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The Reaction of Chloromagnesium Bis(2,3,5,6-tetrachlorophenyl)copper with Butyllithium

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Chloromagnesium bis(2,3,5,6-tetrachlorophenyl)copper, prepared from two equivalents of 2,3,5,6-tetrachlorophenylmagnesium chloride and one equivalent of copper(I) chloride in *THF*, reacts with one equivalent of butyllithium at —78 °C to give, subsequent to derivatisation with chlorotrimethylsilane and then with acetyl chloride, (1-acetyl-2,3,5,6-tetrachlorophenyl)trimethylsilane (20%), 1-(trimethylsilyl)-2,3,5,6-tetrachlorobenzene (17%) and 1-acetyl-2,3,5,6-tetrachlorobenzene (34%) along with some trace products. The formation of these products is explained on the basis of the intermediate formation of chloromagnesium bis(1-lithio-2,3,5,6-tetrachlorophenyl)copper, a functionalised cuprate reagent.

[Keywords: Chloromagnesium Bis(1-lithio-2,3,5,6-tetrachlorophenyl)copper; Cuprate]

Die Reaktion von Chlormagnesium-bis(2,3,5,6-tetrachlorphenyl)kupfer mit Butyllithium

Chlormagnesium-bis(2,3,5,6-tetrachlorphenyl)kupfer, das aus zwei Äquivalenten 2,3,5,6-tetrachlorphenylmagnesiumchlorid und einem Äquivalent Kupfer(I)chlorid in *THF* hergestellt wurde, ergab mit einem Äquivalent Butyllithium bei —78 °C nach Derivatisierung mit Chlortrimethylsilan und dann mit Acetylchlorid folgende Produkte: (1-Acetyl-2,3,5,6-tetrachlorphenyl)trimethylsilan (20%), 1-(Trimethylsilyl)-2,3,5,6-tetrachlorbenzol (17%) und 1-Acetyl-2,3,5,6-tetrachlorbenzol (34%) neben einigen weiteren Produkten in Spuren. Die Bildung der genannten Produkte wird mit Chlormagnesium-bis(1-lithio-2,3,5,6-tetrachlorphenyl)kupfer, einem funktionalisierten Cuprat-Reagens, als intermediär gebildeter Verbindung erklärt.

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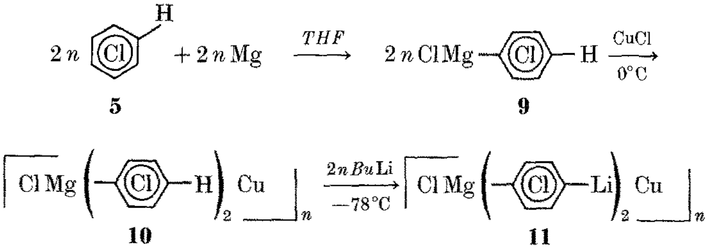
Introduction

Both organolithium[1] and organocopper[2] reagents have been extensively employed in synthesis for several decades. Lithium diorganocoppers, the *Gilman* reagents[3] or their magnesium counterparts and the *Normant* reagents[4] are capable of effecting many reactions with such stereo-, regio- and chemoselectivity as is unobtainable with the corresponding lithium or *Grignard* reagents. Similarly, organolithium reagents can undergo many reactions in which the *Gilman* or *Normant* reagents are totally ineffective. Nevertheless, all these reagents with exploitable differential reactivity are extremely useful in synthesis. We thought that perhaps a mixed dimetallic reagent containing both an organolithium and an organocopper moiety in the same molecule would be of interest both from theoretical and synthetic points of view. We describe below our attempt to prepare one such reagent namely, chloromagnesium bis(1-lithio-2,3,5,6-tetrachlorophenyl)cuprate*.

Results and Discussion

Pentachlorobenzene **5** was reacted with magnesium in *THF* to give 2,3,5,6-tetrachlorophenylmagnesium chloride[7], **9**. This reagent was converted into chloromagnesium bis(2,3,5,6-tetrachlorophenyl)copper (**10**) by metathesizing it with one half equivalent of copper(I) chloride at 0 °C (Scheme **1**). The formation of **10** was indicated by its reaction[13–15] with acetyl chloride at 0 °C to give, subsequent to hydrolysis, 1-acetyl-2,3,5,6-tetrachlorobenzene (**1**) in 57% yield.

