



The results of the reactions of 1b with carbonyl compounds are summarized in Table I. The only acrylate adducts observed with enones 3-9 were those resulting from 1,2-carbonyl attack. In contrast, the reaction of 1b with methyl vinyl ketone 10 yielded the conjugate addition product exclusively. This latter result cannot be rationalized solely by steric arguments, since increasing the steric hindrance around a carbonyl center as in compound 6 failed to produce any 1,4-addition product. Furthermore, substrate 12, which contains a fixed cisoid-enone system, still reacted with 1b to yield predominantly the 1,2-addition product. A final indication that the organocuprate 1b does not behave like simple dialkyl or divinylcuprates comes from its reaction with benzalacetophenone 11. Despite the low reduction potential of 11, 1,4-conjugate addition of 1b did not predominate. Thus, there would appear to be no direct correlation<sup>4</sup> between the reduction potential of the enone and the ability of reagent 1 to add in a conjugate manner.

The reactions of 1b with simple ketones at  $-78^{\circ}\text{C}$  quantitatively yielded the carbonyl addition products. While many organocuprates react with aldehydes at low temperature, the reactions of dialkylcuprates with ketones does not usually proceed at  $-78^{\circ}\text{C}$ . The possibility of carbonyl complexation and activation by the organocuprate reagent is consistent with an electrophilic copper reagent. From low temperature NMR studies,<sup>5</sup> the addition product from 2-methylcyclohexanone (13b) appears to be the cis-isomer (>95%) resulting from axial attack on the carbonyl group. Thus, the organocuprate 1b is extremely stereospecific in its addition to  $\alpha$ -substituted cyclic ketones.

In order to probe the compatibility of other functional groups with cuprate 1b, we surveyed its reactions with several  $\alpha$ -substituted ketones. The reaction of 1b with 2-carbomethoxycyclopentanone failed to yield an adduct, presumably due to the competitive deprotonation of the acidic enol. When 2-chlorocyclohexanone was used as the substrate, dehalogenation occurred and the resulting copper enolate condensed with 2-chlorocyclohexanone to yield the aldol-type product 14 in high yield.<sup>6</sup> When 2-acetoxycyclohexanone was treated with reagent 1b, the expected carbonyl adduct was isolated in 80% yield. This result is in contrast to a reported reduction of an  $\alpha$ -acetoxyketone by dimethylcuprate.<sup>7</sup>

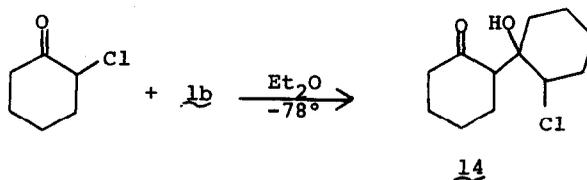
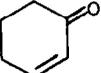
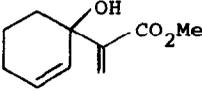
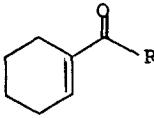
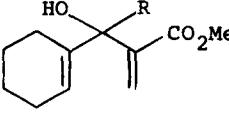
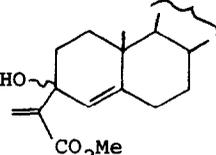
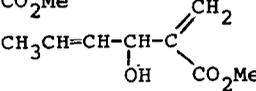
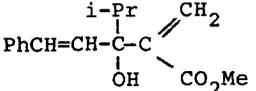
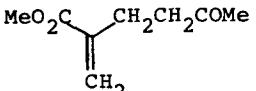
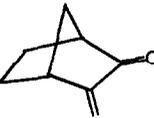
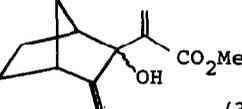
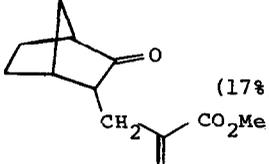
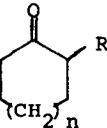
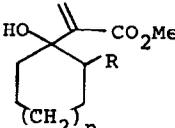


