Tetrahedron Letters No. 36, pp 3425 - 3428.
©Pergamon Press Ltd. 1979. Printed in Great Britain.

0040-4039/79/0901-3425$02.00/0

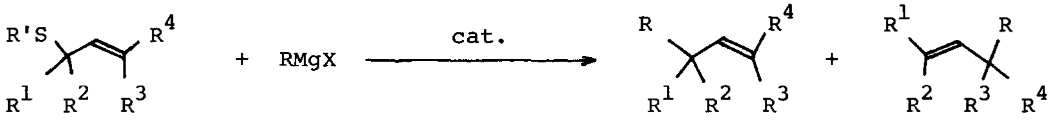
# CROSS-COUPLING OF ALLYLIC SULFIDES AND GRIGNARD REAGENTS CATALYZED BY NICKEL-PHOSPHINE COMPLEX

Hisashi OKAMURA and Hisashi TAKEI*
Department of Life Chemistry, Tokyo Institute of Technology,
Nagatsutacho, Midori-ku, Yokohama 227, Japan

SUMMARY: Allylic sulfides smoothly couple with Grignard reagents in the presence of Ni(II)-phosphine complexes as catalysts to give the corresponding unsaturated compounds in good yields.

Allylic sulfides have lately attracted considerable attention in the field of synthetic organic chemistry because of their usefulness as intermediates for the formation of a new carbon-carbon bond. One of the most representative examples is synthesis of olefinic hydrocarbons by the condensation of lithiated allylic sulfides with alkyl or allylic halides followed by desulfurization.1) This procedure has been applied widely, however, some difficulty lies in the desulfurization step since the desulfurization is accompanied by overreduction (saturation of the double bond)2) or isomerization (migration of the double bond)3) in some cases. Direct formation of such olefinic hydrocarbons from allylic sulfides with loss of a sulfur-containing group has little been described.4)

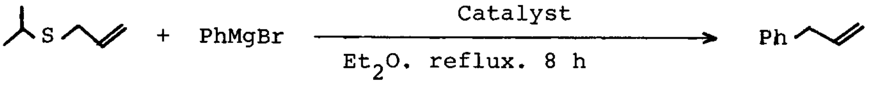
Recently we reported that alkenyl or aryl sulfides couple with Grignard reagents in the presence of catalytic amounts of nickel-phosphine complexes.5) On the basis of mechanistic consideration,6) we examined the nickel-phosphine complex catalyzed coupling reaction using allylic sulfides(1) with the expectation that sulfur-containing groups of allylic sulfides would be directly replaced by alkyl or aryl groups of the Grignard reagents(2). As expected, coupling products were obtained in high yields, though $S_N$'-type products(4) were formed together with $S_N$-type products(3).



(1) (2) (3) (4)

First, we examined the catalytic activity of some nickel, palladium and iron complexes using the combination of allyl isopropyl sulfide and phenylmagnesium bromide. The results are listed in Table 1.

Table 1. Cross Coupling of Allyl Isopropyl Sulfide with Phenylmagnesium Bromide in the Presence of Transition Metal Complexes.a)



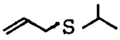
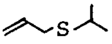
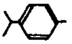
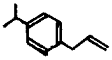
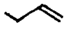
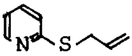
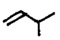
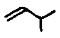
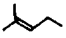
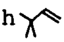
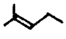
| catalyst |  yield (%)b) |
|---|---|
| $NiCl_2(Ph_2PCH_2CH_2CH_2PPh_2)$ | 90 |
| $NiCl_2(PH_2PCH_2CH_2CH_2PPh_2)$ | 77c) |
| $NiCl_2(PPh_3)_2$ | 99 |
| $NiCl_2(PPh_3)_2$ | 90c) |
| $NiCl_2$(2,2'-bipyridine) | 70 |
| $NiCl_2$ | 70 |
| $Ni(CH_3COCHCOCH_3)_2$ | 68 |
| $PdCl_2(PPh_3)_2$ | 86 |
| $Pd(PPh_3)_4$ | 52 |
| $Fe(PhCOCHCOPh)_3$ | 19d) |

a) All of reactions were carried out in refluxing ether for 8 h, unless otherwise noted. Molar ratio of Catalyst/Sulfide/PhMgBr is 0.03/1.0/1.5. b) The yields were determined by glpc. c) The reaction was carried out for 1 h. d) Isopropylbenzene (12%) was also detected (confirmed by GC-MS).

