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HYDRIDE ABSTRACTION AND REGIOSELECTIVE INSERTION REACTION AT β C-H BOND OF ALKYLLITHIUM BY ETHYL(PHENYLTHIO)METHYLENE CARBENOID

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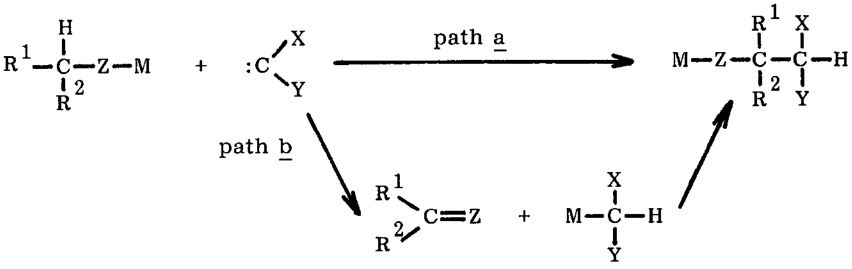
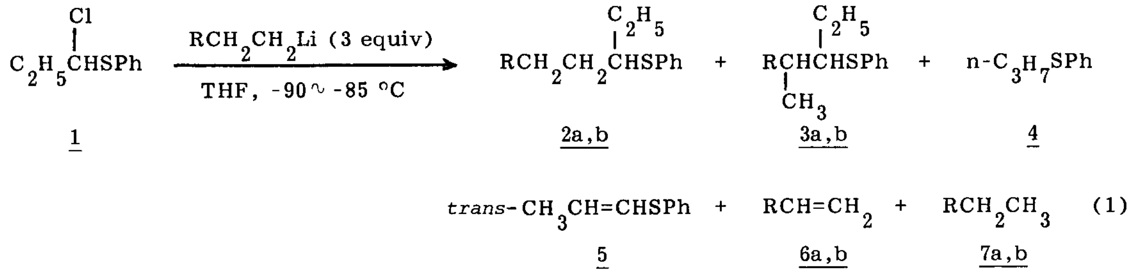
Abstract: Study on the reaction of alkyllithium with 1-chloropropyl phenyl sulfide showed two novel reactions, the regioselective insertion and the hydride abstraction, at the β C-H bond of alkyllithium by ethyl(phenylthio)methylene carbenoid.

Recent reports from this laboratory disclosed an enhanced reactivity of the α C-H bond of alkoxides in the carbenic insertion reactions (Scheme I, Z = O).[1] We showed that the insertion by alkylidenemethylene carbenoid ($R^1R^2C{=}C{:}\cdots MX$) proceeds through a concerted mechanism (path a) or a hydride abstraction-recombination mechanism (path b), depending on the nature of alkoxides.[1d] We are interested in a possible reaction of alkyllithium with carbenes or carbenoids at its β C-H bond since alkyllithium that possesses an isoelectronic structure with alkoxides (Secheme I, Z = CH_2, M = Li) is expected to show an enhanced reactivity analogous to that of alkoxides in both C-H insertion and hydride abstraction reactions. In this reaction, the hydride abstraction cannot be followed by the recombination reaction and, therefore, it could be readily defferentiated from the insertion. Reported here is our novel observation that both C-H insertion and hydride abstraction reactions proceed regioselectively at the β C-H bond of alkyllithium in the reaction with ethyl(phenylthio)methylene carbenoid ($Et(PhS)C{:}\cdots MX$).[2]

Scheme I



Z = O, CH_2
M = Li, Na, K



$$\underset{\underline{1}}{C_2H_5\overset{\overset{Cl}{|}}{C}HSPh} \xrightarrow[\text{THF, } -90 \sim -85\ ^{\circ}C]{RCH_2CH_2Li\ (3\ equiv)} \underset{\underline{2a,b}}{RCH_2CH_2\overset{\overset{C_2H_5}{|}}{C}HSPh} + \underset{\underline{3a,b}}{R\underset{\underset{CH_3}{|}}{\overset{\overset{C_2H_5}{|}}{C}}HSPh}\ \text{(sic)} + \underset{\underline{4}}{n\text{-}C_3H_7SPh}$$

$$+\ \underset{\underline{5}}{trans\text{-}CH_3CH{=}CHSPh} + \underset{\underline{6a,b}}{RCH{=}CH_2} + \underset{\underline{7a,b}}{RCH_2CH_3} \qquad (1)$$

Table I Reactions of 1-Chloropropyl Phenyl Sulfide with Alkyllithium

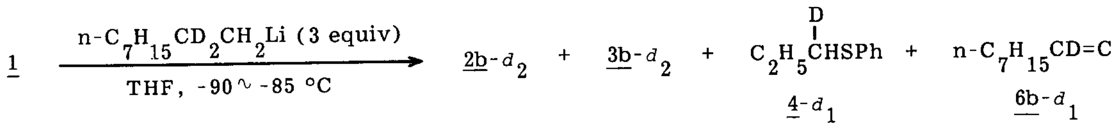
Alkyllithium	Products (Yield %)[a]											
n-C_4H_9Li	2a	(21)	3a	(7.2)	4	(23)	5	(8.5)	6a	--[b]	7a	--[b]
n-$C_9H_{19}Li$	2b	(21)	3b	(12)	4	(22)	5	(5.9)	6b	(22)[c]	7b	(88)
n-$C_7H_{15}CD_2CH_2Li$	2b-d_2	(16)	3b-d_2	(4.1)	4-d_1	(20)	5	(6.0)	6b-d_2	(21)	7b-d_2	(89)

[a] Yields were determined by capillary GC (OV-101, 30 m) analysis based on 1. [b] Formation of 6a and 7a was not analyzed. [c] Values are corrected by subtracting a small quantity of 1-nonene which was contained in the reagent.

