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THE REACTION OF 1,1-DIBROMO-1-ALKENES WITH ORGANOCOPPER REAGENTS

by J. Klein and R. Levene

The Department of Organic Chemistry, The Hebrew University
of Jerusalem, Jerusalem, Israel.

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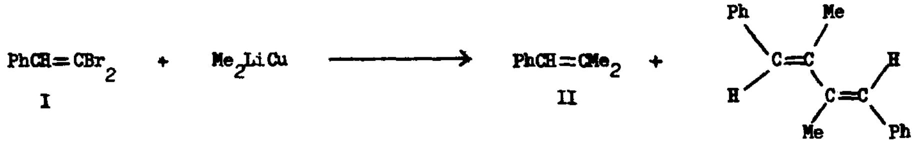
The reaction of vinyl bromides and iodides with lithium dialkylcuprates can lead to the replacement of the halide with either the alkyl group or with copper.[1,2,3] A recent publication[4] has shown that the reaction of benzylic dichlorides with dimethyllithium copper involves either the displacement of both halogens by methyl, or the replacement of one halogen by methyl accompanied by dimerisation. α,α-Dichloroesters[5] also react by the replacement of only one halogen by methyl, and the replacement of the second halogen by copper is assumed. However, unactivated 1,1-dichloroalkanes fail to react.[6] It was therefore of interest to study the reaction of 1,1-dibromo-1-alkenes with organocopper reagents.

The 1,1-dibromo-1-alkenes are easily prepared by a recently developed method.[7] When β,β-dibromostyrene[7] (I) was reacted in ether for 3 hours with 3.5 molar equiv. of Me_2CuLi at -80°, or with 2.5 molar equiv. for 15 minutes at 0°, we obtained a mixture of 2-methyl-1-phenyl-1-propene (II) (40% yield) together with (E),(E) 2,3-dimethyl-1,4-diphenyl-1,3-butadiene (III) (45% yield). Metallic copper was also formed. The product (III) had m.p. 129-131° (acetone) and was identical with that obtained (in both cases in low yield) by the reduction of 1-phenyl-1-propene with Li metal[8,9] or with diisobutylaluminium hydride.[9] Further evidence for the structure of III was obtained by ozonolysis, followed by treatment with Ph_3P, which gave benzaldehyde and no acetophenone.



I

II

III

Reaction of I with 3.5 molar equiv. of diphenylcopper lithium (15 min. at 0° followed by protonolysis) gave cis and trans-stilbene in the ratio 68:32 (43% yield) together with 1,1,2-triphenylethylene (35% yield). No dimer equivalent to III was formed. Deuterolysis of the reaction mixture produced cis and trans-stilbene both containing 79% D, showing that a copper derivative was formed in the reaction. The amount of cis stilbene in the product changed slowly at 0°, and after 20 hours the ratio of cis to trans stilbene after protonolysis was 57:43. That this isomerisation probably involves free radicals was shown by deuterolysis of the reaction mixture after 20 hours. There was a fall in the D content of trans stilbene to 65%, while that of the cis stilbene had fallen only to 76%.

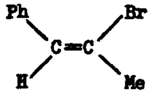
When 4 molar equiv. of allylcopper-magnesium halide complex (prepared from allylmagnesium chloride and copper iodide[10]) was reacted with I, a 45% yield of the triene (IV) was isolated. The compound (IV)

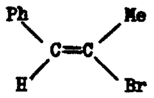
$$CH_2{=}CH\cdot CH_2Cu\cdot MgClI \quad + \quad PhCH{=}CBr_2 \xrightarrow[18\ \text{hours}]{-30^\circ} \underset{\text{IV}}{PhCH{=}C(CH_2CH{=}CH_2)_2}$$

was isolated by GLC and it had n.m.r., mass and u.v. spectra in accord with the assigned structure.[11] Divinylcopper lithium and dipropenylcopper lithium did not react with I.

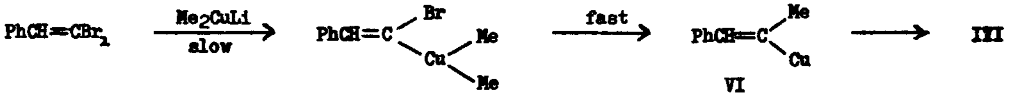
A striking feature of all the reactions performed on I is the replacement of both bromine atoms and the absence of products containing one bromine. However, in the reaction of diphenylcopper lithium with 1,1-dibromo-1-pentene, there was no formation of dimer, nor replacement of bromine by hydrogen (via a copper compound). Although after 20 hours at room temperature, 1,1-diphenyl-1-pentene was obtained (55% yield, GLC), a shorter reaction time gave also 1-bromo-1-phenyl-1-pentene.

The reaction of I with Me_2CuLi cannot involve an elimination followed by addition to an acetylenic intermediate,[12,13] since this cannot give the required products. The intermediacy of (Z) or (E) 2-bromo-1-phenyl-1-propene (Va,b) was also considered. These isomers were prepared by bromination and debromodecarboxylation[14] of (E)[15,1] and (Z)α-methylcinnamic acids[16] respectively.[18] Neither isomer reacted with Me_2CuLi at -80° and at room temperature they gave only 2-methyl-1-phenyl-1-propene (II).