Table I. Reactions<sup>a</sup> of Reagent lb with Carbonyl Compounds

Substrate	Products <sup>b</sup> (Yields) <sup>c</sup>
3 	 (65%)
4-6  4 R=H 5 R=Me 6 R=i-Pr	 R=H (80%) R=Me (92%) R=i-Pr (90%)
7 Cholest-4-en-3-one	 (90%)
8 Crotonaldehyde	 (50%)
9 PhCH=CHCO-i-Pr	 (88%)
10 MeCOCH=CH <sub>2</sub>	 (75%)
11 PhCH=CHCOPh	1,4-adduct (17%); 1,2-adduct (53%)
12 	 (33%)  (17%)
13 	a) n=0, R=H (100%) b) n=1, R=Me (100%) c) n=2, R=H (100%) d) n=1, R=OAc (80%) 

<sup>a</sup> All reactions were carried out in ether at -78°C with 1.5 equivalents of reagent lb.

<sup>b</sup> All new compounds have been fully characterized spectroscopically and by microanalyses.

<sup>c</sup> Yields were determined by n.m.r. analyses using an internal standard.

An unexpected complication which has emerged from our study of enones involves the structure of reagents la and lb. With substrates 3, 11 and 12 varying amounts (10-40%) of 1,4-methyl transfer products were isolated.<sup>8</sup> While this fact indicates that certain enones are susceptible to competitive methyl transfer, a complete correlation between structural type and methyl transfer is not possible at this time. We are currently investigating the source of this active methyl species. Preliminary work in our laboratory with the mixed cuprate lc<sup>9</sup> indicates that with enones such as 5 and with cyclic ketones, the acrylate ligand is selectively transferred at -78°C to the carbonyl group. Other studies in progress indicate that the methyl ligand of lc may be preferentially transferred. Thus, our present rationale for the source of 1,4-methyl transfer with reagent lb is the mixed cuprate lc which may result from ligand reorganization during the formation of lb.

Despite the occasional 1,4-methyl transfer reaction which occurs with reagents la and lb, these organocuprates are very efficient synthons for the introduction of an acrylate unit. The acrylate adducts of enones and ketones are useful synthetic intermediates which are highly reactive and extremely difficult to obtain by other means.

Acknowledgements: We gratefully acknowledge Professor C. H. Bushweller for the low temperature NMR studies of the adduct 4. Partial support of this work through a Dow-Britton Fellowship to D.M.F. is also appreciated.

#### References

1. A preliminary report was presented at the 169th ACS National Meeting (ORGN 21), Philadelphia, Pennsylvania, April 7, 1975.
2. J. P. Marino and D. M. Floyd, *J. Amer. Chem. Soc.*, **96**, 7138 (1974).
3. G. H. Posner, *Organic Reactions*, Vol. **19**, 1 (1972).
4. H. O. House and M. J. Umen, *J. Amer. Chem. Soc.*, **94**, 5495 (1972).
5. Coalescence NMR studies have indicated that @ -30°C, the vinyl region resolves into four distinct doublets. This has been interpreted to indicate that the isomer from axial attack 4 is present since both conformers are equally probable; however, further studies are in progress to rigorously define this stereochemistry.
6. For related Cu-enolate reactions see: (a) K. K. Heng and R. A. J. Smith, *Tetrahedron Lett.*, 589 (1975); (b) C. Wakselman and M. Mondon, *Tetrahedron Lett.*, 4285 (1973).
7. J. R. Bull and A. Tuinman, *Tetrahedron Lett.*, 3055 and 4349 (1973).
8. Authentic samples were independently synthesized for direct comparison.
9. This is a modified procedure of J. Klein and R. Levene, *J. Chem. Soc., Perkin Trans.*, **2**, 1971 (1973).