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Preliminary communication

THE GENERATION OF GEM-DIFLUOROALLYLLITHIUM BY THE TRANSMETALATION REACTION

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Summary

3,3-Difluoroallyltrimethyltin was prepared by reaction of chlorodifluoromethane with the ylide reagent $Ph_3P{=}CHCH_2SnMe_3$. gem-Difluoroallyllithium, which was generated by the reaction of n-butyllithium with 3,3-difluoroallyltrimethyltin in THF at -95°, was of very limited stability at that temperature. However, in situ procedures and alternate incremental addition procedures allowed its application in the synthesis of 1,1-difluoroallylsilanes from chlorosilanes and of $CH_2{=}CHCF_2C(OH)Et_2$ from 3-pentanone.

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gem-Dichloroallyllithium, which can be prepared in good yield by the transmetalation reaction between $Ph_3PbCH_2CH{=}CCl_2$ and n-butyllithium in THF and which is stable in THF below -80°, is an ambident nucleophile which shows unusual regioselectivity in its reactions with carbonyl compounds (1). We have extended our studies of allyllithium chemistry to gem-difluoroallyllithium, a reagent, which, if accessible, would permit the synthesis of diverse unsaturated organofluorine compounds and whose regioselectivity in C=O addition would be of interest to examine.

An appropriate starting material of type $CF_2{=}CHCH_2Z$ or $ZCF_2CH{=}CH_2$ is required for the preparation of gem-difluoroallyllithium either by direct lithiation (Z=H), ether cleavage with metallic lithium (Z = PhO) or transmetalation (Z = R_3Sn, R_3Pb, RHg). We have developed a procedure based on the latter reaction using $Me_3SnCH_2CH{=}CF_2$ as the difluoroallyl anion source.

The 3,3-difluoroallyltrimethyltin required for this study was prepared in good yield using a trimethyltin-substituted Wittig reagent (eq. 1-3). In the first reaction of this

$$Ph_3P{=}CH_2 + Me_3SnCH_2I \xrightarrow{Et_2O} \underset{\underline{1}}{[Ph_3PCH_2CH_2SnMe_3]I} \qquad (1)$$

$$[Ph_3PCH_2CH_2SnMe_3]I + (Me_2CH)_2NLi \xrightarrow{THF} Ph_3P{=}CHCH_2SnMe_3 + (Me_2CH)_2NH + LiI \qquad (2)$$

$$2\ Ph_3P{=}CHCH_2SnMe_3 + HCF_2Cl \longrightarrow Me_3SnCH_2CH{=}CF_2 + Ph_3P + [Ph_3PCH_2CH_2SnMe_3]Cl \qquad (3)$$

sequence, ethereal triphenylphosphinemethylene is added to an ether solution of iodomethyltrimethyltin (2). The phosphonium halide which precipitates, 1, generally is contaminated with 10-15% of $[Ph_3PCH_3]I$. It can be purified by fractional crystallization to give analytically pure material, mp 122.5-123.5° (dec). However, for use in the eq. 2,3 sequence it need not be purified, as the $CH_2{=}CF_2$ formed from the $[Ph_3PCH_3]I$ impurity (via $Ph_3P{=}CH_2$) is too volatile to interfere in product isolation.

In the second step of this sequence the phosphonium salt is added to the cooled (ice bath) THF solution of lithium diisopropylamide* in THF to give a cranberry-red ylide solution. Removal of the diisopropylamine formed in reaction 2 is essential in order to obtain good product yields in the subsequent step and to effect this, the volatiles are removed at 0.02 torr

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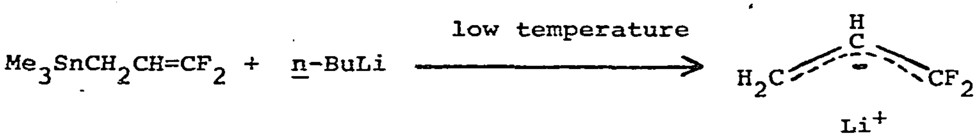
* Organolithium reagents, e.g., PhLi, cannot be used since they attack at tin as well as at the protons α to phosphorus.

and 50° by trap-to-trap distillation into a receiver at -196°. The ylide which remains is redissolved in diethyl ether and treated, at 0°, with one-half molar equivalent of chlorodifluoromethane, following the procedure of Burton (3). The precipitated phosphonium salt is filtered and the filtrate is distilled. The product, $Me_3SnCH_2CH=CF_2$, bp 129-131°, $n^{25}D$ 1.4465, is obtained in 74% yield and triphenylphosphine is recovered from the distillation residue in 79% yield.

Further experiments examined the preparation of gem-difluoroallyllithium from 3,3-difluoroallyltrimethyltin (eq. 4).