Va

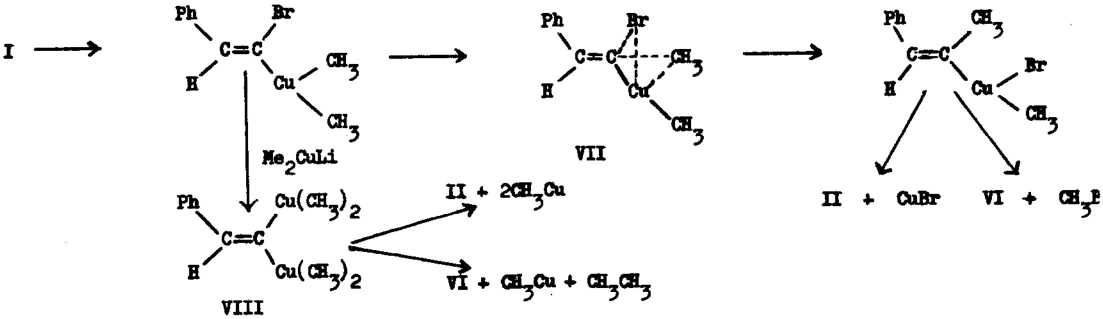

Vb

It is probable that the reaction of I with Me_2CuLi involves preliminary replacement of one bromine atom by copper.[1] This is followed by coupling,[12,13,19] probably after formation of VI by replacement of the second bromine by methyl:-



The formation of III, and the predominance of *cis*-stilbene in the reaction of I with Ph_2CuLi, suggest not only that the reaction with Me_2CuLi proceeds *via* VI, but also that VI has copper predominantly *trans* to the phenyl group. The exclusive formation of III, as compared to a mixture of (Z), (E) isomers, may be due to isomerisations to III, which is probably the most stable isomer.[8]

It is clear that the displacement of the second bromine atom in I is faster than that of the first. This effect can be due either to an intramolecular displacement such as in VII, or to an activation of the vinylic bromide by the geminal copper atom, which reacts further to VIII:-



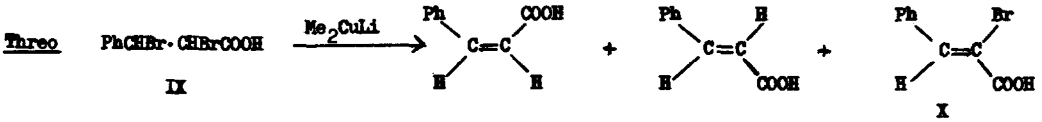
An alternative reaction path is the formation of a carbene (PhCH=C:) from I, since this would rapidly add the elements of MeCu to produce VI. However, no carbene adduct could be detected when the reaction was carried out in the presence of cyclohexene.[20] Posner[4] also failed to detect the presence of a carbene in a similar reaction.

The formation of 1-bromo-1-phenyl-1-pentene in the reaction of 1,1-dibromo-1-pentene with Ph_2CuLi

can partially be explained by the fragmentation of the Cu (III) derivative $PrCH{=}CBrCuPh_2$ being faster than the reaction of the second bromine.

We also examined the reaction of 1,2-dibromoalkenes with Me_2CuLi, and these were found to undergo exclusive debromination to alkynes. Thus trans tolan dibromide gave tolan (95% yield) after 18 hours of reaction with 5 molar equiv. of Me_2CuLi at room temperature. The sequence of bromination-debromination when applied to tolan was performed with 85% recovery of tolan. This, coupled with the mildness of the reaction conditions and the ability of copper reagents to tolerate a wide range of functional groups[21], offers a method of protecting a triple bond.

Since the completion of the work, Posner[22] reported that 1,2-dibromoalkanes also undergo debromination, to alkenes, with Me_2CuLi. Our investigations showed that even in the presence of an activating group an intermediate in which one or both bromines have been replaced by methyl cannot be isolated. Thus erythro-2,3-dibromo-3-phenylpropionic acid gave a near quantitative yield of trans cinnamic acid when reacted with 3.5 molar equiv. of Me_2CuLi in ether for 3 hours at -80° or for 30 min. at room temperature. The threo isomer[23] (IX) reacted more slowly, being inert at -80°. After one hour at room temperature, a mixture of cis (20%) and trans (45%) cinnamic acids together with (Z)α-bromocinnamic acid[17] (X) (35%) was obtained. cis Cinnamic acid is not isomerised under the reaction conditions. As in the cases reported by Posner[22], the stereoselectivity of the reaction is limited. Dehydrobromination of IX gives X exclusively, not only because anti elimination is favoured, but also because X is the more stable product. Miller[24] showed that d,l-stilbene dibromide undergoes dehydrobromination with LiCl in DMF. However, as also found by Posner[22], only trans stilbene, and no α-bromostilbene, is formed in the reaction of d,l- or meso-stilbene dibromides with Me_2CuLi.



Phenylpropiolic acid dibromide[25] (XI) reacted with markedly greater rapidity than did tolan dibromide. Thus, after 3 hours at -80° with 7 molar equiv. of Me_2CuLi, a near quantitative yield of (Z)β-methylcinnamic acid[26] (XII), containing less than 2% of the (E) isomer, was obtained from XI. Phenylpropiolic acid is an intermediate:-

This was shown by using less reagent, or a shorter reaction time, when phenylpropiolic acid was isolated from the reaction mixture. However, it was always accompanied by XII. No difference in reactivity could be discerned between the pure trans XI and a mixture containing 62% cis and 38% trans isomers.

Debromination also occurred with o-dibromobenzene, but was very slow. When o-dibromobenzene was treated with 5 molar equiv. of Me_2CuLi for 5 days, followed by deuterolysis, a 30% yield of o-deuterotoluene resulted, which contained 0.80D (mass spectrum). Benzyne is a possible intermediate, though none could be trapped when the reaction was performed in the presence of furan.[27]

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