As shown in Table 1, nickel-phosphine complexes proved to be the best. The other nickel compounds and palladium complexes have moderate activity. The iron complex has little activity, but the formation of isopropylbenzene suggests that the reaction mechanism may be somewhat different from that for nickel and palladium complexes.

Then, using $NiCl_2(PPh_3)_2$ or $NiCl_2(Ph_2PCH_2CH_2CH_2PPh_2)$, we examined the coupling reaction between a variety of allylic sulfides and Grignard reagents. The results are summarized in Table 2.

Table 2. Cross Coupling of Allylic Sulfides with Grignard Reagents Catalyzed by Nickel-Phosphine Complexes.$^{a)}$

| run | Sulfide | RMgX(eq.) | | Cat.$^{b)}$ | Time(h) | Product$^{c)}$ | (Yield$^{d)}$%) |
|---|---|---|---|---|---|---|---|
| 1 |  | PhMgBr | (1.5) | A | 8 | Ph | (89)$^{e)}$ |
| 2 |  | MgBr | (1.6) | A | 10 |  | (82)$^{f)}$ |
| 3 | PhS  | PhMgBr | (1.2) | A | 8 | Ph | (88) |
| 4 | PhS  | PhMgBr | (2.4) | A | 8 | Ph | (90) |
| 5 |  | PhMgBr | (1.2) | A | 8 | Ph | (87) |
| 6 |  SMe | PhMgBr | (1.5) | A | 8 | Ph(14), Ph(14)$^{g)}$ | |
| 7 |  SMe | PhMgBr | (1.5) | B | 8 | Ph(66), Ph(31) | |
| 8 |  SMe | PhMgBr | (1.5) | A | 8 | Ph(33), Ph(24)$^{h)}$ | |
| 9 |  SMe | PhMgBr | (1.5) | B | 8 | Ph(55), Ph(38) | |
| 10 |  SMe | PhMgBr | (1.5) | A | 8 | Ph( 7 ), Ph( 7 )$^{i)}$ | |
| 11 |  SMe | PhMgBr | (1.5) | B | 8 | Ph(62), Ph(35) | |
| 12 | PhSMe | PhMgBr | (1.5) | A | 8 | PhPh | (96)$^{e)}$ |
| 13 | PhSMe | PhMgBr | (1.5) | A | 8 | PhPh | (83)$^{e)}$ |
| 14 | $PhCH_2SMe$ | PhMgBr | (1.5) | A | 8 | PhPh | ( 9 )$^{j)}$ |
| 15 | $PhCH_2SMe$ | PhMgBr | (1.5) | B | 8 | PhPh | ( 4 )$^{k)}$ |

a) All of reactions were carried out in refluxing ether in the presence of catalyst (3 mole %). b) A: $NiCl_2(Ph_2PCH_2CH_2CH_2PPh_2)$, B: $NiCl_2(PPh_3)_2$. c) The structure of the products was confirmed by comparison with authentic samples by glpc or spectral data. d) The yields were determined by glpc, unless otherwise noted. e) Isolated yield by tlc. f) Isolated yield by distillation. g, h, i, j, and k) The starting sulfides were recovered in 66, 36, 69, 72, and 76 % yields respectively.