Scheme 1



The above cuprate reagent (**10**) was reacted, without further isolation, with butyllithium at —78° to give a reagent or a mixture of reagents one of the constituents of which could be chloromagnesium

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* For the nomenclature of the "ate" complexes see Ref.[5].

bis(1-lithio-2,3,5,6-tetrachlorophenyl)copper (**11**). This reagent did not give a positive response to the *Gilman* test I[8], indicating that in the reaction mixture there was no free organolithium function sufficiently accessible for a reaction with *Michler*'s ketone. This copper reagent was then derivatised first with chlorotrimethylsilane and then with acetyl chloride. The compounds **1**–**8** (Table 1) were formed subsequent to the hydrolytic work-up.

Table 1. *The products of the reaction of chloromagnesium bis(2,3,5,6-tetrachlorophenyl)copper with butyllithium followed by trimethylsilylation and acetylation*

No.	Name of the product	Yield %
1	1-Acetyl-2,3,5,6-tetrachlorobenzene	34
2	1-(Trimethylsilyl)-2,3,5,6-tetrachlorobenzene	17
3	1-Acetyl-4-(trimethylsilyl)tetrachlorobenzene	20
4	1,4-Bis(trimethylsilyl)tetrachlorobenzene	2
5	Pentachlorobenzene	trace
6	2,3,5,6-Tetrachlorobenzene	trace
7	Butyltrimethylsilane	trace
8	Hexamethyldisiloxane*	little

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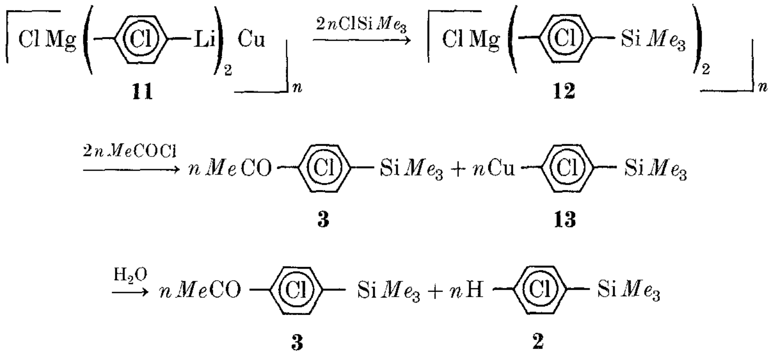
* In addition, pentachlorophenyltrimethylsilane (a little) and another compound were present in the reaction mixture. This last compound could have been 1,4-bis(acetyl)tetrachlorobenzene, but was not positively characterized.

Chloromagnesium bis(2,3,5,6-tetrachlorophenyl)copper reacted extremely slowly with chlorotrimethylsilane under the reaction conditions. This agrees with the previous observation that either the organocopper reagents do not react with chlorotrimethylsilane to give silylated products in the same way as the corresponding lithium reagents do or they react very slowly indeed[13]. Thus a large part of each of the silylated products obtained in our experiment was likely to have formed from the reaction of chlorotrimethylsilane with the organolithium rather than the cuprate function of **11** (or of whatever reagent formed). On the other hand organocopper reagents react with acid halides to give ketones in high yields[13–15] whereas, organolithium and magnesium reagents further react with the ketones produced to give the metal alcoholates[16]. The copper reagent **10** likewise gave, after reaction with acetyl chloride, 1-acetyl-2,3,5,6-tetrachlorobenzene in 57% isolated yield as mentioned before. But no such ketone was obtained when the magnesium compound **9** or its lithium analogue was reacted with acetyl chloride under our reaction conditions. This indicated that all the acetylated compounds obtained were formed by the reaction of acetyl chloride with the organocopper species only.

Since no silylated or acetylated butyl compounds were observed to have formed in any noticeable amounts, it is unlikely that the reagent, obtained by the reaction of **10** with *Bu*Li, contained butyl groups in any significant extent.

