A Reagent-dependent Highly Chemoselective Halogenation Reaction of Zirconacyclopentenes

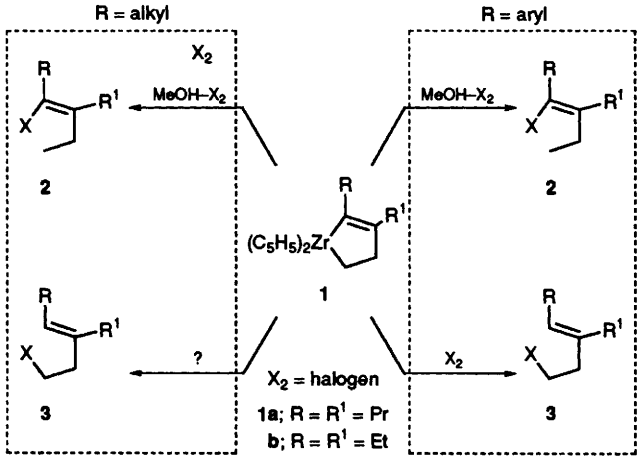
Tamotsu Takahashi,* Koichiro Aoyagi and Denis Y. Kondakov

Institute for Molecular Science and Graduate University of Advanced Studies, Myodaiji, Okazaki, 444 Japan

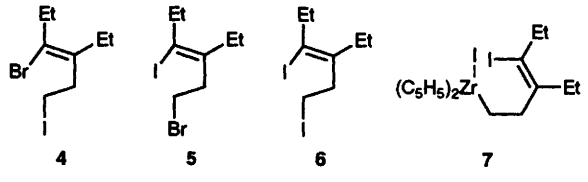
Chemoselective monobromination reactions of 2,3-dialkylzirconacyclopentenes are highly reagent dependent; NBS or Br_2 give alkenyl halides selectively, whereas CCl_3Br or CBr_4 give homoallylic halides with a high chemoselectivity.

Zirconacyclopentenes are readily prepared from alkenes and alkynes on zirconocenes.[1] Although several reactions of zirconacyclopentenes with various reagents have been reported,[1a,b,2] a control of chemoselective reactions has not been intensively investigated. Recently we have reported the chemoselectivities of monohalogenation reactions of zirconacyclopentene compounds **1** with I_2 or with an excess of MeOH–I_2.[3,4]

As shown in Scheme 1, when R is an aryl group, alkenyl halides **2** are provided by MeOH–X_2 (X_2 = I_2 or Br_2) and homoallyl halides **3** are obtained by treatment with X_2. However, when R is an alkyl group, both methods, X_2 and MeOH–X_2 give alkenyl halides **2** selectively. Therefore there is no method to prepare homoallylic halides **3** from zirconacyclopentene **1** when R is an alkyl. This situation prompted us to develop a new halogenation reagent with an opposite chemoselectivity to X_2. Here we report that CCl_3Br or CBr_4 are new bromination reagents for some organozirconocene compounds and that these reagents gave a highly chemoselective monobromination product of zirconacyclopentenes (R = alkyl) with an opposite chemoselectivity to NBS or Br_2 which are the usual bromination reagents of organozirconium compounds.



Scheme 1



4 5 6 7

Typical procedure is as follows. To a solution of **1a**, prepared *in situ* using $Zr(C_5H_5)_2Cl_2$ (1.2 mmol), ethylmagnesium bromide (2.4 mmol) and oct-4-yne (1.0 mmol), was added carbon tetrabromide (0.398 g, 1.2 mmol) at 0 °C and the mixture was stirred at room temp. for 1 h. After hydrolysis a monobromination product, 7-bromo-5-propylhept-4-ene **3a** was obtained in 94% yield with >99% isomeric purity. The ^1H and ^{13}C NMR spectra of the isolated product were consistent with the formulation.†

The results are shown in Table 1. It is noteworthy that the selectivity of the reaction with CCl_3Br or CBr_4 was >99%. This high chemoselectivity can lead to a practical chemoselective mixed dihalogenation of a zirconacyclopentene compound. It is more difficult to produce a chemoselective bromination–iodination product. For example, sequential treatment of **1b** with NBS (1.1 equiv.) and I_2 (2 equiv.) gave the desired product **4**‡ in 74% yield. However, two dihalogenation products, **5**§ and **6**¶ were also formed in 7 and 15% yields, respectively. Reversal of the treatment, *e.g.* I_2 followed by NBS was less useful. The major product was **6** (60% yield); presumably a consequence of a halide-exchange reaction of the intermediate **7** with NBS, liberating NIS which reacted, in turn, with an alkyl carbon to give the diiodide **6**. However, when CCl_3Br and I_2 were used in this order for **1b**, the desired product **5** was obtained in 89% yield with >98% isomeric purity. Diiodide **6** or isomer **4** were not detected.