The results summarized in Table 2 contain several features worthy of note.
(1) In general, this cross coupling reaction between allylic sulfides and Grignard reagents proceeded much faster than that with alkenyl or aryl sulfides. So, Grignard reagents reacted specifically with the allyl residue of allyl aryl sulfides even when an equimolar amount of Grignard reagent was used (runs 3-5).
(2) In the case of allyl sulfides, both catalysts, $NiCl_2(Ph_2PCH_2CH_2CH_2PPh_2)$ and $NiCl_2(PPh_3)_2$, were effective and the products were obtained in high yields (runs 1-4 and Table 1).
(3) $NiCl_2(Ph_2PCH_2CH_2CH_2PPh_2)$ showed a little activity in the reaction of sterically hindered allylic sulfides (runs 6, 8, 10), while $NiCl_2(PPh_3)_2$ exhibited a good activity (runs 7, 9, 11).$^{7)}$
(4) But cinnamyl methyl sulfide regioselectively coupled with Grignard reagents

catalyzed by $NiCl_2(Ph_2PCH_2CH_2CH_2PPh_2)$ to afford unsaturated compounds in high yields (runs 12, 13).

(5) These two catalysts have only a little activity in the coupling of benzyl sulfide (runs 14, 15).

(6) Even the sulfides which contain relatively acidic hydrogen coupled with Grignard reagents to afford the corresponding olefins in high yields (runs 3, 4, 5).

The following experiment provides a typical procedure for the cross coupling. At room temperature an ethereal solution of p-isopropylphenylmagnesium bromide prepared from p-bromoisopropylbenzene (11.95 g, 60 mmol), magnesium turnings (1.58 g, 65 mmol), and ether (20 ml) was added to a mixture of allyl isopropyl sulfide (4.36 g, 37.5 mmol) and $NiCl_2(Ph_2PCH_2CH_2CH_2PPh_2)$ (0.6 g, 1.1 mmol) in ether (80 ml) with stirring. The resulting yellow solution was heated to reflux for 10 h. After addition of 1 N hydrochloric acid and ether, the mixture was filtered. The organic layer was separated, washed, and dried. In general, the amount of product was measured by glpc using a suitable internal standard. After removal of solvent, p-allylisopropylbenzene was isolated by distillation; bp. 110-115°C/35 mmHg, 4.90 g, 82 %. NMR($CCl_4$):$\delta$=1.18(d, 6H, $-CH_3$, J=7 Hz), 2.80(m, 1H, $-CHMe_2$, J=7 Hz), 3.27(m, 2H, $-CH_2-$), 4.83 and 5.05 (m, 2H, $=CH_2$), 5.5-6.2(m, 1H, -CH=), 6.7-7.3($A_2B_2$-system, 4H, aromat.H).

References and Notes

1) G. C. Barret, "Organic Compounds of Sulfur, Selenium, and Tellurium", Vol. 3, p. 26. The Chemical Society, London (1975).
2) H. Okamura, M. Miura, and H. Takei, unpublished results.
3) K. Narasaka, M. Hayashi, and T. Mukaiyama, Chem. Lett., 1972, 259.
4) Y. Gendreau, J. F. Normant, and J. Villieras, J. Organomet. Chem., 142, 1, (1977); P. Barsanti, V. Calo, L. Lopez, G. Marchese, F. Naso, and G. Pesce, J. Chem. Soc., Chem. Commun., 1978, 1085.
5) H. Okamura, M. Miura, and H. Takei, Tetrahedron Lett, 1979, 43.
6) Although the mechanism of this reaction has not yet been fully clarified, the coupling may occur through the reaction sequences similar to the cases of alkenyl halides.[8)]
7) Similar phenomena were reported in the cases of alkenyl or aryl halides.[8)]
8) K. Tamao, K. Sumitani, Y. Kiso, M. Zembayashi, A. Fujioka, S. Kodama, I. Nakajima, A. Minato, and M. Kumada, Bull. Chem. Soc. Jpn., 49, 1958 (1976).

(Received in Japan 27 June 1979)