## CHLOROACETYLENES AS MICHAEL ACCEPTORS. II.

## DIRECT ETHYNYLATION AND VINYLATION OF TERTIARY ENOLATES.

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<u>Summary</u>: The reaction of CIC=CCI, PhC=CCI and PhSC=CCI with a variety of tertiary enolates leads in 43-90% yields to  $\alpha$ -chloroethynyl,  $\alpha$ -phenylethynyl and  $\alpha$ -thiophenylethynyl derivatives. The -C=CCI group is smoothly converted to -C=CH using copper powder in HOAc/THF, or is directly reduced (H<sub>2</sub>/Lindlar catalyst) to the -CH=CH<sub>2</sub> group, thus providing facile access to many  $\alpha$ -ethynyl and  $\alpha$ -vinyl ketones and esters.

We have recently demonstrated that the condensation of  $Cl_2C=CHCI$  with certain ketone enolates proceeds by way of a dichloroacetylene intermediate.<sup>1</sup> Taken with the firm evidence that the reactions of enolates with hexachlorobutadiene often proceed through the intermediacy of  $Cl_2C=CCI-C\equiv CCI$ ,<sup>2</sup> this suggests that some 1-chloroacetylenes can serve as convenient Michael electrophiles toward enolate nucleophiles. Based on this mechanistic reasoning, we have developed simple methods for the facile choroethynylation, phenylethynylation, thioethynylation, ethynylation and vinylation of a variety of tertiary esters and ketone enolates.

Dichloroacetylene [readily available from  $Cl_2C=CHCl$  and  $LiN(SiMe_3)_2$  as described in the preceeding communication]<sup>3, 4</sup> and PhC=CCl (from PhC=CH, NaOH, and  $Cl_2)^5$  each react with enolates of the carbonyl compounds listed in the Table (columns 1 and 2). Condensation products are formed in 64-95% yields, except for sodio diethyl methylmalonate which reacts to give only 50% of the chloroethynyl derivative.<sup>6</sup> In a typical procedure, a dry ether solution of  $ClC=CCl^{1,3}$  (1 ml,  $\circ$ 5 mmoles) is added to the enolate of 2,6-dimethylcyclohex-2-en-1-one (1 mmole, from 1.1 eq each of LDA, HMPA, in 5 ml THF) at -78°C and allowed to warm to room temperature over several hours to give 2-chloroethynyl-2,6-dimethylcyclohex-2-en-1-one in 64% yield after MPLC. An alternative procedure used for several of the entries in the Table is described in the footnotes of the Table.

Enolates not at tertiary centers also react with the above chloroacetylenes, but rapid isomerization of the primary adduct occurs to give conjugated allenes. Thus, the lithium enolate of 3pentanone reacts with PhC=CCI to give 66% yield of the allene ketone 8.







More interesting is the reaction of sodio diethyl malonate with CICECCI, reported by Ott to give the presumed linear diadduct  $(C_2H_5O_2C)_2C$ -CCI=CH-C $(CO_2C_2H_5)_2$ .<sup>6</sup> This reaction appears to proceed by way of the conjugated chloroallene <u>9</u> (eqn 1), which undergoes a second Michael addition of malonate to yield 86% of the "Ott diadduct" which can be shown by <sup>1</sup>H nmr to have the chlorovinyl structure <u>10</u> (eqn 2).



Our preliminary studies suggest that  $\alpha$ -chloroethynyl ketones and esters may be versatile synthetic intermediates. These compounds are smoothly converted by Cu powder (5 equiv. Cu powder, 10/1 THF/AcOH, 70°C, 1-2 hrs) to the corresponding  $\alpha$ -ethynyl derivatives (Column 3 in Table),<sup>7</sup> which in turn may be hydrated (saturated HgSO<sub>4</sub> in 1% H<sub>2</sub>SO<sub>4</sub>, MeOH, reflux for 24 hrs, eqn 3) or conc. H<sub>2</sub>SO<sub>4</sub> (room temperature for 24 hrs, eqn 4) to dicarbonyl systems.



Semihydrogenation of  $\alpha$ -chloroethynyl carbonyl compounds over Lindlar catalyst<sup>8</sup> [H<sub>2</sub> (1 atm), Lindlar catalyst (Aldrich), 10/1 EtOAc/Et<sub>3</sub>N, room temperature] gives the corresponding  $\alpha$ -vinyl compounds<sup>9</sup> in high yields (Column 4 in Table) providing particularly direct access to these potential precursors for Cope rearrangements.<sup>10</sup>

The compound 1-chloro-1-hexyne does not react with enolate nucleophiles under our usual conditions; 1-bromoalkynes react with Br transfer.<sup>11</sup> Thus it appears that mild stabilization of a carbanion intermediate  $\beta$  to the chlorinated carbon is necessary for the observed reactivity, in accord with a probable addition-elimination mechanism. Consistent with this is our finding that PhSC=CCI (available in 40-50% yield by addition of PhSCH=CCI<sub>2</sub><sup>12</sup> to LiN(SiCH<sub>3</sub>)<sub>2</sub> in THF, -78°C to room temperature) is highly reactive toward enolates, leading to condensation products (Column 5 in Table) in good yields. The scope of these condensations and the chemistry of the resulting  $\alpha$ -ethynylated ketones and esters remains under study in our laboratories.<sup>13</sup>

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