Received, 29th November 1993; Com. 3/07062J

Table 1 Reagent-dependent chemoselective monobromination reactions of zirconacyclopentenes

Zirconacyclopentene	Reagent[a]	*T*/°C	*t*/h	Product[b] 2 : 3	Yield[c] (%)
1a	CBr_4	Room temp.	1	<1 : >99	94
	CCl_3Br	Room temp.	1	<1 : >99	76
	Br_2	0	1	94 : 6	79
	NBS	0	1	96 : 4	98
	$CuBr_2$	35	1	90 : 10	30
1b	CBr_4	Room temp.	3	<1 : >99	90
	NBS	0	3	90 : 10	87

[a] 1.1 equiv. [b] NMR spectra of isolated compounds were consistent with the formulas. [c] Combined yields of monobromination products based on alkynes. Yields were determined by GC.

Footnotes

† **3a**: ^1H NMR($CDCl_3$, $SiMe_4$) δ 0.83 (t, *J* 7.2 Hz, 6H), 1.24–1.36 (m, 4H), 1.86–1.96 (m, 4H) 2.45 (t, *J* 7.9 Hz, 2H), 3.34 (t, *J* 7.6 Hz, 2H), 5.15 (t, *J* 7.9 Hz, 1H). ^{13}C NMR ($CDCl_3$, $SiMe_4$) δ 13.79, 14.02, 21.58, 22.97, 29.81, 31.83, 31.99, 40.40, 128.34, 136.26.

‡ **4**: ^1H NMR($CDCl_3$, $SiMe_4$) δ 1.01 (t, *J* 7.6 Hz, 3H), 1.11 (t, *J* 7.3 Hz, 3H), 2.16 (q, *J* 7.6 Hz, 2H), 2.48 (q, *J* 7.3 Hz, 2H), 2.7–2.9 (m, 2H), 3.1–3.3 (m, 2H). ^{13}C NMR ($CDCl_3$, $SiMe_4$) δ 1.29, 13.37, 13.64, 25.59, 31.00, 41.08, 127.74, 138.17.

§ **5**: ^1H NMR($CDCl_3$, $SiMe_4$) δ 0.9–1.2 (m, 6H), 2.23 (q, *J* 7.6 Hz, 2H), 2.57 (q, *J* 7.3 Hz, 2H), 2.7–2.9 (m, 2H), 3.3–3.5 (m, 2H). ^{13}C NMR ($CDCl_3$, $SiMe_4$) δ 13.48, 14.66, 25.03, 29.36, 35.11, 45.41, 106.43, 142.01.

¶ **6**: ^1H NMR($CDCl_3$, $SiMe_4$) δ 1.01 (t, *J* 7.6 Hz, 3H), 1.06 (t, *J* 7.3 Hz, 3H), 2.22 (q, *J* 7.6 Hz, 2H), 2.53 (q, *J* 7.3 Hz, 2H), 2.7–2.9 (m, 2H),

3.1–3.2 (m, 2H). ^{13}C NMR ($CDCl_3$, $SiMe_4$) δ 1.24, 13.53, 14.59, 24.73, 35.06, 46.52, 108.98, 143.90.

References

1 (*a*) E. Negishi, D. R. Swanson and S. R. Miller, *Tetrahedron Lett.*, 1988, **29**, 1631; (*b*) M. Mori, N. Uesaka and M. Shibasaki, *J. Org. Chem.*, 1992, **57**, 3519; (*c*) R. A. Fisher and S. L. Buchwald, *Organometallics*, 1990, **9**, 871; (*d*) T. Takahashi, M. Kageyama, V. Denisov, R. Hara and E. Negishi, *Tetrahedron Lett.*, 1993, **34**, 687; (*e*) T. Takahashi, Z. Xi, C. J. Rousset and N. Suzuki, *Chem. Lett.*, 1993, 1001.
2 S. L. Buchwald and R. B. Nielsen, *Chem. Rev.*, 1988, **88**, 1047.
3 T. Takahashi, K. Aoyagi, R. Hara and N. Suzuki, *J. Chem. Soc., Chem. Commun.*, 1993, 1042.
4 T. Takahashi, K. Aoyagi, R. Hara and N. Suzuki, *Chem. Lett.*, 1992, 1693.