In contrast to the efficient addition of organolithium to alkylidene-methylene carbenoid[3] or cyclopropylidene carbenoid,[4] a treatment of 1-chloropropyl phenyl sulfide (1) with 3 equiv of *n*-butyllithium (hexane solution) or *n*-nonyllithium (ether solution) in THF at -90 ∿ -85 °C yielded several products besides addition product 2a or 2b (eq 1).[5] Yields of products are listed in Table I.[6,7]

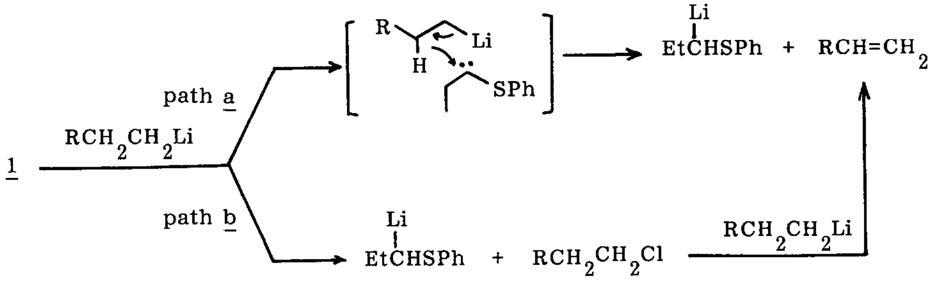
As being evidenced by the formation of 3a,b, the insertion reaction into β C-H bond of *n*-butyl- or *n*-nonyllithium proceeded regioselectively. This clearly demonstrates that the reactivity of the β C-H bond of alkyllithium is enhanced against the carbenic insertion reaction. While the regioselective insertions into β C-H bond of the less polarized organometallics such as organotin,[8] silicon,[8] and mercury compounds[9] have been reported, the study on the C-H insertion of alkyllithium is rare.[10] To our knowledge, this is the first observation of the intermolecular regioselective insertion into β C-H bond of simple alkyllithium compounds.

More noteworthy is the formation of phenyl propyl sulfide (4) whose yield is approximately equivalent to that of 1-nonene (6b) in the reaction with *n*-nonyllithium. This result together with the observation that 4 was absent in the reaction of 1 with MeLi[11] suggests that the carbenic species generated under the present reaction conditions undergoes hydride abstraction at the β position of *n*-nonyllithium to give 4 and 6 (path a in Scheme II). The alterna-



$$\underline{1}\xrightarrow[\text{THF, }-90\sim-85\ ^{\circ}\text{C}]{n\text{-}C_7H_{15}CD_2CH_2Li\ (3\text{ equiv})}\underline{2b}\text{-}d_2+\underline{3b}\text{-}d_2+\underset{\underline{4}\text{-}d_1}{C_2H_5\overset{D}{C}HSPh}+\underset{\underline{6b}\text{-}d_1}{n\text{-}C_7H_{15}CD{=}CH_2}\qquad(2)$$

Scheme II



tive path b (Scheme II) which involves halogen-lithium exchange was explicitly excluded by the following deuterium labeling experiment: When 1 was treated with *n*-nonyllithium-2,2-d_2 (d_2 content 94%)[12] under the same reaction conditions, propyl sulfide-1-d_1 (4-d_1) was obtained with 82% deuterium incorporation (eq 2).[14] Thus, another example of the hydride abstracting reactivity of carbenoids is clarified in the reaction with alkyllithium.[15] The reactivity is indicative of a highly electrophilic character of the carbenoid that has been suggested on the basis of ^{13}C NMR[16] and theoretical studies[17] and recently demonstrated by the addition reaction of alkyllithium to a carbenoid.[3b]

In summary, we have shown here two novel reactions of ethyl(phenylthio)-methylene carbenoid at the β C-H bond of alkyllithium, i.e., the regioselective insertion and the hydride abstraction reaction. The observed reactivity of the β C-H bond of alkyllithium, together with the oxyanionic effect on the α C-H bond of alkoxides, suggests that a negatively charged atom can generally activate the adjacent C-H bond in the reaction with carbenoids.

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5) *1* was slowly added to the solution of alkyllithium (3 equiv) at -90 ∿ -85 °C and, after 30 min, the reaction was quenched by the addition of AcOH-THF at the same temperature.

6) Authentic samples of sulfides *2a*, *3a*, and *3b* were prepared by the mesylation (MsCl, Et_3N / CH_2Cl_2) of the corresponding secondary alcohol followed by the reaction with PhSNa in THF.

7) Formation of a minor ammounts of diphenyl disulfide was also detected.

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11) The reaction was performed at -85 ∿ -45 °C in THF employing MeLi (3 equiv). 2-Butyl phenyl sulfide was isolated in 60% yield.

12) *n*-Nonyllithium-2,2-d_2 was prepared starting from nonanal according to the following reactions; 1) D_2O / Py,[13] 2) LAH / THF, 3) PBr_3 / HMPA, and 4) Li / ether.

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14) Deuterium content was determined by mass spectral analysis. Other products with the following deuterium incorporation were obtained; *2b*-d_2; 96%, *3b*-d_2; 94%.

15) While the exact nature of the carbenic species, or extent of the complexation with metal salts, is yet unclear, the reaction conditions employed for the generation of the carbenic species may preclude the intervention of a free carbene.

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