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# CONJUGATE ADDITION OF ALLYLIC LITHIUM ORGANOCUPRATES AND ALLYLIC ORGANOCOPPER(I) COMPOUNDS TO α-ACETYLENIC ESTERS

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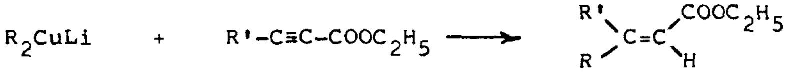
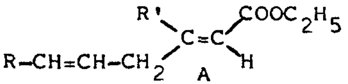
Summary : at low temperature, allylic lithium organocuprates and allylic organocopper(I) compounds add stereoselectively (cis-addition) to α-acetylenic esters to afford α,δ-biethylenic esters.

Lithium organocuprates react at low temperature (-78°) with α-acetylenic esters to give α-ethylenic esters corresponding to a cis-addition :

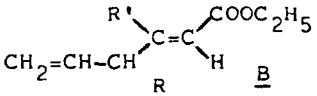


When the mixture is allowed to reach room temperature before hydrolysis, a mixture of stereoisomeric ethylenic esters is obtained, which corresponds to both a cis- and a trans-addition ; this loss in stereospecificity probably results from equilibration of the copper(I) enolate first formed at -78°C. This addition reaction has been described with organocuprates $R_2CuLi$, R= alkyl1), vinyl2), allenyl3) or cyclopropyl4). It was worth trying the extension of this reaction to allylic lithium organocuprates, especially as the ability of $R_2CuLi$ reagents to undergo conjugate addition with an α-enone is known to decrease in the order $nC_4H_9 \sim CH_2{=}CH > C_6H_5 \sim sC_4H_9 \sim CH_3 > tC_4H_9 > CH_2{=}CH{-}CH_2$5).

An organocuprate $(R{-}CH{=}CH{-}CH_2)_2CuLi$6) can react by either of its two reactive carbon atoms : therefore, esters A and B (cis-addition), C and D (trans-addition) could be formed in this reaction.

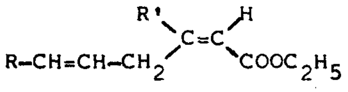


A

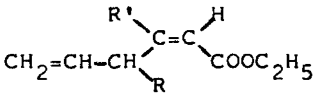


B

(cis-addition)



C



D

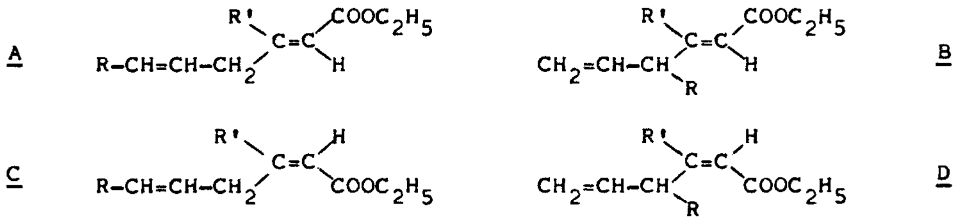
(trans-addition)

At −15°C, the organocuprates $(R\text{-}CH{=}CH\text{-}CH_2)_2CuLi$ (R= H, $CH_3$, $C_2H_5$) form conjugate adducts with good yield from α-acetylenic esters, but the reaction is not stereoselective : both cis- and trans-addition products are obtained. The cis-addition is unregioselective : both esters A and B are formed (R= $CH_3$ and $C_2H_5$). Yet, the only trans-addition ester C is detected.

When the reaction is run at −90°C, the addition becomes stereoselective (cis-addition) but is still unregioselective.

With the organocuprate $(C_6H_5\text{-}CH{=}CH\text{-}CH_2)_2CuLi$ 7), the reaction at −90°C is stereoselective (cis-addition) but in unregioselective. Moreover, it is accompanied by the formation of a large quantity of dimers R-R (R= cinnamyl). We remind here that the major side product in conjugate addition reaction with $R_2CuLi$ reagents is often the dimer R-R, which is very likely related to a side oxidation reaction 9,10).

