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EFFECTIVE METHODS OF CARBONYL METHYLENATION USING CH_2I_2-Zn-Me_3Al AND CH_2Br_2-Zn-$TiCl_4$ SYSTEM

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Reported are two methods for terminal olefin synthesis by means of the organozinc reagents which are prepared simply and effectively. The new technique provides an alternative to the Wittig reaction[1] which has some limitations.[2] The Wittig type carbonyl methylenation by means of CH_2I_2-Zn has been described already especially in the presence of a large excess of zinc,[3,4] although the recorded yields are far from satisfactory from the preparative point of view.

Based on our previous observations on the dramatic effect of co-existing organoaluminium reagents on the Reformatsky type aldol reaction,[5] we have examined the behaviour of the CH_2I_2-Zn reagent in the presence of a number of aluminium compounds and disclosed following general procedure of terminal olefin synthesis, the results of which are summarized in Table 1.

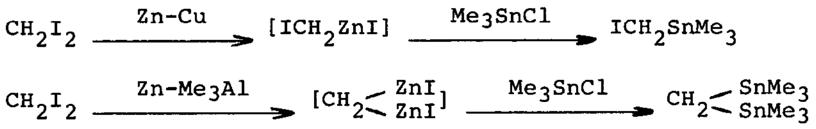
To a suspension of zinc dust[6] (1.18 g, 18 mmol) and diiodomethane (1.61 g, 6.0 mmol) in dry tetrahydrofuran (THF, 10 ml) was added a solution of trimethylaluminium in hexane (1.0 M, 1.2 ml, 1.2 mmol) at 25° under argon atmosphere. The resulting mixture was stirred until the exothermic reaction had subsided (10 min). A solution of cinnamaldehyde (0.26 g, 2.0 mmol) in THF (2 ml) was added dropwise at 0° and the mixture was stirred for 1 hr. The mixture was diluted with ether (10 ml) and the organic solution was washed with 1N HCl (20 ml) and with brine (2x20 ml). Chromatography on a silica gel column (20 g, hexane) gave the desired olefin as a colourless liquid (0.20 g, 75% yield) which was identical with an authentic sample of 1-phenyl-1,3-butadiene.[4a]

TABLE 1. Reaction of RCOR' with CH_2I_2-Zn-Me_3Al to Afford $RR'C=CH_2$[a]

entry	RCOR' R	R'	Temp (°C)	Time (hr)	$RR'C=CH_2$ Y(%)[b]
1	Ph	H	25	1	86[c]
2	Ph	Me	25	2	67[c]
3	PhCH=CH-	H	0	1	75
4	$CH_3(CH_2)_{10}$-	H	0	4	81
5	$CH_3(CH_2)_7$-	$CH_3(CH_2)_2$-	25	2	62
6	-$(CH_2)_{11}$-		25	6	65
7	(citral)		25	4	80

[a] Three mol of CH_2I_2, nine mol of Zn and 0.6 mol of Me_3Al were employed per mol of carbonyl compound. [b] Isolated yield unless otherwise specified. [c] Glpc yield by internal standard method.

Rather surprisingly, no cyclopropanes were isolated, which should be ascribed to the Simmons-Smith reaction of the olefinic linkage of the carbonyl components (entry 3,7) or of the resulting $RR'C=CH_2$. Seyferth and Andrews[7] obtained ICH_2SnMe_3 from the reaction of the Simmons-Smith reagent with Me_3SnCl. On the other hand our reagent gave $CH_2(SnMe_3)_2$[8] exclusively under the same condition and no ICH_2SnMe_3.



$$CH_2I_2 \xrightarrow{\text{Zn-Cu}} [ICH_2ZnI] \xrightarrow{Me_3SnCl} ICH_2SnMe_3$$

$$CH_2I_2 \xrightarrow{\text{Zn-}Me_3Al} \left[CH_2{<}\begin{matrix}ZnI\\ZnI\end{matrix}\right] \xrightarrow{Me_3SnCl} CH_2{<}\begin{matrix}SnMe_3\\SnMe_3\end{matrix}$$

We therefore are tempted to attribute the formation of Wittig type olefins to the divalent species, although the role of Me_3Al is still not clear. This gem-dimetallic nature of the reagent has been further confirmed by the fact that preformed iodohydrin $PhCH(OH)CH_2I$[9] was recovered practically unchanged after treatment with the reagent prepared as above. Olefination of aldehyde and ketone carbonyls by gem-dimetallic reagent of the type MCH_2M has been described to afford variable yields.[10] Exclusive carbonyl methylenation of enals (entry 3,7) is unprecedented.

TABLE 2. Reaction of RCOR' with CH_2Br_2-Zn-$TiCl_4$ to Afford RR'C=CH_2[a]

entry	RCOR' R	RCOR' R'	Temp (°C)	Time (hr)	RR'C=CH_2 Y(%)[b]
1	$CH_3(CH_2)_7$-	$CH_3(CH_2)_2$-	25	12	89
2	-$(CH_2)_{11}$-		25	12	80
3	-$(CH_2)_6$-		25	6	83[c]
4	(camphor)		25	40	92[c]
5	(geranylacetone)		25	12	83
6	$CH_3(CH_2)_{10}$-	H	0	4	55[d]

[a] One and a half mol of CH_2Br_2, three mol of Zn and 1.1 mol of $TiCl_4$ were employed per mol of carbonyl compounds. [b] Isolated yield. [c] Glpc yield by internal standard method. [d] $CH_3(CH_2)_{10}CH(OH)CH(OH)(CH_2)_{10}CH_3$ was also obtained (24%).

The yields of the methylenated products from ketone could not be improved over 70% in spite of various attempts made. Examination of other Lewis acids has now disclosed the second procedure using $TiCl_4$, which is effective with ketones and enables us to use CH_2Br_2 instead of CH_2I_2.

The reaction of 4-dodecanone to 2-propyl-1-decene is typical. A suspension of zinc dust (0.59 g, 9.0 mmol) and CH_2Br_2 (0.52 g, 3.0 mmol) in THF (10 ml) was treated with $TiCl_4$ (2.2 ml of a 1.0 M dichloromethane solution, 2.2 mmol) at 25°. Instantaneous reaction occurred under evolution of heat and rapid colour change to dark brown. After 15 min, 4-dodecanone (0.37 g, 2.0 mmol) in THF (2 ml) was added dropwise and the resulting mixture was stirred at 25° for 12 hr. Extractive work-up followed by chromatography on a silica gel column (20 g, hexane) gave the desired olefin as a colourless oil (0.32 g, 89%): IR (neat) 1643, 890 cm^{-1}; NMR (CCl_4)δ 4.60 (S, 2H) 1.94 (bt, 4H); MS m/e (%) 56 (100), 139 (5, M^+-43), 182 (4, M^+).

The results were shown in Table 2. Neither cyclopropyl compound nor isomerized olefin was isolated. Entry 3[11] and 4[12] showed the superiority of the method over the Wittig reaction. The reductive coupling of RCOR'[13] was observed only with an aldehyde (entry 6), although the desired olefin was still produced in fair yield. Both systems of CH_2I_2-Zn-Me_3Al and CH_2Br_2-Zn-$TiCl_4$ are complementary. The mechanistic details are still obscure, but the mild conditions and high yields characterize the two systems as a useful alternative for the Wittig carbonyl methylenation.[14]

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