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Gallium-Mediated Highly Regioselective Reactions of Trimethylsilylpropargyl Bromide and Trimethylsilylallyl Bromide with Carbonyl Compounds

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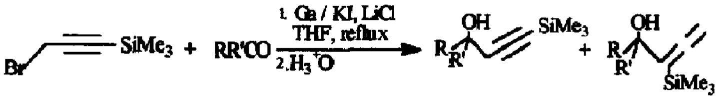
Abstract: One-pot reactions of gallium powder, trimethylsilylpropargyl bromide, aldehydes or ketones in the presence of KI and LiCl show very high acetylenic selectivity and under the same conditions, trimethylsilylallyl bromide also exhibits very high selectivity favoring α-adducts.

Methods for selective nucleophilic propargylation or allylation of carbonyl compounds remain an important topic of research in organic chemistry. Allenyl and propargyl metal derivatives are in equilibrium in solution and these isomers react differently with carbonyl compounds.

The regioselectivity is dependent on the kind of metal. For example, Zn[1] and Sb[2] reagents show acetylenic selectivity, while Al[1] reagents exhibit allenic selectivity. The regioselectivities of trimethylsilylallyl organometallic reagents towards carbonyl compounds are also dependent on the kind of metal, e. g. Li and Zn[3] show α-adducts, B[4], Ti[4] and the recent described Cr[5] exhibit γ-adducts. However, their regioselectivities are not very high. We noticed that the organogallium compounds and metallic gallium[6] itself have been scarcely used for synthetic purposes. Herewith we report our findings. The trimethylsilyl propargyl gallium reacted with a variety of aldehydes or ketones in refluxing THF in the presence of KI and LiCl or Lewis acids ($MgBr_2$ and $BF_3\ OEt_2$) to give, after subsequent hydrolysis, homopropargylic alcohols exclusively in high yields as shown in **Table 1.**

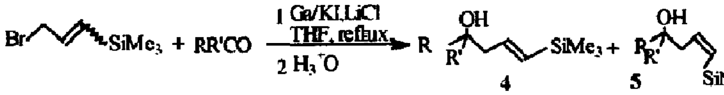


1 **2** **3**

Aromatic aldehydes, aliphatic aldehydes and ketones regioselectively gave corresponding homopropargylic alcohols in high yields(**3** < 3%), while Sb[2] reagent gave a mixture of **2** and **3**. The yields of Zn[1] reagent reacting with carbonyl compounds was moderate, **2**:**3** = 90:10, when the substrate was cyclohexylaldehyde.

Furthermore, we found the yield of this reaction could be improved greatly by the addition of LiCl or Lewis acids, such as, $MgBr_2$ and $BF_3\ OEt_2$, without altering the regioselectivity. Without LiCl or Lewis acid the reaction progressed sluggishly only in the yield of 18% even by refluxing for 10 hrs. Although the reason for Lewis acids to improve the yield has not yet been clarified, it presumably involves that the coordination of lithium ion or Lewis acids to carbonyl group results in activating the carbonyl group and increasing the yield.

Under the same conditions, gallium can also promote the reaction of trimethylsilylallyl bromide and carbonyl compounds. Only α-adducts[7] were obtained in excellent yields (see **Table 1**).



The ratios of E- and Z-isomer of products were generally greater than 90:10 (except for Entry 9 and 10) irrespective of the isomer proportion of starting material trimethylsilylallyl bromide (E/Z = 96:4 or 37:63).

The following experimental procedure is typical: Into a suspension of gallium powder(84mg,1.2mmol) in THF was added potassium iodide(249mg ,1.5 mmol), lithium chloride (42.5 mg , 1 mmol) ,trimethylsilylpropargyl bromide (286.5mg, 1.5mmol) and 4-chlorobenzaldehyde(140.5mg, 1mmol). The mixture was refluxed for 2h under argon. After the usual work-up,1-(4-chlorophenyl)-4-(trimethylsiyl)-3-butynol was obtained in 99% yield.

Table 1. Selective Syntheses of Homopropargylic Alcohols[a] and Homoallylic Alcohols[a]

Entry	RR'CO	Time(h)	Product ratio[b] (2 / 3)	Total yield[c] (%)	Time(h)	Product ratio[b] (4 / 5)	Total yield[c] (%)
1	C_6H_5CHO	2	>99:1	92	2	91:9(91:9)[d]	95(93)
2	p-$CH_3C_6H_4CHO$	2	>99:1	97	2	90:10	92
3	p-ClC_6H_4CHO	2	>99:1	99	1.5	92:8(92:8)	96(97)
4	p-FC_6H_4CHO	2	>99:1	91			
5	$C_6H_5CH=CHCHO$	3	98:2	78			
6	c-$C_6H_{11}CHO$	3	98:2	89	2	91:9	95
7	n-$C_5H_{11}CHO$	3	97:3	87			
8	n-$C_9H_{19}CHO$	5	>99:1	82			
9	$(CH_2)_5CO$	5	>99:1	85	2	85:15(85:15)	90(88)
10	$C_6H_5COCH_3$	5	>99:1	87	2	85:15	91
11	p-BrC_6H_4CHO				1.5	91:9	94
12	β-naphthaldehyde				2	90:10	90

a). All the reactions were performed as described in the text. All of known compounds gave satisfactory ^1H NMR and IR or MS, unknown compounds gave satisfactory spectral and element analytical data. b). Determined by 300MHz ^1H NMR analysis. c). Isolated yield based on aldehydes. Unless otherwise noted, the E/Z ratio of the trimethylsilylallyl bromide used as starting material was 96:4. d). The data in the parentheses show the results when trimethylsilylallyl bromide as the starting material(E:Z=37:63).

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References and notes:

1. Daniels, R.G.; Paquette, L.A., *Tetrahedron Lett.*, **1981**, 22, 1579.
2. Zhang, L.J.; Mo, X.S.; Huang, J. L., Huang, Y. Z., *Tetrahedron Lett.*, **1993**, 34, 1621
3. Ehlinqer, M. P., *J. Am. Chem. Soc.*, **1980**, 102, 5004.
4. Reets, M. T., *Top. Curr. Chem.* **1982**, 106, 1.
5. Hodgson D. M.; Wells C., *Tetrahedron Lett.*, **1992**, 33, 4761.
6. (a).G. Zweifel, "Organic Copounds of Group 3 Metals," in "*Comprehensive Organic Chemistry*," ed by Derek H. R. Barton and W. D. Ollis, Pergamon Press, Oxford (**1979**), Vol. 3, Part 15.3, pp 1013-1041. b).Araki, K., Ito, H., Butsugan, Y., *Appl.Organomet.Chem.*, **1988**,2, 4757.
7. The gallium-promoted reaction of crotylbromide with aldehydes gave γ-adduct exclusively.

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