Table. Reaction of $(R\text{-}CH{=}CH\text{-}CH_2)_2CuLi$ with $R'\text{-}C{\equiv}C\text{-}COOC_2H_5$. Products distribution.



| R | R' | Temp.(°C) | Yield(%) | A | B | C | D |
|---|---|---|---|---|---|---|---|
| H | $nC_4H_9$ | −15 | 80 | 50% |  | 50% |  |
|  |  | −90 | 90 | 100% |  | a |  |
| H | $CH_3$ | −15 | 60 | 60% |  | 40% |  |
|  |  | −90 | 90 | 100% |  | a |  |
| $CH_3$ | $nC_4H_9$ | −15 | 80 | 45% | 25% | 30% | a |
|  |  | −90 | 95 | 15% | 85% | a | a |
| $C_2H_5$ | $nC_4H_9$ | −15 | 75 | 45% | 18% | 37% | a |
|  |  | −90 | 75 | 30% | 70% | a | a |
| $C_6H_5$ | $CH_3$ | −90 | 60 | 30% | 70% | a | a |
| $C_6H_5$ b | $CH_3$ | −90 | 40 | 55% | 45% | a | a |

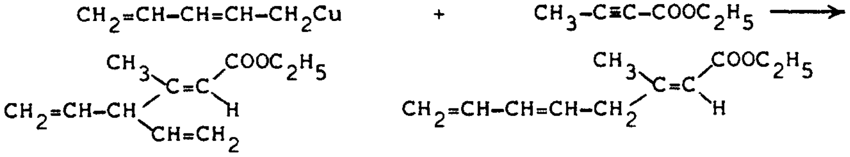
[a] We were unable to detect this isomer by GLC and NMR.

[b] Reaction of $C_6H_5\text{-}CH{=}CH\text{-}CH_2Cu$.

Next, we tried to prepare the organocuprate $(CH_2{=}CH{-}CH{=}CH{-}CH_2)_2CuLi$ [11] and to react it with ethyl-2-butynoate : we obtained an untractable mixture.

Therefore, we turned to the use of organocopper(I) compounds R-Cu : these compounds are known to readily give an 1-4 addition reaction with α-acetylenic esters (R= alkyl [1b, 1c, 1j, 12], vinyl [13] or allyl [13b]).

The use of 2,4-pentadienylcopper(I) [14] proved successful : by operating at -90°C, we obtained, from ethyl-2-butynoate, a mixture of esters E and F (cis-addition) (E/F = 92/8)(yield 70%).



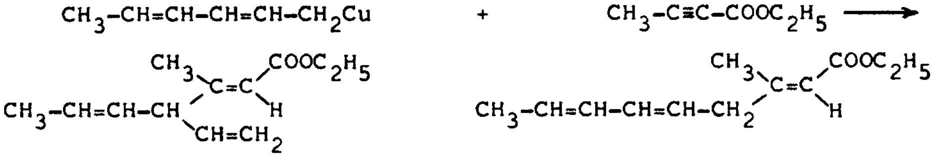
E

F

Like the addition of organocuprates, the addition of this organocopper(I) compound is stereoselective (cis-addition) and unregioselective.

Next, we reacted cinnamylcopper(I) [15] with ethyl-2-butynoate at -90°C. We obtained (Table) a mixture of esters A and B (cis-addition) practically free from dimeric hydrocarbons, which is very convenient for an easy isolation of the esters. In agreement with literature [16], it thus appears that organocopper(I) compounds are less prone than lithium organocuprates to give dimeric derivatives.

In the same way, the reaction, at -90°C, of 2,4-hexadienylcopper(I) [17] with ethyl-2-butynoate gave (cis-addition) a mixture of esters G and H (G/H = 13/87)(yield 50%), together with some $C_{12}$ dimeric hydrocarbons.



G

H

## References and notes

All new compounds were isolated by distillation, separated by preparative GLC and identified by their NMR and IR spectra.

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14) 2,4-pentadienyllithium is added at -75°C to cuprous iodide (one equivalent) in THF.

15) Cinnamyllithium is added at -75°C to cuprous iodide (one equivalent) in THF.

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17) A solution of 0.8M n-butyllithium (0.09 mol, 112 ml) in pentane is cooled at -15°C under nitrogen and treated with 1,4-hexadiene (0.1 mol) in THF (40 ml). The mixture is stirred one hour at -15°C. The resultant deep red solution is added to cuprous iodide (0.1 mol) in ether (90 ml) cooled at -75°C. The black mixture is cooled at -90°C and a solution of ethyl-2-butynoate (0.053 mol) in ether (25 ml) is added. After stirring 2h at -90°C, the mixture is poured onto a mixture of aqueous ammonium chloride and ammonia.

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