+ n-$BuSnMe_3$ (4)

All experiments which were carried out to preform a solution of this reagent in this manner, prior to addition of the substrate, at temperatures between -95° and -130°, have failed thus far. The transmetalation does occur since n-butyltrimethyltin is formed in good yield (73% in one such experiment which was carried out at -95°, together with a 12% recovery of unconverted $Me_3SnCH_2CH=CF_2$). However, chlorosilanes can be converted to 1,1-difluoroallylsilanes in high yield by an in situ procedure in which n-butyllithium in hexane (∿2 molar equivalents) is added slowly at -95° to a mixture of ∿1 molar equivalent of $Me_3SnCH_2CH=CF_2$ and ∿4 molar equivalents of R_3SiCl in THF. Prepared in this manner were $(n\text{-}C_3H_7)_3SiCF_2CH=CH_2$ (86%), $PhMe_2SiCF_2CH=CH_2$ (75%) and $Me_3SiCF_2CH=CH_2$ (64%) (yields by GLC after trap-to-trap distillation of the reaction mixture and concentration of the distillate).

It is of interest to note that the products had the structures shown, and not the isomeric $R_3SiCH_2CH=CF_2$ structure. It would appear that as in the case of the gem-dichloroallyllithium-trimethylchlorosilane reaction, which gives $Me_3SiCCl_2CH=CH_2$ exclusively (4), these reactions of gem-difluoroallyllithium are subject to kinetic control of product formation. The structure of the $R_3SiCF_2CH=CH_2$ products was indicated clearly by their proton NMR spectra which showed only complex multiplets in the vinyl region (∿4.9-6.4 ppm), in addition to the resonances due to the R groups. In addition, the isomeric $Me_3SiCH_2CH=CF_2$ was prepared (in 90% yield) for comparison by the general route shown in eq. 1-3, with the differences that Me_3SiCH_2I was used in eq. 1 and that methyllithium was used to generate $Ph_3P=CHCH_2SiMe_3$ from $[Ph_3PCH_2CH_2SiMe_3]I$ (eq. 2). This silane, a known compound (5), had a very different proton NMR spectrum: δ 0.04 (s, 9H, Me_3Si), 1.11-1.31 (d of t, $^3J_{HH}$ 9 Hz, $^4J_{FH}$ 1.5 Hz, 2H, CH_2Si) and 3.68-4.44 ppm (12 line pattern, $^2J_{HH}$ 9 Hz, $^3J_{FH(cis)}$ 3 Hz, $^3J_{FH(trans)}$ 24 Hz, 1H, =CH) (in CCl_4, $CHCl_3$).

The _in situ_ procedure could not be applied successfully to the difluoroallylation of carbonyl compounds since the rate of attack of _n_-butyllithium at C=O appears to be greater than its rate of attack at tin. A successful addition of _gem_-difluoroallyllithium to 3-pentanone, however, could be effected by a procedure in which a solution of $Me_3SnCH_2CH=CF_2$ (∿6 mmol) in THF, cooled to -95°, was treated alternately with 1 mmol portions each of _n_-butyllithium in hexane (over a 15 sec. period, with 30 sec. of stirring) and 3-pentanone (followed by 3 min. of stirring). This procedure of 1 mmol alternate additions was repeated identically at 3 min. intervals until 25 mmol of each reactant had been added. The product alcohol was isolated and characterized as its trimethylsilyl ether, $CH_2=CHCF_2CEt_2OSiMe_3$, and was obtained in 75% yield.

These experiments have demonstrated that _gem_-difluoroallyllithium, although it is of very limited stability at -95°, can serve as a useful reagent, giving difluoroallyl group transfer in high yield, provided that appropriate procedures are used. Our further studies will examine its reactions with other substrates. Of special interest will be a study of its reactions with other carbonyl compounds. Its reaction with 3-pentanone parallels that of _gem_-dichloroallyllithium, which reacts with dialkyl ketones to give products of type $R_2C(OH)CCl_2CH=CH_2$ exclusively (1). It may be expected that _gem_-difluoroallyllithium will show similar regioselectivity, with the direction of addition to C=O being determined in the main by substrate electronic factors.

The availability of $Ph_3P=CHCH_2SnMe_3$ and $Ph_3P=CHCH_2SiMe_3$ provides a new and useful route for the synthesis of allylic tin and silicon compounds by Wittig reactions of our ylides with aldehydes and ketones. A separate report will detail our investigations in this area (6).

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References

1. D. Seyferth, G.J. Murphy and R.A. Woodruff, J. Amer. Chem. Soc., 96 (1974) 5011.
2. (a) D. Seyferth and S.B. Andrews, J. Organometal. Chem., 30 (1971) 151; (b) D. Seyferth, S.B. Andrews and R.L. Lambert, Jr., J. Organometal. Chem., 37 (1972) 69.
3. G.A. Wheaton and D.J. Burton, Tetrahedron Lett. (1976) 895.
4. D. Seyferth, G.J. Murphy and R.A. Woodruff, J. Organometal. Chem., 66 (1974) C29.
5. (a) V.F. Mironov, O.M. Rad'kova, V.D. Sheludyakov and V.V. Shcherbinin, Dokl. Akad. Nauk, SSSR, 207 (1972) 207; (b) V.D. Sheludyakov, V.V. Shcherbinin, N.A. Viktorov and V.F. Mironov, Zh. Obshch. Khim., 44 (1974) 1935.
6. D. Seyferth, K.R. Wursthorn and R.E. Mammarella, J. Org. Chem., in press.