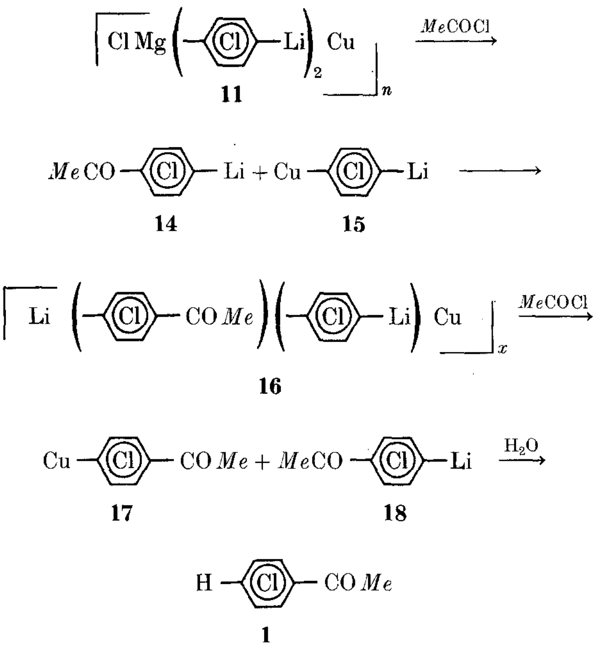
The formation of almost equimolar amounts of 1-(trimethylsilyl)-2,3,5,6-tetrachlorobenzene (**2**) and 1-acetyl-4-(trimethylsilyl)tetrachlorobenzene (**3**) may be explained if one assumes that the reagent produced by reacting **10** with *Bu*Li has a stoichiometry shown in **11** (Scheme 2). The reaction of **12** with acetyl chloride would produce in the first instance **3** and **13**. The latter reagent being less nucleophilic than **12**, would be slow to react further with acetyl chloride. It could thus remain unreacted in the reaction mixture until it was finally hydrolysed to **2** during work-up.

Scheme 2



However, the formation of one of the major products (the mechanisms of the formation of the minor products, being self-explainatory, are not discussed here) namely, 1-acetyl-2,3,5,6-tetrachlorobenzene (**1**) cannot be easily explained from the reaction of just **11** with the substrates. One explanation could be that, if formed, **11** could probably be involved in an interaggregate "higher" complex cuprate formation through the free organolithium functions of one of its clusters with the cuprate functions of the other. This "higher" cuprate was probably not very reactive towards chlorotrimethylsilane but was able to react with acetyl chloride at the periphery to produce **1** subsequent to hydrolysis. The other probable alternative explanation is that all of **11** did not react with $ClMe_3Si$ under the experimental conditions perhaps because of steric reasons. The same steric reasons may be invoked to explain why **11** did not give a positive response to the *Gilman* test I. The unreacted **11** could then react with acetyl chloride to give **14** and **15** (Scheme 3). The species **14** and **15**, if formed, would not probably

Scheme 3



remain as such but would be expected to form different "ate" complexes. One of these could be **16***. This new "ate" complex would not be expected to react with chlorotrimethylsilane for the same steric reasons as before but would react with acetyl chloride to produce **17** and **18** among other products. These species on hydrolysis would be expected to produce **1**, although **18** could react further with itself or any ketonic moiety or chlorotrimethylsilane to produce other products. The

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* The other important "ate" complex could be formed by the intermolecular reaction of **15** with itself and this, subsequent to reaction with acetyl chloride and then water, could also form **1**.

types **17** and **18** together could also generate a new cuprate reagent which could then undergo reactions characteristic of diorganocuprates.

We further observed that the reaction of 2,3,5,6-tetrachlorophenylcopper rather than the corresponding "ate" complex with butyllithium, followed by derivatisation with (i) chlorotrimethylsilane and then with (ii) acetyl chloride, did not produce any 1-acetyl-2,3,5,6-tetrachlorophenyltrimethylsilane in a glc-detectable amount. It then appears that a suitably substituted organic group of a diorgano homo cuprate can be more easily lithiated than that of the corresponding organocopper(I) compound.

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Experimental Part

The reactions described were conducted in an oxygen-free dry dinitrogen atmosphere. *THF* was dried over sodium wire and further purified by distilling it from sodiumbenzophenone ketyl. Butyllithium in hexane was obtained from the Foote Mineral Co. and was used at the strength determined by the supplier. Magnesium turnings were from the Mallinckrodt Chemical Works. Anhydrous copper(I) chloride was obtained commercially and was purified[6] prior to use.

Glc analyses were carried out on an F and M Model 500 Gas Chromatograph, using a 120 cm × 0.65 cm column packed with 15% Silicon Gum Rubber on Chromosorb W (60-80 mesh). For quantitative glc *n*-docosane was used as the internal standard. For preparative glc, the same column was used. The yields were computed on the amount of 2,3,5,6-tetrachlorophenylmagnesium chloride formed.

