Run	Solvent	Yield of 3c / %[a]	Run	Solvent	Yield of 3c / %[a]
1	N,N-Dimethylformamide	99	4	2-Pyrrolidone	86
2	N,N-Dimethylacetoamide	99	5	2-Methyloxazoline	99
3	N-Methyl-2-pyrrolidone	99	6	Tetrahydrofuran	no reaction

a) The reaction mixture was stirred for 2 h at room temperature.

References

1) G. Courtois and L. Miginiac, J. Organomet. Chem., 69, 1 (1974).
2) J. L. Luche and J. C. Damiano, J. Am. Chem. Soc., 102, 7926 (1980).
3) J. A. Katzenellenbogen and R. S. Lenox, J. Org. Chem., 38, 326 (1973).
4) R. A. Benkeser, Synthesis, 1971, 347.
5) R. A. Benkeser, M. P. Siklosi, and E. C. Mozdzen, J. Am. Chem. Soc., 100, 2134 (1978).
6) R. A. Benkeser, W. G. Young, W. E. Broxterman, D. A. Jones, Jr., and S. J. Piaseczynski, J. Am. Chem. Soc., 91, 132 (1969).
7) F. Barbot and Ph. Miginiac, Bull. Soc. Chim. Fr., 1977, 113.
8) F. Barbot and Ph. Miginiac, J. Organomet. Chem., 132, 445 (1977).
9) Y. Yamamoto and K. Maruyama, J. Org. Chem., 48, 1564 (1983).
10) M. Gaudemar, Bull. Soc. Chim. Fr., 1962, 974.
11) M. Gaudemar, Bull. Soc. Chim. Fr., 1963, 1475.
12) D. Abehaim, E. Henry-Basch, and P. Freon, Bull. Soc. Chim. Fr., 1969 4038.

13) T. A. Killinger, N. A. Boughton, T. A. Runge, and W. Joseph, J. Organomet. Chem., 124, 131 (1977).
14) C. Petrier and J. L. Luche, J. Org. Chem., 50 910 (1985).
15) C. Petrier and J. L. Luche, Tetrahedron Lett., 26, 1449 (1987).
16) C. Einhorn and J. L. Luche, J. Organomet. Chem., 322, 177 (1987).
17) S. R. Wilson and M. E. Guazzaroni, J. Org. Chem., 54, 3087 (1989).
18) Y. Yamamoto, H. Yatagai, Y. Naruta, and K. Maruyama, J. Am. Chem. Soc., 102, 7107 (1980).
19) T. Mukaiyama, T. Harada, and S. Shoda, Chem. Lett., 1980, 1507.
20) T. Mukaiyama and T. Harada, Chem. Lett., 1981, 1527.
21) K. Uneyama, H. Matsuda, and S. Torii, Tetrahedron Lett., 52, 6017 (1984).
22) K. Uneyama, N. Kamaki, A. Moriya, and S. Torii, J. Org. Chem., 50, 5396 (1985).
23) H. Tanaka, S. Yamashita, T. Hamatani, Y. Ikemoto, and S. Torii, Chem. Lett., 1986, 1611.
24) H. Tanaka, S. Yamashita, T. Hamatani, Y. Ikemoto, and S. Torii, Synth. Commun., 17, 789 (1987).
25) D. C. Billington, Chem. Soc. Rev., 14, 93 (1985).
26) S. Duradetti, S. Sibille, and J. Perichon, J. Org. Chem., 54, 2198 (1989).
27) Y. Okude, S. Hirano, T. Hiyama, and H. Nozaki, J. Am. Chem. Soc., 99, 3179 (1977).
28) T. Hiyama, M. Sawahata, and M. Obayashi, Chem. Lett., 1983, 1237.
29) T. Hiyama, M. Sawahata, and Y. Kusano, Chem. Lett., 1985, 611.
30) M. Wada and K. Akiba, Tetrahedron Lett., 26, 4211 (1985).
31) J. Souppe and H. C. Kagan, Tetrahedron Lett., 23, 3497 (1982).
32) G. W. Kramer and H. C. Brown, J. Org. Chem., 42, 2292 (1977).
33) A. Hosomi and H. Sakurai, Tetrahedron Lett., 17, 1295 (1976).
34) F. Sato, K. Iida, S. Iijima, H. Moriya, and M. Sato, J. Chem. Soc., Chem. Commun., 1981, 1140.
35) Y. Yamamoto and K. Maruyama, Tetrahedron Lett., 22, 2895 (1981).
36) T. Immamoto, T. Kusumoto, Y. Tawarayama, Y. Sugiura, T. Mita, Y. Hatanaka, and M. Yokoyama, J. Org. Chem., 49, 3904 (1984).
37) The commercially available DMF (Wako Pure Chemicals Ltd.) was used as received.
38) The Zn plate (Mitsuwa Pure Chemicals, Ltd.) was used without any pre-activation.
39) M. Gaudemar, Tetrahedron, 32, 1689 (1976).
40) C. H. Heathcock, S. Kiyooka, and T. Blumenkopf, J. Org. Chem., 49, 4214 (1984).

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