Reaction of chloromagnesium bis(2,3,5,6-tetrachlorophenylcopper) with butyllithium

To a filtered solution of 2,3,5,6-tetrachlorophenylmagnesium chloride[7] prepared from pentachlorobenzene (0.05 mol) and magnesium (0.05 g—at) in *THF* (100 cm^3) was added copper(I) chloride (0.025 mol) at 0 °C and stirred for 3 h during which time the *Gilman* test I[8] became negative. The brown homogeneous reaction mixture was cooled to —78 °C and butyllithium (0.05 mol) was added slowly over a period of 1 h. The mixture was stirred for an additional two-hour period. An aliquot, withdrawn from the reaction mixture, showed a negative response to the *Gilman* test I. Trimethylchlorosilane (0.05 mol) was added and the mixture was stirred at —78 °C for 6 h and at room temperature for 1 h. Acetyl chloride (0.05 mol) was then added and the mixture cooled to 0 °C. After stirring at this temperature for 6 h *n*-docosane (2.015 g) (internal standard) was added along with 100 cm^3 of benzene and the mixture was stirred vigorously for some time. An aliquot was withdrawn, hydrolysed with aq. sodium acetate solution, and the benzene layer was examined by glc (column temperature, 300 °C; injection temperature, 300 °C; N_2 flow-rate, 50 cm^3 per min). The various products obtained along with their yields are shown in Table 1.

The above experiment was repeated once with approximately similar results.

The 1-acetyl-4-(trimethylsilyl)tetrachlorobenzene obtained as above was collected by preparative glc and its identity confirmed by comparing its m.p. and the ir and nmr spectra with those of an authentic sample prepared as described below. For glc comparison purposes (2,3,5,6-tetrachlorophenyl)trimethylsilane[9], 1-acetyl-2,3,5,6-tetrachlorobenzene (prepared by reacting 2,3,5,6-tetrachlorophenyllithium first with Cu$^{(I)}$ Cl and then with CH_3COCl)[10] and bis(trimethylsilyl)-2,3,5,6-tetrachlorobenzene[11] were prepared by standard procedures.

Preparation of 1-acetyl-4-(trimethylsilyl)tetrachlorobenzene

To 2,3,5,6-tetrachlorophenyltrimethylsilane[9] (0.05 mol) in *THF* (100 cm^3) at —78 °C was added butyllithium (0.05 mol) dropwise over 15 min. The mixture was stirred for 4 h and then copper(I) chloride (0.05 mol) was added all at one time. The mixture was stirred overnight at —78 °C, acetyl chloride (0.05 mol) added, and the mixture stirred at —78 °C for 1 h and at room temperature for 3 h. Hydrolytic work-up and purification by distillation with the help of a spinning band column gave 1-acetyl-4-trimethylsilyltetrachlorobenzene (42%); m.p., 51-52 °C (from methanol). Found: C 40.35%, H 3.52%; calc. for $C_{11}H_{12}Cl_4OSi$: C 40.00%, H 3.67%. The ir spectrum showed the characteristic bands for C=O and —Si*Me*$_3$. The ^1H nmr spectrum showed two singlets at δ (ppm) = 2.49 and 0.52 in the integrated ratio of 1:3.

Reaction of 2,3,5,6-tetrachlorophenylcopper[10b] *(prepared from* 1-LiC_6Cl_4H-4[10] + Cu$^{(I)}$Cl*) with butyllithium*

To 1,2,4,5-tetrachlorobenzene (0.05 mol) in *THF* (100 cm^3) at —78 °C was added butyllithium (0.05 mol) drop by drop with stirring over 10 min. The *Gilman* test II[12] was negative within 2 h; but the *Gilman* test I[8] was positive. Copper(I) chloride (0.05 mol) was then added all at one time and the mixture stirred for 4 h. At this point an aliquot showed a negative response to *Gilman* test I. The reaction mixture was maintained at —78 °C during all this time. Butyllithium (0.05 mol) was added dropwise over 10 min and the mixture stirred for 3 h. Chlorotrimethylsilane (0.05 mol) was then added, the reaction mixture was allowed to come to 0 °C and stirred for 1 h. Acetyl chloride (0.05 mol) was added and the mixture stirred for 2 h. *n*-Docosane in 100 cm^3 of benzene was added and stirred for 0.5 h. An aliquot was examined by glc. No (1-acetyl-2,3,5,6-tetrachlorophenyl)trimethylsilane was detected to have formed at that time. The major product was 1-acetyl-2,3,5,6-tetrachlorobenzene (60%).

Reaction of chloromagnesium bis(2,3,5,6-tetrachlorophenyl)copper with (i) acetyl chloride and (ii) chlorotrimethylsilane

(i) *With acetyl chloride*: To 2,3,5,6-tetrachlorophenylmagnesium chloride [prepared from pentachlorobenzene (0.05 mol) and magnesium (0.05 g-at) in *THF* (100 cm^3)][7] at 0 to —5 °C was added copper(I) chloride (0.025 mol) and the mixture was stirred for 2 h. During this time *Gilman* test I became negative. Acetyl chloride (0.05 mol) was then added and the mixture stirred for an additional 2 h period. Customary hydrolytic work-up followed by purification by column chromatography on silica gel gave 1-acetyl-2,3,5,6-tetrachlorobenzene (**1**) (57%), m. p. 63-64 °C (mixed m. p. with an authentic sample[10b] was undepressed).

(ii) *With chlorotrimethylsilane*: To a similar preparation of chloromagnesium bis(2,3,5,6-tetrachlorophenyl)copper (0.025 mol) chlorotrimethylsilane (0.05 mol) was added, and the mixture stirred at 0 °C for 1 h. A glc analysis of a hydrolysed aliquot indicated that only a very small amount, approximately, 0.8% of (2,3,5,6-tetrachlorophenyl)trimethylsilane (**2**) was formed. The major products were 1,2,4,5-tetrachlorobenzene and hexamethyldisiloxane.

Reaction of 2,3,5,6-tetrachlorophenyllithium and -magnesium chloride with acetyl chloride

2,3,5,6-tetrachlorophenyllithium was prepared on a 0.05 mol scale in *THF* at —78 °C by following a previously described procedure[10] and reacted with 0.05 mol of acetyl chloride at —78 °C. The reaction mixture was allowed to come to 0 °C and kept at that temperature with constant stirring for 2 h. Hydrolytic work-up gave a white solid which was a mixture by glc and did not appear to contain a ketone (ir evidence).

Similar results were also obtained when 2,3,5,6-tetrachlorophenylmagnesium chloride was employed in place of the lithium reagent in the above reaction.

References

[1] *Gschwend H. W.*, *Rodriquez H. R.*, Org. Reactn. **26**, **1** (1979); *Gilman H.*, *Morton jr.*, *J. W.*, Org. Reactn. **8**, 258 (1954).

[2] *Jukes A. E.*, Adv. Organometal. Chem. **12**, 215 (1974); *Posner G. H.*, Org. Reactn. **19**, 1 (1972); *Normant J. F.*, Synthesis **1972**, 63; *Posner G. H.*, Org. Reactn. **22**, 253 (1975).

[3] *Posner G. H.*, An Introduction to Synthesis Using Organocopper Reagents. New York: J. Wiley. 1980.

[4] *Normant J. F.*, Pure Appl. Chem. **50**, 709 (1978).

[5] *Tochterman W.*, Angew. Chem., Internat. Ed. **5**, 351 (1966); *Wittig G.*, Quart. Rev. **20**, 191 (1966).

[6] *Keller R. N.*, *Wycoff H. D.*, Inorg. Syn. **2**, **1** (1964).

[7] *Rahman M. T.*, J. Organometal. Chem. **225**, 25 (1982).

[8] *Gilman H.*, *Schulze F.*, J. Amer. Chem. Soc. **47**, 2002 (1925).

[9] *Shiina K.*, *Brennan T.*, *Gilman H.*, J. Organometal. Chem. **11**, 471 (1968).

[10] a) *Tamborski C.*, *Soloski E. J.*, *Dills C. E.*, Chem. and Ind. **1965**, 2067. b) *Webb A. F.*, *Gilman H.*, unpublished studies.

[11] *Shiina K.*, *Gilman H.*, J. Amer. Chem. Soc. **88**, 5367 (1966).

[12] *Gilman H.*, *Swiss J.*, J. Amer. Chem. Soc. **62**, 1847 (1940).

[13] *Jukes A. E.*, *Dua S. S.*, *Gilman H.*, J. Organometal. Chem. **21**, 241 (1970).

[14] *Rahman M. T.*, *Gilman H.*, J. Indian Chem. Soc. **53**, 582 (1976).

[15] *Smith jr. M. R.*, *Rahman M. T.*, *Gilman H.*, Organometal. Chem. Syn. **1**, 295 (1971).

[16] *Negishi E.-I.*, Organometallics in Organic Synthesis, Vol. I, part II. New York: J. Wiley. 1980.